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SYSTEMATIC APPROACH TO CONSIDERATION THE SCIENTIFIC ACTIVITY OF PROFESSOR A.P. OGURTSOV

In 2024 we mark the 90th anniversary of the birth by Anatoly Pavlovich Ogurtsov, a famous educator and scientist who made a long and fruitful journey from an assistant lecture to rector of DSTU, from a postgraduate student to doctor of technical sciences, professor, academician of the Academy of Higher School. He achieved significant results in metallurgical science and the reconstruction of educational environment; therefore a systematic analysis of his activity is relevant and has practical significance for effective mastery by successors. The work proposes the use of graphic modeling using the Ishikawa diagram and a double causal (cause-and-effect) diagram, which streamline the research process and make its methodology more accessible.

Keywords: *system approach, metallurgical science, double causal diagram, graphic model, research results.*

У 2024 році виповнюється 90 років зі дня народження Анатолія Павловича Огурцова – славетного освітянина і науковця, який пройшов довгий і плідний шлях від асистента до ректора ДДТУ, від аспіранта до доктора технічних наук, професора, академіка Академії вищої школи. Він досяг значних результатів у металургійній науці та організації вищої та передвищої освіти, тому системний аналіз його діяльності є актуальним і має практичне значення для ефективного опанування наступниками. У роботі запропоновано використання графічного моделювання за допомогою діаграми Ісікави та подвійної каузальної (причинно-наслідкової) діаграми, які впорядковують хід дослідження та дозволяють зробити його методологію більш доступною.

Ключові слова: *системний підхід, металургійна наука, подвійна каузальна діаграма, графічна модель, результати досліджень.*

Problem's Formulation

The organization and conduct of research in modern conditions, as a rule, is carried out with a scientific justification. But at the same time, it is important to take into account not only the systemic connections that are inherent in the chosen topic or task, as well as the existence and influence of the supersystem. Then you can proceed to solving not only a separate task, but also to solving of a certain chain at research tasks or to the solution of an actual problem [1]. From the very beginning of the research being conducted, it is useful to analyze the situation at a sufficiently high level of overview, so that the results obtained are then naturally integrated into the current state of the chosen science [2].

Currently, research conducted by graduate students and faculty staff is limited in time and resources. Therefore, at all steps of their implementation, starting with the preparation of the work plan, high efficiency of actions must be ensured. For this, versatility and completeness of a priori processing of data are important. With a systematic approach to solving the problem, it is suggested to use graphic modeling to control the adequacy of actions.

Analysis of recent research and publications

Currently, metallurgical science is developing dynamically, and the prospects for deepening and improving developments are quite attractive. As a basis for the success of the actions, you can use the systematic findings of previous years with a widespread analysis of methods and results that were effective. It is natural that they are personalized, special within the boundaries of successful scientific schools.

In DSTU, one of the most famous schools in metallurgy is associated with the activities and achievements of Anatoly Pavlovich Ogurtsov. The physical-chemical essence and complications of the processes of obtaining pipe metal are already presented in the early works of A.P. Ogurtsov [3]. Over the years, work on research and modeling of heat and mass transfer processes in metallurgy, with his participation and leadership, gained great intensity, led to the expansion and deepening of the activities of the productive scientific school, which he headed. The career of a lecturer and administrative figure of a higher school also developed successfully and went in the direction of the development of the educational institution. However, there are few scientific publications on the relevant subject and they are not completely systematized, which complicates the use of effective tools of scientific and pedagogical activity by the next generation of specialists. Some information can be obtained from the anniversary editions of the Dneprodzerzhinsk Industrial Institute and the Dniprovsky State Technical University [4—6]. To clarify the bibliography of the works of A.P. Ogurtsov, the catalogs of the National Library of Ukraine named after V.I. Vernadskyi, the library of DSTU, other well-known Ukrainian and foreign libraries that store his printed works. After rethinking and systematization, Anatoly Pavlovich's experience and results can be useful to contemporaries in many ways.

Formulation of the study purpose

The purpose of the work is to factorize the achievements of the famous Ukrainian metallurgist A.P. Ogurtsov as a scientist and educator, to determine directions, terms and results at professional activity. With the help of graphic models, the steps and stages of solving the actual problems of metallurgical production, higher education and society as a whole are presented, as an example of the use the effective methodology of applied research and development.

