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Industrial Electrical Engineering and Automation

Designing the Expansion of a Manufacturing Plant

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PREFACE

This master thesis has been written during the autumn and winter of 2004/2005 as the final part of our education. We have attended a Master of Science program in Mechanical Engineering at Lund University. The thesis has been conducted at Prestando AB in cooperation with the Department of Industrial Electrical Engineering and Automation at Lund University.

There are a number of persons we would like to thank. Our supervisors at Prestando AB, Per-Olof Jönsson and Håkan Jönsson, have given us great support, good advice, and a lot of laughter. Our tutor at Lund University, Gustaf Olsson, has provided valuable guidance, and motivated us with his positive and enthusiastic spirit all along the way.

We will also give a great thanks to Rudolf Abelin and Lars Snogerup with help from Bo Svensson at Pedensia AB, Tim Lewis at 3DLabs and Thomas Stenberg at AMD Sweden for kind donations of computer related hardware that has enabled us to move the computational limits forward.

We are also grateful to all persons that have given us support and shared their knowledge during meetings, visits and numerous interviews. This goes to people within Prestando AB and also to the representatives from Lindab and Borgströms Mekanisk Verkstad AB that has given us opportunity to visits them.

Lund 30 Mars 2005-04-13

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ABSTRACT

Title	Designing the expansion of a manufacturing plant.
Authors	Olof Jepson, Johan Jönsson
Tutors	Per-Olof Jönsson, Håkan Jönsson at Prestando AB. Gustaf Olsson at department of Industrial Electrical Engineering and Automation.
Problem statement	Prestando AB manufactures and sells stamped and welded products as well as press tools. During the last years Prestando AB´s order stock have increased significantly why the production capacity now is too small. Today Prestando AB is running near 100 % of the capacity, which means that a lot of the employees work overtime. This situation is not sustainable over time, which has lead to that Prestando AB will make an expansion of the manufacturing to increase the production with about 50 %. Our job was to help Prestando AB´s decisions maker to investigate and generate solutions of how an expansion could be made.
Procedure	In our work we have generated simulation models in Quest and ProEngineer mostly to visualise the suggestions in a 3-D environment. We have made two main layouts of placement of the machine. We have also suggested a couple of technical solutions that can simplify and contribute to a more efficient production.
Conclusions	The result is that there is no big difference in output between the two solutions, but one of the layouts has more advantages concerning other problems. The flexibility is one of the mayor advantages of this solution. Another issue is that with this solution it is easier to expand in stages. The technical solution we present may simplify the logistic of the raw material into the building. Another suggestion of technical solutions is a new system for storing coils, which would reduce the area of floor space.

CONTENTS

1
Introduction

In this initial chapter we give an account of the background to the project, the purpose and which goal we have for the project.

1.1 Background

The company Prestando AB has nearly 80 employees. The company is located in Trelleborg, a small town in south of Sweden, since the beginning 1959.

Prestando AB develops and manufactures mostly components to the vehicle industry. The company has several large customers for example Volvo, Lord and Renault. The main products are stamped and welded products. There are many producers of stamped and welded products and the competition in the market is hard. Prestando AB has specialized on thick sheet metal stamping (3-12mm).

During the years Prestando AB has expanded the organization by acquiring a smaller firm that develops and makes tools both for its own production and for sale. This department is not located at the same area as the production department instead it is located on the other side of the town. In the future this department will be moved to the same place as the current production to locate the organisation at one place and to avoid unnecessary transports. The tool department will be placed in the new building.

Today Prestando AB has six large production lines that produce more or less complete products from coils, a coil being a roll of steel. These six lines have a press force ranging from 1000 kN up to 15000 kN. Prestando AB also has an automatic robot cell offering drilling, chamfering, thread cutting and vision control. The plant produces up to 2000 different articles with an output of about 25 000 000 details each year (Internal information from Prestando AB, 2004).

