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ELECTRONIC DATABASES FOR MATERIALS SELECTION

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Summary: *The increasing market competition necessitates the creation of products of better quality with the lowest possible price. One way to achieve this is an appropriate materials selection that will enable better and cheaper product. Knowing the quality of the available materials and their characteristics, as well as tracking trends in the development of new materials, are essential parts of good engineering practice. The materials selection is not an easy task in engineering practice and it is one of the few in the process of constructing a product that is subjected to constant changes. On the other hand, the wrong materials selection in the very beginning of constructing could have irretrievable damage to the manufacturing and exploitation process.*

Data and information about materials must always be available to constructors and designers of new products, as well as to technologists. They can be found in classic literature (manuals, catalogs, standards, recommendations,...) or in electronically prepared databases on the computer (intranet, internet).

Part of the available software tools for the selection of materials with the basic characteristics will be presented in this paper. Also, several tools will be described in more detail.

Key words: *Material, database, materials selection*

1. INTRODUCTION

The increasing market competition necessitates the creation of products of better quality with the lowest possible price. One way to achieve this is an appropriate materials selection that will enable better and cheaper product.

The materials selection is not an easy task in engineering practice and it is one of the few in the process of constructing a product that is subjected to constant changes. On the other hand, the wrong materials selection in the very beginning of construction could have irretrievable damage to the manufacturing and exploitation process. Knowing the quality of the available materials and their characteristics, as well as tracking trends in the development of new materials, are essential parts of good engineering practice [1].

Data and information about materials must always be available to constructors

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and designers of new products, as well as to technologists. They can be found in classic literature (manuals, catalogs, standards, recommendations, ...) or in electronically prepared databases on the computer (intranet, internet) (Figure 1).

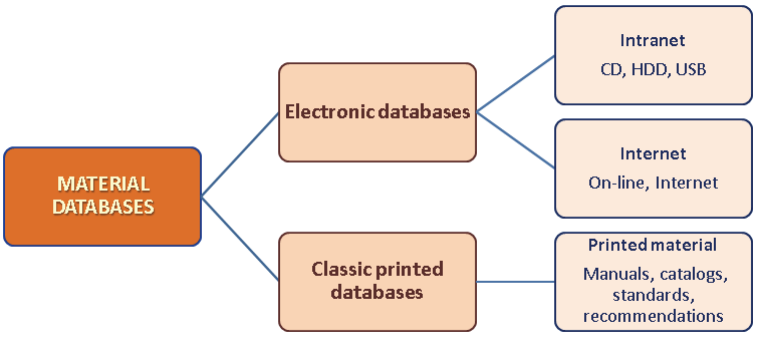

Fig. 1 *Forms and types of databases and information systems*

Since the number of materials rises each day more and more, and bearing in mind that the large number of properties can be attributed to any material that users potentially need, then the data from classical literature, because of their inertia, lose their importance more and more, and data and information about materials that are systematically collected, evaluated and stored in computer databases for the last several decades, are increasingly gaining importance [2].

Intensive development of software and hardware in previous years has enabled a step further, i.e. creation of special software packages – expert systems, which not only include the aforementioned databases, but also offer opportunity for interactive materials selection for various engineering applications. The above mentioned expert systems allow to not expect an expert knowledge of materials from constructor and provide faster informing and decision making in product development and materials selection.

Computer databases exist in a number of companies, enterprises and public services, and many of them are commercially available, while the knowledge bases are less developed.

Therefore, at the present time, there is a growing practice that the results of research and testing of materials are rapidly transferred into engineering activities using information and communication technologies.

2. MATERIAL DATABASES

Smaller production companies usually have neither personnel nor the financial abilities for the serious development of electronic material databases, so they turn to the use of material databases from external sources.

The external information resources can be reached in the following ways [3, 4]:

a) By purchasing, lending or exchanging packages of materials data on CD,

b) By online connection with a base with relevant data about materials (membership is usually necessary to access),

c) Using the internet, which allows the search of numerous databases (with mostly free access).

Data and information obtained from primary and secondary sources have various degree of complexity, reliability and comparability. These data may be the result of standard or non-standardized testing methods. Defining a set of relevant data and the structure of database requires a deep and detailed expert analysis. Expectations of database users can be very different – from informing to the optimization in the materials selection. Therefore databases differ in types and number of collected data, degree of their accuracy and comparability, structure of recorded data, search capabilities, number and type of users, etc.

