FOUNDER

Kyiv National University
of Construction and Architecture

Certificate of the State Registration
KB № 23029-12869P dated 27.12.2017

ISSN 2617-0264

DOI: 10.31493/tit1812

Published twice a year

2018
Vol 1(2)

INTERNATIONAL SCIENTIFIC JOURNAL

TRANSFER OF INNOVATIVE TECHNOLOGIES

Founded in December 2017

Publication of original works and authoritative reviews of innovative technologies in construction, architecture, and other fields of science and technology. New solutions and methods for measuring, predicting and studying the properties of materials, structures, technological processes. Different aspects of design, production and operation of industrial, civilian objects, infrastructure. Problems of energy, ecology, computer and information technologies

The journal is included in the List of scientific professional editions of Ukraine in accordance with the Order of the Ministry of Education and Science of Ukraine

Approved by Academic Council of Kyiv National University of Construction and Architecture
December 14, 2018, protocol No.19

Languages of the publications English, Ukrainian

Content

Sustainable Tourism Development in Ukraine

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Received on 22.06.2018, accepted after revision on 10.10.2018
DOI: 10.31493/tit1812.0101

Abstract. The publication is a contribution within the framework of the United Nations Development Programmed project UKR/95/003 «Introduction of Sustainable Development Principles into Governmental Institutions». The objective of this project is to introduce sustainable development principles into the policies, programmed and planning activities of major Governmental institutions in Ukraine in accordance with: a) the priorities of the Government; b) the resolutions reached at international conferences in which Ukraine participated; c) the international conventions or agreements to which Ukraine is a signatory.

The project which is implemented with UNDP resources, it is designed to stimulate a high-level policy dialogue on sustainable development issues in Ukraine and broaden participation in such a dialogue amongst Government institutions, as well as to disseminate the knowledge and tools necessary for the preliminary integration of sustainable development principles into the policy and strategy of the Government of Ukraine.

The primary focus for ecological tourism in Ukraine is on recreational activity, however it is limited by the need to meet environmental protection demands. The legislative preconditions for ecotourism organization are stated in the laws "On the natural reserve fund of Ukraine" (1992), "On tourism" (1995), and “On resorts" (2000) [1, 2, 3].

This publication was prepared with the assistance of the National Commission on Sustainable Development under the Cabinet of Ministers of Ukraine.

Key words: types of tourism, natural and historico-cultural resources, territorial organization of ecotourism.

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INTRODUCTION

The strategy for forming an optimal living environment in Ukraine foresees that urbanization in the future will seek to maintain an ecological balance with the maximum preservation of the natural environment.

Recreational landscapes (forest, sea, mountain), sanitary resources (mineral waters and medical clays) and territories and objects of the natural reserve fund (biosphere reserves, national natural and regional landscape parks, parks − monuments of horticultural art), which provide a proper basis for development of recreation opportunities for the population as well as organization of tourism system, constitute a considerable part of the natural potential in Ukraine.

Following current international trends concentrated on the transfer of the standards of urban life as well as recreational activities into the rural and natural areas, and thus bringing one closer to nature, Ukraine is seeing the development of new processes within the country, such as ecological tourism development, adjustment of country dwelling for family vacation, development of country cottage and garden villages, etc [8 − 10].

The present situation and outlook for the development of ecotourism in Ukraine, and its functional and regional peculiarities in the context of general tourism development in Ukraine are presented in this article.

THE CURRENT STATUS AND OUTLOOK FOR DEVELOPMENT OF TOURISM IN UKRAINE

Types of tourism

The legal basis for the development of tourism in Ukraine is set forth within the law "On tourism", in which it is stated, that "tourism is a temporary departure of a person from the place of his permanent residence with health-improving, educational or professional purposes" [2].

There are many varieties of tourism in Ukraine − cultural and educational (in historical places); health-improving and sports (at sea, in forest and mountain regions), ecological and green (on landscape territories), rural and agrotourism (in rural areas) [4].

Large tourist-zones were created in Ukraine, such as "Namysto-Slavutich" along the Dnieper river, "Yaremcha-Vorohta" in the Carpathians, "Great Yalta" on the Black Sea shore, as well as tourist centres that are functioning in historical cities such as Kyiv, Lviv, Kamyanets-Podolsky and others. Lately, complexes of ecological (green) tourism are being created and developed in places of preserved biodiversity.

The objects of the interest of the people in the sphere of ecotourism are the sea and mountains, rivers and lakes, forests and steppe ecosystems, as well as the flora and fauna that inhabit these areas.

Ecotourism is a part of a whole system of tourism in Ukraine; ecotourism is carried out especially on landscape − recreational territories and within the boundaries of the natural reserve fund [1].

Recreational Resources Potential

Ukraine is one of the largest European states with a geopolitical position in the centre of Europe (Fig.l). It has unique natural recreational resources that are very favorable for international tourism development [5].

The area of potential recreational territories in Ukraine comprises 12,8% of the country's area and is divided accordingly to the natural peculiarities of the regions (Fig.2). The present state and perspectives of natural recreational resource utilization in the boundaries of Ukraine as a whole and it's oblasts, are shown in the diagrams (Fig.3, 4).

The health-improving resources are unique, since more than 500 mineral water and clay deposits have been found. Beaches comprise 47% of the sea shore territory of the Black Sea and Azov Sea [5].

This natural potential needs to be protected, reserved and rationally used because it forms the basis of sustainable development of health-resorts, recreational zones, tourism.

In Ukraine a special resolution of the government confirmed over 240 resort settlements, which are situated in the boundaries of

Fig.1. Ukraine on the territory of Europe

Fig.2. Ukraine's recreational potential

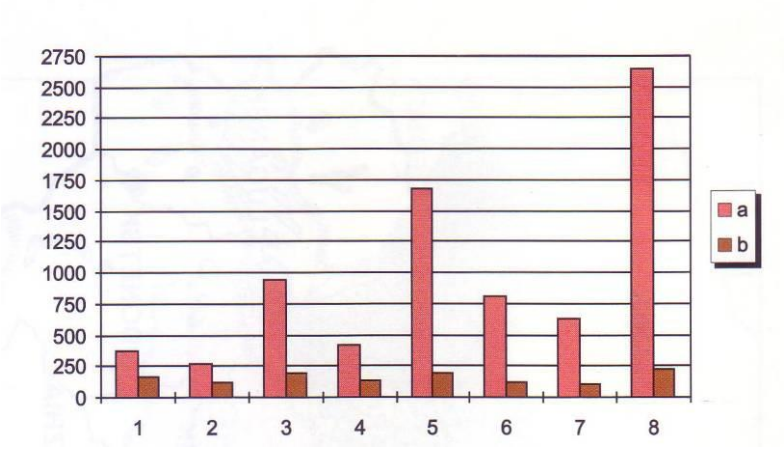


Fig.3. Recreational territories structure distribution among regions.
Recreational territories area, thousand ha: *a* − altogether; *b* − developed territories. Oblast groups:
1 − Donetsk, Lugansk; 2 − Dnipropetrovsk, Zaporizhzhya, Kirovograd;
3 − Poltava, Sumy, Kharkiv; 4 − Kiyv, Cherkassy; 5 − Volyn, Zhytomir.Rivno, Chernygiv;
6 − Vinnytsya, Ternopil, Khmelitski; 7 − Mykolayiv, Odessa, Kherson, Crimea autonomous republic; 8 − Zakarpatya, Lviv, Ivano-Frankivsk, Chernivtsy

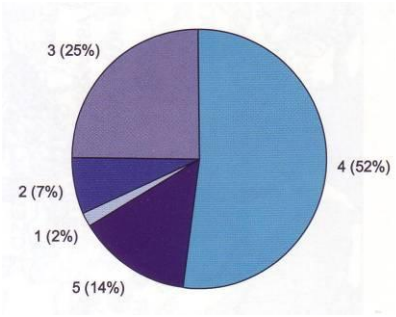


Fig.4. Recreational territories of Ukr
stage use structure.
Recreational territories area, %:
1 − 1 stage (until the year 2006);
2 − II stage (until 2016);
3 − III stage (2026);
4 − reserve of recreational territo
5 − used territories

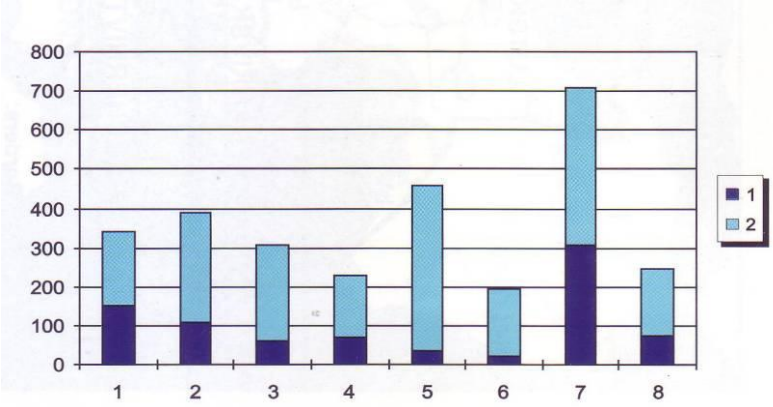


Fig.5. Recreational facilities according to oblasts development dynamics.
Capaciusness of recreational health and tourist establishments, th. people/places:
1 − present situation;
2 − perspective (until 2026)

7 recreational regions [6]. These regions include the sea shore of the Autonomous Republic of Crimea, the Black Sea shore and the Azov Sea shore, the mountainous and foothill regions of the Carpathians and in other localities. Among these settlements there are 27 health resort cities and 214 villages which have a special status for the development of recreational and tourist functions.

According to statistical data the general capacity of permanent recreational, health-improving and tourist facilities comprises more then 800 thousand beds.

In the section of functional specialization health-improving facilities (sanatoriums, holiday hotels, prophilactoriums) comprise 23,6%, recreational (houses and centers, children health-improving facilities) − 66,3%, tourist facilities − (hotels, tourist centers, motels-campings) − 10,1% [8]. The capacity and the prognosis for the stage development within the framework of recreational facilities (health-improving, tourism) are shown in the diagram (Fig.5).

Natural Reserve Fund

The network of the natural reserve fund comprise 8032 territories and objects, with an overall area of 3922 thousand hectares, which comprise 6,49% of the Ukraine's territory. The situation plan of the main objects of the natural-reserve fund are shown in Fig.6, and their share in each region − in Fig.7.

National natural parks, regional landscape parks and biosphere reserves play a very important role for the ecotourism organization in Ukraine (Table 1). It is in the location of these natural sites that recreational activity takes place, and is one of the foreseen areas of direction for the future development of these facilities.

Biosphere reserves comprise 6,42% of the structure territory of the nature reserve fund, national natural parks – 30,99%, regional landscape parks - 19,34%. Artificially created objects and parks and monuments of horticultural art are also part of the nature- reserve fund, although their share is less than 1%.

The structure and volume of the natural-reserve fund objects of Ukraine are shown in diagram (Fig.8).

As far as natural reserves, zakaznyks, and nature-monuments are concerned, they can be used only for ecological, educational work and tours. At the same time, the possibility for wider use of the reserves and nature-monuments territories for commercial ecotourism has been looked into. For this the corresponding economic mechanism to guarantee self-financing measures to preserve biological diversity is being created. In Table 1 you can see the most preserved and attractive for ecotourism and specially guarded nature sites.

Ukraine has actively joined the complex development of international ecotourism process. Through this connection, the formation of interstate natural reserves within the country's territory is very important. Largetracts of land "Stuzitsa" (14665 ha) became a part of the first Central European trilateral interstate territory − biosphere reserve "Eastern Carpathian" [11].

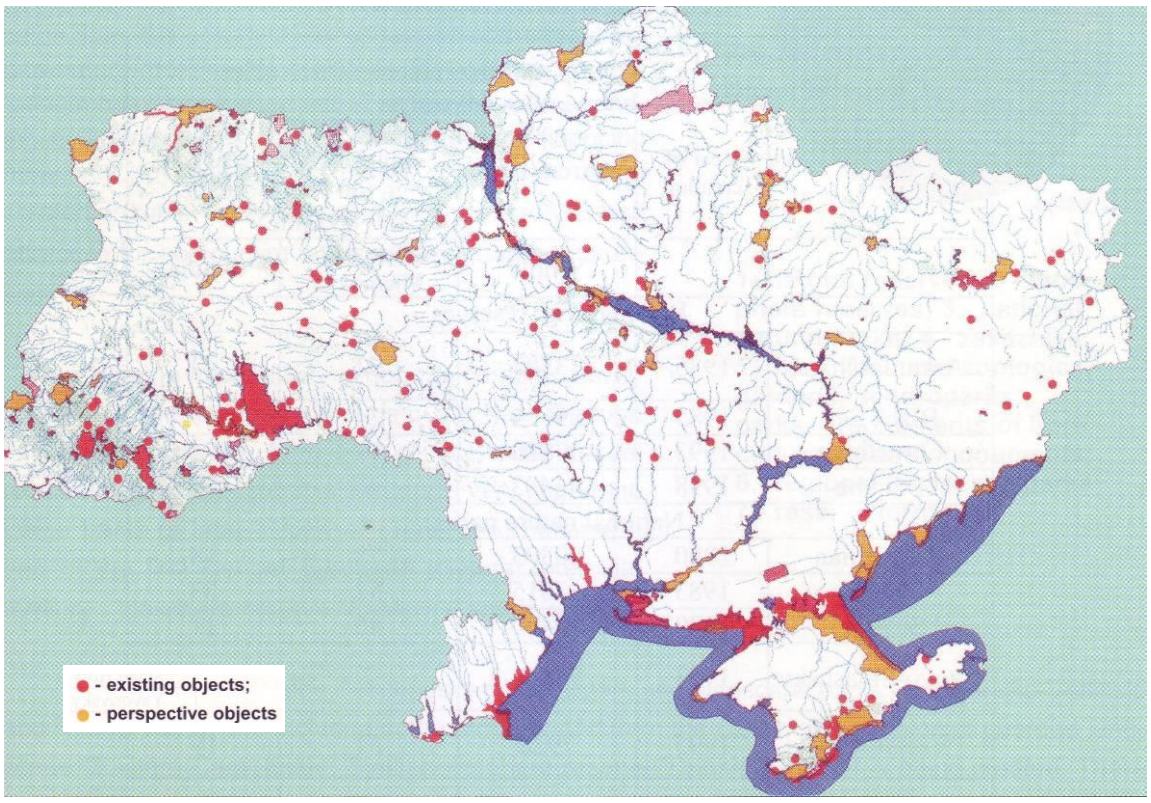
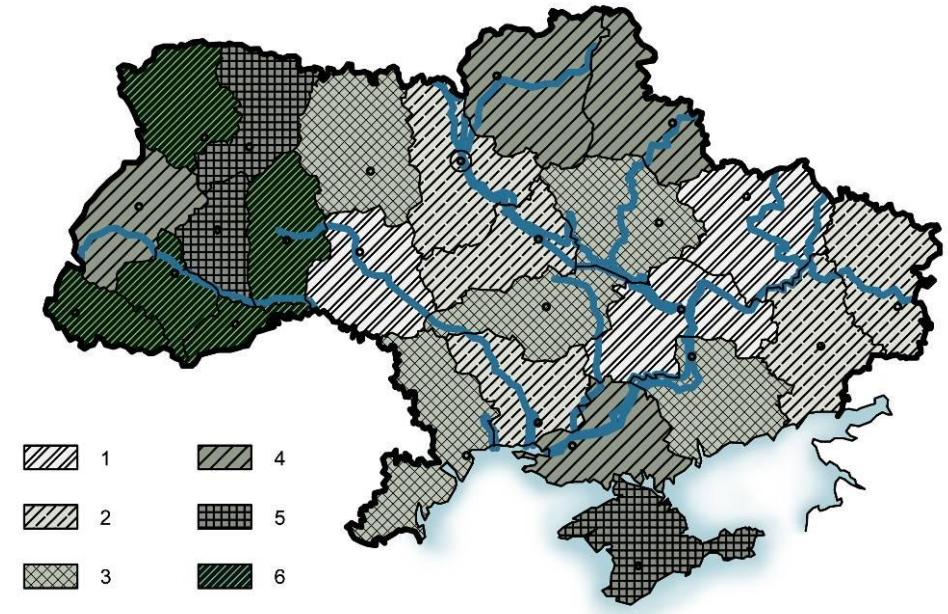


Fig.6. Natural reserve fund of Ukraine



Питома вага заповідних територій у площі області: 1 - до 3% (Вінницька, Дніпропетровська, Харківська); **2** - до 4% (Донецька, Київська, Луганська, Миколаївська, Черкаська); **3** - до 5% (Житомирська, Запорізька, Кіровоградська, Одеська, Полтавська); **4** - більше 5 до 8% (Львівська, Сумська, Херсонська, Чернігівська); **5** - більше 8 до 10% (Автономна республіка Крим, Рівненська, Тернопільська); **6** - більше 10 до 16% (Волинська, Івано-Франківська, Хмельницька, Чернівецька, Закарпатська)

Fig.7. Reserve level on the territory of oblasts

Table 1. Biosphere reserves and national nature parks of Ukraine

Nature-reserve establishments		Nature-reserve territories		
Name	Year of creation	Area (ha)	Quantity of flora and fauna species, entered in the Red Book of Ukraine	
		Whole	Flora and Microbiota	Fauna
Biospherical reserves				
Askania-Nova	1985	33307	22	41
Black Sea	1985	89129	24	69
Carpathian	1993	57880	92	74
Danube	1998	46403	8	61
National nature parks				
Carpathian	1980	50495	78	18
Shatsky	1983	48977	32	33
"Sinevir"	1989	40400	40	11
Azovo-Sivashsky	1993	57400	7	18
"Vizshnitsky"	1995	7928	31	19
"Podilski Tovtry"	1996	261316	60	79
"Sviati Hory"	1997	40589	48	50
Yavorivsky	1998	7108		27
Skolivski Beskydy	1999	35261		

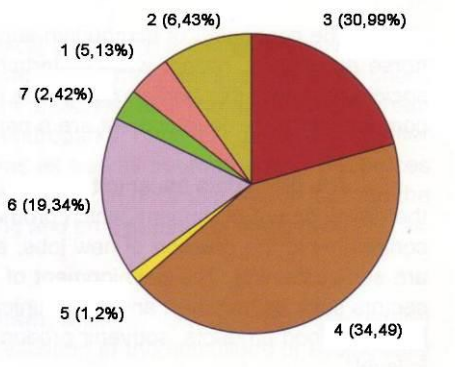


Fig.8. Natural reserve fund structure:
1 − natural reserves;
2 - bios phere reserves; 3 − national natural parks; 4 − zakaznyks;
5 − botanical and zoological gardens, dendroparks, parks − monuments of horti culture, natural monuments;
6 − regional landscape parks;
7 − reserve territories

From the Polish side Beschadsky national park and landscape parks − Tsisniansko-Vetlinski and "Sleep Valley" are included in the territory; and from the Czech side - region of guarded landscape "Eastern Carpathian". Similar biosphere reserve "Dunaiski Plavni" is being created. There is a proposal to create such interstate biosphere reserves, as: Polish-Ukrainian "Western Polissia", Russian-Ukrainian "Briansk and Starogutsk forests" etc. Those objects might in perspective be the most popular for developing a transnational ecotourism system [17].

Tourism as economic category

Ukraine, a country with a transitioning economy, has a goal to achieve a level of profitability and competitiveness within the tourism industry since it is an important branch of its economy.

So far profits from tourism within country's economy are low. Revenues from tourism in gross domestic product equate to about 1%. Ukraine's share in international tourist exchange is about 0,06%. In total volume of gross tourism revenues Ukraine's share is only 0,13%.

The contingent of ecotourism supporters − those, who are fond of speleotourism, foot and horse excursions, hiking, water entertainment − is not covered by official statistics. According to sociological data this portion comprises up to 8% of the entire number of tourists. The economic components of its development are a part of tourism economics on the whole.

The given data attest to the great reserves in tourism development and economic profits of the development of tourism, which promotes the quality of life and raises the standards of living, contributes to the creation of new jobs, and ensures that the environmental protection measures are self-sustaining. The development of tourism in Ukraine stimulates the development of other sectors such as transport and communication, the production of building materials and biologically cleans food products, souvenir production, which provides for the country's rise of an economic level [7, 18-21].

PECULIARITIES OF ECOLOGICAL TOURISM ORGANISATION

Typology of objects of ecological tourism

Ecological tourism (ecotourism) in Ukraine has developed within the territory of the natural reserve, in the boundaries of which people can take long-term or short-term vacations, acquaint with the flora and fauna. Ecological tours and environmental education may be carried out. At the same time a special environmental protection regime is ensured. To the categories of the national reserve fund of Ukraine, where ecological tourism can be developed, belong: national natural parks (Carpathian, Shatsky, Sinevirsky, Azov-Sivashsky and others), regional landscape parks (Dnister Canyon, Kinburn Split, Dikansky and others), and biosphere reserves (Carpathian, Askaniya Nova, Black Sea, Danube) [11].

Green tourism has a lot in common with ecological tourism. It is being organized within the territory of natural landscapes with the provision of amenities, where conditions exist for short-term vacations (from 5 − 10 hr to 1 − 2 days), vacation on the beaches, etc. The areas where green tourism may take place, are: forestparks, hydroparks, dendroparks, botani-

cal gardens and other landscape complexes which can be situated in rural areas as well as in urban areas. Resources for the organization of green tourism exist in all Ukraine's regions, in particular -green lines on the riverbanks of the Dnieper, Desna, Danube, Southern Boug and on a number of small rivers, lakes, reservoirs.

Another variety of ecological tourism is ***rural tourism,*** which is oriented on the use of rural settlements for a long term, as well as for a short-term vacation in the conditions of ecologically clean landscape. Traditional for Ukraine, dacha villages, which have since lost their agricultural function, are also part of country tourism. Of great importance for rural tourism development are ethnic peculiarities, the ethnographic characteristics of Ukraine's population's life, the existence of folk trades and folk architectural and the historic monuments (in particular - palace-park facilities of XYIII − XIX centuries).

Similar to ecological tourism is also ***agrotourism*** on the agricultural arable land, where the conditions for producing the agricultural products exist, as well as for vacation and the voluntary involvement the population in some kinds of jobs (harvesting fruits, vegetables and berries, looking after domestic animals).

There are a lot of agrorecreational villages in Ukraine, gardening associations villages, agroparks, also farms and farmsteads suitable for vacation (***farm tourism***). Low-income families prefer to go on vacation to rural areas, where they are provided with ecologically clean produce and inexpensive housing, get acquainted with ancient customs and involve children in practical agricultural work, folk trades and rituals [4].

An interesting example is a project for tourists called "The Big Tavria Ring". It is a route in the Crimea, by which planners envisage the creation of farms and farmsteads to fulfill double functions for tourists and agro-food. It has been proposed to develop on tourist routes mini-hotels, small factories for agricultural produce processing, to construct horse farms for tourism needs.

Ecological tourism development resources

Nature resources. In Ukraine there are three main categories of natural reserve areas, which may directly become the basis of ecotourism development: national nature parks, regional landscape parks and biosphere preserves.

According to the UNESCO "Man and Biosphere" program 4 biosphere preserves have been created in Ukraine. One of their goals is connecting nature preservation, tourist-vacation and economic activities. The most famous is "Askania-Nova" preservation (built in 1874) in Kherson region. Except standard steppe sections and rare animal species that are guarded in preservation there is a dendropark and zoo, which are very attractive for tourists.

Forty seven national nature parks were created in Ukraine. The first park was created in 1980 − Carpathian National Nature Park, the biggest in Europe tourist-vacation region. This and other national nature parks − Shatsky, Sinevir compared to international national parks not only are very "young", but also so far are not well equipped. In the vicinities of these parks there are working tourist-recreational facilities, working tourism sites and infrastructure, while additional service infrastructure development is needed [11].

Among nature preservation territories of Ukraine which can be the most practically utilized for ecological tourism development an important role belongs to 69 regional landscape parks and 58 dendroparks. Regional landscape parks are in formation stage, and

dendroparks, such as "Sofiivka" in Uman, "Olexandria" in Bila Tserkva, Trostianets in Chernihiv region and others are magnificent examples of Ukraine's landscape architecture (there are more then 100 of those in Ukraine), and a substantial part of which is in rural areas [12, 13].

Historico-cultural resources. In Ukraine important tourist attractions are: historical monuments, archeological monuments, ethnographic and cultural facilities, and museums. There are also trades − hunting and fishing, handicrafts − weaving and ceramics, folk architecture and folklore, which attract tourists. The spirit of the people, which is preserved in Ukrainian rituals and customs (for example, holidays "Christmas", "Shrove/tide", "Easter", "Green holidays" etc.) is extremely important in education of children and younger generation and attraction of tourist, including foreign.

There are scansenes − museums of folk architecture and life under the open sky in Kyiv, Uzhgorod, Pereyaslav-Khmelnitski. Creation of such natural ethnographic museums, which depict the ethnic specific features of certain regions of Ukraine is a proposed direction for ecotourism development.

Territorial organization of ecotourism

Among the first national natural parks created in Ukraine are the Carpathian Park in 1980 (area 50,5 th. ha) and Shatsky Park in 1983 (area 48,9 th. ha). The main unique feature of these national natural parks is the use and adaptation of the existing recreational fund and infrastructure, in the framework of a functionally new object without constructive changes. At the present moment these and other national parks are only limited to the popularization of nature by means of excursions, regional studies and other ecotourist functions. Rational territorial organizations and high level of amenities in national parks, biosphere reserves and regional landscape parks would be a favorable basis for ecotourism development.

The Ukrainian legislature is regulating the creation of functional zones in national parks: reserve, regulated recreation, stationary recreation, regulated economic activity [1].

Besides allocating new tourist and recreational facilities or use of existing ones, an important measure is the creation of "landscape-route corridors", "exposition zones", "ecological roads", "tourist land" (for fishing, berry-

mushroom gathering, hunting, skiing). Equipment for special views and barbecue places, building of ecologically safe roads is also foreseen.

One of the examples of ecotourism com-

plex formation is the idea of the South scientific center of the National Academy of Sciences of Ukraine and tourist-commercial company "Euginia Travel LTD" (Odessa). It has been suggested to locate the ecotourism complex 50 km from Odessa in the zone of the "Tyligulsky" regional landscape park on the grounds of cooperative land (10 th. ha), where the zakazniks are located − ornithological, botanical and zoological; environment − dry steppe with a unique microclimate, which is characteristic of only this part of Ukraine. The Tyligulsky landscape evokes great interest in different categories of the population: tourists, sportsmen, scientists, and businessmen. There are beautiful views here, diversity of the flora and fauna, thrilling hunting and fishing.

The territorial organization of the ecotourism complex foresees the creation of a zoo "Steppe safari", contemporary farms, deltaplanerism club, exotic recreational settlements, equipment of places of interest tourism (crab and lobster catching, hunting, horse riding, troikas riding). Several hundred jobs will be provided for the servicing of tourists, rebirth of crafts and growing of ecologically clean products. On the account of the volume of services to local and foreign tourists, a high level of economic effectiveness of this ecotourism complex functioning is being prognosed.

A similar project of creating an international ecotourism complex on the shore of the Zhabrianska Bay of the Black Sea at the border with Romania was proposed by the Ministry of ecological safety and urban building SRPI. The unique natural resources of this region are the Danube delta, the Sasic salt lake, Zhebrianskaya split. In the Danube biosphere reserve, unique flora and fauna are preserved. The Danube delta − a unity of islands − and the aquatoria are part of the water-marsh land of international importance.

An attractive site for tourists is the Vilkovo village with numerous channels − the so-called "Ukrainian Venice". A wonderful waterlink by the Danube gives an opportunity of acquaintance with this phenomenon of nature for tourists from many countries and with the analogy with the above mentioned project considerable economic profits can be obtained here.

Ecotourism development organizational measures

Ecotourism in Ukraine is in the making. Certain facilities exist in different regions of Ukraine − tourist hotels, tourist centers, motels, camping grounds, which accept and provide services to groups or individuals, who engage in their favorite vacation activities (fishing, hunting, yacht sailing, skiing, horseback riding, berry, mushroom, herb collection; speleo-tourism, alpinism, etc.). Special ecotourism marketing and commercial services are yet to be developed.

One of the first steps towards the establishment of demands concerning ecotourism organization in Ukraine was the holding in 1996 by the World Bank and Ministry of Ecological Safety of Ukraine an International seminar on the "biobusiness", where the problems of "ecobusiness" and development of "ecotourism business-plans" were discussed. The organizational preconditions for ecotourism development were the following: attractiveness of landscape resources for ecotourism; the existence of accommodations to receive tourists and servicing facilities; presence of specialists

-tour guides, instructors, translators, who can provide ecological tours and individual security. All these questions must be taken into consideration in the business-plan of the ecotourism complex organization, when expenses and income are established, investment sources, price prognosis and risk description, taxes, commercial − informational program, etc.

Thus, valuable landscape complexes in Ukraine will be not only "high standards of nature", but also become profitable commercial ecotourism enterprises, which will be able to provide for the preservation and restoration of nature by its own means.

ECOTOURISM DEVELOPMENT IN THE REGIONS OF UKRAINE

According to the recreational regioning of Ukraine, there are 7 regions on its territory: Carpathian, Transdniester, Dnieper, Transdonetsky, Transazov, Black Sea, Crimean (see Fig.2).

The Carpathian recreational region

The Carpathian region is are one of the most interesting ecotourism regions of Ukraine, with continental-European climate, landscape diversity, rich flora and fauna and a great number of natural resort objects.

