Maintenance system improvement in cast iron foundry

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Abstract

The work presents the issue of technical equipment management in an iron foundry basing on the assumptions of the TPM system (Total Productive Maintenance). Exploitation analysis of automatic casting lines has been carried out and their work’s influence on the whole production system’s functioning has been researched. Within maintenance system improvement, implementation of autonomic service and planned lines’ review have been proposed in order to minimize the time of breakdown stoppages. The SMED method was used to optimize changeover time, and the OEE (Overall Equipment Effectiveness) was applied to evaluate the level of resources usage before and after implementing changes. Further, the influence of the maintenance strategy of casting devices’ efficiency on own costs of casting manufacture was estimated.

Keywords: Application Of Information Technology To The Foundry Industry, Automation And Robotics In Foundry, Productive Maintenance, Ationalization Of Production Systems

1. Introduction

Nowadays, customers require producers to come up with better and more modern products with the lowest possible prices. Moreover, external environment of enterprises undergoes constant changes, which requires dynamic reaction in the field of company management. In order to meet these needs, iron foundries have to possess appropriate machinery and maintain it in good technical condition [1, 2, 3].

Technical objects in foundries work in difficult conditions, get older faster and are more often damaged than in other branches of industry. Consequently, there is a need to use the resources effectively, but also to prevent the results of their damages. Enterprises aim at increased technical objects’ reliability and improved operation quality, as well as prolonged exploitation time, shortened time of ineffective use and general increase of their productivity [4].

Implementation of the TPM system assumptions in a foundry significantly facilitates control over machinery and integrates production with maintenance (Fig. 1).
TPM is an innovative system of maintenance and machine service which allows to increase the efficiency of their use and decrease the number of breakdowns. It also requires independent control of workplaces condition by particular workers.

Changes taking place in enterprises rationalize communication processes between people operating and those using technical objects. Hence, the number of breakdowns dealt with by maintenance workers diminishes. Most repair action is replaced by preventive action. Taking over a part of routine service actions and simple repairs, operators do not have to call maintenance workers and consequently feel more important and responsible for their workplaces. An important advantage resulting from the TPM system implementation is awareness among workers which accompanies their problems and finds occasions for constant improvements of workplaces.

A well-implemented system of managing technical devices’ exploitation unites a team, erases divisions between departments and directs all workers on their common target, which is increasing machinery effectiveness [5, 6, 7].

2. Research object, aim and methodology

The research aim in the present work is casting production system composed mainly of a melting shop and three automatized casting lines (two box lines and one Disamatic type line). The melting shop is equipped with two arc furnaces and seven induction ones for melting and storing liquid alloy. Each line has its own station of moulding mass transformation as well as positions of cast cleaning in the quality control and final machining department, as well as for turning and grinding [8, 9].

The paper deals with improvement of maintenance management in a foundry and minimisation of risk factors influencing the process of cast iron production (Fig. 2).

Fig. 2. Risk factors in the process of casting manufacture realisation

In order to lower the risk level it is necessary to eliminate particular factors or decrease their influence on the production system functioning [10].

Cast production schedule is often outdated in the course of its realisation by different kinds of disturbances (Fig. 3). The disturbances take place in the course of the production process in periods in which they were not foreseen. The frequency of disturbance appearance depends on the efficiency level of elements creating the production system, the influence of environment and other unpredictable factors.

Each disturbance is located in time and space and determined by two events: appearance of a disturbance and elimination of the disturbance [11, 12].

Fig. 3. Casting production management in case of disturbances

The research uses modern techniques supporting work time management and technical devices exploitation management. The main focus is on efficiency of automatic lines for box moulding. Damage level analysis of particular groups of lines has been carried out and line service with the use of TPM rules was suggested. The work also uses the SMED method for changeover time optimisation in casting lines.

3. Description of the obtained results

Taking into consideration low level of using automatic casting lines, which constitute the weakest link in the system of casting production, an analysis of appearing breakdown stoppages was carried out. Figure 4 shows the devices which undergo damages the most frequently and constitute the main cause of disturbances.

On the basis of historical data for a group of about 70% of line A devices, autonomic service was introduced and schedules were prepared of planned service to be realised by maintenance staff.
Table 1. Division into external and internal activities by casting line exchange

<table>
<thead>
<tr>
<th>External activities</th>
<th>Internal activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model panel exchange (~1 min)</td>
<td>Supplying model panels on the heating place</td>
</tr>
<tr>
<td>Spraying the panel with separator (~15 s)</td>
<td>cleaning model panels</td>
</tr>
<tr>
<td>Setting up the laser controlling the level of silicic mortar (~3 min)</td>
<td>applying marks</td>
</tr>
<tr>
<td>Regulation of forming device parameters (~3 min)</td>
<td>putting the panel on a rotary table</td>
</tr>
</tbody>
</table>

Fig. 4. Stoppage time of line A for devices’ level per year

Positive effects in efficiency of an improved line may be achieved by properly performed preventive measures. Thanks to such action, it was possible to decrease the number of breakdown stoppages by almost 44% (Fig. 5).

An important factor influencing production liquidity is line changeover. The number of changeovers depends on the size of casts’ batches and on capacity of furnaces preparing cast iron. Changeovers take place several times daily, which means even a few dozen minutes of stoppage. Such stoppage brings about very high costs related mainly to energy consumption. For this time, a line stops only seemingly as it does not form or pour, but all transporters and conveyer belts keep working and cast iron has to be heated.

In order to shorten exchange time, external and internal activities were enumerated, according to the assumptions of the SMED method (Table 1).

As it turns out, introduction of the SMED method will allow to shorten exchange time of forming machines on casting lines by about 40% monthly (Fig. 6).

Fig. 5. Breakdown stoppage time before and after implementation of TMP within a month

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Fig. 6. Average time of line A changeover monthly before and after implementing the SMED method

Fig. 7. Overall equipment effectiveness of line A for one month
Further, the effects of implementing improvements in the system of cast production using the overall equipment effectiveness (OEE) were evaluated. This indicator allows to identify, compare and analyse causes which affect the difference between theoretical and actual production capacity. It takes into account losses caused by breakdowns, waiting for materials and information, set-ups and regulations as well as bad quality of manufactured casts.

Figure 7 presents OEE indicator levels for a line during one month. The average efficiency level for line A after the changes amounts to 74.8 in comparison to its former level of 71.9.

4. Conclusions

Implementation of TPM in a production enterprise from casting industry will allow for efficient management of machinery and increase of its effectiveness, which will result in improved productive flow and lower production costs.

![Fig. 8. Analysis of workplace cost depending on line service strategy](image)

Exploitation cost limitation and increase of production efficiency may be achieved by ordering organisational structures and ways of decision making, proper organisation of maintenance staff, optimization of material and documentation flow among particular organisational units and, finally, by implementation of a computer system supporting basic exploitation task.

Adoption of proper strategy related to service was used in order to improve line’s efficiency, which should be reflected in improved production liquidity and decreased own costs of manufacturing (Fig. 8).

The research should be continued focusing on rationalization of liquid cast iron feeding, elimination of transport problems and decreasing the level of rejects.

Literature