It should be noted that only a small number of electronic databases have free data access, while for most it is necessary to pay for a single or multiple access through membership (usually per month or per year), either for online access, or for the purchase of license for the use of database in the form of installation software.

Databases differ according to the group or type of treated materials (metals, ceramics, polymers, composites), but also in properties and characteristics (physical, chemical, optical, mechanical, ...), or according to material application areas (automotive industry, aircraft industry, biocompatible materials, etc.).

Some of the available databases with their main characteristics are:

- **Material Index** is the database of manufacturer MEMSnet, whose contents represent general material properties. It is free of charge and can be found at http://www.memsnet.org/material/,
- **Principal Metals Online** is the database of manufacturer Principal Metals which contains the basic properties of metal alloys. It can be found free of charge at http://www.principalmetals.com/,
- **SteelSpec Web Edition** is the database of manufacturer UK Steel Association. This database is a Web page of the printed edition of Steel Specification. It can be found, with the necessary membership, at http://www.steelspec.org.uk/index.htm,
- **Prospector** is the database of manufacturer IDES-Integrated Design Engineering Systems. It contains 49000 pages about plastic materials from 400 suppliers. It can be found at http://ides.com/, membership is necessary.
- **Campus Plastics** is available database on internet (http://www.campusplastics.com/). Campus is the only database that offers high quality and comparable informations about polymer materials, based on unique international standards, like ISO 10350, ISO 11403-1.
  It provides information such as: brief description of material, mechanical properties, thermal properties, electrical properties, general material characteristics, diagrams, resistance to chemical influence.
- **Alu SELECT** is one more internet database. It contains technical information about the most commonly used aluminium alloys. This free website (http://aluminium.matter.org.uk/aluselect/) allows the user to obtain information about mechanical, physical and chemical properties of aluminium alloys.
- **WinSteel** is electronic database that contains information about more than 180 thousand different types of steel worldwide. It contains information on the chemical composition and properties of steel from various international standards (http://www.metaldata.info/eng/). Also, it can be used to find equivalent steel marks according to different standards. This base is commercial.

- **Key to metals** is a global database of ferrous and non-ferrous materials, developed and designed for worldwide use. This electronic database represents the most comprehensive database in the field of materials, including information on materials and suppliers from more than 30 countries worldwide. Using the software of this database, user is able to obain information about material he needs in a very short time (http://www.keytometals.com/). Database can be installed on a personal computer from a CD or can be used online with appropriate compensation.
- **Steel Selector-Metal Ravne** is electronic database of steelworks Metal Ravne. It can be found on internet, it is free of charge, and there is a download option (http://www.metalravne.com/). This database provides ability to search steel from the production program of steelworks Metal Ravne.
- **Matweb** is an internet database of manufacturer Automation Creatins. It contains data about large number of materials and the search possibility. It is free (with registration) and can be found at http://matweb.com/. It contains information about a large number of materials such as polymers, pure elements (metals), ceramics, super alloys, iron alloys, non-iron alloys as well as many other engineering materials.
- **StahlWissen Navimat-Online,** made by Dr. Sommer Werkstoffechink, is multimedia software that contains characteristics of the steel. It can be found at https://www.werkstofftechnik.com/. Installation CD that needs to be paid is needed for installation on the computer. Electronic database StahlWissen-NaviMat then enables a search through installed program on a personal computer. This database has developed an application for mobile devices (Figure 2).

