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Database for foundry engineers – simulationDB – a modern database storing simulation results

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Analysis and modelling

ABSTRACT

Purpose: of this paper The main aim of this paper is to build specific database system for collecting, analysing and searching simulation results.
Design/methodology/approach: It was prepared using client-server architecture. Then was prepared GUI - Graphical User Interface.
Findings: New database system for foundry was discovered.
Practical implications: System development is in progress and practical implication will be hold in one of iron foundry in next year.
Originality/value: The original value of this paper is innovative database system for storing and analysing simulation results.
Keywords: Database system; Simulation results; Analysing system

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1. Introduction

The complexity of metallurgical processes requires the use of modern, advanced computational tools for the calculation, optimization, storage and analysis of technical data. Currently, the computing power of a good class of computers is measured in gigaflops, i.e. in a number of floating point operations performed in a second ((FLOPS - Floating Point Operations Per Second). Based on the input parameters (initial boundary conditions), modern computer simulation programs and high performance computing machines (workstations, clusters) enable prediction and forecasting of phenomena and physical processes occurring in the solidifying castings. The use of ICT tools in all fields of science and industry is now a standard, and foundry industry seems to be no exception to the rule. Various computer programs are used by foundry industry. They are divided according to the following applications: CAD - Computer Aided Design, CAE - Computer Aided Engineering, CAM - Computer Aided Manufacturing, CAQ - Computer Aided Quality. Application also find all kinds of databases, which have become a key tool in the everyday life of contemporary information society.

The interdisciplinarity of foundry technology requires the use of modern tools for its design and optimization. Modern industry has adopted customer satisfaction as an indicator of the effectiveness of manufacturing processes, and the basic requirement of customers is to by provided with quality products. This tendency is not unknown to the manufacturers of machinery and equipment, including products made by casting techniques.

Unfortunately, due to their complexity, the casting processes require the implementation of dozens, sometimes hundreds of simulations of the metallurgical process done in one project.

2. Current state of the art

To minimize production costs, foundries are using specialized simulation softwares, mapping the actual thermo-kinetic processes taking place during pouring and solidification of castings. Research centers and foundries using simulation softwares face problems with the storage of data produced by these systems. The data are stored in different ways: in the form of photos, videos, animations, tables, graphs, sets of parameters in different directories, depending on the project version, type of alloy and molding sand, overall dimensions, and the technology used. The number of projects developed and of the simulations performed in a single project is so large that easy and quick finding of specific information is impossible, or at least very difficult and time consuming. These figures are estimated at tens of terabytes per year in a country.

One can risk the following statement: "The data from simulation software are never used again for another project." There are several reasons making this statement true:

- Problems with the storage of projects (what category should be used in their storage?),
- Very time-consuming search for specific projects,
- Very large volume of data.

Due to the increasing amount of data generated by simulation programs, the technologist has big problems with the storage, archiving, and above all, easy retrieval of specific projects. This is due to a common way of storing the data (projects) in the directories (hierarchical structure). A common practice is to store the same projects in different directories, broken down by many categories such as: type of alloy, type of molding sand, casting size, number of castings in mold, casting weight, minimum casting wall thickness, and the weight and number of risers, the customer, price, and many others. However, this increases the volume of the occupied disk space. A large number of parameters that define the technology (design) makes easy search for the projects that meet certain criteria very difficult. Currently, the increasing capacities of hard disc drives and disc arrays can solve the problem of the quantity of data generated, but for the development of new technology most important is the fact that the technologist has no possibilities to search for specific projects that meet certain criteria, except the laborious search for individual projects that have some features common with the newly developed technology. To some extent it proves the thesis: "The data from the simulation software are never used again for another project." This is a serious problem, and its solution is discussed in this paper.

3. „SimulationDB" system

A solution to this problem is an interdisciplinary, innovative design of interactive, intelligent computer system, the main task of which is to store the simulation results and metallographic data, and to provide an easy search of specific projects using special criteria for data retrieval, technology analysis, and building of a technical knowledge base. A technological knowledge base will comprise the following elements: the results of the developed simulation, a full description of technological procedures, and recommendations for technology optimization. The system has a client - server architecture and is based on a relational database, while user interface is built using the latest and most advanced application, i.e. Microsoft Visual Studio 2008 Professional.

Designing a "SimulationDB" system initiated a new technological process, which is characterized by an innovative approach to the problem of foundry technology preparation. Namely, the technologist does not begin with carrying out a simulation, but defines the specific characteristics of a casting, which are also used as criteria of the search for simulation results in a database. As a result, a list of projects that meet the previously preset criteria is received. After a brief analysis of selected projects of a similar nature, the technologist is developing a new technology based on knowledge accumulated in the database. The developed database system is characterized by the fact that it is independent of the applied program of simulation, and hence can be used in any foundry that has a program for the simulation of foundry processes.

