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AUTONOMOUS AND PROFESSIONAL MAINTENANCE IN METALLURGICAL ENTERPRISE AS ACTIVITIES WITHIN TOTAL PRODUCTIVE MAINTENANCE

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The content of this publication consists of notions connected with Total Productive Maintenance (TPM) in metallurgical enterprise. The basic areas of devices condition management through Autonomous and Professional Maintenance are described here. Mentioned areas of activities are performed in metallurgical enterprise ArcelorMittal Poland within pillars of World Class Manufacturing (WCM). The aims of UR programs are to maintain the basic functionality of the devices and decrease the number of failures in order to reach improvement of production efficiency.

Key words: metallurgical enterprise, failure-free devices, Total Productive Maintenance (TPM), World Class Manufacturing (WCM)

INTRODUCTION

Manufacturing in metallurgical enterprises is based on technological portfolio which consists of machines and devices as well as technologies which enable conduction of manufacturing processes. Machines and devices similarly to all other phenomena in the world around us undergo wear and tear and continuous changes. Following phases of evolution can be observed in cycles from the moment of purchase of device, through its full operation and use, till its wear. In case of metallurgical enterprises applied devices are expensive and their assembly, setting in motion and operation requires time and specialised knowledge. Each breakdown of metallurgical devices generates losses which have negative influence on the efficiency of manufacturing. Metallurgical enterprises aim at limiting the amount of losses resulting from failures of manufacturing devices. They apply the assumptions of TPM and perform activities which constitute system approach to eliminate the breakdowns of devices and increase of efficiency of production lines.

TPM AS PILLAR OF WCM

WCM is based on implementation and use of the best available work practice in the field of management and work organisation in order to achieve the best efficiency on the operational level of the enterprise. With the implementation of the most modern solutions the enterprises strive at reduction of costs and increase of productivity through elimination or reduction of all the losses [1]. In the language of WCM methodology, a loss is a difference between a current result and the ideal result (sometimes impossible to achieve, but assumed one), for example reduction of output loss on convertors from 89 % to 100 % is an unreal assumption, whereas reduction of output losses from 89 % to 92 % is a real result (possible to achieve). WCM standards are based on the assumption „banish waste and create wealth in your corporation" [2]. Achievement of WCM standards requires implementation of a set of coordinated activities in the areas of: quality improvement, work safety, work organisation, enterprise management, cooperation with surrounding, services, rational resources management, development of employees, and management of costs. Among the pillars of WCM there are activities of TPM which assume teaching machine operators and workers how to look after the company's equipment. The essence of the concept is zero stoppages and zero breakdowns [3, 4]. In WCM methodology the assumptions of TPM are implemented in a number of topic areas. In key areas there are activities defined as Autonomous Maintenance – AM and Professional Maintenance – PM. The aims accepted within TPM are: zero defects of devices, zero breakdowns, zero repairs, zero stoppages, etc. Mentioned aims are treated as real due to the fact that they belong to category of employees' abilities and conducted preventive activities [5]. AM as pillar of WCM deals with increase of efficiency of production line through the actions of devices operators (each worker is responsible for device with which they are working). PM here means all the actions of the specialised services of maintenance which deal with structural approach to eliminate the breakdowns of devices. Actions which are performed within

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AM and PM are connected with cost analysis (Cost Development – pillar of WCM), Early Equipment Management – EEM and focused improvement (Focus Improvement − FI in WCM). Besides the key set of interactions the TPM remains in connection with other pillars of WCM, which are Health and Safety – HS, Environmental Protection – EP , People Development – PD, Product Quality – PQ and Customer Service – CS [1].

