УДК 658.114.5:658,588,5(045)
JEL L23

KOVALEVSKYI S.V.
Dr. Tech. Sci., Professor, Head of the Department of Technological Engineering of Machines
Donbaska mashinobudivna academy_ya.
Akademichna street, 72., t. Kramatorsk, Ukraine, 84313
E-mail:kovalevskii@i.ua
ORCID: 0000-0002-4708-4091

KOVALEVSKA O.S.
Cand. tech. Sciences, associate professor, doctoral student,
National Technical University of Ukraine "KPI"
(Kyiv Polytechnic Institute of the Institute of Igor Sikorsky).
Ave. Victory, 37, m. Kyiv, 03056
ORCID: 0000-0002-5884-0430

OSIPOV V.M.
Dr. Econ. Sciences, professor
science scholar co-worker
Institute of Market Problems and Economic and Environmental
Studies of the National Academy of Sciences of Ukraine
French Boulevard, 29, Odessa, Ukraine, 65044
E-mail: osipov@gmail.com
ORCID: 0000-0003-1657-9849

CONCEPT OF THE MULTYNOMENCLATURE RECONFIGURABLE MACHINE REPAIR CLUSTER

Topicality. . *Ensuring reliable functioning of equipment and mechanisms by forming a machine-building cluster, which reduces the idle time as a result of the creation of flexible technological systems based on numerically controlled machine tools. The reliability of the functioning of production facilities created at the machine-building and processing enterprises is achieved not only by high-quality manufacturing, but also by the level of service, which is a continuous support of the working capacity of machines and mechanisms, based on the timely provision of spare parts and repair and maintenance products.*

Aim and tasks *The purpose of the article is to search for innovative model of repair production, based on ensuring its flexibility through adaptive reconfiguration of technological equipment, focused on supporting the life cycle of the main production. Development of high-performance technologies, aimed at achieving advantages in the selected sectors of the economy.*

Research results. *The conceptualization of the maintenance of the machine-repair function in the structure of the reconfigurable multi-cluster cluster, formed on the innovation platform of the machine-assembly shop on the basis of mobile intelligent machines with kinematics of a parallel structure, was realized. The gamma (dimensional series) of elements of the reconfigurable manufacturing system on the basis of mobile machines with parallel kinematics and intelligent control systems, which allows maintenance of a machine-repair cluster on the basis of reconfigurable productions, is developed. The proposed concept can be offered as a market product in the form of a gamut of mobile machines with intelligent control for different productions. The concept of reconfigurable multi-nomenclature production, based on a fundamentally new approach to layout, in particular, a mechanic-assembly shop of competitive production with the use of mobile intelligent machines with kinematics of a parallel structure, has been formed. The method of position identification, kinematic and dynamic parameters of mechanisms with the parallel kinematics structure, of which mobile machines are composed, is developed.*

Conclusions. *The proposed ideology of the formation of the production structure of the cluster will ensure the consolidation of all types of capital: production, labor, financial, social and create conditions for the synergistic effect as a result of constructive interaction in the process of functioning of the BRMK.*

Key words: *machine-repair production, cluster, flexible production-technological systems, CNC machines.*

КОВАЛЕВСЬКИЙ С.В.
д-р техн. *наук, професор, завідувач кафедри технології машинобудування*
Донбаська державна машинобудівна академія.
Академічна вулиця, 72., м. Краматорськ, Україна, 84313
E-mail:kovalevskii@i.ua
ORCID: 0000-0002-4708-4091

КОВАЛЕВСЬКА О. С.
канд. техн. наук, доцент, докторант,
Національний технічний університет України «КПІ»
(Київський політехнічний інститут імені Ігоря Сікорського).
просп. Перемоги, 37, м. Київ, 03056
ORCID: 0000-0002-5884-0430

ОСИПОВ В.М.,
д-р екон. наук, професор,ст.наук. співроб.
Інститут проблем ринку та економіко-екологічних
досліджень НАН України
Французький бульвар, 29, м. Одеса, Україна, 65044
E-mail:osipov@gmail.com
ORCID: 0000-0003-1657-9849

КОНЦЕПЦІЯ БАГАТОНОМЕНКЛАТУРНОГО РЕКОНФІГУРУЄМОГО МАШИНОРЕМОНТНОГО КЛАСТЕРА

Актуальність. *Забезпечення надійного функціонування обладнання і механізмів за рахунок формування машинобудівного кластера, що знижує тривалість простоїв в результаті створення гнучких технологічних систем на базі верстатів з числовим програмним управлінням та реконфігуруємих технологічних систем. Надійність функціонування виробничих потужностей, що створені на машинобудівних і переробних підприємствах досягається не тільки високоякісним виготовленням, а й рівнем обслуговування, а це є безперервною підтримкою працездатності машин і механізмів, що засноване на своєчасному забезпеченні запасними частинами і ремонтно-експлуатаційними виробами.*

