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Місце винахідництва як складової інтелектуально–фахового потенціалу науковців у вдосконаленні промислових технологій

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The place of invention as a component of the intellectual and professional potential of scientists in improving industrial technologies

Анотація. *Сучасний етап розвитку науки і технологій характеризується зростаючою потребою у пошуку нових рішень, що забезпечують підвищення ефективності промислового виробництва, його екологічність, енергоощадність, раціональне використання ресурсів мінеральної сировини та конкурентоспроможність. У цьому контексті особливого значення набуває винахідництво як прояв інтелектуально-фахового потенціалу науковців, здатного трансформувати фундаментальні знання у прикладні інновації, що безпосередньо впливають на вдосконалення сучасних промислових технологій. Винахідництво не є ізольованим процесом – воно формується в системі взаємодії науково-освітнього, виробничо-технологічного та соціально-економічного середовищ. Його розвиток зумовлений низкою умов - від наявності сприятливої нормативно-правової та інституційної бази до стимулювання процесу на всіх етапах його життєвого циклу. Народжуватися, як форма творчої діяльності, винахідництво може там, де ці складові взаємодіють у середовищі, якщо воно стає фактором стимулювання його виникнення, сприяння розвитку та подальшої реалізації – в освітньо-науковому просторі, виробничо-технологічному середовищі та інноваційно-привабливому економічному полі. Обґрунтовано доцільність визначення фахово-професійної складової потенціалу особистості як п**осередника між знаннями та практикою**, використання корисних властивостей якої сприяє перетворюванню інтелекту та креативності на конкретні результати професійно - творчої діяльності особистості. Як спосіб самовираження, здатність людини до винахідництва в своїй діяльності не з'являється сама по собі, її можна цілеспрямовано розвинути з використанням наступних засобів: **освітніх, практичних, психологічних та соціально-професійних.** Показано, що професійна складова займає рівноправне місце поряд із розумовою та емоційною складовими, адже саме вона забезпечує практичне застосування двох інших у сфері трудової діяльності та самореалізації в науковій діяльності. В досліджені використано аналітико-оглядові методи дослідження умов розвитку винахідництва в напрямку удосконалення металургійних процесів, з акцентуванням їх фізико-хімічної сутності та спрямованості. Показано, що нівелювання ролі особливостей трансформації властивостей фізико-хімічного потенціалу об'єкту/процесу дослідження знижує як наукову цінність, так і не сприяє визначенню спектру реальних функціональних можливостей їх перетворення. Метою дослідження є обґрунтування факторів впливу, зовнішніх та внутрішніх за походженням, та умов, що сприяють розвитку винахідництва як творчої форми діяльності науковця з визначенням ключових складових потенціалу особистості, що, в свою чергу, є умовою розробки інноваційних, конкурентоспроможних рішень. Останні спроможні більш раціонально вирішувати проблеми енергоефективності, збереження ресурсів мінеральної сировини, енергії та суттєвого зменшення втрат корисних властивостей потенціалу навколишнього середовища. Вперше, теоретично обґрунтовано, що фахово-професійна складова (ФПС) є третьою та ключовою складовою потенціалу особистості, поряд із розумовою та емоційною. Існують праці, результати яких, визначені їх авторами, близько окреслюють роль професійного чи фахового потенціалу в структурі особистісного розвитку. Їх підходи, що використано при визначенні складу та ролі факторів впливу, опосередковано, підтверджують вагомість фахового компонента саме як складової, що забезпечує професійну, творчу самореалізацію особистості і у винахідницькій діяльності. Але прямої згадки про модель-тріаду «розумова – емоційна – фахово-професійна» складові інтелекту особистості дослідниками не знайдено. Винахідництво, займаючи центрально-інтегративне місце серед факторів впливу поєднує їх у єдину систему, створює ефект синергічного прискорення розвитку науки й технологій, переводячи інтелектуально - фаховий потенціал суспільства у конкретні інноваційні результати на практиці.*
Ключові слова: *винахідництво, фаховий потенціал, інноваційний результат, фахово-професійна складова, потенціал особистості.*

Abstract. *The current stage of development of science and technology is characterized by a growing need to find new solutions that ensure increased efficiency of industrial production, its environmental friendliness, energy saving, rational use of mineral resources and competitiveness. In this context, invention is of particular importance as a manifestation of the intellectual and professional potential of scientists, capable of transforming fundamental knowledge into applied innovations that directly affect the improvement of modern industrial technologies. Invention is not an isolated process - it is formed in the system of interaction of scientific and educational, production and technological and socio-economic environments. Its development is conditioned by a number of conditions - from the presence of a favorable regulatory and institutional framework to stimulating the process at all stages of its life cycle. Invention, as a form of creative activity, can be born where these components interact in the environment, if it becomes a factor stimulating its emergence, promoting*