AUTONOMOUS MAINTENANCE (AM) IN METALLURGICAL ENETRPRISE

Executors of Autonomous Maintenance are the workers of production lines who operate each of the devices. Operators are obliged to maintain normal working condition of machines and devices as well as to restore the initial condition of their functioning. AM as activity conducted within TPM is based on a few basic steps, which are presented in Figure 1. The aim of AM is to reduce the number of breakdowns of devices. Operators of devices are obliged to eliminate the anomalies connected with devices. The anomalies are understood as minor failures, abnormal working of device, minor errors connected with work of machines and devices. In analysed metallurgical enterprise the situations which are referred to as anomalies there are: loose parts of devices (undone holding-down bolts of the protection covers), lacking parts in devices (i.e. dismounted covers or too loose covers, for example protection rollers in roller-coaters – production of metal sheets, loose unit switches), bent parts (most often bent covers), leaks, spindrifts, vibrations of devices, superheating of devices etc.

Specific character of the anomalies results from type of manufacturing. Anomalies undergo identification (each worker is obliged to write out a tag with found anomalies). Tags are in two colours: blue (anomalies which can be fixed by the workers themselves or with the help of technical service workers) and red (anomalies which are fixed by the workers of Professional Maintenance). Tags should be filled in two copies, one

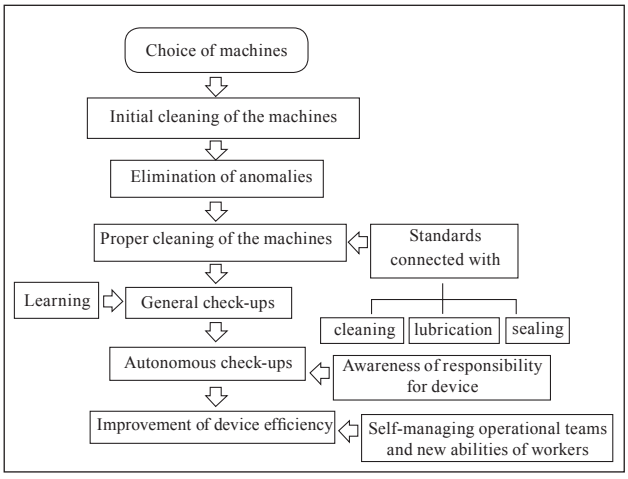

Figure 1 SimpliÃed procedure of AM

is placed on the machine and the second is placed on announcement board which is located next to critical devices. Each of the manufacturing sections in Arcelor-Mittal Poland (AMP) defines which devices are most critical (so-called AA). These are mostly such devices, the failure of which results in full stoppage or slowdown of the manufacturing process or production line.Among the key devices in the section producing metal plates there are: furnace (galvanizing line), accessories of tub and knifes (galvanizing line), a straightening machine (galvanizing line), coating machines set (coating line), chemical coating machine (coating line), and bundling machine (coating line). The remaining categories of devices are: A, B and C. Classification of devices is conducted annually. Information connected with devices is also completed according to the influence of potential failures on the quality (quality losses, i.e. loss of output, claims for refund from customers, index drop of punctuality of customer service [6]), job safety (number of accidents), environment (dangers to the environment) etc. Example of quality losses: furnace for heat treatment breaks down and therefore all products connected with it need to be re-qualified. The assumption of TPM is removal of losses (all the wastage) in order to reach the biggest effects in the shortest time possible (including higher efficiency of work of devices) [7]. Losses identified during diagnosis of the work of devices become ordered. According to general classification the losses in the analysed enterprise were divided into a few groups. Example groups of losses are as follows: losses which have negative influence on the efficiency of equipment (losses as a result of failures, start-ups, stop-overs, drop of productivity etc.); losses which have negative effect on the efficiency of human resources (losses resulting from movement or changing the organisation of production line, absences of the workers); losses which have negative influence on the use of media (losses of energy, water vapour , leaks, unsealing, losses of output), losses which have negative influence on the use of materials (losses of materials during breakdown of device, decreased quality of products, substandard products, losses of alloy additions. An indicator was subscribed to each type of loss – a kind of measuring tool for assessment of efficiency level, i.e. productivity in tonnes per hour , productivity in tonnes per worker, cost of re-processing of the substandard products, time of delivery of products to customers, time of execution of production cycle, indicators of frequency and severity of accidents, use of media per one tonne of products, pollution emission per 1 tonne of products. A very important activity within TPM is setting detailed aims besides strategic aims, namely „zero breakdowns of devices". Detailed aims are most commonly formulated in reference to previous year (reference year), i.e. costs of claims for refunds (zloty per tonne) should be limited by 15 % in reference to previous year and the loss of output should be reduced by 40 % in relation to reference year [8].

