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Supporting the Bronze CastingThrough Information Structuring Based on Ontology application

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Abstract

A significant part of the knowledge used in the production processes is represented with natural language. Yet, the use of that knowledge in computer-assisted decision-making requires the application of appropriate formal and development tools. An interesting possibility is created by the use of an ontology that is understandable both for humans and for the computer. This paper presents a proposal for structuring the information about the foundry processes, based on the definition of ontology adapted to the physical structure of the ongoing technological operations that make up the process of producing castings.

Keywords: Bronze casting, Casting defects, Decision support systems, Ontology

1. Introduction

Market forces constantly increasing requirements on quality of products and the use of modern technology. This necessitates the introduction, possibly also modification, of different methods of supervising the work of a production plant. Very important is the use of information on the production process collected and processed on a current basis. This information should be linked to information about the requirements imposed on the final product. In general, of the greatest importance is information related to the potential occurrence of defects in products.

The task undertaken refers to an analysis of the needs and capabilities of the existing theoretical methods, taking into account the characteristics of a foundry plant. Important and also the most feasible for use in industrial practice is reference to a group of decisions of an operating and optimisation character, regarding the determination of production conditions for individual production departments and their coordination, control included. Very important is also the problem of an inspection system and regulation of technological parameters providing the desired quality of products.

2. Defects and their causes

The technological process carried out in a casting plant consists of a series of operations, whose combination depends on the type of metal and technology used. Understanding the cause-and-effect relationship that occurs between the above parameters determines the effectiveness of decisions regarding the individual process steps. Particularly important is the relationship between the common casting defects, the causes of their origin, and the parameters of technological operations [6, 7]. A schematic representation of important relationships is shown in Figure 1.

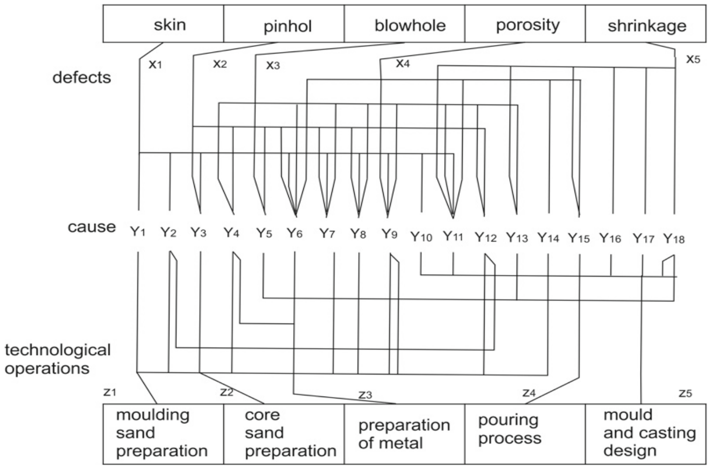

Fig. 1. Cause-effect relationships in a defect-cause-prevention system [6, 7]

These links point out to the need for analysis of technological data. The analysis was conducted on the example of cast bronzes. Based on data provided by a foundry shop, the empirical distributions of individual parameters were identified. Figure 2 shows the distribution of parameters for moulding and core sands. An area defining the parameter values acceptable in this case was marked in the drawing. Marking of this area allows estimating the probability of exceeding the range permitted by the technology.