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development and further implementation - in the educational and scientific space, the production and technological environment, and the innovative and attractive economic field. The expediency of defining the professional component of the potential of the individual as a mediator between knowledge and practice Vanyukov A.A., Kamkina L.V., Myanovskaya Y.V., Kovalyov M.D., Tsibulya E.V., Chumak D.D., the use of useful properties of which contributes to the transformation of intelligence and creativity into specific results of the professional and creative activity of the individual, is substantiated. As a way of self-expression, a person's ability to invent in his activity does not appear by itself, it can be purposefully developed using the following means: educational, practical, psychological and socio-professional. It is shown that the professional component occupies an equal place alongside the mental and emotional components, because it is it that ensures the practical application of the other two in the field of labor activity and self-realization in scientific activity. The study used analytical and survey methods to study the conditions for the development of invention in the direction of improving metallurgical processes, with an emphasis on their physical and chemical nature and orientation. It is shown that leveling the role of the features of the transformation of the properties of the physicochemical potential of the object/process of research reduces both the scientific value and does not contribute to determining the spectrum of real functional possibilities of their transformation. The purpose of the study is to substantiate the factors of influence, external and internal in origin, and the conditions that contribute to the development of invention as a creative form of activity of a scientist with the definition of key components of the potential of the individual, which, in turn, is a condition for the development of innovative, competitive solutions. The latter are able to more rationally solve the problems of energy efficiency, conservation of mineral resources, energy and a significant reduction in the loss of useful properties of the environmental potential. For the first time, it is theoretically substantiated that the professional component is the third and key component of the potential of the individual, along with the mental and emotional. There are works, the results of which, determined by their authors, closely outline the role of professional or professional potential in the structure of personal development. Their approaches, used in determining the composition and role of factors of influence, indirectly confirm the importance of the professional component precisely as a component that ensures professional, creative self-realization of the individual and in inventive activity. But researchers have not found a direct mention of the model-triad "mental - emotional - professional-professional" components of the intelligence of the individual. Invention, occupying a central-integrative place among the factors of influence, combines them into a single system, creates the effect of synergistic acceleration of the development of science and technology, translating the intellectual - professional potential of society into specific innovative results in practice.
Keywords: *ingenuity, professional potential, innovative result, professional component, personal potential.*

Introduction.

The modern development of industrial technologies increasingly depends on the level of intellectual and professional potential of scientists, among the key components of which invention occupies a special place. It acts not only as a tool for generating new ideas, but also as a catalyst for creating innovative technological solutions that can ensure the competitiveness of production in the conditions of the global economy. Inventive activity reflects the synthesis of knowledge, professional competencies and creativity, transforming scientific and technological progress into practical results that contribute to the improvement of industrial processes, increasing the level of rational use of their resource base and reducing the negative impact on the environment.

The process of forming inventive activity occurs within the framework of the complex interaction of the system of the scientific and educational environment, production and technological complexes and socio-economic factors. Education and science provide training of qualified personnel and generation of new knowledge, industry forms a demand for innovative solutions, and socio-economic conditions determine real opportunities for the commercialization of inventions. In this context, the relationship with business is important: it is the business environment that becomes the leading platform for testing, implementing and scaling new technologies, acting as a partner in technology transfer, an investor in innovation and the ultimate beneficiary of the results of inventive activity. At the same time, cooperation between science and business provides a two-way effect: scientists gain access to resources, and enterprises gain access to original solutions, which creates a synergy of intellectual capital development and economic growth**.**

Thus, the study of the place, role and conditions for the development of invention as a component of the intellectual and professional potential of scientists is an urgent task of modern science and practice. Its results will allow us to determine the optimal mechanisms for integrating scientific and technical creativity into production processes, strengthen the partnership between science and business, and lay the foundation for creating an innovation-oriented model of industrial development.

Analysis of the results of the influence of factors of internal and external origin on the state and role of invention as a factor contributing to the enrichment of scientific knowledge, the development and improvement of metallurgical technologies. The result of using the potential of scientific research, both fundamental and applied, is the development of innovative technologies. An important condition for the effective implementation of their results is inventive activity - a component of the intellectual and professional potential of scientists, which is the basis for the development of effective technological solutions. Invention is also one of the important factors influencing the development of scientific areas and the state of modern industrial technologies. Its place is expedient to define as a transformative link between scientific knowledge and its practical implementation in the form of new technologies, materials, processes or their products. If fundamental science creates knowledge, mainly of a theoretical nature, and the technological factor provides a technical basis, then it is invention that allows this knowledge to take an applied form and launch the mechanism of technological transformation, which is the logical conclusion of the process of integrating science and technology.

Regarding the importance of invention, its role among the factors of development of science and technology, it should be noted that its implementation as a creative process:

- ensures the transformation of intellectual potential into real technological and economic achievements;
- acts as a catalyst for the emergence of a source of synergy between various factors (science ↔ economy ↔ technology ↔ ecology ↔ information), the effects of which contribute to the implementation of processes in a given direction with the expected results;
- creates the basis for the competitiveness of technologies, products of their implementation and sustainable development of society, economic security, sustainable development of production in general.

The primary source of the emergence of invention, with high probability, is the combination of three components of human potential: intellectual (scientific knowledge, creative thinking); professional and technical (mastery of tools, technologies, methods); socio-economic (market needs, challenges of society, limitations of mineral raw materials and energy resources). As a form of creative activity, invention can be born where these components interact in the environment, if it becomes a factor stimulating its emergence, promoting development and implementation - in the educational and scientific space, the production and technological environment and the innovative and economic field.

