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SIMULATION OF A PRODUCTION PLANT IN THE BRICK INDUSTRY

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ABSTRACT

The paper deals with a simulation study on a planned production plant in the brick industry. We implemented this plant in TAYLOR II. Although the boundary conditions seemed relatively simple, we had to manage a complex, non-linear system. For this reason we implemented "dynamic priority" to the main part of the system, the travelling crane. Still this sophisticated logic was not enough to guarantee good operation, because in some situations the system runs out of capacity. We then gave recommendations how to improve the situation for a perfect operation of the production system. For this purpose we finally made an analysis of the necessary investment costs against the running costs caused by system breakdown.

1 INTRODUCTION

In this study, discrete-event simulation was applied to the improvement of a production process in the brick industry, with particular emphasis on material handling and transport via a travelling crane within this process.

The simulation deals with a planned manufacturing plant. The aim of the simulation is to prove, if the planned capacity of the components is sufficient. We got the layout of the plant in CAD-format and the data (capacities, cycle times, etc.) in EXCEL. The simulation was just for security reasons; the company plans to build the plant on this given data. The plant has the following boundary conditions:

- 4 different products with different processing in the plant,
- Up to 10 machines with 3 different types (precedence of the machines, processing time, priority),
- 50-100 storing positions called buffer places (for cooling down of the products),
- 1 travelling crane.

The simulation of the plant was carried out on the old plant with genuine data of the delivery (number and distribution of the new materials per day).

On account of this given distribution, the concrete entry of the products was determined stochastically into the system.

2 PROBLEM SPECIFICATION

Product 1 has the following processing steps (the other products have slightly different processing steps):

- The palettes are brought into the crane field by means of a conveyor.
- If machine 2 is free, the palette is brought to the conveyor to this machine by the crane, otherwise to a free buffer.
- From machine 2, the palettes are brought to the crane by a conveyor.
- If machine 3 is free, a conveyor brings the palettes to machine 3; otherwise the crane delivers them to a free buffer. It stays there, till machine 3 is free again. The maximum time for staying in the buffer area is 30 minutes. The time for staying in the machine 3 is also limited; the products should not stay more than 50% of the time in machine 3.
- The palettes are then brought by the crane to the cooling places (like buffer), where they stay at least 24 hours.
- The palettes are brought again to machine 2, if the machine is free. If not, it waits, till the priority is high enough, that it can reserve the machine (depending of the number of products in the system).
- With conveyer and crane, the products come again to the cooling places, where they stay at least 8 hours.
- In the last step, the products leave the system by means of the crane.

In spite of these relatively simple limiting conditions, the system results in a complex, not linear system.

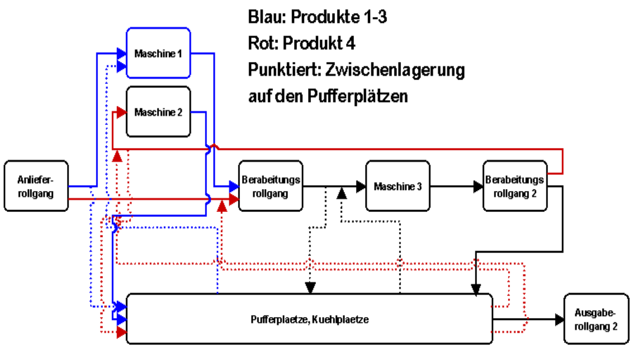

Figure 1: Material Flow in the System

The situation is even more complex, because from machines 1 and 2 up to 5 production units can be in the system simultaneously.

The most complex part in this simulation project was the travelling crane since just this one crane carries out all transportation. The crane therefore, must fetch the products at logically 12, but at physically over 150 places and carry the products to the logically nearest component.

These none linear, time-depending courses of events could possibly not be analysed without the aid of simulation.

3 SIMULATION

3.1 Implementation

Since the company already owned a version of TAYLOR II (F&H Simulation 1996), we implemented the simulation part into that version and not in the newer one, TAYLOR ED, which we use for our projects since 1998.

The following picture (Figure 2) shows the layout of the plant, as we implemented it in TAYLOR.

Figure 2: Layout of the Plant in Taylor II

The following Figure 3 is illustrating a typical situation in the plant after the warm-up period is over.

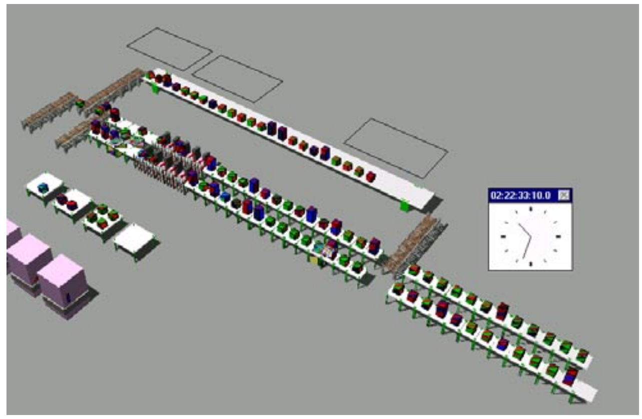

Figure 3: Simulation after Simulating 14 days

As one can expect from the layout of the plant, the crane has to travel a lot to get all products and put it in the right place again.

In fact, the programming of the crane was the most complex part of the simulation. We had to develop a complete new logic, because the given crane-logic from the manufacturer was much too simple for this plant.

3.2 Development of "Dynamic Priorities"

We developed a "changing priority logic", which means that the priority which product the crane should catch next is changing during the simulation, depending on the utilization of the whole system and of the components. The following programming example shows one Taylor-function, developed for this problem:

```
function b_voll
…

if
 elqueue@sum[25..140]>elqueue[11]/2+matrix[6,1]
then
 priority[9]:=15 else priority[9]:=25
```

This example changes the priority of the crane, depending on the number of products on the buffer places, the products waiting for being processed on the machines and the number of products waiting for leaving the system.

