UDC 111.32-044.46:[572.026-029:6]

X. YAO^{1*}, T. O. RADKEVICH^{2*}, T. Y. CHARKINA^{3*}

Marginalization of Man in Technical Civilization

Purpose. This article aims to study ways of reconsidering the naive and optimistic view of technology in contemporary philosophical literature. Theoretical basis. The research draws on the concepts of phenomenology and philosophical anthropology. Originality. The focus of critical reflection is on negative trends in technological development that pose a threat to humanity's survival. In this context, the in-depth study of philosophical questions about what technology is and what it means to be human becomes particularly relevant. Naive interpretations often suggest that technology plays a central role in shaping human identity. For instance, Marxism embodies this idea, viewing the level of technological development (tools and means of production) as both a primary factor in historical human formation and a measure of social progress. Naivety also manifests in the belief that radical global change is justified. However, as modern scholars of the history of philosophy and philosophy of technology convincingly argue, these views are superficial and rely on partial readings of classical texts. Today, the recognition of non-technical factors - such as language, rituals, and play - in human development is widely accepted and productive. A deeper understanding of current technological interpretations opens new perspectives for exploring humans' role in culture and exploring human responsibility. Conclusions. In modern times, the most urgent issue is how people's relationship with technology is evolving. This is reflected in growing uncertainty and fear. Modern researchers warn that the naive reception of technology as a tool results in disconnecting technology from culture, philosophy, and ethics. The emancipation of technical rationality from value-based one, breaking the link between philosophy and science, truth and goodness, is particularly troubling. Consequently, there is an urgent need to find ways to humanize technology, beginning with a fundamental rethink of the technomorphic view that defines humans as tool makers. The marginalization of humans stems from the dominance of ideas portraying technology as an external tool. Recognizing the importance of language, rituals, and play in human development is both profound and justified. The notion that technology is a means to realize human essence – that is, working on oneself (psyche) – remains compelling. Moving beyond naive views of technology and developing sound philosophical frameworks is a crucial step towards understanding human nature and discovering one's purpose in the universe. A detailed exploration of this concept will be the subject of the next publication.

Keywords: man; technology; philosophy of technology; technomorphism; good; evil; responsibility

Introduction

Throughout history, the main task of humans was to cultivate a higher principle within themselves. Other motives of human behavior, especially the desire to radically change the world around them, played a secondary role. This situation has changed significantly over the past few centuries, as technology has come to the forefront as a means of transforming the world. The scale of humanity's ability to change the world is increasing dramatically; that is, technology is becoming an ever more powerful force. At the same time, humans have gradually lost their key status. These changes have repeatedly attracted the close attention of philosophers, leading to the

^{1*}Shaanxi College of Communication Technology (Xi'an, China), e-mail yaoxinukraine@gmail.com, ORCID 0000-0001-6490-279X

^{2*}Ukrainian State University of Science and Technologies, SEI "Dnipro Institute of Infrastructure and Transport" (Dnipro, Ukraine), e-mail tat.radkevich@gmail.com, ORCID 0009-0002-3312-6059

^{3*}Ukrainian State University of Science and Technologies, SEI "Dnipro Institute of Infrastructure and Transport" (Dnipro, Ukraine), e-mail charkina@i.ua, ORCID 0000-0001-6202-0910

development of the philosophy of technology. Today, the ambiguous consequences of rapid technological development are of particular concern. As a result, interest in several long-standing and seemingly resolved problems is growing: What are the main trends in technological development, and how do they influence human existence? What are the ambiguities and contradictions of this development? What negative consequences and threats does technological progress pose? To what extent does the rise of modern technophobia relate to real threats to human survival? What changes in worldview are necessary for a radical improvement in the current situation? It is important for us that the genesis of anthropological currents in philosophy, i.e., existentialism, philosophical anthropology, personalism, etc., is closely connected with the development of technology.

Schematically, the diagnosis of the current spiritual situation looks like the dominance of a naive interpretation of the essence of technology. The basis of this approach is the ancient desire of men to change and master the world around them. It is correct to note that over the last few centuries, technology as a means of satisfying this human need has been adored, and the level of progressive development of mankind has been unambiguously linked to the level of technological development. We are talking about a simple and unambiguous dependence, namely, the level of development of technology is the main indicator of social progress, and therefore, the level of human perfection. The last few hundred years of the development in human history are usually classified as technical civilization. Although it is difficult to deny the large-scale changes and rapid progress in the field of technology, at the same time the destructive consequences of its development, which are associated with the way of human existence, are undeniable.