This creative process, obviously, does not operate in isolation, invention is a node in the system of interaction of influencing factors. Synergy, the source of which is the mutual influence of factors, arises when the action of each factor is enhanced by interaction with others. As a result, positive effects arise that bring the process closer to the expected result. To increase the level of informativeness regarding their relationships, it is advisable to present this process in the form of a chain of positive effects of synergy:

- scientific and educational factor - generates knowledge, forms personnel, creates a theoretical basis for the emergence of invention and becomes the primary source of accumulation of practical skills;
- technological - research factor - provides technical opportunities for the implementation of ideas in the experiment and their implementation in practice;
- economic factor - creates incentives, investments, market demand for innovative technological solutions;
- information factor - accelerates the spread of knowledge, ensures communication and their digital transformation;
- environmental factor - sets criteria for sustainable development, forms new restrictions and priorities for inventions;
- inventive factor - integrates all previous synergy effects, transforming knowledge and needs of the economy into new solutions. The latter, through a reverse impulse, launch another reverse cycle of development - scientific and technological breakthrough. As a result, new science, technologies, and economics are created.

Schematically, the sequence of effects of invention as a creative process can be depicted by the following simplified scheme: “scientific and educational → technological → economic → informational → environmental → inventive”, the implementation of which creates a reverse impulse for the development of all previous ones. Thus, invention occupies a central and integrative place among the factors of influence: it not only combines them into a single system, but also creates the effect of synergistic acceleration of the development of science and technology, translating the intellectual and professional potential of society into specific innovative results. And the main task of the state and the Ukrainian National Office of Intellectual Property and Innovations (UKRNOIVI) in solving this problem is to create institutional tools that will help citizens realize their innovative potential [1]. It also includes the protection of rights to intellectual property objects and promoting the introduction of new technologies into business.

The main directions of scientific and technical development (S&T) of the main branches of industry were formed under the influence of economic, technological, environmental, social and other factors of both internal and external origin. Obviously, they became the source of the formation of their scientific and technical potential. The feedback scheme in the system "influence factors ↔ directions of scientific and technical progress (STP)" in the form of a structural diagram is given in Fig. 1.

Let us analyze in more detail the factors of influence, formed into groups according to the main, specific for them, features, on the current state and prospects for further development of STP using examples in Table 1.

The main feature of the relationship of influencing factors (Table 1) is to determine their mutual influence and integration, which becomes the source of the emergence of innovative technologies - the basis of the economic security of an enterprise, industry, state.

For a more complete understanding of the spectrum of functional purpose of intelligence, determining its capabilities in solving problems of improving technological processes, we will determine the features of its components regarding their rational application.

The mental component, which is manifested in the ability to think, analyze, create, learn, forms the intellectual basis on which a person builds knowledge and makes decisions [4].

The emotional component determines the level of emotional intelligence: the ability to manage one’s own emotions, empathize with others, and build relationships with them [5]. Therefore, it is the basis of social interaction and stress resistance, determining the level of socialization of the individual in society. The professional (professional) component is characterized by the level of integration of acquired knowledge, skills, and experience that a person

receives in the process of learning and professional activity. It plays the role of a practical tool that allows mental and emotional resources to be implemented in a specific area – from science and technology to art and enterprise personnel management. Thus, we determine that the professional component (FPS) is the third and key pillar of the individual's potential, along with the mental and emotional – a factor that determines the influence on the formation and its development. A conclusion similar in essence and meaning was indirectly made by the author of study [6].

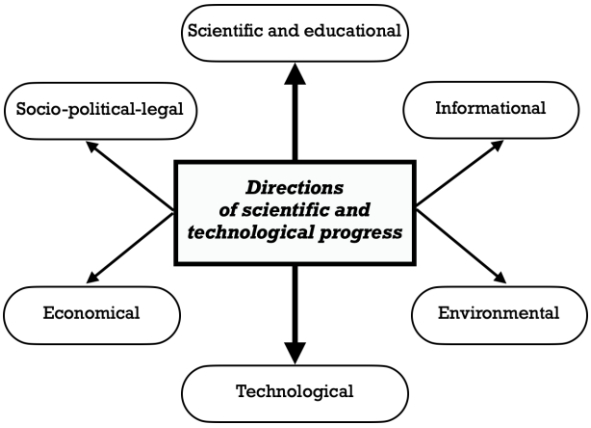

Fig. 1. The main factors influencing the directions of scientific and technological progress

Table 1. Main groups of factors of influence on the development of STP directions

Group of factors	Examples of influence
Economical	Competitive struggle, the need to reduce costs and increase productivity, globalization of markets.
Technological	Breakthroughs in fundamental sciences (physics, chemistry, physical chemistry, computer science), the emergence of new innovative technologies.
Environmental	Strengthening environmental legislation, climate challenges, the need to reduce the carbon footprint.
Social	Growing demands for quality of life, urbanization, demographic changes, labor shortage in high-tech sectors of the economy.
Political and legal	State innovation support programs, international standards, patent law, compliance, trade restrictions, sanctions.
Scientific and educational	Development of STEM education, international scientific cooperation, startup incubators and technology parks [2, 3].
Informational	Rapid exchange of knowledge thanks to the Internet, open access to scientific data, development of collective research platforms.
Human (personal)	Formation of the components of intelligence: mental (IQ), emotional (EQ) and professional (PC - professional component).

In open scientific sources, we were unable to find an exact formulation of such a conclusion, therefore, the definition of the professional component (PCC) as the third, which is probably a key component of the personality potential, along with the mental and emotional, is the result of the authors' analytical research. However, there are works, the results of which closely outline the role of professional or professional potential in the structure of personal development. These approaches used in [6] confirm the importance of the professional component precisely as a component that ensures professional self-realization of the individual, in our opinion, also in inventive activity. But no direct mention of the model-triad "mental - emotional - professional-professional" components of the personality's intelligence was found in this study.

