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CASTING PRODUCTION MANAGEMENT SYSTEM

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The paper presents the results of casting production management system for foundry industry. The production proces management system collects data from the entire production preparation proces, technology development using simulations, molding sand parameters, liquid metal, quality control, etc. By using the system, the foundry is able to reduce the time needed to prepare the production proces while maintaining high quality of the casting.

Keywords: management system, data analysis, artificial intelligence, machine learning

INTRODUCTION

Most foundries have a production management system. Such a system covers the entire production process from the moment of receiving the offer, through the feasibility analysis, acceptance of the order, development of technology using CAD – Computer Aided Design and CAE – Computer Aided Engineering systems, casting, quality control, mechanical treatment, heat treatment, to sales and after-sales services. Project-related data is collected at each stage. Based on the analysis of these data, it is possible to reduce the number of casting defects, improve the documentation flow process, improve production efficiency and the quality of castings. Such a large amount of data can be used by artificial intelligence algorithms (machine learning, deep learning). Artificial intelligence algorithms can be used to predict the mechanical properties of new alloys, classify casting defects, optimize electricity consumption, and much more.

PRODUCTION MANAGEMENT SYSTEM

The production management system is a system for monitoring and controlling the production process by collecting information from each stage of the production process. The system is modular in order to better manage parameters from different stages of the production process.

The Figure 1 shows a general block diagram of the production management system. The data in the system is collected from the moment of receiving the offer, i.e. the subject of the order, number of pieces, date of completion, technical documentation. Then, these data are used for a feasibility analysis in order to check whether the company has the appropriate material, human and engineering resources.

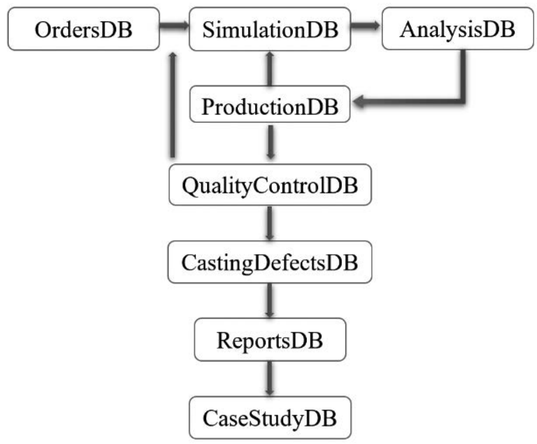

Figure 1 Block diagram of the production management system [1].

After positive verification of the feasibility analysis, the order is accepted or rejected. If the order is accepted, execution is planned, a team is allocated, inventory is checked, and the necessary materials are ordered.

Figure 2 shows a login page of production management system.

These data result from the feasibility study and appropriate measures are taken at this stage. The next step

Figure 2 Production management system – login page [1].

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is to develop a technology with the use of CAD systems and simulate the mold cavity pouring and solidification CAE in order to eliminate casting defects already at the design stage. This process may be a long process due to the size and complexity of the casting, proper selection of the gating system, risers and casting chills.

It is common to perform a dozen or so different versions of the simulation to achieve the desired effect (a casting without casting defects).

To reduce the number of simulations performed, and thus the time to prepare the technology, it is recommended to use the original SimulationDB – Simulation DataBase system. The advantage of this system is the use of previously performed simulations and knowledge in order to develop technology for a new casting.

In Figure 3 we can see a SimulationDB system for optimizing and improving technology preparation.

This shortens the technology development process by at least one simulation. In the case of serial, large-size castings, the time saving is approximately 33 %.

When the developed technology is approved, the molding sand, model, gating system, alloy, etc. are prepared. All these elements must comply with the technology developed using the CAE system.

Any discrepancies between the parameters of the „virtual" technology and the actual technology will result in casting defects.

The next stage is pouring the mold cavity, breaking it out and cleaning the casting. The casting is subjected to quality control, compliance of parameters with the specification is checked, chemical composition and mechanical properties tests are performed, etc [3].

If fixable defects are found at this stage, they are rectified. If the defect is so serious, the casting is considered defective and serves as batch scrap. In the next steps, mechanical treatment and heat treatment take place in order to improve the mechanical properties of the casting.