During a period of ten years the company has more then tripled its turnover from 50 to 170 MSEK. A reason for the large increase in turnover is great orders from companies in Germany and in the later years also from the USA.

While the order stocks have increased significantly during the last few years, the situation has now come to a state where the capacity has reached an upper limit. Prestando AB needs to increase the output from the production to be able to complete the assignments.

The current factory building cannot house another press line, why a new production plant is necessary to allow further expansion.

1.2 Problem introduction

The objective of our work is to generate and evaluate solutions for a new production layout. The investigation will include an evaluation of performance and limitations of the plant. We will also generate and analyse possible technical solutions to avoid problems that are common today.

The purpose of this project is to analyze possible alternatives for an expansion of Prestando AB. We will here investigate and simulate different kinds of layout solutions to find a solution that suits the needs of Prestando AB. We will also investigate technical solutions that could simplify the material handling.

The goal of the project is to generate and present possible solutions of an expansion of a new manufacturing plant to be used as foundation for investment decisions.

As mentioned we will analyse and investigate solutions. To facilitate the understanding for the different alternatives our goal is to visualise our solutions in a 3-D environment, this mostly to make it understandable the manager at Prestando AB. This report is also aimed to be understandable to people with an engineering background.

2
Problem statement

This chapter will describe the current order of work at Prestando AB and bring up the problem areas.

Prestando AB consumes a lot of steel, which is delivered on coils, large rolls of steel. The size of the coils is in the range from less than 100 kg to about 5000 kg. Today an average of between two and three trucks arrives per day with raw material. The raw material is unloaded with a forklift truck. The time to unload raw material depends on the material, the way the material is packed and who is conducting the unloading operation. To unload the larger coils with a forklift truck is not a satisfactory method from a safety point of view, since the payload is close to the maximum capacity of the forklift truck. Accidents have happened why this is an operation in need of improvement especially as a 50% increase of coil delivery is expected due to the expansion.

A 50% increase in raw material consumption will of course influence the extent of product shipment as well. All shipment is conducted with forklift trucks that load euro-pallets on the trucks. Also the load process varies in time in a stochastic matter determined by who is conducting the load, what kind of material and what kind of truck is being loaded.

With the expansion there will be four trucks of raw material, three trucks to pick up goods and two trucks to collect scrap iron that will arrive and depart per day. This will demand a lot of the warehouse department and a possible problem could be the actual space at Prestando AB. This can be a problem especially as the trucks do not arrive in a deterministic way. Four trucks with the same material can arrive at the same day, delivering a couple of orders at the same time.

Both the loading and unloading processes need to be investigated in terms of how they are conducted and how much space that is needed for loading and unloading.

The coils that arrive are stored in tents outside of the plant. The coils are moved from the unloading area, later to be moved inside the plant. Inside some coils are stored as a buffer upstream the production lines.

In this load and unload area a lot of material handling is conducted and a lot of floor space is required for coil storage. Alternatives for the transportation back and forth as well as alternative storage systems should be investigated.