The generalization, integration or synthesis of several theoretical concepts, namely emotional intelligence (EI) as an important component of personal potential, cognitive (mental) resources and professional competence, allows the implementation of these resources in inventive activity. Such concepts are obviously often found in the psychology of professional development, but the issue of determining the independence of the components of the integral potential or their equivalent trinity requires finding compromise solutions through further research.

The place and role of the FPS should be defined as a mediator between knowledge and practice, which transforms intelligence and creativity into specific results of the professional and creative activity of the individual. It is through professional activity that a person contributes to the results of joint work, therefore, the level of qualitative development of the FPS is an indicator of its value for society and an integrator that can combine mental abilities and emotional competence in the ability of a person (team) to act responsibly and effectively.

As a generalized conclusion based on the research results, it should be noted that the mental and emotional components create potential, and the professional component is a path (channel) for the rational and effective realization of the intellectual potential of the individual, and together they make human potential socially and economically significant. Obviously, without this component, a person's professional and emotional maturity will remain unrealized.

Based on the analysis of the essence and role of the main components of the potential of the individual, the place of the professional component along with the mental and emotional components has been determined, which is given in Table 2.

Table 2. The triad of components of the potential of the individual, their essence, role, and relationships

Component of human potential	Essence	Main role
Mental	Knowledge, logic, analytical skills	Provides the ability to think, learn, solve problems, make decisions
Emotional	Empathy, self-control, motivation	Determines the ability to interact with others, manage one's own emotions
Professional	Competencies, practical skills, experience	Implements knowledge and emotional abilities in specific activities, shapes its effectiveness

Thus, based on the data given in the compact scheme - the triad (Table 2), it is necessary to determine that the professional component occupies an equal place along with the mental and emotional components, because it is it that ensures the practical application of the other two in the field of labor activity and self-realization in scientific activity. A visual representation of the triad in the form of a triangle with equal components is given in Fig. 2.

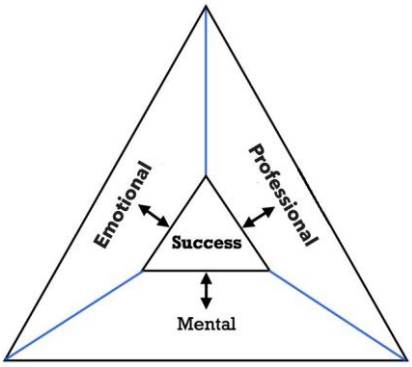

Figure 2 - The triad of components of individual potential as a condition for the success of its implementation

Thus, mental - provides analysis, logic, knowledge, intellectual base; emotional - is responsible for motivation, resistance to stress, interpersonal relationships; professional - practical application of knowledge and emotions in the field of work, self-realization, creating a result. Each component, like the vertex of the triangle, is equally important, therefore, the true power of human intelligence is revealed in the interaction of these three components, which form the components of the intellectual potential of every conscious Ukrainian.

Regarding the importance of emotional intelligence in overcoming the path to "SUCCESS", according to [7], it should be noted that mental development together with emotional (IQ + EQ) is a useful tool for increasing the level of creativity and efficiency of activity as the ability to solve problems in business and generate valuable ideas. Thus, the level of mental intelligence is useful for scientists conducting research, analyzing large arrays of experimental data. Emotional intelligence is responsible for intuition, creativity and empathy. According to the authors, it is more subjective, helps in teamwork when performing interconnected operations, for example, the main stages of metallurgical production.

Analysis of the means that contribute to the formation of a person's intelligence, in the field of his professional activity, the ability to invent, made it possible to determine that it does not appear by itself - it can be purposefully developed using educational, practical, psychological, socio-professional means, through systematic training in logic, critical thinking, methods of scientific knowledge; acquaintance with the history of inventions and their impact on scientific and technological progress. At the same time, the condition for its formation is the analysis of mistakes, successes of inventors with the determination of the sources of their occurrence by developing creativity through modeling, business games, experiments, thinking outside the box. An important means should also be recognized as working in a team with specialists from different fields, scientific directions; participation in competitions, startups, engineering projects, where there is space for practical testing of

ideas with the determination of the level of their value and prospects for implementation.

Considering the need for every person in scientific, production and everyday life to rationally use raw materials, fuel, energy, equipment and other resources, let's analyze the reality and feasibility of the slogan we have defined: "You may not become an inventor, but you must become a rationalizer."

The use of certain means in the system "inventor ↔ rationalizer" can be effective for the formation of the ability to invent in the human intellect. At the same time, the slogan "You may not become an inventor, but you must become a rationalizer" has a deep meaning, because invention is the creation of something fundamentally new, which requires a high level of creativity, scientific training, time and appropriate resources. This is the path of units. Rationalization is a creative search for ways to more effectively use existing resources: raw materials, energy, equipment, working time. This is a task that every employee can do, even in everyday life. It is also necessary to note that rationalization is a basic competence of a modern person. It fosters an economical attitude to resources, environmental responsibility and at the same time promotes the development of inventive skills. The one who has learned to rationalize creates the basis for further inventions and discoveries. Therefore, in our opinion, this motto is very apt and timely, because it makes invention a matter of choice, and rationalization a necessity. In a world where resources are limited, the ability to use them rationally should become a habit of every person, regardless of their profession. Invention is a matter of personal choice, and rationalization is a necessity, therefore, in a world where resources are limited, the ability to use them rationally should become a habit of every person, regardless of their profession or field of activity.

