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The contribution of Academician I. H. Aleksandrov to the development of national hydraulic engineering (on the example of scientific and engineering approaches to irrigation problems in the Turkestan region)

***Abstract.** History of science and technologies as a branch of scientific knowledge is aimed at studying the most significant ideas of prominent scientists and practitioners and their influence on the world science development and the technologies' advancing. In the opinion of the authors of the article, one of such figures of the early twentieth century is Academician I. H. Aleksandrov. Historical and scientific analysis of life and activity of I. H. Aleksandrov as a scientific theoretician, engineer, a science organizer is of high topicality due to the scale and versatility of his scientific contribution. Scientific creative work of I. H. Aleksandrov can be divided into five main directions of development of science and technologies: hydraulic engineering, hydropower, geographic zoning, railway transport and irrigation. In the context of the development of hydraulic engineering and hydropower, I. H. Aleksandrov had world-class achievements that glorified national science. But till recent years I. H. Aleksandrov is mostly recognized as the designer and one of the constructors of the Dnipro hydroelectric power station near Zaporizhzhia (1927-1932) (he prepared a project and directed the construction of the largest hydroelectric power station in Europe at that time) or as a creator and developer of the methodology for economic zoning of the Soviet Union. Other achievements and ideas of Academician I. H. Aleksandrov are rarely mentioned in the scientific papers and researches. The article concludes that the breadth of scientific and technical interests of I. H. Aleksandrov was the result both of his individual abilities and of the thorough theoretical and practical training received by a young engineer I. H. Aleksandrov from the highly qualified teaching staff of the Moscow Higher Technical School and the Moscow Engineering School of the Office*



of the Ways of Communications. I. H. Aleksandrov's gigantic working capability played an important role in his life as well. Great number of sources showed that occupying different positions, I. H. Aleksandrov participated in solving complex technical issues of contemporary epoch, and his scientific interests had always been in the context of the tasks of the engineering and science of his time. I. H. Aleksandrov initiated scientific discussions on the construction of ports and canals, in his work he contributed in every way to the development of home industry in general, and to hydraulic engineering in particular. The authors assert that the modern view on the scientific heritage of I. H. Aleksandrov in the context of the development of hydraulic engineering, hydropower and rail transport unambiguously acknowledges that in a concentrated-generalized form ideas, theories and concepts, put forward and scientifically grounded by Academician I. H. Aleksandrov almost a hundred years ago, even today contribute to the development of scientific and technological process.

Keywords: *I. H. Aleksandrov; hydraulic engineering; irrigation projects; energy supply projects; river flow regulation*

Introduction

Ivan Havrylovych Aleksandrov (1875-1936) is considered to be one of the most prominent hydropower engineers and hydro-technicians of the soviet period. As it is known, I. H. Aleksandrov is the founder of the complex designs of large hydroelectric stations and irrigation systems in the USSR. Ideas by I. H. Aleksandrov significantly influenced the development of both soviet and world hydropower scientific concepts and approaches. Furthermore, the original ideas of the scientist were innovative at the level of world achievements of the corresponding period technology. I. H. Aleksandrov's contribution to solving the problems of irrigation of the lands of Central Asia is surely to be considered a striking example of his engineering creativity in the early twentieth century (Zenzinov & Ryzhak, 1978). Historical and scientific analysis of the life and activity of I. H. Aleksandrov as a scientist, engineer, organizer of science and technology is relevant in view of the scale and versatility of his scientific contribution. In the context of the development of hydraulic and hydropower engineering, the development of transport communications, I. H. Aleksandrov had the achievements of the world level, which glorified the national science.

O. Isaienko, in his investigation of the life path, scientific contribution, and organizational and educational activity of academician Ivan Havrylovych Aleksandrov, substantiates that scientific researches by I. H. Aleksandrov were carried out in the context of the challenges of the engineering science of his time (Isaienko O. & Isaienko S., 2016). Scientific and creative contribution by I. H. Aleksandrov can be divided, according to O. Isaienko, into five main directions of science and technology development: hydraulic engineering, hydropower, geographic zoning, railway transport and irrigation (Isaienko, 2018).

Our analysis of a large selection of historical and literary sources of the second half of the nineteenth – early twentieth centuries about the life and activities of a prominent engineer and scientist showed that although the breadth of scientific and technical interests of I. H. Aleksandrov and the versatility of his gift impressed contemporaries and successors, today there is a lack of scientific publications, which would consider the activity and development of scientific views of Academician I. H. Aleksandrov in the context of development of hydraulic engineering and hydropower in our country.

