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S. KLUSKA-NAWARECKA*, D. WILK-KOŁODZIEJCZYK*,**, J. DAJDA**, M. MACURA*, K. REGULSKI*

COMPUTER-ASSISTED INTEGRATION OF KNOWLEDGE IN THE CONTEXT OF IDENTIFICATION OF THE CAUSES OF DEFECTS IN CASTINGS

WSPOMAGANA KOMPUTEROWO INTEGRACJA WIEDZY, W KONTEKŚCIE IDENTYFIKACJI PRZYCZYN POWSTAWANIA WAD ODLEWÓW

The paper outlines the rules of creating diagnostic tasks scenarios in determining the causes of defects in castings. The paper presents as well the rules of operation of the computer system for data integration based on Extract-Trasform-Load technology, and a description of prototype implementation of this system, also examples of the tests that was carried out.

Keywords: casting defects diagnostics, data integration, ETL Extract-Transform-Load

W pracy naszkicowano zasady tworzenia scenariuszy działań diagnostycznych przy określeniu przyczyn powstawania wad odlewów. Przedstawiono zasady działania informatycznego systemu integracji danych opartego na zastosowaniu technologii Extract-Trasform-Load, oraz opis prototypowej realizacji tego systemu, a także przykłady przeprowadzonych testów.

1. Introduction

Diagnosis and detection of causes of casting defects is a problem that has been studied for years. As a result of these studies, numerous variants of expert systems, as well as of databases and knowledge bases to facilitate diagnostic procedures have been created. Previous experience of the authors [1,2,3,4] points out to the fact that small and medium-sized foundries often lack the equipment allowing for the current measurement of all parameters of the process responsible for the formation of defects. The lack of appropriate measuring equipment also makes the detection of the causes of defects in earlier technological operations impossible. In such situations, the assessment of the causes of defects is difficult and based mainly on expert experience.

It should be noted that both the traditional expert system as well as expert-technologist often indicate as the cause of certain defects the pre-committed irregularities and errors in the choice of technology, poorly selected raw materials, failure to comply with standards, etc. In such cases, the diagnostic procedure should allow the determination of the ”sources” of faults that lie not only in the technological process itself, but in an environment in which this process is being implemented.

The purpose of this article is to show the broader aspects of diagnostic measures, taking into account external factors that may contribute to the formation of defects in castings with particular emphasis put on dynamic changes taking place in an industrial environment.

The creation of such a perspective requires the availability of technical means to enable the acquisition and integration of data from multiple sources that characterize the current state of the environment under consideration.

A selected example of such a diagnostic procedure has been presented, and in this background, the operation of an information system, implemented with the help of ETL (Extract-Transform-Load) technology, has been discussed.

2. The search for the causes of casting defects

The Polish standards highlight a few dozen types of defects in castings. Similar numbers of defects are given in foreign source materials - French, German, and Czech. Studies of a larger number of defects together with their causes are far beyond the scope of a single publication. Therefore, in this study, the discussion of defects has been limited to consideration of the defects associated with one of the most important stages of the casting process, which is the construction of a foundry mould, including the preparation of moulding and core sand. The diagram in which the individual steps taken in the foundry mould preparation process have been marked is shown in Figure 1.

These operations are executed according to a predetermined scheme shawn in the drawing, and so the properties of the ready mould are the result of a given sequence of events associated with certain technology-related decision-making

* FOUNDRY RESEARCH INSTITUTE, ZAKOPIAŃSKA 73 STR., 30-418 KRAKÓW, POLAND

** AGH UNIVERSITY OF SCIENCE AND TECHNOLOGY, AL. A. MICKIEWICZA 30, 30-059 KRAKÓW, POLAND

process. Moreover, the whole moulding process and its practical execution are strongly dependent on the choice of moulding and core materials (as defined by a respective set of parameters). This choice is made taking into account the adopted technological objectives, and as such may be subjected to some limitations (e.g. related with prices of raw materials, or with the location of the supplier of raw materials).

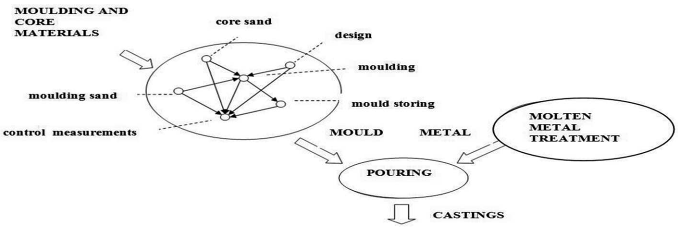

Fig. 1. Elements of the process of preparing the models and molds

The selection of a suitable moulding material is dictated by the properties that determine its suitability for the performance of a casting of the required technological properties. Often the cheapest moulding sands (and binders appropriate for these sands), which can ensure the required technological properties, are used. When the required parameters are not observed, the risk of the casting defect occurrence can be expected. Care should also be taken to eliminate the unwanted substances penetrating from the mould into a casting (i.e. oxides, nitrides, sulfoxides, nitroxides, carbonitrides, and steam).