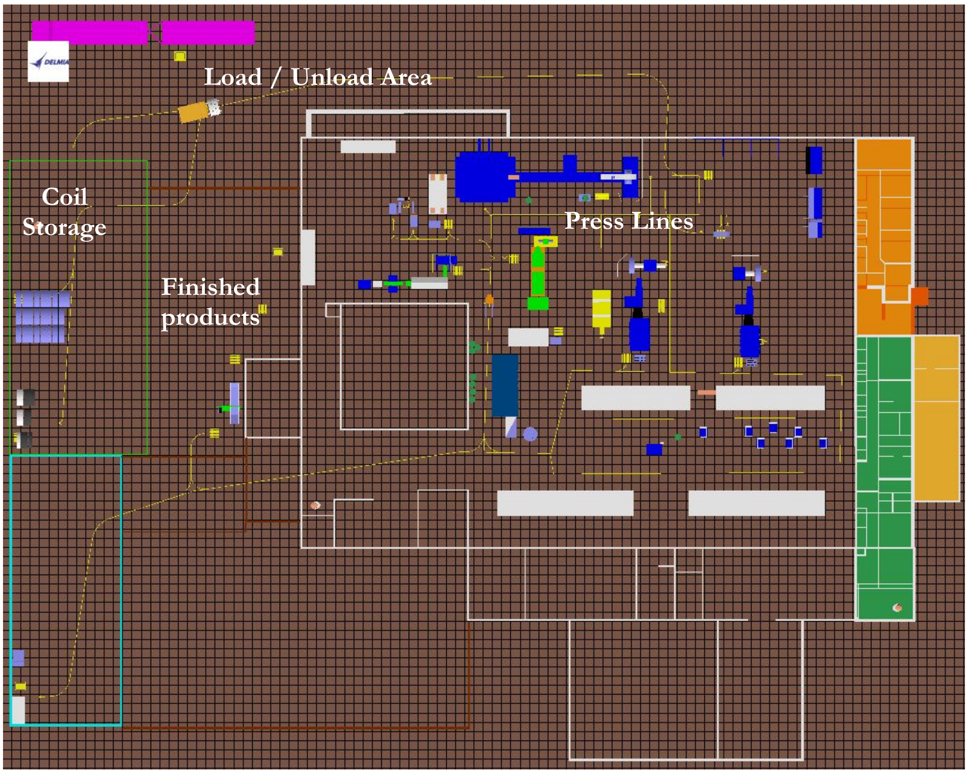

Figure 1: An overview of the current production plant.

A typical line is built up by a loading area, where the coils are hung up. The steel is then processed in a rolling mill. It is then refined through cutting, stamping and drawing in the different tool stages finally to be washed and placed in a pallet. In this project we will see a production line as a closed system with a constant cycle time. This cycle time will be estimated with the cycle time of the lines in the existing plant and the predicted cycle times of the machines being installed in the new plant.

We will investigate the material flow to and from such a production line i.e. coils to the line, scrap iron and finished products from the line.

The coils are loaded with an overhead crane. This crane will then be unavailable for a certain amount of time for the other production lines. This time is determined mainly by the design of the loading area of the machine. It needs to be established that this overhead crane has the right capacity for serving the different lines.

Between batches the tool in the press needs to be changed. Some of the tools weight up to 10 tons and therefore needs special equipment. Today the change process is conducted with a special carrier. It is not an uncomplicated process to change tool with this. Therefore alternatives like using only the overhead crane should be investigated.

Every cycle that delivers a new detail also produces scrap iron. About 50 % of the material will be scrapped why the scrap iron handling is an important issue. The most modern line in the existing plant has a conveyor system directly connected to the line, transporting the scrap to containers outside. This allows the operator to focus on the details instead of the scrap being produced. This is a solution appreciated at Prestando AB but some problems are associated with this process as well. One problem is the wear and tear of the conveyor belts, since the sharp edges of the scrap can tear the belts apart causing production stops and high repair costs. Another problem in the scrap area is the containers being used. The size of the containers is 3000 x 2000 x 1500 mm. When they are filled too much it is very hard or impossible to move them because of the weight. The filled and empty containers also take up a lot of space outside, space that will be needed for loading and unloading. A smaller, stackable container would be preferred.

Alternatives to the plastic belts used today in the conveyors needs to be examined.

The details being produced are normally finished products ready for shipment, but some of them need refining in downstream machines. The capacity, flexibility and robustness of this internal system need to be analyzed.

All shipment is conducted with forklift trucks. The procedure of loading one single pallet can involve the use of more than one forklift since one forklift is needed to get the pallets out of the storage area and another is needed to load the truck outside. This is another issue that needs to be investigated in order to make the load process more effective.