The most attractive zones for ecotourism are natural parks: "Carpathian", which embraces mountain heights and river basins; "Sinevir", with the largest in the Carpathian Sinevir lake − the so-called "sea eye", "Vyzhnitsky", which takes up great areas of forests, etc [12].

The natural aspects of the Carpathian region are wildly used for the organization of ecological mountain tourism. The large areas of Swidovets, Marmaros with the Goverla mountain (2061 m), Beskidy, Svaliava landscapes, carts caves − are very interesting ecotourism sites. The mountain relief and favorable climate attract tourists and sport participants, who are interested in winter sports, such as skiing, and the developed network of rivers for those who are into boat sailing.

The Carpathian flora has over 1100 types of plants. The picturesque "Narcissus valley", where the only European wild thicket of narcissus is being protected, as well as the vegetation of the alpine zone attract a great number of tourists [16].

The animal inhabitants of the Carpathian region are also significant. There are more than 220 species of ground spine animals, birds, snakes, amphibian. Here you can find bear, lynx, deer, golden eagle, black stork, and trout.

The Carpathian region is rich in natural, historic and ethnic monuments, and original folklore. A developed recreational infrastructure, with a network of walking routs for ecological tourism was created here. Besides the existing shelters, tourist grounds, hotels, the construction of private facilities for servicing tourists are also being developed here, including mini-hotels, family vacation homes, and national cuisine restaurants.

The Carpathian region is situated on the crossroads between Western and Eastern Europe, highlighting the country's important place in international tourism development on the basis of creating international nature reserve sites for Ukraine, Belarus, Poland, and Slovakia.

Transdniester recreational region

The Transdniester unites a considerable territory of the western part of Ukraine at the Dniester river basin. The Podil height, has a favorable climate − a mild winter and warm summer.

On the region's territory a considerable number of environmental protection objects are concentrated. The most significant among these are the natural reserves "Roztochchya"; "Medobort", which border with the Carpathian region, national natural parks "Shatsky" and "Podil Tovtry" and the western part of the regional landscape park "Pripyat-Stohid". Among the significant ecotourism objects are also the Dniester reservoir, Tovtry-cliffs canyons, caves and grotto's. Among the forest flora of the different regions are beech, hornbeam, lime-tree; and among the fauna − elk, wild boar, and muskrat which are widely spread.

The region is rich in natural, historic, cultural and architectural monuments, especially in Ternopil, Khotin, Galich, Zhovkva cities. In the city of Kamyanets-Podilsky a historic-cultural reserve was created − "Old City".

These natural and cultural reserves of the Transdniester promote the development of ecological and other types of tourism - educational, scientific, speleotourism etc. The tourist infrastructure has been developed in this region. There are tourist bureaus and hotels in the cities of Kamyanets-Podilsky, Chernivtsy, Ternopil, Khmelnitsky, as well as interesting tourist routs.

On the frontier territories of the region ecotourism can be developed as part of international natural reserve territories of Ukraine and Moldova.

The Dnipro recreational region

The territories by the Dnipro river basin have favorable climate conditions, a variety of recreational resources and a network of areas under environmental protection. Ecological and other types of tourism have been developed here as well including "the nostalgic" for the untouched Ukrainian nature.

In the Transdnieper a national system of tourist tour routs was created − "Namysto Slavuticha". In this region such natural reserves are situated as Kanivsky and Dniprovsko-Orilsky; and partially the Black Sea biosphere reserve. Other ecotourism sites incldue historical-architectural reserves such as "Chigirin" and "Hortytsya"; dendroparks − "Sofiivka", "Trostyanetsky", "Olexandriya".

The region is known for its vegetation diversity − forest, marsh and steppe areas. In the hunting farms, hunting of elk, deer, and wild boar is organized and fishing of pik, sheat-fish and other has been developed. The monuments of historic-cultural heritage, that relate to the Kyiv Rus period (IX − XII) and development of Ukrainian statehood (XYII − XYIII), are important. Among them are historic-cultural reserve "Kievo-Pechersky"; archeo-

logical monuments of the Trypillya, ancient, Scythian culture, remarkable historical cities: Kyiv, Pereyaslav-Khmelnitsky, Chernigiv, Odessa.

A tourist infrastructure has been created in the region: transport connections were developed, and there is a network of tourist agencies, tourist centers, and hotels. The majority of them are concentrated in the regional centers of the area. In the capital of Ukraine, Kyiv, there are first class hotels, which are adapted to foreign tourists (3 − 4 stars) − "Kyivskaya Rus", "Dnipro", "Lybid" and others.

Transdonetsk recreational region

This region is situated in the forest-steppe region, has a developed network of river and water services and a considerable number of areas under environmental protection.

In Transdonechina the following sites are located: the national natural park − "Sviati Gory"; "Ukrainski Stepovy" natural reserve and others. The vegetation in this region cover steppe, forest and marsh areas with a lot of plant varieties, and fauna numbering over 400 animal species.

Natural-recreational resources, and the presence of historic-cultural monuments of heritage (XYI-XIX sent.) favor the development of ecological, cognitive and educational tourism types in this region. A developed tourism infrastructure was created here that includes tourist agencies, a network of tourist facilities, especially in Dnipropetrovsk, Kharkiv, Donetsk, Lugansk, Poltava, and transport connections

In this highly industrialized region a large international business community is active, thus conditions could be created for business-tourism, as well as ecotourism, with the goal of providing the working conditions and vacation opportunities for people.

The Transazov recreational region

This region takes up the territory along the shores of the Sivash. The Azov Sea has considerable health − resorts, recreational resources and environmental protection objects, among which the most siginificant are: the biosphere reserve − «Askaniya Nova», natural reserves-Ukrainian Steppe and Lugansky, Azov-Sivash national natural park, natural monuments − Granite cliffs, Stone tomb, etc.

The flora of these places is unique. The topography includes sea sands, lakes and estuaries, marshes and meadows. Among the fauna, the birds are wonderfully unique to the area. In the migration period, mountain stork, vulture and other birds can be found here.

Some types of ornitofauna of the Transazov are included in the Red Book of Ukraine and the European Red list; water- marsh territories

(according to the Ramsar convention) are of international importance [15].

The uniqueness of nature, the presence of historical, cultural and architectural monuments (XVII − XIX cent.), create favourable conditions for the development of ecological and other types of tourism. The region has a developed tourism infrastructure: a modem transport network, and a considerable number of tourist agencies and hotels − «Zaporizhzhya» in Zaporizhzhya; «Parus» in Berdyansk and others.

The Transazov region is a part of a single tourist-recreational system of the Black and Azov Seas, the development perspectives of which are laid in «The sea shore zone tourism development Program» (1996), prepared by the Ministry of ecological safety under the assistance of the World Ecological Fund [21].

The Black Sea recreational region

The territory of the southern part of Ukraine is known for its unique complex of natural resources, has broad access to the Black and Azov Sea basins and the majority of Ukrainian rivers − the Danube, the Dniester, the Dnipro, the South Bough. Because of exceptional natural conditions (warm sea with sand beaches, medicinal resources), this region is highly developed for vacation and treatment at health resorts, becoming particularly attractive to international tourism.

There are a couple of hundred environmental protection objects in the region, the most well known among them are: the Black Sea and the Danube biosphere reserves. The flora and fauna have specific features intrinsic in the Black Sea steppe and Eastern − European forest geobotanical provinces. Rich vegetation and the diversity of animals (roe deer, elk, wild boar), birds (falcon, pheasant, great bustard), fish (anchovy, sturgeon, gray mullet) contribute to the quality of the area.

There are unique natural monuments in the region- the Odessa catacombs, cliffs, historical and cultural monuments, including the State archeological reserve ancient "Olviya".

The tourist infrastructure has been developed well, and there is a powerful transport potential, a network of tourist establishments, especially in the administrative centers of the region. In Odessa there is a sea port and a tourist center of international importance; in Mykolayiv and Kherson there is tourist centers

and hotels, the most comfortable among them being "Southern Boug", "Ochakiv" and others.

The Danube delta, second largest in Europe, is a natural body of water of global significance. The rare, natural richness and particular quality of this locality create unique conditions for scientific work, amateur fishing and hunting, ecological education of the population and ecotourism development in the system of the international Danube shipping route.

The Crimea recreational region

The Crimea is the most famous for its natural recreational potential not only among Ukrainian regions, but also among the countries of the Mediterranean and Black seas. This peninsula has a combination of unique recreational resources: the sea, the mountains, beaches, picturesque landscapes, historical monuments and natural reserve objects.

The Yalta Mountain-Forest, Crimean, Karadakh and other natural reserves, which are unique in their natural value, are situated in the Crimea. There have been proposals raised for creating a national natural park called "Chatyr-Dag".

The Crimea mountains, specifically mountains Roman-Kosh (1545m) and Ai-Petri (1334m), the steep cliffs in the region, the Great Canyon, the Baydaro-Kostropilsky wall, and Chatyrdag slopes offer great opportunities for ecological, mountain tourism, cliffhanging, speleotourism, and gliding in Crimea. Other unique places for such outdoor recreation opportunities include the caves and cave cities (where ancient people used to dwell), and many landscape resources such as 1000 year old yew tree and beech forests. There are also a lot of water marsh territories, ornithological zakaznyks in Crimea. In sea-shore territories, the Kerch strait in particular, there exist trout and clam cultivation farms [22].

The most attractive for ecotourism conditions exist where there is a combination of different natural peculiarities: eloquent mountain relief forms, Mediterranean flora, southern fauna, historical-cultural monuments. Among such cities are Yalta, Gurzuf, Noviy Svit, Bahchisarai and others.

In the region's borders excursion for tourists have been developed, and appropriate infrastructure has been created in cities and villages, situated along the shore. Tourist routes

have been organized, equipped with walk paths and viewpoints, and include places for practicing speleotourism. In the region of the Uzun-Sirt Mountain gliding has been developed as a sport [23].

A network of tourist facilities exists in Simpheropol − the capital of the Crimean Autonomous Republic, Yalta, Sevastopol, Bahchisarai and other cities. For foreign tourists can stay in world standard hotels such as − "Yalta", "Oreanda", "Palace".

Recently necessary conditions for the formation of the national natural park "Turida" have been created. For the development of ethnic and historic- cultural tourism in the borders of this national park, the development of the "Great Tavriya Ring" is planned with the aim of the rebirth of cultural traditions in places of the Crimean national minorities' residence.

According to the Convention on Black Sea protection from pollution (1992) and Ministry Declaration on Black Sea protection (1993) the Crimea, Black Sea and Transazov are regions of special ecological status and international attention. They represent the recreation of resource potential, biological diversity of their unique ecosystems, as well as integrate the rational use of the natural − cultural resources of the shore line for all types of tourism.

CONCLUSIONS

1. The analysis of ecotourism development in Ukraine shows that the presence of great natural opportunities, which haven't been fully used. Due to the current difficult economic situation in Ukraine, the development of a national tourism system focused on eco-recreation and health-resorts is presently in a state of stagnation.

2. The main tasks which are necessary for the development of an ecotourism industry are:

• *restructuring* of the existing recreational, sanitary and tourist fund according to social needs of the population and market economy conditions:

• construction of new establishments, which answer *world standards*, for the development of the national tourism system and integration into international tourist structures;

• provision of vacation conditions of socially-sensitive categories of the population, especially those, *who were exposed to radiation* from the Chernobyl accident;

• creation of legislative conditions for the development of *ecotourism*, which will promote the rational use and protection of landscape resources.

3. The prognosis for tourism, recreation, health − resort system development determines the main directions of solving the above mentioned problems during 3 stages: I stage (2001 − 2006) − the growth of the given branch fund is projected to be 1,2 times; II stage (2006 − 2016) − 1,5-2 times; III stage (2016 − 2026) − 2,1…3 times. These are the periods of implementing investment programs, modernization to the world standard levels of the existing tourism infrastructure and ecotourism development − internationally acclaimed phenomenon of the XXI century.

4. The priority directions of ecotourism development in Ukraine are:

• normative-legal provisions in this sphere, in particular, concerning the preservation and use of biodiversity, ecological entrepreneurship, international ecotourist activity;

• improvement of ecotourism territorial organization on the basis of international ecological existence of landscape complexes and quality assessment;

• solving the questions of financial and tax priorities concerning the use and protection of natural reserve areas, which fulfill ecotourism functions;

• norm development of ecological nature use, economical mechanisms of balanced ecotourism development, models of integrated management in the conditions of departmental management of ecotourism objects;

• creation and implementation of ecotourism development projects, broadening through mass media of ecotourism organization advantages.

5. International cooperation will play an important role in the development of ecotourism and problem solving in Ukraine. This cooperation is carried out in different programs in the regions of the Carpathians, the Black and Azov Sea shores, with assistance of the UN, the World Bank and other international organizations. The further activation of this cooperation and the development of external economic activity with a unique natural-cultural potential are designed to play a significant role in the international tourism system.

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Развитие экологического туризма в Украине

Тамара Панченко, Михаил Сукач, Андрей Голуб

Аннотация. Публикация является вкладом в рамках проекта Программы развития Организации Объединенных Наций UKR/95/003 «Внедрение принципов устойчивого развития в государственные учреждения». Целью этого проекта является внедрение принципов устойчивого развития в политику, программы и мероприятия по планированию деятельности крупных правительственных учреждений в Украине в соответствии с: а) приоритетами Правительства; б) резолюциями, принятыми на международных конференциях, в которых участвовала Украина; с) международными конвенциями или соглашениями, участником которых является Украина.

Проект осуществленный с использованием ресурсов ПРООН, призван стимулировать политический диалог высокого уровня по вопросам устойчивого развития в Украине и расширять участие в таком диалоге между государственными учреждениями, а также распространять знания и инструменты, необходимые для предварительной интеграции принципов устойчивого развития в политике и стратегии Правительства Украины. Главное внимание в данной публикации уделено проблеме устойчивого развития туризма в Украине и экотуризма в частности, учитывая требования охраны природы и Законов Украины «О природно-заповедном фонде», «О туризме» и «О курортах».

Эта публикация была подготовлена при содействии Национальной комиссии по устойчивому развитию при Кабинете Министров Украины.

Ключевые слова: типология туризма, природные и историко-культурные ресурсы, территориальная организация экотуризма.

Decorative-formative and spatial organization of representative architecture 1930s − early 1950s as a reflection of the state-ideological goal

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Received on 30.05.2018, accepted after revision on 19.07.2018
DOI: 10.31493/tit1812.0102

Abstract. During the first half of the social history XX century of European countries and the Soviet Union as a reaction to world events: the First World War, the revolutionary outbreaks in many European countries, the political, economic and cultural crisis, the disappointment of various segments of the population in the existing political regimes − in the European countries were born national-socialist parties that in some states formed totalitarian political regimes on the basis of a single party headed by a leader. From the side of state power, the replacement of the system of government led to the need for the formation of the urban environment as a carrier of a new state ideology, from the side of society there was a birth of a new social consciousness, which inevitably reflected in new directions of development of culture and architecture

During the 1930s, the Soviet Union, both theoretically and practically, consolidated itself in positions of totalitarianism of the authorities with corresponding changes in architecture. Due to the common features in the system of governance, European states and the USSR certainly had common directions in architecture − axial symmetry, which as an architectural means always proclaims the order in the state, the large scale of buildings − a sign of strength and invincibility, composition based on the subordination of parts as a whole, reflecting the need for praise of power. But the differences in social stratification, which is natural in European countries, created on the basis of taking into account the property status of the owner, and artificial, adopted in the USSR, on the basis of the rise of the social role of the worker as a social hegemonic, led to the embodiment to the architecture a different state-ideological goal: in European countries − the ideal of strength, power, order, national superiority over other peoples; in the Soviet Union − equality, reliability of the protection of the state, a bright future in the life of the people.

Keywords: European states, Soviet Union, architecture, political regime, totalitarianism, state symbols, form and style in architecture.

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THE INTRODUCTION

The first half of the twentieth century, beginning in the 1920s, marked the emergence of totalitarian regimes in European life as a reaction to the political upheavals that took place in a number of countries after the First World War.

The First World War caused a great political, economic and cultural crisis, rejecting the established norms, values, moral restrictions and especially the imagination of the value of human life [21]. After its completion, a revolutionary wave swept through Europe, which in 1917-1921 captured Russia, Spain, Finland, Germany, Austria, Hungary, Italy and other European countries [22]. As a result, representatives of the monopoly capital, the agrarian aristocracy, employees and part of the workers took the view that it was impossible to secure a solution to the crisis through bourgeois-parliamentary institutions [14] and necessary to establish a rigid, authoritarian power. That is why, in a number of European countries, the formation of reactionary parties and the change of political regimes took place, and in Spain, Italy, Portugal and Germany a system of government was formed based on a one-party system headed by a leader. Representatives of these political forces called themselves National Socialists or fascists[1].

For these countries, it was characterized by the presence of rigorous control on the part of the elite of power to all sides of life − an economy where private property and market relations were maintained, a policy of categorical non-perception of other political forces and movements, a culture in which various forms was reflected the idea of creating a public consciousness on the basis of the feeling of the exclusivity of the nation, and therefore its priority right to decide the fate of other peoples.

THE PURPOSE OF THE RESEARCH

It is need to make comparison of the architectural heritage of European countries and the USSR that in the first half of the twentieth century belonged to states with totalitarian political regimes, to establish the main tendencies in their architecture − the common features and differences − and to find out the reasons for their appearance.

[1] The name "fascism" comes from the Latin. "Fasces" – "fascia", a handful of rods with an ax of a lictor (guardian of consuls in ancient Rome).

THE METHODS OF THE RESEARCH

The methods of research of the problem under consideration are a comparative analysis of the historical architectural heritage that emerged during the 1920s and early 1950s in European countries and the USSR during the existence of totalitarian regimes, and the causal link between the political regime and architecture.

THE RESULTS AND DISCUSSION

What distinguished the Soviet political system from European political regimes? First, the idea of democracy in the form of local councils of people's deputies (the authorities from below, from the people − upwards) was absorbed by the party system, formed on the principle "on the contrary", as a command system (from the helmsman to the people). Therefore, in the process of perfection, it turned into a conglomerate in which the legislative branch of power became a puppet and completely dependent on the main party component of the system of government [2-4]. Second, there was no private property in the USSR. Land and other natural resources, all means of production belonged to the state, were at the disposal and under the strict control of the authorities. Thirdly, public consciousness was formed in the spirit of patriotism, love for national culture, faith in the bright future, which would determine the party leadership (which meant the transfer of responsibility for its own fate to the representatives of the authorities) and friendly relations with other peoples. The public consciousness forming the direction of the development of culture was a consequence of the embodiment of the state-ideological essence of social life to thinking of the society, which was programmed by the leadership of the state [6].

The means of architecture that are under the influence of state ideology, the specifics of the economic system, the formed psychology of society and social consciousness, forms an artificial environment of human being, which, on the one hand, reflects socio-political processes, on the other, creates an environment that edu-

cates a person in a certain the corresponding direction. Under totalitarian systems, both sides are pushing for a person stronger in the direction desired by the ruling power, limiting its freedom is felt stronger than in a democratic political system.

Thus, the first half of the twentieth century was marked both in Europe and in the Soviet Union by the creation of totalitarian regimes, which were clearly reflected in the formation of the architectural environment. So whether the common features in the political-economic system, political events and the development of the culture of European states and the USSR influenced onto architecture, its form and style? Have any cardinal differences been observed? When were they, what caused their appearance? Where did the causal link between the political-economic system and architecture look?

In Fig.1 there were given some examples of German architecture in the times of totalitarianism. The Berlin Reconstruction Program − transforming it into the capital of the world − was provided of the creation of two mutually perpendicular axes, along which the main buildings of the German Empire were to be located (see Fig.1, *a*). Thus, according to A. Speer's project, the North-South axis had to combine the railway station and the Hall of the People with 18,000 members present at a height of 320 meters with a vault of 315 meters in diameter (see Fig.1, *b*-*c*). In the interval between them it was necessary to place the largest triumphal arch in the world in height of 117 meters and a width of 170 meters [15]. But Hitler's main toy, according to the testimony of historian-analyst D. Khmelnitsky [24], was the railway, which he planned to build in the form of four-track tracks with a track width of 3 meters, first to Munich, and then to Spain, St. Petersburg and Donetsk, to India and Afghanistan. On these new tracks, 1,200-meter long trains had to be traversed with 41-meter long two-story wagons equipped with bathrooms, hairdressers, cinemas and an anti-aircraft platform.

Rationalistic German architecture with features of functionalist simplicity and neoclassical tendencies in the form of square pylons was supplemented by the Reichsandler - the state symbol in the form of an eagle holding a wreath with a swastika in the middle - an eastern symbol of death (see Fig.1, *h*), sculptures of the eagle (see Fig.1, *e*), his head (see Fig. 1, *k*), the eye (the lamps in the largest to date Tempelhof airport, see Fig.1, *m*), the bull (see Fig.1, *g*), the man (see Fig.1, *f*, *i*). For all the buildings was characterized by monumentality, axial symmetry of object-spatial structure, strict color and extraordinary ambitious architectural design − huge dimensions, the destination for the masses of people. German architects − supporters of the new government − have clearly created a new direction in architecture, using the new trends of the early twentieth century − functionalism - and investing in it a new great-power content through time-tested vertical divisions, present in classical architectural forms, almost Egyptian simplicity and conciseness of monumental forms.

The German ambitious plans to create the world capital were not fully implemented due to lack of funds in the country that occupied the territory of neighboring countries.

The period of the establishment of the totalitarian regime in Italy was a turning point in which, as always, in art and architecture, two main tasks of creativity arose − the search for a new image and new means of expressiveness. It was on them that Italian artists and architects concentrated on finding solutions to the problem of creating an actual new form that would meet the requirements of the time and require the development of new professional techniques [16].

The Italian architecture of the totalitarian period of rule was based on the historical architectural heritage of ancient Rome (Fig.2). Even the name of the political regime was created with the use of ancient symbols (see Note 1). Ancient forms, built on the widespread use of arches, orders, sculptures, were transformed into lapidary forms: from the arcade only the contours of the caverns were left (see Fig.2, *j*, *n*, *o*, *q*), from the order − thin or massive pylons (see Fig.2, *e*, *f*), gracefully processed sculptures turned into clumsy figures with a primitive expression of the face as symbols of simple brute force (Fig.2, *j*, *k*, *l*), instead of

Architecture of Germany
1930s - 1940s

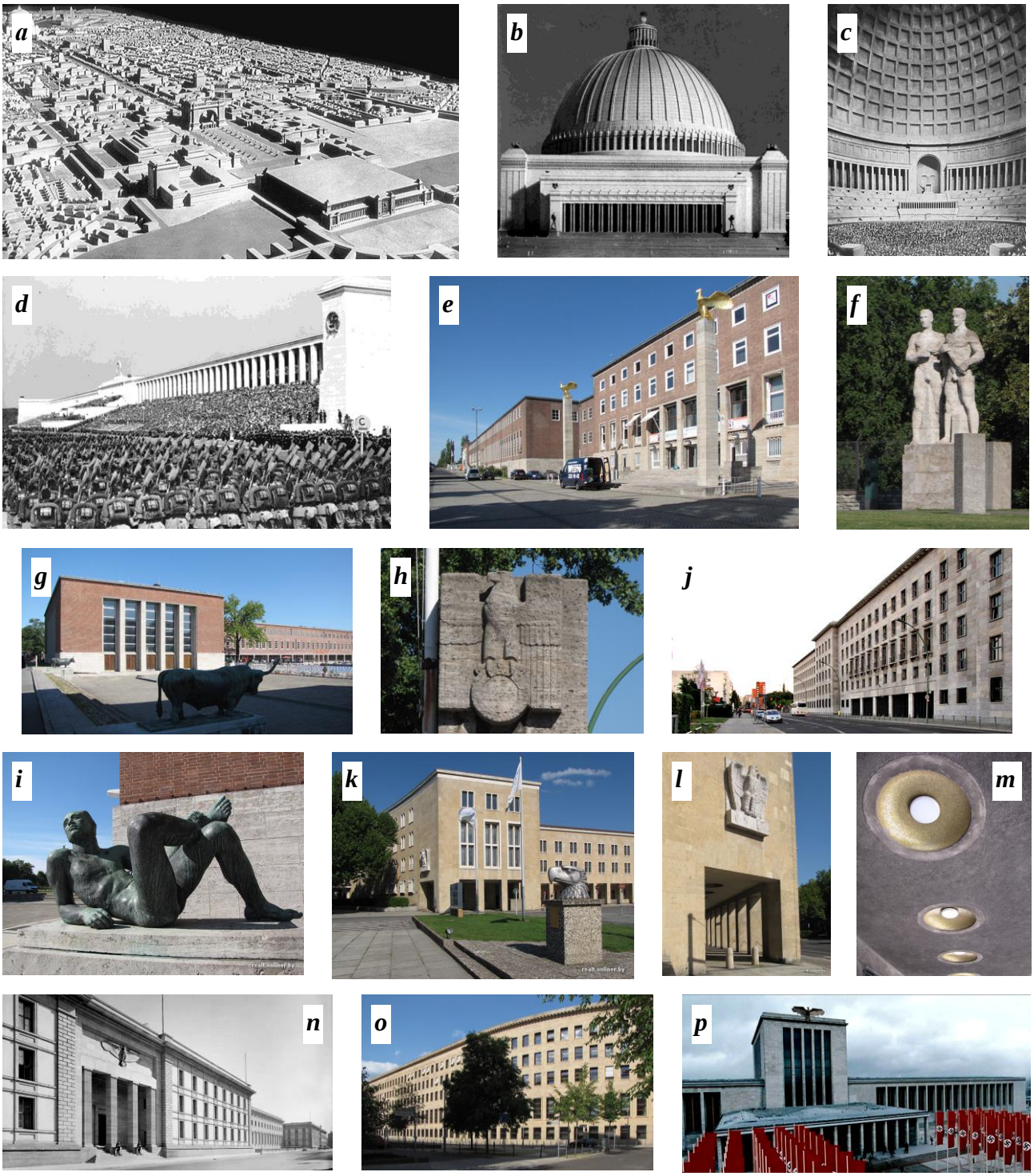


Fig.1. Examples of German architecture 1930 − 40: *a* - Welthauptstadt Germania (Germany Capital of the World), Berlin, layout, arch. A. Speer; *b-c* - Hall of the people on 180 thousand, Berlin, layout, arch. A. Speer, outlook, interior; *d* - The main tribune of Zeppelinplatsu for parades in the congresses of the NSDAP, Nuremberg; *e-h* - Reihssportfeld, Olympiastadion, Charlottenburg, Berlin, 1934-36; "House of German Sport", arch. V. Marh; sculpture "Runners Relay", courtyard with sculptures of bulls; Reichsadler; human sculpture; *i* - Imperial Ministry of Aviation, Berlin, 1936, architect. E. Zagabile; *j-m* - New Terminal Airport Tempelhof, Berlin, arch. E. Zagabile, 1934: fragments of the outlook, lamps; *n* - The Reich Chancery, Berlin, 1939, photo - Bundesarchiv, Germany; *o* - Ferbelliner Place, Berlin; *p* - Exhibition pavilion "Messe Berlin", arch. R. Hermish, 1937, during the filming of the film "Operation Valkyrie". All photos except "1, *n*" − db@onliner.by [15].