It is now increasingly obvious that the rapid development of technology over the past few hundred years has led to the destruction of the environment and a destructive impact on humans. Therefore, those philosophical texts whose authors thematize the problem of technology and the nature of its impact on basic human values are especially valuable. Here, the publications of K. Jaspers and M. Heidegger, L. Mumford, J. Ellul, H. Skolimowski, etc. should be mentioned first of all.

The main focus is on the modern man as the bearer of unchecked power and the unprecedented scope of his/her possibilities. In a time of catastrophic growth in unpredictable consequences, traditional interpretations of good and evil as fundamental ethical concepts need to be reevaluated. By the mid-twentieth century, it was clear to Jaspers that technology in itself is neither good nor evil. However, the technological power of modern humans has subtly become a monster, posing a threat to both physical survival and inner well-being. Under such circumstances, the importance of fundamental research aimed at developing a new ethics for technological civilization is unquestionable. This is where Hans Jonas's work, "The Imperative of Responsibility: In Search of an Ethics for Technological Civilization", comes into focus. "The former ethics", he writes, "does not teach us such norms of *good* and *evil* that would correspond to the completely new modalities of human power and its possible manifestations" (Jonas, 2001, p. 7).

Analyzing the current state of man in culture reveals a significant gap between the expectations built over centuries and reality. We are discussing the negative effects of man's efforts to control the world and secure a central role within it. Why is modern man disappointed with his optimistic expectations? It is about man's loss of control over technological development and the transformation of man into an extension of the machine. From this analysis, the main problem of the article becomes clear: how to find ways to prevent human marginalization in a technological civilization.

Purpose

To analyze ways of rethinking the naively optimistic interpretation of technology in modern philosophical literature.

Statement of basic materials

Even a superficial acquaintance with the research literature allows us to state naivety as the main feature of traditional interpretations in technology during the 18th-19th centuries. This involves the interpretation of technology as a man-made tool that should bring only the expected positive results. Turning to the origins of technical civilization in European culture, it is impossible to ignore the philosophical heritage of Francis Bacon and René Descartes. The first, as is well known, belongs to the first technocratic utopia in European culture – "New Atlantis". On its pages, the author demonstrates firm confidence in the unconditional positivity of the human mind and the technical tools that are its carriers. Descartes' name is usually associated with the justification of man's right to transform the world and the conviction that human efforts are successful. The question of how realistic these ideas are will be discussed below.

A vivid example of a naive interpretation of technology is the Marxist concept of a man as a being who makes tools, developed in the second half of the 19th century. According to it, the process of making tools is the main factor in the formation of a man, that is, one's transformation from an animal into a real man. The founders of Marxism also emphasize the decisive role of the economy in social life. Such ideas still dominate scientific and popular science literature, which can be easily verified by surfing the Internet. Examples of its uncritical reproduction at the end of the 20th century include the interpretation of technology by the modern German philosopher Vittorio Hösle (2003), for whom technical activity is the most important fundamental feature of a man (p. 98). However, the example given is more a tribute to established traditions than a manifestation of a modern interpretation of the place of technology in the mankind's life. And although, today there are still widespread superficial ideas that the process of introducing the latest technologies is accompanied by the humanization of social life, however, in modern philosophical literature, culture, there is a radical change in emphasis. Nowadays, the naive idea of the movement of history as the progress of technology is increasingly assessed as a dangerous illusion.

In the process of a closer look, with the methods of critical understanding concerning the current trends in the development of technical civilization, it is impossible to ignore one of the most prominent works of the second half of the twentieth century, entitled "Technique or the Challenge of the Century" (1954). As its author, Jacques Ellul, aphoristically figured out it, the main purpose of the book is "a call to the sleeper to wake up". He proclaims and convincingly substantiates the thesis of the autonomy of technology as a subject of historical development: "technology causes and determines social, political and economic changes" (Ellul, 1954, p. 133). Revealing his vision of the nature of the main threat, he rightly notes that modern technology imperceptibly accustoms a man to itself. The latter, he writes, purrs like a cat, minimizing the feeling of threat as much as possible. Moreover, a modern man, adhering to an optimistic approach, imperceptibly loses control over the process of technology development, turning into an instrument of its development. The increase in the scale of technology's influence is due to the gradual expansion of technical approaches to all spheres of human activity, the mediation of all forms of human activity. This trend is threatening to the foundations of human civilization, which is why the title of Jacques Ellul's work is given.

