Post-production lifecycle phases of the fifth technological paradigm based heavy equipment vehicles

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Abstract. According to the current data Russian Federation is using the considerable amount of outdated heavy equipment vehicles of the third and forth technological paradigm. Some of these heavy equipment vehicles are being used for more than ten years already. At the same time the developed countries have successfully implemented the fifth technological paradigm and are currently advancing towards the sixth technological paradigm. The government of Russian Federation made a decision to improve the capabilities of the heavy equipment vehicles with the benefits of the fifth technological paradigm. This approach requires manufacturers to implement new technologies in product life management including update to the system of technical support to incorporate international standards.

Technological setup (TS) is an integral sustainable formation, within which there is a closed circle starting from the mining and getting the first resources and finishing with the ready-made products output, corresponding to the society demands at the certain moment of time.

Nowadays the world community has formed five [1] and has entered the sixth TS. Reduction of every next TS cycle length is related to attracting all economical and intellectual resources available by the technically developed countries. The USA being a leader of the technological “race” invests 10 times more in technologies development than Russia does, and already manufactures and uses machines of TS VI [2].

This shift is considerably connected with the development of information and communication technologies at the end of the XX – beginning of the XXI centuries. Back in early 2000s the structure of active part of main American funds was the following: IT equipment – 26,5 %; processing machinery – 34,8; transporting – 19,6; other – 19,1 %. That was the moment when Russia ceded the leadership to other countries and still produces and uses mobile machinery of IV TS.

Russia, having “restructuring” at that moment unlike the USA and other leading countries, has stopped at the TS IV and is late for the whole TS, i.e. for 40 years. Nowadays Russian industry is late in the pace of development and implementation of technologies and machinery of TS V and is only starting to adopt leading countries experience [3].

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Russian government takes some actions to change the situation in these industries by developing Strategies of their development till the year 2030. The main idea of these Strategies is to develop and use Russian machinery of TS V.

Herewith, the expected results of their implementation are the following: growth of Russian mechanical engineering production, machinery export growth and intensive renovation of heavy equipment vehicles.

Increase of workforce productivity and TS V machinery economic indicators is supposed to be done by automation of production and lowering the impact of human factor, by implementing robotics, using remote monitoring systems as well as systems of technical control and diagnostics.

It is worth noting here that the main attention of the authors of these Strategies for mobile machinery is focused on the requirements for its production only, i.e. one of the stages of its full life cycle. However, according to international claims machinery producers are nowadays responsible for taking part in all the stages of their products life cycle (PLC) including operation and technical support. Although the Strategies do not contain these areas of machinery producers activity.

This approach was typical for Soviet period when the main investments were directed to form production capacities while postproduction stages — maintenance and repair work — were financed residually.

However, TS V is characterized by the changed customer requirements for the production especially for the complicated equipment. Nowadays consumers buying highly productive (and rather expensive) machinery make serious demands on the process of its usage: on reliability targets, technical support in both guarantee and post-guarantee periods, and even on the processes of its utilization after shut down. These consumer requirements are reflected in the international and national laws, rules and regulations. Machinery producer is now responsible for almost all stages of the product life cycle including post-productive.

Foreign machinery manufacturers pay equal attention to formation of post-productive stages of PLC (organization and technologies) used in the sphere of technical support of TS V as well as to the processes of its development and production. It is connected with the fact that the lack of such attention may be a reason of reduction in competitiveness and consumers demand. Nowadays the admitted way of technical support for such machinery is the reduction of failures remedy time while operation. This time is estimated now not as days but hours. To ensure such pace and provide technical operations in time, we need a higher level of staff competence, workers who are able to use technological basis professionally at all post-productive stages of PLC.

It is common knowledge that Russian manufacturers of mobile machinery lag behind foreign colleagues in these issues. This delay can bring to naught all their success in creating and producing machines of TS V. Russian producers are required to develop and implement a new concept of forming an engineering sphere, highly qualified personnel of which will use corresponding technologies and provide the accordence with international and national customer demands regarding post-productive stages of this machinery life cycle. There is no such a concept yet.

