SimulationDB – advanced, intelligent database system for casting simulation results

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Summary

Many foundries and Scientific Institutes which are using simulation programs, they generate a huge amount of data. These data are mainly simulation results and various analysis especially results of research work investigations. This huge amount of data growing to hundreds of terabytes per year in Poland and thousands terabytes per year in other European countries altogether.

There is no special informatics tools, systems to manage these simulation results, to archive them and to find information in easy way. To solve this inconvenience, there is a need to build modern, intelligent informatics system based on Client – Server architecture using Relational Database.

System called "Database for Foundry Engineers – SimulationDB" was prepared as PhD work – "Interactive database in preparation production process" in Faculty of Foundry at University of Science and Technology in Krakow. Promoter and supervisor of this PhD work is well known in "foundry world" Prof. Jozef S. Suchy.

Advantages of using "Database for Foundry Engineers – SimulationDB".

- "Database for Foundry Engineers – SimulationDB" is very complex, modern and useful for technologists informatics system which allows you:

- to access to simulation results without knowledge concerning operating simulation program, without trained staff and any time you want,

- to archive these simulation results in the same structure,

- to find particular projects(simulation results) using different searching criteria in easy way,

- to compare several versions of simulated project, and allows you to compare virtual computer simulation with real process in a foundry,

- to manage of many projects efficiently,

- to generate reports based on input information,

- to look through a lot of statistics.

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Many foundries and Scientific Institutes which are using special simulation software to predict casting defects, they generate a huge amount of data. These data are mainly simulation results like pictures, animations, tables of different parameters, charts, etc. This huge amount of data growing to hundreds of terabytes per year in Poland and thousands terabytes per year in all European countries altogether. Technologists have serious problem to find specific version of simulation or even specific project in collection of hundreds different projects. Each project has 30 versions in average. Depends on casting dimensions generated results size in GB of one version can be different. There is no special systems to manage of many projects efficiently, to archive them, to analyze them, etc.

There is a problem to collect all simulation results in one place, to find specific project or simulation version in easy way. To solve this inconvenience, there is a need to build modern, intelligent informatics system based on Client – Server architecture using Relational Database. Main purpose of the system is to gather all information concerning the whole foundry process prepared by simulation software, to archive all versions of simulation, to analyze and compare simulation versions and also to manage of many projects efficiently. Some advantages of using Database for Foundry Engineers – SimulationDB is decrease amount of faults and defects, improve casting quality using database resources, teach young inexperienced technologists in very short time, decrease production costs, which is very important in terms of foundry competitive. I suppose this huge amount of data probably will never be use again. There is no adequate applications, tools on European market to collect these data, to keep all of them in one place and to find simulation results in easy way using special searching criteria.

DataBase for Foundry Engineers – SimulationDB is a new database system for storing simulation results deriving from different simulation programs: like MagmaSoft, ProCast, SolidCast, NovaFlow&Solid, etc. That innovative system allows you to keep simulation results on one machine (server), to collect all projects in the same structure, to find specific results using appropriate searching criteria, to analyze technology, to compare simulations with each other and with a real process, to teach young inexperienced technologists, to create different reports like: project, version, comparison for documentation, to generate a lot of statistics.

DataBase for Foundry Engineers – SimulationDB contains several modules for various implementation:

- Input/Output Data Module,

- Searching Module,

- Analyzing Module,

- Comparator Module,

- Report/Statistic Module,

- Diagram Module.

