

УДК 621.9.06: 621.9.08: 621.797

I. Verba, Ph.D., O. Danylenko, Ph.D., A. Yakhno, bachelor, master's student

National Technical University of Ukraine „Kiev Polytechnic Institute named after Igor Sikorsky“

MACHINE-BUILDING TECHNICAL EXCLUSION: TRENDS, PERSPECTIVES, WAYS

The article is devoted to the problems connected with the maintenance of functioning (survival?) in the conditions of the modern economy of enterprises or business structures, whose activities are aimed at the production of material assets, which is associated with the use of machine tools. Taking into account that it is mainly small and medium-sized enterprises, the equipment with modern high-performance but also high-cost equipment for them may not be feasible. Therefore, modernization and repair of existing universal equipment is becoming topical. Repairs „alone“ require the creation of a powerful repair service, which again involves significant costs. The problem will also be personnel issues: providing a repair service to the workers needed for this high qualification, which need to provide the necessary amount of work and the corresponding wages.

Another direction is participation in the secondary equipment market. Realization of the existing equipment allows to receive even small funds, but the combination of them with unused repair and modernization costs simplifies the purchase of the necessary equipment.

A special position is occupied by large-sized equipment, the bearing system which in itself has a significant value (not only material), and it serves as a basis for the modernization or at least the restoration of such machines.

Key words: *modernization, repair, expediency of restoration, methods of repair, secondary market, large-sized machines.*

Introduction. The level of development of machine tools in any country determines the state of its industry, that is, its state of the economy and eventually the level of welfare of the population. Speaking about Ukraine, the development of machine tools, as well as machine building as a whole, does not give grounds for cloudless optimism. The situation is rather controversial: there are enterprises that are at a fairly decent level in terms of equipment (mainly imported), which is used in the production of its own products, and even among these products there are even domestic machines, and there are others - with a very outdated machine tool park, which determines quality and cost of produced products and requirements for the qualification of machine operators. One of the causes of the crisis in mechanical engineering is the uncertainty of the market situation and economic development, which determines the demand for rising decision-making speed. Added to this is the unpreparedness of enterprises to modernization, unqualified management, low management, technology, marketing literacy, ineffective information provision, lack of a systematic approach to the problem of modernization. And as a consequence - the deterioration and loss of competitiveness in the market both domestic and world, lowering the technical level and the potential of machine-building enterprises. In order to solve the problem of technical re-equipment of machine-building enterprises with a view to transfer to an innovative way of development, a radical renewal of the active part of fixed assets must be made, and, for this, a mandatory condition is the restoration and expansion of domestic competitive enterprises capable of assuming the delivery of equipment that is functionally can be used instead of imported.

Formulation of the problem. The import dependence in the volume of the machine tool park is now about 98% (Germany's largest share is 21.6%, followed by Italy and China), and in the beginning of 2013, domestic machine-building products were even exported ($\approx 40\%$ of the produced) [1]. Imported equipment is very expensive and it is not possible to quickly solve the problem of technical re-equipment of enterprises. Consequently, the problem of replacing imported equipment of machine-building plants in the short term in the conditions of the decay of domestic machine tools, limited investments and limited human reserves (the share of skilled workers in finishing operations is $\approx 50\%$ and half of them of retirement age, that is, existing chronic personnel deficit for existing technological equipment).

Analysis of recommendations and possible actions. The market conditions put Ukrainian machine building and, in particular, machine tools, the task of quality, volume and cost of production, which can not be solved by the existing park of technological equipment, first of all - equipment for cutting. The reasons for this are significant physical and mental deterioration (the average age is more

than 20 years), that is, the impossibility of implementing modern technology. The structure of the park also does not meet modern requirements and trends, for example, a large proportion of equipment with manual control in a shortage of labor resources, especially skilled personnel. Even that machine park, that is, is not maintained in proper condition because of the reduction of the scope of the system of planned and preventive repairs in modern conditions, and so on.

In [9] the possible ways of solving the problem are given:

- creation of machine tool enterprises, jointly with leading manufacturers of machine tools, as a way to produce costly special, heavy and precision (precision of 1.0-0.1 microns) equipment required by the defense and aerospace industries;
- the restoration and technical re-equipment of their own machine-tool enterprises with the focus on the production of CNC machines of traditional layout, average cost and medium accuracy (0.02-0.001 mm);
- development of small and medium-sized enterprises focused on the production of small-scale industrial, household and educational equipment and mechatronic knots for different purposes of comparatively low accuracy (0.05-0.02 mm) and significantly lower value.