The architecture of Italy
1920s - 1940s

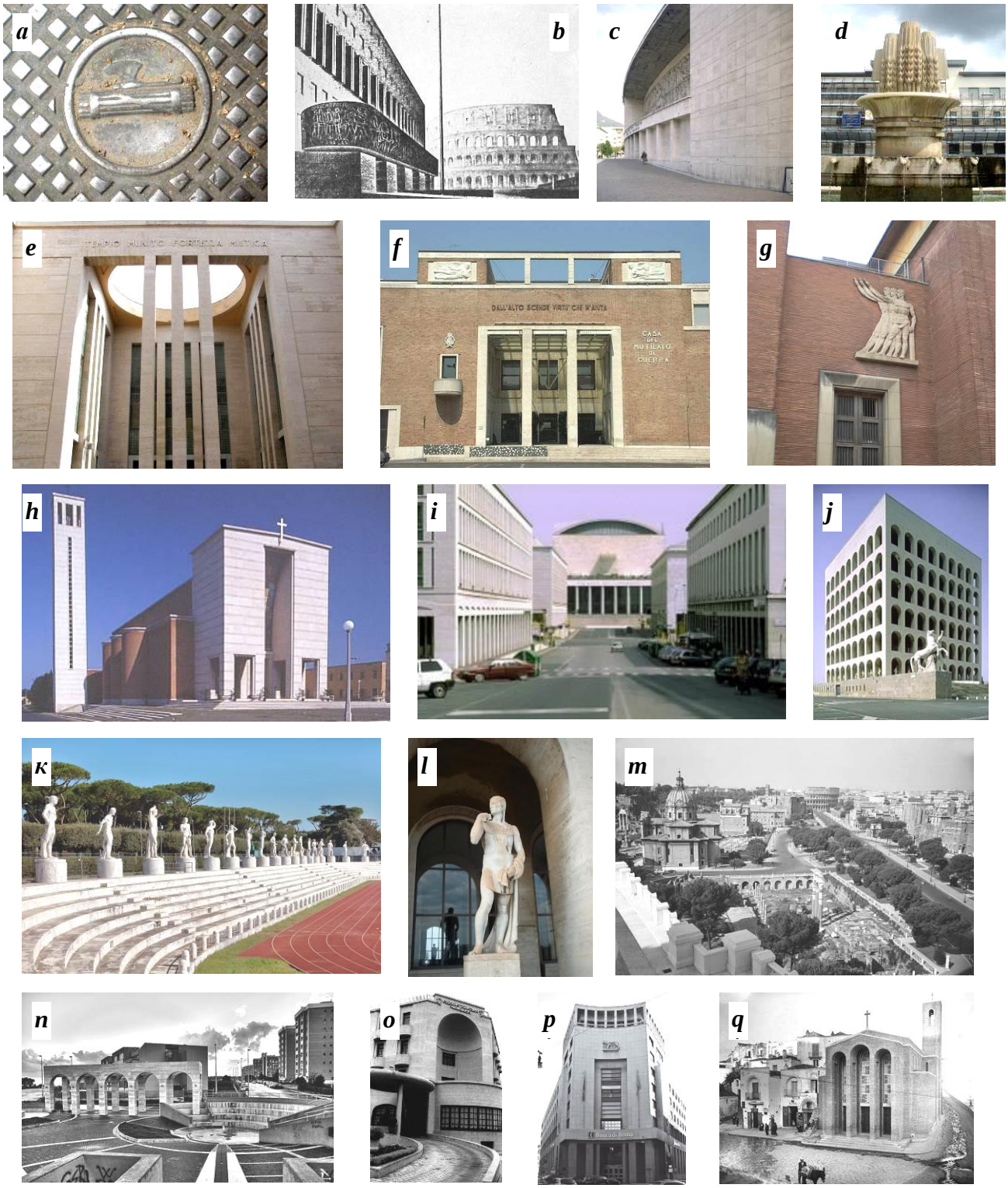


Fig.2. Examples of Italian architecture 1920-40: *a* - sidewalk tile with licker ax and fascia; *b*-competition project at the Vittorio Palace, arch. Di Renzi, 1933; *c* - the building of the Financial Service in Bolzano; *d* - fountain with fascia and colic, Littoria-Latina; *i* - Municipality of Palermo; *f* - Invalid buildings, m. Ravenna; *g* - Saragos Gate, Bologna; *h* - the church, the city of Sabaudia, the province of Lazio; *i* - Congress Palace, 1954; *j* - Espo-sizione Universale Roma (EUR), Palace of Italian Civilization, arch. J. Gwernin, 1943; *k* - sculpture in EUR; *l* - the stadium in Rome; *m* - avenue in Rome, laid out through the ancient forums; *n* - Pomezia in the province of Lazio; *o* - building on o. Rhodes; *p* - Bank of Rome, Milan, 1941; *q* - a house in Basilikata. All photos - https://lord-k.livejournal.com/199376.html [1, 10]

perfect forms the friezes became unusually massive (Fig.2, *b*, *c*). In all the projects of the reconstruction of the city of Rome in the 1920-1940's there was a shameful attitude not only to the development of the historical Italian heritage [8, 19], but also to the preservation of urban ensembles of the historical centre (Fig.2, *m*), to the formed coastline, which led to the destruction of important architectural monuments and historically formed environments.But researcher S. Lipgart saw that there were the other side of the relationship between professionals and the customer to the heritage in the reconstruction of the city of Rome in the 1930s, it was the perception of historical buildings as spectacular theatrical scenery, where new buildings did not diminish the meaning of the olds and did not hide among them [20]. Yes, there was no gigantism in Italian fascist architecture, it was quite a measure of human scale [1, 10].

For the architecture of Portugal and Spain, the period of totalitarianism was also characterized by the simplicity of forming, the large scale of architectural objects − the symbols of the new government, the widespread construction of representative architectural buildings (Fig.3).

So, an overview of the architectural and urban heritage has shown that for all European countries, where reactionary regimes were established, the following was typical: giantomania in the size of objects that were prestigious for the authorities and the state; style building based on national, ancient traditions; purism, asceticism, lapidary and, at the same time, simplicity and monumental forms; axial symmetry of city-building ensembles; moderate, but accurate, in the main places of use of state symbols; application of additional decorative symbols emphasizing the connection with the ancient past: figures of a physically strong man, a bull, horses, more often in the form of sculptures, less often - bas-relief; monotonous interpretation of the wall - without cavities or with identical cutouts, which served as a monumental background for a separate sculpture, emphasizing its symbolic meaning. The rationalism of architectural forms was manifested in the purity and concordance of the plan, the architectonics of the building, which brightly and precisely helped to focus the viewer's attention and emphasized the value of a single symbol. The simplicity of the formation of European functionalism, which was combined with the symmetry of the architectural-spatial composition and the neoclassical manifestations of the warrant, the great-power symbols and monumental forms, as well as expensive materials, created a special direction of the open-mindedness of the state-ideological content of architecture. By such means, the architecture articulated outside clearly demonstrative and ideological reference to an absolutely indisputable order in the state, based on conquering the authorities, carrying the order to other peoples and deciding their fate at the discretion of this power.

D. Reynolds, who considered the specifics of the historical movement of the Soviet Union, argued that Stalin had formed the second revolution since October 1917, at that time "from above", which was supposed to transform both society and the economy. Its main objects were gigantic projects of industrial complexes, justified by ideological reasons. The victory of totalitarianism contributed to the emergence of an official company against "cosmopolitanism", whose purpose was to eliminate all kinds of internationalist tendencies [9]. Therefore, the Soviet Union entered the path of rebirth and creative rethinking of the classical heritage, as were defined by leading party documents. Before the war, the Soviet Union embarked on a path of rebirth and creative rethinking of the classical heritage. With drew from the tendencies of the spread of constructivist industrial forms in the urban environment, Soviet architecture moved through the formation of the Russian empire.

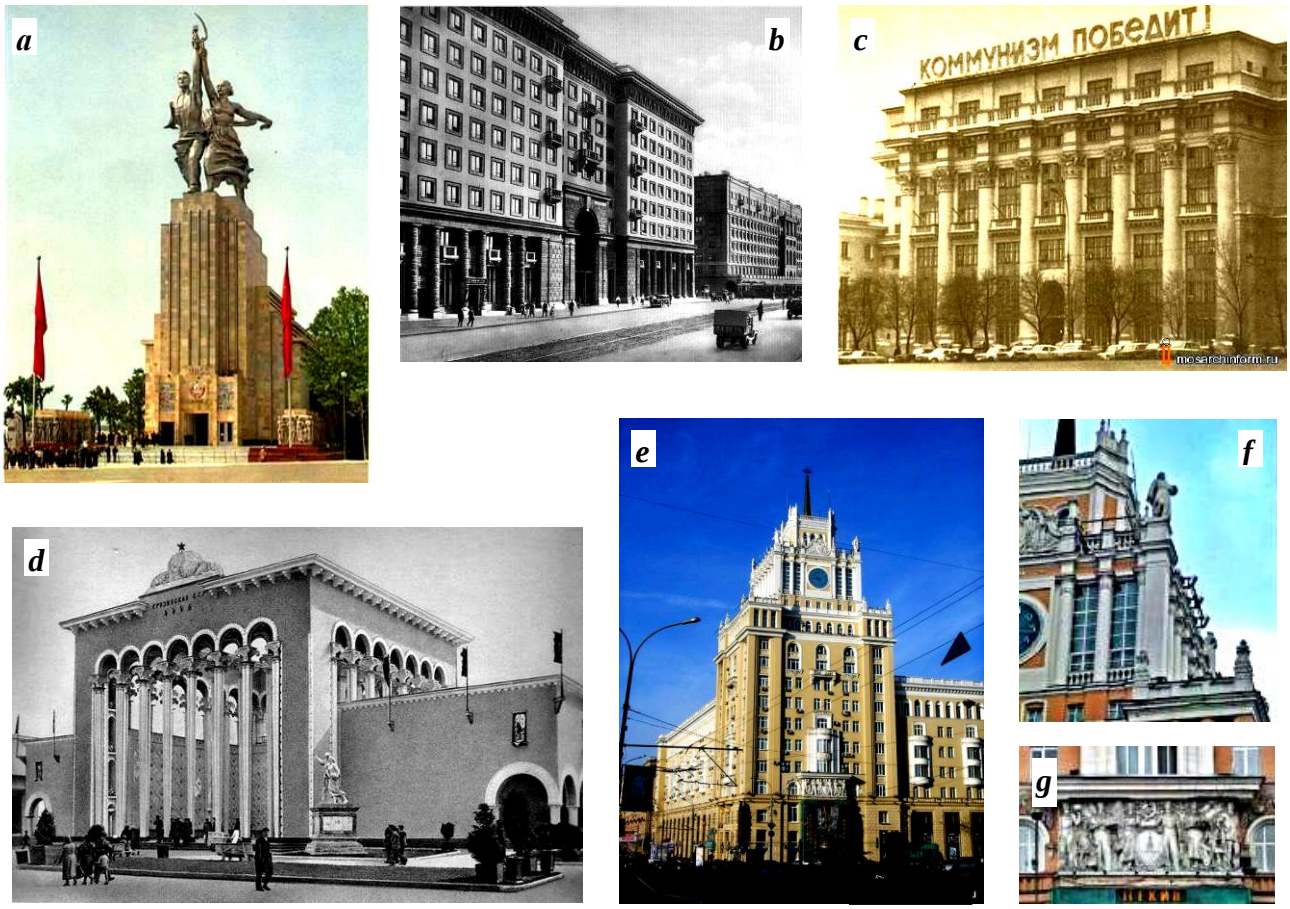
Thanks to the desire to glorify the existing system of government at that time, the USSR chose the classic principles in architecture: the classical perimeter building of quarters and the symmetrical structure of the facades were revived; the mandatory formation of the main city center on the basis of the axis of symmetry and the main buildings with towers and spikes in completion, with many state

Architecture of Portugal
1930s - 1950s

Architecture of Spain
1940s - 1950s

Fig. 3. Examples of Portuguese and Spanish architecture: *a* - pl. Areéiro, m. Lisbon, arch. C. de Silva, 1930s; *b* - the statue of Christ in the city of Almada, 1949-1959; *c* - Palace of Justice, Porto, 1940s; *d* - the statue of Themis in front of the Palace of Justice; *e* - Memoir to killed in the Civil War, Valley of the dead, 1940s; *f* - Triumphal arch, arch. M.L. Otero, P.V. Santefliou, 1950-1956; *g* - Headquarters of the Air Forces, Madrid; h - Spain House, Madrid, arch. J. Otammendi, 1953. All photos - https://birdinflight.com/ru/mir/20170522-architecture-european-dictators-2.html [19]

Architecture of the Soviet Union
1930s - the beginning of the 1950s



Architecture of Soviet Ukraine
1930s - the beginning of the 1950s

Fig. 4. Examples of Soviet Architecture: RSFSR, Moscow: a - All-Union Agricultural Exhibition (AAE), sculpture "Worker and Collective Farmer", sculptor V. Mukhina; b - residential house, Chervonosilskaya st., arch. I. Rozhin, A. Khryakov, 1937; c - residential building, Mokhovaya st., arch. I. Zholtovsky, 1934; d - AAE, pavilion of Georgia, arch. A. Kurdiani, G. Lezhava; i - Beijing Hotel, arch. D.Chechulin, 1949-1955, f - element of completion, g - frieze over the entrance; Ukrainian SSR, Kyiv, Khreshchatyk st.: h - residential complex number 23, 25, 27; i-j is the central part of the building No. 25 and its completion; k-l - the end of the dwelling house number 23 and decorative design of the bay window and balcony [17]

symbols, which looked like an explicit selection of decorative forms and details. Among the examples of the Soviet legacy of the so-called "Stalinist" period in Fig. 4, *b*, is a photo of a residential building located in Moscow on the street Chervonosilskaya, whose facade architecture dated back to the then German architecture (see Fig.1, *e*, *j*, *o*).

In the postwar period, Stalin's skyscrapers, "absolute absurdity, such figurines" were constructed in the words of D. Khmelnitsky [24]. State symbols that had to remind of the role of the Soviet state in the life of the people and to demonstrate the differences between Soviet architecture and the architecture of the Russian Empire, began to appear anywhere. The unlimited number of that symbolism simply shouted about the ideological purpose, but at the same time it reduced its value. In addition to such obsessive use of symbolism, the psychological effect was enhanced by other decorative elements that performed an additional auxiliary function. It is a variety of symbols of fertility, labor, a bright future that awaits the people in the form of justice, equality, peaceful life, and well-being. The combination of a heavy order with a richly decorated facade created in the architecture of a fairy tale about a strong, reliable, mighty state, which promised protection and happiness to its people. An unlikely architectural form and style that did not correspond to real situations (repressions in the country and arms race among the states) formed a decorative screen that covered the real state-ideological content of the formed urban environment.

THE CONCLUSIONS

1. Consequently, the architectural and urban heritage of European countries and the Soviet Union was formed at the time of the totalitarianization of political regimes. But European countries differed from the USSR by maintaining private property at the same time as the strict control of the state, the Soviet economic system provided for the full ownership of land and all means of production to the state. In European countries, social stratification was formed naturally on the basis of property status, in the USSR − on an artificially constructed system with workers − the class that has no property − above.

2. The political regimes of all the countries under review were organized on the basis of a system of government with a one-party system and a leader at the head.

3. The public consciousness of the peoples was formed in the spirit of faithfulness to the authorities; therefore, in culture and architecture, the manifestations of the state-ideological goal of countries with totalitarian political regimes were clearly reflected - the need to glorify forces, power and invincibility of power. The architectural heritage of European states significantly differed from that of the USSR by the fact that European states frankly proclaimed the ambition of their own political programs, and the Soviet state, having an artificially constructed social structure, with the help of architectural means created an idyll of peacefulness and a bright future for the people.

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Декоративно-формообразующая и пространственная организация предста-вительской архитектуры 1930-х – начала 1950-х годов как отображение государственно-идеологической цели

Людмила Бачинская

Аннотация. В течение первой половины XX столетия социальной истории европейских

стран и Советского Союза в ряде европейских стран зародились национал-социалистические партии, которые в нескольких государствах создали тоталитарные однопартийные политические режимы во главе с вождем. Эти события произошли как реакция на мировые события − первую мировую войну, революционные всплески во многих европейских странах, политический, экономический и культурный кризисы, разочарование разных слоев населения в существовавших политических режимах. Со стороны государственной власти замена системы правления приводит к необходимости формирования архитектуры городской среды как носителя новой государственной идеологии, со стороны социума происходит рождение иного общественного сознания, что неминуемо отражается в новых направлениях развития культуры и архитектуры.

Советский Союз в течение 1930-х годов и теоретически, и практически укрепился на позициях тоталитаризации власти с соответствующими изменениями в архитектуре.

Имея общие черты в системе правления, европейские страны и СССР сформировали общие направления в архитектуре – осевую симметрию, что как архитектурный метод свидетельствует о порядке в государстве, большой масштаб сооружений – признак мощи и непобедимости, композицию на основе подчиненности частей целому, которая отображает необходимость прославления власти. Но отличия в социальной стратификации – естественной в европейских странах, созданной на основе учета имущественного положения владельца, и искусственной, принятой в СССР, на основе возвышения социальной роли рабочего как общественного гегемона – привели ко внедрению в архитектуру разной государственно-идеологической цели: в европейских странах – идеала силы, мощи, порядка, национального превосходства над другими народами; в Советском Союзе – равенства, надежности защиты государством, светлого будущего в жизни народа.

Ключевые слова: европейские государства, Советский Союз, архитектура, политический режим, тоталитаризм, государственные символы, форма и стиль в архитектуре.

The meanings and techniques of lighting in the car service

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Received on 06.09.2018, accepted after revision on 19.10.2018
DOI: 10.31493/tit1812.0103

Abstract. The notion of a harmonious light environment involves the execution of a variety of sos-free functions. First of all, it is the creation of comfortable living conditions for people, which is to ensure the safety of traffic and pedestrians and the holistic perception of city accounting in the dark period of time. The provision of light comfort in the evening and at night is achieved on the basis of rationally selected quantitative and qualitative characteristics of artificial lighting, which are regulated by the norms.

Use of territories under the car-care center is used by special measures for engineering improvement. This makes it possible to create a high level of general and artistic and aesthetic perception of the objects of the city's car service.

Quality lightning is profitable. Since, the good lightning of the city reduces the number of injuries in an accident. The level of personal safety currently depends on the quality of lighting of courtyards, footpaths and playgrounds.

Information to enrich or change the emotional comfort of a person is possible with the help of the right color. The basis of the formation of architectural and urban light space play of colors of the light are solved by multiple tasks: there is a light floral environment, take into account the stakes and the transfer of the color from artificial light sources at night. It is not allowed color bright "separation", bright" failure", excessive brightness, which violates the unity of the composition. The quality of light delivery depends on the spectral composition of the light source, which determines its light transmission.

Lighting techniques are aimed at identifying the characteristics and effects of lighting. Lighting of facades of buildings with general flood lighting should provide visibility of its decorative and plastic elements. The main requirement for the system of light ensembles of the city is-taking into account the visual perception of a person of the illuminated object in space.

Keywords: light, light gray deposit, objects and elements of the pavement, criteria of influence, measures for the engineering improvement of the city, objects of car service.

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INTRODUCTION

Light is a powerful tool that allows you to discover the beauty of the world and emphasize the cultural and architectural value of the city.

Lighting equipment and technology must meet the requirements of energy saving, which provides for the optimization of constructive and energy parameters [2, 5]. It is important to consider not individual objects or areas, and the whole complex of lighting systems areas, spaces, architectural and landscape objects in general.

MATERIALS AND METHODS

The aim of the work is to identify the main criteria of influence on the lighting system of the modern city. Identify the types of modern artificial lighting. To study the process of lighting design for auto-salons and ways of their implementation.

The main criteria for the impact on the system of lighting the territory of the modern month include: visibility-provides normal conditions of visibility for drivers and pedestrians and the required level of quantitative and qualitative parameters of lighting, characterized by the current norms.

Security. Traffic safety in transport is ensured by the normal functioning of all components of this complex "man − vehicle − environment".

Meanwhile, the lack of reliability of the elements of this system (low discipline of traffic participants, poor technical condition of vehicles and roads) is the cause of road accidents and transport accidents [1, 2, 6]. Quality lightning is profitable. Since, the good lightning of the city reduces the number of injuries in an accident. The level of personal safety currently depends on the quality of lighting of courtyards, footpaths and playgrounds.

Economics. The factor of decision-making. The ability to create a quality lighting device at minimal cost. In practice, in the process of operation and repair of cheap lighting can require significant costs, compared to expensive. Therefore the characteristic of comfort of the light environment of the city is carried out by the most economic way in the presence of the choice of technical means for its providing.

Aesthetics. Modern society requires the lighting not only to perform
functional tasks, but also compliance with modern requirements of a harmonious world environment. There is a variety of outdoor lighting facilities of the city (streets, squares, open spaces, gas stations, service stations, transport interchanges, facades, etc.). Aesthetics should be combined with the real possibilities of society, contribute to the formation of visual comfort and visual and artistic specificity in the city.

Social life. Good lighting has a positive impact on such aspects of the social life of the city as trade, tourism, sports; creates a favorable psychological climate; has a biological impact on the human body; is the basis for a more open and active lifestyle.

To create the concept of a comfortable light environment of the city, a number of other factors are needed: the scale of the city, its functional zones; public centers; features of landscaping; the system of highways and maintenance. For each city characteristics of typical its lighting concept, which brings together external, architectural, accessory, advertising types of lighting [2, 4, 7].

There are the following types of permanent lighting systems:

- for street lighting (providing lighting necessary for the safety of traffic and pedestrians);
- for architectural and artistic development (creation of light architecture of the city in the evening with the identification of the most valuable architectural, historical and artistic buildings, structures, monuments, fountains, etc., as well as entire complexes);
- for advertising lighting (information the population of trade, household and cultural news, window dressing mA-shops, kiosks, etc.);
- for light signals (indicators pedestrians driving directions, locations, stops, crossings, etc.) [3, 4, 8].

Information to enrich or change the emotional comfort of a person is possible with the help of the right color. The basis of the formation of architectural and urban light space play of colors of the light are solved by multiple tasks: there is a light floral environment, take into account the stakes and the transfer of the color from artificial light sources at night. It is not allowed color bright "separation", bright" failure", excessive brightness, which violates the unity of the composition. The quality of light delivery depends on the spectral composition of the light source, which determines its light transmission [2, 6].

Modern artificial lighting is divided into types: decorative, architectural (total flood, local-gradient (fragmentary) lighting of the façade, hidden, projection (facades that glow),

silhouette, contour, upper (multiple, ordinary light, lighting the top), landscape (step-by-step lighting, marking, sliding, flood, shading), lighting schedule, illumination (the light show, performance, temporary story, multimedia projects, laser scenography), static and dynamic color.

Architectural lighting is a direction of lighting design, engaged in artistic illumination of facades of buildings. By means of correctly executed architectural illumination it is possible to emphasize art features of the building, distinct elements (bas-reliefs, columns, windows, platbands), etc., to give it a beautiful esthetic look at night, to make dominating among other surrounding objects [8, 9]. Before architectural lighting, there are a number of requirements: a variety of possible lighting effects; ease of maintenance and operation of architectural lights; electrical safety and protection of equipment from the effects of natural conditions; orientation; efficiency.

There are certain types of lighting: normalized (daily), emergency, periodic and festive. The choice of the type of lighting depends on the urban situation, the nature of the object, its purpose, especially the placement of lighting equipment, the creative design of the architect [2, 10].

STARTING POSITION URBAN-ECO-PHYSICAL PARALLELS

Lighting techniques (selection of lighting equipment, their placement and possible ways of transformation, relationship, etc.) are aimed at identifying the characteristics and effects of lighting. Lighting of facades of buildings with general flood lighting should provide visibility of its decorative and plastic elements. This is achieved through a combination between the lighting and shadow zones (Fig.1). It is recommended to illuminate small diameter volumes with spotlights at a long distance. To identify the nature of multi-faceted objects lighting sources should be placed asymmetrically. There are three main ways of illumination of buildings and structures: local; lighting fill type; hidden architectural illumination of buildings.

1. Local illumination-illumination of the most interesting and bright parts of the structure. This effect is achieved by fixing special spotlights on the facade.

2. General filling of the facade with light. It is used to illuminate historical architectural structures or on the facades of buildings. Powerful spotlights illuminate the object in the selected color scheme.

3. Hidden architectural lighting. With the help of a light source creates its own pattern,

Fig.1. Lighting of the façade of the car service by way of creating a light contrast be tween the evening appearance of the given controversy and the surrounding landscape

which makes it possible to both emphasize and change the appearance of the architectural forms of the building. Choosing one of the listed methods of illumination it is necessary to consider features of architecture of the building and its color scale.

Contour illumination is used during the holidays when illuminating the squares and streets of the city with mass illumination of buildings, monuments, bridges and fountains. In the building sometimes emit more bright light some interesting and spectacular part of it. This contributes to the creation of light contrast within it, enhances the overall impression of the evening view of the building and the surrounding landscape (Fig.4) [6, 12].

RESULTS AND EXPLANATIONS

The problem of placement of light composition of the city is associated with the creation of light ensembles of different scales. At the same time, the light scale is a part of the architectural space, forming a single light architectural composition. The interaction of artificial light and architectural composition takes care in the following areas − space, volume, plastic and color. All this creates a light space, light-forms, light-plastic and light-color. The main requirement for the system of light ensembles of the city is-taking into account the visual perception of a person of the illuminated object in space [1, 15, 16].

This approach makes it possible to illuminate the city, highlighting the main highways and the most important places, facilities and structures. Highways and streets stand out in cities in a special system, opposite the pedestrian − with clear spatial boundaries, special requirement trunk systems for s for the quantity and quality of light and light information (Figs.2, 3). All types of lighting systems work

a

b

Fig.2. An example of the lighting of a transport magistral (*a*), illustration of the street (*b*)

a

b

Fig.3. Examples of interior illumination of autolights (*a* − pendant lamps such as dome or bel, *b* − trunk systems for linear luminaires)

in cooperation with each other, taking into account the brightness of road surfaces of streets, squares and sidewalks, the brightness of showcases, light advertisements and lamps, as well as illuminated monuments and fountains, the degree of proximity that occurs in the field of view of a person. This takes into account the requirements of energy saving, operation, management of lighting systems according to the infrastructure of the modern city [6, 8, 13].

Highways and streets stand out in the cities in a special system, opposite the pedestrian- with clear spatial boundaries, special requirements for the quantity and quality of light and light information.

Energy efficiency of lighting is influenced by the following factors: technological: availability of lamps, control systems, types of installation that can be used to reduce the power consumption of lighting systems compared to conventional practice.

- Economic: different methods of assessing the cost of the lighting system. The cost of the lighting system can be defined as the sum of capital costs and operating costs).

- Value: money, ecology, design.

- Perception: psychological evaluation of lighting. Level of visibility and visual comfort. Social status, health and appearance.

- Waiting: user's predictions about good lighting for each specific case [2, 14, 16].

Architectural lighting of the facades of car showrooms is also important as well as internal lighting. It helps to attract the attention of many people and emphasize the features of the building.

Due to the sizes, types, optics, LEDs, as well as a wide range of lighting control, lamps-based LEDs can be used for general flood lighting (lighting of small architectural forms, contour illumination) and to create media facades of dynamic lighting, etc (Figs.4, 5). Such lamps have certain characteristics: efficiency, sustainability, to external influences and mechanical vibration loads; the minimum level of light pollution; the possibility of creating light paintings due to the possibility of light control [1, 17, 19].

Poorly adapted lighting conditions can include: the monotony of space; the impossibil

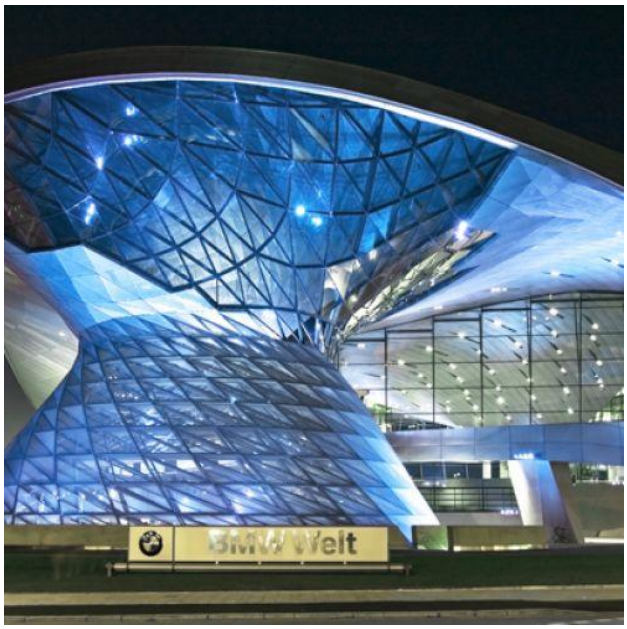


Fig.4. Lighting of the façade of the car service by way of creating a light contrast between the evening appearance of the given controversy and the surrounding landscape

Fig.5. Lighting of glass facades inside line lanterns on the example Motor Show "Eurosib Mazda"

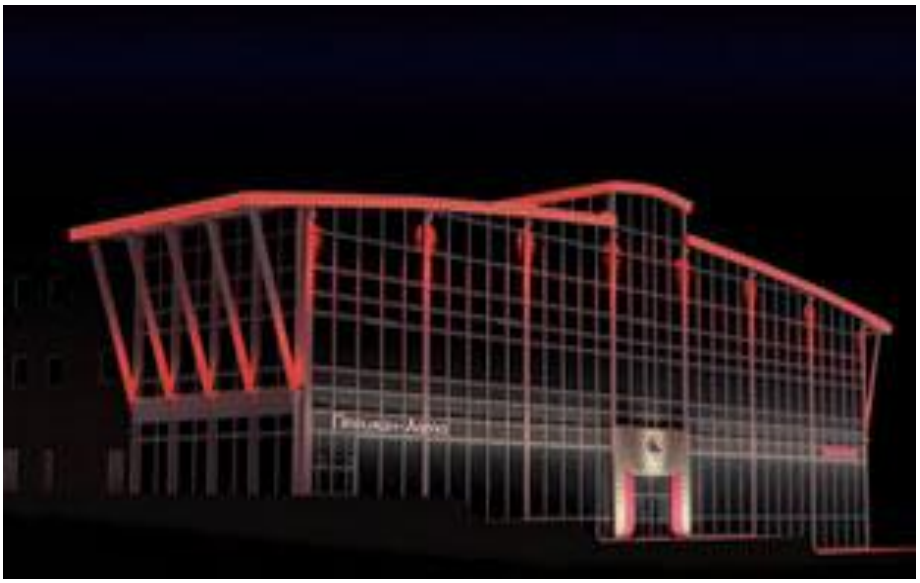
ity of safe orientation in space; the lack of eye-catching points, or vice versa, unnecessary attraction of attention; the use of finishing materials and their colors (which are poorly consistent with ambient lighting or even absorption of light), pale or aged in cool tones coloring the surrounding surfaces; failure to take into account energy consumption, excessive

heat; high cost and inconvenience of maintenance; lamp design that does not fit into the situation, etc. [18, 20]. All this violates the integrity of the architectural design of the city.

Therefore, to create a harmonious comfortable light urban environment complex combination of different lighting techniques and types of social functions, inscribed in the infrastructure of the modern city is important (Fig.6).

CONCLUSIONS

1. In today's world, thanks to the emergence of new technologies in the field of lighting, you can decorate the exterior of buildings as a whole, facades or parts of them; allocate certain buildings and their architectural features in the darkness of the night; provide a refined look.



a

b

Fig.6. The option of lighting the car dealership Nissan brand: *a* − an example of lighting the avosalona brand Nissan in red, *b* − horizontal zone on the main facade, where the logo of the car dealership is lit white in color

2. Properly designed lighting showrooms allow you to convey to the buyer the color of the corresponding car, as well as its appearance and increase sales.

3. The process of designing lighting for showrooms and their implementation is very specific since it requires the possession of certain knowledge and skills in the design of this direction.