The sections above describe how some of today's processes work and the problems associated with them. When designing a new layout we would like to avoid the problems that exist today. Some of the issues concern only space and can be investigated and visualized with the use of CAD software. Many of the other problems are much more complex and include a lot of uncertainties such as machine failures and repair times etc. A way to analyse those kinds of problems is to use simulation software.

We want to create a well designed system that can handle changes in the input parameters, e.g. if we increase the number of machines, the overhead crane and other support system should be able to handle the increase of coil delivery, product shipment and scrap handling. The layout should also be designed in a way that minimizes the transport distances and material handling.

The flexibility and robustness of the system can be tested by changing different parameters in a simulation model, e.g. if the failure time is shortened or the batch size is changed, what will the effect on output and the utilization on the overhead crane be?

To summarize the problem statement, there are a number of issues that have to be analyzed:

- Finding the adequate floor space for the various operations by using a 3-D software to illustrate and analyze the operations from a geometrical point of view.
- Analyzing the sequences of operations and how they are affected by stochastic disturbances, such as non-deterministic delivery times of raw materials, machine failures and repair times. This is further discussed in the next chapter.
- Designing and/or investigating possible technical solutions that can simplify the material handling.

3
Planning the material flow

In this chapter will we describe how we will face the material and logistic flows and which method we use to get an overview of the problems. We will also show the material flow of the current plant.

3.1 Procedure

As mentioned before will we investigate the material flow, both the internal logistics and the external logistics. The inside material flow is mostly about transporting material to and from press lines. The outside logistic is a more complex issue. It has to be planned well to avoid traffic jam since the traffic will increase due to increased production. Before starting to plan this we had to collect information of how it looks today.

We will use both observations and interviews as a method to collect information about the different processes that we want to investigate. We use the observation to get a holistic perspective of the problem. It helps us to understand how different procedures work and what kind of problems that occurs. These initial, unstructured observations will generate questions about the different processes. To get the information we need to continue interviews with the personnel at respective department are necessary.

The interviews will be unstructured and more as a meeting where we can discuss the problems today to get the employees version and vision as a base to create possible solutions that can be of interest.

3.2 *Mapping the flow*

From our observation and research we have identified how the material flow looks today. Figure 2 is a map over the current material flow. The white line describes the arriving transports with raw material. The red lines indicate how the internal transport works. The yellow shows the outgoing material as finished products.