Мета та завдання*. Метою статті є пошук інноваційної моделі ремонтного виробництва, заснованого на забезпеченні його гнучкості шляхом адаптивної реконфігурації технологічного обладнання, що орієнтоване на підтримку життєвого циклу основного виробництва. Розробка високопродуктивних технологій, спрямованих на досягнення переваг в виділених секторах економіки.*

Результати. *Здійснено концептуалізацію забезпечення машиноремонтної функції в структурі реконфігуруємого багатономеклатурного кластера, сформованого на інноваційній платформі механоскладального цеху на базі мобільних інтелектуальних верстатів з кінематикою паралельної структури. Розроблена гамма (розмірний ряд) елементів реконфігурованої виробничої системи на базі мобільних верстатів з паралельною кінематикою і інтелектуальних систем управління, що дозволяє підтримувати машиноремонтний кластер на базі реконфігурованих виробництв. Запропонована концепція може бути запропонована як ринковий товар у вигляді гами мобільних верстатів з інтелектуальним управлінням для різних виробництв. Сформована концепція реконфігуруємого багатономенклатурного виробництва, заснованого на принципово новому підході до компонування, зокрема, механоскладального цеху конкурентоспроможного виробництва із застосуванням мобільних інтелектуальних верстатів з кінематикою паралельної структури. Розроблено метод ідентифікації положення, кінематичних і динамічних параметрів механізмів з кінематикою паралельної структурі, з яких складаються мобільні верстати-роботи.*

Висновки. *Запропонована ідеологія формування виробничої структури кластера забезпечить консолідацію всіх видів капіталів: виробничого, трудового, фінансового, соціального і створить умови для отримання синергетичного ефекту в результаті конструктивної взаємодії в процесі функціонування БРМК.*

Ключові слова: *машиноремонтне виробництво, кластер, гнучкі виробничо-технологічні системи, верстати з ЧПУ.*

Problem statement and its connection with important scientific and practical tasks. The production capacities created at machine-building and processing enterprises vary greatly from universal to highly

automated equipment and automated systems. The reliability of their operation is achieved not only by high-quality manufacturing but also by the level of service. In particular, it is continuous support of the working capacity of machines and mechanisms involved in continuous processes, based on the timely provision of spare parts and repair and maintenance products [1].

Analysis of recent publications on the problem. Based on the experience of the main mechanics of enterprises and the assessment of the impact of the conditions and modes of operation of the main equipment on the costs associated with the maintenance and repair of this technique, it can be concluded that optimization of the repair base and the maintenance rules of the equipment of the main production allows more than 50% increase the number of operational equipment without removing it from the production cycle [2, 3, 4, 5]. Optimization of spare parts stocks also increases the reliability of machinery of the main production [6, 7]. However, there is no information about the organization of repair production on the basis of modern ideas about flexible manufacturing, based on the concept of reconfigurable production systems.

Allocation of previously unsolved parts of the general problem. The main energy-consuming equipment of large enterprises, which can include processing and logistics complexes, have a long operating life, which negatively affects reliability and leads to higher costs for maintaining its efficiency. At the same time, there are no promising system solutions aimed at a radical reconstruction of the existing repair production. Also, there are no substantiated decisions related to the necessity of constant updating of the equipment and its adaptation to the nomenclature of spare parts and constantly changing repair and maintenance products.

Formulation of research objectives. The purpose of the study is to find an innovative model of repair production, based on providing its flexibility through adaptive reconfiguration of technological equipment, focused on supporting the life cycle of the main production.

Outline of the main results and their justification. The most effective form of economic organization and interaction in the implementation of the tasks is a cluster that should be defined as a voluntary association of engineering and operating machine-repair enterprises, consumers of their products and services and service outsourcing companies united in a single innovative investment platform. Consolidating the basis for the cluster to be social capital, ensuring effective exogenous and endogenous production and information links that allow you to get the maximum synergistic result which should be distributed transparently between the founders and members of the cluster. [8]

Such comprehensive paradigm lies in the economic experiment, implemented within Adzhalyksky transport and logistics hub for example maintenance of cargo handling equipment that almost all 26 stevedore companies that are part of this contact zone "land-sea".

Based on the pilot project (Phase 1 experiment) carried out under the TIS group companies – Trans-invest-service planned to test the organizational and economic mechanism of repair and optimize the operational management of the service handling equipment.

Given the strategic perspective of a moulded hub, estimated at $ 3 billion worth of investment. by 2038., the economic efficiency of the developed engineering cluster has significant potential both in the short-term and in the long-term period.