That is, one of the main tasks is the creation and expansion of their own enterprises that are capable of producing machines that can be used instead of imported and cheaper, while simultaneously contributing to the development of the domestic economy and providing jobs. But all this is complicated by limited financial and human resources and timing.

Presentation of the main material. Technical re-equipment of the enterprise, which will ensure the growth of its competitiveness, is aimed at:

- introduction of new (progressive and flexible) technology and modernization of the existing, which will change not only the age structure of the park, but also technological and standard size and level of automation of production;
- introduction of up-to-date technologies and, accordingly, increasing production volumes and reducing the labor-intensive production processes and reducing the number of skilled personnel;
- upgrading of personnel skills, which will result in increased productivity and quality of processing, as well as qualified equipment operation;
- improving the structure and organization of production (for example, increasing the loading of equipment and, accordingly, returning assets, eliminating bottlenecks, etc.).

Technical re-equipment of existing enterprises may involve a partial reorganization and extension of production space due to significant equipment dimensions or vice versa. For example, technological design of the project involves the use of rationally sound and non-standard equipment, which is chosen on the principle of "optimal technological specialization" and may result in a significant reduction of the area (in practice, up to 2-5 times [2]), which will lead to a decrease in the cost of production and, accordingly, will increase its competitiveness.

In general, the technical re-equipment of the enterprise may have different goals: commercial or strategic, the implementation of which is determined by the type of modernization. For example, complete re-equipment of production and the introduction of advanced technologies provides long-term competitive advantages, lower costs, improving product quality, modernizing and replacing certain obsolete and physically worn out equipment - reducing costs for individual operations and improving their quality, and improving the support and economic services - reducing indirect costs and reducing the number of workers that are not directly involved in production [2].

The choice of technological equipment to replenish and refurbish the machine tool park is a rather challenging task. Provides an assessment of the competitiveness of the technical characteristics and performance indicators and cost, but also on non-price indicators, such as authority and business reputation of the manufacturer, product certification, availability and level of maintenance, the ability to obtain, if necessary, nodes or parts for replacement and repair services, etc. . In information sources, information is available on the methodology for predicting the development of a machine gun, determining the rating of enterprises, estimating the technological structure of the park and its flexibility. A. Korniyenko [4] shows inconsistencies that are possible between an array of parts to be processed (characterized by type of processing, dimensions, precision, labor intensity), and capabilities of the machine tool park:

The choice of technological equipment to replenish and refurbish the machine tool park is a rather challenging task. Provides an assessment of the competitiveness of the technical characteristics and performance indicators and cost, but also on non-price indicators, such as authority and business

reputation of the manufacturer, product certification, availability and level of maintenance, the ability to obtain, if necessary, nodes or parts for replacement and repair services, etc. In information sources, information is available on the methodology for predicting the development of a machine gun, determining the rating of enterprises, estimating the technological structure of the park and its flexibility. A. Korniyenko [4] shows inconsistencies that are possible between an array of parts to be processed (characterized by type of processing, dimensions, precision, labor intensity), and capabilities of the machine tool park:

- dimensional - when there is no equipment of the required standard size and processing is carried out using a larger size, which results in an increase in the cost of processing (occupies a larger area and consumes more energy). A very significant increase in cost can be a justification for the purchase of equipment of the required standard size;
- structural - when there is no equipment of the required technological group and it has to be purchased or leased;
- productive - when an existing park does not provide the required productivity.

A. Kornienko introduces the notion of a harmonious park, that is, a park that is capable of ensuring the implementation of a promising volume of work with minimal cost. Thus, the purpose of the enterprise is to transfer the park to a harmonious state. As criteria for choosing ways to eliminate inconsistencies, one can consider the costs and time to harmonize the park provided that the production program is being carried out.

Modern machine-building production differs significantly from the Soviet era and not only the quality, capabilities, technical characteristics of equipment, automation of logistics, and above all the level and principles of organization and management.

In conditions of mass and large-scale production, it was impossible to introduce a constructive change in the machine-tool existing in the enterprise or its technical characteristics, and any adjustment was not related to other products, but to other standard sizes of products (with the exception of aggregate machines), it took a considerable amount of time and yet it was limited.