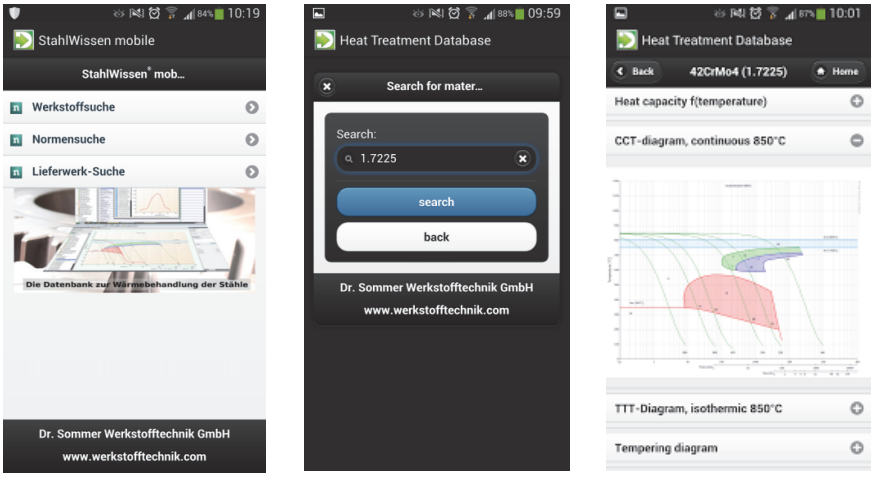

Fig. 2 *Database StahlWissen-NaviMat mobile phone application*

- **StahlSchlussel** (**Key to Steel**) is material database of manufacturer Verlag Stahlschlussel Wegst Gmbh. Internet adress http://www.keytosteel.com/en.aspx gives information about it, while paid installation CD is needed for the use. It is one of the most competent databases and contains more than 70 000 standards, as well as information for about 300 steelworks and suppliers.

3. EXPERT SYSTEMS

Expert systems (ES) are created in the mid-twentieth century and have been developed on the basis of expert knowledge and practical experience, using methods of artificial intelligence. ES tries to imitate the way of expert's problem solving using different methods of reasoning, assessment and decision making, based on more or less reliable or complete information. The main problem in the implementation of the EC is to collect, evaluate and shape the knowledge for later processing in a specific situation. It is also a problem to find experts who can adequately present the necessary knowledge and decision making process, as well as so-called "knowledge engineers" whose task is to gather, systematize and shape expert knowledge and procedures, and then transfer it into the computer. Today, there are some developed modules that facilitate the organization of ES so it can write and add data and rules, building its own ES [5,6].

Knowledge is represented by assigning demands for material properties, then by recommendations about suitable materials and the relations between properties, to the parameters of production processes and the behavior of material in exploitation. Based on these rules the process of reasoning and decision making significantly accelerates.

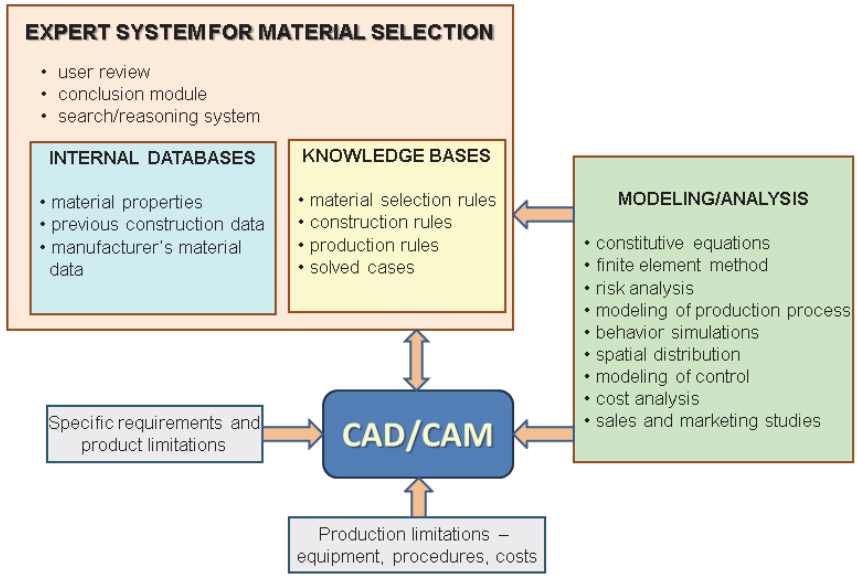

Fig. 3 *The conceptual scheme of the structure and functioning of the system's expert system* [6]

Expert systems usually contain material and manufacturing process databases as well as the knowledge bases for search, reasoning and decision making.

Knowledge bases are programmed using object languages (C++, Java, Prolog, Lisp, etc.) and they use artificial intelligence methods for estimation and approximation, for example *"fuzzy logic"* is used in determination of material characteristics, in malfunction analysis (fracture, wear) and in the material selection.

Figure 3 shows the conceptual scheme of expert system functioning which is

able to communicate with the team of constructors and with software package for modeling and structure analysis [6].

The basis of this system consists of a database and knowledge base of the properties, behavior and application of different materials.

Databases of material contain information about different material properties and their behavior in production processes and in exploitation. The information in database can be given in numerical form, descriptive, in the form of formulas, diagrams or figures. The quality of the database depends on the number of materials and their properties, as well as of its source and reliability.