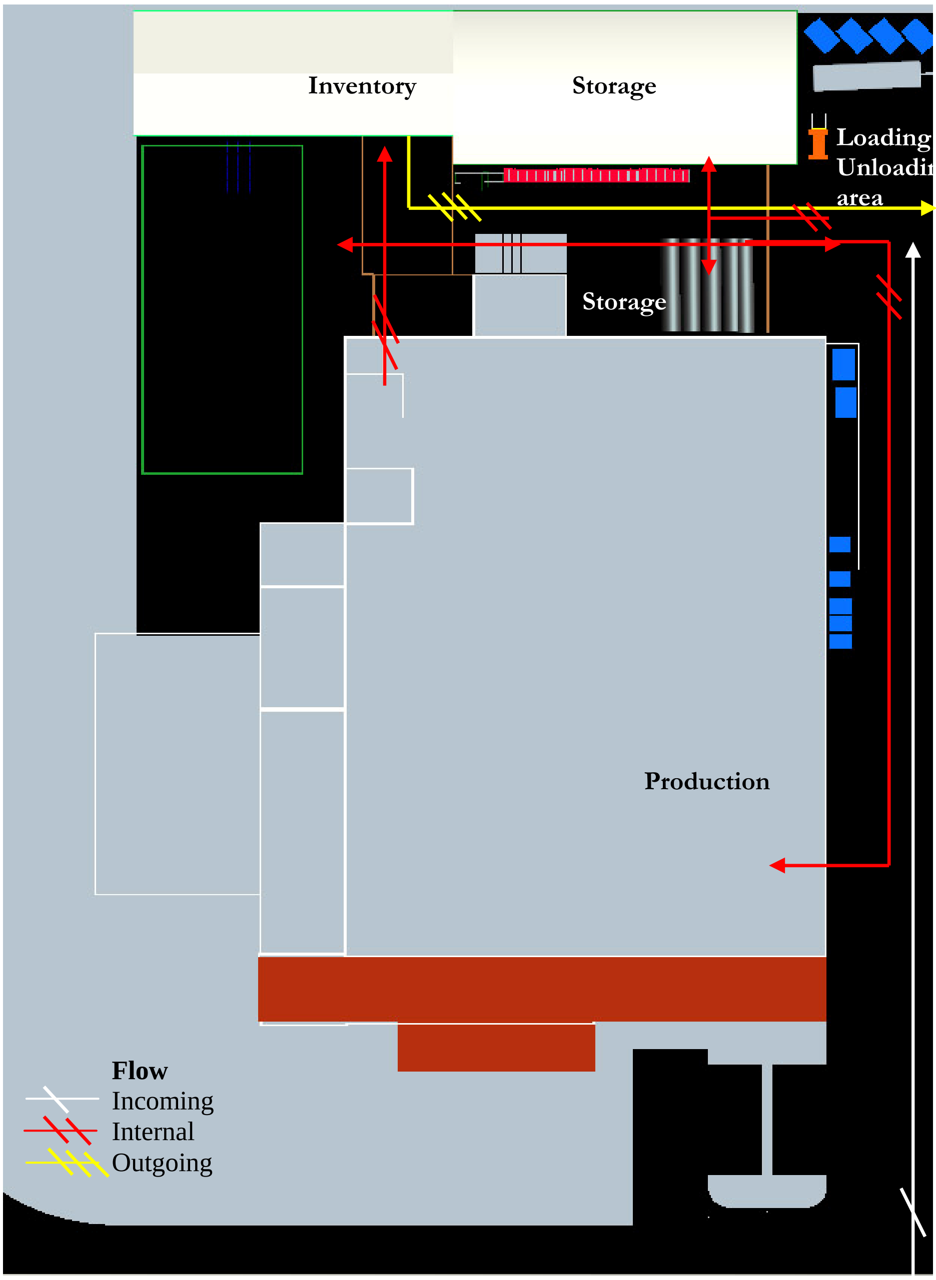

Figure 2: Map over the current material flow.

All material flow begins with the arrival of the trucks, containing the raw material. The trucks are unloaded at the unloading area showed in Figure 2. The raw material is then transported with a forklift to one of the two main storage places that they have. The process is continued with delivering coils to the buffer inside the plant that provide the lines with material. Inside, the raw materials, coils, are refined to finished parts which are stored in pallets. The pallets are then transferred to get packaged and transported to the inventory for finished goods. Finally all pallets are moved to trucks at the loading area to get shipped out to customers.

3.3 Approaching the problem

In order to solve the problems stated we need two different kinds of tools. Discrete event simulation is an essential tool for the analysis and description of the production flow and a 3-D software is good to represent the visualisation. The background of simulation is described in Chapter 4. In order to analyse the layout of the plant and its equipment and transporting facilities we have used the software Quest. This is further described in Chapter 5.

4
Discrete event Simulation – an Introduction

Simulation is very useful in several aspects. It is used to analyze, optimize, plan and present solutions. It is adequate to use simulation for systems that are very expensive, dangerous and difficult and time-consuming to build. This chapter describes different issues of why to simulate and how the simulation procedure is made.

4.1 What does simulation imply

Building a simulation model is a way of trying to describe the reality in a way that allows the user to vary the conditions surrounding it and being able to investigate the sensitivity of the system. But to describe the reality exactly demands an enormous amount of data, why generalizations and simplifications often are necessary. To reflect for example a production line, only the most important variables will be simulated, for example the cycle time, travel speed, buffer size, distance between elements etc. What happens inside the various machines is ignored to avoid a gigantic, complex model (Solding, 2001).