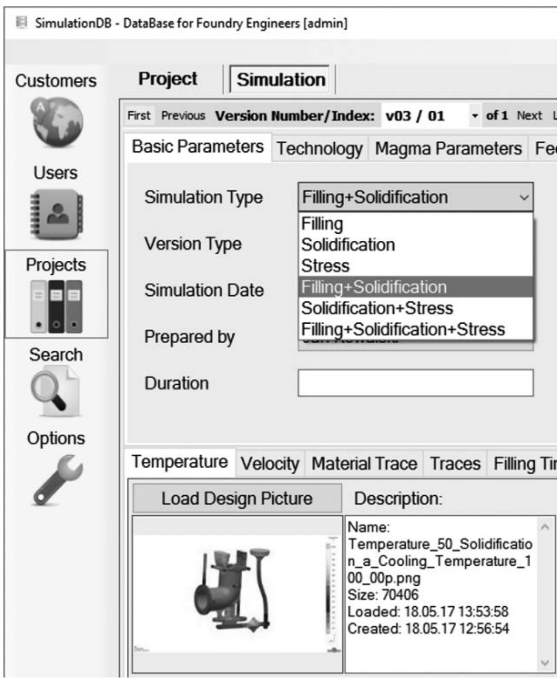

Figure 3 SimulationDB system [1].

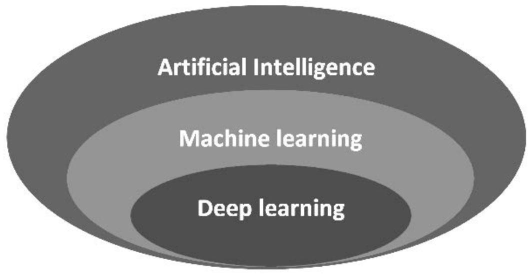

Figure 4 Division of Artificial Intelligence areas.

ARTIFICIAL INTELLIGENCE IN FOUNDRY INDUSTRY

Artificial intelligence as one of the most important technologies of industry 4.0 can also be used in the foundry industry.

The figure shows a set of sub-fields used in artificial intelligence. Artificial intelligence replaced expert systems that were based on inference mechanisms. These were systems with the so-called symbolic artificial intelligence [5].

In Figure 4 it can see how Artificial Intelligence is divided.

We divide machine learning into:

Supervised learning,
Unsupervised learnin,
Reinforcement learning.

Machine learning is a sub-field of artificial intelligence and involves the use of dedicated algorithms on data sets, thanks to which you can predict values, classify casting defects, optimize energy consumption and other resources.

To perform the machine learning process on a data set, you need to do a few steps:

identify the problem (e.g. classification, regression, etc.),
analyze the data,
clean up the data,
check the correlation of features with the forecasted values,
choose a machine learning algorithm and a performance metric,
divide the data set into training data and test data,
Check out other machine learning algorithms,
Tune the hyperparameters.

The above-mentioned actions, depending on the problem, can be extended to many other more complex issues.

Deep learning [2, 4] is a sub-field of machine learning and is based on multi-layer neural networks.

The measure of the effectiveness of the neural network is achieved by the use of the back propagation algorithm, thanks to which the weights of the neurons are updated and the effectiveness of the neural network is improved.

Deep learning is the most effective learning method, but it requires a lot of computational resources. The current algorithms allow you to perform calculations on GPU - Graphical Processor Unit. New TPU coprocessors - Tensor Processor Unit optimized to work with deep neural networks were also created.

In foundry, artificial intelligence can be used in many areas:

- creating new alloys with specific mechanical properties,
- classification of castings (in accordance with the assumptions, defective),
- classification of casting defects,
- optimization of electricity consumption,
- real-time analysis of production data to prevent the formation of defective castings,
- predictive diagnostics for high pressure die casting machines, robots in order to predict failure occurrence,

CONCLUSION

The use of a production management system is very important nowadays. Collecting production data from various stages of the process and using it in machine learning and deep learning processes gives the foundry a huge added value, which translates into a competitive advantage.

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Note: The responsible for English language is Oliwia Lewek, Krakow, Poland