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Development of the enterprise process management system based on «Total Productive Maintenance» («TPM») technology

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ABSTRACT

The article considers the production process at the industrial enterprise of “GAZvtorresurs” LLC and identifies its main problems and existing losses. For this purpose, the downtime of the equipment on the plastic casting line was identified and measures for the implementation of "Total Productive Maintenance" ("TPM") were proposed.

The research conducted by the authors suggests the efficiency of production management today is an integral part of any industrial enterprise which seeks to achieve maximum efficiency from its work in accordance with its goals.

Key words: Total Productive Maintenance, TPM, production process, efficiency, production control.

1. INTRODUCTION

The most important element of the enterprise's work in up-to-date conditions is the organization of production, which, first of all, includes the most appropriate combination of basic technological processes, auxiliary services, as well as service links, which ensure the effective use of labor tools, labor items and labor itself to meet social needs for products and maximize profit.

To achieve the above-mentioned objectives of enterprises and organizations, managers must be able to find rational ways to increase the work efficiency, improve the working conditions, improve the quality of products, increase labor productivity, and have an idea of the system of measures developed at the enterprise with the aim of intensifying production based on scientific and technological progress [5]. Therefore, studying the basic forms and principles of production organization in enterprises of various forms of ownership, as well as the main elements of production planning, including intra-company planning, is an obligatory for ensuring the effective development of enterprises.

The issues of organizing and improving production processes in their researches were considered by such national scientists as A.P. Agarkov, M.I. Bukhalkov, A.M. Golikov, R.S. Golov, A.A. Goryushkin, I.N. Ivanov, N.I. Novitsky, M.P. Pereverzev, M.V. Radievsky and many other national and foreign scientists.

2. RESEARCH

Analysis of the production process and efficiency of equipment use will be carried out on the data basis of LLC "GAZvtorresurs".

The company LLC “GAZvtorresurs" develops a program for the production for each month. In November 2018 - March 2019, there was a significant increase in production volumes due to an increase in the customer's plan.

As it could be seen from Table 1, the output was increased by 2.16 times to 45,581 units.

Table 1 - Production volume on two plastic casting lines in November, 2018 to March, 2019

Machining line	Production volume, pc.				
	Nov.18	Dec.18	Jan.19	Feb.19	Mar.19
Line 1	10 835	14 575	13 484	20 457	27 443
Line 2	10 250	19 165	19 086	21 518	18 138
Total	21085	33 740	32 570	41 975	45 581

From Figure 1, a slight decline in production volumes on both lines in January, 2019 could be seen. This situation was caused by the shutdown of equipment to carry out preventive work, painting machines and cleaning them.

Figure 1 shows the dynamics of production volume on two plastic casting lines in November, 2018 to March, 2019.

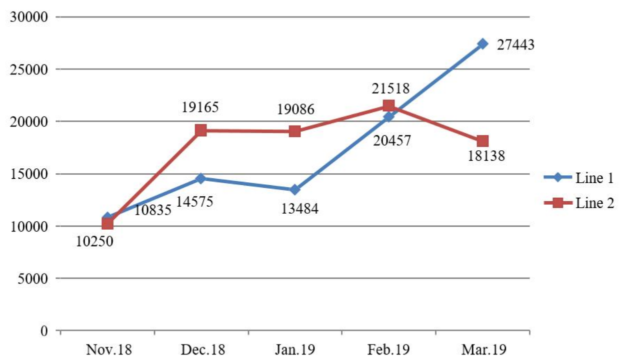

Figure 1 - Production volume on two plastic casting lines for the period from November 2018 to March 2019

The number of units produced on line 2 by 5915 pcs in December, 2018 is more than in November, 2018. It is due to changes in customer volumes (changes in changes are agreed in the terms of the contract). In March, 2019, the decline in production volumes on line 2 was due to a breakdown in the engine of the “Battenfeld” equipment. Due to the absence of this spare part in the warehouse and the preliminary placement of an order for it, line 2 was completely stopped for three days (this equipment is the first during the plastic casting process) [2]. During the order and delivery of the new knock-out grille from Germany, it was decided to switch to an alternative solution: work using one knock-out grille (since the second knock-out grille did not function due to engine failure), which led to the start of the line with increased cycle time.

