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ERGONOMIC AND WORK SAFETY EVALUATION CRITERIA OF PROCESS EXCELLENCE IN THE FOUNDRY INDUSTRY

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The article presents a concept of criteria assessment called the "process excellence" for ergonomics and work safety in enterprises of the foundry industry as well as points to the possibility of its application.

Key words: foundry industry, ergonomics, process excellence, work safety

INTRODUCTION

Improvement can be understood as a project that is undertaken to obtain additional benefits to the organization and its customers. In the literature, the term is most often present in the context of pro quality activities as a "continuous improvement". In the companies' practice it is striving for excellence that manifests itself through the implementation of various concepts, methods and improvement techniques and the use of models and matrices to evaluate the effectiveness of their implementation. That is why, such terms as Manufacturing Excellence and World Class Manufacturing – WCM, models and matrices that are their representation are of growing interest [1]. The overriding theme of the companies which follow this thought is to "be the best" in each area of activity (eg. production) and in any relevant issue (eg. corporate social responsibility). The foundry industry easily exposes growing interest in models and matrices which enable to determine in an objective way the directions of improvement. In small and medium-sized enterprises these functions are performed by self-assessment questionnaires which are provided to organizations by their customers (a form of assessment whether the organization meets customer requirements). Large organizations, particularly transnational ones build their own models, which are used as benchmark tools to improve internal processes in specific plants and external comparisons of achievements between particular enterprises and setting new targets. Regardless of the purpose for which they were developed, their scope encompasses related assessment criteria. The criteria of excellence assessment, which most often occur in these models include: strategic planning, knowledge management, environment, process control, movement maintenance, safety, health and ergonomic working environment. Closer analysis used in the models of criteria reference indicates a balanced approach to all relevant issues related to the industry in relation to both internal and external conditions.

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EXCELLENCE CRITERIA ASSESSMENT OF FOUNDRY PROCESSES

Excellence assessment level of a company (in the literature often called the level of maturity) refers to all of the realized processes and aspects relevant for them [2]. Therefore, in order to perform an accurate and complex evaluation one needs to obtain information from a lower level, which means from the process level. The basic criterion for the excellence assessment of the realized foundry processes (i.e. casting and other additional processes) are quality requirements. They are described by qualitative characteristics such as Rq, Rv, Rp, Rz, Rmax [3]. The obtained percentage of defects is a more tangible indicator of the process, however, it is applied in a more aggrevated way. Evaluation category results from the assumed manufacturing technology which will condition specified ranges of classes of the derived parameters- such as the quality of the surface layer which is closely correlated with the foundry technology [4]. Due to the fact that, quality requirements are interdependent from other, in practice, one needs to use a wide variety of requirements. The most commonly used criteria for evaluating the implementation of process excellence in realizing the products in the foundry industry are therefore:

- the quality (eg, reject rate, the rate of customer complaints),
- productivity, often built cumulatively with the other, for example by an OEE factor (Overall Equipment Effectiveness - consisting of Availability, Performance and Quality),
- logistics (eg, ensuring continuity of supply, quality of raw materials),
- maintenance (eg. the number of failures),
- innovation,

– the environment (eg use of natural resources, energy costs),
– ergonomics and safety at work, often described as a universal coefficient of effect on the human being - Days Away from Work Injury and Illness (DAFWII) Rate.

The literature research suggests that the greatest potential for improvement in the foundry processes are energy and labor costs. Because of the wide scope of these criteria, the article focuses on one of them - the work, concretely: safety and ergonomics of the working environment. Despite the ongoing automation of foundry processes, especially small and medium-sized enterprises perform multiple operations in a manual manner. Moreover, even in automated molding lines, there are many activities in which the human is irreplaceable (eg, preparatory and maintenance processes, precise overview of the cores). Thus, it is reasonable to conduct formal assessment of ergonomic parameters in work environment [5].

The study that has been conducted in two foundries (SMB) in 2013 enabled to identify the factors affecting ergonomics of the work environment. Successively, the most identifiable problems were: heat - microclimate, dust, noise, static load, awkward posture, dynamic load, energy expenditure (calories), work duration, vibration, low light, repetitive task, cognitive stresses. With respect to these factors, the determinants of safety conditions in the broad sense of ergonomics in the work environment is a plastic molding material and the type of molding materials. The composition of molding compound, and in particular the masses of binding is one of the main factors of state of the atmosphere in the workplace. Exposure to various factors is variable for different jobs, but due to the rotation of the employees, the aforementioned factors are characteristic of the most production workers in the foundry industry. These factors may therefore provide a basis for the construction of an ergonomic assessment model in the foundry processes, but its design must assume modularity due to the diverse specificity of particular processes in the foundry industry.