At the initial stage of constructing a cluster, the following models may be used:

a) Cluster, the creation of which focuses on the creation of a joint management body in which members of the cluster delegate their representatives, giving them the right to take decisions in the area of competence of a policy document cluster (logistics, investment, introducing effective technologies, search for contractors to create innovative technologies, etc.)

b) A cluster, in the creation of which the primary value is the accumulation of total funds of cluster members for further implementation of program objectives.

c) A cluster, the creation of which begins with the creation of a budget for the implementation of program objectives, with the determination of the stake contributions of cluster members.

g) Cluster. the construction of which occurs through the creation of a business enterprise-legal entity, or without such - within the framework of the agreement on joint activities involving the bank as a body controlling the spending of funds.

Maintenance of processes associated with downtime and high costs, such as loading and unloading, is of paramount importance because tens of thousands of hryvnias cost an idle time. Such is the servicing of transport and lifting - transport mechanisms on the railroad, or sea freight transport. It is also important for the maintenance of warehouses.

Repair production of the services of chief mechanic is traditionally equipped with machining equipment, the technological capabilities of which depend on its standard sizes, qualifications of machine-tool workers and the level of automation of production. A variety of spare parts and repair and maintenance products require the maintenance of a large park of technological equipment. This increases the cost of spare parts and repair and maintenance products and the risks increase the duration of idle equipment involved in cargo handling and logistics operations. This is a way to increase losses from the downtime of the main freight transport of seaports and railways.

One of the factors behind the increase in the cost of repairs is the formation of a park of technological equipment on the principle: "for all occasions." The need for purchase and its subsequent use is dictated by the features of the range of spare parts and repair and maintenance products - instability in time and a large range of sizes and requirements to them. However, this property of this nomenclature has a close affinity to the requirements of the market, to the variety and variability of products that participate in the market environment.

A traditional approach to addressing this issue involves the creation of flexible manufacturing technology systems based on numerical control equipment. The high cost of flexible manufacturing complexes (FMC) is one of the main reasons for the low level of their acceptance or satisfaction. Unlike specialized systems, CNC machines are not designed to meet the technological needs of spare parts production. Rather, CNC machines of general purpose are constructed before the manufacturer selects the machines and before the process of planning is started to adapt the machine and the process to the part. Flexible systems and machines are created with all possible functionality since the machine tool manufacturer does not know in advance the area of the use of the processing centre, which creates the main expense. Thus, providing the general assumption that the VHS is capable of producing: any product (within a given family), in any combination of parts and in any sequence. This approach increases the cost because it requires a parallel system structure for FMC, which uses powerful processing centers of general purpose with a very large tool magazine and multiple tool sets, which is a very costly solution. However, there is a stable low level of performance of such systems at a high-cost level.

Assuming that the complexity of manufacturing T_i of products i is directly proportional to the complexity of the product C_i and inversely proportional to the technological capabilities of j equipmentA_j, then the characteristic of the multi-choice production is the set of $\sum_i N_i(C_i)$, which is related to the speed of release products with the following ratio (1):

$$\sum_i \int_0^{C_i/A_j} V(A_j, t)dt = \sum_i N_i(C_i) \quad (1)$$

where $V(A_j, t)$ is the speed of satisfaction with the technological system of the needs for spare parts and repair and maintenance products.

For the function $V(A_j, t) = k \cdot A_j^{\alpha \cdot t}$, where α is an index of its nonlinearity (α> 1), expression (1) takes the form (2):

$$\sum_i [k \cdot \frac{A_j^{\alpha \cdot t}}{lnA_j}] = \sum_i [k \cdot \frac{A_j^{\alpha \cdot \left[\frac{C_i}{A_j}\right]}}{lnA_j}] = \sum_i [k/lnA_j \cdot (A_j^{\alpha \cdot \left[\frac{C_i}{A_j}\right]} - 1)] = \sum_i N_i(C_i) \quad (2)$$

From this, we can conclude that the range of complexity of spare parts and REI requires the adaptation of technological capabilities equipment machinery repair facilities. In fact, the functional connection $V(A_j, t) = k \cdot A_j^{\alpha \cdot t}$ and equation (2) represent the process connection of the nomenclature $\sum_i N_i(C_i)$ and the technological capabilities of the equipment, -any moment of time these opportunities should be flexible to meet the continuity of satisfaction of repair and operational needs. Therefore, the improvement of production and technological systems is the most important component of the development of the production of new products, which can compete in the machine-building market for a long period of time. The problems associated with the use of equipment that has formed these production facilities are shared by us because of the fact that the traditional technological processing systems of materials have approached their technological limit and almost completely exhausted their resources and opportunities for significant improvement of technical and economic indicators [10 , 12, 13, 17].

Among these problems is the provision of technological flexibility of equipment in the conditions of multi-choice production with a wide range of product parameters, and one of the ways of solving this problem is the concept of reconfigured clusters of main equipment [18, 19, 20, 21, 22, 23, 24]. Particular prospects for the rebuilding of the machine-building park of machine-assembly workshops open up mobile machine tools on the basis of mechanisms with the kinematics of a parallel structure [11, 12, 13, 14, 17].

