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Modelling for design of industrial equipment and processes

W. Andree

Abstract

The paper gives an overview about the application of modelling for design of industrial equipment , industrial processes and optimisation of industrial processes, including portfolio analysis and production analysis.

Introduction

Numerical Modelling in process industries is an important tool for cost improvements in the design of products and processes as well as in the R&D and market introduction of new products. Due to more transparency and better understanding of the complex processes and their parameters, the technical risk at prototype installations for new products and systems can be drastically reduced by advanced modelling technique. Especially for process design and process optimisation modelling is the most efficient way to get light into the darkness of the complexity of interconnected systems and processes.

1. Modelling for design of industrial equipment

Modelling is a must for the design of products and systems using the electromagnetic field for melting, heating or improving the quality of metals. This modelling is based on 2d and 3d numerical solutions of Maxwell-Equations in connection with the Fourier equation of heat transfer.

1.1 Design of Induction furnaces

Induction furnaces (Figure 1) with power levels of up to 16 MW are exposed to strong thermal and mechanical forces. Numerical modelling of such systems is a standard engineering task. Dimensioning of the system, the design of the core components, usages of better materials and changes in construction – all that based on numerical modelling. Figure 1 is a part of investigation to improve the efficieny of a Faraday-Ring in an induction furnace.

Fig. 1: Design and numerical modelling of an induction furnace

1.2 Design of inductive heated processes

Inductive heated processes – well known in the forging process for automotive parts – are characterized by high power density and fast temperature increase. Modelling is the basis for the design of the heating equipment and the sensitive control of the heating process.

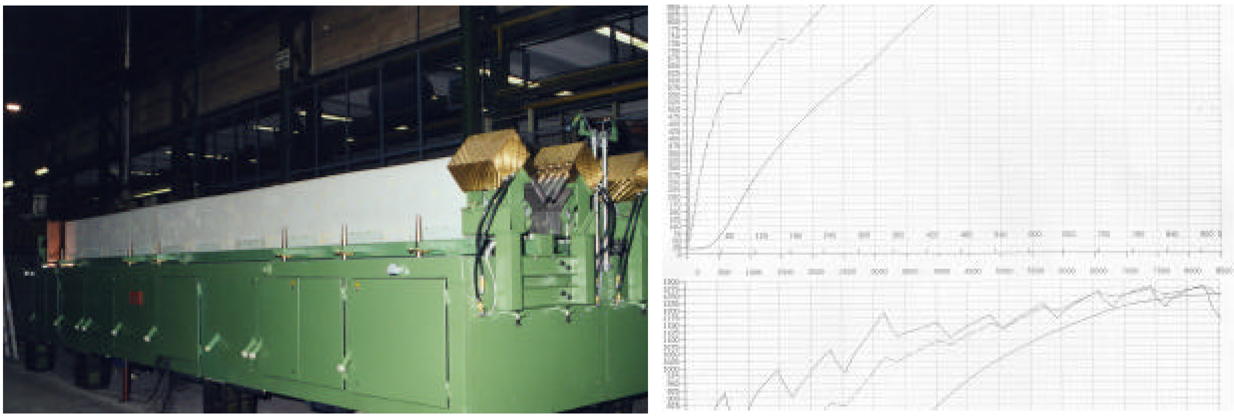

Fig. 2: Inductive billet heater and temperature distribution over the time

The design, number of coils, induced power level and the control of the different coils can be exactly determined by modelling without prototyping.

