KNOWLEDGE COMPONENTS DESCRIPTION, SUPPORT TO PREVENT DEFECTS OF METAL PRODUCTS USING METHODS BASED ON ARTIFICIAL INTELLIGENCE AND ETL TECHNOLOGIES

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Abstract

The process of creating knowledge components which allow preventing the formation of defects in metal products was described. Components are the result of the integration of knowledge from databases containing information on defects in castings, from publications dealing with the problems of metallurgy, and from standards and articles discussing causes of defects in metal products. Tools for knowledge integration are based on selected methods of artificial intelligence and ETL technology.

Keywords: defects in metal products, crack defect, integration of knowledge

1. INTRODUCTION

When describing the problem area associated with the diagnosis of casting defects, attention should be paid to the fact that it includes several distinct sub-areas where only the relevant global perspective allows for a satisfactory solution of diagnostic tasks. It is about the knowledge of modern technologies of casting, and in particular about the parameters that have importance from the point of view of the casting quality, that is, the possibility of the occurrence of defects. Such knowledge can be obtained from standards, catalogues, and theoretical studies, and also from the technological instructions and expert experience [1-10].

The problem is how to combine the elements of knowledge from different sources into a coherent whole and give them a form that will allow the component processing.

In the approach proposed by the authors, this process includes the following steps presented previously and consisting in:

- Identification of sources of knowledge created in different countries, comprising the classification of defects.
- Diagnosis of the type (name) of defect and of the causes of its occurrence, based on the representation of knowledge in the form of attribute table.
- And a new approach to the final step: Indication of how to prevent the occurrence of defects based on knowledge combined from distributed sources using ETL technology.

Adoption of this procedure is, on the one hand, justified by the desire to meet the comprehensive needs of the user while, on the other, it satisfies the need to have a systematic selection of formal methods and means how to use them.

2. THE DESIGN OF AN ATTRIBUTE TABLE

The specific character of knowledge about the defects in castings consists, among others, in this that the available sources give this knowledge in a linguistic form. Therefore the concept of knowledge representation in the form of an attribute table was proposed [11, 12]. The content of this table is the result of analysis of source materials and numerous discussions with experts.

The starting point for the creation of an attribute table are systems for classification of the crack defects described in standards, catalogues and guides, both domestic and foreign.

A variety of principles for the classification of this type of defect applied in selected countries are shown on the examples of several typical systems.

In the French system shown in **Fig. 1**, this division is very developed. In the example presented here, attention has been focused on one class of defects only. Classes of defects are marked with letters from A to G. The defects in the form of cracks can be classified as class C, which was named *discontinuities*. Each class contains several groups of defects (e.g. C100, C200, C300), these groups contain subgroups (e.g. C110, C120 ...), and in the subgroups are included the defects indicated by a letter denoting the class of defect to which they belong and a three-digit number denoting affiliation with a group and subgroup (e.g. C111 ....). Analyzing more broadly the entire contents of the source (French atlas of defects) and comparing it to other sources, it should be noted that defects in the form of cracks can also be found in category B, where surface defects are described. Here, in the drawing, a broader description of this category has been omitted, but further studies (attribute table) allow for defects also in this category.