This paper's purpose is to highlight the development of I. H. Aleksandrov's scientific views, as well as to evaluate scientific and engineering contribution of the Academician to the development of national hydraulic engineering.

Research methods

The methodological basis of the work comprises the scientific principles of research, such as objectivity, historicism, systemic, complexity. The principles of objectivity and that of historicism enable consideration of the studied historical events in their interrelation and development, giving the grounds to a comprehensive analysis and reliable assessment of historical facts (Pylypchuk & Strelko, 2016; Pylypchuk & Strelko, 2017; Pylypchuk & Strelko, 2019). The application of the systemic principle to the work allowed investigating more comprehensively the achievements of I. H. Aleksandrov in the field of hydraulic engineering development.

Results and discussions

In 1912 I. H. Aleksandrov was invited to work at the Land Resources Department of the Ministry of Agriculture of the Russian Empire. He readily accepted the proposal, since the latter was fully in line with his plans to devote himself to solving the problems of hydro-engineering and, above all, to the problems of using “white coal”, that is, hydropower.

However, initially during a year Ivan Havrylovych was not concerned with hydro-engineering and hydropower, but was designing concrete bridges over irrigation channels in the Holodnyi Steppe (Turkestan). His designs of bridge spans of various types were quickly implemented. Therefore, Ivan Havrylovych was appointed the head of the exploration works in the Syr Darya basin, which were carried out in connection with the planned construction of irrigation reservoirs at the top of the river.

Appointment of a talented engineer to be the head of the exploring parties in Turkestan seemed strange to many. Even some colleagues and friends of Ivan Havrylovych were unclear as to why the Ministry of Agriculture needed to send a gifted engineer from St. Petersburg to the largest “shackle” of the empire – into the Syr Darya river basin. However, such a “business trip” is easy to explain. In the years leading up to the First World War, the interest of the government and private capital to the problems of irrigation of the fertile lands of Central Asia increased sharply. The government, in turn, believed that the irrigation of Turkestan was a crucial

condition for enhancing colonialist activity in this troubled land. Only by moistening the local lands one could expect to relocate to this royal colony some part of the Russian peasantry, which was intended to become the pillar of colonial policy of the Russian Empire, the defender of the interests of autocracy and Russian capitalism in Turkestan. The interest of private businesses could also be explained simply. It was a sober and far-sighted calculation of huge profits at the expense of the harsh colonial exploitation of the local population, which was involved mainly in the cultivation of valuable raw materials – cotton and other southern industrial and fruit crops. Existing irrigation facilities were supported only by the hard and time-consuming work of the population for whom water was synonymous with life. They could not be effectively used to meet the new challenges posed by the tsarist government and private capital.

The development of irrigation in the Turkestan region required, along with large allocations, the participation of first-class engineers and specialists (Hurinchuk, 2012). The last circumstance also explains the choice of the Ministry of Agriculture to nominate Professor I. H. Aleksandrov, a well-known St. Petersburg engineer, the best suited for conducting large-scale studies that were of paramount importance for the irrigation of the vast expanses of Central Asia.

Ivan Havrylovych leaves St. Petersburg, leaves a young family in a small apartment on Vereyska Street and travels to distant and almost unknown Turkestan, where he is awaited by new vivid impressions and his favourite practical work. Here Aleksandrov, for the first time, demonstrates himself as a talented researcher and irrigator in the management of research at the Syr Darya Basin. The exploration works in Central Asia were conducted by I. H. Aleksandrov in the summer, after which in September-October, he and his assistants returned to St. Petersburg. There, for several months, engineers carried out the cameral processing of materials obtained in the expedition.

As a highly educated person of his time, I. H. Aleksandrov stressed that irrigation in Central Asia, as in other countries in the East, had existed for thousands of years. In ancient times (BC), it was already well developed, but later due to a number of wars and adverse political and economic conditions, irrigation in the eastern countries degraded. In the early twentieth century Turkestan's irrigation was in a state of decline. The irrigation network was limited and its technical level was very low (in general, irrigation techniques remained the same as in the old days). In addition, within the feudal organization of economic life, irrigation systems and structures were in the hands of the ruling classes not wishing to invest in upgrading it or at least in developing the system.