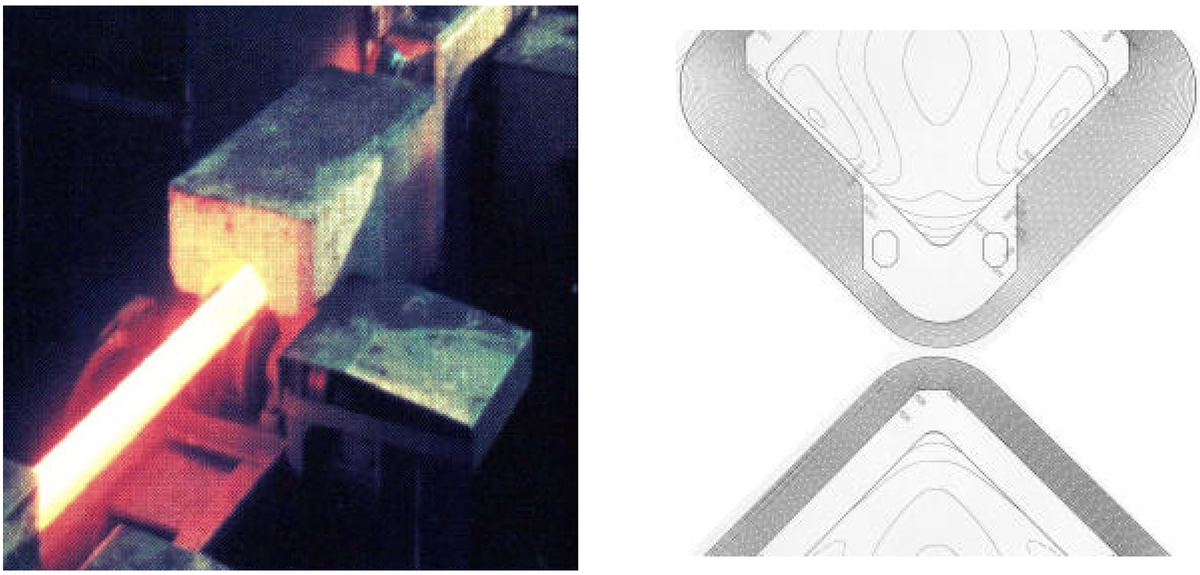

Fig. 3: Inductive bar heater and temperature distribution over cross section

The temperature difference between the core and the surface is one of the most important process parameters to be achieved. This can be only calculated with precision but very difficult to measure.

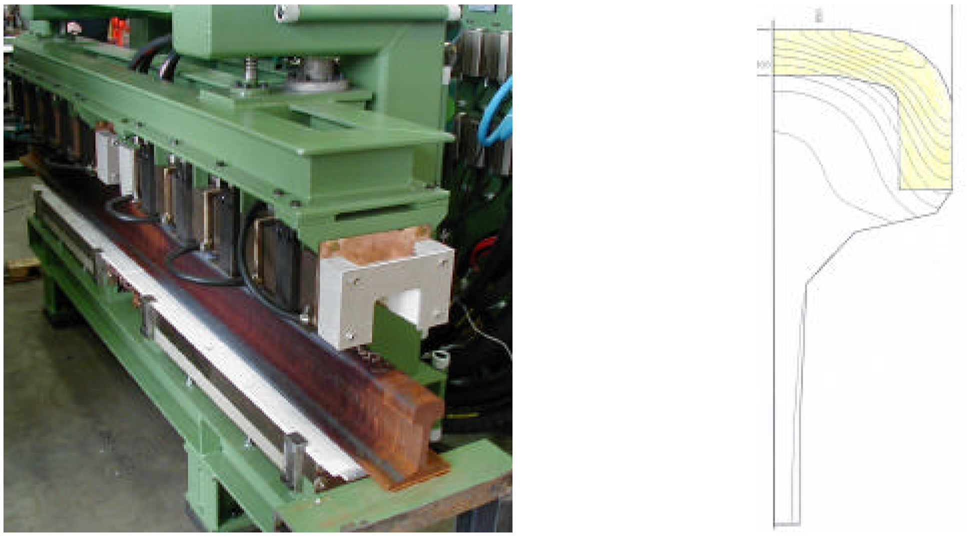

Fig. 4: Partial heater for railway tracks and temperature distribution in the head

For special applications numerical simulations are indispensable for the overall design to reduce pre-engineering cost as in the case of the partial heater, shown in figure 4.

1.3 Design of electromagnetic stirrer

Electromagnetic stirrers are used to improve the reaction, heat- and mass-transfer. The process in fluid media can be simulated with high accuracy to optimise the stirrer or the brake for different applications.