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Значение и приемы освещения в автосервисе

Ольга Петруня

Аннотация. Понятие гармоничная световая среда включает выполнение разнообразных социальных функций. В первую очередь – это создание комфортных условий проживания человека, что заключается в обеспечении безопасности движения транспорта и пешеходов и целостного восприятия образа города в темное время суток. Обеспечение светового комфорта достигается с помощью использования рационально выбранных количественных и качественных характеристик искусственного освещения, которое регламентируется нормами.

Использование территорий под автосервис проводится с помощью определенных мероприятий по инженерному благоустройству. Это дает возможность создавать на высоком уровне общее и художественно-эстетическое восприятие объектов автосервиса города. Качественное освещение выгодно. Так как, при хорошем освещении снижается количество травм при ДТП. Уровень собственной безопасности на

данный период времени зависит от качества освещения дворов, пешеходных дорожек и детский площадок.

Информационно украсить или изменить комфортное пространство вокруг человека можно с помощью правильно подобранного цвета. Формирование архитектурной и градостроительной световой среды выполняется игрой цвета. Таким образом решаются многочисленные задачи: создается световое окружение, учитывается цвет и передача цвета от искусственных источников света в ночное время. При этом не допускается цветовой яркий «отрыв», яркий «провал», безмерная яркость, которая нарушает единство композиции. Качество подачи света зависит спектрального состава источника света, который определяет его светопередачу. Приемы освещения направлены на выявления характерных особенностей та эффектов освещения. Освещение фасадов зданий общим заливным светом должно обеспечивать видимость его декоративно-пластичных элементов. Это достигается путем соединения между собой осветительных зон и теней. Главным требованием к системе световых ансамблей города является – использование зрительного восприятия человеком определенного объекта освещения в пространстве.

Ключевые слова: свет, световая среда, объекты и элементы благоустройства, факторы влияния, мероприятия по инженерному благоустройству города, объекты автосервиса.

Теоретические основы расчета скобовидных пластинчатых рессор

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Получено 01.09.2018, принято после просмотра 09.10.2018
DOI: 10.31493/tit1812.0201

Аннотация. Даны теоретические основы расчета на прочность скобовидной пластинчатой рессоры. Она представляет собой упругую пластину, концы которой отклонены от ее средней части в одну и ту же сторону и выполнены в виде консолей, снабженных приспособлениями для шарнирного крепления. Средняя часть пластины расположена параллельно линии действия нагрузки. Пластина выполнена с переменным по длине сечением, при этом в каждом сечении ось, относительно которой момент инерции сечения максимален, перпендикулярна плоскости изгиба рессоры. Запатентованная рессора спроектирована как «балка равного сопротивления».

Приведенные расчетные схемы и основные уравнения напряженного состояния скобовидной пластинчатой рессоры не обусловлены какой-либо определенной формы ее поперечного сечения. Рассмотрены напряженное состояние скобовидной пластинчатой рессоры прямоугольного поперечного сечения с прямой нейтральной осью в ненагруженном состоянии. Методика проектировочного и поверочного расчетов приведена для различных профилей ее поперечного сечения. Расчет относится к средней части рессоры и полкам, непосредственно примыкающим к упругому устройству для шарнирного соединения рессоры со смежной с нею деталью конструкции.

Рассмотрен случай, при котором нейтральная линия рессоры в первоначальном состоянии имеет большую или меньшую кривизну. Это − участки перехода от полок к полотну или участки, занимающие всю протяженность полок, если последние специально выполнены криволинейными. Поскольку кривизна таких участков велика, то их расчет выполнятся с учетом особенностей изменения напряженного состояния в кривых брусьях.

Даны рекомендации для выбора допускаемых напряжений при проектировочном и поверочном расчете скобовидной пластинчатой рессоры на прочность и наибольших эквивалентных напряжений, определенных в наиболее опасных сечениях устройства. Они должны быть сопоставлены с напряжениями, допускаемыми для данного расчетного режима. При этом рассматриваются случаи двукратного статического испытания на максимальную нагрузку и многократного (циклического) динамического нагружения при изменении знака напряжения в рессоре.

Ключевые слова: скобовидная пластинчатая рессора, напряженное состояние, упругая пластина, изгибающий момент, криволинейный участок, полки.

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Напряженное состояние скобовидной пластинчатой рессоры

Конструктивные отличия скобовидной пластинчатой рессоры (СПР) заключаются том, что она состоит из упругой пластины, концы которой отклонены от ее средней части в одну и ту же сторону и выполнены в виде консолей, снабженных приспособлениями для шарнирного крепления, а средняя часть расположена параллельно линии действия нагрузки [1 − 3]. Пластина выполнена с переменным по длине сечением и при этом в каждом сечении ось, относительно которой момент инерции сечения максимален, перпендикулярна плоскости изгиба рессоры.

На Рис.1 изображена расчетная схема СПР с консольными концами (полками), отклоненными от средней части под углом, близким к прямому [4, 5]. Две силы P, одна из которых является внешней нагрузкой, а другая − равной и противоположной ей реакцией, приложены в центрах шарниров, присоединяющих СПР к смежным с нею деталям.

Векторы этих сил действуют по одной линии, параллельной нейтральной линии средней части (полотна) СПР в ненагруженном состоянии. На Рис.1 ненагруженное состояние СПР изображено основными линиями, а нагруженное − тонкими линиями, утрированно показывающими взаимное расположение нейтральных линий упруго деформированных полотна и полок СПР. Линия действия A_1D_1 расчетной нагрузки P и всех промежуточных нагрузок совпадает с межшарнирной линией AD ненагруженной СПР.

В некотором поперечном сечении рессоры m, наклоненном под углом φ к ее симметрии, будут действовать (без учета момента трения в шарнирах) следующие силовые факторы:

- изгибающий момент

$$M_{zm} \approx P(t\cos\varphi_1 + y), \qquad (1)$$

- нормальная сила

$$N = P\cos\varphi, \qquad (2)$$

- касательная сила

$$Q = P\sin\varphi, \qquad (3)$$

где местный прогиб нейтральной линии полотна

$$y = \int dy;$$
$$dy = dS\sin\varphi,$$

элементарный участок нейтральной линии полотна

$$dS = \rho_m dy,$$

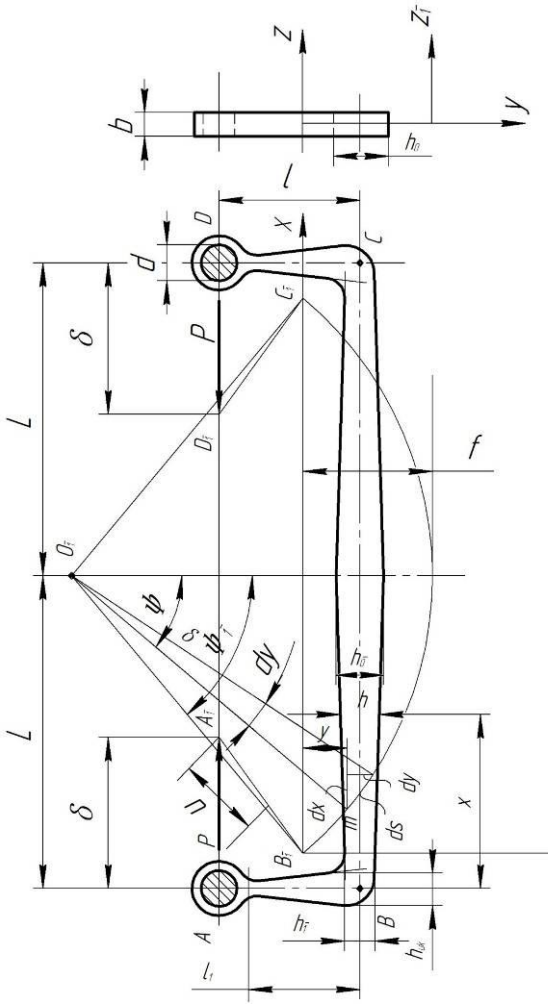

Рис.1. Расчетная схема скобовидной пластинчатой рессоры

Fig. 1. Calculation scheme of the bracketed leaf spring

где φ_1 – угол поворота крайних сечений полотна СПР; ρ_m – радиус кривизны упругой линии в сечении m.

При $\rho_m = \rho$=const.

$$y = \int_{\varphi}^{\varphi_1} \rho \sin\varphi d\varphi = \rho(\cos\varphi - \cos\varphi_1). \quad (4)$$

Наибольший поперечный прогиб полотна СПР

$$y_{\max} = f = \rho(1 - \cos\varphi_1). \quad (5)$$

Из теории изгиба известно (2), что в любом сечении изогнутого бруса

$$\frac{1}{\rho_m} = \frac{M_{zm}}{EI_{zm}}, \quad (6)$$

где I_{zm} – момент инерции поперечного сечения бруса, относительно главной центральной оси, перпендикулярной плоскости изгиба.

Если момент инерций сечения I_{zm} будет изменяться по длине рессоры так, что правая часть уравнения (6) останется постоянной, то неизменным будет и радиус кривизны упругой линии

$$\rho_m = \rho = \text{const},$$

то есть упругая линия будет дугой окружности.

При этом очевидно

$$\rho \approx \frac{L}{\varphi_1}. \quad (7)$$

где L – полудлина пролета рессоры.

В этом случае, с учетом (7),

$$\frac{M_{zm}}{EI_{zm}} = \frac{\varphi_1}{L} = \text{const}. \quad (8)$$

Если рассматриваемая рессора является "рессорой равного сопротивления", то во всех ее сечениях, при полном использовании несущей способности материала, максимальное эквивалентное напряжение

$$\sigma_{экв_{IV}} = [\sigma] = \text{const}, \quad (9)$$

где $[\sigma]$ – допускаемое нормальное напряжение.

Предварительные исследования показали [6, 7], что для конструкций, представляющий практический интерес, основной составляющей эквивалентного напряжения является максимальное нормальное напряжение от изгиба

$$\sigma_{м} = \pm \frac{M_{zm}}{W_{zm}}. \quad (10)$$

Очевидно, напряжение σ_m может быть постоянным по длине рессоры только при условии

$$\frac{M_{zm}}{W_{zm}} = \text{const}. \quad (11)$$

При этом, поскольку момент M_{zm} нарастает от крайних сечений к середине рессоры, то соответственно должен увеличиваться и момент сопротивления ее сечений W_{zm}.

Приведенные выше выражения не обусловливают какой-либо определенной формы поперечного сечения рессоры, однако одновременное соблюдение условий (8) и (9) требует, чтобы во всех ее сечениях соблюдалось соотношение

$$\frac{I_{zm}}{W_{zm}} = \text{const}. \quad (12)$$

Максимальный изгибающий момент, возникающий в сечении на оси симметрии рессоры, при $\varphi = 0$

$$M_{z_0} = P[l\cos\varphi_1 + \rho(1 - \cos\varphi_1)]. \quad (13)$$

Кроме изгибающего момента в этом же сечении действует нормальная сила

$$N_0 = P.$$

Нормальное напряжение сжатия в этом сечении

$$\sigma_{N_0} = \frac{P}{F_0}, \qquad (14)$$

где F_0 – площадь поперечного сечения рессоры при $\varphi = 0$.

Максимальное эквивалентное напряжение не должно превышать допускаемого

$$\sigma_0^{эк} = \left|\sigma_{M_0}\right| + \left|\sigma_{N_0}\right| \le [\sigma], \qquad (15)$$

где величина $[\sigma]$ зависит как от материала СПР, так и от режима нагружения, на который рассчитывается рессора.

Напряженное состояние СПР прямоугольного сечения

С точки зрения упрощения технологии производства скобовидных пластинчатых рессор, наибольший практический интерес представляет анализ напряженного состояния и разработка методики проектировочного и поверочного расчета СПР, имеющих прямоугольное поперечное сечение.

Выше было показано, что СПР, имеющая прямоугольные поперечные сечения, должна быть выполнена так, чтобы изгиб происходил в плоскости ее наибольшей жесткости, т.е. в большинстве рабочих сечений рессоры высота h должна быть больше, чем толщина b (см. Рис.1).

Учитывая увеличение изгибающего момента от крайних сечений полотна СПР к ее середине вследствие нарастания прогиба y, из условия (11) можно заключить, что, для обеспечения постоянства изгибных напряжений вдоль полотна СПР, размеры b и h ее сечений должны изменяться одновременно или порознь. Для рессоры, работающей преимущественно на сжатие, по технологическим соображениям представляется более целесообразным, чтобы толщина полосы b, из которой изготавливается рессора, сохранялась постоянной, а, следовательно, от крайних сечений полотна к его середине высота сечения h должна увеличиваться [8, 9].

Естественно, при этом не может быть обеспечено строгое постоянство отношения (12), поскольку при $h \neq \text{const}$

$$\frac{I_{zm}}{W_{zm}} = \frac{h}{2} \neq \text{const}.$$

Весь вопрос в том, насколько переменность высоты сечения h нарушает условие совместности выражений (8) и (9) при решении практических инженерных задач.

Обозначив высоту прямоугольного сечения полотна h_0 на оси симметрии СПР (при $\varphi = 0$) и найдем величину максимального изгибного напряжения в этом сечении при постоянной толщине b (Рис.1)

$$\sigma_{M_0} = \frac{6P[l\cos\varphi_1 + \rho(1-\cos\varphi_1)]}{bh_0^2}. \qquad (16)$$

С учетом выражений (14) и (15) найдем, что при полном использовании несущей способности материала рессоры эквивалентное напряжение в среднем сечении полотна СПР

$$\sigma_0^{эк} = \frac{P}{bh_0}\left\{\frac{6[l\cos\varphi_1 + \rho(1-\cos\varphi_1)]}{h_0}\right\} \le [\sigma]. \qquad (17)$$

Для решения уравнения (17) находим величину ρ из выражения (6)

$$\rho = \frac{Ebh_0^3}{12M_{z_0}}. \qquad (18)$$

В соответствии с уравнением (13),

$$\rho = \frac{Ebh_0^3}{12P[\rho - (\rho - t)\cos\varphi_1]}, \qquad (19)$$

а с учетом (7) это уравнение приводиться к виду

$$\frac{12P}{Ebh_0^3}[\frac{L^2}{\varphi_1^2}(1-\cos\varphi_1) + \frac{Ll}{\varphi_1}\cos\varphi_1] - 1 = 0. \qquad (20)$$

При поверочном расчете СПР, поскольку рессора уже спроектирована, а возможно и изготовлена, всегда известны материал рессоры и его модуль упругости E, а также геометрические размеры b, h_0, l, L. Поэтому первым шагом поверочного расчета является определение из уравнения (20) угла φ_1 по заданной расчетной нагрузке P.

Тригонометрическое уравнение (20) решается обычно методом итерации и не вызывает затруднений.

После определения величины φ_1, из формулы (7) находят ρ и затем по уравнению (17) вычисляют исходное эквивалентное напряжение в среднем сечении полотна СПР $\sigma_0^{эк}$ и сопоставляют его с допускаемым напряжением $[\sigma]$.

Напряжение в крайнем расчетном сечении полотна СПР при $X = 0$ (см. Рис.1) определяется величиной напряжений в корневом расчетном сечении полки (при $y = 0$).

Напряженное состояние полок СПР определяется приложенной к ним нагрузкой и их геометрическими размерами. На Рис.2 изображена рабочая часть полки, непосредственно примыкающая к устройству для шарнирного соединения СПР со смежной с нею деталью конструкции.

В граничных сечениях B_1 и C_1 корневых частей полок рессоры (см. Рис.1), примыкающих к ее полотну, действуют (без учета момента трения в шарнире) следующие силовые факторы, Рис.2:

- изгибающий момент

$$M_{uk} = Pl\cos\varphi_1; \qquad (21)$$

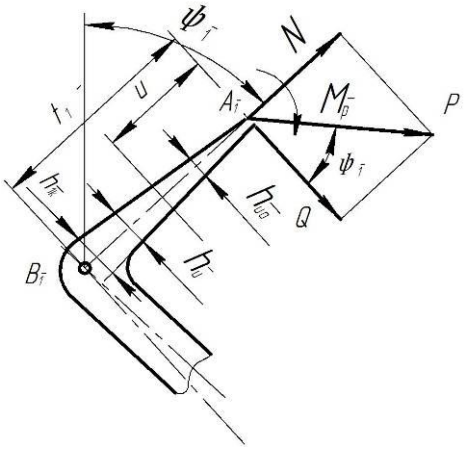

Рис.2. Расчетная схема полки рессоры
Fig. 2. Calculation scheme of spring shelf

- нормальная сила

$$N_{uk} = P\sin\varphi_1; \qquad (22)$$

- поперечная сила

$$Q_{uk} = P\cos\varphi_1. \qquad (23)$$

В наиболее удаленных от нейтральной оси волокнах в расчетных сечениях B_1 и C_1 корневых участков полок рессоры возникают напряжения:

- от изгиба

$$\sigma_M = \frac{6Pl\cos\varphi_1}{bh_{uk}^2}; \qquad (24)$$

- от растяжения

$$\sigma_N = \frac{P\sin\varphi_1}{bh_{uk}}. \qquad (25)$$

Наибольшее касательное напряжение

$$\tau = 1{,}5\frac{P\cos\varphi_1}{bh_{uk}} \qquad (26)$$

возникает на нейтральной оси сечения, но при этом напряжение от изгиба σ_M=0.

Наибольшее суммарное нормальное напряжение

$$\sigma_{uk} = \frac{P}{bh_{uk}} = \left(\frac{61}{h_{uk}}\cos\varphi_1 + \sin\varphi_1\right), \qquad (2.27)$$

где h_{uk} – высота крайнего расчетного сечения полки.

Поскольку в крайнем расчетном сечении полотна СПР ($x = 0$), расположенном в рассматриваемом случае под прямым углом к корневому расчетному сечению полки, нормальная сила $N_1 = P\cos\varphi_1$, а поперечная сила $Q = P\sin\varphi_1$, то эквивалентное напряжение в крайних волокнах этого сечения, имеющего высоту h, определяется по формуле

$$\sigma_1^{эк} = \frac{P\cos\varphi_1}{bh_1}\left(\frac{6l}{h_1} + 1\right) \le [\sigma]. \qquad (29)$$

В крайних волокнах некоторого сечения, расположенного под углом φ к плоскости симметрии рессоры (см. Рис.1) возникают напряжения

$$\sigma_{M\varphi} = \pm\frac{6P\left[l\cos\varphi_1 + \rho(\cos\varphi - \cos\varphi_1)\right]}{bh^2}; \qquad (30)$$

$$\sigma_{N\varphi} = \pm\frac{P\cos\varphi}{bh}. \qquad (31)$$

Прочность рессоры в этом сечении проверяется по формуле

$$\sigma_\varphi^{эк} = \frac{P}{bh}\left\{\frac{6\left[l\cos\varphi_1 + \rho(\cos\varphi - \cos\varphi_1)\right]}{h} + \cos\varphi\right\}. \qquad (32)$$

Очевидно, что закон изменения $h = h(\varphi)$ должен быть при этом известен.

Продольная деформация СПР является удвоенной суммой трех перемещений точек A и D ее шарниров вдоль линии действия внешней силы и вызванной ею реакции:

- перемещения от поворота полки, δ_1,
- перемещения от прогиба полки, δ_2 и
- перемещения δ_3 за счет уменьшения длины хорды по сравнению с начальным пролетом $BC = 2L$.

$$\delta_1 = l\sin\varphi_1. \qquad (33)$$

Перемещение δ_2 зависит от закона изменения высоты сечений полки и кривизны ее нейтральной линии. Если нейтральная линия полки прямая или близка к прямой, а высота сечений полки изменяется по параболическому закону, как у балки равного сопротивления изгибу, то, согласно [10], (Рис.3)

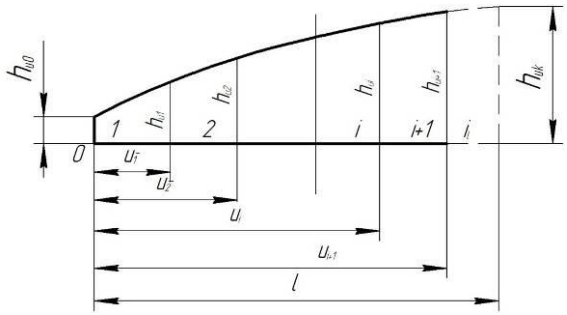

Рис.3. Профиль полки «равного сопротивления»
Fig. 3. Profile of the "equal resistance" shelf

$$\delta_2 = \frac{2Pl^3\cos^2\varphi_1}{3EI_{uk}}; \qquad (34)$$

$$\delta_3 = L - \rho\sin\varphi_1 = L\left(1 - \frac{\sin\varphi_1}{\varphi_1}\right). \qquad (35)$$

Суммарная продольная деформация СПР

$$\Delta = 2(\delta_1 + \delta_2 + \delta_3). \qquad (36)$$

Поперечный прогиб СПР

$$f = \rho(1 - \cos\varphi_1), \qquad (37)$$

или

$$f = \frac{L}{\varphi_1}(1-\cos\varphi_1). \qquad (38)$$

Напряженное состояние криволинейных участков СПР

Уравнения, выведенные выше, позволяют выполнить расчет на прочность участков рессоры, нейтральная ось которых в ненагруженном состоянии прямая. Однако, наряду с такими участками, в СПР обычно имеются участки, нейтральная линия которых и в первоначальном состоянии имеет большую или меньшую кривизну. Это − участки перехода от полок к полотну или участки, занимающие всю протяженность полок, если последние специально выполнены криволинейными.

Если кривизна таких участков велика, то их расчет следует выполнять с учетом особенностей изменения напряженного состояния в кривых брусьях [11].

Напряженное состояние криволинейного участка СПР, на протяжении которого высота сечения h остается постоянной, может быть определено по известным формулам (2), выведенным для случая чистого изгиба с корректировкой на влияние нормальной силы N и поперечной силы Q, действующих в каждом сечении участка.

В таком участке (Рис.4) нейтральный слой (н.с.) концентрично смещается к оси кривизны относительно слоя, проходящего через центры тяжести сечений, на радиальное расстояние

$$e \approx \frac{h^2}{12R}\left[1+\frac{4}{15}\left(\frac{h}{2R}\right)^2\right], \qquad (39)$$

где R − радиус линии центров тяжести сечений.

Абсолютные величины нормальных напряжений изгиба в крайних волокнах сечений определяются по формулам:

на внутренней поверхности участка

$$\sigma_1 = \frac{Mh_1}{FeR_1}; \qquad (40)$$

на наружной поверхности участка

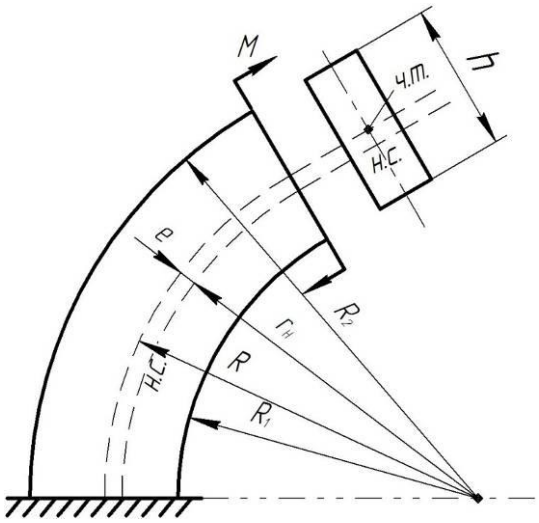

Рис.4. Расчетная схема криволинейного участка рессоры

Fig. 4. Calculation scheme of the curved spring section

$$\sigma_2 = \frac{Mh_2}{FeR_2}. \qquad (41)$$

Здесь M − изгибающий момент в рассматриваемом сечении участка; F − площадь поперечного сечения,

$$h_1 = \frac{h}{2} - e; \quad h_2 = \frac{h}{2} + e;$$

$$R_1 = R - \frac{h}{2}; \quad R_2 = R - \frac{h}{2}.$$

Если в сечении криволинейного участка СПР кроме изгибающего момента действует и нормальная сила, то при определении напряженного состояния этого участка учитывают напряжения от обоих этих силовых факторов [11]. Касательные напряжения в реальных СПР обычно не оказывают заметного влияния на прочность, и их, как правило, не определяют.

Разница в напряжениях, вычисленных по формулам (40) и (41), по сравнению с напряжениями, определенными по формулам, применяемым для расчета балок с прямой осью, обычно составляет:

при $\frac{h}{R} \le \frac{1}{15}$ – 2%; при $\frac{h}{R} \le \frac{1}{10}$ – 3%;
при $\frac{h}{R} \le \frac{1}{5}$ – 7%.

Поэтому для участков малой кривизны

$$\sigma_{эк_{max}} = \frac{M}{W} + \frac{N}{F} \le [\sigma], \qquad (42)$$

где $W = \frac{bh^2}{\sigma}$.

Для участков большой кривизны

$$\sigma_{эк_{max}} = \sigma_{1,2} + \frac{N}{F} \le [\sigma]. \qquad (43)$$

Здесь $\sigma_{1,2}$ вычисляется по формуле (40) или (41) в зависимости от того, какое из вычисленных значений приводит к наибольшим эквивалентным напряжениям.

Обоснование выбора допускаемых напряжений

При проектировочном, а также при поверочном расчете СПР на прочность, наибольшие эквивалентные напряжения, определенные в наиболее опасных сечениях рессоры, должны быть сопоставлены с напряжениями, допускаемыми для данного расчетного режима.

Обычно подлежат выбору допускаемые напряжения для двух случаев нагружения рессоры:

- при испытании на максимальную статическую нагрузку и
- при многократном динамическом нагружении.

1. Допускаемое напряжение при двукратном статическом испытании на максимальную нагрузку может быть выбрано на основании рекомендации И.Г.Пархиловского [10]: "Для того, чтобы уменьшить динамические нагрузки, передающиеся на узлы автомобиля в условиях эксплуатации, и уменьшить вес рессоры, выбирают ее статические и динамические деформации настолько большими, насколько это допускается пределом упругости материала рессоры".

Предел упругости материала обычно ГОСТом не регламентируется. В ГОСТ 14959-69 на сталь рессорно-пружинную регламентированы лишь величины предела прочности $\sigma_в$ и предела текучести $\sigma_т$.

Условным пределом упругости Г.С.Писаренко [11] называет "наименьшее напряжение, при котором остаточная деформация достигает заданной величины (обычно 0,001...0,05%) от измеряемой длины образца".

Для рессорно-пружинных сталей предел упругости обычно превышает предел пропорциональности $\sigma_{пц}$, который, по данным Г.С.Писаренко, составляет для высокоуглеродистых сталей 80…85% от $\sigma_т$. Поэтому, учитывая эпизодичность (обычно двухкратность) нагружения при испытании рессоры на максимальную нагрузку, можно принять $[\sigma]_{max} = \sigma_{уп} = (0{,}9...0{,}93)\sigma_т$.

2. При многократном (циклическом) динамическом нагружении в условиях эксплуатации изменение знака напряжения в рессоре возможно только при вертикальных ускорениях, превышающих что встречается редко. Следовательно, знакопеременная циклическая нагрузка не может рассматриваться как рабочий режим для рессоры при расчете ее на усталость.

Предельным режимом со знакопостоянной циклической нагрузкой является пульсирующий режим, при котором напряжения меняется от σ_{max_0} до нуля $\sigma_{max_0} = 0$. При этом коэффициент асимметрии цикла

$$r = \frac{\sigma_{min_0}}{\sigma_{max_0}} = 0. \qquad (44)$$

По данным Писаренко [2, С.589], условный предел усталости для стали при изгибе при симметричном цикле:

$$\sigma_{-1}^4 = 0{,}40\sigma_в. \qquad (45)$$

Предельное напряжение при асимметричном цикле [2, С.603]:

$$\sigma_{max_0}=\sigma_{-1}^{u}+(1-\psi_\sigma)\sigma_{c_0}, \qquad (46)$$

где коэффициент ψ_σ зависит от прочности стали и может быть взят из Табл.1.

Среднее напряжение пульсирующего цикла:

$$\sigma_{co}=\frac{\sigma_{max_0}+\sigma_{min_0}}{2}=0,5\sigma_{max_0}. \qquad (47)$$

Таблица 1

Значения коэффициента ψ_σ

σ_6, МПа	700…1000	1000…1200	1200…1400
ψ_σ	0,10	0,20	0,25

В частности, для стали 60С2А:

$$\sigma_{-1}^{u}=0,4\cdot 1600=640 \text{ МПа};$$

$$\sigma_{max}=640+(1-0,25)\times 0,5\sigma_{max_0};$$

$$\sigma_{max_0}=\frac{640}{0,625}=1020 \text{ МПа}.$$

Если реальный цикл нагружения рессоры имеет коэффициент асимметрии $r>0$, то $\sigma_{max_r}>\sigma_{max_0}$.

Фактическая величина r подлежит экспериментальному определению [12].

Допускаемое нормальное напряжение в рессоре при циклическом нагружении:

$$[\sigma]=\frac{\sigma_{max}}{n_\sigma}, \qquad (48)$$

где запас прочности n_σ, по рекомендациям Г.С.Писаренко, при достаточной однородности материала и высоком качестве технологических процессов может быть принят равным 1,3…1,4 [13].

В частности, для стали 60С2А, при $[\sigma]=[\sigma_0]$, где $[\sigma_0]=\frac{\sigma_{max_0}}{1,3}$, будет

$$[\sigma]=[\sigma_0]=\frac{1020}{1,3}=785 \text{ МПа}.$$

В условиях эксплуатации автомобиля при $r>0$ и выбранном допускаемом напряжении, запас усталостной прочности рессоры $n_{\sigma_r}>1,3$.