One of the most developed in the irrigation terms in Turkestan, the Fergana Region – the “pearl of Central Asia” as it was sometimes called at those times – is located in the Syr Darya Basin, yet in the pre-revolutionary period (until 1917-1924) it had nevertheless hundreds of thousands of hectares of non-irrigated land. These undeveloped lands under proper irrigation could give the most valuable crops: cotton, grain, fruits, grapes etc. However, the local and foreign capital as well as the tsarist government spent only a pitiable sum on the irrigation of the lands. During the period

from 1883 to 1917 the cost of capital irrigation works in some part of the territory of the former Turkestan amounted to only 36.4 million rubles. These costs were sufficient to complete the irrigation works of only 80000 hectares of old and new lands (Shamsutdynov, 1949, p. 14). With great difficulties, progressive domestic hydro-technicians sought scarce funds for research and exploration aimed at improving the irrigation of Central Asia. After all, this was a vital condition for the development of the region's richest agricultural resources and the fight against the terrible impoverishment of the local peasantry.

The exploration works in the Syr Darya Basin over several years (until 1917) provided material for the development of a project for irrigating half a million hectares of land in south-eastern Fergana. This project was "implemented" by I. H. Aleksandrov in 1918. The project covered large tracts of irrigated land in Skobeliev, Kokand, Osh and Andijan regions. It should be noted that these lands on the left shores of Syr Darya and Kara Darya, had previously attracted the attention of private entrepreneurs. In 1910 and 1912, attempts were made to obtain concessions from the tsarist government for their irrigation. The project of irrigation of these lands, proposed by private entrepreneurs, involved the construction of a dam on the Naryn river, the principal structure of the main canal crossing the Kara Darya aqueduct (approximately along the Andijan river meridian) and running parallel to the Central Asian railway line up to the river Kokand. This channel was expected to irrigate more than 200,000 ha of desert land.

Having thoughtfully studied the previously developed plan, Ivan Havrylovych proposed a completely different project, which was fundamentally different from the previous one in that water was used not from the Naryn river but from the Kara Darya and smaller mountain rivers that flowed from the Altai Ridge: the Ak-Bura river, the Soh, the Shakhimardan and others. The Kara Darya river is a large tributary of the Syr Darya. Developing a project for regulating the drainage of Syr Darya, I. H. Aleksandrov was convinced that Kara-Darya waters could be used for irrigation of about 500000 hectares, and this solution of the problem was to give the most rational distribution of water in the Syr Darya basin and release the waters of the Naryn for irrigation of the Dalversinskyi and Holodnyi steppes.

The project by I. H. Aleksandrov envisaged regulating the runoff of the Kara Darya by means of a large reservoir, in which water could be stored during the period when it was not needed for irrigation, and given to the river at times of lack of water in the irrigation network. Ivan Havrylovych considered the most suitable place to construct a reservoir near the village of Kampir-Rawat, where the high rocky shores converged at a close distance. All these circumstances, as I. H. Aleksandrov noted, allowed "comparatively profitable to build a dam and form a giant reservoir of water". The irrigation project of south-eastern Fergana was drawn up by I. H. Aleksandrov according to the materials of the exploration works, which were carried out for 4 years, from 1913 to 1917 (Aleksandrov, 1923a). The project impressed not only with the originality and brilliant technical design, but also with

the enormous research material, on the basis of which the author built undoubtedly the best irrigation scheme for that time.

Regarding his project in comparison with the proposals of the earlier period, Ivan Havrylovych gave the following considerations:

1. To irrigate the left-bank (southeast) Fergana the waters of the Kara Darya should be completely used; the waters of both Naryn itself and those stored in reservoirs located in the upper Naryn should be used completely for irrigation of the Holodnyi and Dalversynskiyi steppes and lands in the lower reaches of the Syr Darya.

2. The Kara Darya water should be used more sparingly, since winter runoff should also be fully utilized.

3. The length of the main canal and with it the amount of wasted water should be reduced.

4. The need to construct a large aqueduct through the Kara Darya is then eliminated.

5. The channel route should go higher than planned in the project of private entrepreneurs. Due to this, a large amount of land was involved in the irrigation area and water use was regulated over a large area. In other words, the “command area” is expanding, that is, the irrigation area by the waters of this large channel.

6. In the area of subordination to the channel there were included the lower sections of Ak-Bura, Aravan-Sai, Isfayrak and Shakhimardan systems, which were not sufficiently provided with water.

