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LOGISTIC SIMULATOR FOR STEEL PRODUCING FACTORIES

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ABSTRACT

The logistic processes in most steel producing plants are very complex. To assist the decision makers in steel producing plants, Incontrol Enterprise Dynamics have developed for and in cooperation with SMS Demag in Germany, a simulator that can be used to rapidly model any steel plant. The Steel Plant Simulator has been built using the software package Enterprise Dynamics® and allows for rapid insight into the influences of lay-out changes, process and speed parameters, length of production runs, changes in planning and type of products that are being produced. The Simulator incorporates a dynamic scheduler to create a realistic production planning. Results include production Gantt charts, time-path diagrams, utilization figures and production statistics.

1 INTRODUCTION

Steel producing from a production perspective is basically a simple process. Scrap and sometimes liquid iron from a blast furnace are put together in a furnace and is melted. The liquid steel is tapped into a ladle and can be treated in the so-called secondary metallurgy processes for steel quality improvements. The demands for special steel qualities nowadays are such that different processes are developed to improve the quality of the steel. Based on the desired end-quality, the steel ladle can undergo a number of processes in different order. When the correct quality has been reached the ladle is cast in a continuous caster. The end products are slabs or beams of steel.

The casting itself is a process that requires a good planning. The slabs and beams that need to be produced can be of any length. In order to create a product length independent from the amount of steel in a ladle, the beams are produced as an ‘endless’ length, which are slit after the casting process. This continuous casting approach reduces the number of changeovers on the caster. When a ladle is cast, the next ladle can be prepared so that it can start casting within a minute from the previous ladle. If for any reason a ladle is too late, the casting has to be interrupted and the caster has to be prepared again, which results in loss of valuable production time. A ladle should not be produced too early as the steel will cool down. Also the ladles themselves are expensive so you do not want to use too many ladles in a plant. The number of ladles in one sequence depends on customer demand and on steel quality. Typical run lengths consists of 3 up to 20 ladles between changeovers.

For the transport of the ladles between the different processes rail-guided vehicles and heavy cranes are used. Usually more than 1 crane is placed on a track (up to 4 cranes on a track is not unusual). Besides the transport of the steel ladles, the cranes have other tasks like emptying slag pots and transporting empty ladles to- and around ladle maintenance.

Due to the limited availability of (expensive) transport equipment in combination with the different routes of steel ladles throughout the plant and the influence of transports and cranes on each other, it is difficult to get insight in the overall production. It is hard to predict what the performance of the total steel plant will be if equipment is added or relocated or if process times are changed. For non-existing systems is extremely difficult to predict how a system would perform. The only way to be able to have real insight in the logistics and dynamics of the operations, is simulation.

SMS Demag is one of the leading suppliers worldwide of equipment for the steel producing industry. The company faced more and more detailed questions from their customers. Furthermore SMS Demag wanted to give their potential customers an extra service in analyzing the logistics of the steel plant. SMS Demag acknowledged that simulation was the only way to get the detailed answers and to consult their customers on how a potential plant could be run. In their search for a partner for developing a simulator for the steel plant industry they choose Incontrol Enterprise Dynamics for reasons of knowledge, experience and technical advancement in their simulation platform Enterprise Dynamics® (ED).

