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SimulationDB – technological knowledgebase – new trend of data management

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ABSTRACT

Purpose: Main purpose was to create database system for storing simulation results, technologies, cad files, animations, filling and solidification parameters, etc.
Design/methodology/approach: The SimulationDB system is first step in technological data management. The next step is more complex database system called MasterDB, which allows you manage all technological data not only in one foundry but in the whole concern.
Findings: Technological knowledge base called „SimulationDB" lets you store information from each production process stage like: orders, preparation specific technology, production, quality control, etc. SimulationDB was made because there are a lot of problems storing different kind of technological data. Each production process stage generate a lot of parameters, information, technologists annotations, analysis and technology comparisons. Knowledge base for technologists – SimulationDB completes a gap in informatics infrastructure in each foundry lets you fast and easy access to information from each technological process.
Practical implications: SimulationDB was successfully implement in Alstom Power Department of Metallurgy in Elblag.
Originality/value: Original value of the paper is innovative, patented database system with unique method of creating technology with very good quality and low cost.
Keywords: Project Management,; Productivity and performance management; Database for simulation results; Advanced data analysis

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1. Introduction

Knowledge base is a database for storing information on various scientific, manufacturing and technological aspects. Today, numerous industrial plants and foundries develop their IT infrastructure by introducing new database systems that store relevant data associated with technological expertise. An experienced technologist with a deep technical and practical knowledge, supported by specialized simulation programs and data management solutions, is of great value for each company.

Industrial plants organize numerous internal training sessions to improve skills of their employees. A deficit of qualified staff can be seen of the market [1-3].

A technological knowledge base SimulationDB allows for storing data from each step of the casting production preparation process: from placing an order, through developing the right technology, doing a test cast, switching to batch production, verifying the quality of the cast in accordance with the order, to delivering the cast to the customer. In each stage of the process, various technological parameters, data, technologists' comments, comparisons and analyses are stored. Technological knowledge base fills a gap in the IT infrastructure of any enterprise, enabling quick and easy access to information from any step of the casting production preparation process. A database system has numerous advantages. Some of them are listed below:

- Data from the whole process is stored in a single system SimulationDB,
- Easy access to simulation results, even when a user is not familiar with specialized simulation programs,
- Possibility of comparing virtual and real technologies,

Training young inexperienced staff, Creating new technologies based on knowledge stored in the database.

A technological knowledge base is divided into several modules:

- OrdersDB,
- CustomersDB,
- SimulationDB,
- ProductionDB,
- QualityControlDB,
- CastingDefectsDB,
- CaseStudyDB.

A technological knowledge base SimulationDB stores detailed information from each step of the production process, as shown in Figure 1. A foundry receives an order from a customer to deliver a specific cast in accordance with detailed contract documentation and drawings. Each order is assigned a unique number, and is then stored in the OrdersDB module. The order is assigned to a customer who had placed it. Data regarding the customer is stored in the CustomersDB module. A finished cast must meet technological and strength parameters specified by the customer, such as tensile strength, resilience, etc. The order is carefully analyzed in terms of production capacity, meeting quality conditions, compliance with the order, etc. During the analysis process, a technological department also gets involved as it has the appropriate substantial knowledge required to deliver the cast. When the order is approved, its documentation is sent to the technological department. Employees of the technological department develop an appropriate manufacturing technology using available simulation programs. This technology and simulation results are stored in a technological knowledge base for each version of the simulation. The SimulationDB module includes two additional tools for comparing versions of simulations and for analyzing technologies. After developing the final version of the simulation, the project proceeds to the next stage – doing a test cast. The next step is validation of the parameters assumed in the simulation process against the actual parameters. Then, the cast is examined for the occurrence of casting defects. Once this test is passed, another step – batch production – begins. If casting defects are found, we go back to the technology development process, and information regarding these defects is saved in the CastingDefectsDB module.

The CaseStudyDB module is a software overlay for OrdersDB, CustomersDB, SimulationDB, ProductionDB, QualityControlDB and CastingDefectsDB modules. This module is designed for staff training, especially for training young inexperienced engineers. The entire process is described here, from the moment the order is placed, through developing an appropriate technology, doing a test cast, examination for the occurrence of casting defects, improving the technology, to launching a batch production. In a large foundry, where several technologists work, gathering such a large amount of projects in a single system gives a very solid foundation for training personnel with the CaseStudyDB module.