In order to determine the differences in the levels of creative activity in the system "inventor → rationalizer → household user", the data of Table 3 were formed, which gives their characteristics with a definition of the role in professional activity.

Table 3. Comparison of the levels of creative activity in the system "inventor → rationalizer → household user"

Level	Characteristic	Role in the activity
Inventor	Creates new fundamentally original ideas, technologies, methods, devices	Provides scientific and technological breakthrough, forms the basis of future industries
Rationalizer	Improves existing tools, processes, and methods	Increases efficiency, resource savings, ease of use
Household user	Uses ready-made solutions in his life and work	Realizes practical benefits, introduces innovations into everyday life

The influence of the factors identified as the main ones is manifested:

- economic - through stimulating the development and implementation of automation, increasing energy efficiency and resource conservation in the implementation of production processes and their digitalization to reduce resource costs for the production of relevant products;
- technological - through innovative breakthroughs opening up new areas, such as additive manufacturing or the use of artificial intelligence;
- environmental - through relevant requirements accelerating the development and application of "clean" technologies and renewable energy.

In modern conditions, the directions of development of STP are becoming more and more dependent on the interests, laws of business development, which as factors of influence, are becoming more and more decisive for its activities. Therefore, one of the effective instruments of influence of state institutions is the creation of conditions that will allow balancing relations in the system "business ↔ STP ↔ state" as conditions for sustainable development of industry, economic security of its industries, enterprises. As a result, business, in the absence of any influence and control from the state institutions of its side, will always defend, regardless of the conditions of development, the position of the state, first of all, its own interests, guided by the laws of business development in a market environment. The motto "your business - your problems" should also have no place in the interaction of the state and business. And fruitful interaction of the state and business in the interests of both parties is an important condition for their economic security and sustainable development in changing environmental conditions.

The results of the systematic analysis of the main directions of scientific and technological progress as a criterion for determining the features and directions of improvement of industrial technologies are given below in Table 4.

In fact, the industrial Internet of Things [7] is the “nervous system” of modern production, which allows obtaining information about the state of machines, energy consumption, product quality and other parameters of processes and mechanisms in real time. To the main areas given in Table 4, it is advisable to add transport and logistics innovations; cybersecurity, the use of functional components of compliance, protection of “know-how” data, etc.

An effective technology is the use of artificial intelligence, created by the efforts of the integrated potential of the individual, to improve the efficiency of existing enterprises. The study [11] identifies areas for the effective implementation of artificial intelligence in various areas: in business, in the financial, banking

sectors, industry, marketing, and others. The authors studied examples of the implementation of artificial intelligence technologies by leading world companies in various sectors of the world economy, its various methods and technologies. The high relevance of this area of research was found, especially in times of rapid development of new technologies, when the experience of leading world companies shows that the development of artificial intelligence and its implementation contributes to improving the efficiency of enterprises, accelerating development and increasing profits. It is noted that today AI technologies create new opportunities for enterprises and give them broad powers in various industries, because each process in which AI is implemented optimizes costs, which ultimately has a positive effect on overall financial indicators.

Table 4. Results of the systematic analysis of the main directions of scientific and technological progress

Direction	Essence and examples
Automation and robotization of production	Introduction of industrial robots, automatic lines, CNC systems; use of the Industrial Internet of Things IIoT in production environments [8]. This is a network of industrial sensors and systems that provides data collection, processing and analysis for optimizing industrial processes. The role of IIoT is to create a “smart production” that is based on data and is able to increase energy efficiency, reduce costs, improve quality and safety, and ensure the adaptability of the enterprise to changing conditions. A feasible function of IIoT platforms can be to use data on the physical and chemical characteristics of the relevant technologies as a basis for analytics and rational decision-making.
Digitalization and artificial intelligence	Using large arrays of source data (scientific forecast, experiment, practice), neural networks for process optimization, forecasting and management [9].
Innovative materials, technologies	Development of nanomaterials, composites, biomass-based materials [10]. Development of technologies using useful components of hydrogen potential. Import substitution of resource base materials.
Energy efficiency and resource conservation	Renewable energy: solar and wind installations, regeneration of the useful properties of hydrogen potential, utilization of secondary energy from processes.
Environmentally friendly technologies	Emission reduction CO_2/CO/NO_x/SO_x; recycling of technogenic waste using secondary energy and raw materials - components of their resource potential; closed water circulation systems and low-waste technologies.

Let's move on to the next stage of the study - determining the main components of modern business intelligence, their detailed consideration and establishing their impact on its development. It, as a potential of useful properties, is obviously formed by integrating the following components, which it is advisable to consider in the following, interrelated planes:

- human intelligence (personal) is formed from knowledge, experience, creativity, professional competence of personnel and is determined by the ability to make rational decisions, generate innovative ideas, form corporate ethics, culture;
- organizational intelligence forms management systems, business processes, corporate standards, patents, knowledge bases, brands, which are characterized by stability, even when changing the personnel of the company/enterprise.
- information and technological intelligence forms analytical systems, information resources, databases, creates innovative technologies, and also determines the most effective methods to support decision-making;
- analytical intelligence allows businesses to convert input data into knowledge and make strategic decisions.

