SCIENCE REVIEW. – 2012. -№2(10). – P. 21-27

THE EXPERIENCE AND THE PROBLEMS IN IMPROVEMENT OF TECHNICAL LEVEL AND ECONOMIC EFFECTIVENESS OF AGRICULTURAL MACHINERY

Kanaev A.T., Nukeshev S.O.,
Zhusin B.T., Milokumov V.S.

Abstract

The tasks of raising the technical level and economic efficiency of agricultural machines require that in assessing costs effectiveness of service time increase designer organizations and manufacturers were guided by the absolute priority of operational (end) technical and economic indicators instead of the industrial (intermediate). This will allow the full use of modern means of increasing wear resistance and durability of the working bodies and get significant economic effect.

Key words: durability, wear resistance, tests, reliability, material consumption, agricultural machines, hard alloy.

Material and technological aspects of the problem are considered in many publications on the wear resistance and durability of working bodies. This is because high wear resistance of the material is required (with some exceptions) for ensuring durability of the parts exposed to wearing. But this condition is not sufficient, since the resource of details is determined not only by the intensity and amount of wear, but to a great extent by the nature of its distribution, affecting the quality of its performance. As a result, it is not durability of the material that matters, but durability of the construction in general, which ensures efficiency of the product. In this regard, the use of high wear resistance materials does not guarantee prolonged life of details, unless combined with optimized values of the parameters that define structural durability.

Increase of working bodies' durability is a part of the overall problem of raising durability of agricultural equipment, but the goals, solutions and the importance of the tasks related to the machines themselves and their working bodies are different. The cost of working bodies contribute to a small part of the total costs of farm machinery and the maintenance of their working order, but the wear of these parts has decisive impact on the quality of processes conducted by these machines. Losses due to parametric failures resulting from wear of working bodies are not comparable to their cost that justify almost any expenses to increase the wear resistance of working bodies. The latter are tools, not spare parts for machines, although they are included in the nomenclature notebook, and acquisition costs are accounted when calculating the average expenses to determine the optimum lifetime of the machine.

The task of raising the technical level and economic efficiency of agricultural machines require that in assessing costs effectiveness of service time increase designer organizations and manufacturers were guided by the absolute priority of operational (end) technical and economic indicators instead of the industrial (intermediate). This will allow the full use of modern means of increasing wear resistance and durability of the working bodies and get significant economic effect [1].

In abroad agricultural engineering firms take full responsibility for the condition of machines for the whole duration of their service and communicate with agriculture through middlemen distributors and dealers. Distributors serve a wide agricultural region, where a number of dealers operate (UK). The U.S. dealers also vary in scale totaling to more than 16 thousand. Company «John Deere», for example, has ten regional offices for sales and service incorporating 2,600 dealers. The company «International Harvester» has 2500 dealers in the United States assisting in the sale, maintenance and repair of agricultural machinery in nine zonal centers [2].

One of the most important functions of dealer firms is information about all the shortcomings of machines that emerge in the operation and repair. This allows the firm to quickly adjust the design or manufacturing of machines, taking into account features of their work, depending on the natural zone, improvement proposals of farmers and dealers. Thus, communication between engineering companies and machines' operators is effective, especially as the dealer represents only one company and is actively involved in the improvement of technology, strengthening the position of the company in the competition.

System COFEC (Cause of Failure, Effect and Corrective Action) is characterized by high efficiency), it is widely applied abroad. Firms improve their products for the benefit of the consumer and in this way strengthening their positions on the market. The presence of fast-acting feedback between the spheres of production and operation of machines allow firms to invest more in improving technology, especially as farmers are suspicious of price reductions on the machines and working bodies, unless combined with the operational benefits.

The search for a compromise between the maximum profit and the interests of the consumers do not always end up with the best result for the latter. But when creating new machines firms plan their own profits as well as income of dealers and the economic effect of new products implementation by farmers. The approach to the quality of products was clearly stated by the President of «Allis-Chalmers» corporation: «The quality should be measured in terms of costs, revenues and profits."

One of the possibilities for the improvement of agricultural equipment is related to the diversification of agricultural engineering, when companies enter the new industry for themselves, becoming a diversified complex. It uses advanced technical solutions developed in the automotive, aerospace, defense and other industries.

However, it is common for foreign agricultural engineering to have a broad cooperation with companies in other industries. In particular, many large firms in England, the USA and several other countries do not develop their own production of metal intensive working bodies, placing orders for metallurgical factories, as well as small enterprises.

High quality of the products is ensured mainly by optimization and stabilization of technological processes. In most USA plants technical control departments are not subject to the production manager and their main is early detection of defects and taking actions for immediate elimination of causes. Quality control through field testing is considered to be ineffective, because it gives the belated information.