Integration of all the presented modules in a single system offers many possibilities of analyzing data from different stages of the entire process. The Reports module provides numerous configuration panels for reporting the entire process, individual stages of the process, etc [4-6].

The global trend indicates that the next 5-10 years in the foundry industry will be a time simulation programs and databases. Simply storing information in databases is not enough. These systems must provide semi-automated analysis of selected information. They must be intelligent database systems that support manufacturing processes, reduce production cost, and increase company's competitiveness.

2. Technological knowledgebase — SimulationDB description

On the basis of the results of the classic method of production preparation, it can be stated that it is theoretically possible to improve the process of power technology preparation show in Fig. 1 by significantly reducing duration of archival documentation analysis and quality records for repetitive production of castings.

The main problem is the lack of dedicated solutions for the foundry industry. This is due to the specific character of the sector, which limits the use of standard solutions. This applies in particular to foundries manufacturing unitary products, where the process is modified during its course, depending on quality performance. The number of potential indications generates the need of changing the order of operations or adding new ones that were not planned previously.

The first professional attempt to integrate data in the foundry industry is the SimulationDB database designed at the Faculty of Foundry Engineering at the AGH University of Science and Technology in Cracow.

The database designed by a team led by Pawel Malinowski PhD, Eng. integrates some basic records of customers served and identification data of products. The database has been implemented and tested at the ALSTOM Power foundry as part of a targeted project 04550/C.ZR7-6/2010 carried out jointly by the AGH University and ALSTOM.