The advantages of using a simulation of a production line before an investment of a new plant or new machines are that several scenarios can be tested to analyze problems and therefore minimize the risks of making poor investment decisions. Therefore simulation is a tool to help the decision maker to make a correct decision.

Good examples when simulation is used are when we wish to compare several alternative solutions, evaluate special functions and predict the results.

As mentioned above simulation is a tool to describe the real world. But before starting simulating it is necessary to verify whether it is meaningful to simulate or not. If the problem involves any of the following items it can be useful using simulation (Banks, 2004).

- Examine a complex system
- Plan a new system without stopping current production
- Visualize and animate problems concerning production processes
- Identify bottlenecks
- Predict outputs
- Training the team

But it is not always an advantage to use a simulation. The disadvantages of simulation can include the following.

- Simulation results might be difficult to interpret
- Modeling and analyzing can be time consuming and expensive
- Simulation might be used inappropriately, which means that an existing analytical solution is possible or even preferable
- Simulation does not give the optimal result
- Simulation does not solve problems

Therefore simulation should always be used with care, and the validity of the corresponding model should be carefully evaluated.

4.2 Different kind of systems

When using simulation as a tool, it is important to define which kind of system that will be simulated. A system is defined as an assembly of units that are connected to each other working in the same direction. The system consists of states that describe the system. A system can be divided into static or dynamic, discrete or continuous and stochastic or deterministic systems (Dudás, 2003).

Static or dynamic

A static system is a frozen state. Analyzes of a static system occur at a fixed times. A manufacturing facility often contains a large number of machines, such as robots, processing machines and material handling equipment. They are typically dynamical systems and can be modelled as ordinary differential equations or difference equations. This type of equations describes system that change over a specified time (Olsson-Rosen, 2005).

Discrete or continuous

Discrete systems can be described as always being in one well defined state. For example, a machine can only be operating or idle or repairing, which means that it can only be in one of these three states at any given moment. A continuous system is more like a flow in a tube where the state changes do not occur at specific times. The continuous dynamical system is commonly described by ordinary or partial differential equations (Olsson-Rosen, 2005).

Stochastic or deterministic

A stochastic system will not have the same output after every run with the same input parameters because of the variance in the distributions. Uncertainties can be described by stochastic processes and can relate measurement uncertainties as well as parameter uncertainties or process disturbances. A deterministic system however gives the same result with same input independent of how many runs being performed (Olsson-Rosen, 2005).

Disturbances and uncertainties

A tool breakdown is a disturbance that is an example of a discrete event. Events like this occur at random times and are usually not predictable. Another kind of disturbance can be the change of batch sizes or the number of press lines being used (Olsson-Rosen, 2005).

4.3 Our system

Our system includes elements where events occur more or less stochastic. Underlying issues of this is that there are some events that can’t be controlled.

An example is the arriving trucks that delivers raw material in a somewhat stochastic manner. Although the arriving deliveries are ordered to a fixed time, it will not always come exactly at this time. Additionally, suppliers occasionally deliver several order at once causing storage problems. A distribution that is able to reflect these issues is hard to find. The difference between the estimated distribution and the reality implies uncertainties.

Other disturbances that we have to include in our model are the failure rate at the machines and other equipment. Also the repair time is stochastic depended on the nature of the failure.
How should we then work to handle these issues? Since we have a problem that includes in a stochastic and dynamic system our opinion is that no

common calculation methods are possible to use, instead simulation software is necessary.

Our job is also to visualize a future scenario. To accomplish this, software like Automod, Extend or Quest could be used.

We have decided to use the software Quest, since we have some knowledge of this before and we have heard about it from a well-recognized consulting firm that they use this software for such kind of problem (Interview Semcon).

Another essential reason for using the Quest software compared to other simulation programs is the easy to use graphical representation that makes it possible to present your model and discuss different issues without the opposite part being forced to understand all the underlying logic that govern the model.