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The theoretical basis for calculating the bracketed leaf springs

Mykhailo Sukach

Abstract. Given the theoretical basis for calculating the strength of the clamp plate spring. It is an elastic plate, the ends of which are deflected from its middle part in the same direction and made in the form of consoles equipped with devices for pivotal attachment. The middle part of the plate is parallel to the line of action of the load. The plate is made with a variable length section, with in each section the axis, relative to which the moment of inertia of the section is maximum, is perpendicular to the plane of the spring bend. The patented spring is designed as a "beam of equal resistance."

The given calculation schemes and the basic equations of the stressed state of a clamp-shaped lamellar spring are not caused by any particular form of its cross section. The stress state of a clamp-shaped lamellar spring of rectangular cross-section with a straight neutral axis in an unloaded condition is considered. The method of design and calibration calculations is given for different profiles of its cross section. The calculation refers to the middle part of the spring and the shelves immediately adjacent to the elastic device for the articulated spring connection with the adjacent construction part.

The case is considered in which the neutral spring line in the original state has a greater or lesser curvature. These are sections of transition from shelves to linen or areas that occupy the entire length of the shelves, if the latter are specially made curvilinear. Since the curvature of such sections is large, their calculation will be performed

taking into account the peculiarities of the change in the stress state in the bars.

Recommendations are given for the choice of allowable stresses in the design and testing of the clamp plate spring for strength and the largest equivalent stresses defined in the most dangerous sections of the device. They must be compared with the stresses allowed for this design mode. In this case, cases of double static tests for maximum load and multiple (cyclic) dynamic loading are considered when the sign of the voltage in the spring changes.

Keywords: bracketed leaf spring, stressed state, elastic plate, bending moment, curvilinear section, shelves.

Development of the mathematical model a single stage pulse hydraulic drive

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Received on 05.11.2018, accepted after revision on 10.12.2018
DOI: 10.31493/tit1812.0202

Abstract. The hydraulic drive is used in most structures of construction and road equipment. Hydrostatic volumetric drive allows the working bodies of construction machines to perceive heavy loads with a high rate of energy transfer. This gives of advantages not available on electric machines.

The control of the hydraulic drive can be proportional and discrete. Proportional control is more precise control in comparison with discrete, however, more energy consuming. The discrete switching mode of the hydraulic drive can be performed using a high-speed valve, which is widely used for pilot valves because of their advantages in terms of simplicity of digital control, low power losses and insensitivity to contamination. However, to control such hydraulic valves, it is necessary to clearly understand and represent the principal features of the operation of a pulsed hydraulic system, to know the optimal values of the control system settings and transient parameters, to understand the relationships between the input control signals and the outgoing kinematic parameters.

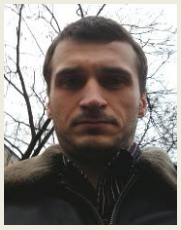
In this study, we developed a mathematical model that allows us to investigate the dynamics of high-velocity fluid flow switching valve for controlling the hydraulic power consumer.

Mathematical modeling is proposed to be carried out over a typical cell of a hydraulic system consisting of a linear hydraulic cylinder, which is a consumer of hydraulic energy and a high-speed control spool valve. The actuating spool valve consists of a body inside which the valve moves, driven by a solenoid, at the input contacts of which a variable magnetic flux is generated, forming a variable magnetic force. Inside the body of the high-speed valve, the return spring of the spool is also installed, which is used to balance it.

For the input of the valve control electric solenoid is energized variable frequency. By adjusting the fill factor of the control signal by pulse-width modulation, it is possible to change the magnitude of the spool force, thereby performing its programmatic movement.

Thus will be regulated distributor spool slits overlap, thereby passing a continuous flow and fluid pressure through a distributor.

Keywords: high-speed hydraulic valve, control performance, mathematical modeling.



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INTRODUCTION

The current need to carry out regulated software transfer of the working equipment of machines by hydraulic actuating devices poses a challenging practical task for researchers and engineers [1] associated with the development of new and improvement of existing designs of hydraulic control devices [2, 3].

The use of hydraulic systems with high values of working pressures (about 32 MPa, 64 MPa) significantly complicates the processes

of controlling the working equipment of machines, due to the effect on the installation and components of the machine of high hydrostatic forces [4, 5]. This is especially necessary for the construction of construction equipment, such as excavators. In article [6], a new design of a digging machine is considered, the hydraulic system of which requires new modern hydraulic discrete control systems.

Thus, the problem of modeling of the hydraulic actuator for the purpose of investigation of dynamic parameters is an actual practical work.

PURPOSE OF WORK

Using traditional control valves with discrete control to regulate changes in the direction of flow working fluid in the hydraulic drive mechanisms of construction machines, if it is necessary to perform control according to the specified laws of movement the working body, an overflow valve and control flow of the working fluid are additionally installed.

Through the fact that that the construction machine is operating under various load conditions, it is not possible to fine-tune the parameters of the control system, which leads to a change in the working conditions of the working body of the machine. Ambiguity and volatility of the machine does not affect the efficiency of hydraulic manipulators, building robots and lifting jib cranes [7], which deteriorates accuracy and smoothness of stroke is significantly reduced [8] is very much such.

Proportional hydraulic control allows the construction machine control system been adapted to external conditions. The technical advantages of proportional control are primarily in controlled switching transitions, smooth control of specified values and reduction in the number of hydraulic devices for defining control tasks, since most control tasks are solved at the program level by programming the proportional valve electronic control unit [9]. The development and introduction of proportional valves in construction machinery are engaged in such foreign companies like Bosch Rexroth, Brevini Hydraulics, Hydrocontrol, Sauer Danfoss, the basic knowledge which is based on the investigations of proportional control Follingera A. [10] A. Schmitt, Krettsa D. Scholz D. [11] and others.

Although the proportional hydraulic drive has an advantage over the discrete one, under the same conditions it requires a more complex control system. Such a control system will have to monitor the position of the control spool and perform a change in its position in accordance with a given program. In high pressure hydraulic systems, the efficiency of proportional control is reduced, since it requires a significant amount of energy to implement such control.

One of the ways to reduce energy consumption in the control system of hydraulic actuators is the use of discrete control valves with high-speed switching of the control element based on pulse-width control [11]. High-speed valves are widely used in hydraulic and pneumatic systems due to their advantages, such as compact design, low cost, easy digital control, low power loss and insensitivity to contamination. The switching frequency and the nominal flow of the working fluid are the two main and important indicators for evaluating the effectiveness of hydraulic high-speed valves.

Thus it serves to investigate qualitatively workflow discrete hydraulic actuator with a pulse-controlled parameters to identify its rational use.

TASKS OF RESEARCH

The purpose of this work is to develop a mathematical model of control of a volumetric hydraulic drive with a high-speed control valve switching. Valve control should be implemented through an electrical system with pulse-width modulated control signal.

METHODS OF THE STUDY

The D'Alember approach is used as the main method for describing the equations of motion of the executive body of the hydraulic drive and the working element of the spool. Electrical transients in an electromagnetic converter is written based on the Maxfel equations and Ohm's law. The dynamics of the hy-

draulic system is described by the equations of continuity of fluid flow, the equations of state and the equations of energy.

RESULTS OF RESEARCH

To construct a mathematical model of the high-speed control of a linear hydraulic cylinder, considered single-control valve with magnetic actuator, the circuit is shown on Fig. 1.

The structure of the distributor includes a housing *1*, a spool *2*, a solenoid electromagnet *3* and a spring *4*. When applying to the electromagnet *3* voltage with different on/off frequency, various power loads are formed on the movable slide 2.

The dynamic transient of a high-speed electric solenoid can be written as [12, 13]:

$$U_{em} = R_{em} I_{em} + L_{em} \frac{dI_{em}}{dt} + \psi \frac{dx_z}{dt}, \qquad (1)$$

where

U_{em} – control voltage at the input of the solenoid, which is performed by moving the valve spool,

R_{em} – active resistance of the solenoid winding,

L_{em} – the inductance of the winding of the solenoid electromagnet,

I_{em} – current in the control coil of the solenoid,

ψ – coefficient of anti-driving force,

x_z – movement of the distributor spool, which for the solenoid electromagnet is its anchor.

The plunger of the spool valve distributor under the action of electromagnetic force will begin to move in the direction of the force action vector, and braking forces will arise from the elastic link, which, together with the dissipative forces, will resist displacement. The dynamic equation of motion of this process will be described as follows:

$$m_z \frac{d^2 x_z}{dt^2} = F_m - F_c - F_b - F_R, \qquad (2)$$

where

m_z – it is mass of the plunger,

F_m – it's driving electromagnetic force,

$F_c = c_{np\_z} x_z$ – it's spring resistance force,

$F_b = b_z \frac{dx_z}{dt}$ – the force of viscous resistance from the friction of the plunger along the

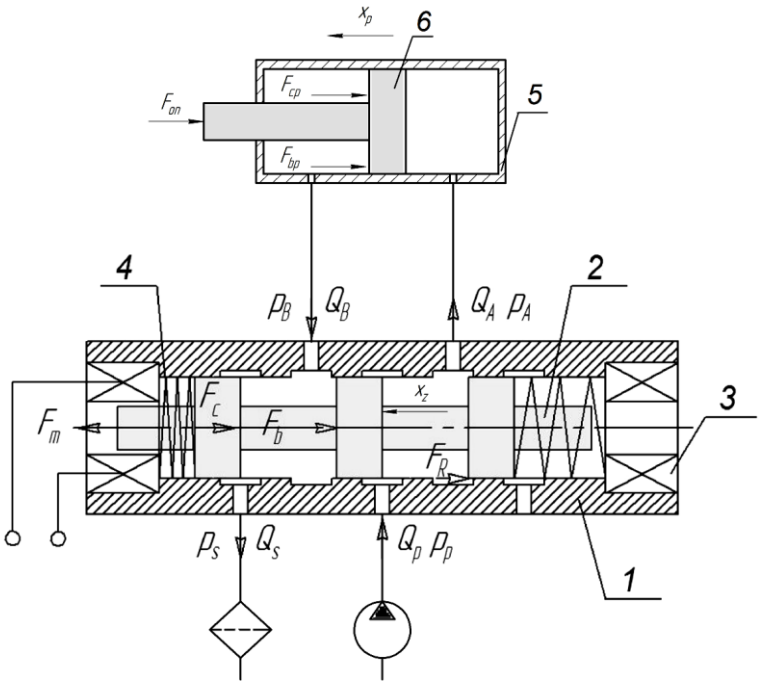

Fig.1. The design scheme of the distributor with an electromagnetic drive: *1* – case; *2* – spool; *3* – electromagnet; *4* – spring; *5* – hydraulic cylinder; *6* – movable piston

sleeve of the spool body,
F_R – hydrodynamic force acting on the gold from the working fluid,
c_{np_z} – spring stiffness,
b_z – it's the coefficient of viscous friction in the gap between the plunger and the sleeve of the grain trap.

On the basis of Maxwell's electromagnetic theory, the magnetic force, which the high-speed solenoid creates, can be defined as follows [14]:

$$F_m = \frac{\lambda \Phi^2}{2\mu\pi r^2}, \quad (3)$$

where
μ – is the magnetic permeability of the air,
r – is the plunger radius,
λ – the efficiency of the magnetic field of the solenoid (from 0 to 1),
Φ – is the total magnetic flux, the average value of which for a solenoid with the number of turns N is determined by the following expression

$$\Phi = \frac{I_{em} N}{R_{em}}. \quad (4)$$

The nature of the pressure change in the working hydro lines of the hydraulic distributor, which provides the supply of hydraulic energy to consumers, is determined from the flow continuity equations taking into account the compression of the working fluid [15]:

$$\frac{dp_A}{dt} = \frac{E_{зв\_A}}{V_1}(Q_A - q_1), \quad (5)$$

$$\frac{dp_B}{dt} = \frac{E_{зв\_B}}{V_2}(-Q_B + q_2), \quad (6)$$

where
Q_A and Q_B – fluid flow in the pressure and discharge lines of consumers connected to the appropriate distributor channels,
$E_{зв\_A}$ and $E_{зв\_B}$ – the module of the bulk elasticity of the working fluid in the corresponding cavities of the consumer connected to the distributor,
V_1 and V_2 – it's the initial volumes of the working fluid in the injection and discharge cavities of the consumer, taking into account the volumes of fluid in the adjacent pipelines,
$q_1 = \pi r^2 \frac{dx_z}{dt}$ and $q_2 = \pi r^2 \frac{dx_z}{dt}$ – the change in the flow rate of the working fluid in the discharge and drain of the consumer.

The flow of the working fluid in the pressure and drain line of the consumer is determined by its costs through the cylindrical slots of the spool valve:

$$Q_A = \eta_A \pi d_з x_z \sqrt{\frac{2|p_p - p_A|}{\rho}} sign(p_p - p_A), \quad (7)$$

$$Q_B = \eta_B \pi d_з x_z \sqrt{\frac{2|p_B - p_s|}{\rho}} sign(p_B - p_s), \quad (8)$$

where
η_A and η_B – the coefficients of the flow rate of the working fluid through the throttle channels of the distributor,
ρ – is the density of the working fluid,
p_p – working pressure of the hydraulic pump,
p_s – pressure in the drain line,
$d_з$ – the diameter of the plunger spool.

The acceleration of the movement of the hydraulic cylinder rod will be determined from the equation:

$$\frac{d^2 x_p}{dt^2} = \frac{1}{m_\Sigma}(p_A S_A - p_B S_B - F_{on} - F_{cp} - F_{bp}), \quad (9)$$

where
m_Σ – the mass of the moving parts of the rod of the hydraulic cylinder,
$S_A = \pi \frac{D_A^2}{4}$ and $S_B = \pi \frac{(D_A^2 - D_B^2)}{4}$ – respectively, the area of the piston and rod planes of the hydraulic cylinder,
D_A – the diameter of the piston,
D_B – the stem diameter,
F_{on} – it's external resistance force,

$F_{cp} = c_{np\_p} x_p$ – the reaction from the compression of the walls of the cylinder, pipelines and liquids,

$F_{bp} = b_p \frac{dx_p}{dt}$ – it's the additional effort that is spent on damping the fluid in the drain line,

$\frac{dx_p}{dt} = \int \frac{d^2 x_p}{dt^2}$ – it's piston speeds.

The obtained equations of the mathematical model are proposed to be investigated using numerical modeling with the recommended iteration step of more than 1000 steps.

The algorithm for calculating the proposed mathematical model is presented on Fig.2.

At the initial stage of calculations, it is proposed to determine and enter the technical parameters of the hydraulic drive, such as cylinder, stem and spool diameters, pressure at the hydraulic pump outlet and in the drain line, average stiffness and damping coefficients, external force resistance, solenoid winding resistance and its inductance. It is necessary to determine the initial parameters of the system and set their values after that. Further, according to the algorithm, it is necessary to form a cycle and determine by numerical calculations the parameters of the magnetic force needed to move the spool, its speed and displacement, acceleration, speed and displacement of the piston of the driving hydraulic cylinder.

In [16], the efficiency of using a high-speed hydraulic switching valve, which is similar to what is investigated in this article, is shown. However, in this work, a pilot valve with a maximum pressure of 1,35 MPa and a flow rate of 5 L/min is considered, but for a controlled dynamic mode of operation of the machine, a single-stage valve is quite suitable.

FINDINGS

As result of the study, a mathematical model of a high-speed hydraulic distributor was analyzed and constructed, which should then be solved using numerical mathematical methods.

In the process of the work done, it became clear that the problem of mathematical modeling of volumetric hydraulic drives is a difficult technical problem, the solution of which is engaged in a number of scientific schools.

In the preliminary calculations, it became known that in the future to build an effective system of discrete hydraulic control, it is necessary to develop a two-stage control system and determine its dynamic characteristics.

The management concept it is proposed to use the proposed algorithm in the article [11].

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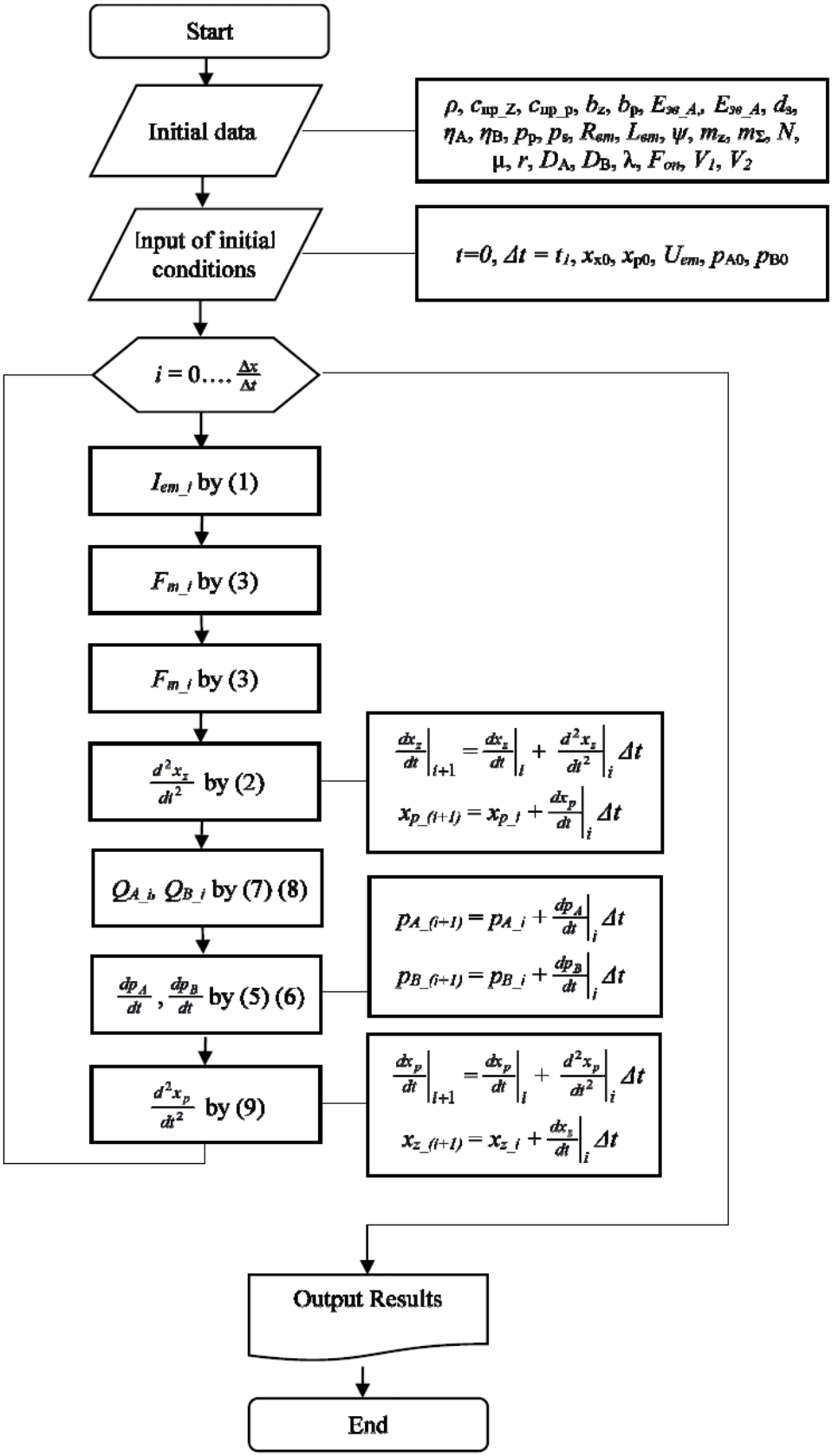

Fig.2. The algorithm for calculating hydraulic drive

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Разработка математической модели одно-каскадного импульсного гидропривода

Дмитрий Мищук

Аннотация. Гидравлический привод используется в большинстве конструкций строительной и дорожной техники. Гидростатиче ский объемный привод позволяет рабочим органам строительных машин воспринимать тяжелые нагрузки с высокой скоростью передачи энергии. Все это дает преимущества по сравнению с аналогичными соизмеримыми электрическими приводами машин.

Управление гидравлическим приводом может быть пропорциональным и дискретным. Пропорциональное управление является более точным управлением в сравнении с дискретным, однако и более энергетически затратным. Дискретный режим переключения гидравлического привода может быть выполнен с использованием высокоскоростного клапана, который широко используется для пилотных клапанов из-за их преимуществ с точки зрения простоты цифрового управления, низких потерь мощности и нечувствительности к загрязнению рабочей среды. Однако для управления такими гидравлическими клапанами необходимо четко понимать и представлять принципиальные особенности работы импульсной гидравлической системы, знать оптимальные значения настроек системы управления и параметры переходного процесса, понимать взаимосвязи между входными управляющими сигналами и исходящими кинематическими параметрами. В представленной работе разработано математическую модель, которая позволяет исследовать динамику быстродействующего клапана переключения потока жидкости для управления потребителем гидравлической энергии.

Математическое моделирование предлагается провести над типовой ячейкой гидравлической системы, состоящей из линейного гидравлического цилиндра, который является потребителем гидравлической энергии и высокоскоростного управляющего золотникового клапана. Приводной золотниковый клапан состоит из корпуса внутри которого перемещается золотник с приводом от соленоида, на входных контактах которого генерируется переменный магнитный поток, формирующий переменную магнитную силу. Внутри корпуса быстроходного клапана также установлено возвратную пружину золотника, которая используется для его уравновешивания.

Для управления клапаном на вход электрического соленоида подается напряжение переменной частоты. Регулируя коэффициент заполнения сигнала управления широтно-импульсной модуляцией, можно изменять величину тягового усилия золотника, выполняя тем самым его программное перемещение. Таким образом будет происходить регулированное перекрытие щелей золотникового распределителя, пропуская тем самым непрерывный поток и давление жидкости через распределитель.

Ключевые слова: быстродействующий гидравлический клапан, показатели управления, математическое моделирование.

The methods of homotopic skeletonization of bit-mapped drawings of parts of sea transport

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Received on 08.06.2018, accepted after revision on 10.12.2018
DOI: 10.31493/tit1812.0301

Abstract. Solution of the problem of recognition and vectorization of parts of sea transport requires formation of skeletonized images, homotopic (geometrical primitives, topologically equivalent in shape and their coherence) to parts' shapes.

The author has performed a comparative analysis of the best methods of parallel, topological skeletonization of the area objects, based upon application of space extractors. The analysis showed that the methods existing in the investigated objects zone possessed typical drawbacks, expressed in iterative distortions of primitive topology and their compositions.

The objective of the article is to through the light upon the developed methods of improvement of topological equivalence of the resulting skeletons to the shapes of the parts of sea transport, by means of gradual correction of typical distortions of skeletons.

The developed methods assumes correction of skeleton's iterative distortions by modified extractors of the principal method of skeletonization and restoration of the resulting skeleton by extractors of restoration of homotopic skeleton, on the basis of developed rules of its reconstruction.

Execution of the proposed method was carried out on example of the basic method Wu R.Y. & Tsai W.H. Examples of the results of skeletonization of parts' drawings were given, verifying efficiency of the proposed methods. The methods can be adapted to the methods of topological skeletonization of area objects, based upon application of space extractors.

Keywords: drawing, shape, skeleton, extractor ,distortion coherence, homotopic character.

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INTRODUCTION

According to the principles, laid in the basis of skeletonization objects' of bit-mapped area images the following groups of methods can be singled out: approximation of the boundary of an area figure by a polygon [1 − 3], path-tracing method [9], stripes graphs [5], tracking of pixels [1, 2, 6], distance maps method [10], wave method [7], method of topological thinning [11 − 16].

The analysis of merits and flaws of each group of methods showed that methods of parallel iterative topological thinning Rutovitz, Pavlidis, Wu&Tsai et al.), ensuring skeletons of better quality seemed to be most promising in the zone under investigation.

These methods are based on placing space extractors on the local neighbourhood of the points of bit-mapped image withy the objective of extracting "simple dots, extraction of which does not infringe structural similarity and integrity of the skeleton of part's shape [10]. The methods belonging to this group

differ in their sets of extractors, the criteria of images dots affiliation with the skeleton and ways of dots testing on correspondence with such criteria.

Still, from the point of view of the analyzed objects zone, the existing methods possess, in spite of their merits [1, 9, 10, 17], a common substantial drawback, emerging as violation of homotopic character of the resulting skeleton, as compared to the original part's shape on the drawing, particularly:

- distortion of topology of right angles of the skeleton at iterative parallel thinning of part's shape;
- in violationв of skeleton's coherence at the process of thinning of part's shape;
- in violation of skeleton's topology in the points of intersection of geometrical primitives of the shape;
- in sensibility of skeleton's topology to local properties of the shape (thickness, for instance).

THE OBJECTIVE AND METHODS

The objective is development of the methods of topological skeletonization of drawings of sea transport parts, ensuring homotopic character of skeletons with original parts' shapes, by means of correction of typical distortions, by application of basic methods of skeletonization.

A substantial increase of skeleton's structural correspondence to the part's shape is reached by gradual application of the developed set of methods:

- At the first stage at iterative thinning of a part a correction of iterative distortions of skeleton with modified extractors of the basic method of skeletonization is performed;
- at the second stage, after the entire skeleton has been obtained, reconstruction of the skeleton is performed with restoration homotopic extractors, on the basis of the developed instructions for reconstruction of distorted zones of intersections of geometrical primitives.

Correction of the skeleton is supposed to be performed with the aid of the designed extractors, in accordance with the following principle:

- the aperture of a "simple" dot, removed by a basic method is compared to the nuclei of the developed set of correcting and restoring extractors with a possibility of their turning by angles, divisible by 90°;
- in case of coincidence of the dot's aperture with the nucleus of any extractor the skeleton is corrected, in accordance with the developed instructions for adoptions of solutions, specific for each type of skeleton's distortions.

THE RESULTS AND COMMENTS

Among the methods of topological skeletonization of objects, when space extractors are used, Wu R.Y. & Tsai W.H. [18] method, ensuring the best result is of special interest.

The extractors, applied in Wu R.Y. & Tsai W.H. method are represented in Table 1. It is characteristic that these extractors contain unused positions with the unidentified beforehand values, hence, allowing variability. The elements of extractors nuclei with alternative colours are marked with "?" sign, whilst unused nuclei elements are marked with «□» sign.

Application of these positions for reconstruction of distorted skeletons allows ensuring their structural correspondence to part's shape, required in the object's zone.

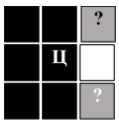
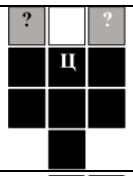
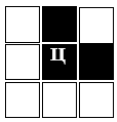
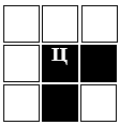
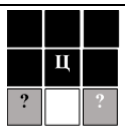
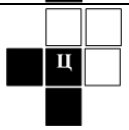
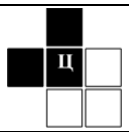
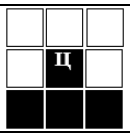
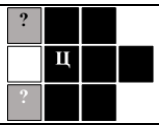
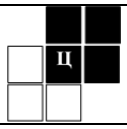
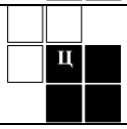
Now, let us consider the proposed methods of restoring homotopic character of the skeleton, generated by the principle method on the example of the method of Wu&Tsai.

THE METHOD OF CORRECTING DISTORTIONS OF THE TOPOLOGY OF SKELETON'S RIGHT ANGLES

The first type of skeleton's distortions is described by iterative violation of the topology of skeleton's right angles (Fig.1).

To explain the essence of the problem of appearance of such a distortion we shall introduce the required definitions:

Table 1. Extractors $\{Z\}_a^k$ for R.Y. Wu, W.H. Tsai [18] method

Index	Extractor	Index	Extractor	Index	Extractor	Index	Extractor
a		*d*		*g*		*j*	
b		*e*		*h*		*k*	
c		*f*		*i*			

- We'll call the point «*a*» the vertex of the convex angle in 4-connected neighbourhood, where adjacent points b_k and b_{k+1} $(k\in[0,3])$ belong to the shape (Fig.2, *a*);

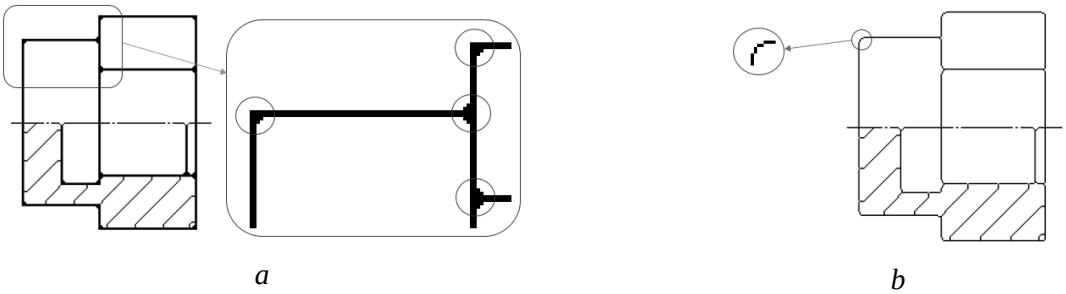
- We'll call the vertex of the concave angle the black "a" in 8-connected neighbourhood, where only one of point of all diagonal points$\{b_1, b_3, b_5, b_7\}$ belongs to the background (Fig.2, *b*).

In the principle method of thinning the convex angles, extractors, using 4-connection "Manhattan" metric are applied, in which distances from the vertex of the convex angle of the shape to the background $\rho_0^M = \rho_6^M = 1$ (see Fig.4, 5, *a*). In accordance with the principle idea of the method, the vertex of the convex angle is considered to be a "simple" point and is removed by $\{Z\}_a^k$ extractors with one pass.