As part of innovations, to effectively eliminate the already mentioned substances penetrating from mould to casting, new materials are used (reclaim-based sands, resin-bonded sands, cold-cured furan resins, ester-hardened sands with water glass, etc.).

Wrong choice of the parameters of moulding and core sands can give rise to the occurrence of the following defects:

- non-homogeneous sand with moisture content too high ⇒ pinholes;
- sand too dry ⇒ sand inclusions;
- sand too weak ⇒ deformations;
- unprocessed sand components ⇒ gas inclusions;
- cores too weak ⇒ fracture, shape defects;
- wrong mould protective coating ⇒ surface defects;
- wrong design ⇒ mechanical damages, misruns, knobs, flashes, mismatches, push out, distortion.

The design of foundry pattern and making of foundry mould are a very important step in the casting process. The design of the pattern and of risers decides about the future functional properties of casting (shape, dimensions, stress formation, gating system design, the distribution and number of chills, wall thickness, etc.). Most often, designing of a pattern also includes the simulation modelling of the casting pouring process to exclude design errors . Therefore, the role of a simulation model is to ensure the required quality still at the design stage to minimise the risk of the occurrence of this cause of defects in castings, what was frequently recalled in the literature [5,6,7,8]. Yet, obtaining adequate simulation results requires knowledge of the parameters of moulding materials, such as: permeability, grain size distribution, moisture content, reclamability, refractoriness, peculiarity of some characteristics, and composition. In the simulation model they are represented by thermal conductivity, specific heat and specific gravity.

The above considerations highlight the following procedures applied to determine the causes of defects in castings:

- a set of potential causes of defects should be defined in relation to a particular type of defect, taking into account the structure of a technological process;
- in addition to the parameters of the technological process as such, it is necessary to take into account the external factors, especially parameters of the raw materials used (depending on the choice of the supplier and the technology applied);
- it is necessary to observe dynamic changes in the production environment (new suppliers, changes in customer requirements, new technologies and innovative materials).

Consequently, for each type of defect it is advisable to create a scenario defining the procedure that should be adopted to acquire the current set of information, enabling further identification of the causes of defects and an indication of the possibility of their removal.

An example of such a scenario prepared for the selected type of defects is shown in Fig. 2.

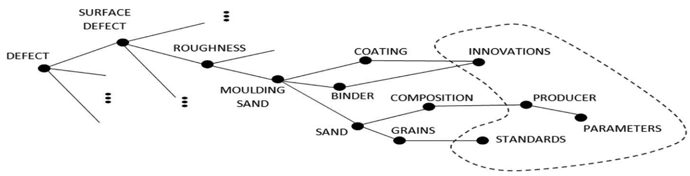

Fig. 2. Scenario of defining the procedure of acquiring the current set of information

3. The prototype system for data integration

Data integration is an actively developing area in computer science in the past few years, and its application is wherever there is need to analyze large amounts of digital data sources [9]. Currently, the most mature approach is the concept of the ETL process, which was used in this work.

ETL (Extract-Transform-Load) means designing a relational database dedicated to a given problem and energising next its data from existing data sources. The process itself is composed of three phases. The first phase involves the selective extraction of data from external data sources, and thus, in the problem under consideration, from a repository of standards, company brochures, or publications database (SINTE). In the second phase, the extracted data are cleaned and transformed to a form compliant with the scheme of the designed database. This scheme is called global scheme. In the third phase, the data is loaded and stored in a dedicated database where it can be downloaded for further analysis by the relevant business rules. Figure 3 illustrates the above process as applied to the problem under discussion. In this figure one can see how the data from external sources are stored in the dedicated tables of the global scheme of a dedicated database.

The implemented prototype system focused on the integration of data from the foundry was based on the ETL process, but due to the limitations of current ETL technologies, most of which are based on relational data sources, it has been enriched with logic layer extracting data from online sources. Another extension is the aspect of semantic integration as a mechanism to create connections between data elements. The solution enables the integration of any data sources and implementation of analytical methods in one environment. The whole was executed based on open CloverETL technology, a MySQL database and a JSoup library for parsing web documents to provide the functionality of data extraction and manipulation. For the purposes of evaluation of the prototype and concept demonstration, three data sources relating to defects, standards and publications were integrated.