The situation is hard because the direct transfer of such work technologies applied in leading countries to Russia is impossible nowadays. At the moment Russian machine producers are not able to create a competitive system of technical support for their product.

There are many reasons for that. One of the reasons is difficult economic and technical condition of enterprises manufacturing mobile machinery. It determines to a considerable extent the lack of attention from machine producers to post-productive stages of PLC.

Unlike Russia, mobile machines producers from the USA, Germany, Japan and other countries created highly technological enterprises providing mass production of machines TS V as well as highly productive system of engineering enterprises for the new TS. Both types of enterprises closely cooperate with each other, providing customers with not only “smart” machines but also high-tech operational service, maintenance, repair and utilization.

Foreign post-productive enterprises use the highest technologies including distant condition monitoring. A lot of attention is paid to the development and implementation of efficient utilization
technologies for the retired facilities (RF). Economic basis for creation and maintenance in good operating condition of the enterprises included in this sphere is mainly formed by the utilization fee for the produced machines taking into account both government institutions and manufacturers themselves.

Another reason for this situation is hard economic condition of the industries using mobile machines (agriculture, forest industry, etc.), which are forced to use a wide variety of machine types from different TS. A considerable part of these machines has run its course. For instance, tractor forces of agro-industrial complex (AIC) is nowadays of around 470 thousand items, however according to the calculations of Federal scientific agroengineering center VIM its number must be at least around 900 thousand [3]. Furthermore, the majority of tractors (67%) is operated during 10 to 17 years [4]. A small number of machines that corresponds to TS V are mainly foreign. Other branches of industry are facing similar problems.

Consumers do not get almost any kind of technical support services from manufacturers. A lot of foreign equipment operated in Russia is used beyond warranty periods and also is not provided with such service. Technological support of enterprises providing such services does not allow them to perform various technical implications abiding legal requirements, which is mainly absent on the majority of such enterprises. All this leads to aging of machines and its further decrease in efficiency.

Foreign expertise shows that one of the most efficient ways to renovate mobile machines park and to stimulate the demand on them is timely utilization of RF. To implement this way machine manufacturers in leading countries (with the participation of government institutions) for more than 20 years there are national systems of RF utilization – it is an efficient organizational technological mechanism based on the mutual cooperation of all participants of this system. In this system the ministerial duty is held by the enterprises carrying out all the activities concerning post-productive stages of PLC, including its utilization. These enterprises provide a solution for a number of important state tasks including: machine park renovation, increase in demand for new machines, ecology, cost-effective use of resources, creating new working places etc. The majority of such enterprises are created in the basis of service centers of mobile machines manufacturing plants and its revenues are comparable to those of machine producers.

The conditions to create such a mechanism in Russia are being formed now. In 2014 in addition to The Federal Law 89-FL from 24.06.1998 “Production and consumption waste” the utilization (ecological) fee for mobile machines (art. 24.1), as well as responsibility of manufacturers to utilize produced vehicles after its retirement (art. 24.2) was introduced. This law forces manufacturers to utilize machines themselves or by using special enterprises to perform this work.

It is worth noticing that Russia has chosen not the most efficient option of economic support for this system of RF utilization out of the three being used in Europe as shown on figure 1 [5].

This option is based on using funds from utilization fee. However, system management and development functions are retained by the state.

But despite the fact that utilization fee for mobile machines has been filling the state budget for 3 years already, there are no works on control the RF utilization system on the state level yet. And this is the third reason making the process of creation and usage of V technological set up machines in Russia very complicated.