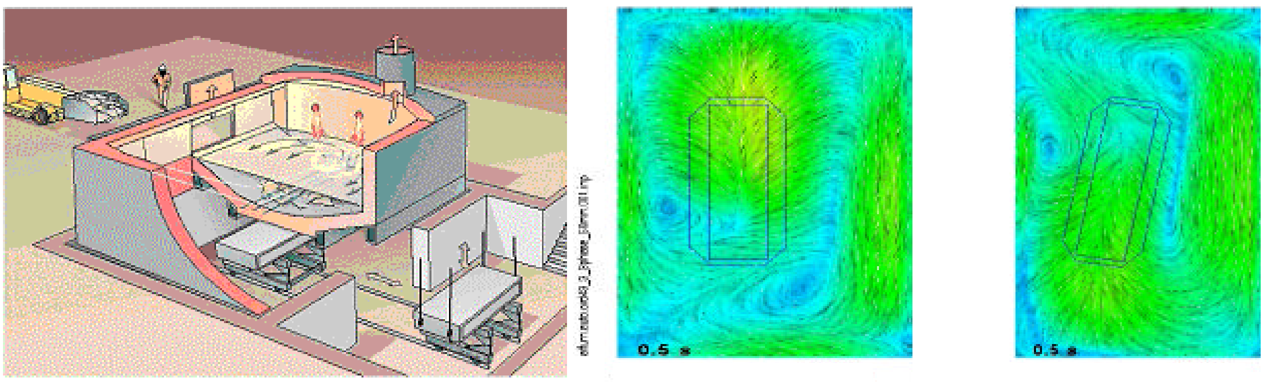

Fig. 5: Electromagnetic stirrer and different stirring patterns of a rectangular furnace

2. Modelling for design and optimisation of industrial processes

Modelling for the design of industrial equipment is only one small application – the simulation of complex industrial processes in order to make them more transparent is even more important. The optimisation of the supply chain (from order entry to product delivery) is a key driver to increase both portfolio flexibility and operative margins. The goal of the process simulation is to identify bottlenecks, increase throughput time and increase the net margin of the operation.

Key areas for modelling of industrial processes are

- Portfolio analysis (Do existing assets fits for futures market situations ?)
- Production analysis (Bottleneck analysis, productivity analysis, cost analysis)
- Production planning (Order sequencing, production job planning algorithms, order-to delivery checks, throughput maximization)
- Plant layout (Parameter optimisation and scenario assessments, storage and transport logistics and dimensioning)

2.1. Portfolio analysis

The design of the melt shop in a foundry (consisting of melting, holding and pouring furnaces and the corresponding ladle handling) is a very complex optimisation task that goes far beyond the optimisation of individual components within the production process. The simulation must take the entire casting process into account so that the combination of investment and operating cost achieve maximum plant availability for trouble-free and economical operation.

Each product in the process line is described by a set of parameters based on a software solution. Typical products in the melt shop are:

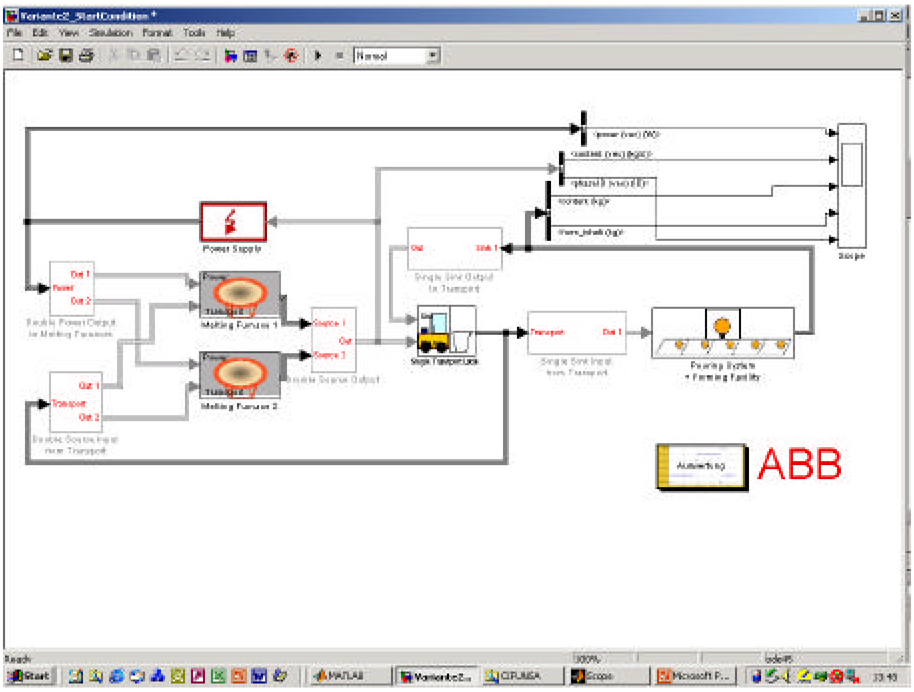

Fig. 6: Melt shop structure with 2 melting furnaces, ladle transport, pouring furnace and moulding line

- Melting furnaces (characterized by capacity, power and other production parameters)
- Ladle (characterized by capacity and other production parameters)
- Pouring furnaces (characterized by capacity and other production parameters)
- Moulding line (characterized by production parameters)

The result of the simulation is the production data showing the efficiency or the bottle-necks of the simulation process (Figure 7).