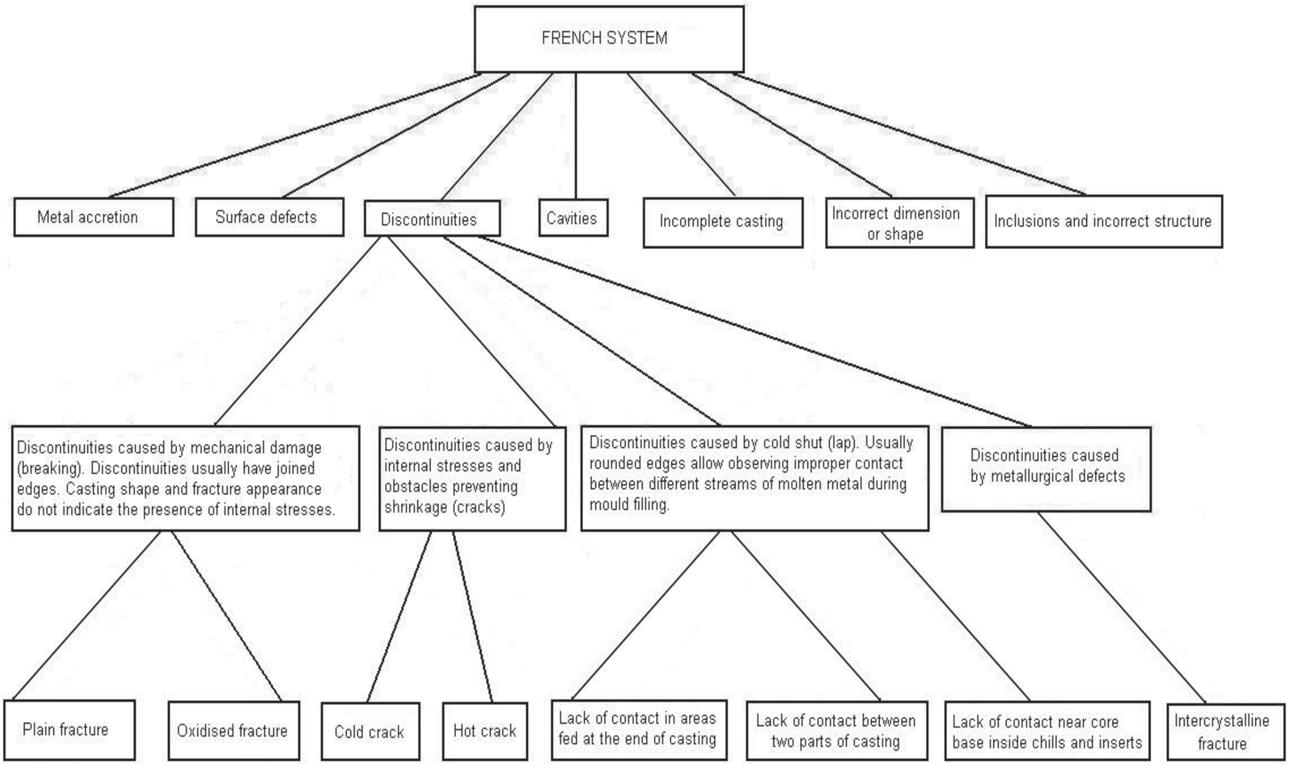

Fig. 1 The classification of defects in a French system

Fig. 2 illustrates the system described in the Polish standard 85/H-83105 [literature]. Here there is a division into four classes of defects, marked with symbols consisting of letters and a three digit number, e.g. W-300 for the crack defect. Each of the classes includes the defects marked with W and a three digit number, which is the class number (e.g. 301 indicating the cold crack defect). Comparing only the number of "steps" in the division, without paying attention to the contents of the defect description, a large diversity between these systems is noted. The next drawing (see **Fig. 3**) presents the Czech system, in which the number of the levels of division is similar to the Polish system, but when individual names of defects are analyzed, some discrepancies emerge.