Presenting main material

Two main areas of application the systems analysis for solving applied problems [7]:

- the first area is characterized by the desire to develop a general methodology for solving various complex problems that initially do not lend themselves to reliable metric description. It involves clearly identifying the problem as a discrepancy between the existing and desired state of affairs in the issue under study, formulating reliable criteria for solving the problem, a comprehensive assessment of the consequences at its solution in technical, economic, social, and environmental terms, monitoring the implementation of decisions taken, and other operations;

- the second area in systems analysis is formed closer to the practical activities of a researcher scientist and is characterized by the desire to identify the internal structure of the object under study to the greatest possible extent, to trace the interrelations of the elements that make up the object, and at the same time to preserve the idea of the object under study as an independent, integral system. The combination of a detailed analysis for the object under study with the desire for a holistic idea of it is achieved through the widespread use of mathematical modeling and the use of computers to solve the very complex problems that arise.

Both of these directions A.P. Ogurtsov used it in his work, as evidenced by the books of the final 10-volume monograph [10—13, 16—20]. The use of a systems approach can be illustrated using graphical modeling, which makes decomposition and aggregation during the research or design process visual.

When graphically modeling the process of solving technical and economic problems in the process of designing and using equipment and technologies, establishing cause-and-effect relationships can be started with the Ishikawa diagram [8, 9]. Such a diagram has a simple geometric structure of connection the rectangular elements by directed segments and is used for the purpose of graphically displaying the relationship between the solved problem and the reasons affecting its occurrence

(Fig. 1). This tool is used to ensure the completeness of ordering by key categories (6M) in causes and the problem itself: (M1) Man; (M2) Material; (M3) Machines; (M4) Management; (M5) Manufacturing; (M6) Measurement.

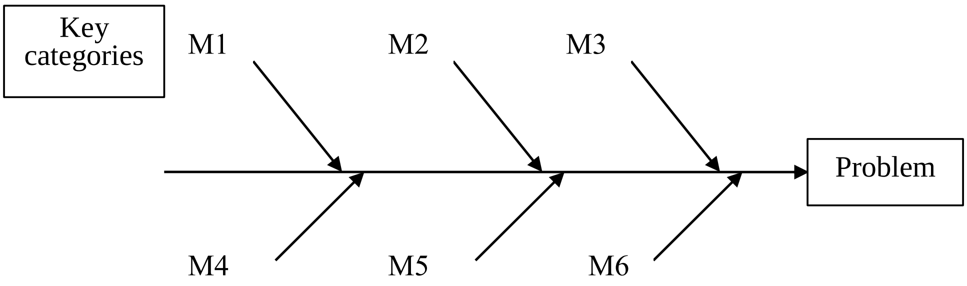

Fig. 1. Start form of the Ishikawa diagram

When constructing an Ishikawa diagram, it is customary to use an algorithm that regulates the selection and placement of vertices and edges of this specific directed graph. The main points of the methodology:

1. The vertices of the figure are the selected problem and categories of reasons, which are represented by rectangles. To achieve clarity, they are placed on a work sheet, and the figure depicting the problem is inside the sheet. A straight line is drawn from this place, around which figures corresponding to the categories of the causes by the problem are depicted. The number of categories is chosen depending on the given problem. As a rule, up to six categories (men, methods of technology, mechanisms, material, measurement, management) are used so that there is no information overload of the analysis.

2. Slanted lines are drawn from the figures by each category of reasons to the central line. They are the edges of the Ishikawa diagram. Each of the reasons is detailed by component. In order to deepen the analysis, the causes of the problem identified during the preliminary analysis are distributed according to established categories and indicated on the diagram in the form of "branches" adjacent to the main edges.

3. The most significant and important factors affecting the investigated problem are revealed. The results of the analysis are recorded in the form of "branches" of the next, lower order. The process of detailing the reasons continues until all a priori information is taken into account or the time limit is exhausted.

4. Under significant circumstances, further work may be carried out with the extension of research. The results of the application of the constructed causal model may require its further development with the preservation of the already constructed and used part, that is, completion of the Ishikawa diagram or, on the contrary, selection of some of its parts. It is important to take into account the known applied nature of the factors, the connections between them and the results.

In accordance with the content of the research work, the initial diagram is reconstructed with the transition of some categories to an implicit form, they become "invisible" in the figure; for other categories, as a rule, decomposition is performed - branches turn into trees.

Taking into account the technological orientation of research, some of the categories "man", "management", "measurement" become implicit when it is assumed to involve personnel with a sufficient level of competence, if management and measurement are carried out in accordance with modern requirements with a sufficient level of scientific and technical validity.