As for any type of human activity, it is advisable to consider human intelligence as the most important in business. It is people who create innovative technologies through inventive activity, form business models, determine strategies and tactics for further activity. The most modern information systems remain tools, and their value is manifested only through a person's ability to effectively apply them.

Human intelligence or personal intelligence in the business environment ensures the rational use of its useful properties in solving the following tasks:

- strategic management, which includes setting goals, determining ways to achieve them using competitive advantages, developing appropriate business models;
- innovative development through the creation of new products, services, technologies, searching for non-standard solutions to current business problems;
- adaptation to changes through rapid response to crises that differ in their causes, scale and consequences of their implementation, as well as crises related to production, sales of products, finances and management;
- knowledge management to transform experience

into corporate capital;

- communication and leadership, which includes team building, motivation, and interaction with the external environment.

Thus, the above-defined triad of components of the potential of the individual is the basis, and the components of the intelligence of modern business, when examined in detail, are its derived components of the business, the role and key tasks of which are likely to be determined by the conditions of development, the needs and goals of the business in a competitive economic environment.

Analytical capabilities are identified as an important component of business intelligence, they integrate all the others, transforming information into knowledge, which, in the future, are used in justifying and making strategic decisions regarding the directions of business development: strategic planning, forecasting, assessment of conditions and consequences of the implementation of risks [12].

Main areas of activity, tasks, methods of achieving goals in the metallurgical business. Business relations with state institutions, society, attitude to the resource base of raw materials and energy in wartime are important issues that, by determining the main directions of scientific and technological progress, contribute to the economic security of the enterprise, industry, and state. Generalized data on the main directions of activity of t*he metallurgical business in wartime*, including tasks, methods, and interaction with the external environment, are given below.

The main types of production activities of a business of metallurgical origin should include: production - smelting of pig iron, steel, ferroalloys, rolled products, pipe products; innovation - search for alternative fuels (hydrogen, biocarbon), development of electrometallurgy, digitalization of processes; export - ensuring supplies to foreign markets despite restrictions and changes in logistics conditions; energy - reducing consumption of gas, coal (carbon footprint), electricity; use of energy generated by own generation (hydrogen, wind, sun, water, nuclear energy); social - support for personnel, participation in the reconstruction of the country, preservation of jobs; defense - production of special products for the needs of the Armed Forces of Ukraine (armored steel, elements of fortifications and other structures).

The main tasks of business as factors of its further development, in modern conditions, are:

- stabilization of production in conditions of destruction and supply disruptions;
- diversification of the raw material base (alternative suppliers, use of scrap);
- minimization of energy consumption and increase of energy efficiency;
- preservation of competitiveness of products in European and world markets;
- protection of ecology and fulfillment of requirements of the EU "green deal" (CBAM - Carbon Border Adjustment Mechanism);
- integration into European and global supply chains.

The results of Ukraine's interaction with the European Bank for Reconstruction and Development (EBRD), presented in [13], indicate the gradual and continuous development and deepening of these relations, which are important for the Ukrainian economy.

The most effective in terms of results are the following methods and methods of achieving them in modern conditions: *technological* (transition to electric steelmaking and induction furnaces; increasing the share of scrap metal in the charge; use of pulverized coal fuel (PCF), biochar, hydrogen); *organizational* (creation of reserve routes for the supply of mineral raw materials, fuel and electricity), transition to technologically flexible production (short batches, adaptation to the customer); *economic* (attraction of investments from the EBRD; public-private partnership programs; insurance of wartime risks, etc., which require further justification); *social* (safety programs for personnel; relocation of enterprises or parts of production; humanitarian and defense assistance).

The development of a network of small metallurgical plants that will operate with minimal material, energy and environmental costs as a solution to restore the economy of Ukraine, as indicated by the authors [14], is debatable in our opinion. The potential and certain advantages of metallurgical plants have not yet been exhausted. The path to their restoration is the improvement of existing ones, the creation of innovative technologies and equipment. By the way, the PRC, as a successful economy that has gone from the expansion of "micro-iron production" to the current state of the main industries as a component of the economy, ignore the irrational, study, improve and use to our conditions - yes.

Let us proceed to consider the process of evolutionary development of metallurgical technologies with the definition of the role of invention in it. Each step of the path of continuous improvement of technologies was based on the use of new solutions for the use of oxygen and stabilization of hydro-gas-dynamic processes in the converter bath; regulation of blast and slag melting modes, the use of innovative refractories; vacuum steel processing, continuous casting of billets and, currently, the use of hydrogen as a reducing agent and fuel in DR-shaft and electric arc steelmaking furnaces. Solving these problems has determined the main directions of development of ferrous metallurgy, and their consistent implementation will allow to reduce the energy intensity of the process and determine the directions of reducing the consequences of the carbon footprint in the environment [15,16].

Protection and commercialization of innovations at enterprises of relevant industries, including metallurgical, can be effectively carried out by: introducing new procedures for combating violations of intellectual property rights; promoting licensing and technology transfer to industry; developing tools for

international patenting of Ukrainian developments. Thus, the state, through UKRNOIVI and other institutions, builds a chain of interconnected elements, promoting its development: education → patenting → protection → commercialization → integration into the EU and world markets. This is a systemic toolkit for realizing the innovative potential of Ukrainians.