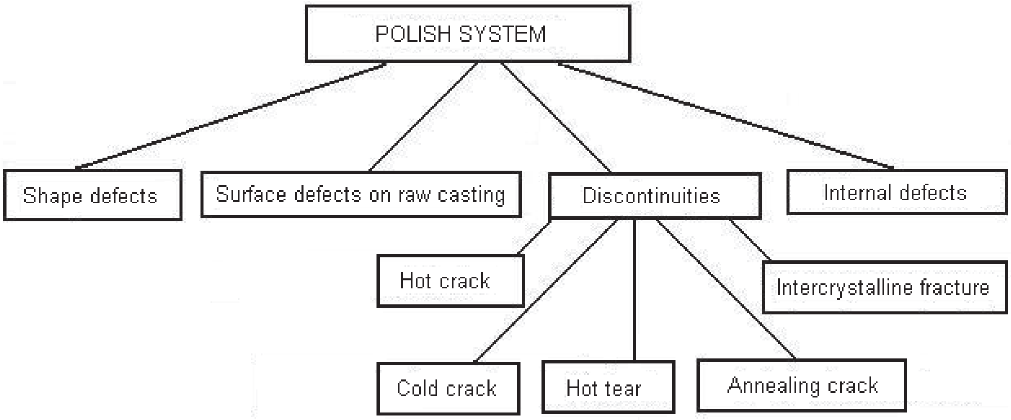

Fig. 2 The classification of defects in a Polish system

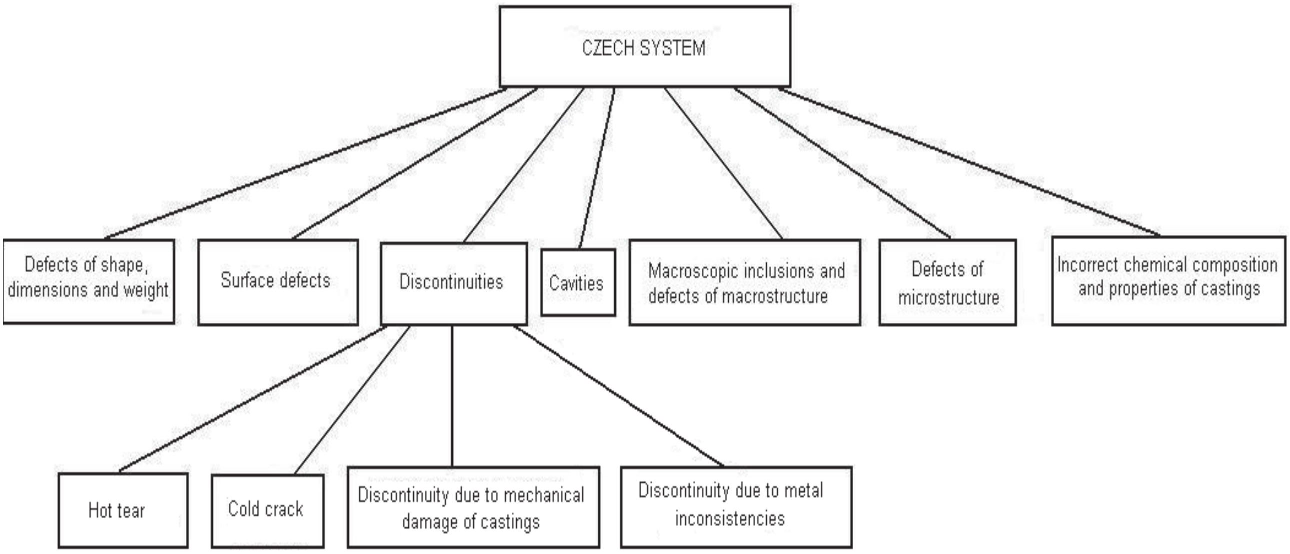

Fig. 3 The classification of defects in a Czech system

Considering the above differences in description of the defects located in different classification systems, to have the possibility of application of selected computer method of data integration, a table has been created in which each name of the defect defined in any classification system has been described using the defined attributes. A fragment of such a table, generated for the defects associated with cracks in castings is shown in **Fig. 4**.

Defect name	Damage type	Visibility	Damage size	Amount of material	Distribution	Localization	Form material	Inclusions	Abundance	Defect shape	Cast material
121 BROKEN PART OF THE CASTING HEAT Czech System	severance	visible	marked	underflow	local	surface	each	absence	unitary	irrelevant	each
						edge					
		invisible to the naked eye			extensive	protruding elements					
					concentrated	part					
W104 FLASH Polish System	sheet	visible	marked	overflow	local	wall	irrelevant	bleaching	unitary	irregular	each
	outgrowth					parting face		metal		flat	
W105 SHIFT Polish System						edge	irrelevant	absence	unitary	no data	each
	displacement	visible	marked	irrelevant	local	parting face					
						core					
						form					
W106 STRAIN Polish System	swelling	visible	marked	overflow	local	whole	moulding sand	veins	unitary	convex	each
	deformation					surface					