We also developed a lot of other functions to make the simulation as realistic as possible.

4 RESULTS AND CONCLUSIONS

4.1 Simulation Results

The simulation yielded to two interesting results:

- The machines are no bottlenecks at all. The planned minimum number of machines is sufficient, even if the production is increased by 20%.

- The crane is not just very complicate to model. Even with the developed dynamically changing priority the crane becomes a bottleneck under certain circumstances

The next Figure 4 shows, that there are enough machines parallel in the system. The time, which a product stays in the machines are close to the ideal time (20, 30, 40 or 60 minutes).

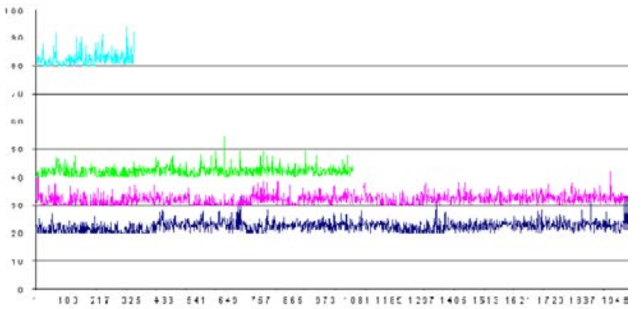

Figure 4: Time of the 4 Different Products in Machine 3 (Time in Minutes Against Number of Products)

The main problem is the travelling crane. If very much products are in the system, the crane also has to travel to the buffer places, which are very far (up to 100 meters) from the machines. The following Figure 5 shows the utilization of the travelling crane.

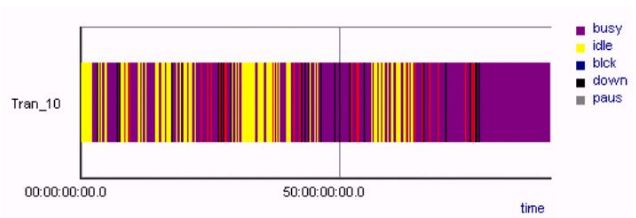

Figure 5: Utilization of the Travelling Crane

In the case, when the system is nearly full, the situation gets even worse because of the long distances (and the long times) the crane has to travel. The following Figure 6 illustrates the fact.

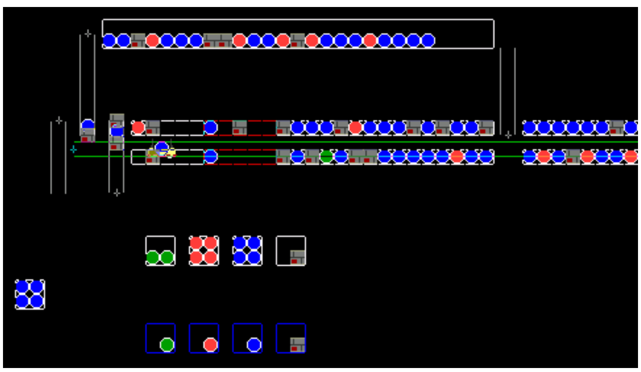

Figure 6: System Nearly Used up to Capacity

With the help of the simulation we found out that the buffers are temporarily completely full so that it comes to a system overload. This would have directly yielded to a stop in the production.

The following graphics (Figure 7) shows the number of full buffers in a time-period of 90 days, where we used the input data of the old plant exactly one year ago.

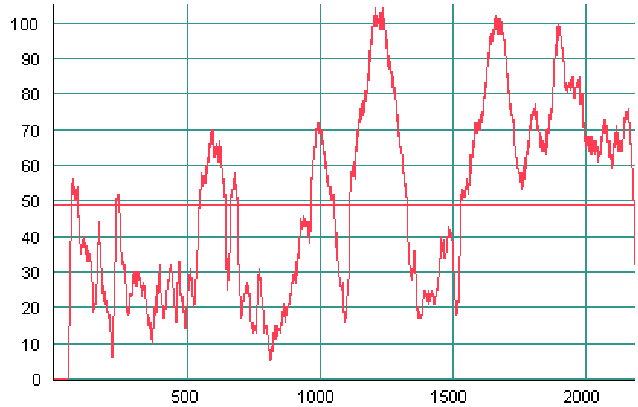

Figure 7: Occupied Buffers Against Time (in Hours)

We saw, that the buffers would be full at three different times in this 90 days (approx. day 50, 71 and 79). If the company had built the plant, as they planned before we made the simulation, the production had to be stopped for several hours on each of these three days, just to bring the already finished out of the system.

Each of this production standstills would cost approx. 50.000 €, that means in just 90 days, the new plant would have losses through standstills of over 150.000 € (which is approx. four times the cost of the simulation).

4.2 Recommendations

On account of the simulation results and the subsequent optimisation, we gave the following recommendations:

- Delivery of the new materials should be optimised as far as possible. Because of very variable customer needs, this was not possible. The whole system could work as it was planned, if there were no such strong variations. So the predictions of static systems like Excel-Sheets did not work in this case.
- Improvement in the discharging times of the transportation crane or increase of the speed of the transportation crane. Because of technical limits, this was also not possible.
- At the end, we recommended a second travelling crane for the outer parts of the system. We also simulated this variant and came to the result, that the necessary investments are quite small against the possible losses due to the stops in the production process.

REFERENCE

F&H Simulation. 1996. *Taylor II User manual*, Utrecht: F&H Simulation.

AUTHOR BIOGRAPHIES

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