The requirement to ensure the flexibility of equipment and quick adjustment for the production of small batches of other products has led to the widespread use of the modular method in design. Modern machine-tool plants are oriented more quickly to the assembly of finished purchase modules or aggregates that combine several modules and are also functionally independent, rather than the development and production of the machine and its components directly. Exception is the carrying systems, which are projected directly at the plant. The modules of different manufacturers of the same functional purpose are represented on the market and the designer should (on the basis of comparative analysis, using methods of system analysis, etc.) to select the components that are best suited for the execution of the technical task. It is clear that the assembly and layout of the machine may be different, and the tasks will be solved similar, or, conversely, technical specifications will be provided that will differ significantly and the area of the used equipment will be different. Modular equipment can be developed by the manufacturer for a specific order and needs of future operation and significantly accelerate the development of new products. The next step is the additive modular machines that are oriented not to processing with the removal of unnecessary material, but to "cultivate" the details of the desired shape and size. Thus, small and medium-sized businesses, which are tasking with the production of mechatronic modules, is a rather promising direction, all the more so that much smaller areas and human resources are required for its implementation, and the shortage of skilled personnel is offset by the high level of equipment automation.

Development of the concept of equipment upgrades, project documentation, selection of components and assembly and adjustment may be carried out by engineering centers already operating in Ukraine and offering their services. However, modernization and repair may engage a specialized company and directly to the enterprise user, if it allows the qualification of its employees who know the products and capabilities of the enterprise, used equipment (especially specialized) and can identify problems arise.

In [5], the character of the decline in the utility index (contains relative factors of productivity and accuracy) for the user with the operating time on the example of turning and milling machines with manual control are given. Equipment loses half of its usefulness at the age of 15 years, so existing machines at their age have usefulness no more than 30% of the nominal. So is it worth to repair them and still have a loss from idle time? Maybe it's better to dispose of it and get very little money? Losses from simple art equipment (CNC machines, machining centers, flexible manufacturing modules, etc.)

20-30 times higher than the losses from idle tools universal, which leads to increasing demands for quality and duration of repairs.

Of the total cost of repair, 60-65% is spent on the manufacture of spare parts, while the greatest cost are the spare parts made in the repair shop of the plant, which machine is operating: they are more expensive than those produced by the manufacturer-manufacturer, approximately 4.5 times. Progressive methods for restoring parts (vibro-impulse surfacing, different types of coatings, the use of epoxy compounds and polymeric materials, etc.) can restore worn surfaces to nominal sizes, but these methods are often used in a primitive form due to the fact that they are implemented for small batches and a limited range of parts. But unequivocally the task of choosing a centralized or specialized form of repair organization is not resolved because of the many varieties of equipment and components that need to be replaced depending on whether the production of equipment continues and in which country (for example, a number of US, Hungary, Germany, Japan and some companies other countries supply the user with any details of the equipment 10-12 years after the cessation of production [7]).

Machine tools that have been in service for a long time and are worn out and outdated have a certain value for the enterprise: they can be sold (secondary equipment market) and use the funds received to purchase state-of-the-art equipment, but the amount received requires a substantial additional payment, which the entrepreneur may not be capable. So many of the entrepreneurs are forced to restore the machines with simultaneous modernization, especially when it comes to large-sized machines that produce them limited and they do not have a constant load (that is, it is more expedient to apply also to execute orders of other firms). The secondary market of machines is constantly expanding. American and German firms have a great deal of experience in the restoration and modernization of machine tools [7]. For example, in the United States it is considered inappropriate to rebuild and modernize machines, the cost of which is less than 125 thousand - more profitable to dispose of and buy new ones. American firms are trying to repair and upgrade very large machines (horizontally boring, turning carousels aged 30-40 years), which have well-preserved base parts and are thermally stabilized. Manufacturers can repair and upgrade both their own machine tools and machines of other firms. With increasing complexity of repairs consider different types and categories of repairs [4]. Repair firms even compete with direct manufacturers (replacing everything except casting, the components use the same ones as the manufacturers), some 60% of the company's turnover is spent on the purchase of large horizontal boring and turning carousel machines, their restoration, modernization and subsequent realization, and this process lasts no more than 4 months. The cost of a completely refurbished machine is 55-60% of the cost of the new and pays off at its cost from 250 thousand dollars [7]. The repair firm (for example, New Century Remanufacturing) even performs the appropriate calculations and, if possible, satisfies the requirements and wishes of the customer who need to make constructive changes, qualitatively restores the technical documentation, especially hydraulic and electrical schemes, which, of course, increases the cost of repair and modernization.

In Germany, the limits of the efficiency of repair and modernization are significantly lower than in the United States: from 150 thousand marks. The upper limit (500 thousand marks) exists for large milling and multipurpose machines (the companies Heyligenstaedt, Schiess, Dorries-Scharmann, Wotan and Skoda), the cost of refurbished the machine is 30-50% of the cost of the new. In Germany, the modernization of machines, even their only equipment with CNC systems of varying degrees of complexity, has broad prospects [7].