7. The use of differences in the rivers’ flows to generate electricity should pay back the cost of their construction and give a sufficient amount of energy to supply Fergana (Aleksandrov, 1923a, p. 179).

The proposal to use the hydraulic differential energy was first put forward by I. H. Aleksandrov in the hydraulic engineering and science. It was a very important innovation in the creation of irrigation facilities. For the first time, a prominent engineer considered the close combination of irrigation problems with the wide and rational application of water resources of Central Asian rivers (Aleksandrov, 1923b).

Large-scale studies of this kind are supposedly “harbingers” of his later projects of large hydropower plants (including in Central Asia). Yet while conducting research in the Syr Darya basin, Ivan Havrylovych confidently predicted the great importance of the Central Asian rivers as a powerful source for obtaining cheap electricity. Of course, he considered receiving this energy in connection with the construction of irrigation facilities. Proposed by I. H. Aleksandrov, ideas about combining irrigation tasks with obtaining cheap electricity through installations built on large irrigation canals and dams of reservoirs were absolutely original in technical terms. These ideas, further developed by Ivan Havrylovych and other home scientists and engineers, led to the remarkable successes of the complex design of hydropower structures in the former USSR.

The preparation of the irrigation project for south-eastern Fergana and the Tashkent region was preceded by extensive work on the study of the Syr Darya basin, the results of which were outlined by I. H. Aleksandrov in articles and separate

publications: “Surveys on the arrangements of reservoirs in the upper reaches of the Syr Darya River” (1914) (Aleksandrov, 1914), “Regime of rivers of the Syr Darya River Basin” (1923) (Aleksandrov, 1923c), “Regulation of the flow of the Syr Darya River and prospects of irrigation in its basin” (1923) (Aleksandrov, 1923d) and others.

Ivan Havrylovych realized that only new forces and hard work would be able to turn backward and beggarly Turkestan of those times into the area of innumerable people’s riches, “... the development of material culture in the Tashkent region,” the scientist wrote, “will always be connected with the development of irrigation and energy supply, since no crops are possible at all in Turkestan without irrigation, and energy is important especially in Tashkent region, which promises to become the main industrial centre of Turkestan in the future, deep wounds caused to the economy in the last decade, will quickly heal with the friendly work of the young forces” (Aleksandrov, 1923b, p. 56).

Conclusions

On the basis of a large number of sources it is determined that occupying various positions I. H. Aleksandrov successfully participated in solving complex technical issues of hydraulic engineering. One can substantiate that scientific researches by I. H. Aleksandrov were carried out in the context of the challenges of the engineering science of his time. Scientific and creative contribution by I. H. Aleksandrov can be divided into five main directions of science and technology development: hydraulic engineering, hydropower, geographic zoning, railway transport and irrigation. The hydraulic engineering period in the scientific activities by I. H. Aleksandrov was the first where the future Academician applied his knowledge, skills, enormous organizing abilities, and proved his potential. The ideas of I. H. Aleksandrov were frequently linked with scientific ideas and concepts of his predecessors: P. P. Melnykov, D. I. Zhuravskiy, M. A. Beleliubskiy, S. D. Kareisha and others. However, they always were creatively re-thought by the talented scientist and engineer (Isaienko, 2013). It demonstrates that the works of I. H. Aleksandrov is a significant contribution to the development of hydraulic engineering and hydropower science, through which the scientist occupied the position of one of the leading scientists and brightest engineers of his time.

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Внесок академіка І. Г. Александрова у розвиток гідротехніки (на прикладі наукових та інженерних підходів до проблем іригації Туркестану)

Анотація. Історія науки та техніки як галузь наукових знань спрямована на вивчення найбільш значущих ідей видатних вчених та практиків та їхній вплив на просування цих технологій та світовий розвиток науки. На думку авторів статті, однією з таких фігур початку ХХ століття є академік І. Г. Александров. Історичний та науковий аналіз життя та діяльності І. Г. Александров як наукового теоретика, інженера, організатора науки вирізняється високою актуальністю завдяки масштабності та універсальності його наукового внеску. Науково-творчу роботу І. Г. Александрова можна розділити на п'ять основних напрямків розвитку науки і технологій: гідротехнічне будівництво, гідроенергетика, географічне районування, залізничний транспорт та зрошення. У контексті розвитку гідротехніки та гідроенергетики І. Г. Александров мав досягнення світового рівня, які прославляли національну науку. Але до останніх років І. Г. Александров здебільшого визнаний проектантом і одним із будівельників Дніпровської ГЕС поблизу Запоріжжя (1927-1932) (він підготував проект і керував будівництвом найбільшої на той час в Європі гідроелектростанції) або ж як творцем та розробником методології економічного районування