In the U.S., for a number of critical parts it is proposed to eliminate the control, also known as demonstrative, tests of reliability and to apply the system "Life Cycle Costing". This system regulates the minimum total cost of purchase and use of the product agreed with the customer, and the firm-supplier is committed to providing highly reliable products at the lowest cost over the life of products. Counting on these commitments and based on market conditions firm receives tangible opportunity to improve product design and production technology stability. The attention to the stability of product quality is indicated by rapid growth in the cost share of production automation and quality control in the total amount of investment for the purchase of machinery and equipment plants.

Production of certain equipment is carried out by relatively small plants where processes are not automated. In particular, production of plowshares is dispersed between eight factories; the nomenclature of these products is significant. Only "John Deere" company in its prospectus offers farmers plowshares of nine various types for tillage of different soils with varying modes of processing.

According to approximate average data in the U.S. 0.1 kg plowshares is spent for treatment of 1 hectare, while in Russia, and in domestic conditions - 0.327 kg. Accordingly, operating materials consumption of operation is more than three times lower for the U.S. plowshares than for the domestic, but the unit cost of these working bodies is comparable. [4]

Under conditions of high concentration of working bodies production in the domestic agricultural engineering complete automation of their production is an urgent task, without which it is not possible to ensure a high technical level of agricultural machinery. The main goal of automation is ensuring consistently high quality of products and cost reduction of manual labor. Cost of working bodies in this case will decrease slightly, because the cost of materials takes large share in it (up to 70-85%) and the share of labor in it is only a few percent (e.g., plow dumps - about 2.5%, which explains their low cost and quality).

Costs of working bodies' production automation should be paid off in the national economy in a very short period of time, mostly by productivity increase, decrease of downtime, lower fuel consumption and other benefits of a stable work of machines.

Well-developed structures with properly chosen materials and ways of strengthening should be subjected to the automated production. Special attention should be given to optimization of the heat treatment of steel and selection of hard alloys for various operating conditions of the working bodies.

From these data it follows that in order to ensure reliable operation of the parts the decisive factor is not the search for some special chemical composition of steels, but the use of stable heat treatment regime. In the selection of steel and hard alloys the main indicator should be properties that provide wear resistance and durability of working bodies, then availability of these materials, and only after that - the cost.

The difference in the prices of steel used in the production of agricultural machinery working bodies is much less than a possible difference in durability with optimal hardening technology. An even greater difference is between the increase in the cost of hard alloys and life time of hardened working bodies. With the right choice of material for wear resistant layer, which is especially important for the cutting working bodies, it is possible to achieve manifold increase in the resource of working bodies for a relatively small increase in cost, as the cost of hard alloy contributes to only a few percent of the total price of the product (for plowshares, for example, about 4 - 5%).

Brochures of foreign companies do not contain the sufficient information on application of hard alloys in manufacture of working parts of agricultural machines. It is known, however, that hard facing is applied in manufacture of ploughshares, cultivator blades, disks, rippers and similar items, and volumes of its application grow.

"Castolin-Eutectic", the company which was founded in Switzerland and has become international, has manufacturing enterprises and the centres of experts' preparation in 157 countries of the world. The company conducts works on surfacing wearing out details of various machines.

Research-and-production programs carried out by this company under the name "Teroplan" provide working out of technology of hardening of details with application of surfacing means and their implementation on the enterprise of the customer. It is noticed that the resource of details increases in 3-6 times. The company has experience of hardening of ploughshares, chisel plough points, knives and other working parts with application electroarc surfacing, and also a plasma and flame spraying.

The program "Teroplan" is a private variant of general system COFEC (Cause of failure, effect and Corrective Action) implemented in foreign mechanical engineering. The analysis of causes of failures which is carried out in agriculture by means of dealers, allows to find out sites of the accelerated wearing out of details and to offer ways of increase in their resource. Protection of these sites hard alloys coverings raises a resource of details several times. Wear resistance of details thus raises and self-sharpening maintenance is possible.

The program "Teroplan" is a private variant of general system COFEC accepted in foreign mechanical engineering (Cause of failure, effect and Corrective Action - a cause of a failure, its consequences and adjustment measures). The analysis of causes of failures which is carried out in agriculture by means of dealers, allows to find out sites of the accelerated deterioration of details and to offer ways of increase in their resource. Protection of these sites твердосплавными coverings raises a resource of details several times. Wear resistance of details thus raises and self-sharpening maintenance is possible.