We will analyze the dynamics of equipment downtime between November, 2018 and March, 2019 on both plastic casting lines. On line 1, the most standstill time was recorded on the “Battenfeld” VA 1500-630 VK equipment of the German company. The main reason is errors in the program and the inability to quickly repair, and the installers do not have the necessary competencies to quickly correct the error. Let's take a closer look at the down time dynamics of the plastic casting equipment on line 1, as shown in Table 2.

Table 2 - Dynamics of equipment standstill time for plastic casting on line 1 for the period of November, 2018 to March, 2019

№	Equipment	Standstill time, min					
		Nov.18	Dec.18	Jan.19	Feb.19	Mar.19	Total in equipment, min
1	Battenfeld» BA 6500-700 HM Unilog 9000	0	0	10	15	0	25
2	«Battenfeld» BA 1500-630 BK	110	0	15	215	45	385
3	«Engel Victory» 330H 80W 120	0	15	0	0	0	15
4	«Engel Victory» 500-120 Spex	10	0	0	0	15	25
Total in months		110	10	25	230	60	450

In November, 2018, standstill time on the first line of plastic casting on “Battenfeld” the VA 1500-630 VK equipment amounted to 110 minutes, which was affected by program failures. In February, the largest amount of standstill time was recorded, which amounted to 215 minutes, which was again affected by program errors and power failures, which caused errors in the equipment system in turn.

The “Engel Victory” equipment has no malfunctions, but downtime of 15 minutes and 25 minutes has been detected and the operator could set a new program. Let's look at the situation on the plastic casting line 2 in Table 3.

Table 3 - Dynamics of equipment downtime on line 2 since November, 2017 until March, 2018

№	Equipment	Standstill time, min					
		Nov.18	Dec.18	Jan.19	Feb.19	Mar.19	Total in equipment, min
1	Battenfeld» BA 6500-700 HM Unilog 9000	0	15	0	15	0	30
2	«Battenfeld» BA 1500-630 BK	0	90	0	80	35	205
3	«Engel Victory» 330H 80W 120	0	0	0	20	0	20
4	«Engel Victory» 500-120 Spex	0	0	0	0	15	15
Total in months		0	30	0	65	50	270

As it’s shown in Table 3, the highest number of outages also occurred for “Battenfeld” VA 1500-630 VC equipment and amounted to 205 minutes, which indicates outages on the second plastic casting line happen less in time than on the first. This standstill came out because there was a clogging due to the oil which lubricates the equipment, since the oil density was higher than normal.

It is also necessary to note the positive aspects in the operation of the equipment on both lines. Both lines have the least downtime, and some equipment does not have it at all.

Nevertheless, corrective measures are required to minimize the downtime of the equipment.

3. RESULT AND DISCUSSION

For the period from November, 2018 to March, 2019, simple equipment on both plastic casting lines amounted to 720 minutes. The main reasons are the instability of the machine due to a program and configuration failures and the lack of parts in the spare parts warehouse. One of the tools of lean production, which use allows to reduce the losses associated with equipment downtime due to breakdowns and excessive maintenance, is universal productive maintenance ("Total Productive Maintenance" - "TPM").

The main idea of "TPM" is to involve all personnel of the enterprise in the process of equipment maintenance [6].

The working cycle of the equipment consists of sequential alternation of two phases:

- operation;
- maintenance.

In addition to the operators and repair services participation, it is also necessary to involve management [3]. For managers, it is necessary to conduct an analysis of outages, develop documentation, monitor the production process.

To achieve this goal, a working group should be organized to plan activities and monitor the results of the planned activities.