Reconfigurable production systems is a new production approach that not only combines the high throughput of specialized lines with flexible FMC but also is able to respond to changes quickly and efficiently. This is achieved through the design of the system and its machines, adapting the structures that allow system scalability in response to market demands and system adaptation to new products. The structure can be corrected at the system level and at the machine level (change of machine hardware and software management, for example, adding spindles, or changing tool store) [19,20]. Functional capabilities and cost-determine the difference between reconfigurable production systems, traditional automatic lines and FMC. While automatic lines and FMCs are installed in full functionality, the PBX changes capabilities and functionality over a long period of time, as the system responds to changing circumstances in the market.

Thus, the reconfigurable systems differ from their existing systems with their ability to change. The main advantage is the ability to have the given flexibility for manufactured products. It is also very beneficial to manufacturers that the fact that, with its flexibility for flexibility, the PBC is much cheaper than existing flexible systems. This is due to the use of cheaper equipment.

The formation of a progressive method of mechanic-assembly shop requires the specification of its features, similar to the scheme of causal relationships, proposed (Fig. 1).

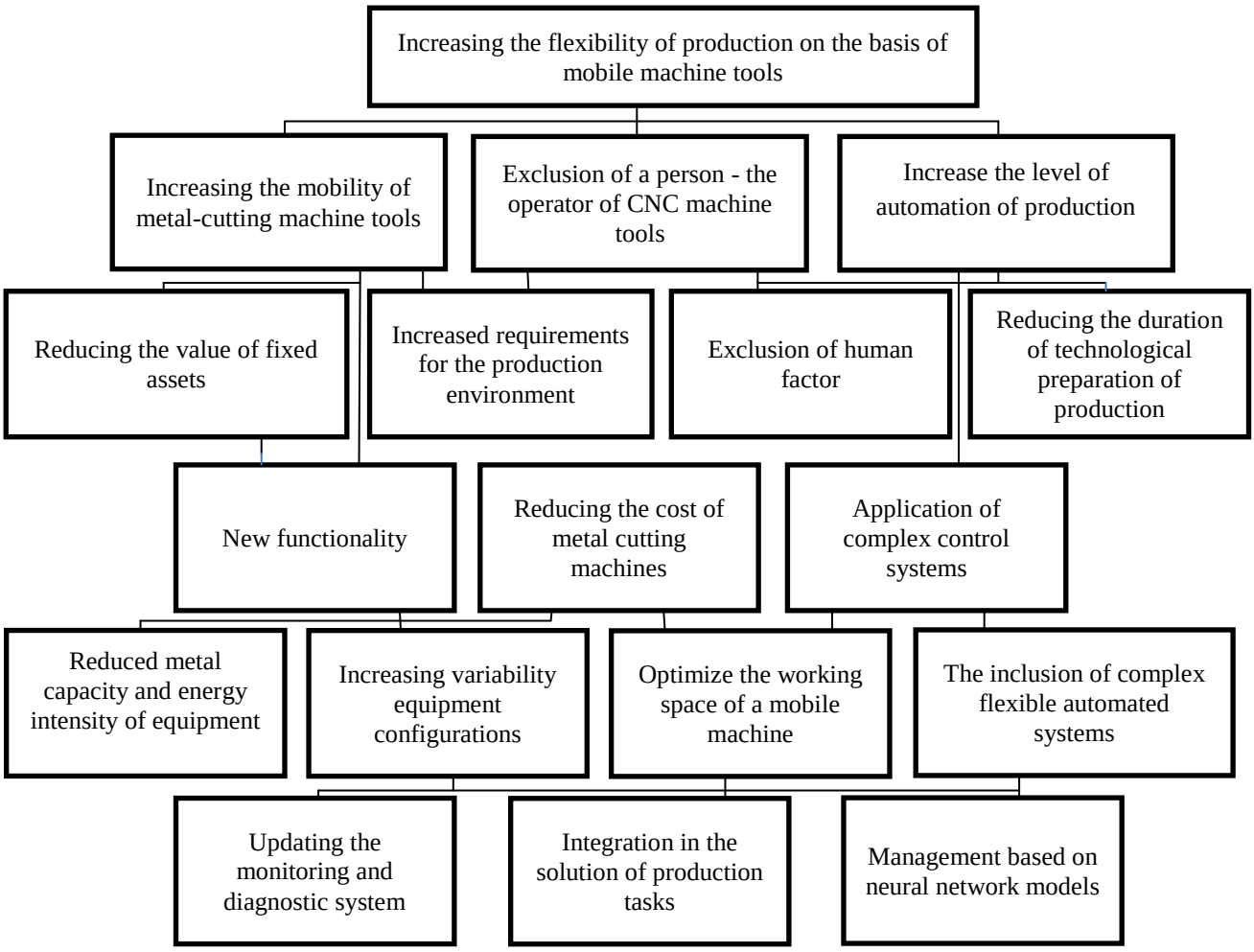

Fig. 1 Interconnection of features of production on the basis of mobile machines with kinematics of parallel structure

Source: author's development

As shown in the scheme, the use of mobile machines with the use of mechanisms requires the complex management of their executive units, which are based on fundamentally new methods and methods of control and diagnosis of new equipment, technological processes and products. And the introduction of mobile machines provides:

- change of the structure of the production environment by changing the layout of equipment, an organization of working space, transportation;
- change of properties of components of the environment;
- reduction of the information entropy of the environment;
- change of energy saturation of the environment;
- change of information saturation environment;
- change of intellectual properties of the environment.