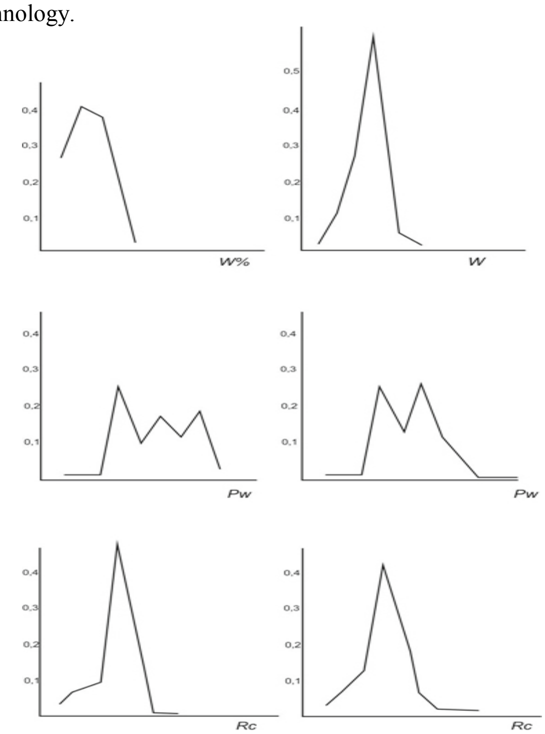

Fig. 2 a. Distribution of parameters for moulding and core sands

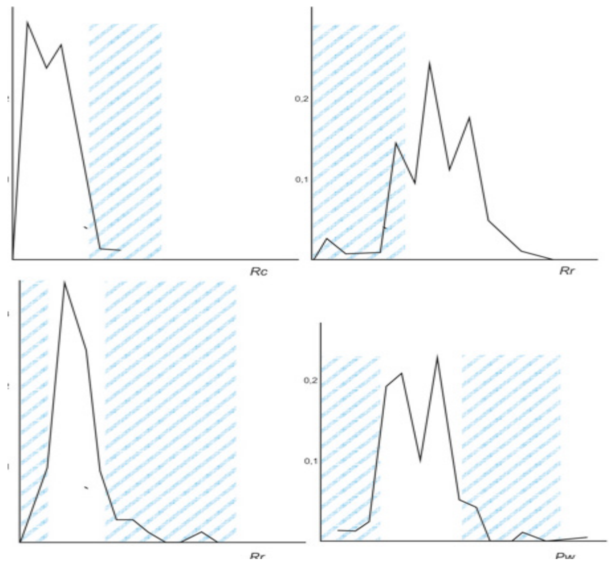

Fig. 2 b. Distribution of parameters for moulding and core sands

Improving the quality of the final product is associated with the selection of process implementation conditions and with proper organisation of the system of measurements and control. An important element of this activity is detailed specification of casting defects to determine their causes and combine them with the process of measurement and control. Figure 3 shows the number of different types of defects recorded during 37 working days of the production of a given type of casting. A comparison of data from Figures 2, 3 is expected to enable an assessment of the effect that metal and moulding sand parameters can have on the occurrence of different types of defects.

The specific character of the individual technological process steps (no mathematical models, imperfect measurement methods) is the reason why consideration of issues related with the diagnosis of defects encounters so great difficulties. Therefore, it is proposed to refer the analysis of the reasons that cause the occurrence of defects in castings to a model that has three separated technology tracks, to which relevant decision blocks can be assigned [6,7]. These are:

- Central decision-making system;
- Metal melting block;
- Moulding process block

At the same time it is necessary to ensure the flow of information between the tracks for which the use of ontology has been proposed, as it is expected to enable the creation of a coherent information system for the whole technological process.

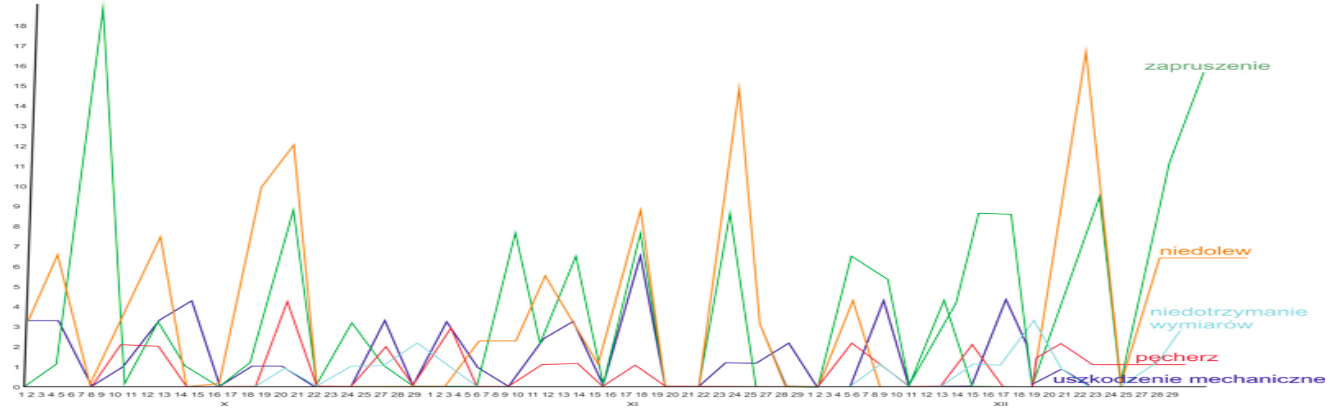

Fig. 3. Number of different types of defects recorded during 37 working days

3. Ontological model

Ontology is a record of information about the reality prepared in the form understandable for the data-processing computers. The elements of the model are concepts that correspond to specific objects. Most often, the model of the knowledge used to build an ontology is based on a framework that underpins the construction of blocks of ontology. The model of the knowledge can use several types of frames: classes, slots and instances. Classes define a new ontology. Instances are elements of classes. Classes can be structured hierarchically. Slots make possible the definition of the individual properties of the classes and relationships that occur between them. Ontologies with the occurring instances of classes - concepts form together a knowledge base.[1,2,3,4,5,8]

The first thing to do when the problem of determining the information flow diagram for a foundry plant is considered is to state the purpose which it is supposed to serve. The purpose adopted in determination of the structure of the scheme of the casting process under consideration is to extract the basic production units (divisions) operating similar technology, equipped with certain type of equipment and manufacturing products characterised by the same parameters. Also important are the general quality and quantity requirements imposed onto products within a single unit (subsystem) as well as the relationships that should exist between the subsystems. Figure 4 shows the concept of activities of a centralised decision-making system including the following subsystems:

- Metal melting
- Making moulds and cores, and assembly of moulds and cores (included in one aggregated subsystem)
- Pouring of moulds with metal

Subsystems including cooling, knocking out of castings and their finishing were excluded from the decision-making system operation.