Input/Output Data Module is the main(core) module in SimulationDB system. It is used for insert various type of data like: pictures, animations, descriptions, set of parameters, tables, diagrams, charts, etc. When project is in database you can glance through all inserted data. The module is divided into two parts: Project, Simulation.
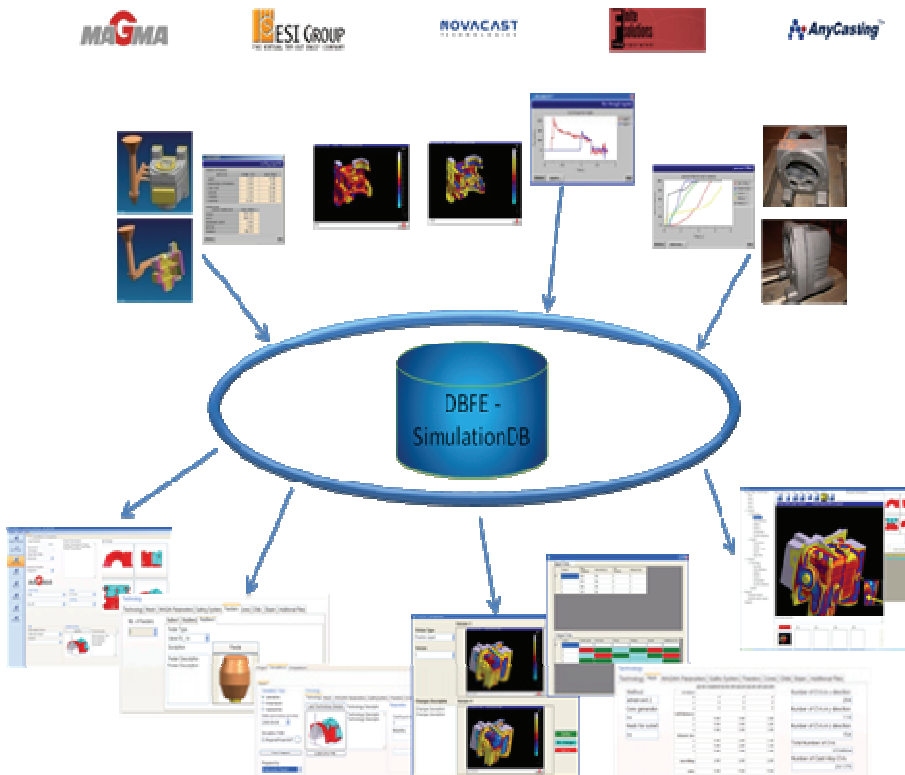

Figure 1: Exemplary data.

In the Project part you can place all constant data concerning that specific project like: Project Name, Project Number, Alloy Type, Moulding Type, Casting Type, Volume, Weight and Dimensions of the Casting, etc.

The Simulation part is divided into next two parts: Technology, Results.

- Technology section contains input parameters which we can change in next versions.

• Result section contains output information which are generated by simulation program.

Searching Module is used to find projects using specific searching criteria. It is very useful. You set searching parameters (criteria) and you get all projects from database which fulfill your criteria.

Analyzing Module is one of the most useful module for analyzing technology. We can see what happened in previous versions then what we did to avoid that problems, etc. You can study all steps made by technologist, how he solved technical problem. You can investigate step by step, version by version all important information included in database.

Comparator Module with Analyzing Module is used for teaching young inexperienced technologists. You can compare several projects, specific simulations, versions from different projects, virtual simulation with real process in the foundry.

Report/Statistics Module is used for generating several kinds of reports and a lot of various statistics.

Diagram Module is used for describe the project structure, relation between simulations, etc.

In database we can store different type of data for instance: pictures, videos, animations, technical parameters, charts, tables, descriptions, analysis, etc.

GUI(Visual Basic 2008) – Graphical User Interface – it is a graphical application using database resources. The GUI is divided into several modules which were described in previous chapter. To use database resources we used dedicated MySQL Connector, because it is faster than a most common ODBC (Open DataBase Connectivity) Connector.

Core – that is the main part of the SimulationDB system. It is used for object representation of information downloaded from database. We can use the core for connect another interface like web interface.

Connector – it is dedicated MySQL Connector. It is like a bridge between the database and the interface.

DB – relational database with client – server architecture. There are about 30 tables join with each other with special relations. Database enable to store different type of data like: animations, films, pictures, tables, set of parameters, charts, diagrams, etc. The database is normalized to 3NF – Third Normal Form by Codd's own account.

The database is divided to 21 tables where all data will be written. Each single table has a primary key which contain one or more columns. Some of the tables have foreign key to combine tables using specific relation into one data structure. Using that system you can increase competition of polish and European foundries.

There are different type of data stored in database like:

- Pictures: HotSpot ,FillTime, Gradient,Porosity, Casting in four different views, etc.
- Films and animations: Filling, Solidification, Tracers, etc.
- Numerical data: Name of project, Number of project, amount of versions, used simulation program, type of cast, etc.
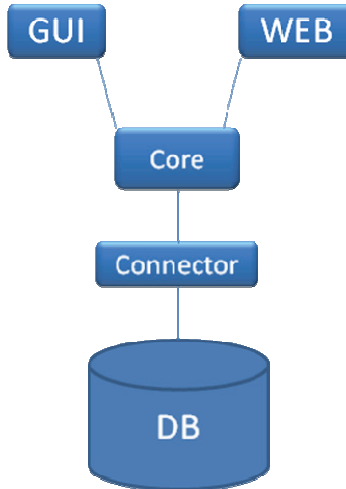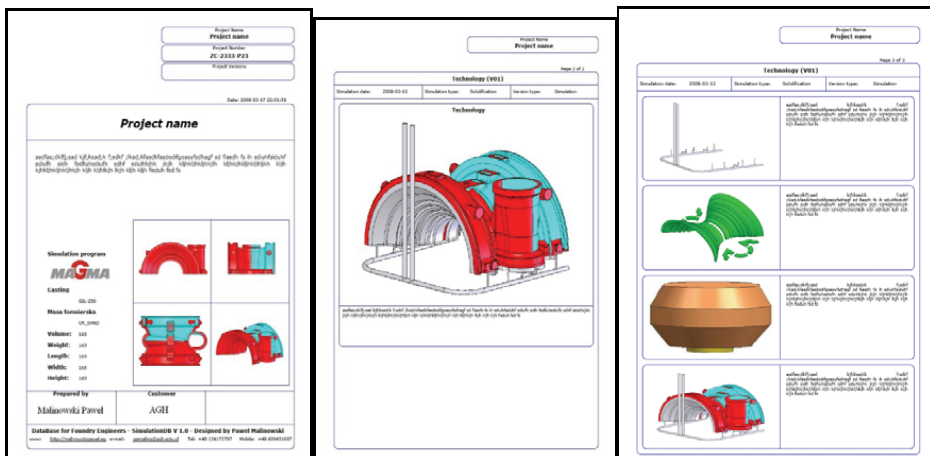