This list is based on the development of operations of technological, energy, information and communication production support.

Unlike mobile robots, here under the working environment to understand the environment of the work piece or product to be collected. As you know, for the processes of processing billets of parts and assembling machines requires the accuracy of the movements of the actuator. Standard model also requires high accuracy of implementation (within 1-2 microns). This is the difference between work on the research of mobile adaptive robots and works on research in the field of creation of mobile intelligent robot machines. Of course, this level of autonomy of mobile machines is the highest.

In works [15, 16] the reasons for the need to optimize the management of complex mechanisms of technological machines are presented, as well as models of processes for controlling equipment with parallel kinematics, which are effective on the criteria of energy consumption, using their dynamic and static models. It is shown that in an undesired range of speeds of a working body when implementing such control, we can not take into account the masses and inertial parameters of elements of such equipment. However, the main advantages of equipment with parallel kinematics are most pronounced in the conditions of high velocity of movement of actuators with a given accuracy of the trajectory of moving the instrument and its positioning.

We have developed a method for identifying the position, kinematic and dynamic parameters of mechanisms with parallel kinematics, of which mobile machines are composed. Excitement of the design of the experimental machine tool by a low-power acoustic signal with the distribution of signals of the same amplitude allows us to determine the dependences F (A, t) ≡x (t), y (t), z (t), where F (A, t) is the excitatory signal x (t), y (t), z (t) - coordinates of the actual point of the object. These data can be used to control the positioning of the executive link of the mechanism with parallel kinematics. In this regard, the purpose of the presented study is to confirm the possibility of a multicomponent analysis of the parameters of objects (processes and equipment). As an informative source of the diagnostic signal, it is necessary to use its amplitude-frequency characteristic of the object's own oscillations in the acoustic range.

For research, a fast calculation algorithm for the discrete Fourier transform [11] using the FFT analyzer was used.

The estimation of the spectral density is carried out in accordance with the known realization of the XR (t) signal by generating from it a discrete sequence x (n), n → 0,1, ..., N □1 and processing this sequence in accordance with the given quantization.

Manage executive mechanisms of a technological machine with mechanisms of parallel structure is a complex problem whose solution can be obtained on the basis of solving the problems of kinematics and dynamics of executive mechanisms. As a result, conditions can be created for the precise positioning of working bodies of executive mechanisms at optimal speeds and accelerations of their movements in a given trajectory. For these purposes, management systems should be equipped with informative object identification systems. To confirm this, we propose the results of experimental studies that provide the basis for the establishment of systems for the diagnosis of kinematics and dynamics of the mechanism, on the basis of which the authors create mobile machines for use in reconfigurable production systems of mechanical processing.

Method of experimental research.

The purpose of the research is to build a neural network reference model for diagnosing the current characteristics of the object. The choice of diagnosed characteristics of an object is determined by the tasks of object management:

- an increase of accuracy of positioning of the mechanism of the object;
- ensuring the dynamic adjustment of the executive mechanism;
- optimization of the trajectories of displacements of the working body.

According to the indicators of the experimental base created, the neural network diagnostic models were constructed by the authors of the work:

- a configuration of the mechanism;

- geometric parameters of the mechanism when working motor-spindle;

- dynamics of movement of knots of the mechanism of the experimental stand with variable speed and load on the drive;

- changes in the temperature of the object.

This allowed to solve the following tasks of object management:

- increase the accuracy of the positioning of the object's actuator;

- providing dynamic adjustment of the executive mechanism;

- optimization of trajectories of displacements of the working body.

The adequacy of the models is confirmed by a multiple excesses of the calculated value of Fisher's criterion over its table value for the given probability of error for models of m inputs – frequency ranges of the acoustic spectrum constructed on n lines of the tuple of the output data.

To create the intellectual control system, the main components of the reconfigurable production are the method of acoustic diagnostics for the mechanisms of technological machines (machines - robots), which allow to diagnose their different conditions in different conditions. It is shown the possibility of using the proposed approach to the management of complex technological machines, such as machines with mechanisms based on parallel kinematics to improve the accuracy of the positioning of actuators, ensuring their dynamic adjustment and optimizing the trajectories of displacements of work equipment bodies (including cutting tools). All this allows you to expand the range of opportunities to increase the accuracy and performance of their work.