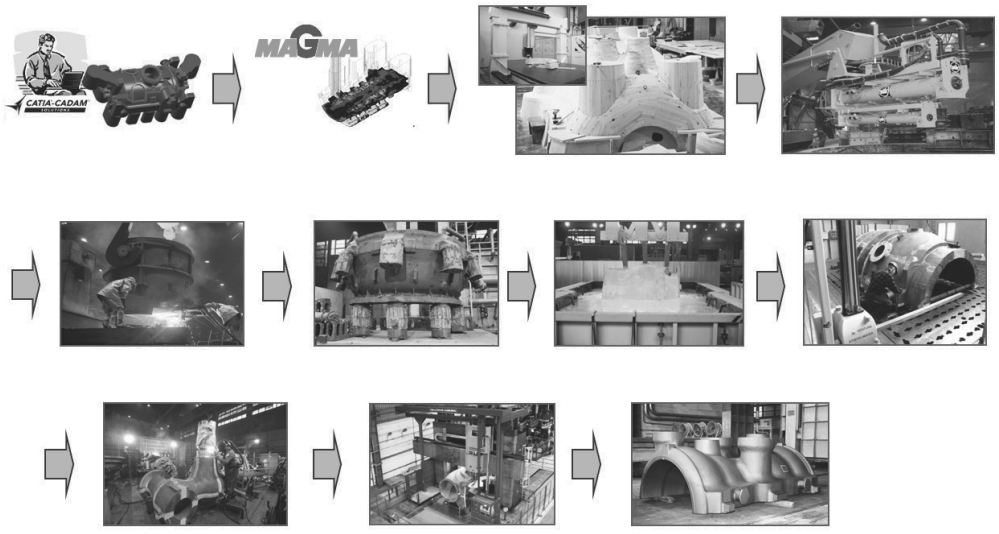

Fig. 1. Production process

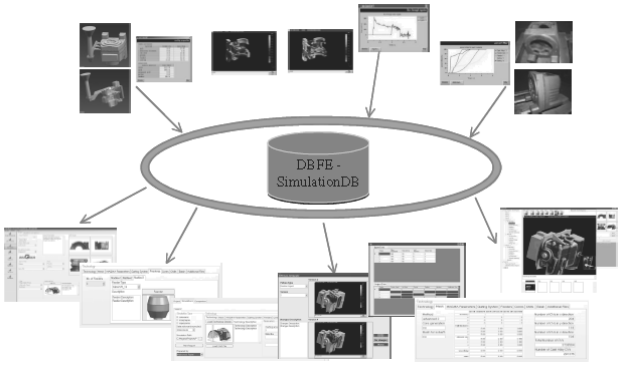

Fig. 2. Production process

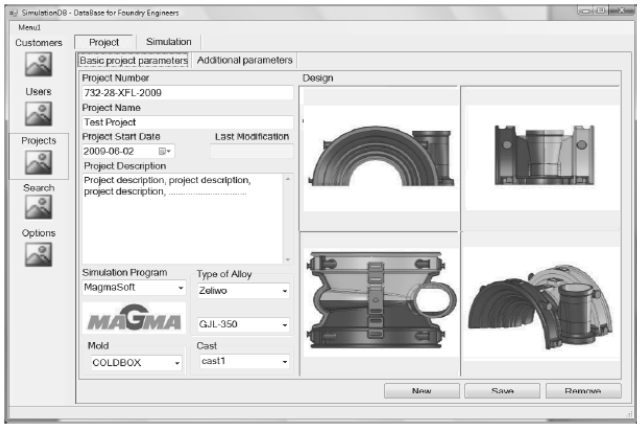

Fig. 3. Project data

However, the designed database has one important limitation. It is an amazing tool to collect and organize data prepared by the lead technologist. It provides an easy way to find information about a particular technology, successive versions of the simulation, and the results of the simulation. Finding a cast with similar defined characteristics is easy as can be.

However, there is no feedback from the casting process in the workshop.

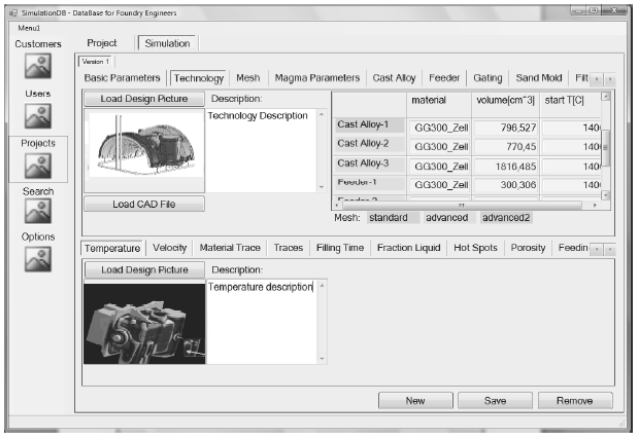

Fig. 4. Simulation data

A user-friendly interface allows for intuitive entering and searching data about structures and technologies. Unfortunately, SimulationDB cannot connect to other production systems in order to create an integral whole.

SimulationDB can be upgraded by adding new functions that integrate records available from the process. Such a modification requires developing new macros/translators between existing systems. However, this work needs to be performed only once. At the same time, the amount of work to be done in the foundry

remains unchanged. Persons, who have been entering data to the known systems, will continue to do so in the usual way. No need for software changes or additional training is one of the many advantages of this solution.

Once the database allows for automatic collection of data from the production process, this will help to eliminate errors at the reproducible product analysis stage. This is an area which has not been covered by specialized programs and database systems so far. Experience has shown that there was no interest in such systems so far due to the fact that they were not dedicated to the foundry industry.

The above scheme shows the possibility of integrating all existing sources of information in one place without having to change existing data recording method. All systems that require integration allow for developing an interface that will automatically link the current sources with the SimulationDB database.

Implementation of SimulationDB allows, above all, for reducing the casting technology preparation time, which means a faster response to customer needs. Based on experience, the estimated time is about 2 working days per one project.

In order to estimate time savings resulting from the application of the modified database system, a process of using the modified database during the development of power supply technology was simulated. The simulation consisted in preparing the required range of materials for the analysis by an independent, experienced employee who was not involved in the project.

This process allowed the lead technologist to focus solely on the analysis of documents, without having to search for them.

Under the current rules, the lead technologist was able to develop 31 technologies in a 250-day working year (250:8 = 31.25, assuming that only reproducible technologies were developed, and that the process was always simulated three times).

When using the modified SimulationDB solution, and under the same boundary conditions, the technologist is able to develop 41 technologies (250:6 = 41.66).