Figure 2: System architecture

Figure 3: Reports

Searching engine and client application is very flexible and usefull. You can choose several different criteria to find your results. Concerning on this results you can prepare a new technology.

You can store several types of simulations like Filling, Solidification, Stress. Depends on simulation type you can collect results in different tabs:

- Filling

    Temperature
    Velocity
    Material Trace
    Tracers
    Filling Time
    Criteria
    Additional files

- Solidification

    Fraction Liquid
    Hot Spots
    Porosity
    Feeding
    Hardness
    Solidification Time
    Additional files

- Stress

    Displacement
    Principal Stress
    Normal Stress
    Additional files

Transaction is an executable program, which create a logical processing unit in a database. Single transaction can consist one or more database access operation like insert, delete, update and select. Each transaction should has specific ACID (Atomicity, Consistency preservation, Isolation, Durability) properties.

- Atomicity refers to the ability of the Database Management System to guarantee that either all of the tasks of a transaction are performed or none of them are.

- The consistency property ensures that the database remains in a consistent state; more precisely, it says that any transaction will take the database from one consistent state to another consistent state.

- Isolation refers to the requirement that other operations cannot access or see the data in an intermediate state during a transaction.

- Durability refers to the guarantee that once the user has been notified of success, the transaction will persist, and not be undone.

Table 1: Normalization

Normal form	Brief definition
First normal form (1NF)	Table faithfully represents a relation and has no *repeating groups*
Second normal form (2NF)	No non-prime attribute in the table is functionally dependent on a part (proper subset) of a candidate key
Third normal form (3NF)	Every non-prime attribute is non-transitively dependent on every key of the table
Boyce-Codd normal form (BCNF)	Every non-trivial functional dependency in the table is a dependency on a superkey
Fourth normal form (4NF)	Every non-trivial multivalued dependency in the table is a dependency on a superkey
Fifth normal form (5NF)	Every non-trivial join dependency in the table is implied by the superkeys of the table
Domain/key normal form (DKNF)	Every constraint on the table is a logical consequence of the table's domain constraints and key constraints
Sixth normal form (6NF)	Table features no non-trivial join dependencies at all (with reference to generalized join operator)

In the field of relational database design, **normalization** is a systematic way of ensuring that a database structure is suitable for general-purpose querying and free of certain undesirable characteristics—insertion, update, and deletion anomalies—that could lead to a loss of data integrity. Edgar F. Codd, the inventor of the relational model, introduced the concept of normalization.

SimulationDB system based on multi-level security system. The first security level is authorization. Access control in computer systems and networks relies on access policies. The access control process can be divided into two phases: policy definition phase, and policy enforcement phase. Authorization is the function of the policy definition phase which precedes the policy enforcement phase where access requests are granted or rejected based on the previously defined authorizations. The second level of security is SSL (Secure Socket Layer) protocol used between client and server. Next level of security based on 3rd layer of OSI/ISO (Open System Interconnection/ International Organization for Standardization) model. And last

one based on 2nd layer of OSI/ISO model.

Using Database for Foundry Engineers – SimulationDB system young inexperienced technologist can decrease time, which is need to teach an expert. Technologist using module for analyzing and for generating reports and statistics, study proposed solutions, check how they solve the problem, maybe there is a need to implement different method or solution. This system can be also used in universities for teaching students, PhD students and also scientists.

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During preparation of the system I applied for and get two grants:

- Adviser Grant,
- InnoGrant.

Now the DataBase for Foundry Engineers – SimulationDB is being prepared for implementation in one of polish foundry.

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