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ENVIRONMENTAL FAVOURABLE FOUNDRIES THROUGH MAINTENANCE ACTIVITIES

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Maintenance today contributes to the aim of sustainable development in society, including environmental and energy saving, safety and economical aspects. The main purpose of the paper is to present the role of maintenance in the realization of sustainable developing practices in a foundry industry. Maintenance offers numerous opportunities to reduce the influence of foundry processes on the natural environment and utilize resources more efficiently. Maintenance activities can help to reduce losses and thereby improve the efficiency of the processes used in the production of resources (e.g. raw materials, energy, etc.), especially in areas such as: the choice of an appropriate strategy for the maintenance of machinery and equipment (e.g. reactive, preventive, proactive); inventory management of spare parts; lubrication management and management of technology media.

Key words: foundry industries, environment, maintenance, sustainable development

INTRODUCTION

The foundry industry structure has changed from a labour-intensive to a technology-intensive industry. However, technology cannot be effective without excellent maintenance management [1]. A foundry does not work without highly reliable and predictable machines and processes. A failure in equipment or facilities can not only result in loss of productivity, but also may lead to safety and environmental problems which may destroy the company image. Hence, maintenance management should be one of the main pillars of new business models in foundry industries.

Sustainable maintenance is a new challenge for enterprises realizing concepts of sustainable development. It can be defined as pro-active maintenance operations striving to provide balance in the social, environmental and economic dimensions (see Figure 1).

The goal of the paper is to present the role of maintenance in the realization of environmental issues of developing sustainable practices in the foundry industry. Thus, particular stress was put on the opportunity for the application of the Reliability-Centered Maintenance (RCM) approach. RCM focuses on system functions and directs maintenance efforts at those parts and units where reliability is critical. As proven by literature research and observation of practical cases, the method is applied only occasionally in foundry industries.

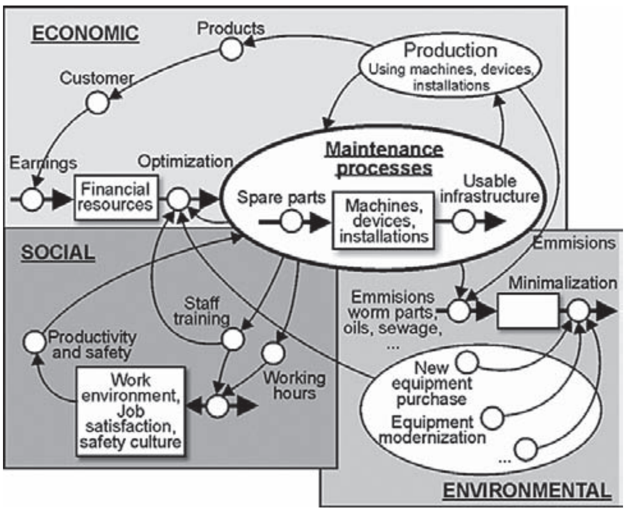

Figure 1 General model of interdependencies in sustainable maintenance [1]

THEORETICAL BASIS - SUSTAINABLE MAINTENANCE

Sustainable manufacturing is the paradigm presently dominating the production area. The paradigm evolved from the concept of sustainable development and was introduced at the 1992 UNCED conference in Rio de Janeiro as a guide to help companies and governments in the transition towards sustainable development [2]. A key to sustainable manufacturing is finding where and why the production process is wasting resources and energy. The consequence is that production processes have to be analysed not only in the context of the technology applied, but also in the context of how all resources are used and maintained (including human, material, technical and information resources) [3].

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The shifting of the production paradigm towards sustainable development has resulted in a maintenance management paradigm change towards social and environmental issues instead of focusing only on financial issues (applied in the traditional view of maintenance as a cost). Sustainable maintenance is a new challenge for enterprises implementing a sustainable development approach. It can be defined as proactive maintenance operations striving to provide a balance in the social dimension (welfare and satisfaction of maintenance operators and their stakeholders), environmental dimension **(6R)** and economic dimension. It requires the introduction of a broad analysis concerning losses or risks to continuity of enterprise performance, should the maintenance strategy taken and actions implemented not provide required condition of machines [4].

RESULTS AND DISCUSSION

The economic, environmental and social dimensions of maintenance are interrelated and any change in the objectives of a dimension greatly influences the other two dimensions. Taking this systematic approach as a key principle in building sustainable maintenance enables relations between various dimensions to be found: economic (e.g. cost of technical services, technical diagnostics tools, IT systems etc.), social (e.g. health and safety, ergonomics, satisfaction from work, etc.), environmental (e.g.. recycling, regeneration, minimization of energy, water, waste, air pollution etc.) [1, 4].