This way we obtain a 32% (41:31 = 1.32) increase in the productivity of a group of technologists, which makes it possible to manufacture additional products. Another benefit is the better utilization of the installed assets, which results in lowering the unit cost of power technology development.

This only affects time and cost aspects of production preparation area, however, one should always keep in mind the lower risk of passing over some critical data. Such risk is difficult to evaluate, and the element of human error should always be taken into consideration.

Similarly, the area of preparation of a technology for a new product can be considered. Some characteristics of castings for the power industry can be similar in different structures, especially in case of retrofit casting.

Assuming that approximately 20% of castings' characteristics are similar and can be applied during the development of technologies, the following results can be achieved.

Under the current rules, the lead technologist was able to develop about 25 technologies in a 250-day working year (250:10 = 25, assuming that the process was always simulated three times).

When using the modified SimulationDB solution, and under the same boundary conditions, the technologist is able to develop 28 technologies (250:9 = 28).

This way we obtain a 12% increase in the productivity of a group of technologists.

As far as it's possible, a technologist should use colleagues' experiences and, above all, learn from the mistakes of others. This is possible through the analysis of the results of castings developed by others.

The integrated SimutationDB becomes invaluable at this point as it allows for searching for castings with similar characteristics in order to use reliable solutions. Another aspect is the reduction of time spent on searching for castings in a paper archive, which contains hundreds of structures, to find the most similar one.

Fig. 5. Archive of paper documentation

The use of the integrated SimulationDB allows for streamlining the process of new technology development and, in extreme cases, avoiding re-development of a technology for an already existing structure.

The modified database can also be an electronic archive of technical drawings which catalogs modifications of the process and successive changes in the design of the product.

Another particularly important advantage of the integrated SimulationDB is the training aspect which allows for continuous professional training of technologists, and makes new recruits familiar with the matter much quicker.

The advantages of implementing the modified database system SimulationDB:

1. Quick access to quality records
2. Lowering costs of quality
3. Increasing the productivity of technologists
4. Reducing costs of casting manufacturing
5. Easy exchange of knowledge between employees – the training aspect

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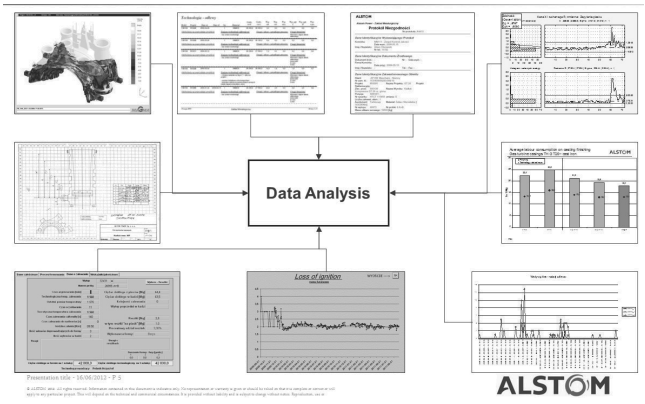

Fig. 6. Data analysis

3. Conclusions

The increasingly growing number of simulations carried out in the casting industry generates huge amounts of data. The solution to this problem is SimulationDB, an innovative technological knowledge base system which has already been implemented at one of the Polish foundries. It can shorten the casting production preparation time by up to 32%. The system needs to be continually developed by adding new modules and new functionalities so that technologists can be provided with a professional working tool. The new modules will enable the development of an innovative training platform for young, inexperienced technologists and students. This in turn will significantly shorten the process of acquiring knowledge, practical skills and experience.

The growing number of simulations in the field of casting causes the generation of a very large amount of data, which needs to be interpreted in response to irregularities occurring during pouring or solidification of the casting. Only highly specialized expert engineers can carry this out. Their knowledge and experience is decisive to product quality and to the speed of preparation of technology that is ready for production. Skillfully recorded knowledge and the guidelines of process engineers, along with the results of computer simulations, comprise additional value. The method of storing this information is significant in terms of how fast in can be used to create new projects, solve technological problems or train specialists.