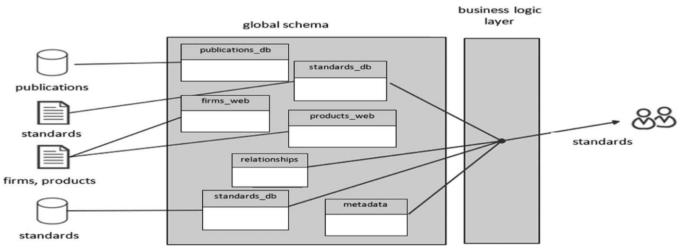

Fig. 3. Integration concept based on the ETL process

4. Verification of performance of the prototype

To verify the prototype, a graphical user interface was used. The prototype was equipped with this interface for a more comfortable use. The verification was based on a search through sources to find some data on casting defects. For the purpose of this paper, an example of the results of two searches for the roughness and blowhole defects was presented.

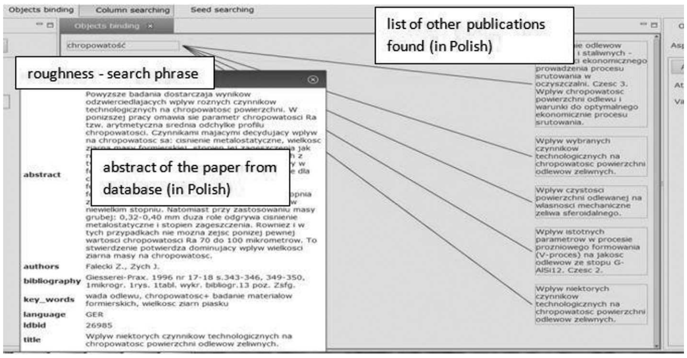

Fig. 4. The search for the causes of the roughness defects

The user interface has dedicated perspectives. One of them allows searching the sources for selected attributes. Figure 4 shows the result of searching an integrated database for standards related with the roughness defect. Database is in Polish language, though results are marked with English descriptions. The result is presented in the form of a graph, where nodes represent the standards found. By hovering the mouse over a particular standard, one can get a preview of the specific attributes of the item. Selection of one of the elements (the right part of the display screen) leads to a corresponding document (attributes).

In the second example, the final goal of the search was to obtain information on the blowhole defect. For this purpose, another perspective of the implemented interface was also used in which, instead of specifying the attribute values with the consecutive search carried out, the user specifies the, so called, "grain", and the system searches in the available resources for connections between the specified aspect (defects) and other aspects. To present the solution in its most general form, in this particular case, the purpose of the search was collecting information on the blowhole defect, using as a "grain" the keyword "blowhole". The search results are illustrated in Fig. 5.

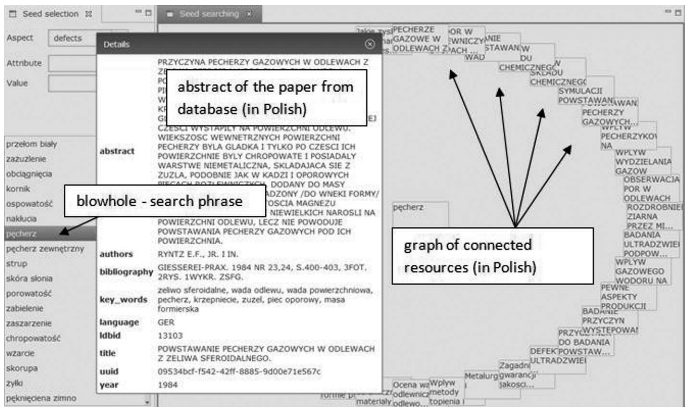

Fig. 5. The search "from the grain" for the blowhole defects

5. Final remarks

The presented results show that the implemented prototype provides the functionality of search through an integrated database system for different queries. As a result, the user no longer needs to search for various sources manually.

It should be noted that the entire process of acquiring information by the user is controlled by determining the relationship between the sources used. Consequently, the obtained data is a sequence describing the tested fragment of reality, taking into account aspects of semantic integration, which is essential to enrich functionality compared to traditional search engines.

In the paper Authors refered to the application for a search for causes of defects in castings, but the realized system could be used in a similar way to other tasks set out the relevant data sources such as search vendors offering materials with specific properties, exploration of innovative technologies for the desired product group etc.

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