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ARTICLE

THE CONCEPT OF LEAN MANUFACTURING IN GEOLOGICAL EXPLORATION ACTIVITIES

Elvira D. Khisamova*, Leyla I. Khasanshina, Irina A. Kodolova, Guzel M. Hasbiullina, Irina M. Solodkova

Dept. of Management, Economics and Finance, Kazan Federal University, Kazan, RUSSIA

ABSTRACT

Maintenance of geological exploration and the preparation works it requires is particularly interesting and topical issue nowadays. Total Productive Maintenance is a necessary part of efficient production in geological prospecting. Total Productive Maintenance (TPM) can be used to ensure reliability and serviceability of geological exploration equipment. It is said to be one of the tools of lean manufacturing. The TPM system is aimed at increasing the efficiency of equipment and reducing maintenance costs. The following factors significantly affect the cost of exploration: the introduction of new and modernization of existing production assets; strict following the established sequence of geological prospecting according to its stages and sub-steps; the quality of geological survey designing; territorial location of geological exploration; organization of supply of geological exploration enterprises; natural conditions; the level of prices for material resources and the level of wages. The main ways to reduce the cost of exploration are related to the improvement of drilling equipment and technology, production and workforce management.

KEY WORDS
production enterprise, efficient production, lean manufacturing, costs, Total Productive

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***Corresponding Author**
Email:
ERTagirova@kpfu.ru

INTRODUCTION

In current economic situation, well-organized production process is said to be the key to success of enterprises. To achieve the efficient level of production it is necessary for every staff member to fully understand his responsibilities throughout the whole process of end product cost determination in accordance with the requirements of all stakeholders.

The development of production relations has an impact on the modernization of management systems. Lean production concept is a tool that allows to achieve a high level of production system development, as well as to increase its efficiency. One of the main objectives of the system is to reduce costs and to manage the production enterprise, basing on elimination of all types of losses. The main aim of lean manufacturing is not to reduce costs, which could subsequently lead to a decrease in product quality but conversely to reduce the losses that exist in each workplace [1].

In practice, it is difficult to identify the losses if their nature is not absolutely clear. Moreover, all losses are connected with each other, and the concept of redundancy is of relative nature. Therefore, the problem of identifying the losses becomes very debatable as employees couldn't decide at once what can be regarded as losses. Practice shows that at the beginning enterprises are guided by seven typical types of losses, and then develop their own loss scheme that is understandable and convenient to work with. For example, in geological exploration enterprises, losses could not be represented in their classical version, they have their own peculiarities. The losses associated with overproduction are mostly of indirect nature. These might be the losses appeared due to drilling more wells than actually required in case the technology was more accurate; excess of processing areas; additionally taken samples (also associated with losses due to excessive processing). The most significant losses in geological exploration are: the loss of time (wait-on-cement time; delivery expectation time, equipment and water supply; the time between the stages of procedures (the sequence of procedures often requires time) [2].

Losses due to excessive transportation arise in geological exploration as well. For example, when it is necessary to have constant water supply while drilling wells. According to environmental requirements, it is prohibited to use water from many surface sources, therefore water carriers are used, consequently, this is accompanied by additional costs. The location of geological sites and transportation of machinery and pipes also lead to the increase of overheads. Losses associated with stock surplus occur when the bulk solids consumed in drilling are not used completely. They remain unused and are stored in warehouses, so, new lots are ordered. This leads to inefficient consumption of supplies and additional storage costs. These overheads include the costs of unused equipment maintenance [3]. Excessive movements connected with the logistics of drilling sites, the locations of workshops and warehouses require extra spending.

Losses associated with defects can be due to non-compliance with technology and ignoring the stages of wells drilling. All these would require reworking and additional checks. There may also be an overload of equipment and people involved, uneven work related to climatic and geographical factors, transportation of equipment. These losses must be eliminated in order to reduce geological exploration costs and obtain the maximum profit [4].

Initially, lean manufacturing originated in car manufacturing, which is said to be more standardized industry compared to geological exploration. If an enterprise manufactures products, then there must be a

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certain algorithm of actions aimed at obtaining the final product. In this case, lean manufacturing will help optimize processes that add value to the consumer, as well as shorten the time for processes that do not bring value but meet customer needs and have no risks [5].

From our point of view, the use of lean manufacturing tools could be the simplest solution that allows us to significantly reduce losses, constantly improve the whole range of business processes, increase the transparency and manageability of the organization, use the potential of each employee of the company, increase competitiveness and obtain a significant economic effect without bearing large financial inputs.