In accordance with the topic of the work, the category of "equipment" is divided into auxiliary and main. In the "technology" category, continuous steel casting is chosen. The "material" category is subdivided into smelting material, equipment material, etc.

The disadvantages of using the diagram include the lack of informativeness in determining the relationship between the investigated problem and its causes, as well as the uncertainty of quantitative dependencies. In order to define the model of the object in more detail according to the selected problem, you can proceed to the transformation of the causal diagram.

To model the entire process of solving the problem, it is proposed to use a double causal diagram based on the Ishikawa diagram (Fig. 2). Well-known tools for solving many problems at the stage of building and using calculation models of the object are: EM — empirical methods, TM — theoretical methods or HM — hybrid methods (EM+TM). At the stage of synthesis of solutions, the following are obtained: PS — project solutions, TTS — technological and technical solutions, OS — organizational solutions.

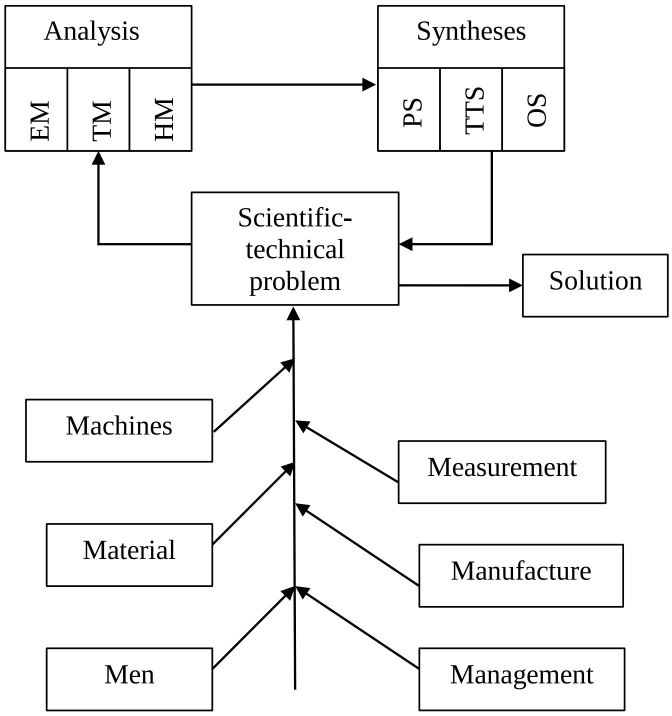

Fig. 2. General scheme of a double causal diagram

As a result of the research the operation of the intermediate ladle of the continuous steel casting machine, it was found that the temperature gradient between the dosing cups can reach 30 °C and lead to a decrease in the quality of cast blanks. Therefore, it was decided to improve the design of the intermediate ladle. To find rational geometric parameters and the location of the refractory partition, a mathematical modeling apparatus was used. The process of solving the problem can be illustrated with the help of a double cause-and-effect diagram, which was obtained after the reconstruction the general scheme in accordance with the specific conditions of the problem (Fig. 3).

The mathematical model of the movement and heat transfer the liquid metal in the intermediate ladle is based on the Navier-Stokes equations, continuity of the metal and heat transfer

$$\vec{v}\nabla\ \vec{v} = -\nabla p + \nu\Delta\vec{v} + \vec{g}\,;$$

$$\nabla\vec{v} = 0\,;$$

$$\nabla\ \vec{v}T\ = \nabla\ \lambda\nabla T\ + Q\,,$$

where $\vec{v}$ — is the velocity vector; p — is pressure; ν — is the kinematic coefficient of the effective viscosity; $\vec{g}$ — is vector of mass forces; T — is the temperature; λ — is the thermal conductivity of metal; Q — is a volumetric heat source that takes into account the heat of steel crystallization.