In [8] the recommendations and results of the survey of leading specialists, the priorities of buyers and customers of the United States are given. The analysis showed that the greatest value of the buyers provide reliability and performance characteristics of machines and accuracy of processing. Considerable attention is paid to the availability of spare parts (priority 91.9%) and the system of factory maintenance and technical support (priority 89.7%), and the cost of spare parts (priority 59.9%) is more important than the cost of the machine (priority is 56.9 %)

Thus, we will note the possible directions of action for the purpose of technical re-equipment of the enterprise or industry as a whole:

- complete replacement of the machine tool park - the road is very costly, requires justification of economic feasibility, even in the case of the creation of a new enterprise;
- use of the necessary equipment purchased on the secondary market (ie upgraded and renewed) or its own repaired;
- full orientation to the equipment, repaired and modernized more desirable with the involvement

of specialists of a specialized enterprise;

– Major repairs of equipment by themselves - the worst option.

Of course, it is unlikely that any of these options will be implemented so to say "in its pure form", but the consequences can be indicated immediately as to the cost associated with the introduction of modern technologies. But in any case it is expedient to develop the secondary market of technological equipment.

The second question (and most importantly!) Is to determine the composition of the required equipment.

To evaluate the technological potential and needs of the enterprise, technological audit is used, which is one of the most widely used methods of complex express-analysis, and involves a combination of quantitative and qualitative estimates of the enterprise, that is, in essence, considered as a method of system analysis. But the purpose of technological audit is specific: it does not indicate the way of solving problems of the enterprise, but assesses the ability to understand and implement necessary changes, in particular, to the introduction of new technologies.

Even assuming that the specialists of the enterprise know the future production program, which in itself is not realistic in the conditions of market conditions and small-scale production, then choose the necessary equipment not at cost, but on indicators of efficiency at a considerable volume of offers in the market is not the same simple task. The study of foreign scientists relates to stable market conditions and to apply their results and, in particular, the methods proposed for managing market relations and ensuring non-crisis development, in Ukraine is impossible.

Now a number of scientific studies on the application of methods of system analysis have appeared, but they mainly concern issues of economics and production management. However, we can call it an example [1, 3, 6]. However, despite these results, these and other open source information do not include specific generalized recommendations.

Conclusions As a result of the analysis, it has been established that in the first place there is a need to develop a methodology for determining specific output data for the technical re-equipment of the enterprise, namely the assessment of the technological potential and needs of the enterprise (determining the required technological groups and standard sizes of equipment according to the future production program), taking into account the analysis market for machine tools and products in demand. To this end, it is expedient to use the capabilities of information systems and operating databases. Without such information, everything will be reduced to intelligent conversations and games with words about how to perform a comparative and competitive analysis of what is unknown, some conditionally chosen equipment that is suitable in all cases, and in practice will not be loaded sufficiently.

There is a problem in structuring information and recommendations on the application of methods of system analysis in a particular engineering industry, for the consideration of specific tasks, which requires, for example, a comparison of technical characteristics similar to the functional purpose of products of different manufacturers.

So the problem posed requires consideration, and not individual researchers for some specific cases, but generalizations.

Information sources

1. Асанов, Р. Э. Выбор мехатронных модулей по их технологическому уровню / Р. Э. Асанов, М. Г. Косов, А. П. Кузнецов // Известия высших учебных заведений. Поволжский регион. Технические науки. – 2013. – № 1 (25). – с. 68–75.

2. Боровский В. Г. Методология управления модернизацией предприятий машиностроительных отраслей: автореф. дис. д-ра. экон наук : 08.00.05 / Моск. гос. техн. ун-т им. Н.Э. Баумана. – М., 2017. – 35с. – URL: <https://search.rsl.ru/ru/record/01006657406>.

3. Гриценко И. В. Выбор конкурентоспособной продукции для адаптации станкостроительного завода к требованиям рынка: автореф. дисс. канд. техн. наук – Москва, 2004 – URL: <http://tekhnosfera.com/vybor-konkurentosposobnoy-produktsii-dlya-adaptatsii-stankostroitelnogo-zavoda-k-trebovaniyam-rynka#ixzz4bb6pF14m>

4. Корниенко А. А. Разработка организационных принципов развития парка технологического оборудования с целью технического перевооружения машиностроительного производства автореф. дис. д-ра. технич. наук : 05.02.22/ Моск. гос. технологич. ун-т «Станкин» – М.: 2007 – 36 с.

5. Кутин А.А., Корниенко А.А. Современные проблемы и концепция повышения конкурентоспособности продукции отечественного станкостроения // Вестник МГТУ «Станкин» №2 (6), 2009 – с. 68-72.