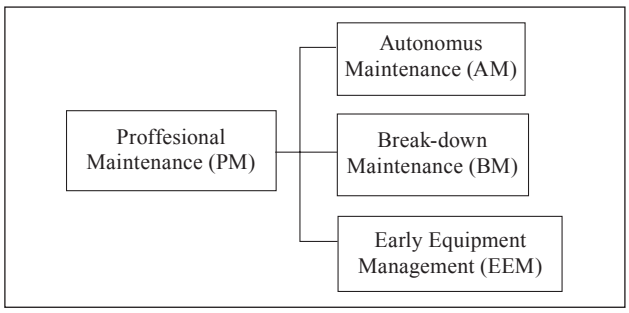

Figure 2 SimpliÃed structure of PM

PROFFESIONAL MAINTENANCE (PM) IN METALLURGICAL ENETRPRISE

The essence of PM is mainly to eliminate the breakdowns of devices by actions which improve the reliability of elements of metallur gical machines. Actions which are conducted are preventive repairs which are performed by specialised teams of workers. Preventive repairs include check-ups of the equipment condition (periodic inspection) and the repair of the device before major failure. Exchange of parts in devices is conducted in accordance with earlier defi ned schedule − Time Based Maintenance (TBM) or on the basis of diagnosis of technical condition – Condition-Based Maintenance (CBM). PM is conducted on the basis ofAM and others conceptions of maintenance (Figure 2).

Besides the preventive repairs the teams of workers repair devices after breakdowns (Break-down Maintenance, BM). According to the assumptions of TPM with the view of total reliability of devices the continuous repair process is taking place (concentrated improvement). Activities within PM are accompanied by activities which constitute Corrective Maintenance (actions connected with improvement of equipment) and Maintenance Prevention MP (improvement and development of new technologies). MP, however, is connected with EEM − Early Equipment Management. Workers of PM besides preventive repairs also remove the reasons of incorrect work of devices which are presented on tags. Besides technical activities (diagnosis of equipment condition, exchanging parts of devices, lubricating activities), the PM service manage the costs of production maintenance, help the operators to maintain devices (exchange of knowledge and experience through guidance and training) and take up logistic tasks (coordination of the time period when the repairs are conducted and the time of production processes). PM activities cannot lead to the decrease of productivity of production line in steelworks. The general aim of PM is understood as increase of reliability and accessibility of devices and a given calendar year is written out into particular detailed aims. In AMP section Swietochlowice, year 2010 was assumed as the year with an aim to reduce the number of failures of critical devicesAA by 10 % in relation to year 2009 [8]. Technicians from production maintenance supported the operators of machines, i.e. show the reasons of breakdowns, show how to identify small breakdowns, identify sources of rare failures as well as those which occur recurrently, take up actions which aim at removal of small breakdowns.