Among all different industries the most polluting industrial sector is the foundry sector. Energy and material efficiency, sustainable production procedures and climate-friendly technologies are among the most important strategic challenges in this industry [5, 6]. Case studies indicate that most foundries could achieve significant energy savings by optimising current practices [7]. Other technologies may also help companies improve their efficiency. Topics include efficient melting practices and technologies, capturing waste heat, improving the efficiency of ancillary services (e.g. compressed air, motors etc.) and new diagnosis practices in maintaining machines and installations.

Energy efficiency is an area where most foundries recognize there is opportunity for improvement. In looking for energy losses, one should also pay attention to the process equipment and how it is used and maintained. The areas where assessment is recommended are, for example, melting and holding furnaces and their lids; the state of their repair; how the ladles are preheated; how the molten metal is conveyed, handled and poured; what the temperature gradients are at each stage; etc.

Whilst the energy efficiency of the foundry will always be one of the key issues, other environmental aspects should also be considered. The aspects most often listed in literature are the following: natural resources consumption, emissions, noise, etc. [8].

As all the actions taken in an enterprise should be assessed in terms of gains and losses, decision makers should consider two important issues:

- What is the level of environmental impact arising from excellent technical condition of equipment of an asset due to effective and efficient maintenance practices? (gains)
- What is the level of environmental impact arising from poor technical condition of equipment of an asset due to ill- defined and/or poor maintenance practices? (losses)

Maintenance offers numerous opportunities for decreasing the influence of foundry processes on the environment and achieving more efficient resource utilization (see Figure 2). From the environmental perspective of sustainable development, the performance of maintenance actions should strive for:

a) assessment of influence of functional failures of machines on environment and selection of suitable service policy (e.g. corrective, preventive, condition-based, proactive [9]);
b) selection of suitable systems of monitoring condition of machines, devices, installations;
c) development of operational standards for machines, devices and installations;
d) modernization of machines and devices and application of new solutions and materials;
e) rational management of spare parts and exploitation materials;
f) increased competences of maintenance staff as well as of operators of machines and devices.

The aim of RCM is to optimize, in a systematic way, the mix of the main maintenance practices; i.e. corrective, preventive, condition-based and proactive. The RCM is a method to identify and select failure management policies to efficiently and effectively achieve the required safety, availability and economy of operation [10].

RCM focuses on the functional failures of systems and components. A systematic process is employed to determine the functions of physical assets, failure modes, consequences of failure, their significance and hence their criticality. RCM utilizes a decision logic tree to identify the maintenance requirements of equipment according to the environmental, safety and operational consequences of each failure and the degradation mechanism responsible for the failures (see Figure 3).