As an important conclusion, it is necessary to determine that all technological solutions that contributed to the development and improvement of steel production methods have a physicochemical nature and orientation, which allowed, for approximately 175 years, through the use of components of scientific and technical potential, to be able to produce about 1 billion tons per year of high-quality steel of a wide range of functional purposes in the world.

The optimal direction for the development of ferrous metallurgy processes for most manufacturers in the next 10–15 years in modern conditions may be a hybrid model, based on the maximum modernization of "ferrous" metallurgy (energy saving, dust and gas purification, partial replacement of coke with hydrogen/gas), with the gradual introduction of "green" technologies in individual processes (electrolysis → H_2 → DRI → EDP), with a gradual increase in the share of hydrogen as the energy for its production becomes cheaper. Thus, in the study [16], which was supported by MIT CS3 and ExxonMobil through its membership in MITEI, the author argues that without the introduction of advanced "greening" technologies, the steel sector could significantly reduce the intensity of CO_2 emissions (per unit of production) using existing steel production technologies - by replacing coal with gas and electricity (especially if it is produced from renewable energy sources), using more steel scrap, and implementing measures to improve energy efficiency.

The main results that are directly aimed at reducing the harmful impact of steel production on the environment include:

- reduction of greenhouse gas emissions - transition from coke blast furnaces to electric steelmaking furnaces (ESF) operating on iron ore product of direct iron reduction (DRI) plants;
- reduction of dust emissions and carbon/nitrogen/sulfur oxides by improving gas cleaning systems, developing coke-free processes;
- increasing the level of energy efficiency through heat recovery (use of physical and chemical energy) of waste gases is the introduction of closed water exchange systems.

When justifying real production schemes for the production of ferrous metals, it is necessary, along with the advantages of "green" metallurgy (reduction of CO_2 emissions and other environmental pollutants, compliance with global environmental standards; long-term reduction of dependence on fossil fuels; image and investment attractiveness; technological modernization of production), to take into account its temporary, but real in time, disadvantages and challenges (high cost of switching to hydrogen; technical limitations associated with limited scale of DRI–H_2 production; energy dependence of hydrogen production, which requires huge amounts of "green" electricity (≈3,5–4 MWh per ton of H_2); the risk of technological dependence on imports (equipment for "green" metallurgy and electrolyzers are mostly produced abroad), it is necessary to take into account the real fact of incomplete use of the potential of ferrous metallurgy (modern blast furnace and converter technologies can already reduce emissions by 20–30% due to modern equipment for dust gas purification; partial replacement of coke with natural gas or hydrogen; transition to pulverized coal fuel with a smaller carbon footprint; optimization of the component composition and granulometry of the charge; stabilization of the properties of the agglomerate and pellets; recovery of thermal and chemical energy of gases, etc.).

In a state of war with Russian aggression, metallurgy in Ukraine in 2022-2023, according to [17], lost more than half of the metallurgical enterprises that were destroyed. Others significantly reduced production, lost their place in the world market and access to the export and domestic markets. The authors determine that in such conditions, metallurgical enterprises of Ukraine need to solve the problems of physical recovery, optimization of raw material and energy costs. The authors, relying on the fact that ~ 90% of steel is produced in the world using the technological scheme "blast furnace - oxygen converter", and the blast furnace produces a product, the use of which in the production of steel in the converter allows minimizing energy costs due to the rational use of the components of the potential of cast iron (its physical heat, and the carbon contained in cast iron), recognize that modern environmental requirements require a reduction in the "carbon footprint" in the production of metallurgical products, including by reducing the production of cast iron in blast furnaces.

The authors [18] propose to change the environmental situation and reduce CO_2 emissions from metallurgical production by expanding the use of direct iron reduction (DRI) technology using hydrogen and subsequent steel production in an electric arc furnace. Therefore, the relationship between business and state institutions should be built on the principles of partnership, mutual responsibility and strategic coordination. In their relationship, we are sure, the motto "your business - your problems" should not take place. Such a slogan has a more advertising or political connotation than a business one, which encourages interaction. In our opinion, the following factors can serve as the basis for their formation, the features of the impact and their main specific features should be analyzed separately.

Indirectness of business influence on scientific and technological progress. Thus, the metallurgical business does not create scientific and technological progress by itself, but only adapts the results of

research, technological solutions and innovations that are formed in the scientific and educational environment and in state development programs. Accordingly, its profits are derived from the general level of development of science and technology.

To determine the external factors of influence that contribute to the development of the inventive abilities of an individual in the field of developing innovative metallurgical technologies, it is advisable to systematize them into several blocks according to the main features of their origin:

1. Scientific and educational environment:

- access to modern knowledge and research platforms (universities, scientific and research institutes, specialized laboratories);
- international academic mobility and exchange of experience;
- state and corporate support programs (scholarships, grants, incubators of ideas).

2. Production and technological environment:

- the presence of modern research and industrial sites for testing new technologies (pilot plants, experimental and industrial units);
- access to digital modeling (CFD, DEM, CAD/CAE) and industrial platforms for "smart manufacturing" (IIoT, big data in metallurgy) [19, 8], which allows, through the systematic use of CAD/CAE, to increase the effectiveness of training and the level of creativity of skills, reduce the time/cost of R&D and improve the quality of results;
- partnership with enterprises for the joint implementation of the results of inventive activity.

