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# Materials and Producers Base Operating in the CAPCAST System

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## Abstract

The article presents two modules operating in a hybrid CAPCAST system implemented in the Department of Applied Computer Science and Modelling, AGH University of Science and Technology, Cracow. These are the modules: CAPCAST-*base of producers* and CAPCAST-*base of materials*. Registered producers may benefit from other modules of the system, the base can also be an independent source of knowledge about Polish foundries and their production capacity, and can serve as a kind of platform for the implementation of the basic functions of e-business. The base of materials can also be a source of knowledge about materials, and it allows searching and filtering the lists of materials in terms of user-selected attributes using a multi-level search engine. This module is integrated with the rest of the system and can be used by other modules. The system has been developed at the AGH Department of Applied Computer Science and Modelling in Cracow.

**Keywords:** Base of engineering materials, Base of producers, Base of foundries, CAPCAST system

## 1. Introduction

With the development of scientific and technological knowledge in areas such as materials science, metallurgy and foundry, the aim of which is to raise the technical level and efficiency of the production of transport means, machinery and tools, it is important to develop computer-based systems to support the production processes.

The market of information systems offers a number of tools supporting the casting producers in many areas, such as:

- the design of machine elements, e.g. the commercial simulation programmes (MAGMA, ProCast, VULCAN, NOVAFLOW, PAM-CAST, SIMTEC),
- the management of production enterprise - integrated ERP systems [1-3],
- supporting the production tasks in enterprises of casting - a variety of authoring systems [4-12]

At the same time there is no common platforms that would allow communication, sharing of information and undertaking joint tasks for many subcontractors involved in the manufacture of cast components. In other areas like building construction there are platforms that allow collaboration between subcontractors.

In Poland there are currently about 400 foundries, of which more than 90 percent are representatives of the SME sector. These companies are scattered throughout the country (as illustrated in Figure 1) and competing mainly on the local market. Their cooperation would be beneficial both for individual companies and for the industry and this is the main task of the CAPCAST system.

A large number of foundry subcontractors include SMEs, and among them there are the following groups:

- *designers of machines and equipment* - looking for materials that meet certain criteria,
- *manufacturers of machines and equipment* - the main markets served by the foundry industry are automotive, general engineering and construction,

- suppliers of raw materials for foundries - noble ferro alloys, scrap assortment, inoculants, secondary trading of non-ferrous metals, etc.,
- market of companies associated with the transport and storage of both finished and raw castings,
- other.

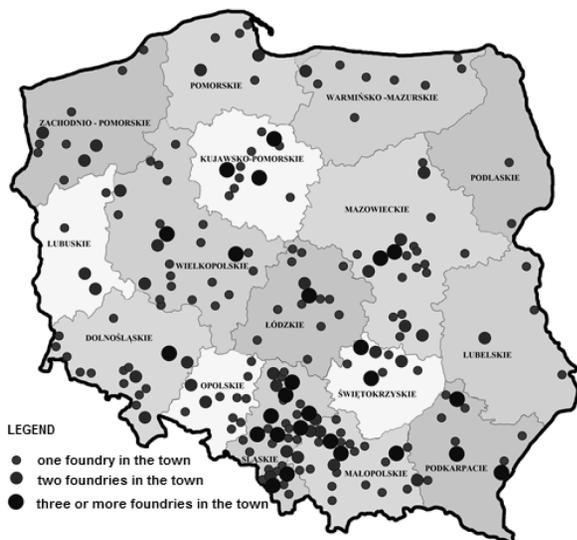


Fig. 1. Map of foundries in Poland  
Source: Own study

Creating a system that integrates these small companies to start cooperation in the area of e-business, especially in B2B and B2C, seems a purposeful task and can bring many tangible benefits to individual contractors, to mention as an example:

- effective search for suppliers of raw materials for the manufacture of a specific range of products,
- quick indication of the manufacturers of castings, who have the infrastructure to perform the contract and ensure the required quality and production volume,
- opening the road to innovation through technology consulting and marketing,
- using this system as a platform for advertising small businesses and their products, and for the exchange of information and the implementation of common tasks in the area of B2B.