The increasing calculation capacity of computers and better optimized calculation algorithms have stimulated the realization of a much larger amount of simulations compared to 5 or 10 years ago. This large increase in simulations generates very large amounts of data, which are not then used to develop new technologies.

Furthermore, archiving and managing such a large amount of information is very difficult without specialized informational tools. Searching for appropriate projects that could aid development of new technologies for a new casting is also so time consuming, that it is not affordable to do so, since developing technology anew will be more effective.

The current method of storing technological data in the form of photographs, animations, graphs, parameter sets, simulation results and production data contained in a defined directory structure is incorrect for several reasons. The most important factor disqualifying the current method of data accumulation is the lack of capabilities of a quick and easy search for specific information regarding a project, simulation, applied technology, alloy, molding sand, etc. Another factor is the large volume of data accumulated in this way. In order to find the project being searched for more easily, the same data was copied to different directories, which increased the volume several times.

The idea of creating a database for technological knowledge rose from the lack of specialized informational tools for managing, archiving, and analyzing detailed information regarding the process of preparing casting technology. The lack of a capability of efficient and effective management of technological data has caused that technologies (designs, technological processes) have never been used a second time for development of technologies for new castings.

The knowledge base is built upon one of the best database models – the relational model with three-layer architecture.

The system possesses an intuitive user interface separated into several modules:

- Client module,
- Design module,
- Analyzer,
- Result browsing module,
- Design search module,
- Result comparison module

In order to address these problems, the applicant intends to design a specialized tool for the process engineer, which will also be used for educational purposes in a new macro-branch of study, entitled “VIRTUAL TECHNOLOGY,” at the Casting Faculty of the AGH Technical University.

The following statement can be risked: “Technological data for a given casting house is not used again for developing new technologies (designs).”

The development of a unique, interactive database system, "SimulationDB", as a technological knowledge base carries with it an original input into the field of casting. The system will serve the purposes of archiving, easy searching, and managing accumulated technological knowledge. Applying the “SimulationDB” system in industrial practice will make it possible to implement a new procedure for developing casting technology using the existing technological knowledge base.

The “SimulationDB” database system is an innovative solution on a global scale. This project is the development and the continuation of a doctor’s thesis, with the solution proposed therein having been submitted to the Patent Office of the Republic of Poland - P.391362, to the European Patent Organization (EPO – European Patent Organization – 10461517.4), and to the United States Patent and Trademark Office (USPTO – United States Patent and Trademark Office – 13/106,523). The presented solution is characterized by product innovation - the SimulationDB system and process innovation - a new method of developing technologies using the SimulationDB system.

The reuse of simulation results (developed technologies) carries with it the following advantages:

- a shorter time for preparation of new technologies – lower production costs,
- perfection of practical skills, gaining of knowledge and necessary experience,
- decrease in human resources (process engineers) being used and decrease of exploitation of very expensive simulation software along with efficient computer hardware.

The saved resources can be used for the realization of new designs.

The idea and method of accumulating information regarding complex and complicated technological processes makes it possible for them to be used again during the creation of technologies for new products. This method is innovative on a European level. The lack of suitable tools for archiving and analyzing technologies is a hindrance to efficient management of technological knowledge, and thus, also to subsequent utilization of the knowledge and experience of process engineers for developing new designs.

Using a technological knowledge base in industrial production justifies the satisfactory result of testing patent clearance and the rising number of process engineers expressing the problem of storage, easy searching, and effective management of such a large amount of information.

The most important aim of the project is developing a technological knowledge base for the casting engineer. Such a database system fulfills many useful functions:

- Archiving of documentation of the entire technological process,
- Easy searching for technologies using specialized search criteria,
- An effective staff training system – CaseStudyDB (Master's, postgraduate, Doctor's studies and internal training at the casting house),
- An electronic, intelligent catalog of casting defects - CastingDefectsDB,
- Advanced technology analysis,
- Access to simulation results without the need for using specialized simulation software,
- An effective system for managing technological knowledge.

Another innovation is the application of the knowledge base as an educational platform for a young and inexperienced group of process engineers. Without a modern system for training process engineers, the deficit of engineers will become more dramatic with each year, which is supported by most studies and analyses.

Additional information

For more information go to page http://simulationdb.com

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