The use of industrial platforms (IIoT/Big Data): allows, according to [20], to provide predictive maintenance, stability of smelters, increase their energy efficiency and safety through inventive activity by pinching the cycle of "observation - abstract ideation - verification. In the context of innovation and problem solving, ideation - allows you to create new, non-standard ideas by breaking free from traditional thinking patterns. Successful ideation also involves not only generation, but also effective management, systematization and improvement of generated ideas to identify and implement the most valuable ones.

3. Socio-economic factors:

- state policy to support innovation (tax breaks, accelerated patenting procedure, venture financing);
- demand for innovation from the steel, alloys and non-ferrous metallurgy market (need for "green" technologies, energy-efficient, resource-saving and environmentally friendly processes);
- competitive economic environment that motivates to seek more effective solutions to maintain competitiveness.

4. Information and communication environment:

- open access to patent databases, international publications, scientific and technical literature;
- digital tools for collective development of ideas (online platforms, innovation clusters, hubs);
- developed communication channels between scientists, engineers and business (industry conferences, international exhibitions).

5. Cultural and psychological environment:

- public support and prestige of inventive activity;
- tolerance for risk and errors in the research process;
- formation of a culture of "open innovation" - a two-way mutual exchange of knowledge between different institutions and companies.

State institutions, we are sure, should perform the function of a key coordinator and investor in the field of fundamental and applied research. It should create a legislative framework, mechanisms for stimulating and protecting the interests of the national manufacturer.

Thus, the success of a scientist-inventor in the field of innovative metallurgy development depends not only on his own mental, emotional and professional potential (internal triad of "success" - Fig. 2), but also on external conditions - the availability of access to resources, a favorable innovation policy of the state, industrial-scientific partnership, as well as socio-cultural support for innovative activity, which make up the external pentad of factors of external origin.

In the study, for the first time, the triad of conditions as factors of internal origin and the influence of a complex of external conditions, including access to resources, a favorable innovation policy of the state, industrial-scientific partnership, as well as socio-cultural support for innovative activity, were substantiated and defined. Together they constitute a pentad of factors of external origin that ensure the development of innovative technologies of metallurgical production, determining the role and place of invention in it.

The authors of [21] consider the problems of the development of inventive activity in scientific institutions in Ukraine and the main barriers to this activity. The indicators of the development of inventive activity in scientific institutions of Ukraine, the issues of methodological support of inventive activity; management of this activity, the experience of organizing inventive activity in scientific institutions are studied. Proposals for improving and managing inventive activity at the level of state authorities and scientific institutions are substantiated.

Thus, the generalization of the factors of influence and the definition of the conditions for the development of inventiveness, consistent with the capabilities of the components of the potential of the individual (mental, emotional and professional) allowed us to highlight the following sources as the main ones, contributing to their rational implementation by substantiating effective innovative solutions.

The need for a partnership model. Relations between business and state institutions should be based on:

- agreed goals: development of strategic industries, industrial modernization, reduction of energy consumption, greening of production;
- on a system of mutual obligations: business invests in production modernization and efficiency improvement, the state invests in scientific

developments, personnel training, infrastructure;

- on social responsibility: taking into account the interests of society (ecology, employment, regional development).

Thus, the profits of the metallurgical business directly depend on the use of the results of scientific and technological progress, therefore relations with state institutions should be based on partnership, joint responsibility and coordination of the interests of science, business and society. And the development of scientific knowledge about the physicochemical essence of processes, as objects of research, with the aim of their improvement is a continuous, objective in terms of sources of origin and logical in terms of the consequences of implementation, process. The main requirement for the practical implementation of the acquired scientific and practical knowledge in the form of a formed life cycle of a process/production method or one of its stages is their compliance with the main features of the invention, with the achievement of significant positive effects, which become sources of increasing levels of energy efficiency, resource conservation, environmental friendliness, productivity, product quality, etc., indicators important for the competitiveness of the process.

The superficial level of knowledge about the physicochemical essence of modern processes of production of cast iron and steel, other materials, which form the corresponding potential of useful properties of raw materials, fuel and energy resources, does not allow to achieve rational in terms of costs and effective in terms of results of their implementation. Physicochemical properties of the initial potential of external factors are an obligatory part of the process, the parameters of which play the role of activator of physicochemical transformations in a given direction, their dynamic development with completion when obtaining the expected result. Of particular importance for the inventor is also practical experience, which is formed during experiments with conducting research on high-temperature models in conditions close to real metallurgical processes.

When improving existing technological schemes for the production of ferrous metals and alloys, it is necessary to realize that between the levels of optimal, i.e. theoretically possible level of perfection, and the actual, which is formed from modern technological solutions, there is a certain gap - a vacuum. Its use is possible provided that the researcher has the components of the individual's potential, which, determining the IQ level, allow applying its components to reduce the gap between theory and practice. This is possible only if there is knowledge about the physicochemical nature of the processes that are the object of improvement, as well as practical skills for their application in existing production conditions.

Conclusions.

The choice of the optimal technology depends on economic, technical and environmental factors, as well as on the scale of production and the availability of resources. An important role in the restoration of the economy of Ukraine by improving metallurgical processes is played by the use of innovative technological solutions, the source of which is invention. The implementation of solutions that meet modern requirements for energy efficiency, resource conservation and environmental safety will allow overcoming the technical lag and bringing the industry to the forefront.

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