TOWARDS CONCENTRATED IMPROVEMENT

The notion of concentrated improvement is the duty of all employees of the enterprise who should, at any stage of their work, concentrate on solving all the problems. In metallur gical enterprises the assumptions of Kaizen philosophy are implemented, which means constant improvement of enterprise functioning in „small steps" [9]. Kaizen refers not only to the improvement of quality of products and services but also to the work of the people the way the devices are operated, existing procedures etc. [10]. In an attempt to reach TPM there are activities conducted within Kobetsu Kaizen and so-called Quick Kaizen. The meaning of the last one is basically a comparison of: description of the problem with the possible reasons of the problem. Such comparison is analysed and on the basis of it either repair action or preventive action takes place. The structure of Quick Kaizen consists of fields: „Problem", „Reason", „Check up" and „Act". In the description of the field „Problem" the following tools are used: 5W and 2H (what, who, where, when, why, how, how often), observation of the device running (registration of the real situation, i.e. with the use of fi lms or photos), application of control tools, i.e. list of controlling questions. „Reasons" (fi eld 2 in quick Kaizen) is fi xed during brainstorming (team discussion of the reasons of the problem) with the use of 5 Why method (reaching the source of the problem) or with the use of Ishikawa diagram (the fishbone diagram according to categories of: men, machine, method, material, measurement and mother nature). Third fi eld „Check up" consists of the real and main reasons of identified problem (the V. Pareto diagram can be used here – analysis of the severity of problems, the reasons and the effects). Achieved possible reasons of the problem undergo classifi cation according to the degree of their influence on the effectiveness in functioning of device. The last field „Act" requires the use of E. Deming cycle – PDCA [9,10]. Quick Kaizen in metallurgical enterprises is conducted in written form in order to manage the work time effi ciently and to avoid the unnecessary discussion and forms of overloading in the process of identification of reasons why a device is working improperly. Quick Kaizen is relatively easy in application, a card of quick Kaizen can be completed from time to time be every worker (common sense and knowledge necessary to identify the problem is needed). Kobetsu Kaizen, however, requires the creation of a group on continuous improvement and is implemented in 10 steps. Step 1 is setting the topic of concentrated improvement (topic should be formulated as a problem). Step 2 is fi xing the members of the team who would deal with the improvement of devices (team is managed by a leader or manager). Step 3 is pointing out the reasons why the chosen problem is considered an impor -

tant problem to solve in reference to aims of TPM. Step 4 is creation of the plan of activities for next steps (6-10). At this stage it is necessary to: determine tasks to be performed, range of work for particular team members, point out so-called milestones (important for solving the problem), fix deadlines for conduction of tasks, provide necessary resources, coordinate the course of activities, and finally control the achieved results. Step 5 includes formulation of aims for the teams which can be measured and presented in numbers, i.e. decrease of the number of breakdowns of devices by 10 % in reference to such number in the previous year by elimination of occurring phenomenon. The aims must be specific; they cannot be formulated in a general way i.e. we want to improve the quality of devices functioning. Step 6 is the description of the current situation of functioning of device. At this stage the analysis of elements of occurring situation is prepared and the repair activities are proposed. During those activities photos, films, diagrams, drawings etc. can be applied. Created documentation makes the analysis of the situation easier. Step 7 consists of decision referring to proposed repair activities (who, what, when, how to perform). Step 8 is the confirmation of results of implemented action which improve the work of devices by giving present indicators of efficiency of work for a given device. Step 9 is the introduction of actions of look-up type by setting standards for operators of devices and services of UR. Standards (or instructions) may refer cleaning and lubrication of device, way of conducting inspection of devices, methods of operating a device, forms of removing anomalies, ways of reporting breakdowns etc. The last step – step 10 is fixing the plan of future improvement activities, i.e. by transferring the improvement on other devices. The idea of Kaizen philosophy is the continuity of repair activities and if we adapt it in TPM it means continuous care of devices and machines. The attempts of enterprises to reach concentrated improvement require the application of many methods and techniques of eliminating losses and reaching higher effectiveness of work of devices [10]. In concentrated improvement the methods used are: FMEA (Failure Mode and Effects Analysis), Poka-Yoke (prevention of human mistakes), SMED (Single Minute Exchange of Die - shortening the assembly to 10 minutes), Maki-Gami (optimisation of the process), PPA (Process Point Analysis) SPC (Statistical Process Control) and 5S methodology (taking care of order in workplace), etc.

CONCLUSIONS

TPM is an excellent completion of space between the care of efficiency of work of devices and the attempt of enterprise to reach the standards of WCM it builds the solid base for the improvement of production efficiency and helps to restore the basic functions of all devices quickly and effectively. Reaching success requires concentrated improvement of devices maintenance by cooperation of professional maintenance services with operators of devices. In analysed enterprise in the branch in Swietochlowice reaching success within the improvement of work organisation was awarded with bronze medal of WCM [8].

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