The constructed ontological system has been based on a flow diagram of the casting production. The constructed model is designed to simulate the data flow in the casting process with particular reference to the factors that can have an impact on the occurrence of casting defects.

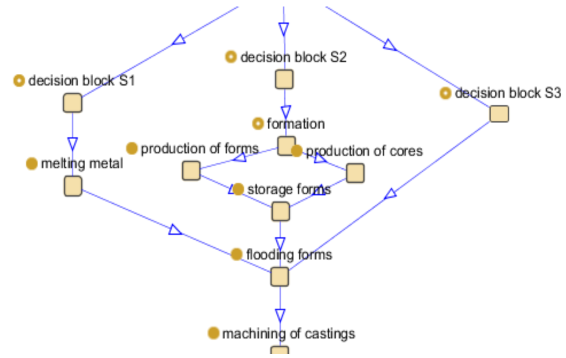

Fig. 4. Structure of an ontological system

The diagram takes into account the fact that in the described process, three parallel technological tracks are discussed, to which the relevant decision blocks (using fragments of ontologies) can be assigned.

The first step considers central decision-making system - this is the area that contains the initial information on the technology used and the desired parameters of the casting. This information is reported to the decision-making units in the corresponding tracks. At the same time, during the process and after its completion, the central decision-making system feedback is provided, defining facts in the process. In the future, the system will be expanded to include the aforementioned information and relationships between the individual pieces of information.

Research on the improvement of casting production quality through the choice of optimum conditions for the implementation and optimisation of the measurement and control system requires determination of the causes of product defects.

The central decision-making system is divided into three decision-making blocks. The decision taken in the first block regards the metal melting process. And so, cast alloys are divided into cast iron, cast steel and non-ferrous metal alloys. Figure 5 shows the division and relationships between these concepts.

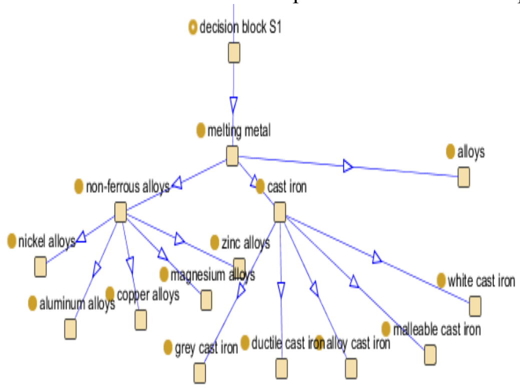

Fig. 5. Division of concepts and relationships existing between them in the casting process for block No. 1

The system can also accept the names of specific alloys, as instances of the class. Each instance can be characterised by slots, as an example, the chemical composition has been used. Other parameters which will additionally enter the system include minimum superheating temperature and. hardness.

The second decision block is responsible for the moulding process. Decisions regarding the shape of mould, casting, and core, as well as the type of moulding sand and the design of a flask were taken much earlier in the central decision-making system at the stage of the production process planning. Here, after the completion of all activities related with the operation of moulding, a message is sent to the decision-making system that the mould is ready for pouring. What is important in this block is, among others, the preparation of moulding and core sand and the method of moulding.A schematic diagram of this block is shown in Figure 6.

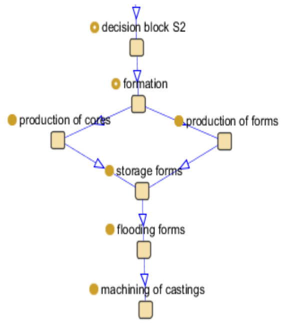

Fig. 6. Decision block No. 3

The third decision block (figure 6) is responsible for the preparation of mould and core for the operation of pouring. The start up of this track takes place as soon as the information about the metal temperature and mould preparation is received. In this process it is important to obtain information about the temperature of the cast metal and to determine the time it takes to pour a mould or moulds in a single casting cycle, including measurement of the pouring height, i.e. the height at which the metal is placed at the time of pouring the ready mould. The next step is heat treatment, followed by inspection, and if no irregularities are detected, the casting is packed and sent to the customer. Depending on the type of material from which the casting is made, the last two steps may occur in a different order or only one of them may occur.

4. Summary

The article proposes a procedure leading to the creation of a system supporting the management of the flow of information that comes at different stages of the technological processes. A novelty in the proposed solution is the applied method of information structuring based on the use of ontologies. As a continuation of the work it is expected to further develop the problem of the exchange of information in a foundry process in the context of its impact on the occurrence of various types of casting defects.

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