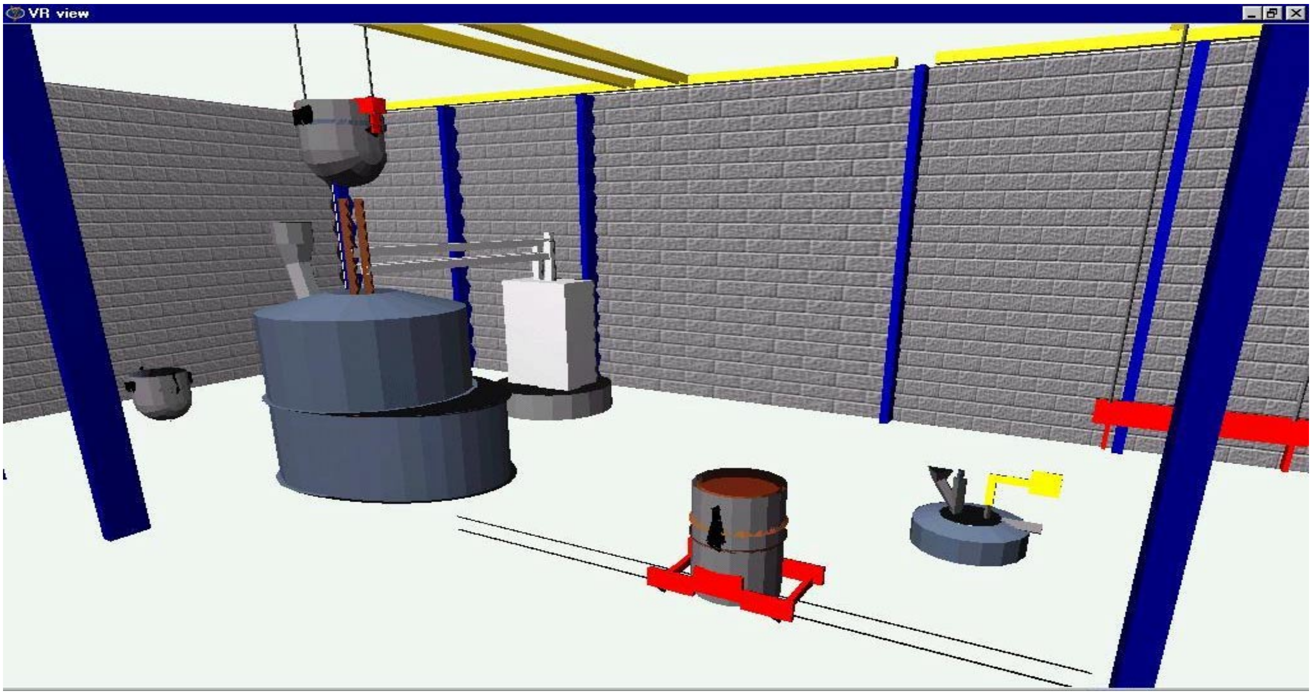

Figure 1: Detail of a Model in 3D Representation

The platform ED is well suited for creating specialized simulation products for specific customers, because of its reusability and expandability of the object libraries and the availability of an effective programming language.

2 CONSTRAINTS FOR THE SIMULATOR

When the Simulator was constructed, the following constraints had to be kept in mind:

1) Rapid modeling
2) Zero user programming
3) Detailed representation
4) 2D and 3D animation

In the following paragraphs, a description has been made on how these objectives have been reached.

2.1 Rapid Modeling

Modeling itself consists of a few steps. All these steps have been accelerated to improve the model building speed.

Step 1: Creating a model lay-out. Because ED works with object libraries, creating models is simply done by dragging objects on a model lay-out form. For the Steel Plant Simulator, Incontrol created new objects that contain the functionality, appearance and parameters of steel plant equipment as specified by SMS Demag.

Step 2: Adding the right parameters. A user can click on every object of the Simulator and enter the correct parameters, e.g. process times, speeds and dimensions. The parameter fields are unique for every object and the terminology of steel plants is used. Standard values have already been entered and the user is supported by an extended help file.

Step 3: Creating the route logic. Because the objects and the relation between the objects in the simulator have been defined in detail, it is possible to pre-define the route logic on objects. The user simply can select from a list of pre-defined rules on an object and complete the route logic by entering parameters.

All these steps lead to a model building time that can be very short. By using the Steel Plant Simulator the time-consuming part of a simulation study now consists of the gathering of data, entering the detailed parameters, experimenting and analyzing results. Relative little time is needed to set-up the lay-out and the control logic in a model.

2.2 Zero user Programming

In a standard simulation package more general objects are used which have to be expanded with route logic and special controls. Also the appearance of such objects in 2D and 3D has to be adapted. SMS Demag wanted to be able to use the Steel Plant Simulator without the need to program or the use of advanced ‘workarounds’. For that reason the objects in the library of the Steel Plant Simulator are designed in such a way that the models only need input parameters; no programming of code is needed by the model builder. The objects contain functionality to be able to cope with any kind of possible layout, combination of routes and production schedules. One of the key objects is the so-called scheduler. The scheduler is discussed in more detail in the next paragraph.

2.3 Detailed Representation

One has to keep in mind that a potential customer has no experience with simulation. If you want to convince such a customer that a simulation model represents his specific situation, it is very important that the model is detailed and accurate. This means that the model should calculate correctly and that all system elements are represented in the model. The detailed representation was realized by translating SMS Demag's years of experience into functionality and logic of all the necessary library objects.

2.4 2D and 3D Animation

While modeling the user can switch between a modeling status and a viewing status. In the modeling status the user is able to view logic related information and in the viewing status the model displays results and animate movements and statuses.

A very important factor in convincing a customer is 3D animation (see figure 1). The 3D and 2D animation is incorporated within the library objects and are directly linked to the simulation run (the animation does not require any post processing). This allows for rapid validation and verification of a model. It also allows a customer to move around in the virtual environment of his plant and immediately see results of changes to the layout, time parameters or production schedules.

3 SCHEDULER

An important feature of a steel plant simulation is the production schedule for the casters (casting program). A customer wants to see his specific schedule being produced and not a simplified production system. Here a potential problem arose as the Steel Plant Simulator should be able to model any kind of lay-outs with resources which could contain different process times. To cope with this challenge a special scheduler object was designed.