4.4 Procedure of simulation

Working with a simulation project, the following procedures are recommended to use to simplify and organize the work (Banks, 2004).

- Define a problem to study
- Collect information and data
- Build a model that represent the problem
- Run the model
- Analyse the output

Figure 3 shows a flow diagram over the procedure in a simulation project.

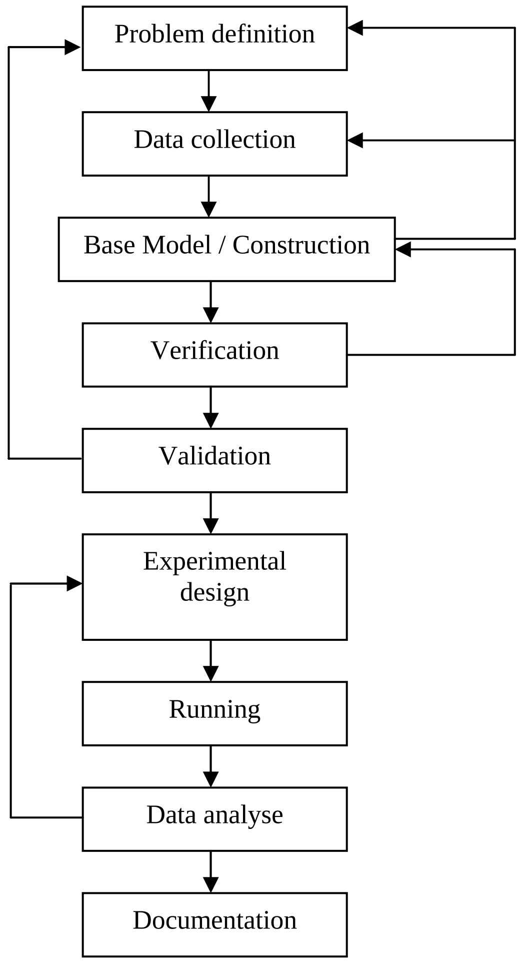

Figure 3: Flow diagram of the simulation process.

4.4.1 Defining and planning the problem

The first step and maybe the most important step is to clearly define the problem. If the statement is provided by those who have the problem (client), the simulation analyst must take extreme care to ensure that the problem is clearly understood.

When starting building a model, it is preferable to construct a small model to avoid far too complex systems. It is a lot easier to expand the model over time than to be fighting with a large system directly. In this step it is also important to estimate time and costs of the project.

4.4.2 Data collection

Shortly after that the problem formulation is accepted, a schedule of data requirements should be submitted to the customer. This data will consist of both deterministic and stochastic data. The deterministic data is the data that is fixed and we don’t have to estimate. Examples of this are cycle times in the machines and speed of the forklifts etc. Stochastic data describes events that takes place randomly and has to be estimated by different distributions. Estimating this kind of distributions often leads to uncertainties and errors. The stochastic data is rather more difficult to collect. Here we have to estimate distributions of different processes. Processes like failure distributions are difficult to estimate, since the variance of how long each downtime is, is dependent of many things. If there are a lot of estimations which can be uncertain the triangular distribution can be a good choice to use if no other distribution can be estimated. The point with this distribution is that the distribution is based on values of the minimum, the most likely and the maximum value.

4.4.3 Base model/Construction

At this moment of the project, a first approximation of the model has to be tested. The base model will be a prototype of the final version. The construction begins with putting all components together. Using 3-D software in the simulation, the customer can easier get involved. If the client is involved during the design this will enhance the quality of the resulting model and increase the client’s confidence in its use. The different elements in the model are also equipped with different kinds of logics to determine its behaviour. The logics are governed by the distributions and parameters that affect the element in question. I.e. a physical machine that produces a certain part using a particular kind of material with a determined cycle time and break down with a triangular distribution of some kind.