Радянського Союзу. Інші досягнення та ідеї академіка І. Г. Александрова рідко згадують у наукових працях та дослідженнях. У статті робиться висновок, що широта науково-технічних інтересів І. Г. Александров була результатом як його індивідуальних здібностей, так і ретельної теоретичної та практичної підготовки, яку отримав молодий інженер І. Г. Александров від висококваліфікованого викладацького складу Московського вищого технічного училища та Московського інженерного училища Управління шляхів сполучення. Гігантська працездатність І. Г. Александрова також відіграла важливу роль у його житті. Велика кількість джерел показала, що займаючи різні посади, І. Г. Александров брав участь у вирішенні складних технічних завдань сучасної йому епохи, а його наукові інтереси завжди були в контексті завдань інженерії та науки того часу. І. Г. Александров ініціював наукові дискусії щодо будівництва портів і каналів, у своїй роботі він всіляко сприяв розвитку вітчизняної промисловості загалом, та гідротехніки зокрема. Автори стверджують, що сучасний погляд на наукову спадщину І. Г. Александрова у контексті розвитку гідротехніки, гідроенергетики та залізничного транспорту однозначно визнає, що в концентровано-узагальненому вигляді ідеї, теорії та концепції, висунуті та науково обґрунтовані академіком І. Г. Александровим майже сто років тому навіть сьогодні сприяють розвитку науково-технічного процесу.

Ключові слова: І. Г. Александров; гідротехнічне будівництво; проекти зрошення; проекти енергопостачання; регулювання течії річки

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Вклад академика И. Г. Александрова в развитие гидротехники (на примере научных и инженерных подходов к проблемам ирригации Туркестана)

Аннотация. История науки и техники как отрасль научного знания направлена на изучение наиболее значимых идей выдающихся ученых и практиков и их влияния на развитие мировой науки и развитие технологий. По мнению авторов статьи, одним из таких деятелей начала XX века является академик И. Г. Александров. Историко-научный анализ жизни и деятельности И. Г. Александрова как научного теоретика, инженера, организатора науки имеет высокую актуальность благодаря масштабности и универсальности его научного вклада. Научно-творческую работу И. Г. Александрова можно

разделить на пять основных направлений развития науки и техники: гидротехника, гидроэнергетика, географическое районирование, железнодорожный транспорт и ирригация. В контексте развития гидротехники и гидроэнергетики у И. Г. Александрова были достижения мирового уровня, которые прославляли отечественную науку. Но до последних лет И. Г. Александров в основном известен как проектировщик и один из строителей Днепровской ГЭС под Запорожьем (1927-1932) (он подготовил проект и руководил строительством крупнейшей на то время гидроэлектростанции в Европе) или как создатель и разработчик методологии экономического зонирования Советского Союза. Другие достижения и идеи академика И. Г. Александрова редко упоминаются в научных работах и исследованиях. В статье делается вывод о том, что широта научно-технических интересов И. Г. Александрова была результатом, как его индивидуальных способностей, так и основательной теоретической и практической подготовкой, полученной молодым инженером И. Г. Александровым от высококвалифицированного профессорско-преподавательского состава Московского высшего технического училища и Московского инженерного училища Управления путей сообщения. Гигантская работоспособность И. Г. Александрова сыграла важную роль и в его жизни. Множество источников показали, что занимая разные должности, И. Г. Александров участвовал в решении сложных технических вопросов современной эпохи, и его научные интересы всегда были в контексте задач техники и науки его времени. И. Г. Александров инициировал научные дискуссии о строительстве портов и каналов, в своей работе он всячески способствовал развитию отечественной промышленности в целом и гидротехнике в частности. Авторы утверждают, что современный взгляд на научное наследие И. Г. Александрова в контексте развития гидротехники, гидроэнергетики и железнодорожного транспорта однозначно признает, что в концентрированно-обобщенном виде идеи, теории и концепции, которые выдвигаются и научно обосновываются академиком И. Г. Александровым почти сто лет назад, даже сегодня способствуют развитию научно-технического процесса.

Ключевые слова: И. Г. Александров; гидротехника; ирригационные проекты; проекты энергоснабжения; регулирование стока рек

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