

## **CREATION OF A SELF ADAPTIVE SIMULATION FOR RADEX HERAKLIT INDUSTRIES**

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### **ABSTRACT**

The main goal of this project was to create a simulation of the production plant of Radex Heraklit Industries (RHI) that offers the possibility to change the structure of the model by adding machines and furnaces and change system parameters. The large amount of data needed soon implied the use of a database connected to the simulation. This resulted in a simulation that not only imported the needed data for simulating but also data concerning the whole model structure. Only a basic structure is implemented and according to the data imported from the database the full simulation model is created on resetting. This offers a high flexibility: machines can be added and removed, parameters changed as well as the whole course of manufacture only by editing the corresponding data in the database. The data collected during simulation allows a precise analysis and comparison of single simulation runs.

### **1 THE MODEL**

The production plant considered in this project consists of a large amount of machines and a complex course of production depending on:

- Part number
- Availability of preprocessed parts needed
- Availability of machines needed
- Temperature of manufacturing

Following points needed to be taken in consideration:

- A high number of different products each of them taking a different course of manufacture
- 60 working places
- 20 furnaces
- Storages between each step of manufacture
- Furnaces can switch between different temperatures. Therefore it may take some time until products can be processed.

The input consists of two kinds of products: those who require preprocessed parts and those who do not. Products are loaded onto pallets with a maximum weight of 250 kg. Figure 1 shows the way of a product after its entering of the system:

- Preprocessed parts wait until they are required
- Parts that require no preprocessed parts are put into storage in front of the next machine to be processed in and stay there until they are requested
- Parts that require preprocessed parts wait until all of them needed parts are available. Then they are sent on to the storage in front of the machine to be processed in next

Two different kinds of machines need to be distinguished:

#### **1.1 Working Place**

Working places as shown in Figure 2 represent a simple manufacturing step. Most of them do not take more than a

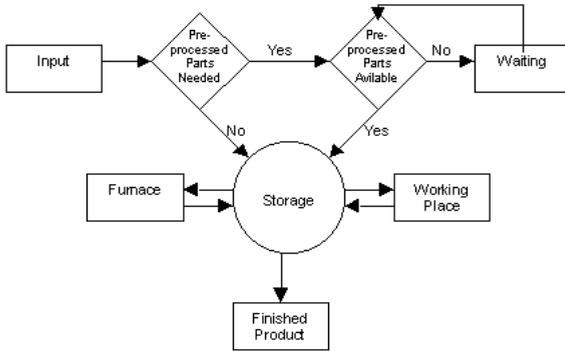


Figure 1: Way of Manufacture

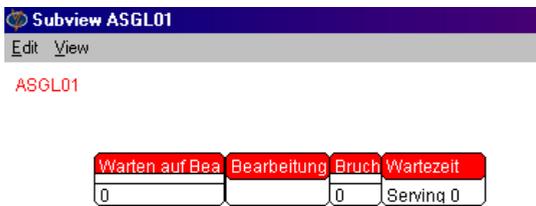


Figure 2: Working place

few seconds per part. The cycle time may depend on the part number to be processed. In this case the pallet carries a label containing the cycle time.

## 1.2 Furnace

Furnaces are more complicated than working places as can be seen in Figure 3. Here no longer pallets are to be considered but cars with a higher capacity than one pallet. Parts that are to be processed are taken from pallets and filled in one car. This is done regardless of part numbers, only the temperature required is considered. After leaving the furnace products are once more loaded on pallets. They are stored for a certain time to cool off again.

If no more products requiring the current temperature are available, the temperature is changed depending on the products waiting to be processed.

Depending on the capacity of each furnace it contains a certain number of cars passing through it. Each car can be processed with a different temperature. In certain time steps the first car leaves the furnace and the next enters. If no parts are to be processed empty cars are sent through.



Figure 3: Furnace

## 2 THE SIMULATION

The simulation was done in Enterprise Dynamics 4.0 due to its open structure and 4d script that offers a very high flexibility as well as an ODBC interface.

According to a production plan the number of raw products to be produced each day is created. This may be up to several thousand on one day. Due to this high number of products in the system only pallets of products are considered. Each pallet has a maximum weight of 250 kg and can carry only products of the same part number.

Each pallet entering the system is assigned a number of attributes:

- Part number – identifies the product to be processed
- Stage - way of manufacture – the way the product has to make through the system
- Temperature - furnaces have to run with this temperature to manufacture this product
- Time – processing time for the next step of manufacture
- Weight of the pallet (maximal 250 kg)
- Weight of one product
- Preprocessed part – true/false
- Time of entering
- Order number
- Number of products carried

All this data is stored in a database and imported and assigned during simulation.

The first thing to be determined is if the new pallet contains parts requiring a number of preprocessed parts. If this is the case the products are stored until the requested parts are available before they start their way through the production plant.

An important fact is the need of each pallet to be put into storage after finishing a processing step. A label assigned on creation that contains the whole way of manufacture is checked every time the pallet goes back to storage to determine the machine to be sent to next. The pallet is placed in the according storage in front of the machine that contains all products to be processed by it. Transport times are considered and depend on the way between machine and storage.

Products are requested by the machines:

- Working places have a capacity of one and request the next product as soon as they are empty.
- Furnaces have a certain capacity of cars as well as a clock cycle. At each clock cycle the first car in line leaves the furnace. At this time products to fill the next car are requested and it enters.