The working group shall consist of the following employees - production director, workshop manager, chief engineer, purchasing manager. One of the engineers who will deal only with the "TPM" project implementation could be involved [1].

It is necessary to organize trainings for the working group and, if possible, to get acquainted with the best achievements in the TPM sphere in international companies. Further, according to the cascade training system, the acquired knowledge and skills will be transferred to site masters, mechanics, repairmen, operators, adjustment workers and electricians.

Start of "TPM" implementing without waiting for the first results of the working group could be implemented. In production, it is necessary to allocate a "pilot" section. Since the most syandstill time (450 minutes) was recorded on line 1, it is proposed to start implementing the TPM principles from it. One of the "TPM" basic principles - dirty equipment cannot be serviceable. Therefore, it is necessary to develop cleaning cards and fix the frequency of cleaning for each shift. This is a small but very important step towards good equipment.

In addition to cleaning, the self-contained service executed by the operator also involves a daily technical inspection of the equipment [4].

An alternative to executing a daily check of the equipment condition is to use the cards shown in Figure 2. Thus, all parameters to be checked are recorded on two-sided cards, which cards are placed on the stand in front of the line. At the beginning of the shift, all cards are turned by the red side (card number 1).

As the check is carried out, the operator turns them with the green side (card number 2), which means that the task is completed.

Thus, the status of the equipment status check during the entire shift could be tracked.

The equipment status check card is shown in Figure 2.

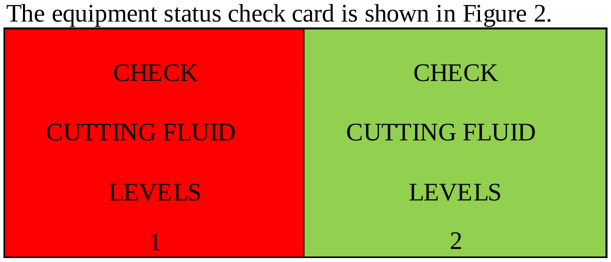

Figure 2- Equipment status check card

It is further recommended a system for collecting and analyzing statistical information on equipment breakdowns and their causes be initiated. A signal system should be developed. Seeing a malfunction the worker cannot eliminate on his own, the operator will need to hang a special red label on the equipment with information about the equipment malfunction shown in Figure 3.

Figure 3 - Tag with information on equipment failure

The color indication of the equipment state shows the site master the equipment state at the moment, which helps to identify defects at an early stage. The installer notices the tags and fixes the problem during the bypass.

In production, it is also recommended to keep a single log of equipment failures, presented in Table 4, which records the name of the machine, the time of its shutdown, the faulty unit, the measures taken to troubleshoot the problems and the start time after repair. Further, consider Table 4.

Table 4 - Single log of equipment breakdowns

№	Machine name	Shut-in time	Faulty place	Measures taken	Launch time
1					
2					
3					
4					
5					

This document will be filled by the master and chief engineer, which will allow to analyze the most frequently breaking units and parts and determine the volume of spare parts' purchases, necessary for repair. Due to them in the future the outages of equipment will be eliminated as much as possible due to the lack of necessary parts and, which will positively characterize the work of the whole enterprise.

It is proposed to hang sheets with standards above each particular machine. It is recommended to develop standards as follows: several trained specialists videotape the process, after the video recording is viewed, all irrational movements executed by the operator are noted. Then adjustments are made to the activity and all of this is embedded in the workflow [7].

After the implementation of all activities, video shooting must be repeated and the result compared, since the presence of the standard assumes which could be improved and changed over time.

It should be noticed it is easier and cheaper to prevent a breakdown than to carry out repairs. Thus it is important to form a lean attitude towards the equipment for the whole team.

4. CONCLUSION

After the equipment operation is improved in the "pilot" section, this system must be implemented to other sections of the enterprise. The economic effect could be millions of rubles only from the fact the equipment was cleaned and kept in accordance with the required standards. This proposal is projected to reduce equipment downtime by 25%.

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