Fig. 4 Fragment of an attribute table for the crack defects

The principle has been adopted that in the description of the properties of objects, the values of all attributes or conditions that these objects must meet are given. Elementary record of the fact stating that the value of the attribute A_i is t has the form $A_i = t$, where $t \subseteq D_i$. Owing to this notation we can get a significant extension of the classic relational data model. Attribute values need not be explicit, so the representation of conditions to be met by individual attributes allows for the specification in the form of an interval or set of values or names.

Attribute values in each column use the description of the defect constructed on the basis of literature sources. The rows are filled with verbal descriptions stated in the source material. These descriptions are usually different (perhaps because they are translated from different languages) and contain ambiguous definitions. To facilitate typing of terms into individual columns, these columns had to be defined (described) stating what type of term may be entered in the column and what is meant by this term. The terms collected in the table serve as an element for data integration using ETL technology.

3. ETL TECHNOLOGY

ETL (Extract-Load-Transform) is based on the task of designing a relational database dedicated to a given problem, and then in powering it up with data from the available data sources. The process itself comprises three phases. The first phase involves the selective extraction of data from external sources and therefore - in the considered problem - from a repository of standards, an attribute table or database of publications (SINTE). In the second phase, the extracted data are subjected to cleaning and transformation to a form compliant with the scheme of the designed database. This scheme is called the global scheme. In the third phase, the data is loaded and stored in a dedicated database wherefrom it can be downloaded for further analysis by the rules previously defined, relevant to a given process of reasoning. In this process one can see how the data from external sources are stored in dedicated tables of the global scheme of the dedicated database.

In this example, the goal of the search was to obtain information on the cracks occurring in castings. As follows from the analysis of the literature presented in the initial part of the article, the defect is classified by different systems under different names. A link for various classification systems, enabling the integration of databases, is the described table of attributes. Results of the integration of data from several sources in the context of the crack defect prevention are given in Figures 5 - 7.