The search for complex trajectories with variable coordinates and derivatives of the first and second order of the trajectory of the movement allows you to determine and predict the state of the object at any given time. In this way, conditions are created to control the position of the working body of the mobile machine tool-robot, taking into account the current working conditions of the machine tool (good and weakly formalized) variables.

On the basis of the presented developments of the authors the concept of reconfigurable multicomponent production, based on a fundamentally new approach to the layout, in particular, mechanic-assembly shop of competitive production with the use of mobile intelligent machines with the kinematics of a parallel structure, has been formed.

Conceptually, this concept implies the presence in the mechanic-assembly shop of units such as:

- a plot of land on the basis of a machine of continuous casting of billets in conjunction with a part rolling mill;

- a mechanical site, which is a platform for the installation of mobile machines with a system of intellectual control;

- a section of assembly and disassembly of mobile machines with the kinematics of parallel kinematics,

- assembly area of the main products.

Conclusions and perspectives of further research. To implement the proposed concept, the authors developed a gamma (dimensional series) of elements of a reconfigurable production system based on mobile machines with parallel kinematics and intelligent control systems that allow the maintenance of a machine-repair cluster based on reconstructed productions. At the same time, the proposed concept can be offered as a market product in the form of a gamut of mobile machines with intelligent control for various industries.

ЛІТЕРАТУРА

1. Осипов В.М. Стратегія підвищення міжнародної конкурентоспроможності машинобудівного комплексу на основі кластерізації / В.М. Осипов // Економіка: реалії часу. - 2015. - №2(18).

2. Повышение эффективности организации деятельности ремонтной службы как важная составляющая функционала главного механика/С.В. Карпенко, И.И. Емец, Ю.А. Харитонов и др.//Уголь. - 2015. - №1. С. 66-68.

3. Drygin M., Kurychkin N., Bakanov A. Ways of increasing excavator fleet productivity in Russian coal open pits (Kuzbass case study)//The 1st Scientific Practical Conference "International Innovative Mining Symposium (in memory of Prof. Vladimir Pronoza)". 2017. Vol. 15 DOI: 10.1051/e3sconf/20171503010

4. Система ППР. [Електронний ресурс]/ Режим доступу: http://www.sdelaemsami.ru/oborudovanie/kran107.html

5. Зимин Н.Е. Влияние воспроизводства технической базы сельского хозяйства на экономическую безопасность предприятий//Вестник ФГОУ ВПО «МГАУ имени В.П. Горячкина». 2017. № 2. С. 35-41

6. Обеспечение надежности техники путем проведения комплексной оценки качества поставок запасных частей при организации технического сервиса/О.Н. Дидманидзе и др.//Международный технико-экономический журнал. 2014. - №5. С. 31-40.

7. Коба Е.Е. Особенности планирования производственных запасов на промышленных предприятиях/Е.Е. Коба.//Журнал «Научный аспект», 2013г., № 2 -том 2. -209-210 с.

8. Кластерная форма территориально-производственной организации (в 2 частях) / В.И.Захарченко, В.Н.Осипов – Одесса: «Печатній дом» «Фаворит», 2010. – 236с.

9. Макаров В. М. Комплексированные обрабатывающие системы. – Ритм. – 2011. - № 6, С. 22–25.

10. Merlet J.-P. Parallel Robots. – Springer-Verlag New York Inc., 2006. – 394 p.

11. Діагностика технологічних систем і виробів машинобудування (з використанням нейромережевого підходу) : монографія / С. В. Ковалевський, О. С. Ковалевська, Є. О. Коржов, А. О. Кошевой ; за заг. ред. д.т.н., проф. С. В. Ковалевського. – Краматорськ : ДДМА, 2016. – 186 с.

12. Кириченко А.М. Проведення до зони обробки жорсткості та податливості обладнання з механізмами паралельної структури / А.М. Кириченко // Вісник Національного технічного університету Україні „Київський політехнічний інститут". Серія „Машинобудування". – 2010. – №59. – С. 205-210.

13. Крижанівський В.А., Кузнєцов Ю.М., Валявський І.А., Скляров Р.А. Технологічне обладнання з паралельною кінематикою: Навчальний посібник для ВНЗ. Під ред. Ю. М. Кузнєцова. – Кіровоград, 2004. – 449 с.

14. Смирнов, В.А. Кинетостатическое моделирование энергоэффективного управления оборудованием с параллельной кинематикой / В.А Смирнов // Вестник ЮУрГУ. Серия «Машиностроение». - 2010. - Вып. 16. - № 29. - С. 65-70.

15. Смирнов, В.А. Повышение производительности обработки на оборудовании с параллельной кинематикой / В.А Смирнов // Вестник ЮУрГУ. Серия «Машиностроение». - 2010. - Вып. 15. - № 10 (186). - С. 72-76.