Nevertheless, scientific community at the beginning of 2000s after thorough studying of foreign expertise in creation of TS V machines have tried to adapt this experience for Russian conditions. Herewith, there is a change in priorities to closer cooperation between manufacturers and consumers of mobile machinery by creating a solid “bridge” in their relations as an engineering sphere of a new format which is to increase the role and quality of works on the post-productive stages of machines lifecycle including its technical support and utilization. The research in agro-industrial complex (AIC) in this sphere has been conducted for more than 15 years already. The main organizations studying the issues of RF utilization in AIC are Russian State Agrarian University - Moscow Timiryazev Agricultural Academy, FSAC VIM, Voronezh State Agricultural University, FSUE “NAMI” etc. The specialists from forest industrial sector have also been involved in this work: TSNIIME and Mytishchi branch of Bauman Moscow State Technical University.
In this context the issues of technical maintenance and repair with the use of IT technologies with regard to mobile machinery of TS V as well as utilization system formation are being studied [6].

![Figure 1. Options of economic support for RF utilization system in Europe.](image)

First commercial samples of TS V mobile machinery were prototyped and produced already in 2019 [7, 8].

This machinery is inconsiderable in number yet but principles of its organization and technology of its production and usage are completely different from those being used now with TS IV machines in AIC. The main peculiarity of this machine is that a consumer will be totally dependent on the level of manufacturer’s participation in the process of its operation. It is defined by both the complexity of mechanical part and difficulties of telecommunication equipment, which is considerably define the quality and efficiency of its functions performance.

However, “the bridge” between the manufacturers of TS V machinery and their consumers is very fragile yet and requires instant reinforcement. The absence of engineering enterprises able to perform operations on the post-productive stages of PLC of TS V and TS IV effectively is an underestimated risk ignoring which can lead to unfavorable consequences and Russian machine engineering underachievement.

This is related to the fact that in the following 10-15 years “old” machinery will still be operated and gradually retire and become utilized. If we take only AIC, there will be necessary to utilize more than 500 thousand tractors i.e. around 50 thousand items per year. By this moment machines of the TS V will have been retired too and will require utilization.

Herewith, to reduce maintenance costs for “old” and “new” machines it will be possible to use suitable and restored parts of machines being utilized.

As the research done at FSAC VIM showed, the most suitable option to solve these tasks at the post-productive stages of complex machinery life cycle is development and implementation of industry-based systems of RF utilization using technological and intellectual potential of engineering enterprises in every branch of industry [6], which will be the link between the manufacturers and consumers. Combination of these industry-based systems will allow to form a National system of waste utilization and will facilitate the solution of the problem with waste utilization in Russia in general.

The conducted research of possible shift of industry to TS V as well as tasks to be solved allows to make a conclusion about the importance of creating an efficient mechanism to perform works on a post-productive stage of PLC of machines both new TS and being used now. Groundwork of this mechanism must be done by manufacturers at the design and production stages and must be implemented with their participation in operation of new machinery. Undoubtedly it will require a certain amount of investment.
There is a possibility of a transition period during which the rotation of new and old machinery will take place. There is no such a period in legislative framework and it will happen spontaneously. This will lead to considerable economic loss meaning losing secondary resources from retiring facilities as well as ecological damage by the waste from non-utilized (or utilized in non-compliance with the ecological norms and standards) machinery. Moreover, if the above mentioned mechanism is not created in the nearest future, these problems will enlarge upon the new TS machines.

The only way to escape losses in this period (and to reduce its length) is an instant shift of State technical policy to solve these problems on the post-productive stages of complex machinery life cycle.

Potential ways of investing works to provide such a shift can be found as a utilization (ecological) fee intended to form the utilization system of RF. Nowadays only a small number of these resources is used to support machine manufacturers including partial compensation of expenditures related to production and guarantee duties for highly productive mobile and towed machinery (Decree of the Russian Government from 16.05.2016 No 416, 417). However, utilization is not included in the guarantee duties of machinery manufacturers which allows them to avoid this utilization issued while this responsibility id stated in the law, article 24.2.

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