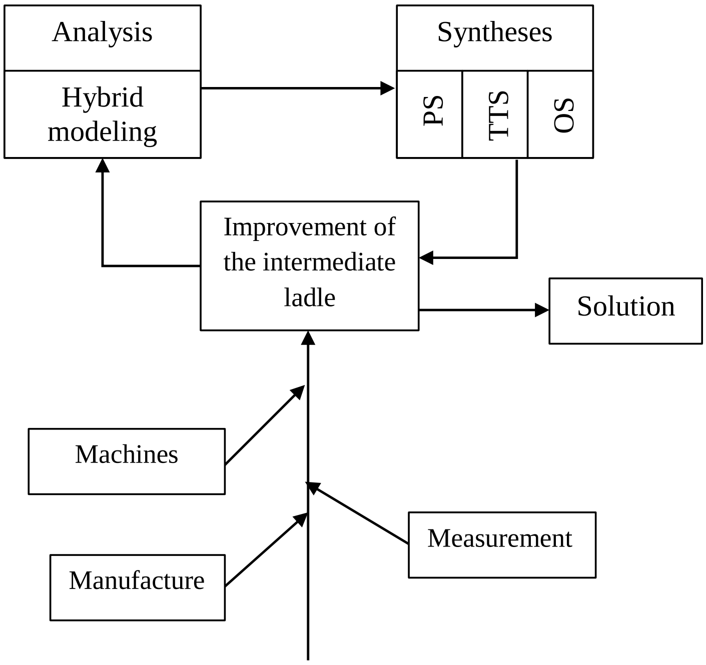

Fig. 3. Double cause and effect diagram of the improvement the intermediate ladle

The basis for the numerical implementation of the momentum transfer equations is the explicit scheme of splitting by physical factors by O. M. Belotserkovsky using a "chess" grid. The equation of the thermal state of the liquid metal and the ladle lining is approximated using the recalculation scheme of N. I. Nikitenko.

To solve the system of equations, a non-uniform grid is introduced. The integration step over time was set constant for the calculation time and was determined from the stability condition of the finite-difference scheme. The algorithm for calculating hydrodynamics and heat exchange in the t intermediate ladle of the continuous casting machine is implemented on a personal computer using an application package in the Turbo Pascal language.

As a result of numerical experiments, it was found that there are several stagnant zones in the volume of the intermediate ladle.

To direct high-temperature flows of liquid metal into stagnant zones and to ensure a minimum temperature difference between the streams, it is proposed to use a refractory partition. As a result of numerical experiments, it was found that the height of the refractory partition should be 450 mm with a length of 3800 mm. As a result, the maximum temperature gradient between the dosing glasses does not exceed 4 $^{\circ}$C.

Over the years, in accordance with the actual achievements, there was an exit from the activity of the scientific school to the level of an innovative (scientific and educational) cluster [21], which was associated with a wide range of topical problems. With the independence of Ukraine, it was necessary to solve the environmental problems of the region [18], intensively move towards energy saving [19], and reform higher education [20]. In accordance with the stated problems, the system approach is implemented in the first of the previously indicated directions [7]. The cluster actually existed (Fig. 4), but was not formalized. Clusters are innovative purposeful. They can reduce not only the cost of production, but also the cost of exchange by improving trade relations and transparency of local resource and product markets.

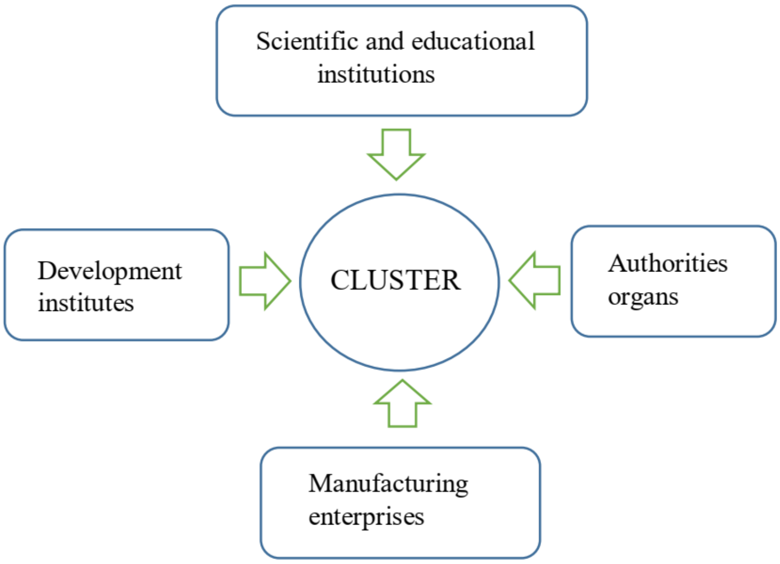

Fig. 4. Diagram of an innovation cluster

A.P. Ogurtsov has always actively responded to the challenges of the time in his professional life. And after leaving the position of rector of DDTU, he remained active in the development and use of innovations in research and teaching activities. With the beginning of the new century, he worked effectively on the modernization of the educational process during the implementation of the modular rating system with extensive use of testing. For example, he participated in the preparation at innovative manual on higher mathematics for future engineering bachelors [22].