Based on data collected in the database it is possible to analyze and optimize the process of production preparation. The development of input data for simulation and performing several simulations is a long-term process, which adversely affects the time of the execution of the tasks set by customers. Using the technology developed, the knowledge base and projects accumulated in the database, we can shorten the time needed for the development of best technology. Obviously, each time, the execution of simulation tests requires a qualitative identification of the causes of defect formation, based on the knowledge and experience of technologists, and also building an appropriate process model, with simulation carried out in an appropriate program. A new quality in this field is the possibility of building a knowledge base, which will consist of the developed simulation results, with full description of the technological procedures and recommendations for technology optimization. Easy access to the database will allow the technologists to quickly react to disturbances resulting from the manufacturing processes and significantly improve the quality of castings.

Nowadays it is very difficult to provide sufficient number of qualified staff that would satisfy the growing needs of the industry. Knowledge and experience of workers is the highest value in each company and it can significantly contribute to the rapid development of technology. An experienced technologist can identify and predict at which point the defect may occur. An intelligent computer system by using a special module for project analysis and technology optimization will in an easy way help gain the necessary experience and broaden our knowledge of the metallurgical processes which take place during casting pouring and solidification. The information tool dramatically reduces the time needed by the technologist to acquire the relevant experience and make knowledge upgrading. The system can also be used as a basic tool for the education of students and post-graduates in metallurgy, foundry knowledge included. Figure 1 shows a graph of productivity (average output per worker) for European countries.

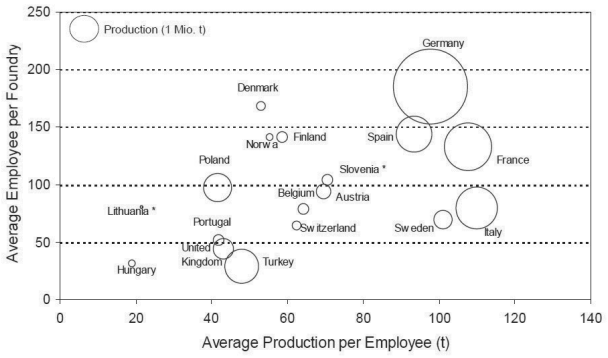

Fig. 1. Production output per one employee.

A new approach to the development of technology brings the following benefits: reduced time needed for technology preparation, reduced use of human resources and expensive equipment, including the software for simulation. In the saved time, these resources can be used to develop other projects and improve business performance. Apart from obvious effects of economic and technological impact, the application of new method changes the up to now used process of upgrading the skills by inexperienced process engineers. In recent years, in Europe, there has been a shortage (deficit) of highly-skilled staff, which is the highest value of each company, meaning much more than machines and/or technologies. Using the system by young, inexperienced engineers will create for them an opportunity of very rapid development through access to the knowledge base.
The advantages of the proposed solution are as follows:

- Access to the simulation results without the need to possess the knowledge of how to operate the simulation programs, at any time and without the help of skilled workers,
- Storage of simulation results while maintaining the same structure of projects,
- Very easy search for specific projects owing to the use of special criteria of this search,
- Comparing different versions of the simulation and comparing the simulation with the real process taking place in foundry,
- Quickly acquired knowledge and experience by the young, having no practical skills, engineers immediately after graduation,
- Effective management of an unlimited number of projects,
- Reports generated in electronic and paper form used for documentation,
- Review of many statistics used for analysis of the entire process of preparation of foundry production.

Development and implementation of a modern computer system for cataloging and archiving the results of simulation, and for monitoring and quality assurance in foundry processes is an undertaking which should lead to improved quality of the cast parts of machines and equipment, while reducing the time of optimizing the manufacturing processes.

Information technology is now widely perceived - also by industrial entrepreneurs - as a necessary factor in building competitive advantage, allowing full use of the corporate resources and development of new products and services. Attention deserves increased awareness of the need to invest in the sphere of IT observed among small and medium enterprises (large companies have long been treating IT as an obvious standard), who saw that to compete effectively with larger enterprises is possible, among others, through the use of business information systems.

Innovation is crucial for any organization. It allows gaining and maintaining a competitive edge, while the ability to continuously improve and optimize business operations increases the enterprise resistance to crisis and turmoil in local and global markets. Many of the studies conducted until now all over the world have indicated that the main obstacle to innovations is inflexible infrastructure, both physical and in information science. This, without any doubt, is true. But we should not forget that the change of IT model is unavoidably associated with the change of applications used by company, and application performance is a key factor affecting the creation of business value.

Changes in the organization and infrastructure entail matching of applications and technologies to specific business objectives. They must support the evolving products, services and processes. In other words, applications must keep pace with business demands, which are constantly changing.

A confirmation of these assumptions are studies ordered by IBM, conducted by British analysts on management of applications. The key findings of these studies relate to beliefs about the relationship between applications and innovation. It should not come as a surprise to anyone that the majority (85%) of respondents to Application Service Benchmark Study consider investment in applications as a necessary precondition for innovative changes introduced to processes and business models.