A striking example of a critical attitude towards the approach to a naive interpretation of technology is Henryk Skolimowski's (1979) position, who proposes to define it with the concept of "technological euphoria". Kurt Hübner recently voiced deep concern about the state of deformation of the ontological status of a modern man under the influence of technology. In his opinion, the main object of philosophical critical analysis today is "the self-knowledge of a modern man, his/her technical and scientific intentionality and, hence, his/her hypertrophied rationality, which has become almost an end in itself" (Hübner, 1978, p. 388).

In this context, the question of the grounds for the conviction of the European man in the legitimacy and expediency of transforming the world on the principles of reason comes to the fore. Traditionally, a meaningful answer to this question in the literature is usually associated with the philosophical teachings of René Descartes. In the research literature, his position is often qualified as a kind of mouthpiece of technical civilization. First of all, we are talking about his absolutization of the cogito as the absolute starting point of philosophizing, revealed through radical doubt. An even more convincing and irrefutable argument for the focus in the teachings of the French philosopher, the father of rationalism, on the radical transformation of the world is his famous thesis from "Reflections on Method" about the possibility of becoming "the lord and master of nature". In the sixth part of this text, he seems to categorically and unambiguously indicate the key significance of this desire for a man. However, as attentive researchers of the history of philosophy have long noted, firstly, this expression is the only case in the thinker's legacy where it directly means the orientation of a person's attention to a radical transformation of the world, and secondly, and no less significantly, the author uses the particle "supposedly", which is often neglected or deprived of attention in the process of quoting.

It is easy to predict the remarks of colleagues that, they say, each era of European history has its own interpretation of the main ideas of the great classics, but it is worth noting their inappropriateness. In other words, this is not so much about interpretation as about mythologizing. It is difficult to deny that in the process of searching for ways to clarify the answer to the question of what the real Descartes is and what his modern interpretation looks like, we come across the fact of the ambiguity of his basic intention, which is hidden by multiple interpretations. However, as A. Malivskyi (2019), one of the modern researchers of the philosophical heritage of the French thinker, convincingly proves, for Descartes, anthropological interest is a priority. As a result of a meticulous study of Descartes' texts and biography, and research by modern Cartesian scholars, Malivskyi argues, firstly, on the undeniable importance of anthropological and ethical motives for him, and secondly, on the artificiality and superficiality of the interpretation of his position as anthropocentrism. One of the main reasons for the long-term neglect of the French thinker's interest in a man was his conscious intention to hide his true beliefs with the help of a mask. In particular, the vast majority of known interpretations of Descartes' legacy as a mouthpiece of technical civilization ignore, firstly, both the important place of the sensory-emotional component in human nature and, secondly, the fact that his last text ("Sentiments of the Soul") is devoted to the sphere of human feelings. The originality of Descartes' philosophical position will become even more obvious to us if we pay attention to the fact that, in searching for ways to solve the problem of improving the world, he focuses not so much on the external as on the internal world. It is significant that for him the ways to improve human nature are not so much associated with enriching it with knowledge as with improving human feelings.

Returning to the main problem of the article, it is right to focus attention on the question of what modern researchers of technology see as the main flaws of the optimistic interpretation of

the role of technology in human life? The most profound teaching among those thinkers who critically rethought the superficial concept of technology is represented by Lewis Mumford. He sees his main goal as a critical understanding of the prerequisites of our emotional fascination with technology and technical progress. He includes the overestimation of the role of tools and machines among the main flaws of the widespread interpretations of technology as culture. Mumford emphasizes that Karl Marx was mistaken about the decisive role of tools in human development. He is firmly convinced that the role of technology in human life cannot be understood if the integrity of human nature is ignored. For him, the habit of seeing human humanity in the manufacture of tools is not convincing. The main disadvantages of this approach are due to ignoring, firstly, a large number of examples of the use of tools by animals and birds, and secondly, the absence of similar manifestations of intelligence in five-year-old children. In other words, the weak point of the widespread approach, according to Mumford, is the neglect of the main chapters of human history. For him, as an expert on the cultures of ancient Egypt and Mesopotamia, it is undeniable that the process of the emergence of technology cannot be understood by ignoring rituals, dances, songs, drawings, carvings, etc. (Mumford, 1972).