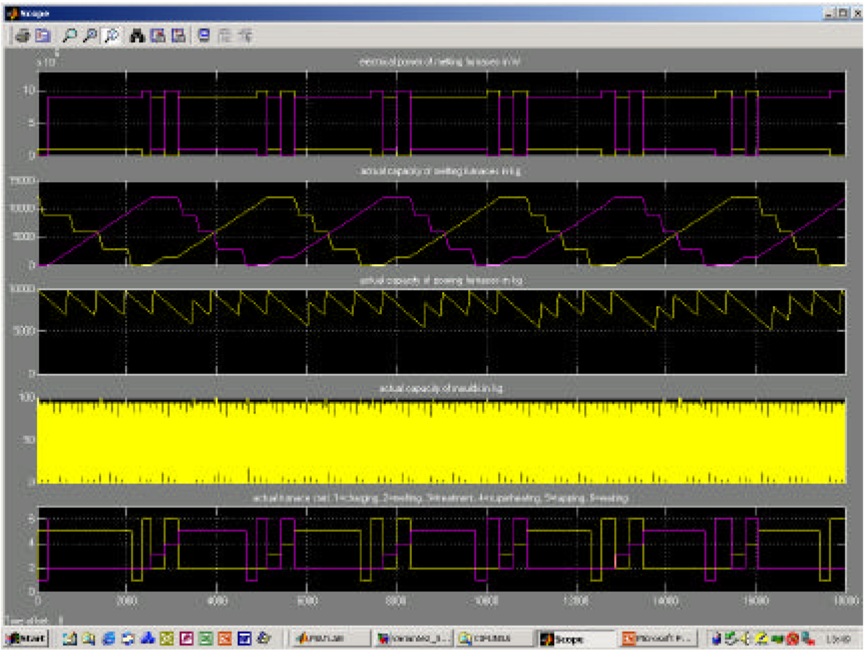

Fig. 7: Melt shop characteristics as a result of the portfolio analysis

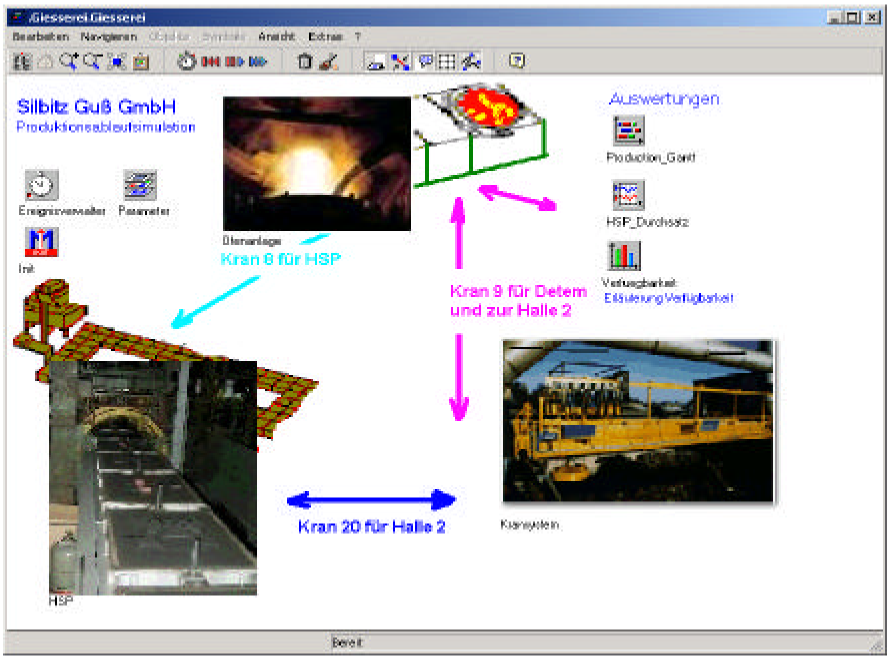

Fig. 8:   Process flow in a German foundry

2.2. Production analysis

Complexity of the production process and flexibility of the production program leads often to the reality of using higher reserves in the production as required. Modern simulation software leads to transparency of the material flow and shows the bottlenecks in the production process.

Figure 8 shows the structure of a German foundry with different interconnections . In Figure 9 is the material flow as a result of the simulation for a certain situation shown.

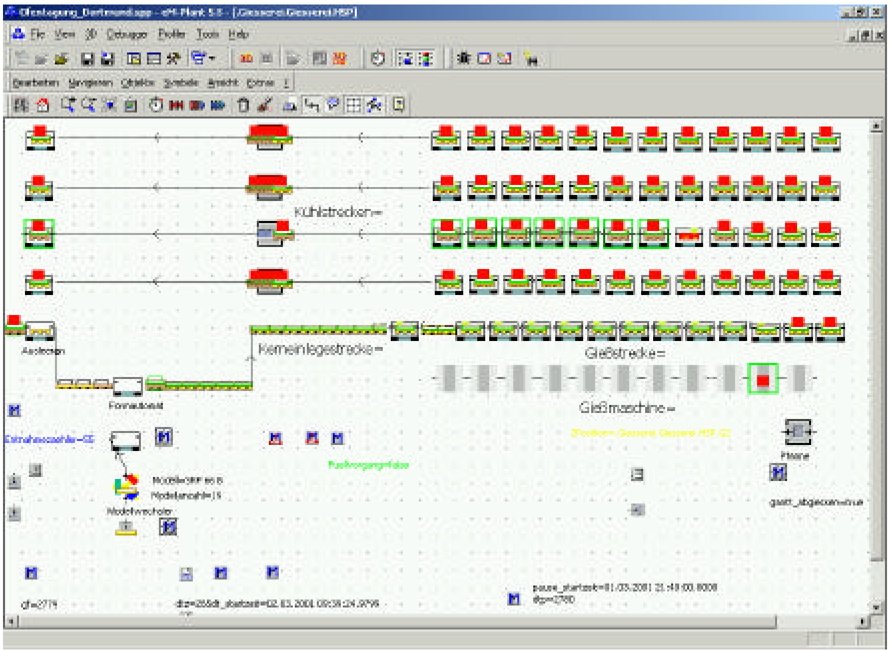

Fig. 9: Material flow in the moulding line area

Conclusions

The great advantage of computerised simulation and visualisation of the products and processes is determining the way of making correct decision, without expecting large amount of material or time, in particular with regard to investments in new product and plant technology.

Author

Dr.-Ing. Andree, Wolfgang
ABB Process Industries GmbH
Kanalstraße 25
D-44147 Dortmund, Germany
E-mail: Wolfgang.Andree@de.abb.com