However, vertexes of concave angles in "Manhattan" metric are not boundary points. So, the vertexes of concave angles can't be removed with one pass only with application of $\{Z\}_a^k$, extractors, it leading to distortion of angles topology (see Fig.1), owing to possible application of different set of extractors during two consecutive iterations, it, finally causing violation ion homotopic character of the shape's skeleton.

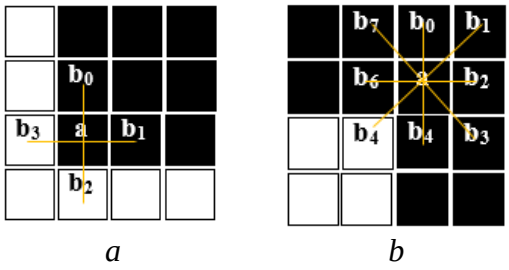
In the proposed method the problem of vertexes' treatment is solved by application of 8-connectoin "chess" metric both for convex and concave angles.

As the distance from vertexes of both convex $(\rho_0^Ш = \rho_6^Ш = \rho_7^Ш = 1)$ and concave $(\rho_7^Ш = 1)$ angles to the background is equal, these vertexes can be removed in one pass. To preserve the shape's topology it is necessary, there, to recognize the vertexes of the concave angles and develop the conditions for preser-



a *b*

Fig.1. Distortion of the skeleton's right angles: *a* − iterative distortion of topology of skeleton's angles; *b* − distorted right angles of the resulting skeleton



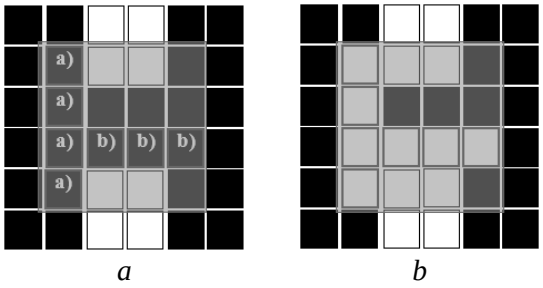
a *b*

Fig.2. Vertexes of the concave and convex angles

vation of skeleton's coherence at their removal. For recognition of the vertexes of the concave angles extractors $\{\tilde{Z}\}_A^I$ (Table 2) were developed.

Elements of the nuclei of basic extractors, unused for the basic method with alternative colours and ignored ones are used there [23]. Here, a candidate to the vortex of the concave angle is marked with «*» symbol. As the vortex of the concave angle has just two neighbouring adjacent points, the shape point may be considered to be the vortex of the concave angle if it is twice marked to be it For realization of this rule for each point of the shape flag $g^{(*)} = 0$ is used.

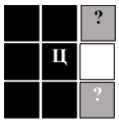
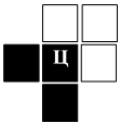
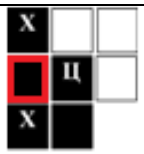
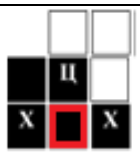
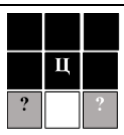
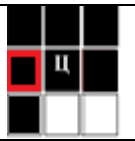
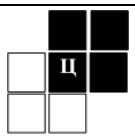
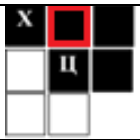
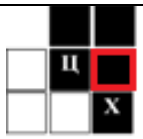
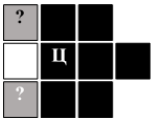
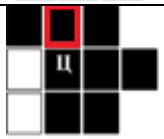
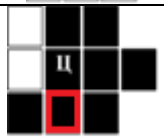
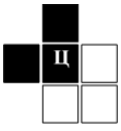
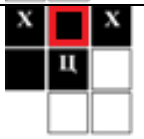
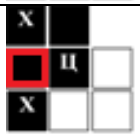
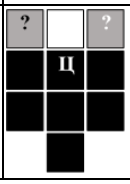
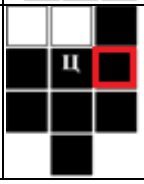
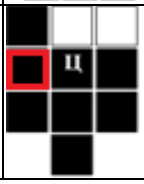
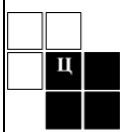
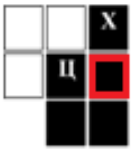
If on any of the correcting extractors a shape point from $\{\tilde{Z}\}_A^I$ is recognized as a vortex of the concave angle it is marked as a corner point and the value of $g^{(*)}$ for this point is increased by 1. Then, if upon completion of checking with $\{\tilde{Z}\}_A^I$ extractors the value of point $g^{(*)} = 2$, then this point is not removed in order to prevent violation of homotopic character of the shape's skeleton.



a *b*

Fig.3. Violation of coherence in the process of thinning of the shape at presence of several concave angles within the boundaries of 4×4 neighbourhood of the point under analysis

Table 2. Extractors $\{\tilde{Z}\}_A^I$

Basic extractor		Developed extractor	Basic extractor		Developed extractor	Basic extractor	Developed extractor
A				E			
B				F			
C				H			
D				I			

THE CORRECTION METHOD FOR IRREGULARITIES IN SKELETON'S COHERENCE

The second type of skeleton's distortion lies in the process of thinning of the shape in case there are some concave angles within the boundaries of 4×4 neighbourhood of the point under analysis (Fig.3).

The points, marked in Fig.3. with the shape, and extractors $\{Z\}_A^B$ will be removed

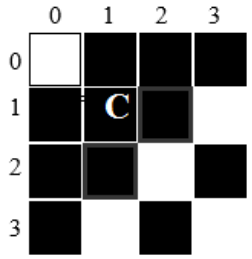


Fig.4. The correcting extractor $\{\tilde{Z}\}_L$

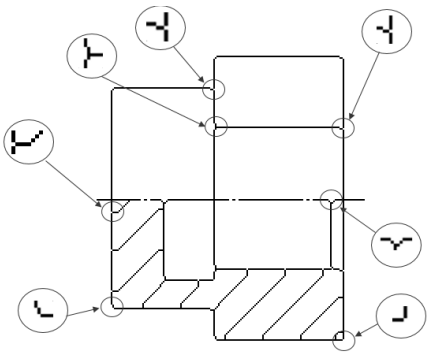
(Indices of extractors removing these points are shown in Fig.3), this is to lead to violation of coherence of the skeleton (see Fig.3, *b*). To solve this problem a correcting extractor $\{\tilde{Z}\}_L$ (Fig.4.) was developed, capable of rotation by angles, divisible by right angle, by application of which the problem of thinning the concave angle at its different orientation is solved.

At that, if the analyzed point of the shape is recognized to be the vortex of the concave angle , it is checked by $\{\tilde{Z}\}_L^{(\angle 0° - \angle 270°)}$ extractor, if the aperture of «C» point coincides with the extractor in one of its four orientations, then the vortex of the concave angle can be removed without violating the skeleton's coherence, the latter being ensured by the extractor's points $\{\tilde{Z}\}_L$ with the coordinated (1, 2) and (2, 1).

THE METHODS OF CORRECTING VIOLATIONS OF THE SKELETON'S TOPOLOGY IN THE POINTS OF INTERSECTION OF GEOMETRICAL PRIMITIVES

The third type of violations lies in violation of homotopic character of the skeleton in points of primitives intersection, as the character of the analyzed object's zone requires affiliation of these points (e.g. vortexes of the skeleton's right angles) with the shape (Fig.5) [23, 24].

The methods of topological skeletonization are sensitive to local properties of the shape, changing after each iteration of its thinning. Thus, for a thickness of the primitive in several points (W ≥1) even during the first iteration with $\{Z\}_A$ extractor a "forepart" artifact turns up, increasing its dimensions from iteration after iteration, greatly distorting the skeleton (Fig.6).



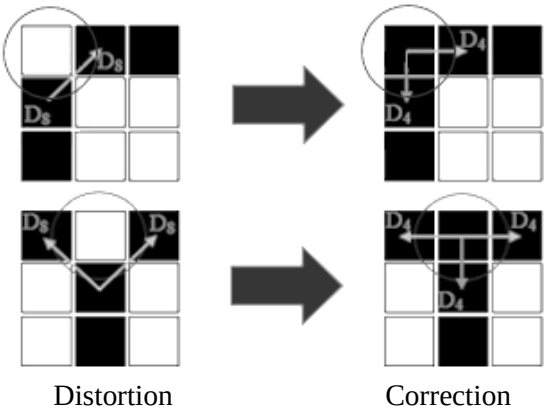


Fig.5. The method of correcting of skeleton's distortions in the points of intersection of the primitives

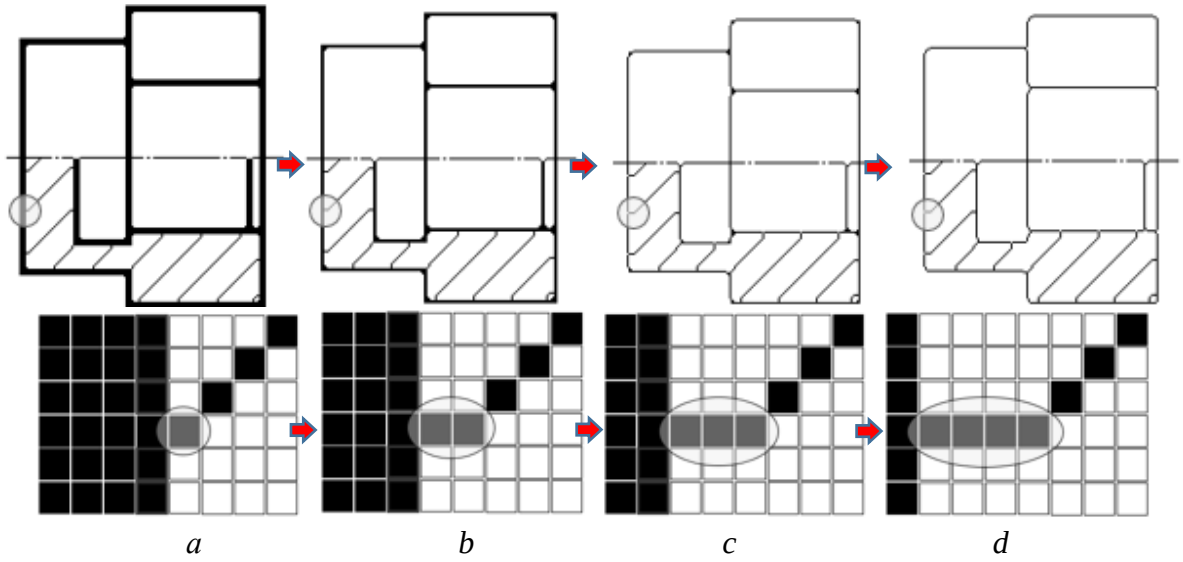


Fig.6. The result of iteration thinning of coupling of the thin and thick primitives of the shape

Elimination of these drawbacks requires regeneration of the resulting skeleton by correction of the artifacts, distorting its topology. Restoring extractors $\{\tilde{Z}\}_{(0)-(18)}^{(\angle 0°-\angle 270°)}$ 5 x[5 in size (Table 3) were developed for this, with possibility of turning by angles 90°, 180°, 270°, and a possibility of their balancing with regard to ordinate axis. $\{\tilde{Z}\}_{(0)-(9)}^{(\angle 0°-\angle 270°)}$ extractors are applied for skeletons at the end of each iteration and after completion of the shape's thinning extractors $\{\tilde{Z}\}_{(10)-(18)}^{(\angle 0°-\angle 270°)}$ are applied just once.

In the Table 3 the following designations are assumed:

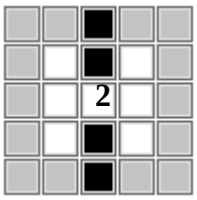
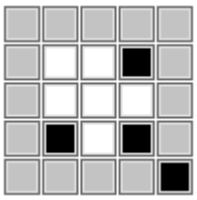
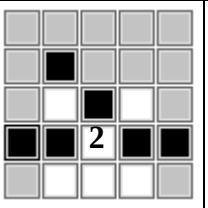
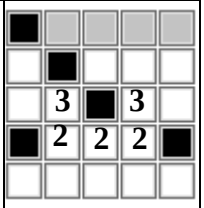
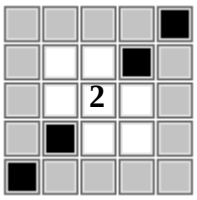
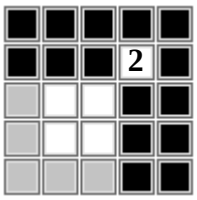
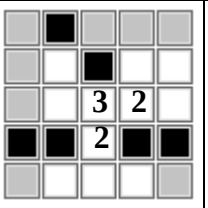
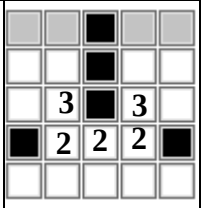
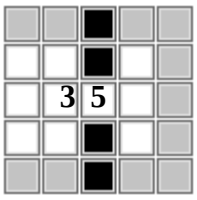
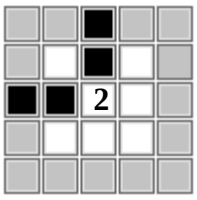
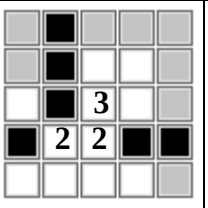
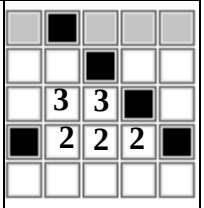
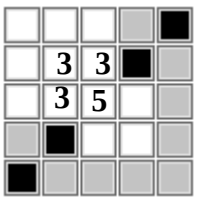
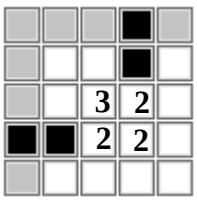
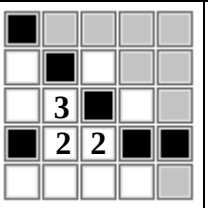
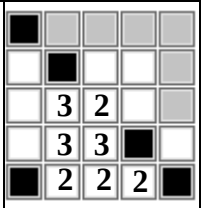
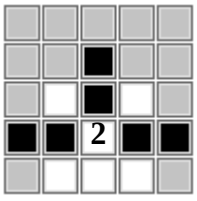
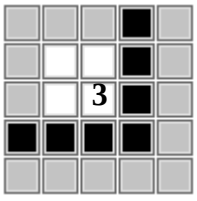
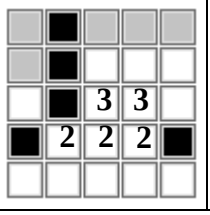
The following main principles were observed or development of $\{\tilde{Z}\}_{(0)-(18)}^{(\angle 0°-\angle 270°)}$ extractors:

- the extractors embrace all possible variants of distortions of the skeleton by the basic method and are classified, according to the groups of distortions as;
- $\{\tilde{Z}\}_{(0)-(1)}$ extractors, correcting points omissions, the extractors of this group are corrected filling the isolated points of the background with shape's points;
- $\{\tilde{Z}\}_{(2)-(3)}$ extractors, for corrections of the lines bends, the extractors of this group

	the background
	the shape
	makes no difference whether shape or background

2	the background, it becomes a shape in case of coincidence with the extractor
3	the shape, but it becomes a background in case of coincidence with the extractor
4	makes no difference whether shape or background, however it becomes background in case of coincidence with the extractor
5	makes no difference whether shape or background, however it becomes background in case of coincidence with the extractor

Table 3. Restoring extractors

Index	Extractor	Index	Extractor	Index	Extractor	Index	Extractor
0		5		10		15	
1		6		11		16	
2		7		12		17	
3		8		13		18	
4		9		14		–	–

straighten distortions of angular type, appearing due to the peculiarities of the primitives of the shape with half-tones, in accordance with Brazenham's algorithms.

- $\{\tilde{Z}\}_{(4)–(5)}$ extractors for correction of distortions of primitives intersections, isolated background points of intersections of vertical, horizontal and diagonal primitives are filled with shape's points;
- $\{\tilde{Z}\}_{(6)–(9)}$ extractors for correction of angles distortions, extractors belonging to this group eliminate thickenings of concave angles and regenerate cuttings off of vortexes of convex angles of the shape's skeleton;
- $\{\tilde{Z}\}_{(10)–(18)}$ extractors for correction of stepwise distortions, emerging, due to application of asymmetric thinning extractors of the basic skeletonization method;
- extractors' configuration must not infringe the local regularities of topology of the shape and the skeleton, for examples, extractors 14 and 15, describing similar stepwise skeleton's distortions produce various structural corrected fragments of the skeleton (Fig.7), corresponding to topological orientation of the primitives in the images' aperture;
- the zone of points (with codes 2…5), of the aperture 5 × 5, changed by the extractor must be surrounded with neighboring background points, or with unchanged shape's points, it allowing to avoid violations of skeleton's coherence at its modification with extractors.

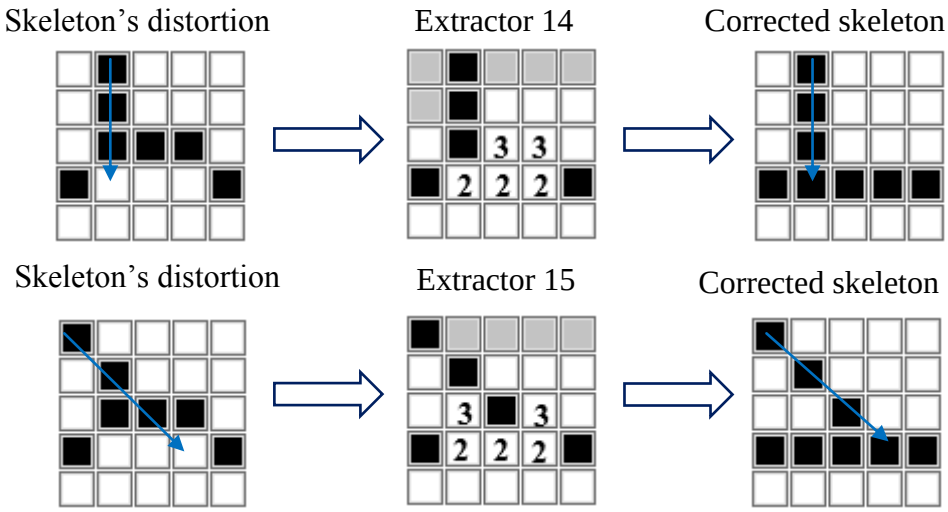


Fig.7. An example of dependence of skeleton's topology upon extractor's configuration

An example of shape's skeletonization of a part of a "Nut" type (Fig.9, *a*) is shown in Fig.8 and 9 with performed according to the basic method, with heavy distortion of the skeleton (Fig.9, *b*) and with application of the improved method, where these distortions have been removed (Fig.9, *c*).

CONCLUSIONS AND RECOMMENDATIONS

Improvement of structural distortions of skeletons is reached by applying of the developed method, the complex of method, consisting of:

- the method of correction of distortions of the topology of skeleton's right angles, based upon application of the "chess" metric, instead of "Manhattan" metric and extractors of recognition of shape's angles;
- the method of correction of violations of the skeleton's coherence, based upon application of the developed correcting extractor;
- the method of correction of violations of topology in the points of intersection of geometrical primitives, based upon application the developed regenerating extractors.

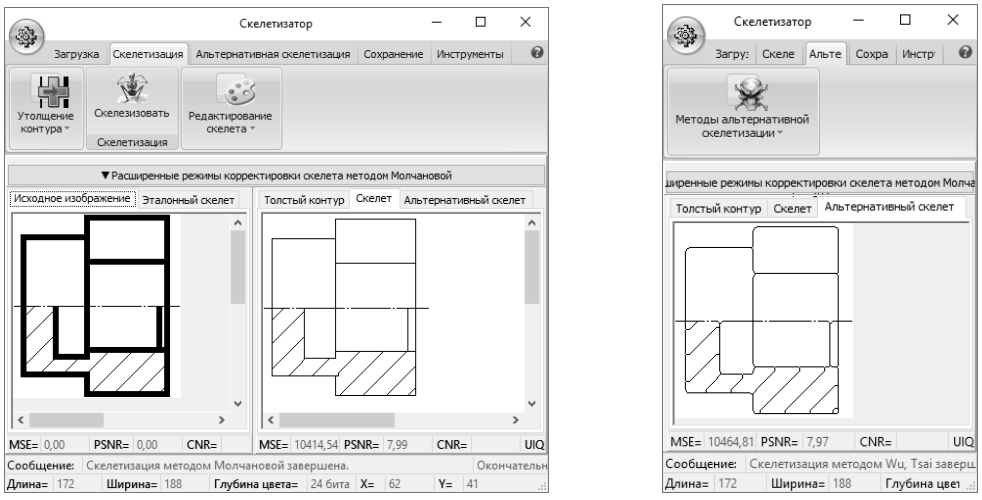
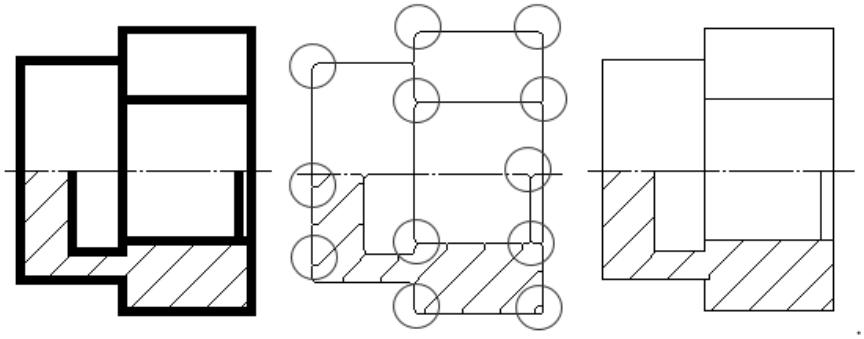


Fig.8. The result of correction of skeleton's topology



a *b* *c*

Fig.9. The result of correction of skeleton's topology: *a* − part's reducible shape; *b* − the skeleton, obtained by application of the basic method, *c*− the skeleton, obtained by the improved method

A substantial reduction in skeleton's distortions is reached by two-staged correction of the skeleton of the part's shape:

- at the first shape during iterative thinning of the part's shape iterative distortions of the skeleton are corrected;

- at the second stage, after the entire skeleton has been formed, reconstruction of distorted zones of intersections of geometrical primitives of the skeleton is done.

The skeleton of shapes of sea transport parts confirmed a substantial improvement of the quality of the produced skeletons with preservation of their topological similarity to the original shapes in the number of geometrical primitives, their shapes and coherence.

The proposed methods of iterative topological skeletonization of drawings of sea transport parts can be used for skeletonization of diagrams of road junctions, engineering drawings, functions graphs and the like.

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Методика гомотопной скелетизации растровых чертежей деталей морского транспорта

Вера Молчанова

Аннотация. Решение задачи распознавания и векторизации чертежей деталей морского транспорта требует формирования скелетных изображений, топологически эквивалентных по формам геометрических примитивов и их связности контурам деталей.

Автором выполнен сравнительный анализ лучших методов параллельной топологической скелетизации площадных объектов, основанных на применении пространственных масок. Анализ показал, что в рассматриваемой предметной области существующие методы имеют типовые недостатки, выражающиеся в итеративных искажениях топологии примитивов и их композиций.

Цель статьи – освещение разработанной методики улучшения топологической эквивалентности результирующих скелетов контурам деталей морского транспорта за счёт поэтапной коррекции типичных искажений скелетов. Разработанная методика предполагает корректировку итеративных искажений скелета модифицированными масками базового метода скелетизации и реконструкцию результирующего скелета масками восстановления гомотопности скелета на основе разработанных правил его реконструкции. Реализация предложенного метода выполнена на примере базового метода Wu R.Y. & Tsai W.H. Показаны примеры результатов скелетизации чертежей деталей, подтверждающие эффективность предложенной методики. Методика может быть адаптирована к методам топологической скелетизации площадных объектов, основанных на использовании пространственных масок.

Ключевые слова: рисунок, форма, скелет, экстрактор, когерентность преобразований, гомотопный характер.

Impact a circular cylinder with a flat on an elastic layer

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Received on 06.09.2018, accepted after revision on 02.12.2018
DOI: 10.31493/tit1812.0302

Abstract. In the work the comparison of the results of solving two plane problems is performed: the impact of a circular cylinder with a plane platform parallel to the cylinder axle (the flat) with an elastic layer and a second − plane strain state of nonstationary interaction of a circular cylinder with a flat with an elastic layer in a purely elastic and elastic-plastic mathematical formulation corresponding. The first contact occurs along the plane of the flat. A good coincidence of the results of the second problem at an elastic stage with the results of the first problem is shown. In the author's works a new approach was developed to solve plane and tree dimension problems of impact and non-stationary interaction in an elastoplastic formulation. The crack growing was simulated using an elastoplastic mathematical model. The numerical solution was obtained using the finite difference method scheme.

The use of an elastic-plastic formulation makes it possible: 1) determine the stress-strain state at the points determined by the partitioning grid of the computational domain, not only on the surface; 2) to give a reliable description of the development of plastic deformations − the stage corresponding to plasticity is a continuation of the elastic stage; 3) reliably determine the destruction toughness. A method has been developed for calculating plastic strain fields and destruction toughness of the material using the solutions of dynamic plane problems of the stress-strain state in an elastoplastic formulation taking into account possible material unloading; 4) to verify and calibrate the solution of problems in an elastoplastic formulation for the first steps by time when the deformation process is elastic, it is convenient to use the solution of the corresponding elastic problem.

Keywords: impact, elastic, elastic-plastic, layer, plane problem, hard cylinder.

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INTRODUCTION

The approach [3 − 7] for solving the dynamic problems, developed by V.D. Kubenko makes it possible to determine the stress-strain state only on the surface of the medium into which the drummer penetrates. In addition, this approach does not allow to investigate the impact of elastic shells of S.P. Tymoshenko type. To the equations describing the dynamics of the shell, the Laplace transform and the development to Fourier trigonometric series are applied. After returning to the space of the originals and using theorem on convolution in integral expressions, the components of the series of normal and tangential displacements of the median surface of the shells of the S.P. Tymoshenko type some nuclei will have asymptotic $O(1)$. Therefore, with increasing

order of a reduced system of integral equations of Volterra of the second kind [1 − 3], the determinant of the system of linear algebraic equations will be indefinitely enlarged – it will seem that the matrix of this system is weak conditioned. However, if use shell of Kirchhoff − Love type [4 − 7], then when solving problems of impact, the convergence of the solution will be guaranteed. This led [8 − 12] to the expediency of developing other mathematical approaches and models. In [13 − 17], a new approach to solving problems of impact and non-stationary interactions in an elastic-plastic mathematical setting was developed [18 − 21].

In this paper it was compared the results of solving two plane problems of the motion of a circular rigid cylinder with a flat on an elastic layer: 1) impact within a strictly elastic model; 2) no stationary interaction in elastoplastic formulation. At the initial moment the circular cylinder contacted with the surface of the layer along the plane of the flat.

PROBLEM FORMULATION

Firstproblem.Thehardcircularcylinderwitht heflatmovesverticallydownperpendiculartothes urfaceoftheelasticlayer $0 \le z \le H$ and contacts it along the lane $\{|x| \le d;\ z = 0\}$, where d − half width of the flat. As in [1 − 3] we associate a cylindrical coordinate system rOz' with a moving cylinder, axis z coincides with the axle of the cylinder. We associate with a layer a fixed Cartesian coordinate system xyz [5 − 7].

The stamp penetrates (Fig.1) an elastic layer at a speed $V_T(t)$, $(0 \le t \le T)$ with initial value $V_0 = V_T(0)$, where T is the time of interaction of a stamp with a layer. We introduce dimensionless variables.

$$t' = \frac{C_0 t}{R},\ x' = \frac{x}{R},\ z' = \frac{z}{R},\ u_t' = \frac{u_t}{R},$$

$$\sigma_{ij}' = \frac{\sigma_{ij}}{K},\ v_T' = \frac{v_T}{C_0},\ w_T' = \frac{w_T}{R},\ p' = \frac{p}{KR},$$

$$q' = \frac{q}{KR},\ M' = \frac{M}{\rho R^2},\ (i, j = x, y, z),$$

$$\beta^2 = \frac{C_S^2}{C_0^2} = \frac{\mu}{K},\ \alpha^2 = \frac{C_p^2}{C_0^2} = \left(1 + \frac{4\mu}{3K}\right),$$

$$C_0^2 = \frac{K}{\rho},\ b^2 = \frac{\beta^2}{\alpha^2} = \frac{3\mu}{3K + 4\mu}.$$

where ρ, μ, K, C_p and C_s is the density, the displacement module, the volume deformation module and the velocity of the waves in the elastic layer.

The motion [1 − 3] of an elastic layer is described by scalar potentials φ and ψ, which satisfy the wave equations [5 − 7]:

$$\Delta\varphi = \frac{\partial^2 \varphi}{\alpha^2 \partial t^2},\ \Delta\psi = \frac{\partial^2 \psi}{\beta^2 \partial t^2},\ \Delta \equiv \frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2}.$$

When problem solving an approach is used [1 − 3], which makes it possible at the initial stage of penetration to identify the linear coordinates along the surface of the layer and body [5 − 7]. As a result, approximate ratios will be executed.

$$r \approx \theta,\ \mathrm{ctg}\theta \approx 1/\theta. \qquad (1)$$

In the contact area, taking into account (1), there is a relationship between u_z and pressure p.