As soon as a pallet has finished its way through the system it is sent to one of two storages depending on the final status of the products it carries:

- Storage of preprocessed parts
- Storage of finished products

There all relevant data for further analysis are extracted and the pallet itself is destroyed. If a part is required by a product waiting for preprocessed parts it is recreated using the stored data.

All machines are kept as simple as possible; the main functionality is implemented in functions defined in an Initialize Atom. They can be called globally only the machine number is needed as a parameter. E.g. the function call Maup(22) starts up the machine with machine number 22.

### 3 INPUT FROM DATABASE

The high amount of data needed for this simulation was stored in an Access database. Enterprise Dynamics offers an ODBC interface that allows easy communication and data import, another big advantage of this simulation tool:

- There already exist a common knowledge of handling Access
- Additional macros offer more comfort
- It offers the possibility to easily create a number of different scenarios
- There is a high compatibility with other systems

#### 3.1 System Related Data

Each interaction between database and ED slows the simulation considerably. Therefore all data is imported on reset and stored in tables in ED to minimize simulation time except the production list.

- Number of working places and furnace
  - The limit is 50 furnaces and 250 working places
- Temperatures
  - A list of all temperatures at that furnaces can go
- Changes in the number of tours for single machines
- Machine up and down times
- Way of manufacture for all products depending on part number

#### 3.2 Machine Related Data

- Machine name
- Transport time from and to storage

- Machine category
- Capacity
- Capacity of furnace cars
- Spoilage
- Clock cycle of furnace cars
- Waiting time
- Number of tours per day
- Cycle time depending on part number and machine category

### 3.3 Adaptation of the Simulation

As soon as all data is received the final structure of the simulation forms itself automatically. 150 working places and 50 furnaces basically already exist. According to the imported data the required number of furnaces and working places are parameterized and connected to the system. For each activated machine a monitor is created to display their status during simulation.

In front of each furnace a storage is created. Figure 4 shows how each of them is divided in as many sub storages, as different temperatures exist. Each pallet is assigned a label on creation, containing the temperature the products it carries will need. According to this they are stored.

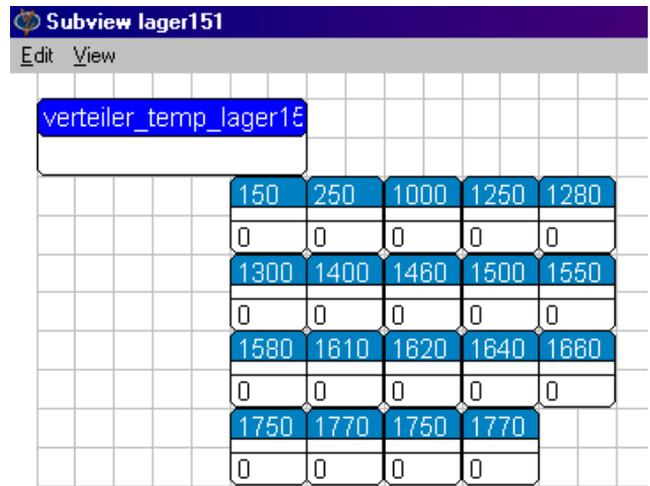


Figure 4: Storage in Front of Furnace

#### 3.4 Shift Work

Four different kinds of shift work are possible:

- One tour: from Monday to Friday from 6am to 2pm
- Two tours: from Monday to Friday from 6am to 10pm
- Three tours: from Monday to Friday from 0am to 12pm
- Four tours: from Monday to Monday from 0am to 12pm

The number of shifts for each machine is contained in a label set on reset. It is possible to change the number of tours for machines during simulation by reassigning the according label.

### 3.5 Spoilage

For each machine, working places as well as furnaces spoilage has to be taken into consideration. It is a machine related parameter provided on reset. A Bernoulli distribution was used here:

```
repeat(i.inhalt,do(
  bernoulli(100-ddb([bruch],name(in(1,c))),
  do(2+2),
  do(
    createatomcopy(i,out(2,c),name(i)),
    createevent(0,out(2,c),20),
    i.inhalt:=i.inhalt-1,
    if(i.inhalt=0,destroyatom(i))
  ))
))
```

Due to the high number of different products in the system it is not possible to regard only pallets here. Therefore spoilage is calculated for each pallet considering the number of products it carries. Spoiled products are taken off the pallet and sent to a special storage for further analysis.

## 4 RESULTS

The goal of this project was to create a simulation where one year of production could be simulated. The possibility to change parameters like number of machines or temperatures that would influence the whole system was offered by creating a self-adaptive simulation.

During each simulation run data is collected to be exported to the Access database for further processing:

- List of products manufactured containing
  - Order number
  - Date of production
  - Part number
- Storage movements, every entering or leaving of a pallet for the
  - Storages in front of all machines
  - Storage of preprocessed parts
  - Storage of products waiting for preprocessed parts
- Machine status over time
- Machine utilization
- Spoilage, a list of each spoiled product containing
  - Part number
  - Time
  - Machine number
  - Order number
- Variations in temperature for each furnace

This high amount of data is written to the database during simulation to keep the amount of working space needed at a tolerable level. It allows a precise analysis of the system after the simulation run.

During simulation the tools offered by ED can be used to show

- Machine status
- Machine utilization
- Queue status of storages

Additionally each machine is connected to a monitor that displays its status – if active or not – as well as its utilization and the current temperature for furnaces.

## AUTHOR BIOGRAPHIES

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