The scales which are used to assess excellence, depend on the measured area. For more formal phenomena, it is feasible to use such indicators as OEE, which is attributed to certain values - 100 % is perfect production [6]: manufacturing only good parts, as fast as possible, with no down time; 85 % is considered world class for discrete manufacturers; 60 % is fairly typical for discrete manufacturers; 40 % is not at all uncommon for manufacturing companies that are just starting to track and improve their manufacturing performance.

In case of ergonomic actions, it is not possible to apply rigid assessment, as this would limit the effect of continuous improvement [7]. According to such a scale, the state of excellence level achieved by the enterprise in the measured area is defined alternatively as: (1) Started point, (2) Below average performance, (3) Average performance, (4) Effective operations, (5) Best practices. The main advantage of this scale is to strive for continuous improvement by upgrading the achieved perfection. This means that given levels must be periodically verified.

LEVELS OF ERGONOMIC EXCELLENCE AND WORK SAFETY IN FOUNDRY PROCESSES

The characteristics of ergonomics and safety have not often formed the main stream of improvement activities in the foundry process. This is due to the significant technological capital intensity, which in most cases allows only the use of corrective solutions within the range of ergonomics [8]. Therefore, it is easy to notice that that the achievable level of excellence in the field of ergonomics and safety is largely determined at the level of technology selection, and less by corrective activities of technical-organizational nature. The predominant tendency shows that at the relatively high level of technological process excellence, there is also a high level of ergonomic excellence for such categories as working conditions associated with pollination and dynamic loads, as well as microclimate; at the same time, however, the level of excellence within the range of static and metal loads has been decreasing. Such an understanding of particular process excellence allows to specify ergonomic determinants regarding the selection of foundry technology, which in the context of the need for technological development in the foundry industry [9] can be a very helpful practical tool. A significant impact of technological change does not mean, however, that the ad hoc corrective solutions should not be implemented. On the contrary, they contribute to the improvement of ergonomic climate for ergonomic reasons, which triggers ergonomic partnership and this results in a better recognition of ergonomic problems. In view of the diversity of foundry technologies, the applied categories of ergonomic excellence factors ought to have the ability to parameterize. The proposed example of a model presenting ergonomic factors of the specific process within the range of foundry techniques has been shown in Figure 1.

Due to such specified model it is feasible to make a comparison between techniques for a particular foundry

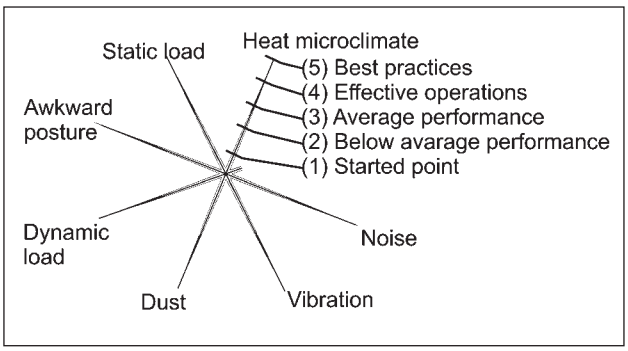

Figure 1 Ergonomics factors model for process (own preparation)

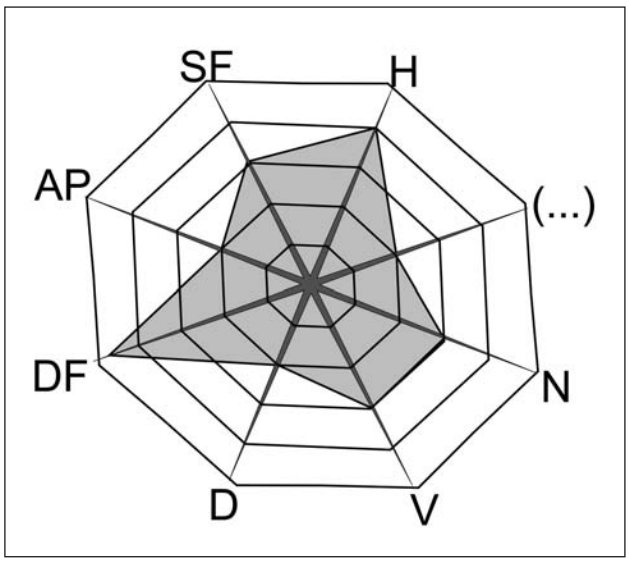

Figure 2 Illustration of excellence of the process regards the ergonomic criteria (own preparation)