Another manifestation of the critical reaction to the dominance of technomorphism is connected with the recognition of the right to exist of the philosophy of technology as an autonomous sphere of philosophical knowledge. This is Skolimowski's idea of the importance of developing a fundamentally new type of technology knowledge, which involves attention not only to instrumental-pragmatic aspects, but also to a holistic vision of human nature. The previous tradition, according to the author, is characterized by a maniacal focus on the quantitative parameters of the world. The lack of attention to the qualitative dimensions of the world and man is one of the most significant shortcomings of the technomorphic worldview. Analyzing possible scenarios of the future of humanity, Skolimowski pathetically expresses his credo in the title of the article – "philosophy of technology as philosophy of a man". In his opinion, in the worldview of the man of the future, a holistic vision of his/her nature will occupy a prominent place (Skolimowski, 1979).

A significant study of the modern man and the world at the peak of technical civilization and the crisis of man is the work of Hans Jonas's "The Principle of Responsibility. In Search of Ethics for Technological Civilization", 2001. Schematically outlining the main points of his interpretation of the current spiritual situation as a crisis state of humanity at the end of the 20th century, it is worth paying attention to the assessment of the current state of man and technology. For him, it is clear that a man today is something more than homo faber, and technology is something more than a technical tool. Explaining the changes in culture hidden from the outside eye, the author emphasizes the importance of going beyond technomorphism and the key significance of the ethical component: "... technology acquires ethical significance due to the central place it now occupies in the subjective goal of human life" (Jonas, 2001, p. 24). The author admits with undisguised sadness that a man today has lost the ability to control and direct the trends in the development of technology. In presenting his/her vision of ways to change this situation, he emphasizes, firstly, the importance of negative forecasts over positive ones and, secondly, the expediency of addressing the feeling of "fear" as a concern about the likely consequences of human activity. This involves using the "heuristic of fear" and "courage to fear". For us, Jonas's thesis that the image of the future must necessarily include not only knowledge of the desired result, but also knowledge of man and the motives of human behavior, is of fundamental importance. At the same time, the latter must not so much encourage

a man to technical activity as they will restrain him /her from excessive activity. The feeling of fear, he rightly writes, "receives a new value". In a situation of radical growth of human capabilities, this feeling is actualized: "We are powerful and conscious of our power, we must today deliberately come to the point of 'learning fear'" (Jonas, 1987, p. 66).

How can and should modern humanity change the direction of the technological development it has created? In exploring this question, it is helpful to briefly review certain points from earlier discussions. This includes, first, Mumford's idea of human development as a process of working on oneself as one's own body, and second, the role of excess psychic energy in shaping human evolution. Importantly, we must recognize the artificiality of the idea that Descartes' philosophical legacy justifies man's right to radically transform the world. The notion favored by some modern thinkers – that man should minimize ambitions, set aside previous achievements, and return to a state resembling that of primitive humans - offers a profound and fruitful perspective. In other words, we need to reject the familiar European-centric view of humanity and acknowledge the presence of doubt, uncertainty, and fear in the human mind. These feelings are especially crucial in our current effort to revise the fundamental principles of the past era. This is what Hans Jonas describes as the "heuristic of fear". In essence, this fear relates to a cautious, balanced, and thoughtful attitude toward the world. In other words, we must move beyond a naive understanding of ourselves and the world, paying attention not only to primary (expected) outcomes but also to secondary and tertiary effects. By taking these steps, we improve our chances of meaningfully understanding the concept of "responsibility", which Jonas highlighted in the title of his foundational work.

Nowadays, artificial intelligence is playing an increasingly important role, which humanity associates with promising prospects for the humanization of culture. How justified are these expectations? To a large extent, the book by the modern German philosopher Richard David Precht (2020), "Artificial Intelligence and the Meaning of Life", offers an opportunity to clarify this issue. The author rightly points out several positive achievements in science and information technology related to artificial intelligence. However, he also acknowledges some valid reservations. This includes both ecological threats and climate change, as well as the undeniable fact that developing and using relevant technical devices is impossible without increased exploitation of nature and its resources. Unlike previous thinkers in the philosophy of technology, Precht does not consider the traditional distinction between animals and humans to be significant. It is questionable for him because it ignores the fact that the emotional principle that unites them yet also greatly distinguishes them in the technical world remains unconsidered. His point is particularly compelling when it comes to the impossibility of a world of human culture without emotional feelings as its main components. The realities of our existence at the beginning of the 21st century convincingly show that a person cannot be reduced to a mechanism and calculation, and his/her creativity is not diminished to the operation of cold machine intelligence.