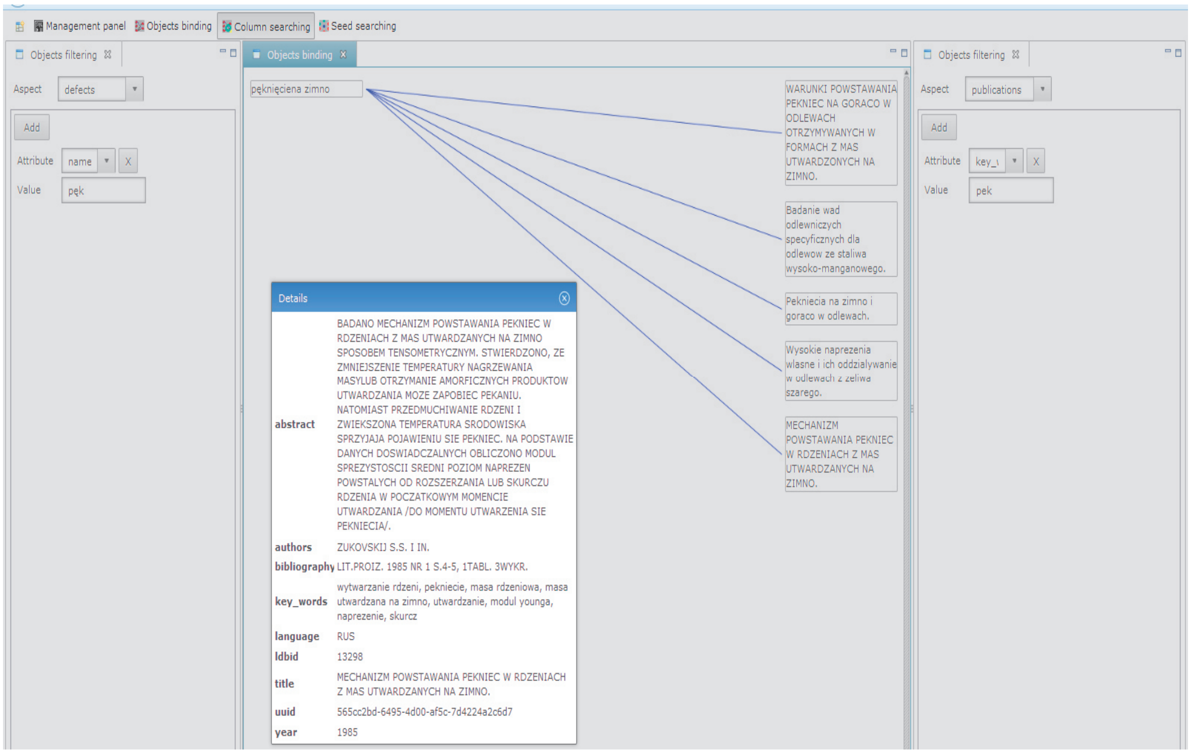

Fig. 5 Searching for the cause of the defect occurrence using the contents of an attribute table (result from data base in Polish)

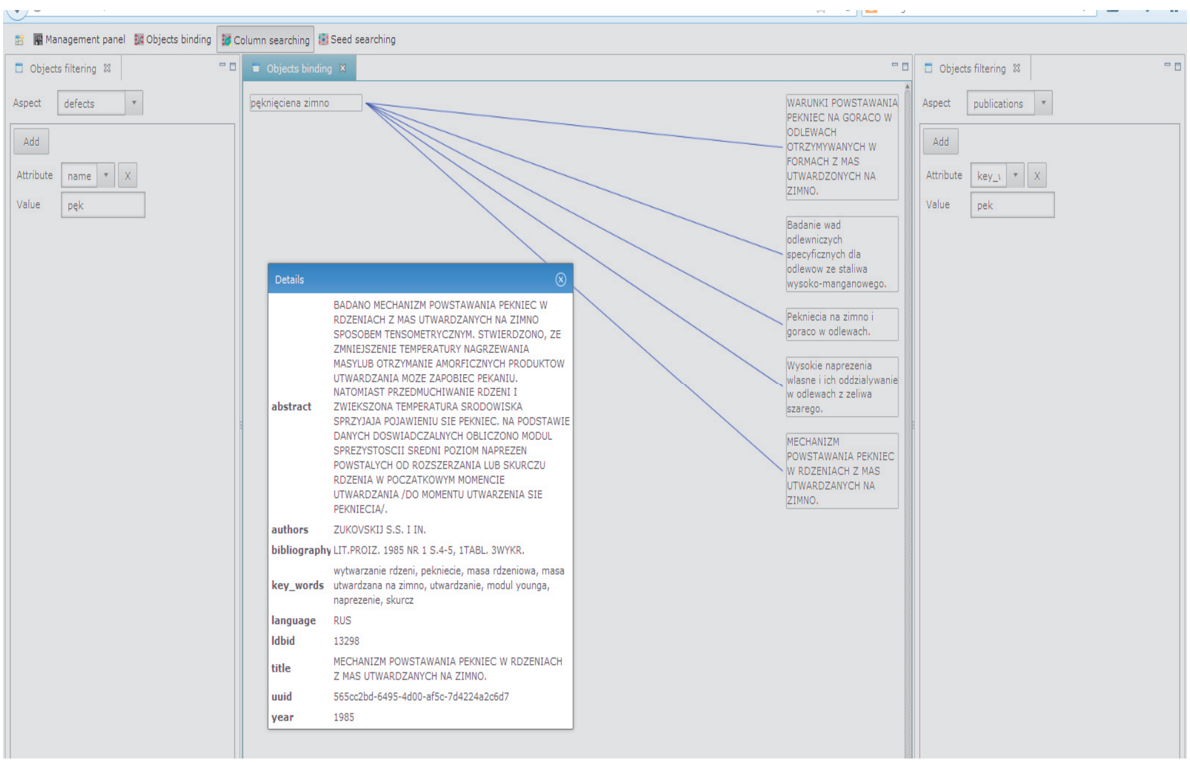

Fig. 6 The results of searching for information on how to prevent the defect (result from data base in Polish)