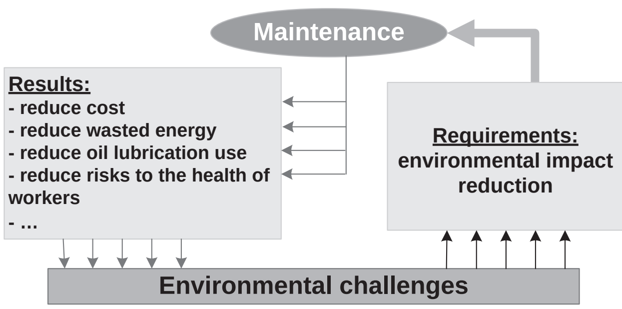

Figure 2 Environmental challenges and maintenance

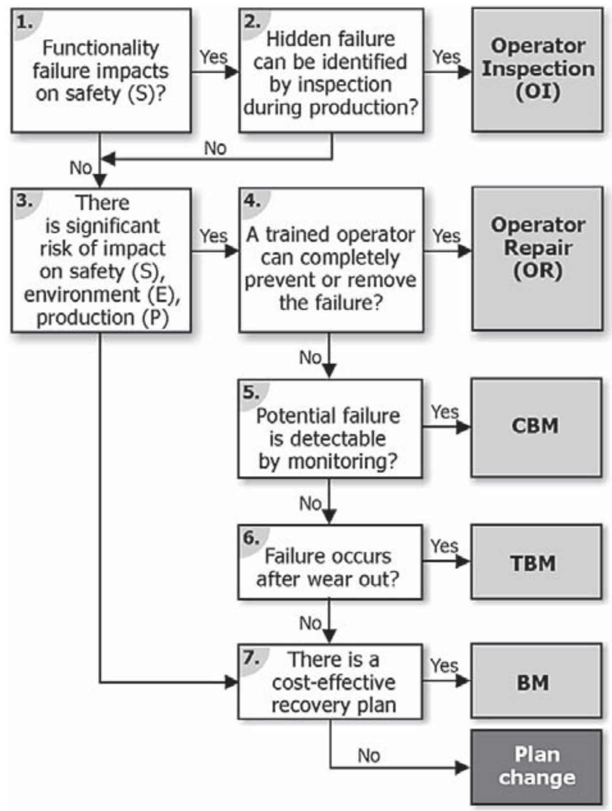

Figure 3 Decision-making process diagram [11]

Such an approach enables the definition of appropriate proportions among individual maintenance policies, considering not only financially but also environmental issues. In many enterprises RCM is an element of TPM approach realization (see Figure 4).

A well-prepared monitoring system allows precise determination of the time a machine is withdrawn from operation, thus eliminating raw material (non-conformant products) and energy losses and extending to the maximum the machines operation time, resulting in tangible financial benefits.

Another tool in the hands of technical personnel are diagnostic and forecasting test methods e.g. vibroacoustics, thermo-vision, oil analysis. Technical diagnostics, next to tribology and reliability theory, is one of the basic sciences on rational use of objects.

Development of operational standards for machines, devices and installations should also be conducted to define optimal parameters of work, resources and technological media use, as well as documenting and analysing all deviations from operational standards accepted, followed by taking corrective actions (formalized cause-effect analysis such as: FMEA, RCA, etc.). Rational management of spare parts and exploitation materials means rational lubrication management, which should cover all activities, from oil selection, through to its storage, delivery to machine, its maintenance during operation, appropriate machine tooling adjusted to the conditions in the machine working environment, well designed oil analysis system, etc.

Increasing competences of maintenance staff as well as operators of machines and devices should come towards the best and reliable information on condition of machines, which can be obtained from operators, but only, however, if they are well trained.

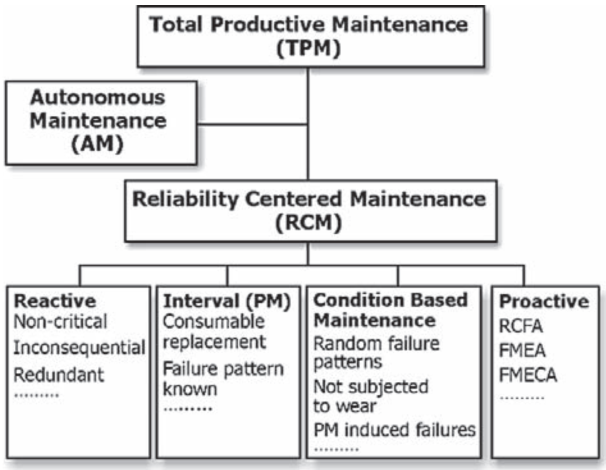

Figure 4 Relation between TPM, RCM and other maintenance approaches [11]

Hence, sustainable maintenance from the environmental perspective can be defined as management of maintenance operations in an environmentally friendly way. It includes all the processes of maintenance, starting with selecting a strategy for an object's servicing, through material selection of raw materials and components necessary for equipment servicing purchasing, warehousing, planned and unplanned maintaining services, managing used materials, exploitation fluids and lubricants [4].

SUMMARY AND CONCLUSIONS

As an investment in the future, maintenance is able to create new productivity and can help to preserve raw materials and energy, protect the environment, and increase profits in the industrial production. From a practical point of view, it requires changes in the approach to maintenance represented by managers and changes in actions performed within the maintenance area. In managing foundries, it must be understood that maintenance is not only about repairs of machines and devices, but also actions striving for more efficient resources management and energy efficiency. The results of foundries which use "the best engineering practices" underline this opinion through reduction:

- the amount of generated waste - incompatible products (e.g. controls of parameters of machine work and preventive measures - about 20 % saving in raw material usage);
- the consumption of technology media (e.g. through modernization of equipment for about 15 % of electricity consumption);
- the consumption of lubricants (e.g. maintenance and diagnostics of oil will extend the life of oil by about 20 %);
- the disruption and inconvenience to the local community (e.g. noise, emissions, pollution).

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Note: The responsible translator for English language is J. Allan Longshadow (Trinity CertTESOL); specialist in academic texts at Longshadow House Sp. z o.o.