The company "Bolide Wear Coatings" (USA) has developed a drawing method on working parts of a hard alloy powder hard alloy, sintered in the furnace. "John Deere" applies a method of arc surfacing a material on the basis of nickel. The university and the agricultural centre of New Southern Wales state (Australia) have tested hard alloys for hardening of duck foot sweep blades of chisel cultivators with use of a material on the basis of tungsten carbide, surfaced by oxy acetylene flame. Besides, sintered tungsten nickel alloy was tested which plates were soldered to blades by silver solder. Experimental alloys with the strengthened edges have surpassed in wear resistance the blades made of the tempered steel with 0,65-0,75 % of carbon, but hardening of all edge because of high costs has been recognized economically unjustified. The effect turns out only at hardening of the peak of blades without surfacing the wings (that confirms the influence of front parts noted above on deterioration of wings of blades).

Hard alloys considerably surpass steels in resistance to abrasive wear process, however their possibilities in manufacture of wearing out details in our country and abroad are not used enough. More than 70 % from total amount of hard alloys are spent in a national economy not in manufacture of details, but for their restoration.

A considerable quantity of hard alloy compositions and methods of their surfacing on a detail is known. The table presents the data about chemical composition, hardness and surfacing methods of the powder hard alloys accepted by member foreign countries for hardening of working parts of soil-cultivating machines. Structures of powder alloys and specifications are regulated by GOST 21448-75, GOST 14546-75, Tech spec 48-19-122-44.

A number of pseudo-alloys like ФХ30-У10Х18Г3Н3С4Д2Р (PS-15-30), ФХ60-У10Г3Н3С4Д2Р (PS-14-60), PS-3 (sormite + cast tungsten carbide), PS-4 (sormite + ferrochrome), PS-5 (sormite - 40 %, ferrochrome - 58 %, ferrotitanium - 2 %), PS-6 (white cast iron + ferrochrome) is also recommended for surfacing. For induction surfacing of working parts a number of alloyed cast irons is also intended, part of which is presented in the table.

Despite presence of the extensive nomenclature of hard alloys of alloyage various systems, now in agricultural mechanical engineering the alloys are used comparable in wear resistance with sormite-1 (PG-S1), developed more than fifty years ago. At factories mainly induction method of surfacing is used, which is highly effective, but requires keeping technological parametres in very narrow limits, in order to avoid overheat of a steel basis, burning out of elements and so forth.

Such methods of hard alloys surfacing as electrocontact cladding, plasma and gas-powder spattering, self-propagating high-temperature synthesis (SHS), freezing-out of liquid alloys, arc surfacing, a detonation method, laser surfacing, electrospark alloying and other methods, each of which can have certain area and application scales in manufacture of working parts, are insufficiently studied and have not received application .

Abrasive wear resistance of hard alloys is studied insufficiently; regularities of their resistance to wear process are developed much more poorly, than for steels, cast-irons, rubbers, plastic and some other constructional and tool materials. Dependence of wear resistance of hard alloys on their composition, structure, hardness, the modulus of elasticity and other properties, and also from technological parametres is insufficiently studied in the absence of unequivocal correlation between fusion mixture of a material with its properties acquired as a result of surfacing of this material on a detail. Technological factors, part of which depends on a material, the form and the sizes of a strengthened detail (a temperature mode, properties of boundary layers, etc.) strongly influence composition and structure of surfaced material. Only sintering of powders, in particular, using electrocontact method, in order to create hard alloy facing, properties of a material are with high certainty correlate with the initial material - its composition, the size of grains, structural uniformity.

Laboratory and field tests have shown expediency of application electrocontact cladding of hard alloys for hardening of working parts of soil-cultivating machines, in particular, ploughshares of sweep cultivators, cultivator blades, etc. Comparing materials, surfaced by an induction method and cladded by electrocontact method, it is established that electrocontact cladding method allows to receive the hard alloy more homogeneous for all indicators, including density, microstructure, hardness, wear resistance and, which is especially important for cutting details, a thickness of a coat layer. Electrocontact cladding method is highly efficient and safe (unlike induction), automation of cladding process is possible.

The analysis of domestic and foreign experience testifies to continuous expansion of volumes and a scope of hard alloys use in manufacture of working parts of soil-cultivating machines. Applying the cheap thermally processed steels of rational profiles and hard alloys surfacing, it is possible to provide agriculture with the economic machinery for soil cultivation completing all agrotechnical requirements. It is necessary to notice that the amount of a hard alloy makes a small part of detail’s total weight, in this connection its cost has no essential value in comparison with major factors - availability of fusion mixture, wear resistance and durability of a received surface. So, the hard alloy for surfacing of one ploughshare costs 27 tenges (4.0 % from ploughshare cost) and if it is required to apply an alloy of the raised wear resistance the price cannot serve as an obstacle for its use.