Knowledge base contains rules for material selection, construction rules, limitations, objects and gained knowledge from already solved cases. Formulas are the basis of physical models in knowledge bases.

Software support of an expert system enables filling out the questionnaire, requirements and selection criteria, processing and presentation of results using tabular and graphical display of all data and information. It is also possible to communicate with other related activities, such as supply of material, manufacturing processes and control processes.

Today's expert systems for material selection include the ability to connect with CAD packages for modeling and structure analysis - FEM (Finite Element Method), constitutive equations, cost analysis, risk analysis, simulation of material and structure behavior, modeling of machining processes, etc.

CES (Cambridge Engineering Selector) is one of the most commonly used EC for material selection (Figure 4). It is a PC application that enables both constructors and material experts, and other engineers, to find proper materials that will constitute the optimum solution for their product. This product is of great help in decision making about materials in the early stage of product design, redesign or replacement of existing material with a new one.

Fig. 4 *Expert system CES*

CES offers tools that support a rational selection methodology developed by Professor Mike Ashbi with colleagues at Cambridge University and Granta Design Ltd company (http://www.grantadesign.com/products/ces/). The method represents the industry standard of systematic approach to the materials selection [7]. CES software and database modules are functionally connected in packages. Each package is designed to allow the complete solution for the specific CAD needs.

CES system is composed of a series of connected modules. The material selection is guided by the design of construction, which means that the input data are exactly the design requirements. These requirements are further transferred into orders for material selection and properties of machining process.

CES Selector is the central module of the CES system, and allows engineers to select smaller groups of materials that optimally meet the design requirements from the existing material databases.

Program then offers the creation of selection charts that give a visual representation of important properties, or a combination of properties of material or process (Figure 5). CES Selector enables numerous tools with sophisticated strategy and automatically maintains the direction of selection results.

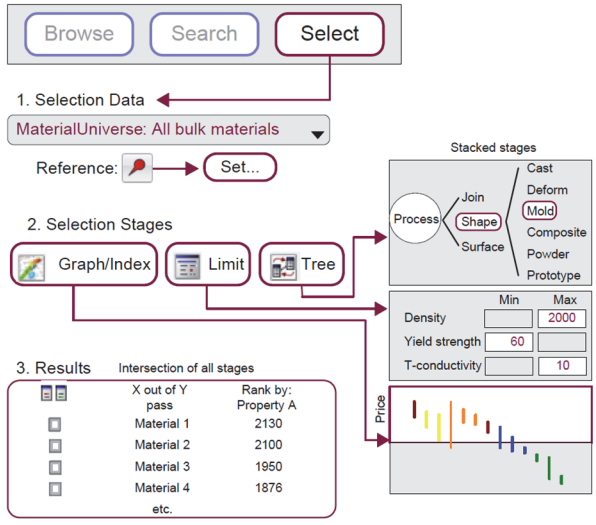

Fig. 5 *Principal scheme of setting limitations in the material and process selection*

Preview of this way ranked material properties is the first step in the materials selection. These charts give a ranking list of potential material candidates. Combining multiple charts can significantly narrow the range of possible candidates. At the point when the group of satisfactory materials is found, CES Selector program enables direct access to a huge source of additional information related to these materials (diagrams, figures, texts, tabular data, etc.) that are enabled by Granta Design, but also to other sources (for example Campus, Prospector, ASME, Internet, etc.).

Even such a complex system for material selection cannot give one particular material as an answer to the required application, but offers a small group of different materials as a solution, so the final selection of material is left to the user (constructors,

engineers) with help of additional information (reference for some materials, or through additional requirements).

4. CONCLUSION

An increasing number of materials and their characteristics, striving for a faster and more reliable search of information, objective and more thorough comparisons, a growing need for modeling and simulations, indicate the use of computer systems that process and store information of materials.

Computer databases exist in a number of companies and many are commercially available through public information services, while the knowledge bases and associated expert systems are less developed.

The main problems faced by manufacturers and users of these databases and systems are their quality and quantity, i.e. database details and number of offered materials, as well as strategy of materials selection using expert systems through existing databases.

Development of software and hardware enables to material base creators to go a step further, i.e. to create special software packages, which will include not only the aforementioned databases, but will also offer opportunities for interactive material selection, which implies two-way communication between users (engineers) and a special software package (expert system).

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