Originality

The focus of critical reflection in the article is on the harmful trends in technological development, which threaten humanity's self-destruction. In this context, the need for a thorough exploration of philosophical questions about what technology is and what it means to be human becomes relevant. Naive interpretations of these concepts often include the idea that technology plays a key role in shaping humanity. The embodiment of this position is Marxism, where the

level of development of the means of production (technical tools) is both the main factor in the formation of man in history and the criterion of social development. The forms of manifestation of naivety also include a person's conviction in the legitimacy of radical change in the world. However, as modern researchers of the history of philosophy and philosophy of technology convincingly prove, these interpretations are superficial, and their justification is based on a fragmentary interpretation of classical texts. Now the thesis about the importance of non-technical factors in the development of man, which include speech, rituals and play, is indisputable and fruitful. A meaningful understanding of modern interpretations of technology opens up new perspectives in the process of studying the problem of man in culture and developing the problem of human responsibility.

Conclusions

Nowadays, the issue of how a person relates to technology has come to the forefront. This is evidenced by increasing uncertainty and fear. According to modern researchers, a naive view of technology as merely a tool leads to a disconnect between technology and culture, philosophy, and ethics. The separation of technical rationality from value-based rationality – essentially, the rift between philosophy and science, truth and good – is especially concerning. As a result, there is a growing effort to find ways to humanize technology. This requires a fundamental rethinking of the technomorphic view of man as simply a being who makes tools. The marginalization of humans stems from the idea that technology is just an external tool. The importance of language, rituals, and play in human development is profound and valid. It's hard to ignore the thesis that the idea of technology as a means is rooted in human nature, specifically in his work on himself (his psyche). Moving beyond a naive view of technology and developing related philosophical ideas is an important step toward understanding ourselves and discovering our purpose in the universe. A clear elaboration of this idea will be the focus of the next publication.

REFERENCES

Ellul, J. (1954). La Technique: L'Enjeu du siècle. Paris: Armand Colin. (in French)

Hösle, V. (2003). Praktische Philosophie in der modernen Welt (A. Yermolenko, Trans.). Kyiv: Libra. (in Ukrainian)

Hübner, K. (1978). Kritik der wissenschaftlichen Vernunft. Verlag Karl Alber. (in German)

Jonas, H. (1987). Technik, Medizin und Ethik. Zur Praxis des Prinzips Verantwortung. Suhrkamp. (in German)

Jonas, H. (2001). Das Prinzip Verantwortung: Versuch einer Ethik für die technologische Zivilisation (A. Yermolenko & V. Yermolenko, Trans.). Kyiv: Libra. (in Ukrainian)

Malivskyi, A. M. (2019). *Unknown Descartes: Anthropological Dimension of Rene Descartes' Philosophical Searching*. Dnipro: Herda. DOI: https://doi.org/10.15802/978-617-7639-22-9 (in Ukrainian)

Mumford, L. (1972). Technics and the Nature of Man. In C. Mitcham & R. Mackey (Eds.), *Philosophy and Technology: Readings in the Philosophical Problems of Technology* (pp. 77-85). New York: The Free Press. (in English)

Precht, R. D. (2020). Künstliche Intelligenz und der Sinn des Lebens. München: Goldmann Verlag. (in German) Skolimowski, H. (1979). Philosophy of Technology as a Philosophy of Man. In G. Bugliarello & D. B. Doner (Eds.), The History and Philosophy of Technology (pp. 325-336). University of Illinois Press. (in English)

LIST OF REFERENCE LINKS

Ellul J. La Technique: L'Enjeu du siècle. Paris : Armand Colin, 1954.

Гьосле В. Практична філософія в сучасному світі / пер. А. Єрмоленко. Київ : Лібра, 2003. 248 с.

Hübner K. Kritik der wissenschaftlichen Vernunft. Verlag Karl Alber, 1978. 442 s.

Jonas H. Technik, Medizin und Ethik. Zur Praxis des Prinzips Verantwortung. Suhrkamp, 1987. 324 s.

Йонас Г. *Принцип відповідальності. У пошуках етики для технологічної цивілізації* / пер. А. Єрмоленко, В. Єрмоленко. Київ : Лібра, 2001. 400 с.