METHODS

To ensure the reliability and serviceability of geological exploration equipment, there can be used Total Productive Maintenance (TPM). It is one of the tools of lean manufacturing. The TPM system is aimed at increasing the efficiency of equipment and personnel, decreasing the number of breakdowns and reducing maintenance costs. The ability to repair equipment in no time can significantly reduce production downtime.

General maintenance of equipment is a necessary part of efficient production in geological exploration because preventive repair work can save the company from accidents and respectively, from additional costs and downtime. The quality of planning plays a key role in the course of scheduled actions as it is necessary to analyze a lot of different information, both on the statistics of equipment breakdowns and on the parameters characterizing the condition of the equipment at the moment.

The quality of repair planning is influenced by the logic of fault management processes and the correctness of the forms filled on repair request and many other factors. Unscheduled work is in charge of taking actions to recover from accidents connected with equipment. This can happen if the planned repair did not remove all possible risks, and the breakdown occurred in the long run. In this case, it is necessary to repair the equipment as quickly as possible, eliminating the downtime of the work team and ensuring continuity of work [6].

Furthermore, maintenance staff together with operating workers have to develop regulations for conducting autonomous maintenance by operators, indicating the scope of work, periodicity, control methods, tools and materials used. It concerns all types of equipment. Additional visualization of the equipment is achieved by using magnetic cards. Throughout the repair process or the exploitation of the equipment, the card is fixed to a special magnetic board.

The most reliable type of repair work is scheduled maintenance. It implies the priority of maintenance and repair of critical equipment, for example, if the time of the scheduled service life has expired - the equipment must be replaced, even though it can still work. Using this approach, almost all company's equipment would be repaired but the company's costs rise. That's why this approach can be used only for critical equipment, the breakdown of which can lead to downtime and cause big losses. Equipment like trailer cars should be repaired according to the maintenance plan due to the actual condition of the equipment, i.e. it is necessary to control the work of existing equipment not waiting for its breakdown, replace it basing on the deterioration of its parameters. The implementation of repair work under this scheme reduces reliability but at the same time decreases the costs comparing to the first option. At the same time, it should be noted that the second approach requires profound monitoring system.

The following activities are carried out during the period of preventive maintenance (PM): control over the admission of repair teams to work; identification of unproductive time losses; implementation of proposals for improvements in the production cycle; development of detailed equipment repair schedules, indicating the planned start and completion of work; organization of operative elimination of the situations arising in the period of PM and leading to an increase in the duration of equipment repair; carrying out a comparative analysis of the implementation of the main repair stages, which helps to use working time properly and not to make the same mistakes in the future [7].

Overall Equipment Effectiveness (OEE) is a key indicator in the TPM methodology. It reflects hidden opportunities, reveals the potential for improving equipment and processes' efficiency. At the same time, OEE does not estimate the efficiency of the repair service. This indicator is influenced both by the production processes, and by the maintenance and exploitation of the equipment. This indicator is a measure by which the productive share of the planned production time is determined.

RESULTS

As We have formed a list of equipment that requires special attention, in terms of its readiness for work, productivity and quality. Observation of the OEE value was taken as a conventional starting point. Having found that OEE value is different from the targeted one (for example, it decreased compared to the previous period), it is necessary to determine what this decline is explained by.

Data collection for OEE calculation begins with recording the downtime periods of all equipment. It is accomplished by filling in a special form and aims at identification and careful analysis of the loss of

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efficiency and productivity with a view to their further elimination. Further, the head of the drilling shop performs calculation of the OEE indicator and analyzes the losses in the operation of equipment and processes. Basing on OEE data, it is concluded whether it is possible to improve performance of the existing equipment or whether its capabilities have actually exhausted and new equipment is needed. [Table 1] lists the equipment for which the OEE is calculated as well as their service life and the value of the OEE indicator.

According to [Table 1], it can be concluded that most of the equipment has a combined score of all OEE criteria, that equals 75-80%. It is considered quite typical for this type of equipment and exploration enterprise in general. It should be noted that there is tendency for improvement. Another part of equipment has an OEE value of 90-100%, which indicates high-quality operation of the equipment, high speed and performance without accidents and stops.

Geological prospecting is less standardized industry and each case of forthcoming works is unusual and has its own peculiarities. Firstly, it is the presence of many non-permanent factors, which are either impossible to influence, or it would be very costly to do. Among them: prominence, climate, water supplies, habitable areas, population density, transport development, energy supply, etc. Secondly, the cost structure of prospecting, exploration wells and deep exploration wells construction for specific areas and purposes varies significantly.

Moreover, time-dependent expenses prevail in all cases. Therefore, the main way to reduce drilling costs is to increase the speed of drilling. The reasons influencing the speed of drilling: delivery; equipment and machinery supply; water supply; breakage of equipment; inefficient logistics, etc.