16. Струтинський В.Б. Теоретичній аналіз жорсткості шестикоординатного механізму паралельної структури / В.Б. Струтинський, А.М. Кириченко // Вісник Національного технічного університету Україні „Київський політех-нічний інститут". Серія „Машинобудування". – 2009. – № 57. – С. 198-207.

17. Koren, Y., Heisel, U., Jovane, F., Moriwaki, T., Pritschow, G., Ulsoy, G., Van Brussel, H., 1999, Reconfigurable Manufacturing Systems, A Keynote Paper, Annals of the CIRP, 48/2:527-540.

18. Юнин И.Ю. Перекомпонуемые производственные системы реконфигурируемого производства/ И.Ю.Юнин, Л.Н.Феофанов// Технология машиностроения, - М., 2008. - 12. - С.53-62

19. Королькова М.М. Реконфігуровані производственные системы/ ММ.Королькова, ОА.Дащенко// Технология машиностроения, - М., 2009. - 1. - С.56-62

20. Безус А.М. Стратегія підвищення інноваційної діяльності підприємства [Електронний ресурс] /А.М. Безус, М.Г. Чуйок // Ефективна економіка. —2018. — № 1. — Режим доступу: http//www.ecnomy.nayka.com.uaVassilvitskii, S., Kubica, J., Rieffel, E., Yim, M. H., and Suh, J. W., 2002, "On the General Reconfiguration Problem for Expanding Cube Style Modular Robots," IEEE International Conference on Robotics and Automation, Washington, D. C., 801-808.

21. Chen, L., Xi, F., and Macwan, A., 2005, "Optimal Module Selection for Preliminary Design of Reconfigurable Machine Tools," Journal of Manufacturing Science and Engineering, 127(1): 104-115.

22. Hoda A. ElMaraghy, Changeable and Reconfigurable Manufacturing Systems, Springer Series in Advanced Manufacturing, 2009, 403 p.

23. Yoram Koren, The Global Manufacturing Revolution: Product-Process-Business Integration and Reconfigurable Systems, Copyright, 2010, 422 p.

24. Dashchenko A. I., Reconfigurable Manufacturing Systems and Transformable Factories, Springer Series in Advanced Manufacturing, 2009, 757 p.

REFERENCES

1. Osipov V.M. (2015) Strategiya pidvishhennya mizhnarodnoï konkurentospromozhnosti mashinobudivnogo kompleksu na osnovi klasterizacií [*Strategy of increasing the international competitiveness of the machine-building complex on the basis of clusterization*] Ekonomika: realiï chasu, 2(18) [in Ukrainian].

2. Karpenko S.V., I.I. Emec, &Y.A. Xaritonov (2015). Povy'shenie e'ffektivnosti organizacii deyatel'nosti remontnoj sluzhby' kak vazhnaya sostavlyayushhaya funkcionala glavnogo mexanika [*Improving the efficiency of the organization of repair service activities as an important component of the functional of the chief mechanic*] / 1. p. 66-68 [in Russian]

3. Drygin M., Kurychkin N.,&Bakanov A. (2017) Ways of increasing excavator fleet productivity in Russian coal open pits (Kuzbass case study) / The 1st Scientific Practical Conference "International Innovative

Mining Symposium (in memory of Prof. Vladimir Pronoza)". Vol. 15 DOI: 10.1051/e3sconf/20171503010 [in English]

4. Sistema PPR. URL (2017).: Retreived from: http://www.sdelaemsami.ru/oborudovanie/kran107.html [in English]

5. Zimin N.E. (2017) Vliyanie vosproizvodstva texnicheskoj bazy' sel'skogo xozyajstva na e'konomicheskuyu bezopasnost' predpriyatij [*The impact of the reproduction of the technical base of agriculture on the economic security of enterprises*] Vestnik FGOU VPO «MGAU imeni V.P. Goryachkina», 2. p. 35-41[in Russian]

6. Didmanidze O.N. (2014) Obespechenie nadezhnosti texniki putem provedeniya kompleksnoj ocenki kachestva postavok zapasny'x chastej pri organizacii texnicheskogo servisa [Ensuring the reliability of technology by conducting a comprehensive assessment of the quality of supply of spare parts in the organization of technical service] *Mezhdunarodny'j texniko-e'konomicheskij zhurnal* – [*International Technical and Economic Journal.*] Vol.5, 31-40. [in Russian]

7. Koba E.E. (2013) Osobennosti planirovaniya proizvodstvenny'x zapasov na promy'shlenny'x predpriyatiyax [*Features of planning inventories in industrial enterprises*] Zhurnal «Nauchny'j aspekt», Vol.2, 209-210. [in Russian]

8. V.I.Zaxarchenko, V.N.Osipov (2010) *Klasternaya forma territorial'no-proizvodstvennoj organizacii [Cluster form of territorial production organization]*.Odessa: «Pechatnij dom» «Favorit». [in Russian]