## 2. The CAPCAST System

In the AGH Department of Applied Computer Science and Modelling, an attempt was made to build a system, one of the major tasks of which would be the integration of Polish foundry industry and its contractors done with the help of computer networks and modern information technology. A project was developed involving a hybrid CAPCAST system (Computer Aided Process CAST) [13-16] aimed at supporting the design decisions in the selection of the most favourable technological parameters used in the manufacture of cast machine components. In its present form, the system consists of five modules (Figure 2):

- base of materials,
- base of producers,
- base of CTP charts,
- base of heat treatment models (OC),
- expert system.



Fig. 2. Basic modules of the CAPCAST system

This study is devoted to discussion and analysis of two of the five basic modules, i.e. the base of materials and the base of producers, both operating in the CAPCAST system.

## 3. Design assumptions of the CAPCAST system

One of the assumptions adopted in the design of the system was to develop an open base of the cast materials producers, where the users would be capable to register themselves by giving their characteristics according to accepted guidelines, and to integrate this base with the rest of the system.

The producer of cast materials registered in the base will be entitled to use the system knowledge bases, which means that he will have the right and the ability to run an expert system for the selection of material adjusted to the adopted design assumptions, will have access to a base of TTT graphs accumulated in the system, as well as the ability to run a simulation module for the developed models of heat treatment.

The CAPCAST system (Figure 3) provides categorisation of users by assigning to them certain roles. The existence of users registered as:

- designers,
- suppliers of raw materials for foundries,
- manufacturers of machines

has been assumed.

Each of these roles differs in terms of reference allowing the operation of the system.

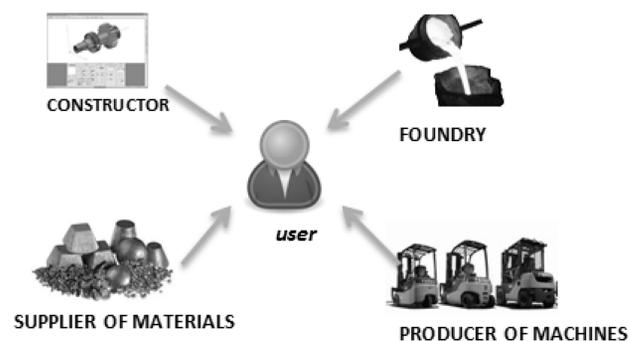
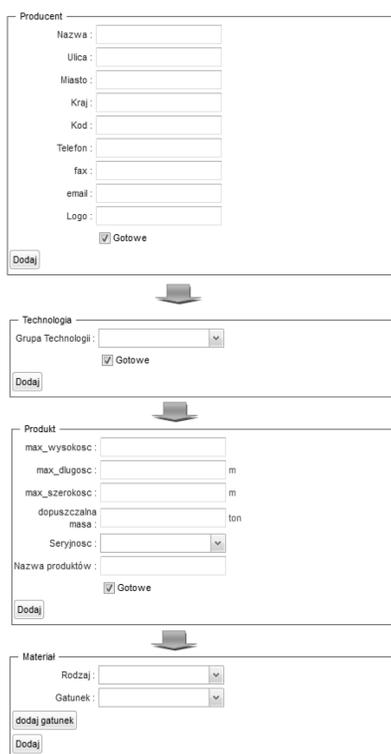


Fig. 3. User roles in the CAPCAST system

The newly created user accounts are by default assigned to the *User* role, while assigning of respective roles is the prerogative of the System Administrator after user verification.

## 4. The CAPCAST base of producers

User of the CAPCAST system is granted constant access to his account, where he can keep updated information about the company. This is the teleaddress information, information about the applied technologies, data on products and own processing capacity, information about the materials used and own offer. For each of the available roles, analysis should be made to know what information has to be included in the registration form. For example, if a user has been registered as a **producer of foundry materials**, he can enter into a database system the information about his company using the form, fragments of which are shown in Figure 4.