Малівський А. М. *Незнаний Декарт: антропологічний вимір у філософуванні*. Дніпро : Герда, 2019. 300 с. DOI: https://doi.org/10.15802/978-617-7639-22-9

Mumford L. Technics and the Nature of Man. *Philosophy and Technology: Readings in the Philosophical Problems of Technology* / ed. by C. Mitcham, R. Mackey. New York: The Free Press, 1972. P. 77–85.

Precht R. D. Künstliche Intelligenz und der Sinn des Lebens. München: Goldmann Verlag, 2020. 256 s.

Skolimowski H. Philosophy of Technology as a Philosophy of Man. *The History and Philosophy of Technology* / ed. by G. Bugliarello, D. B. Doner. University of Illinois Press, 1979. P. 325–336.

С. ЯО^{1*}, Т. О. РАДКЕВИЧ^{2*}, Т. Ю. ЧАРКІНА^{3*}

Маргіналізація людини в технічній цивілізації

Мета. У статті передбачено вивчити шляхи переосмислення наївно-оптимістичного тлумачення техніки в сучасній філософській літературі. Теоретичний базис. Дослідження ґрунтується на концептуальних положеннях феноменології та філософської антропології. Наукова новизна. Об'єктом критичного осмислення є негативні тенденції розвитку техніки, які загрожують самознищенням людства. У цьому контексті актуалізується завдання поглибленого вивчення філософських питань про те. що таке техніка та що таке людина. До форм прояву наївного підходу щодо тлумачення змісту цих понять належать уявлення про ключову роль техніки у становленні людини. Втіленням означеної позиції є марксизм, де рівень розвитку засобів виробництва (технічні знаряддя) постає як основним фактором становлення людини в історії, так і критерієм суспільного розвитку. До числа форм прояву наївності також належить переконаність людини в правомірності радикальної зміни світу. Однак, як переконливо доводять сучасні дослідники історії філософії та філософії техніки, ці положення поверхові, а їх обґрунтування спирається на фрагментарне тлумачення класичних текстів. Нині безсумнівною та плідною ϵ теза про важливість позатехнічних факторів становлення людини, до яких належать мова, ритуали та гра. Змістовне осмислення сучасних інтерпретацій техніки відкриває нові перспективи в процесі вивчення проблеми місця людини в культурі та розробки проблеми відповідальності людини. Висновки. У наші дні на перший план виходить проблема зміни способу ставлення людини до техніки. Свідченням цього є процес посилення невпевненості та почуття страху. На думку сучасних дослідників, наївна рецепція техніки як інструменту зумовлює втрату зв'язку техніки з культурою, філософії з етикою. Особливу тривогу викликає емансипація технічної раціональності від ціннісної, тобто розрив філософії та науки, істини і блага. А тому інтенсифікується пошук форм гуманізації техніки. Її передумова полягає в радикальному переосмисленні техноморфного бачення сутності людини як істоти, яка виготовляє знаряддя праці. Маргіналізація людини стає результатом домінування уявлень про техніку як зовнішні інструменти. Глибокими та правомірними ϵ ідеї про значущість мови, ритуалів та гри в процесі становлення людини. Важко не погодитися з тезою про укоріненість ідеї техніки як засобу сутності людини, тобто її роботи над самою собою (своєю психікою). Вихід за межі наївного тлумачення техніки та розробка відповідних філософських концепцій – важливий крок на шляху самопізнання людини та реалізації нею свого покликання у Всесвіті. Змістовна конкретизація цієї ідеї буде темою наступної публікації.

Ключові слова: людина; техніка; філософія техніки; техноморфізм; добро; зло; відповідальність

Received: 18.02.2025 Accepted: 20.06.2025

 $^{^{1*}}$ Шеньсійський транспортний професійно-технічний коледж (Сіань, Китай), ел. пошта yaoxinukraine@gmail.com, ORCID 0000-0001-6490-279X

^{2*}Український державний університет науки і технологій, ННІ "Дніпровський інститут інфраструктури і транспорту" (Дніпро, Україна), ел. пошта tat.radkevich@gmail.com, ORCID 0009-0002-3312-6059

^{3*}Український державний університет науки і технологій, ННІ "Дніпровський інститут інфраструктури і транспорту" (Дніпро, Україна), ел. пошта charkina@i.ua, ORCID 0000-0001-6202-0910