Table 1: The overall efficiency of the main production equipment as of 10.12.2016

№	Type of equipment	Inventory number	Production date	Year of commissioning	OEE index
1	Tire changer Sh-514	649	2007	01.12.08	75
2	Grinding machine 3K634	664	2008	01.12.09	75
3	Edging and cutting machine OOC	667	2007	01.12.08	75
4	Woodworking circular saw TsB6-2K	681	2007	01.12.08	75
5	Woodworking machine SFb-1	9683	2005	01.12.06	75
6	Milling cutoff machine 8G663-440	9666	2005	01.12.06	75
7	Woodworking machine D300	9682	2005	01.12.06	75
8	Tire changer Sh-515	9650	2005	01.12.06	65
9		9668	2005	01.12.06	70
10	Compressor station PV-10	9577	2003	31.12.04	65
11	Vertical drilling machine 2K522	955810	1996	01.08.97	75
12	Screw-cutting lathe16V20	961120	1999	01.10.00	75

The main factors that have a significant impact on the cost of exploration include: the introduction of new production assets and modernization of existing ones as well as progressive technology of wells drilling in accordance with geological and natural conditions; strict adherence to the stages and sub-steps of geological prospecting; the existence of a sound methodology for the production of geological exploration, which influences both the geological results and the size of costs; the quality of geological task performance, the strengthening of technological discipline and the establishment of strict quality control; the quality of geological survey design; territorial location of geological exploration; organization of supply of geological exploration enterprises; natural conditions; the level of prices for material resources and the level of wages. The main way to reduce costs is the improvement of drilling equipment, technology, production and labor management.

SUMMARY

Thus, the concept of lean production in geological exploration is described by eliminating identified losses, increasing labor productivity, improving quality and the organization procedures of geological exploration. Throughout the research we came to the conclusion that the organization of works on the application of universal equipment maintenance in geological prospecting is said to be very topical issue and provides special interest.

The main risks that can arise in the process of implementing TPM are high costs, mainly connected with preventive actions and the possibility of technical errors due to the lack of qualifications of production workers in this field. Opportunities, which TPM provides are: the reduction of costs for equipment maintenance; increasing the productivity of equipment; improvement of interaction between employees of production, maintenance and repair units; reducing response time to emerging problems; reductions of equipment downtime.

Thus, the organization of the work with the help of TPM aims at:

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- prioritizing the equipment on the basis of negative impact it could have due to breakdowns;
- drawing up algorithms for scheduled repair works and failures fixing time depending on priorities of equipment;
- synchronization of planned and urgent maintenance activities;
- synchronization of repair works with the purchase of spare parts and accessories, as well as with the accomplishment of work;
- control of existing processes of TPM.

In addition, it is necessary to pay attention to the improvement of planning which includes, first of all, the preparation of repair schedules.

In our opinion, the most efficient ways are: to use the network method in organizing scheduled maintenance; to provide systematic control and adjustment of regulatory framework of preventive maintenance systems, considering all internal and external factors.

CONCLUSION

Further improvement of preventive maintenance systems concerns the importance of its adjustment due to the specificity of geological exploration. For example, if the equipment is located outside the base, it would be difficult to conduct preventive maintenance. The main attention should be paid to preventive measures, maintenance of equipment but not to its repair. It is necessary to discuss the possibility of not fixing obsolete and outdated equipment but replacing it with the new one.

It is possible to reduce the time used for repairing if there is a scheme for this kind of work. The scheme might include the following sequence of steps: long-term planning and careful preparation for preventive maintenance, management and supervision of equipment repair, the repair process itself and quality control. The scheme of actions provided by operational repair team could ensure an objective evaluation of the work performed and to identify possible deviations from the plan in advance. The main thing is to control the compliance of preventive maintenance schedules. Constant analysis of schedules allows to react quickly to any change and take appropriate measures to prevent possible backlog. It is also necessary to analyze the performance of repair schedules, finding out the reasons for their non-fulfillment, and so, develop measures on mistakes correction basing on the results of the analysis. Overall Equipment Effectiveness is an indicator that gives an objective assessment of the state and performance of equipment (processes). OEE takes into account all losses (loss of time, loss in speed and loss in quality) leading to the result of measuring the real efficiency of the equipment. Thus, with the use of TPM in geological prospecting, it is possible to cut the number of breakdowns and malfunctions of equipment, to increase the period of its operation; to enhance the volume of geological exploration work; to optimize of stocks; to reduce the likelihood of harm to workers' life and health.

CONFLICT OF INTEREST
There is no conflict of interest.

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