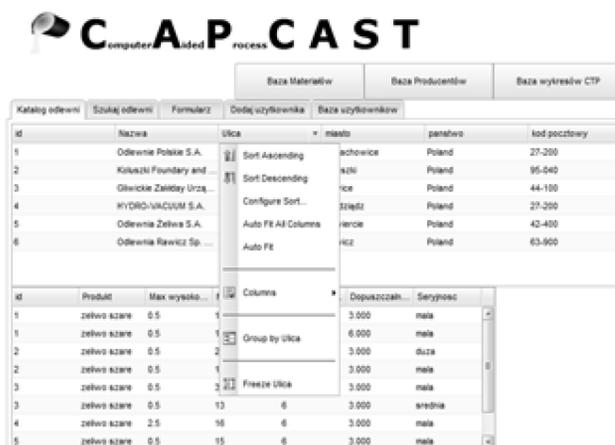


The figure shows four sequential form fragments for registering a producer:

- Producent**: Fields for Name, Address, City, Country, Code, Telephone, Fax, Email, Logo, and a 'Gotowe' checkbox.
- Technologia**: A dropdown for 'Grupa Technologii' and a 'Gotowe' checkbox.
- Produkt**: Fields for 'max\_wysokosc', 'max\_dlugosc' (m), 'max\_szerokosc' (m), 'dopuszczalna masa' (ton), 'Seryjnosc' (dropdown), and 'Nazwa produktow'. Includes a 'Gotowe' checkbox.
- Materiał**: Dropdowns for 'Rodzaj' and 'Gatunek', a 'dodaj gatunek' button, and a 'Dodaj' button.

Fig. 4. Fragments of the registration form for producers of castings

Any person logged in as a *user*, regardless of the assigned role, has the ability to view information about the registered database users. Searches may be conducted according to various criteria, for example, search for registered suppliers of raw materials for the foundry industry in the province of Malopolska, search for manufacturers (foundries) making machine components from the specified material, etc. (Fig. 5).



The screenshot shows the CAPCAST application interface with the 'Base of producers' module active. It displays a table of producers with columns for ID, Name, Address, City, Country, and Postal Code. A dropdown menu is open over the 'City' column, showing sorting options like 'Sort Ascending', 'Sort Descending', 'Configure Sort...', 'Auto Fit All Columns', and 'Auto Fit'. Another dropdown menu is open over the 'Country' column, showing options like 'Dopuszczaln...', 'Seryjnosc', and 'Group by Ulica'.

id	Nazwa	Ulica	miasto	państwo	kod pocztowy
1	Odewnia Polska S.A.		achowice	Poland	27-200
2	Kirkuzzi Foundry and		kozł	Poland	95-040
3	Głowiecki Zaleśny Urząd		ice	Poland	44-100
4	HYDRO-VACUUM S.A.		Trzebież	Poland	27-200
5	Odewnia Zielona S.A.		terce	Poland	42-400
6	Odewnia Rawicz Sp...		KCZ	Poland	63-900

Fig. 5. Base of producers module in the CAPCAST application

## 5. The CAPCAST base of materials

The CAPCAST system also operates module called *base of materials*. The project of database dedicated to this module contains the information required by the system used for both analytical purposes, e.g. information about the materials (name of grade, chemical composition, mechanical properties, physico-chemical properties, uses, identification by other standards, semi-finished products that can be produced from the specified material), and operational purposes (information about the users and the activities carried out by them).

This module is integrated with the rest of the system and can be used by other modules to perform, for example, the following functions:

- download the material characteristics to the simulation module,
- interrelate the range of cast products indicated by producers in the registration form with materials available in the base of materials.

The base can also serve as an independent source of knowledge about materials. A user interface has been developed which allows easy editing and search for materials.

### Project of main navigation

*Search section* - allows searching and filtering the list of materials for user-selected attributes using a multi-level search, which allows not only searching by selected properties, but also combining queries with logical operations: *and*, *or*, *none of the above*.



The screenshot shows the advanced search interface with a search bar and a dropdown menu. The dropdown menu is open, showing options like 'Name', 'Standard', 'HRcMax', and 'greater than'. There are also buttons for 'Match All', 'Match Any', and 'Szukaj'.

Fig. 6. Drawing showing advanced filters

To facilitate the search, simple and advanced filters were implemented.