9. Makarov V. M. (2011) Kompleksirovanny'e obrabaty'vayushhie sistemy' [*Complex machining systems*] Ritm, 6, 22–25. [in Russian]

10. Merlet J.-P (2006) Parallel Robots. Springer-Verlag New York Inc. [in English]

11. Kovalevs'kij S., Kovalevs'ka O., &Korzhov E. (2016) *Diagnostika texnologichnix sistem i virobiv mashinobuduvannya (z vikoristannyam nejromerezhevogo pidxodu)* [*Diagnostics of technological systems and machine-viral machining (with a new technology)*] Kramators'k : DDMA, 186 p. [in Ukrainian].

12. Kirichenko A.M. (2010) Provedennya do zoni obrobki zhorstkosti ta podatlivosti obladnannya z mexanizmami paralel'noï strukturi [Conducting to the zone of processing rigidity and compliance of equipment with mechanisms of parallel structure] *Visnik Nacional'nogo texnichnogo universitetu Ukraïni „Kiïvs'kij politexnichnij institut". Seriya „Mashinobuduvannya". – [Bulletin of the National Technical University of Ukraine "Kyiv Polytechnic Institute". Series "Machine-building]* Vol 59, 205-210. [in Ukrainian]

13. Krizhanivs'kij V., Kuznєcov Yu., Valyavs'kij I., &Sklyarov R. (2004) *Texnologichne obladnannya z paralel'noyu kinematikoyu [Technological equipment with parallel kinematics: Educational manual for universities.]:* Yu. M. Kuznєcova(Ed.). Kirovograd, 449 p. [in Ukrainian].

14. Smirnov, V. (2010) Kinetostaticheskoe modelirovanie e'nergoe'ffektivnogo upravleniya oborudovaniem s parallel'noj kinematikoj [Kinettatic modeling of energy efficient equipment management with parallel kinematics] /*Vestnik YuUrGU. Seriya «Mashinostroenie».- [Bulletin of the Ural State University. Mechanical Engineering Series]* 16 (29), 65-70. [in Russian]

15. Smirnov, V. (2010) Povy'shenie proizvoditel'nosti obrabotki na oborudovanii s parallel'noj kinematikoj [Improved processing performance on equipment with parallel kinematics] / *Vestnik YuUrGU. Seriya «Mashinostroenie».- [Bulletin of the Ural State University. Mechanical Engineering Series]* 15(10) (186), 72-76. [in Russian]

16. Strutins'kij V. (2009) Teoretichnij analiz zhorstkosti shestikoordinatnogo mexanizmu paralel'noï strukturi [Theoretical analysis of the stiffness of the six-coordinate mechanism of a parallel structure] / *Visnik Nacional'nogo texnichnogo universitetu Ukraïni „Kiïvs'kij politexnichnij institut". Seriya „Mashinobuduvannya". – [Bulletin of the National Technical University of Ukraine "Kyiv Polytechnic Institute". Series "Machine-building]*57, 198-207. [in Ukrainian]

17. Koren, Y., Heisel, U., &Jovane, F., (1999) Reconfigurable Manufacturing Systems, *A Keynote Paper, Annals of the CIRP*. Volume 48/2, 527-540. [in English]

18. Yunin I.Yu (2008) Perekomponuemy'e proizvodstvenny'e sistemy' rekonfiguriruemogo proizvodstva [Rebuilding production systems of reconfigurable production] *Texnologiya mashinostroeniya,- [Engineering technology]* 12, 53-62. [in Russian]

19. Korol'kova M.M. (2009) Rekonfigurovani proizvodstvenny'e sistemy' [Reconfigured production systems] *Texnologiya mashinostroeniya, - [Engineering technology]* 1, 56-62. [in Russian]

20. Bezus A.M. (2018) Strategiya pidvishhennya innovacijnoï diyal'nosti pidpriєmstva [The strategy of improving the innovation activity of the enterprise]. *ecnomy.nayka.com.ua* Retreived from: http//www.ecnomy.nayka.com.ua. [in Ukrainian]

21. Chen, L., Xi, F., and Macwan, A. (2005) Optimal Module Selection for Preliminary Design of Reconfigurable Machine Tools. Journal of Manufacturing Science and Engineering, 127(1), 104-115. [in English]

22. Hoda A. ElMaraghy (2009) Changeable and Reconfigurable Manufacturing Systems, Springer Series in Advanced Manufacturing, 403. [in English]

23. Yoram Koren (2010) The Global Manufacturing Revolution: Product-Process-Business Integration and Reconfigurable Systems, Copyright, 422. [in English]

24. Dashchenko A. I. (2009) Reconfigurable Manufacturing Systems and Transformable Factories, Springer Series in Advanced Manufacturing, 757. [in English]