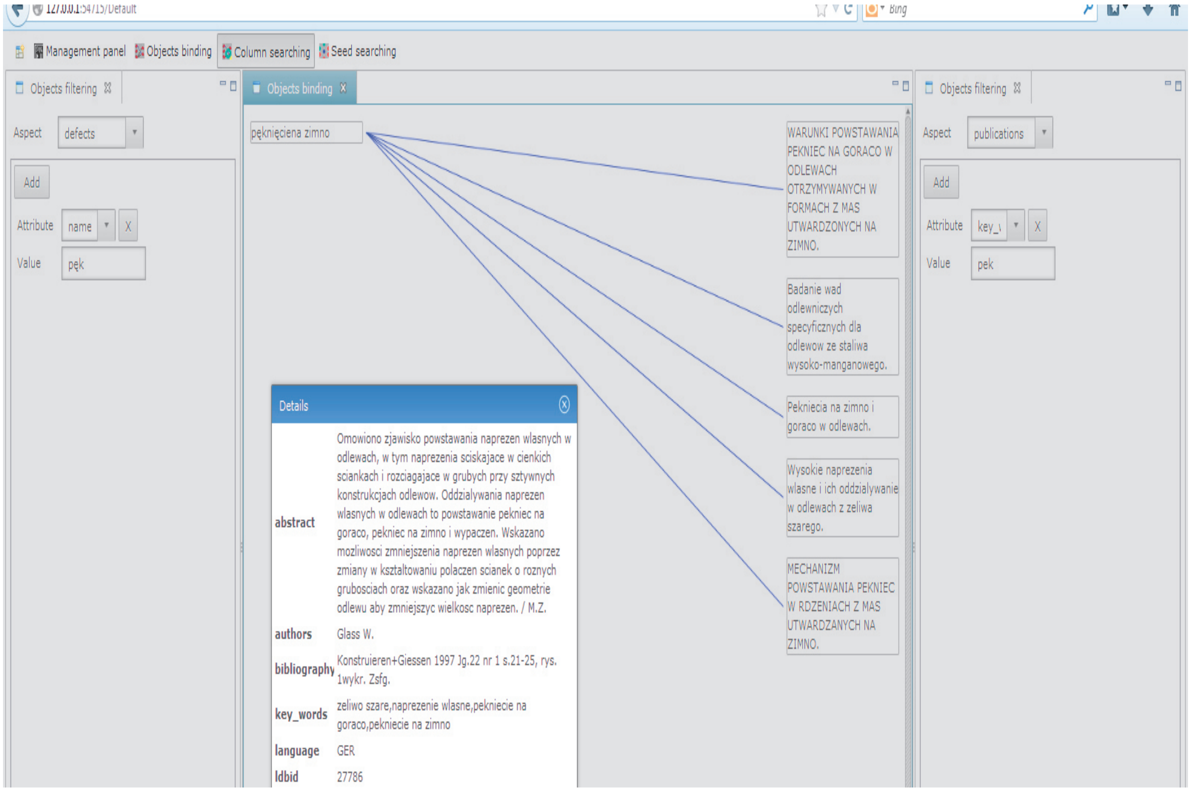

Fig. 7 The results of the search for solutions (result from data base in Polish)

The presented results show that the implemented prototype provides functionality in searching of an integrated database for queries about the causes of defect and possible methods of preventing its occurrence.

CONCLUSION

The paper presents a procedure for constructing knowledge component using the attribute table and ETL technologies. A characteristic feature of this approach is the ability to unify the knowledge source, I.a. based on a variety of classification of defects by standards of different countries. ETL technology leads to the integration of the knowledge created, and consequently convenient for the user to access forms. Action executed application is illustrated on the selected defect, confirmed by obtaining the intended functionality.

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