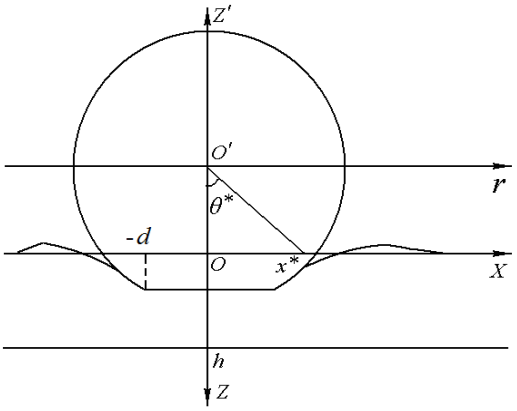

Fig.1. Scheme of the system stamp-layer

$$u_z(t, x, 0) = w_T(t) - H(|x| - d) \times$$

$$\times\left(1-\sqrt{1-(|x|-d)^2}\right), \quad (2)$$

$$w_T(t)=\int_0^t V(\tau)d\tau,\ p(t,x)=-\sigma_{zz}(t,x,0),\ |x|<x^*.$$

Linear zed boundary conditions are as follows:

$$\left.\frac{\partial u_z}{\partial t}\right|_{z=0} \equiv V(t,x)=v_T(t),\quad |x|<x^*(t), \quad (3)$$

$$\sigma_{zz}|_{z=0}=0,\ |x|>x^*(t), \quad (4)$$

$$\sigma_{zx}|_{z=0}=0,\ |x|<\infty.$$

On the surface of the layer $z=h$ there are conditions of hard jamming.

For interaction time $0\le t\le T$ select a rectangle $\{|x|\le l,\ 0\le z\le h\}$, which is occupied by the medium, and the task of impact on the layer can be considered as a problem of impact on a rectangle. The width of the rectangle l is chosen so that the perturbation waves do not reach its boundaries:

$$|x|=l\left(l>\alpha(T-t_0)+x^*(t_0),\ \left.\frac{dx^*}{dt}\right|_{t=t_0}\right).$$

For certainty, we choose the condition of a smooth sliding contact on the lateral surface of the rectangle. Initial conditions of the problem are zero.

$$u_x|_{|x|=l}=0,\ \sigma_{zx}|_{|x|=l}=0, \quad (5)$$

$$\varphi|_{t=0}=\left.\frac{\partial\varphi}{\partial t}\right|_{t=0}=0,\ \psi|_{t=0}=\left.\frac{\partial\psi}{\partial t}\right|_{t=0}=0.$$

The motion of a cylinder as a body outlines the second law of Newton

$$M\frac{\partial^2 w_T}{\partial t^2}=-F(t),\ V_T(0)=V_0,\ w_T(0)=0, \quad (6)$$

where $F(t)$ – the reaction strength of an elastic layer, which is determined considering (2), (4) as an integral from pressure in the contact region:

$$F(t)=2\int_0^{x^*(t)} p(t,x)dx.$$

The boundary of the contact area x^*, taking into account the motion of the particles of the medium and retarding the penetration of the cylinder in the elastic medium, is determined from the condition:

$$w_T(t)-u_z(t,x^*,0)-H(|x^*|-d)\times$$
$$\times\left(1-\sqrt{1-(|x^*|-d)^2}\right)=\begin{cases}0, & |x|\le x^*(t)\\ \varepsilon<0, & |x|>x^*(t).\end{cases}$$

Second problem. Its mathematical formulation is the same as in [10, 11, 13, 16, 17]. Deformation of a beam sample in the form of a rectangle $\Sigma=L\times h$ $(-L/2\le x\le L/2;0\le y\le h)$ is considered. The beam samples based on a completely rigid basis along $\{-L/2\le x\le L/2;\ y=0\}$. The thickness of the sample is considered so large that it would be possible to use the dependences of the plane strain state.

On top of the body a completely hard impact or contacts with beam along the segment $\{|x|\le d;\ y=h\}$. Its effect on the body in the contact area will be replaced evenly distributed normal stress $-P$ which varies with time as a linear function $P=p_{01}+p_{02}\times(t/\Delta t-1)$, where Δt – increment of time.

Given the symmetry of the deformation process with respect to the line $x=0$, only the right part of the transverse section of the body is considered further (Fig.2).

As a result of the impact load we will consider that the material is elastic-plastic with strengthening and calculation of fields of stresses, deformations and their increments, in particular, increments of plastic deformation

intensity $d\varepsilon_i^p$ and the parameter of the Odquist $\kappa = \int d\varepsilon_i^p$ will be carried out on the basis of numerical solution of the corresponding dynamic elastic-plastic problem.

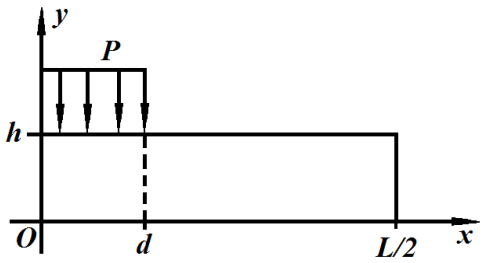

Fig.2. Scheme of the system stamp-layer. Second problem

When calculating the dynamic fields of stresses and deformations the interaction of wave fields, reflection from the boundary of the body were not taken into account.

The equations of motion for a plane problem are used

$$\frac{\partial \sigma_{xx}}{\partial x} + \frac{\partial \sigma_{xy}}{\partial y} = \rho \frac{\partial^2 u_x}{\partial t^2}, \qquad (7)$$
$$\frac{\partial \sigma_{xy}}{\partial x} + \frac{\partial \sigma_{yy}}{\partial y} = \rho \frac{\partial^2 u_y}{\partial t^2},$$

where ρ -material density.

The boundary conditions of the problem, which follow from the assumption that the region of application of the forces of the reaction of the supports is unaltered, as well as the determination of the supporting reactions have done using static methods, are written:

$$x = 0;\ 0 < y < B:\ u_x = 0,\ \sigma_{xy} = 0;$$
$$x = \frac{L}{2},\ 0 < y < B:\ \sigma_{xx} = 0,\ \sigma_{xy} = 0;$$
$$y = 0,\ 0 < x < \frac{L}{2}:\ u_y = 0,\ \sigma_{xy} = 0; \qquad (8)$$
$$y = h,\ 0 < x < d:\ \sigma_{yy} = -P,\ \sigma_{xy} = 0;$$
$$y = h,\ d < x < \frac{L}{2}:\ \sigma_{yy} = 0,\ \sigma_{xy} = 0.$$

Initial conditions are zero. In the basis of the defining relations of the mechanical model, the theory of no isothermal plastic flow of the medium with the strengthening under the condition of Huber-Mises fluidity [10, 11, 13, 16, 17] was applied. The effects of creep and temperature expansion are neglected. Then, considering the components of the deformation tensor by the sum of the elastic and plastic components of it [10, 11, 13, 16, 17], we obtain for them

$$\varepsilon_{ij} = \varepsilon_{ij}^e + \varepsilon_{ij}^p,\ \ \varepsilon_{ij}^e = \frac{1}{2G} s_{ij} + K\sigma + \varphi_1,$$
$$d\varepsilon_{ij}^p = s_{ij} d\lambda, \qquad (9)$$

here $s_{ij} = \sigma_{ij} - \delta_{ij}\sigma$ – components of the stress tensor deviator; δ_{ij} - a symbol of Kronecker; G – displacement module; $K_1 = (1-2\nu)/(3E)$; E – modulus of elasticity; ν -Poisson's coefficient; $K = 3K_1$ – the volume compression module, which binds to the ratio $\varepsilon = K\sigma + \varphi_1$ volumetric expansion 3ε (temperature expansion $\varphi_1 \equiv 0$); $\sigma = (\sigma_{xx} + \sigma_{yy} + \sigma_{zz})/3$-average tension; $d\lambda$ – some scalar function, which is determined by the condition of plasticity (the shape of the surface of the load) and in view of the above, its choice quadratic ally depends on the components of the deviant stress s_{ij} [10, 11, 13, 16, 17]. The material is strengthened with a strengthening factor η_* [10, 11, 13, 16, 17]:

$$\sigma_S(T) = \sigma_{02}(T_0)\left(1 + \frac{\kappa(T)}{\varepsilon_0}\right)^{\eta_*},$$
$$\varepsilon_0 = \frac{\sigma_{02}(T_0)}{E},\ T_0 = 20^\circ\mathrm{C}, \qquad (10)$$

where $\sigma_S(T)$ - the line of fluidity after strengthening the material at a temperature T.

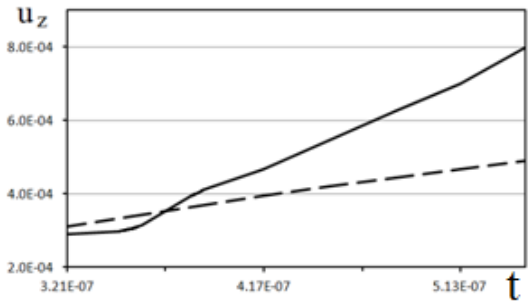

Fig. 3. The vector of the displacement component u_z

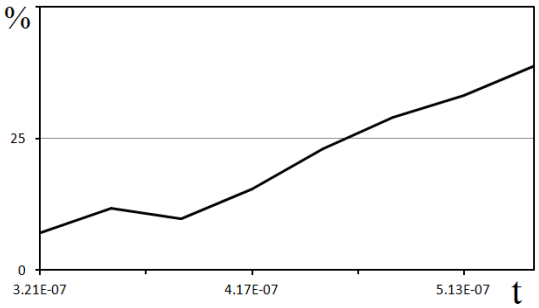

Fig. 4. Rejection of results

SCHEME AND METHODS NUMERIC REALIZATION

The scheme, methods of solving and numerical realization of the first problem are the same as in [1, 2] and for the second problem – are the same as in [10, 11, 13, 16, 17]. The application of the finite difference method to the solution of wave equations is justified in [22] and ensure the accuracy of calculations with an error of not more than $O\left((\Delta x)^2+(\Delta y)^2+(\Delta t)^2\right)$.

As example an aluminum layer was chosen $\mu = 0.3582K$. The figures below represent the results corresponding to the calculation when $V_0 = 0.0002$, $h/R = 0.01$, $M = 0.001$, $l = 0.6$, $T = 0.05$, $h = 0.4$, $d = 0.02$; Δt =4.166667E–5.

The results of the calculation for the second problem are obtained for the following parameters values: the coefficient of strengthening the material η_*=0,05; L=600 mm; h=400 mm; d =2 mm; $p_{01} = 10.1$ MPa; $p_{02} = 4{,}04$ MPa; M=80; N=101. The smallest step of the partition was near the upper surface and equaled 0,01 mm, ($\Delta x_{\min}$ = 0,01 mm; $\Delta y_{\min}$ = 0,01 mm (only the first three layers)), T =50°.

In the elastic-plastic model, the axle Oy coincides with the axis Oz'. In Fig.3 shows the components of the displacement vectors u_z in the first problem and $-u_y$ in the second are shown at the Fig.3 and denoted by u_z. The components of vector displacements u_z in the point (0, 0) in the center of the contact area for the first problem in the elastic model (dashed line) and at the point (0.01, 399.99) for the second problem in the elastic-plastic formulation (solid line) were compared.

The percentage of rejection of the displacement values u_z received for the first and second tasks is shown at the Fig.4. A period has been found for which this deviation does not exceed 8%.

CONCLUSIONS

The results of solving plane problems of the impact of a circular cylinder with a flat in an elastic model and a non-stationary interaction in an elastic-plastic mathematical setting at the elastic stage coincide well. The use of elastoplastic formulation makes it possible:

1. Determine the stress-strain state at the points determined by the grid of the breakdown of the calculated region, and not only on the surface.
2. Give a plausible description of the development of plastic deformations. The step corresponding to plasticity is the continuation of the elastic stage.
3. Authentically determine the destruction toughness K_{Ic}.
4. To verify the solving of problems in the elastic-plastic formulation of the first steps in time, when the deformation process is elastic, it is convenient to use the solution of the corresponding elastic problem.

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Удар кругового цилиндра с лыской по упругому слою

Владислав Богданов

Аннотация. Задачи ударного нагружения твердых деформируемых тел остаются актуальными и исследуются в самых разных постановках. В работе проводиться сравнение результатов решения двух плоских задач: удара кругового цилиндра с плоской площадкой параллельной оси цилиндра (лыской) с упругим слоем и второй − о плоском деформированном состоянии при нестационарном взаимодействии кругового цилиндра с лыской с упругим слоем в чисто упругой и упругопластической математических постановках соответственно. Первоначальный контакт происходит по плоскости лыски. Показано хорошее совпадение результатов второй задачи на начальном упругом этапе с результатами первой задачи.

Разработан новый подход решения задач удара и нестационарного взаимодействия в упругопластической постановке. Численное решение получено с использованием схемы метода конечных разностей. Использование упругопластической постановки дает возможность: 1) определить напряженно-деформированное состояние в точках, определяемых сеткой разбиения расчетной области, а не только на поверхности; 2) дать достоверное описание развития пластических деформаций − этап, отвечающий пластичности, является продолжением упругого этапа; 3) достоверно определить вязкость разрушения. Разработана методика расчета полей пластических деформаций и вязкости разрушения материала с использованием решения динамических плоских задач о напряженно деформированном состоянии в упругопластической постановке с учетом возможной разгрузки материала. 4. Для верификации решения задач в упруго-пластической постановке для первых шагов по времени, когда процесс деформации является упругим, удобно использовать решение соответствующей упругой задачи.

Ключевые слова: удар, упругий, упруго-пластический, слой, плоская задача, жесткий цилиндр.

Декомпозиція операторних рівнянь на основі агрегаційно-ітеративного підходу

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Отримано 16.02.2018, прийнято після перегляду 03.07.2018
DOI: 10.31493/tit1812.0303

Анотація. Побудовано і досліджено агрегаційно-ітеративний алгоритм для нелінійних операторних рівнянь, що охоплює методи ітеративного агрегування для однопараметричного і багатопараметричного випадків та містить як часткові випадки алгоритмів, так і алгоритм, що використовується для дослідження стійкості рішень диференціальних рівнянь в банаховому просторі.

Отримано достатні умови збіжності методів ітеративного агрегування і їх узагальнень, які, на відміну від відомих результатів не містять обмежень щодо знакосталості і монотонності відповідних операторів, а також, не потребують, щоб ці оператори були стискуючими.

Результати досліджень можуть, наприклад, мати застосування при розв'язанні системи лінійних алгебраїчних рівнянь високої розмірності, які описують планові задачі в математичній економіці, та при розв'язанні лінійних інтегральних рівнянь і їх систем та при розв'язанні систем алгебраїчних трансцендентних рівнянь високої розмірності і нелінійних інтегральних рівнянь.

Ключові слова: операторні рівняння, декомпозиція, ітеративне агрегування.

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ВСТУП

Як зазначено в [1, стор. 54] «в прикладній математиці є немало числових методів, особливо тих, що стосуються складних завдань, які не отримали строгого обґрунтування, хоча успішно застосовуються на практиці». Такими є, зокрема, методи ітеративного агрегування, котрі «вивчені мало і умови їхньої збіжності невідомі» [2, стор. 158]. Поміж численних досліджень цих методів одним з найвагоміших є монографія [3]. Методи ітеративного агрегування формально споріднені з проекційно-ітеративними методами [4 − 7]. Істотна відмінність між ними ґрунтується на фактах, що встановлені, наприклад в [6, 7].

Доцільними є також побудова і дослідження «синтезованих» алгоритмів, які поєднують ідеї тих чи інших наближених методів з ідеєю методів ітеративного агрегування (див., наприклад [7, розділ XIII]). Таким способом отримані нові ітераційні методи, яким властиві переваги кожного із вихідних методів і цим розширюються можливості їх використання в прикладних зада-

чах (див., наприклад [4, Вступ]). Цими фактами, а також пристосованістю до розпаралелення обчислень задля реалізації на багатопроцесорних обчислювальних системах та придатністю до побудови таких варіантів багатопараметричного ітеративного агрегування, за допомогою яких можна отримати способи усунути труднощі, спричинені практичною жорсткістю обчислюваних задач, актуалізується доцільність дослідження методів інтерактивного агрегування.

В статті запропоновано і досліджено деякі алгоритми, які охоплюють як однопараметричні, так і багатопараметричні методи ітеративного агрегування для рівнянь з лінійними і нелінійними операторами. Застосуємо започатковану в [6] і експлуатовану в низці досліджень інших авторів методологію, яка не використовує припущення щодо знакосталості і монотонності відповідних операторів і не потребує, щоб ці оператори були стискувальними (див. також [7, розд. XIII]).

ПОБУДОВА АЛГОРИТМУ

Розглядається рівняння

$$x = Ax + b \ (b \in E) \qquad (1)$$

в банаховому просторі E з лінійним неперервним оператором $A: E \to E$. Побудуємо агрегаційно-ітеративний аналог для проекційно-ітеративного методу, який описується формулою.

$$x^{(n+1)} = APx^{(n+1)} + AQx^{(n)} + b \ ,$$

де $P\left(P^2 = P\right)$ – заданий оператор, що проектує елементи простору E в елементи деякого його підпростору, причому $Q = I - P$, де I – тотожний оператор. Вважатимемо заданим лінійний неперервний оператор $S: E \to E'$ та лінійний неперервний оператор $\Lambda: E' \to E'$, де E' – банахів простір, який, взагалі кажучи, не тотожний з простором E. На практиці простір E' здебільшого є евклідовим простором R^N. Будемо вважати, що справджується рівність.

$$S\left(A + \tilde{A}\right)P + \Lambda S \ . \qquad (2)$$

Можна вважати, що цією рівністю означено лінійний неперервний оператор $\tilde{A}: E \to E$. Якщо йдеться про однопараметричний випадок, то замість (2) матимемо

$$\left(\varphi, \left(A + \tilde{A}\right)x\right) = \lambda(\varphi, x), \qquad (3)$$

де (φ, x) – значення лінійного функціоналу $\varphi \in E^*$ на елементах $x \in E$ (E^* – спряжений з E – банахів простір). Якщо $\tilde{A}$ є нульовим оператором, то число λ і елемент φ є власним числом і відповідним йому власним елементом спряженого з A оператора A^*. В загальнішому вигляді рівність

$$SAP = \Lambda S \ , \qquad (4)$$

яка отримується з (2), якщо $\tilde{A}$ є нульовим оператором, можна трактувати, як узагальнення спектральної задачі для оператора AP. Якщо при цьому Λ є матрицею діагонального вигляду, то її елементи є власними числами оператора AP.

Розглянемо систему, яку складено з рівняння (1) та допоміжного рівняння

$$y = \Lambda y - SAQx - Sb + SAPx \qquad (5)$$

з додатковим невідомим $y \in E'$. Вважатимемо, що існує обернений оператор $\left(I' - \Lambda\right)^{-1}$, де I' – одиничний оператор в E'. Множину пар $\{x, y\}$ елементів $x \in E$, $y \in E'$, які задовольняють

$$Sx + y = \theta' , \qquad (6)$$

де θ' – нульовий елемент в E' позначимо через ε_0. Ця множина є підпростором в банаховому просторі $E_0 = E \times E'$ з нормою запровадженою за допомогою формули

$$\|x, y\|_0 = \sqrt{\|x\|_E^2 + \|y\|_{E'}^2}\ . \qquad (7)$$

Використовуючи цей спосіб занурення простору E в простір E_0 побудуємо ітераційний процес за допомогою формул

$$x^{(n+1)} = APx^{(n+1)} + AQx^{(n)} + a^{(n)}\left(y^{(n)} - y^{(n-1)}\right) + b\ ; \qquad (8)$$

$$y^{(n+1)} = \Lambda y^{(n+1)} - SAQx^{(n)} + \alpha_0^{(n)}\left(y^{(n)} - y^{(n+1)}\right) - Sb. \qquad (9)$$

Тут $a^{(n)} : E' \to E$, $\alpha_0^{(n)} : E' \to E'$ є заданими операторами при кожному $n = 0, 1, \ldots$. Для кожного $n = 0, 1, \ldots$ постулюємо виконання умови

$$Sa^{(n)} + \alpha_0^{(n)} = \Lambda\ . \qquad (10)$$

Вибір операторів, що фігурують в (10), конкретизує ітеративний алгоритм, який описують формули (8), (9), за умови, що $x^{(0)}$, $y^{(0)}$ задовольняють рівність (6) при $x = x^{(0)}$, $y = y^{(0)}$. У випадку, коли йдеться про однопараметричний метод ітеративного агрегування і справджується рівність (3), ітеративний процес (8), (9) можна подати у вигляді

$$x^{(n+1)} = Ax^{(n+1)} \frac{APx^{(n+1)}}{\left(\varphi, x^{(n)}\right)}\left(y^{(n)} - y^{(n+1)}\right) + b\ , \qquad (11)$$

$$y^{(n+1)} = \lambda y^{(n+1)} - \left(\varphi, \tilde{A}Qx^{(n)}\right) + \frac{\left(\varphi, AQx^{(n)}\right)}{\left(\varphi, x^{(n)}\right)}\left(y^{(n)} - y^{(n+1)}\right) - \left(\varphi, b^{(0)}\right) + S\tilde{A}Px^{(n)}\ . \qquad (12)$$

Рівність (6) у цьому випадку має вигляд

$$\left(\varphi, x\right) + y = 0\ . \qquad (13)$$

З цієї рівності при $x = x^{(0)}$ знаходимо $y^{(0)} = y$. Зауважимо, що $x^{(0)}$ можна вибирати довільним способом. При цьому справджується рівність

$$\left(\varphi, a^{(n)}\right) + \alpha_0^{(n)} = \lambda\ , \qquad (14)$$

при $n = 0$ завдяки вибору $a^{(n)}$, $\alpha_0^{(n)}$ за формулами

$$x^{(n+1)} = \frac{\left(\varphi, Ax^{(n+1)}\right)}{\left(\varphi, x^{(n)}\right)};\ \alpha_0^{(n)} = \frac{\left(\varphi, AQx^{(n)}\right)}{\left(\varphi, x^{(n)}\right)}. \qquad (15)$$

Очевидно, що однопараметричний алгоритм (11), (12) можна подати у вигляді

$$x^{(n+1)} = \frac{\left(\varphi, Ax^{(n+1)}\right)}{\left(\varphi, x^{(n)}\right)} APx^{(n)} + AQx^{(n)} + b\ . \qquad (16)$$

РЕЗУЛЬТАТИ ТА ПОЯСНЕННЯ

Дослідження збіжності алгоритму (8), (9) ґрунтується на таких доведених авторами фактах.

Лема 1. *Якщо існує обернений оператор* $\left(I' - \Lambda\right)^{-1}$ *і* $\left\{x^*, y^*\right\}$ *з розв'язком системи* (1), (5), *то* $\left\{x^*, y^*\right\} \in \varepsilon_0$.

Лема 2. *Якщо* $\left\{x^{(0)}, y^{(0)}\right\} \in \varepsilon_0$ *і справджуються рівності* (10), *то* $\left\{x^{(n)}, y^{(n)}\right\} \in \varepsilon_0$.

Наслідком цих двох тверджень є такий факт. При $\left\{x^{(0)}, y^{(0)}\right\} \in \varepsilon_0$ за припущення, що існує оператор $\left(I' - \Lambda\right)^{-1}$ виконуються рівності

$$S\left(x^{(n)} - x^*\right) + \left(y^{(n)} - y^*\right) = 0\ \ (n = 0, 1, \ldots). \qquad (17)$$

Умови збіжності. Задля спрощення міркувань вважатимемо $\tilde{A}$ нульовим оператором, припускаючи, що цього можна досягнути, вибравши відповідним чином оператор P. Очевидними є співвідношення

$$y^{(n+1)} - y^* = -\left(I' - \Lambda + a_0^{(n)}\right)^{-1} SAQ\left(x^{(n)} - x^*\right) + \\ + \left(I' - \Lambda + a_0^{(n)}\right)^{-1} a_0^{(n)} \left(y^{(n)} - y^{(n+1)}\right)$$

$$x^{(n+1)} - x^* = \left(A + a^{(n)} \left(I' - \Lambda + a_0^{(n)}\right)^{-1} SAQ\left(x^{(n)} - x^*\right)\right) + \\ + a^{(n)} \left(I' - \Lambda + a_0^{(n)}\right)^{-1} \left(I' - \Lambda\right)\left(y^{(n)} - y^*\right)$$

які випливають з (1), (5), (8), (9) та з припущення про існування оператора

$$\left(I' - \Lambda + a_0^{(n)}\right)^{-1} \text{ при } n = 0, 1, \ldots$$

Звідси, використовуючи співвідношення (17), отримуємо

$$y^{(n+1)} - y^* = -\left(I' - \Lambda + a_0^{(n)}\right)^{-1} \left(SAQ - \psi_0^{(n)} S\right)\left(x^{(n)} - x^*\right) + \\ + \left(I' - \Lambda + a_0^{(n)}\right)^{-1} \left(a_0^{(n)} - \psi_0^{(n)}\right)\left(y^{(n)} - y^{(n+1)}\right), \qquad (18))$$

$$x^{(n+1)} + x^* = \left(A - a^{(n)} \left(I' - \Lambda + a_0^{(n)}\right)^{-1} \left(SAQ - \psi^{(n)} S\right)\left(x^{(n)} - x^*\right)\right) + \\ + \left(a^{(n)} \left(I' - \Lambda + a_0^{(n)}\right)^{-1} \left(I' - \Lambda + \psi^{(n)}\right)\left(y^{(n)} - y^*\right)\right) \qquad (19)$$

із, в цілому, довільно вибраними лінійними неперервними операторами

$$\psi^{(n)} : E' \to E, \ \psi_0^{(n)} : E' \to E.$$

Позначимо

$$h_{11}^{(n)} = A + a^{(n)} \left(I' - \Lambda + a_0^{(n)}\right)^{-1} \left(SAQ - \psi^{(n)} S\right),$$
$$h_{12}^{(n)} = a^{(n)} \left(I' - \Lambda + a_0^{(n)}\right)^{-1} \left(I' - \Lambda + \psi^{(n)}\right),$$
$$h_{21}^{(n)} = -\left(I' - \Lambda + a_0^{(n)}\right)^{-1} \left(SAQ - \psi_0^{(n)} S\right),$$
$$h_{22}^{(n)} = -\left(I' - \Lambda + a_0^{(n)}\right)^{-1} \left(a_0^{(n)} - \psi_0^{(n)}\right).$$

Приймемо позначення $\left\|H^{(n)}\right\|_0$ для норми

оператора $H^{(n)} = \begin{pmatrix} h_{11}^{(n)} & h_{12}^{(n)} \\ h_{21}^{(n)} & h_{22}^{(n)} \end{pmatrix}$.

Встановлено та доведено наступні твердження.

Теорема 1.
Якщо справджується умова

$$\left\|H^{(n)}\right\|_0^{(n)} \le q_0 < 1 \quad (n + 0,1,\ldots), \qquad (20)$$

причому $\left\{x^{(0)}, y^{(0)}\right\} \in \varepsilon_0$, *то ітераційний процес* (8), (9) *зводиться до розв'язку системи* (1), (5) *не повільніше від геометричної прогресії зі знаменником* q.

Теорема 2.
Якщо $\left\{x^{(0)}, y^{(0)}\right\} \in \varepsilon_0$ *і справджується співвідношення*

$$\left\|A - a^{(n)} \left(I' - \Lambda + a_0^{(n)}\right)^{-1} S\left(I - A\right)\right\|_E \le q_0 < 1 \quad (n + 0, 1, \ldots), \qquad (21)$$

де $\|\bullet\|_E$ *норма оператора в* E, *то послідовність* $\left\{x^{(n)}\right\}$, *отримана за допомогою алгоритму* (8), (9) *зводиться до розв'язку* $x^* \in E$ *рівняння* (1) *не повільніше від геометричної прогресії зі знаменником* q_0.

Побудова алгоритму для нелінійних рівнянь

Розглядатимемо рівняння вигляду

$$x = Fx \qquad (22)$$

з нелінійним оператором $F : D \to E$. Задля спрощення вигляду будемо вважати, що в ролі D маємо простір E. Вважаємо, що оператор F має похідну Фреше $F'(x)w$, яка є лінійним неперервним оператором щодо w і неперервним оператором щодо x. Приймемо позначення $A_n = F'\left(x^{(n)}\right)$ та A_n^* для спряженого до A_n оператора. Позначатимемо через E^* спряжений до E банахів простір. Позначення S, Λ, E, E', θ' є тими самими, що й дотепер.

Припустимо, що справджується рівність

$$S\left(A_n + \tilde{A}_n\right) = \Lambda S, \qquad (23)$$

вважаючи заданим лінійний неперервний щодо w та неперервний щодо x оператор $\tilde{A}_n w = \tilde{A}\left(x^{(n)}\right)w$, підпорядкований тільки умові (23).

Аналогом рівняння (5) є рівняння

$$y = \Lambda y + \Lambda S x - SFx. \qquad (24)$$

Множину ε_0 визначаємо за рівністю (6). Задамо лінійні нелінійні оператори

$$a^{(n)} : E' \to E;\ \alpha_0^{(n)} : E' \to E',$$

підпорядкувавши їх умові (10) і маючи на увазі те, що вони в цілому залежать від величини $x^{(n)}$, яка фігурує в ітераційних формулах

$$x^{(n+1)} = Fx^{(n)} + a^{(n)}\left(y^{(n)} - y^{(n+1)}\right), \qquad (25)$$

$$y^{(n+1)} = \Lambda y^{(n+1)} + \Lambda S x^{(n)} - SFx^{(n)} + \\ + \alpha_0^{(n)}\left(y^{(n)} - y^{(n+1)}\right). \qquad (26)$$

Зберігаються твердження лем 1 і 2 в умовах, які постулюємо відповідно до існування оператора $(I' - \Lambda)^{-1}$, і вибір $\left\{x^{(0)}, y^{(0)}\right\}$ з множини ε_0. Це дає підставу стверджувати виконання рівностей

$$S\left(x^{(n)} - x^*\right) + \left(y^{(n)} - y^*\right) = \theta' \ (n = 0,1,...), \qquad (27)$$

якщо $\left\{x^{(0)}, y^{(0)}\right\} \in \varepsilon_0$.