According to his individual research trajectory, he developed methods of mathematical modeling from the application of methods of mathematical statistics and the theory of planning experiments for models of objects as "black" boxes with the transition to establishing clear connections in the structure of the system and the functioning of its elements using finite-difference calculation methods and using the finite element method. The results of the work are reflected in the monograph [23]. The transition to the training of specialists in nanotechnology was being prepared [24]. Over the past decade, the tasks set have not lost their relevance and await their solution in the changed conditions.

Conclusions

The scientific path of A.P. Ogurtsov began with the improvement of the Marten melting technology in the direction of intensification the process while preserving or improving the quality of the metal. Further it was going from the technology of extra furnace process with the improvement the technology of the use and design of melting molds and the composition of slag mixtures and to continuous casting of blanks with the provision of the basics in the quality at metal products.

The works of A.P. Ogurtsov, which is more than 700 scientific papers and 45 author's certificates, is a significant contribution to the development of the theory and practice of metalworking and higher education in Ukraine.

A systematic approach to the analysis of the activity and achievements by Anatoly Pavlovich Ogurtsov, a prominent figure of metallurgical science and higher education in Ukraine, was performed using graphic modeling, because most of the solved problems are difficult to formalize and poorly deterministic. A double causal diagram based on the Ishikawa diagram is used, which makes it possible to characterize in more detail the conditions of influence of technical and economic factors in the processes of steel ingot production and higher metallurgical education.

Possible difficulties of using the diagram include the difficulty of a detailed definition of the relationship between the investigated problem and the factors because the problem is complex. In order to further specify the factors from the diagram, a factorization of research and development of steel ingot production processes in the conditions of Ukraine and outside its borders was carried out in the works of A.P. Ogurtsov. The relevance of the study of the impact of specialist training in the conditions of DSTU on economic and production processes in Dnieper region and the entire state has been established.

Description of the formation and functioning the educational-scientific cluster centered in DSTU at the end of the 20th — beginning of the 21st century, related to the activities of the famous scientist, professor Anatoly Ogurtsov — metallurgist and educator, is useful. Scientific novelty connects with the analysis at the processes of obtaining new knowledge, results and products. Employment of modern systematic methods from scientific school by A.P. Ogurtsov is actual in the design and improvement of steel production processes and training of specialists in the metallurgical industry.

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СИСТЕМНИЙ ПІДХІД ДО РОЗГЛЯДУ НАУКОВОЇ ДІЯЛЬНОСТІ ПРОФЕСОРА А.П. ОГУРЦОВА

Реферат

Використання системного підходу в якості інструменту планування, організації та проведення дослідницької та інженерної діяльності є актуальною проблемою. Така проблематика не має чіткої формалізації, тому важливе опиратися на досвід прикладів ефективних рішень задач, які були отримані у відповідній галузі. На підставі цього, метою роботи став системний підхід до розгляду діяльності А.П. Огурцова, як дослідника, новатора процесів виготовлення

металу та експлуатації металовиробів, освітянина і суспільного діяча, що давав науково обґрунтовані відповіді на сучасні виклики у виробництві, вищої освіті, місцевому господарстві.

Для досягнення мети були вирішені наступні завдання:

- дослідити та наочно надати методи і результати розв'язання науково-технічних проблем виробництва сталі у межах наукової школи сталеплавильників ДДТУ;
- оцінити ефект впливу отриманих рішень на розвиток металургійної термомеханіки, обладнання металургійного виробництва;
- оцінити зміни на рівні міста в процесах підготовки фахівців та інженерної освіти в технічному університеті після набуття Україною незалежності;
- представити реальні результати рішення екологічних проблем промислового регіону, енергозбереження на рівні ЗВО та міста.

У результаті виконання дослідження було виявлено, що за результатами роботи наукової школи й всього технічного університету фактичне склався інноваційний кластер, в якому завдяки синергетизму досить успішно розв'язувалися актуальні для ЗВО, галузі й міста задачі.

Надані результати становлять певний практичний інтерес — можливість, завдяки використання ефективних наукових методів та інноваційних рішень, отримувати за допомогою системного підходу розв'язки актуальних проблем нашого промислового регіону.

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