The scheduler uses the casting program as input. This program states which quality is cast on which caster for a specific amount of ladles (=sequence length). The Scheduler determines the earliest possible start time on the caster by scheduling the expected arrivals of ladles from a furnace. The scheduler will assign ladles to specific recourses by prioritizing on due dates. The scheduler recalculates a schedule whenever unexpected situations arise. If, for instance, a furnace cannot send on a new ladle in time because a resource was not available, the scheduler will attempt to compensate for that.

It is possible that either the process equipment or the transport equipment is a bottleneck in the production system. The user can determine from the animation and the result graphs where the bottleneck is situated. The user then has the possibility to fine-tune the scheduler by altering some key parameters in order to achieve better bottleneck usage.

It is also possible for a user to use the results of a previous production run and manipulate start- and process times from that run. In that way it is possible to schedule exceptions or to determine what the effect is of a different start or process times.

In the case that no casting program is available, the scheduler can also perform in a ‘push’ mode. In this mode ladles can randomly be assigned to casters with random qualities.

4 SIMULATOR RESULTS

For steel industry experts to accept a simulation model, it is important to generate results that are familiar to them and that they are used to in every day operations. To achieve this three important groups of Simulator results have been implemented:

4.1 Equipment Utilization

As described earlier, the objects that are constructed, keep track of the different statuses during the simulation. The status results of both process- and transport equipment can be displayed in pie charts or in table forms.

These figures can be used to determine if the desired utilization of a crane is exceeded. Also the bottleneck equipment can be derived from these results. The results are important to identify if the equipment is used economically.

4.2 Production Figures

The most important process objects show how much steel they have produced in tons. Experienced personnel can see straight away if a machine is used to its capacity. Different scenarios can be easily compared on basis of the production performance of the total plant and of individual equipment.

Both the component utilization and the production figures are available in different formats:

a) The most important figures can be read from the screen during a simulation run.
b) Graphs can be shown during and after a run. The picture of the graph and the data can be exported to for instance Excel® or a word processor.
c) All data are available in a text file report that can be further processed to generate customized reports.

4.3 Production Process

The most important information is delivered by the Gantt chart (figure 2). This chart shows the time that every ladle has remained at different positions in the process. This information can be used in two ways.

a) First of all the process can be followed over a longer period of time and casting interruptions, abnormal staying times and transport times show up immediately.
b) The Gantt chart is also used to pinpoint the time something abnormal has happened (e.g. a long blocking time or a hole in the casting production). Because the stochastic behavior of a model can be switched off, the user can run the model to the point in time when the problem occurred and look in 3D what exactly goes wrong in the system.

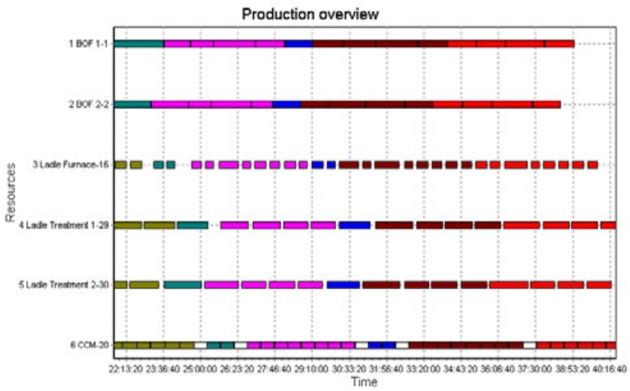

Figure 2: A Typical Production Result Gantt Chart

Gantt chart graphs can be shown during and after a run. The picture of the Gantt graph and the data behind the Gantt graph can also be exported to Excel® or a word processor.

5 FUTURE DEVELOPMENTS

SMS Demag uses the Steel Plant Simulator since spring 2001 and have performed various studies with it. The Simulator has created a very good feed-back from their customers. As simulation has proved successful, SMS Demag is planning to continue to invest in future developments.

The planned new developments is not only limited to the current Steel Plant Simulator. SMS Demag is currently studying if special simulators can also be used in fields other than the steel making processes.

6 CONCLUSIONS

When the development of the Steel Plant Simulator started there where reservations on the constraint that models should both be detailed and requires no programming. The end product's capabilities has exceeded everybody's expectations. There will always be situations that the Simulator cannot model a part of a system using parameters alone. The continuous development will reduce these occasions and for the few exceptions that remain, Incontrol Enterprise Dynamics can create a specific solution for a model.

The modeling time has been reduced considerably. Incontrol has developed a model for SMS Demag, prior to the development of the Simulator. By using the Simulator the new model was much more detailed and modeling time had been reduced by a factor more than 10.

Another conclusion from this project is that 3D animation proves to be more than 'show' alone. As many movements in a steel plant are in a vertical direction, 3D animation is a valuable means for rapid verification and validation of the models. The 3D animation also proves to be useful in supporting the search for potential bottlenecks and improvements.

REFERENCE

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