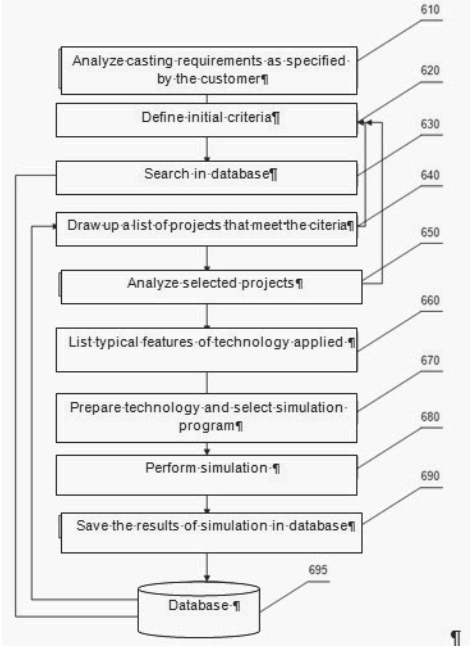

Fig. 2. Methodology

4. Methodology

Figure 2 presents a methodology for optimizing the currently used process of preparation of foundry production. It shows step by step the course of action taken to speed up this process.

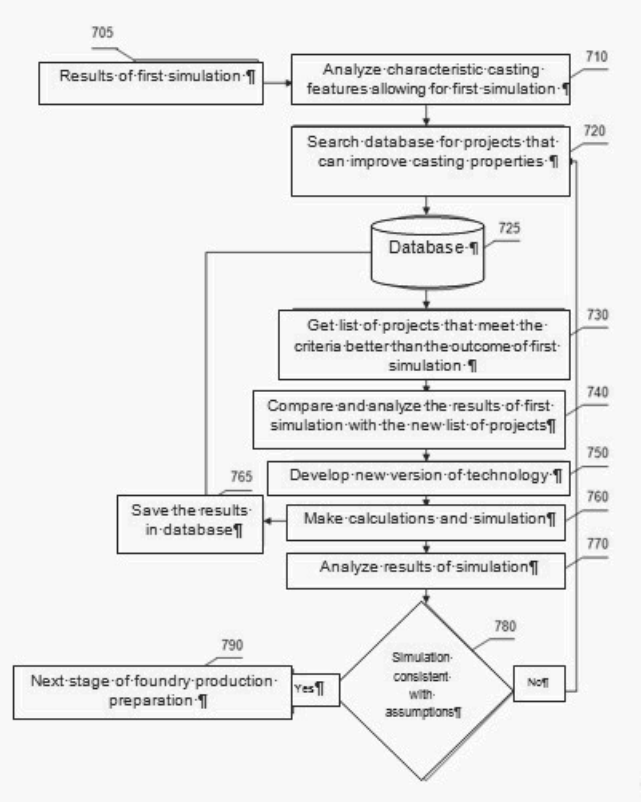

Fig. 3. Methodology next steps

Figure 3 shows further steps of procedure after the first simulation.

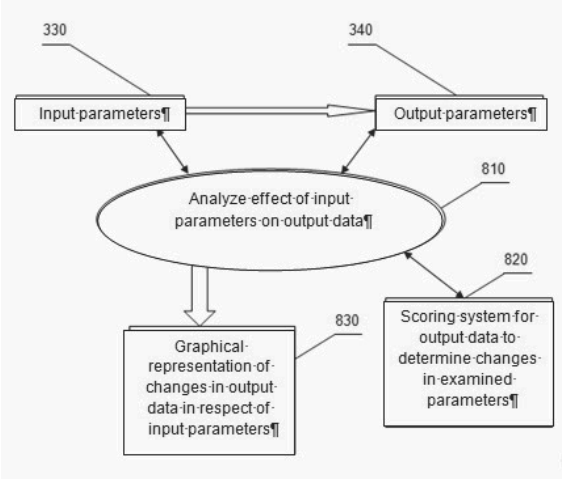

Fig. 4. Analysis of the effect of input parameters on output data

Figure 4 shows a block diagram of an advanced analysis of technology.

5. Summary

Foundries increasingly benefit from the expensive simulation software to reduce production costs (production of prototypes and making batches of test castings). Very high volume of information generated by the simulation programs is causing problems with the storage of data, easy retrieval of projects that meet the criteria defined by the technologist, and management of the increasing number of projects.

Using the developed technology, the knowledge base and projects accumulated in the database, we can efficiently shorten the time needed to develop appropriate technology. Using the "SimulationDB" system, the technologist is building a knowledge base, which will be composed of the developed simulation results with full description of technological procedures and recommendations for technology optimization. Easy access to the database will allow process engineers to quickly react to the disturbances in manufacturing processes and significantly improve the quality of castings.

Creating databases for industry and science is a step towards the computerization of enterprises, streamline procedures and business processes, which greatly reduces production costs and speeds up the development of appropriate technologies, increasing finally the competitiveness of companies in the national and international scale.

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