process, as well as the achieved excellence of the various production and preparation stages. This particular model, you can make a comparison between techniques for a specific foundry process, as well as the excellence of the various stages of production and preparation. An example visualization of ergonomic process excellence assessment is shown (Figure 2).

It should be noted that the mentioned ergonomic categories are of collective nature, and therefore they aggregate a number of factors.

And so for thermal comfort, the analyzed ergonomic factors is not only air temperature, but the total impact of such factors as: thermal radiation and its properties, temperature differences for particular segments of the body, the speed of air flow, pressure differences, relative humidity, etc.

Among ergonomic factors that are typical of the foundry industry, and not listed as a separate group, it is possible to also indicate: odors which occur eg. in the cold-box technology, which despite getting less intensity they are still perceived as a nuisance by the employees. A typical ergonomic problem is also quality control of the cores that affects the monotony and monotypes of the performed activities. These factors, in addition to typical safety aspects which occur in foundry processes such as hot splinters, gases, constitute the reason for which it is necessary to develop process excellence in the area of ergonomics and work safety. Due to the lack of quantifiable data regarding ergonomic factors in Polish foundries and the necessity of their earlier objective assessment it was decided to introduce the relationship in the number of deficiencies with the production volume in tones. According to the authors, the percentage of deficiencies has a large level of correlation with ergonomic working conditions. They are the more important, the less automated foundry processes are. This is confirmed by the results regarding the biggest number of shortcomings for small productions (Figure 3).

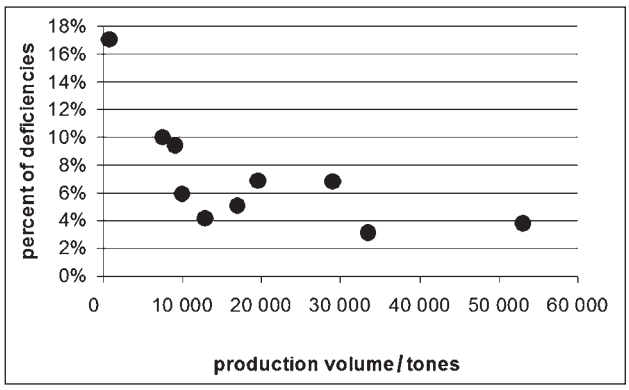

Figure 3 The relationship between production volume and the quantity of deficiencies in the foundry factories in Great Poland (own preparation based on 10)

The level of foundry processes excellence is growing with the increase in the scale of the operation. The relationship that has been presented also confirms the need for a methodological approach of excellence in small companies. One of the ways to successfully introduce changes can be to propose the improvement through ergonomic factors. In view of the social responsibility of employers and the legal regulations for improving work safety, the improvement in this regard could convince decision makers to make an effort and advance in other areas.

CONCLUSIONS

Ergonomic criteria for assessing the foundry processes excellence translate into financial benefits. The average investment in ergonomic solutions for foundry returns within half a year [10]. This means that such solutions bring profit and their implementation will be associated with increasing competitiveness that is necessary in reality of contemporary marketing. However, individual solutions require methodological support which is characteristic to the process excellence. Ergonomic process excellence which is based on configurable criteria will enable to increase the achieved advantages that will transfer on to other areas of foundry activity. There's no denying the fact that this type of approach to ergonomics is of great importance in relation to the demographic challenges facing European industry. The implementation of ergonomic system solutions and principles of continuous improvement in the foundry industry will allow for a much better use of older and more experienced workers while reducing the number of nuisance and threats. However, improvement of ergonomic conditions can not be in antagonism to the quality and economic results. In this aspect, it is necessary to use the whole range of innovations which secure co-production of safety conditions, ergonomics and achieve economic results.

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