For the further development of hardenings of details with hard alloys it is necessary to create a uniform evaluation system of known materials properties and methodical basis for research of new wearproof compositions on the basis of raw materials availability. Questions of constructional wear resistance in a direction of increase of a resource of the strengthened details - for increase of wear resistance and self-sharpening maintenance demand the further development.

The technology of hardening with hard alloys needs improvement, first of all - induction surfacing technology, and development with application of progressive methods of hard alloys surfacing - electrocontact cladding, plasma spattering, etc. Development of manufacture of the powder tapes is also necessary, which application will facilitate development of the automated technological processes of working parts hardening.

The specific requirements for durability and wear resistance have great influence on the organization and the economics of working bodies' production. The main requirement is to keep the changes in cultivation parameters within the limits set by agronomical practice during the predefined operating period, preferably equaling or multiple of seasonal norm. The task of production of durable working bodies must not be set against the task of reducing their costs because of the small savings at the factory in comparison with the possible loss of yield loss when using short life working bodies.

High production efficiency of agricultural machinery will be achieved with such a system of evaluation of manufacturers' economic activities, which will take into account the final results of the use of machines and their working bodies. Fundamental qualitative changes can be achieved in their production if the plants get the part of the effect produced in the agricultural sector as a result of increasing wear resistance and durability of the equipment. For the formation of the feedback in the "plant - field" system, which can serve as an effective managing factor, it is reasonable to organize government control areas with well-established accounting of working bodies consumption.

It is desirable to organize control areas within the administrative boundaries of regions, which will allow use of regional CSO bodies for statistical reporting on the resource of working bodies and regional agricultural authorities - to provide information on the causes of working bodies' performance decrease. These data will allow at the end of each agricultural year to objectively assess the performance of the manufacturer for the period and will encourage rapid implementation of effective technical solutions to improve the durability of working bodies. In case of negative results by the end of year, manufacturers will be subject to sanctions, corresponding to the damage to national economy.

The representativeness of the assessment and its statistical nature will ensure reliable communications between the production and operation of machines, without which a modern quality management system cannot achieve the desired level of performance.

Table 1 - Surfacing powder materials on an iron basis for hardening of working parts of soil-cultivating machines

Country	Material	Chemical composition, %						Hardness, HRC*	Surfacing method**
		C	Cr	Si	Mn	Ni	Other elements		
Russia	PG-S1	2,5-3,3	27-31	2,8-3,2	0,4-1,5	3-5	-	51	I, P
Russia	PG-S27	3,3-4,5	25-28	1-2	0,8-1,5	1,5-2	W -0,2-0,4	53	I, P
Russia	PG-AN1	2-2,8	26-32	1,5-2,5	0,5-1,5	-	B-1,2-1,8	54	P, GP
Russia	PG-FBH6-2	3,5-5,5	32-37	1-2,5	1,5-4	-	B-1,3-2	52	A
Russia	PS-14-80	5,2-7,4	49,0	2,6	0,3	0,3-1,0	B-0,04-0,18	60	I
Russia	PS-14-60	4,0-5,7	35,7	2-3	0,7	0,7-1,8	B-0,1-0,32	57	I
Russia	PS-15-30	2,3-3,8	28,0	2,5-4,0	1,3	1,3-3,0	B-0,2-0,53	52	I
Russia	KBH	4-6	42-52	0,5-1,4	-	-	B-0,7-0,9	60	A
Russia	BH	0,3-1,0	35-44	0,5-1,0	-	•..	B-7-9	63	A
Russia	C-2h	7-10	24-26	0,5-3,0	6-8,5	-	-	54	A
Germany	MPA564	2-2,5	24-30	1,1-1,3	0,5-0,9	12-14	FeCrSi-10-40	60	I
Germany	MPA550	4,5	45	1,0	-	-	B-2,0	60	P,A,GP

Note:

* Lower hardness limits

** Surfacing methods: I-induction; P - plasma; GP–gas-powder; A – Arc with nonconsumable electrode

References

1. Chernoivanov V.I., Blizkih V.V., Severny A.E. et al, "Maintenance and repair of machinery in agriculture". Moscow-Chelyabinsk: GOSNITI, CHGAU, 2003-992 p.
2. Kurchatin V.V., “Reliability and repair of machines”. M: Kolos, 2000.
3. Chernoivanov V.I., Cherepanov S.S. et al, “Scientific basis of technical operation of agricultural machinery”. M: GOSNITI, 1996.
4. Kepner R.A., Bainer R., Barger E.Z. Principles of Farm Machinery. The Avi Publishing Company Inc. – Westport, Connecticut, USA, 1992.