- Easy filtering and sorting operations are available in columns such as the *name of the material/product, standard, application or producer*. Also, within the detail section, sorting in terms of the available criteria is possible.
- A list of vocabulary items for character maps (producers, names of materials, names of standards, names of applications) is provided. This is meant to facilitate for the user the task of searching the database. It also provides a navigation tree (Fig. 8) with the types of cast materials, which after selecting one of them, will be sorted, choosing only those materials that meet the criteria.

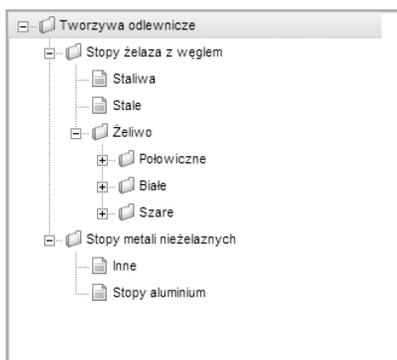


Fig. 7. Cast materials tree in the CAPCAST system

*Detail section* - after selecting the search block section of the material its name will be displayed and all the properties that are in the database. Depending on user's privileges, buttons will show that allow adding forms and editing tables from the database.

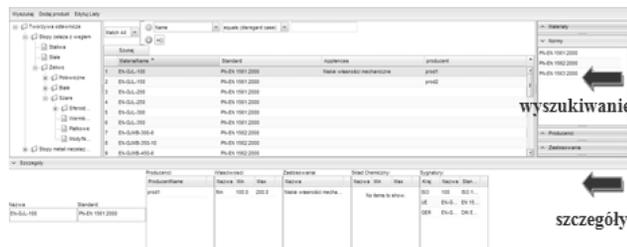


Fig. 8. Base of materials module in the CAPCAST application

The prototype version of the system is equipped with data, information and knowledge regarding the casting of ferrous alloys with particular emphasis on heat treated ductile iron. Architecture of the proposed system has an open character and the ability to expand and include many other materials. Materials are grouped in a hierarchical manner that allows searching for any arbitrary types. The base of materials also includes the possibility of searching by various material designations. For example, Table 1 lists the designations of the ductile iron grades according to different standards.

Table 1.

List of ductile iron designations according to selected standards

Species according to the standards					
PN-EN 1563:2000	PN-92/H-83123	DIN EN 1563:1997	DIN 1693	ASTM A536-84	GOST 7293-85
EN-GJS 350-22	350-22	EN-GJS 350-22	-	-	Vc 35
EN-GJS 400-15	400-15	EN-GJS 400-15	GGG-40 (0.7040)	60-40-18	Vc 45-12
EN-GJS 400-18	400-18	EN-GJS 400-18	-	80-40-18	Vc 40
EN-GJS 450-10	450-10	EN-GJS 450-10	-	-65-45-12	Vc 45
EN-GJS 500-7	500-7	EN-GJS 500-7	GGG-50 (0.7050)	65-45-12	Vc 50-7
EN-GJS 600-3	600-3	EN-GJS 600-3	GGG-60 (0.7060)	80-55-06	-Vc 60-2
EN-GJS 700-2	700-2	EN-GJS 700-2	GGG-70 (0.7070)	100-70-03	Vc 70-2
EN-GJS 800-2	800-2	EN-GJS 800-2	GGG-80 (0.7080)	120-90-02	Vc 80-2
EN-GJS 900-2	900-2	EN-GJS 900-2	-	120-90-02	-

## 6. The CAPCAST database

This chapter describes a fragment of the database operating in the CAPCAST system, responsible for handling modules such as *base of materials* and *base of producers*. It consists of the following tables:

- *users* - this table contains the data needed for the registration process to the system such as login, password, e-mail,
- *admin\_account* - these are the data to create an administrator account,
- *partner* - the main table of the module contains the contact details of the partner (supplier, foundry),
- *partner\_type* - this table determines the type of partner i.e. whether it is a supplier of materials for castings or casting producer,
- *product* - in this table partner publishes the data about his product,
- *technology* - the table contains data on the manufacturing technologies, e.g. casting,
- *technology\_group* - the table with a group of technologies to make individual products,
- *materials* - an associative table, comprises materials from which, in a manufacturing process, the final product offered by the producer is made,
- *chemical\_elements* - dictionary table that stores the names and abbreviations of elements,
- *chemical\_composition* - associative class for tables *materials* and *chemical\_elements*, contains information about the content of an element in a given material,
- *phases* - dictionary list of all the phases,
- *phase\_composition* - analogically to the table *chemical\_composition*, this is the associative class for tables *materials* and *phases* containing information about the content of phases in the specified material,
- *features* - a dictionary list of all the mechanical properties,
- *standards* - contains a list of the names of standards and their types (national, international, industrial),
- *material\_definition* - the associative class for tables *materials*, *standards* and *features*; it stores the index to the name of the material, the index to the name of the mechanical property (from the dictionary table *features*), the numerical values for each of these properties, and the name of the standard (from the dictionary table *standards*),
- *appliances* - stores the table with the names of the material applications,

- *appliances\_composition* - the associative class for tables *materials*, *standards* and *appliances*; it contains a list of applications of the material according to the standards,
- *types* - dictionary table of all the names of the types of materials,
- *types\_composition* - stores a list of the names of the types of materials,
- *country* – dictionary list; it contains a list of all the countries,
- *signature* – the associative class for tables *materials* and *country* with information on the names of the material counterparts in other countries,
- *producer* - table containing a list of the names of producers,
- *producer\_composition* - similar to the above examples, the class containing information about the production scope of materials by manufacturers.

## 7. Non-functional requirements and technologies used by the CAPCAST system

### Non-functional requirements - environmental

The authors have assumed that the system must use open technologies or those that have an open source version and commercial versions. At the moment, many software platforms, libraries or frameworks are available in this distribution model. The basic functionalities are available as freeware with some restrictions, for example, function- or performance-related. In many cases, in the open source model, full functionality is made available with paid technical support and functionality replenishment.

Restrictions on which the project should pursue its functions:

- universality:
  - o does not require the user to install additional software,
  - o is available for current web browsers,
- bases on free software (called open source),
- applied technologies and application architecture will allow for further development of the system,
- due to the complexity of content and ease of presentation of data dependencies it has been decided to use a relational model of the database.

### The choice of technology used by the CAPCAST system

Relational databases are standard in small and medium-sized projects. Large systems and cloud computing increasingly require processing of the large amounts of data, and in such cases the relational databases have limited functionality. The system proposed here can be successfully handled by a relational database. The authors chose the PostgreSQL 9.2 database for the compatibility of SQL language with the commercial Oracle database, a very good support of SQL environment and high quality documentation.

Similar criteria are successfully met by the Java programming language. Java 7 EE is now the dominant programming language of IT projects. It is characterised by very good data control. This reduces the number of errors made in the implementation phase,

and it is easier to debug the programme. Quite an important role is also played by the tools supporting the application components automated tests performed by the developer at the stage of implementation.

For Java there are many tools, among others, the environment of application servers. One of the most popular is the JBOSS application server developed in open source model, which provides the developer with everything one needs to support web applications, starting with the web services and in the object-oriented abstraction of data stored in a relational database ending. The system uses JBOSS in jboss-as-7.1.1.Final version.

To support the development of web applications, a number of libraries containing web interface service elements from the Java language level were introduced. Great popularity has gained the set of GWT libraries developed by Google and used in its web applications. An extension of this library is SmartGWT, which adds new interface elements allowing user to create application components that can provide functionality comparable to excel sheets. The authors used the SmartGWT 4.0 library in a non-commercial version which is operating without some of the more advanced solutions of access to the database and optimising of network communication. These elements are not used at the present stage of application development.

## 8. Summary

Within the framework of the project, the following elements have been developed:

- the CAPCAST-*base of materials* containing the characteristics of materials (supplemented with information on selected grades of ductile iron, which is the starting material to produce ADI),
- the CAPCAST-*base of producers* and the user interface allowing easy registration in the database and profile editing. The database can be used by other modules of the system but it can also operate as an independent source of knowledge about Polish foundries and their production capacity, and can serve as a kind of platform to implement the basic functions of e-business.

Fragment of the system presented in this paper is a prototype, and will be subject to evaluation, development and systematic empirical verification.

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