6. Лазаренко Г. П. Сравнительный анализ металлорежущих станков при технологическом проектировании март 2013 DOI: 10.7463/0313.0541242 – URL: <http://technomag.bmstu.ru/doc/541242.html>.

7. Потапов В.А. Опыт американских и германских фирм по ремонту, восстановлению и модернизации станочного оборудования URL: http://stanki-katalog.ru/st_4.htm

8. Потапов В.А. Требования потребителей к обрабатывающим центрам. // Эксперт – Оборудование (рынок, предложение, цены) – март, 2003 – URL: http://stanki-katalog.ru/st_11.htm

9. Современные тенденции создания модульного оборудования и перспективы модернизации имеющегося станочного парка – URL: <https://www.tecorp-group.com.ua/sovremennye-tendencii-sozdaniya-modulnogo-oborudovaniya-i-perspektivy-modernizacii-imeyushhegosya-stanochnogo-parka>.

Верба І.І., к.т.н., Даниленко О.В., к.т.н., Яхно А.С., бакалавр, студент магістратури
Національний технічний університет України „Київський політехнічний інститут імені Ігоря Сікорського“

ТЕХНІЧНЕ ПЕРЕОЗБРОЄННЯ МАШИНОБУДУВАННЯ: ТЕНДЕНЦІЇ, ПЕРСПЕКТИВИ, ШЛЯХИ

Стаття присвячена проблемам, пов'язаним з забезпеченням функціонування (виживання?) в умовах сучасної економіки підприємств чи бізнесових структур, діяльність яких спрямована на виробництво матеріальних цінностей, яке пов'язане з використанням верстатного обладнання. Враховуючи, що це переважно підприємства дрібного і середнього бізнесу, оснащення сучасним високопродуктивним але й з високою вартістю обладнанням для них може бути нездійсненним. Тому актуальним стає забезпечення модернізації і ремонту існуючого універсального обладнання. Здійснення ремонту „самотужки“ потребує створення потужної ремонтної служби, що знову ж таки пов'язане з значними витратами. Проблемою також буде і кадрове питання: забезпечення ремонтної служби працівниками потрібної для цього високої кваліфікації, яким потрібно забезпечити необхідний обсяг роботи і відповідну заробітну плату.

Інший напрямок – участь у роботі ринку вторинного обладнання. Реалізація наявного обладнання дозволяє одержати хоча і невеликі кошти, але поєднання їх з не використаними витратами на ремонт і модернізацію спроцує придбання потрібного обладнання.

Особливе положення займає великогабаритне обладнання, несуча система якого має сама по собі значну цінність (не тільки матеріальну) і це слугує підставою для модернізації чи принаймні відновлення таких верстатів.

Ключові слова: модернізація, ремонт, доцільність відновлення, методи ремонту, вторинний ринок, великогабаритні верстати.

І.І. Верба, к.т.н., А.В. Даниленко, к.т.н., А.С. Яхно, бакалавр, студент магістратури
Национальный технический университет Украины „Киевский политехнический институт имени Игоря Сикорского“

ТЕХНИЧЕСКОЕ ПЕРЕОБОРУЖЕНИЕ МАШИНОСТРОЕНИЯ: ТЕНДЕНЦИИ, ПЕРСПЕКТИВЫ, ПУТИ

Статья посвящена проблемам, связанным с обеспечением функционирования (выживания?) в условиях современной экономики предприятий или бизнес-структур, деятельность которых направлена на производство материальных ценностей, связанное с использованием станочного оборудования. Учитывая, что это в основном предприятия мелкого и среднего бизнеса, оснащение современным высокопроизводительным но и с высокой стоимостью оборудованием для них может быть невозможным. Поэтому актуальным становится обеспечение модернизации и ремонта существующего универсального оборудования. Осуществление ремонта „самостоятельно“ требует создания мощной ремонтной службы, это опять же связано со значительными затратами. Проблемой также будет и кадровый вопрос: обеспечение

ремонтной службы работниками необходимой для этого высокой квалификации, которым нужно обеспечить необходимый объем работы и соответствующую заработную плату.

Другое направление - участие в работе рынка вторичного оборудования. Реализация имеющегося оборудования позволяет получить хотя и небольшие средства, но сочетание их с не использованными затратами на ремонт и модернизацию упрощает приобретение необходимого оборудования.

Особое положение занимает крупногабаритное оборудование, несущая система которого имеет сама по себе значительную ценность (не только материальную) и это служит основанием для модернизации или хотя бы восстановления таких станков.

Ключові слова: модернізація, ремонт, доцільність відновлення, методи ремонту, вторинний ринок, великогабаритні верстати.

Стаття надійшла до редакції 25.05.2018.