Збіжність алгоритмів (25), (26)

З рівностей (22), (24) та (25), (26) випливає

$$y^{(n+1)} - y^* = \left(I' - \Lambda + a_0^{(n)}\right)^{-1} \Lambda S\left(x^{(n)} - x^*\right) - \\ - \left(I' - \Lambda + a_0^{(n)}\right)^{-1} S\left(Fx^{(n)} - Fx^*\right) + \\ + \left(I' - \Lambda + a_0^{(n)}\right) a_0^{(n)}\left(y^{(n)} - y^*\right) \qquad (28)$$

та

$$x^{(n+1)} - x^* = a^{(n)}\left(I' - \Lambda + \alpha_0^{(n)}\right)^{-1}\left(I' - \Lambda\right)\left(y^{(n)} - y^*\right) + \\ + Fx^{(n)} - Fx^* + \\ + a^{(n)}\left(I' - \Lambda + a_0^{(n)}\right)^{-1} S\left(Fx^{(n)} - Fx^*\right) - \\ - a^{(n)}\left(I' - \Lambda + a_0^{(n)}\right)^{-1} \Lambda S\left(x^{(n)} - x^*\right) \qquad (29)$$

Визначимо лінійний неперервний щодо w та неперервний щодо x оператор $Q_n w$ за допомогою формули (див. [8, стор. 82])

$$Q_n w = \int_0^1 F'\left(x^{(n)} + \tau\left(x^* - x^{(n)}\right)\right) w d\tau, \qquad (30)$$

де $F'(z)$ є похідною Фреше від оператора F в точці z. Задамо лінійні неперервні оператори

$$\Psi^{(n)} : E' \to E;\ \ \Psi_0^{(n)} : E' \to E'$$

і запишемо рівності

$$\Psi^{(n)} S\left(x^{(n)} - x^*\right) + \Psi^{(n)}\left(y^{(n)} - y^*\right) = \theta, \qquad (31)$$

$$\Psi_0^{(n)} S\left(x^{(n)} - x^*\right) + \Psi_0^{(n)}\left(y^{(n)} - y^*\right) = \theta'. \qquad (32)$$

Рівності (28), (29) можна подати у вигляді

$$y^{(n+1)} - y^* = \left(I' - \Lambda + \alpha_0^{(n)}\right)^{-1}\left(\Lambda S - SQ_n\right)\left(x^{(n)} - x^*\right) + \\ + \left(I' - \Lambda + \alpha_0^{(n)}\right)^{-1} \alpha_0^{(n)}\left(y^{(n)} - y^*\right),$$

$$x^{(n+1)} - x^* = \left(Q_n - a^{(n)}\left(I' - \Lambda + \alpha_0^{(n)}\right)^{-1}\left(\Lambda S - SQ_n\right)\right)\left(x^{(n)} - x^*\right) + \\ + a^{(n)}\left(I' - \Lambda + \alpha_0^{(n)}\right)^{-1}\left(I' - \Lambda\right)\left(y^{(n)} - y^*\right).$$

Тоді з рівнянь (31) і (32), отримуємо

$$y^{(n+1)} - y^* = \left(I' - \Lambda + \alpha_0^{(n)}\right)^{-1}\left(\Lambda S - SQ_n - \Psi_0^{(n)} S\right)\left(x^{(n)} - x^*\right) + \\ + \left(I' - \Lambda + \alpha_0^{(n)}\right)^{-1}\left(\alpha_0^{(n)} - \Psi_0^{(n)}\right)\left(y^{(n)} - y^*\right), \qquad (33)$$

$$x^{(n+1)} - x^* = \left(Q_n - a^{(n)}\left(I' - \Lambda + \alpha_0^{(n)}\right)^{-1}\left(\Lambda S - SQ_n - \Psi_0^{(n)} S\right)\right)\left(x^{(n)} - x^*\right) + \\ + a^{(n)}\left(I' - \Lambda + \alpha_0^{(n)}\right)^{-1}\left(I' - \Lambda - \Psi^{(n)}\right)\left(y^{(n)} - y^*\right). \qquad (34)$$

Вважаючи заданим оператор $\tilde{A}_n = \tilde{A}\left(x^{(n)}\right)$, який фігурує в рівності (23), позначимо

$$G_n w = \int_0^1 \tilde{A}\left(x^{(n)} + \tau_1\left(x^* - x^{(n)}\right)\right) w d\tau_1 \quad (35)$$

Рівності (33), (34) можна подати у вигляді

$$y^{(n+1)} - y^* = \left(I' - \Lambda + \alpha_0^{(n)}\right)^{-1}\left(SG_n - \Psi_0^{(n)} S\right)\left(x^{(n)} - x^*\right) + \\ + \left(I' - \Lambda + \alpha_0^{(n)}\right)^{-1}\left(\alpha_0^{(n)} - \Psi_0^{(n)}\right)\left(y^{(n)} - y^*\right), \quad (36)$$

$$x^{(n+1)} - x^* = \left(Q_n - a^{(n)}\left(I' - \Lambda + \alpha_0^{(n)}\right)^{-1}\left(SG_n - \Psi_0^{(n)} S\right)\right)\left(x^{(n)} - x^*\right) + \\ + a^{(n)}\left(I' - \Lambda + \alpha_0^{(n)}\right)^{-1}\left(I' - \Lambda - \Psi^{(n)}\right)\left(y^{(n)} - y^*\right). \quad (37)$$

Позначимо

$$H^{(n)} = \begin{pmatrix} \tilde{H}_{11}^{(n)} & \tilde{H}_{12}^{(n)} \\ \tilde{H}_{21}^{(n)} & \tilde{H}_{22}^{(n)} \end{pmatrix}, \quad (38)$$

де

$$\tilde{H}_{11}^{(n)} = Q^{(n)} - a^{(n)}\left(I' - \Lambda + \alpha_0^{(n)}\right)^{-1}\left(SG - \psi^{(n)} S\right);$$
$$\tilde{H}_{12}^{(n)} = a^{(n)}\left(I' - \Lambda + \alpha_0^{(n)}\right)^{-1}\left(I' - \Lambda + \psi^{(n)}\right);$$
$$\tilde{H}_{21}^{(n)} = \left(I' - \Lambda + \alpha_0^{(n)}\right)^{-1}\left(SG - \psi_0^{(n)} S\right);$$
$$\tilde{H}_{22}^{(n)} = \left(I' - \Lambda + \alpha_0^{(n)}\right)^{-1}\left(\alpha_0^{(n)} - \psi_0^{(n)}\right).$$

Співвідношення (37), (37) дають підставу для такого підсумку.

Теорема 3.
Якщо $\left\{x^{(0)}, y^{(0)}\right\} \in \varepsilon_0$ *і має місце умова*

$$\left\|\tilde{H}^{(n)}\right\|_0^{(n)} \le q < 1 \quad (n = 0,1,...), \quad (39)$$

то послідовність $\left\{x^{(n)}, y^{(n)}\right\}$ *зводиться до розв'язання* $\left\{x^*, y^*\right\}$ *системи* (22), (24) *не повільніше від геометричної прогресії зі знаменником* q. *При цьому*

$$\left\{x^{(n)}, y^{(n)}\right\} \in \varepsilon_0 \quad (n = 0,1,...).$$

Зазначимо, що вибір операторів $\Psi^{(n)}$ і $\Psi_0^{(n)}$ підпорядковано тільки вимозі (36).

Зауваження. Умова $q < 1$ в наведених теоремах може справджуватися як у випадках, якщо відповідний оператор є стиском, і якщо вимога стиску не справджується. Зокрема у лінійному випадку спектральний радіус оператора може бути більшим від одиниці. В такому випадку похибки заокруглень можуть на практиці призвести до розбіжності ітерацій.

Засобом для усунення обчислювальних утруднень в такому разі може бути множина ε_0, якій належить вирішальна роль у перетворенні теоретично збіжного ітераційного процесу в практично збіжний.

ВИСНОВКИ

1. Побудовано і досліджено агрегаційно-ітеративний алгоритм для нелінійних операторних рівнянь, що охоплює методи ітеративного агрегування для одно параметричного і багато параметричного випадків і містить як часткові випадки алгоритми із [3], також алгоритм, досліджений в [9].

2. Отримано достатні умови збіжності методів ітеративного агрегування і їх узагальнень, які, на відміну від відомих результатів не містять обмежень щодо знакосталості і монотонності відповідних операторів, а також, не потребують, щоб ці оператори були стискуючими.

3. Результати досліджень можуть, наприклад, мати застосування при розв'язанні системи лінійних алгебраїчних рівнянь високої розмірності, які описують планові задачі в математичній економіці, та при розв'язанні лінійних інтегральних рівнянь і їх систем та при розв'язанні систем алгебраїчних трансцендентних рівнянь високої розмірності і нелінійних інтегральних рівнянь.

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Decomposition of operator equations based on aggregation-iterative approach

Valery Gavrilenko, Anatoliy Obshta, Bogdan Shuwar

Abstract. An aggregation-iterative algorithm for nonlinear operator equations covering andterative-aggregation methods for one-parameter and multiparameter cases is constructed and investigated and contains both partial cases of algorithms and an algorithm used to study the stability of solutions of differential equations in a Banach space.

Sufficient conditions for the convergence of iterative aggregation methods and their generalizations are obtained, which, in contrast to the known results, do not contain restrictions on the signs of fidelity and monotony of the respective operators, nor do they require that these operators be compressible.

The results of the research can, for example, be used in solving a system of linear algebraic equations of high dimensionality that describe the scheduled problems in mathematical economics, and when solving linear integral equations and their systems, and solving sin systems of algebraic transcendental equations of high dimension and nonlinear integral equations.

Keywords: operator equations, decomposition, iterative aggregation.

Physiological model of one materialized human thought

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Received on 19.04.2018, accepted after revision on 12.12.2018
DOI: 10.31493/tit1812.0304

Abstract. In this article, the creation in the second signal system of a correct reflex ring – physiological model of one of the materialized elementary, or compound human thoughts – is shown on a specific example. As tools, functionally full formal language and predicate logic language are used. The methodology is described in the Theory of axiomatic modeling of Kondratenko [1]. As any other functional problem in any domain, according to the Theory, the problem is interpreted in mathematical logic as a theorem which is subject to proof. The reflex ring is physiological model of one of materialized elementary, or compound, thoughts of the specific person, as the ring represents a fragment of neural network of the person. The logical work of concepts of knowledge reflected in concepts No.1 – 7, is guaranteed to provide the creation of the correct reflex ring having the property of "being physiological model of one of the materialized elementary, or compound thoughts of a person". At reflection on visual carriers of any concrete functionally complete sense received in the course of knowledge of the natural and man-made phenomena of the universe, only purely formulary texts are an ideal format in terms of quantity of the symbols necessary for these purposes. Even the axiomatic format of reflection of the specified meanings demands one-two orders more of symbols, not to mention a verbal format from which the order of magnitude of formulary symbols can exceed four in certain cases. Special importance is gained by this fact at reflection on visual carriers of biological and medical knowledge.

Key words: Axiomatic modeling, artificial intelligence, mathematical logic, thinking, formalization.

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INTRODUCTION

Relevance of a subject. More than two millennia, mankind has been trying to get into physiology of the thinking to understand the mysteries of this phenomenon and to establish the dialectic reasons and physical forces, organizing and managing continuously dynamics of thinking process of the person throughout all his life [2, 3, 4].

However, the problem is extremely difficult, and its knowledge is given to mankind by scarcely noticeable particles for decades. Here and at the moment it became clear that (**Necessary knowledge**) the mentality of the specific person according to the standard project of its genome in neural networks of the nervous system creates for each thought a separate reflex ring on the basis of code words [5] which identify physical quantities in reflex rings of the first signal system.

The thought is considered elementary and correct if it is expressed by one code word, in compliance to which one physical quantity in a

separate reflex ring of the first signal system is put.

The most surprising circumstance is that those restrictions which are recorded in its genome, specifically in rules of creation of reflex rings in the second signal system, are not known to each specific person. In particular, the restriction which is not allowing the presence at a reflex ring of the second signal system of code words which do not have physical implementation in a format of a reflex ring of the first signal system.

Behind this restriction there is prohibition on use by the specific person of the non-materialized thoughts called hypothetical thoughts. Use of hypothetical thoughts in live matter is inadmissible since it inevitably leads to disaster in life activity of this matter.

Not everything is so simple also with reflex rings, both in the first signal system, and in the second signal system. As warning against illusiveness of simplicity in structure of rings, I include below only the functional diagram of correct reflex rings (Fig.1) and terms of their forming in the course of progressive evolution of a human body which is carried out by Nature.

In fact, correct reflex rings represent the closed systems of automatic control (CSAC) with necessary (for steady work!) negative feedbacks (rigid and flexible), program setting devices for adjustable physical quantity and the "intelligent" regulators calculating necessary value of adjustable value in the current conditions of the operating perturbations on adjustable physical quantity. In the functional diagram of a ring, the role of the program-setting device for adjustable physical quantity and the role of the "intelligent" regulator for this value are carried out by "the nervous center".

In a human body Nature spent more than 4 billion years to form the first signal system of modern level.

In a human body Nature spent more than one billion years to form of the second signal system of modern level.

And on forming of one reflex ring of a compound and correct thought in the second signal system, the person of average abilities will need, at least, several working days.

Rules of forming of compound thoughts in the socioeconomic systems of our planet were defined long ago. They specialize in profiles of socially useful activity [6, 7, 8].

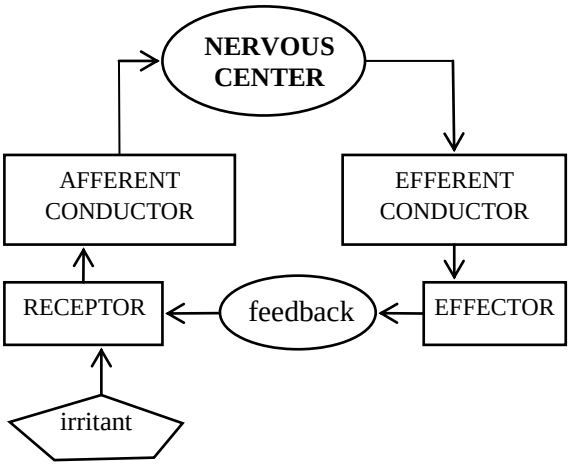

Fig.1. Function chart of a reflex ring

For scientific activity in the exact sciences, for example, these rules are formulated in the special science called mathematical logic. The purpose of knowledge of the exact sciences is only the logic of the cause and effect relations between the physical variables which are functionally fully characterizing one and all statuses of dynamic systems of any complexity.

PURPOSE OF THE ARTICLE

The purpose of the article consists in submission of the description of results of scientific knowledge of the phenomena and processes of the universe on the basis of the correct and materialized elementary and compound thoughts of scientists.

Concepts of knowledge of basic provisions of mathematical logic.

Concept No.1. Mathematical logic is a functionally full formal language which is specially intended for aphoristic (the greatest possible brevity and accuracy!) style of the description of a logical entity of the studied processes and the phenomena in the universe.

Concept No.2. During the solution of each specific logical problem, the described mathematical structure works with the fixed finite

set of operands, to each of which the director of a task appropriated "true" or "false" value.

Concept No.3. Mathematical logic, being a functionally full mathematical structure, is equipped only with four logical actions:

- logical denial
- logical summing (disjunction)
- logical product (conjunction)
- logical following (implication).

Concept No.4. Every specific functional problem, subject to a solution, in any domain is interpreted in mathematical logic as a theorem which is subject to proof.

Concept No.5. Semantic filling of theorems is defined by the code words of monolingual dictionaries of that domain which possesses the problem functional problem subject to a solution.

Concept No.6. The modern science of mathematical logic is equipped with a formal method of 100% of reliability of the automatic theorem proving which does not even demand computer support [9,10,11].

Concepts of knowledge of the highest mental function (HMF) of thinking as a part of HMF of human mentality.

Concept No.7. Thinking – as an informative process. Qualitative characteristics of thinking.

Thinking evolves from practical activities, from sensory perception, but goes far beyond its limits. In turn, the correctness of thinking is checked during practice.

At the level of the second signal system words are perceived and signals coming here are replaced with the speech. Therefore thinking is inseparably linked with speech, both internal, and external. Thinking creates concepts, their understanding and also their interrelations. Thinking operates with concepts which in the form are words, and, in fact – a result of cogitative operations. In turn, specification of verbal concepts can result from thinking.

Thinking takes place only when there is a problematic situation. If it is possible to manage in the old ways of action, then thinking is not required [12,13,14].

Main types of thinking.

In the process of the development of the mentality of a person in the course of his socialization, thinking consistently goes through four stages.

The first way of thinking of the child – subject-effective thinking (aged from 1 up to 3 years), that is, thinking in the form of practical actions. Small children learn the world around them and draw the first conclusions about its device, trying objects by hand, sorting them and breaking.

The following step − evident and figurative − thinking in the form of evident images and representations (visual, acoustical, tactile). It is most developed in ages from 4 up to 7 years, but remains also at adulthood. This thinking relies on practical reality, but can already create and store images which do not have a direct analog in feelings (fairy tale characters).

In figurative thinking which is most developed in artists, designers, advertisers, tailors, hairdressers and architects, materials for the solution of a problem are not concepts, but images – it is more often visual (for musicians – acoustical). They are either taken from memory or recreated by imagination. The prevailing role in this type of thinking is played by the right hemisphere of the brain. The difference from the previous stage is wide use of verbal designs in formation and transformation of images and also use of abstract concepts.

Abstract and logical (abstract or conceptual) thinking works in the form of abstract concepts, symbols and figures. In this case the person operates with concepts, without dealing with the experience obtained by means of sensual organs.

For example, terms of ethics – "justice" and "conscience"; mathematical terms − "degrees" and "derivative"; economic terms − "balances" or "profit" are abstract concepts and cannot be perceived by the person directly his sense organs.

Forms of thinking.

The main forms of thinking [15] are: concepts, judgments and conclusions.

Concept − a thought in which the general, essential signs of objects and phenomena are reflected.

For example, the concept "person" includes such essential signs as work, bipedalism, the articulate speech, etc. The difference of a con-

cept from representation consists that representation is always an image, and the concept is the thought expressed in a word. Besides, representation includes both essential, and insignificant signs, and a concept − only essential. The maintenance of concepts is revealed in judgments.

Judgment is reflection of communications between objects and phenomena or between their properties and features.

It is possible to construct the form of thinking following on complexity of two or more judgments – conclusion.

Conclusion is a connection between concepts or judgments that takes several judgments and produces a new judgment as a result.

Cogitative operations.

Process of thinking includes several operations: comparison, analysis, synthesis, abstraction, generalization, specification.

Analysis is mental partition of an object into the elements with their subsequent comparison. For example, the psychologist carries out the analysis of personal qualities of the client on the basis of results of the Kettel test.

Synthesis is association of separate components into a whole. It is usually adjoin to analysis. Continuing the previous example, we will imagine how the psychologist, after the analysis of several tests, builds the generalized psychological portrait of the person.

Abstraction is allocation of one party of a subject or phenomenon which in reality as separate entity does not exist. As a result of abstraction, concepts are formed. As an example, it is possible to take the concept "reliability" as the low probability of breakage of some kind of household appliances.

Generalization is allocation of the general essential properties in the compared objects. For example, having made the analysis of sales of separate grades of bread, the owner of a bakery comes to a conclusion that rich rolls, irrespective of their sizes and stuffing's are in highest demand.

Specification is an operation, the inverse of generalization, the allocation to a subject or a phenomenon of features, characteristic of it, which are not connected with common features of the corresponding class of subjects or phenomenon's. For example, the owner of a mini-bakery, having found out the increased demand for rich rolls, decides to bake their new look – with sesame and a strawberry stuffing.

Concept No.8. The knowledge in concepts No.1 – 7 provides functional completeness of this knowledge for the purpose of creation by the person of a correct reflex ring in his own second signal system, "being physiological model of one of the materialized elementary, or compound thoughts of this person" [5]. Additional and new knowledge of concept No. 8 is the statement: "being physiological model of one of the materialized elementary, or compound thoughts of this person".

Concept No.8 can be interpreted as the conclusion in the theorem in which hypotheses are concepts No.1 – 7.

MODELING METHODOLOGY

Modeling methodology is the theory of axiomatic modeling of Kondratenko and, in its framework, the Predicate logic of first order as the universal formal language intended for the description of all, known to modern science, logical relations between variables of states(9).

The target theorem can be formulated in the following statement:

The logical product of concepts of knowledge reflected in concepts No.1 – 7 is guaranteed to provide creation of the correct reflex ring having the property of "being physiological model of one of the materialized elementary, or compound thoughts of a person"[16].

The property of "being physiological model of one of the materialized elementary, or compound thoughts of a person" by definition is true, so the ring represents a fragment of neural network of the person – the director of a task.

From now, all problem definitions should be presented in the language of a predicate logic of first order, with the description corresponding to methodology of the automatic theorem proving.

For this purpose concepts of knowledge should be identified the term "axiom" with number of the corresponding concept of knowledge.

For the reflection of the target theorem in a formular form, each of the axioms is stated above in the context of article must be presented as a formula of a predicate logic of first order.

Axiom No.1. $p1(X)$ where $p1$ bears semantic loading of dialectic logic of a context of this axiom, and in brackets – subject variable X identifies the organism of the abstract person.

Axiom No.2. $p2(X)$ where $p2$ – bears semantic loading of dialectic logic of a context of this axiom, and in brackets – subject variable X identifies the organism of the abstract person.

Axiom No.3. $p3(X)$ where $p3$ – bears semantic loading of dialectic logic of a context of this axiom, and in brackets – subject variable X identifies the organism of the abstract person.

Axiom No.4. $p4(X)$ where $p4$ – bears semantic loading of dialectic logic of a context of this axiom, and in brackets – subject variable X identifies the organism of the abstract person.

Axiom No.5. $p5(X)$ where $p5$ – bears semantic loading of dialectic logic of a context of this axiom, and in brackets – subject variable X identifies the organism of the abstract person.

Axiom No.6. $p6(X)$ where $p6$ – bears semantic loading of dialectic logic of a context of this axiom, and in brackets – subject variable X identifies the organism of the abstract person.

Axiom No.7. $p7(X)$ where $p7$ – bears semantic loading of dialectic logic of a context of this axiom, and in brackets – subject variable X identifies the organism of the abstract person.

Axiom No.8. $p8(X)$ where $p8$ – bears semantic loading of dialectic logic of a context of this axiom, and in brackets – subject variable X identifies the organism of the abstract person.

On the basis of logical formulas of axioms No.1 – 8 the formula of the target theorem will have the following appearance:

$$\begin{gathered}(\forall X)\big(p1(X)\wedge p2(X)\wedge p3(X)\wedge p4(X)\wedge \\ \wedge p5(X)\wedge p6(X)\wedge p7(X)=>p8(X)\big) \\ => \\ (\exists X)\big(p1(X)\wedge p2(X)\wedge p3(X)\wedge p4(X)\wedge \\ \wedge p5(X)\wedge p6(X)\wedge p7(X)=>p8(X)\big)\end{gathered} \quad (1)$$

Denote by $F1$ the formula

$$\begin{gathered}\big(p1(X)\wedge p2(X)\wedge p3(X)\wedge p4(X)\wedge \\ \wedge p5(X)\wedge p6(X)\wedge p7(X)\big)\end{gathered}$$

Then formula (1) becomes:

$$\begin{gathered}\Big[(\forall X)\big(\text{Ї}F1\vee p8(X)\big)\Big] \\ => \\ \Big[(\exists X)\big(\text{Ї}F1\vee p8(X)\big)\Big]\end{gathered} \quad (2)$$

The structure of formula (2) contains two formulas connected by the implication symbol:

$$F2(X)\equiv[(\forall X)(\text{Ї}F1\vee p8(X))];$$

$$F3(X)\equiv[(\exists X)(\text{Ї}F1\vee p8(X))].$$

The theory of automatic theorem proving [14], in order to reduce formulas to the canonical format containing only axioms and three logical operations (conjunction, disjunction and negation), 27 formal rules are defined and proven, which describe equivalent transformation of formulas of first order predicate logic.

Two of them look as follows:

$$\big(F2(X)=>F3(X)\big)\equiv\big(\text{Ї}F2(X)\vee F3(X)\big)$$
$$\big(F2(X)=>F3(X)\big)\equiv\big(F2(X)\wedge\text{Ї}F3(X)\big)$$

One of the rules determines

$$\text{Ї}\exists\equiv\forall$$

One prescribes freeing the formula of all generality quantifiers if it doesn't contain any other quantifiers.

If one used four of these last rules, formula (2) becomes

$$\left[\text{Ɪ}F1 \vee p8(X)\right] \wedge \left[\text{Ɪ}\left[\text{Ɪ}F1 \vee p8(X)\right]\right] \quad (3)$$

Formula (3) represents conjunction of only two contrary components.

What demonstrates its discrepancy, but also demonstrates the validity of the theorem in general as the methodology of the automatic proof of theorems is based on a conclusion of discrepancy of a formula of the theorem in general.

Therefore, the theorem is successfully proved.

CONCLUSION

The logical work of concepts of knowledge reflected in concepts No.1 – 7, is guaranteed to provide the creation of the correct reflex ring having the property of "being physiological model of one of the materialized elementary, or compound thoughts of a person"[17]. At reflection on visual carriers of any concrete functionally complete sense received in the course of knowledge of the natural and man-made phenomena of the universe, only purely formulary texts are an ideal format in terms of quantity of the symbols necessary for these purposes[18]. Even the axiomatic format of reflection of the specified meanings demands one-two orders more of symbols, not to mention a verbal format from which the order of magnitude of formulary symbols can exceed four in certain cases[19,20]. Special importance is gained by this fact at reflection on visual carriers of biological and medical knowledge. Amount of fundamental meanings in these sciences such is that their description in a verbal format requires the quantity of symbols on two-three orders exceeding possibilities of long-term memory of a brain of an ingenious person.

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Физиологическая модель одной из материализованных мыслей человека

Виктория Кондратенко

Аннотация. В статье демонстрируется на конкретном примере построение во второй сигнальной системе корректного рефлекторного кольца – физиологической модели одной из материализованных элементарных, либо составных мыслей человека. В качестве инструментария используется функционально полный формальный язык, язык логики предикатов. Методология описана в Теории аксиоматического моделирования Кондратенко [1]. Задача, как любая другая проблемная функциональная задача произвольной предметной области, согласно Теории, интерпретируется в математической логике в качестве подлежащей доказательству теоремы. Рефлекторное кольцо является физиологической моделью одной из материализованных элементарных, либо составных, мыслей конкретного человека, так как само кольцо представляет собой фрагмент нейронной сети человека. Логическое произведение концептов знаний, отраженных в концептах No.1 – 7, гарантировано обеспечит построение корректного рефлекторного кольца, обладающего свойством “являющегося физиологической моделью одной из материализованных элементарных, либо составных мыслей этого человека”. При отражении на визуальных носителях любого конкретного функционально завершенного смысла, полученного в процессе познания природных и рукотворных явлений в мироздании, только чисто формульные тексты являются идеальным форматом с точки зрения количества символов, необходимых для этих целей. Даже аксиоматический формат отражения указанных смыслов требует на один-два порядка больше необходимых символов, не говоря уже о вербальном формате, который может превысить в некоторых случаях и четыре прядка формульных символов. Особую важность приобретает этот факт при отражении на визуальных носителях биологических и медицинских знаний.

Ключевые слова: аксиоматическое моделирование, искусственный интеллект, математическая логика, мышление, формализация.

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- examples of article design and archive of journals – see http://tit.knuba.edu.ua/, http://library.knuba.edu.ua/node/37940

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for publication in
the *Transfer of Innovative Technologies* journal

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INFORMATION ABOUT THE ARTICLE

Language	**Author(s)** (name, surname – *in the language of the article*) (branch, No. of order) / / (number of pages)	**Documents (+/–)**							**Article Title** **Reviewers** (name, surname, scientific degree, academic status – *in the language of the article*)	Order (number of copies)	
		About the article (*F.1*)	About the authors (*F.2*)	Two reviews (*F.3*)	Exp. conclusion (*F.4*)	Agreement (*F.5*)	Approved Translation	Recommendation		Pay-ment (€)	Signa-ture Date
		1	2	3	4	5	6	7			

Form 2

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h-index	Full Name scientific degree, academic status	Place of work, position, address, index	The author's photo (.jpg, 300 dpi)	Cell-phone e-mail ORCID Scopus Author ID

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Form 4

(Sample)

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on the possibility of publishing materials
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(Article Title)

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Scientific Edition

TRANSFER OF INNOVATIVE TECHNOLOGIES

2018 Vol 1(2)

Articles are published in the author's wording

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The original layout is made in the editorial office of the journal
Transfer of Innovative Technologies

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www.tit.at.ua, tit.edit@ukr.net

Publisher and manufacturer

Publishing House Lira-K
Certificate No.3981, series DK
F.Pushina str. 27, of. 20-22, Kyiv, Ukraine, 03115
+38 044 2479337, +38 044 4509196
www.lira-k.com.ua, lira-k@ukr.net

Signed for printing on December 20, 2018. Format 60×84 1/8
Paper offset. Printing offset. Times New Roman
Cond. print. sheets 10,69. Circulation 100 copies