4.4.4 Verifying

After the construction step, the model is ready to be executed. It is very unlikely that the model is a correct representation of the conceptual model from the beginning. A larger model becomes more complex and takes longer time to verify and correct. Therefore is it highly advisable that verification takes place as a continuous process throughout the model-building process, rather than waiting until the model is complete.

4.4.5 Validation

Validation is the determination that the conceptual model is an accurate representation of the real system. The routine of validation is to first check if the system is a good copy of the real world, which means checking the visualization through running with animation. After that the input data and the assumptions must be verified. The final check is to run the model and check the output to see if it is realistic.

4.4.6 Experimental design

In this phase it is time to create various scenarios to be simulated. Decisions about run length, number of runs and the manner of initialization are required.

4.4.7 Production runs and analysis

The model is now ready to run and is used to estimate measures of performance for the scenarios that are being simulated. Based on the output a decision can be made if more simulations are necessary.

4.4.8 Documentation

At last the result of all analysis and recommendation should be reported clearly and concisely. Making a good documentation of the project, both in terms of a good model design and well-documented results, this enables the customer to use the model again in the future. The model can for example perform different simulation tests in the process of developing, or change in, processes. It can also be used in the planning of further expansion or rearrangement of the inventory.

5
Modeling methodology in Quest

This chapter will describe the components that are used to create a model in Quest and the relationship between those components.

The user manual Quest V5 (1995) is referred to in this chapter as a general reference for the discussion.

3.1 Model Component overview

The Quest model can be split up into two parts, the physical and the logical model.

5.1.1 The Logical Model

The core of the Quest simulation model is the logical model. Two types of logical components build up the logical model:

1. Elements – Elements have logic, which are the rules that determine how the element behaves in the model. Elements also have attributes that determine how the element looks in the 3D-enviroment.
2. Parts – Parts are dead things without logics and are the entities that are processed by the elements. Also parts have attributes that determine the appearance of the part.

5.1.2 The physical model

The physical model is a 3D representation of the parts and elements being created in the system. Quest has a built in CAD modelling system where it is possible to create your own physical models. There is also the possibility to import 3D geometries from other CAD programs.

5.1.3 Modeling Elements

There are different kinds of elements with different types of logic. Quest defines the following types of elements:

1. Part creation and destruction classes
   - Sources – A source creates parts and sends them into the simulation environment.
   - Sinks – A sink destroys parts and take them out of the system.
2. Part storage classes
   - Buffers – A buffer storage parts.
3. Processor classes
   - Machines – A machine has the logic to process parts that are sent to the machine.
4. Material handling classes
   - Conveyors – A conveyor has the capability to move parts along a given path.
   - Automatic Guided Vehicles (AGV) – An AGV can carry parts and move them along a predefined track.
   - Labors – A labor can carry parts or be doing some kind of work.
5. Others
   - Decision points – A decision point works like a sensor on different transport system, e.g. a conveyor or a path system. It is used as an interface between a transport system and any other element in the model.
   - Accessories – An accessory has no logic and is only used for the graphical representation in the model to help place the other elements.

5.1.4 **Flow of Parts**

The logical processes in each element and the connections between them determine the flow of parts through the model.

5.1.5 Element Connections

To move parts between elements in the simulation they need to be connected. A connection is a logical link that provides the mechanism for parts to move from one element to another.

Elements normally have at least one input and one output connection; a part arrives to the element via the input connection, is processed by the element according to the element logic and is finally sent away via the output connection to another element. Elements that do not have input and output connections are the source and the sink elements that only have outputs and inputs respectively (since they create and destroy parts respectively).

There are two types of connections in Quest:

1. The Push connection is a connection where the part will move to the next connected element once it is released by the upstream element.
2. The Pull connection demands a request from the downstream element for a part before the part is allowed to move downstream in the model.

5.1.6 Transport Systems

An element connection allows the logical movement between elements, but it does not allow the physical movement e.g. the parts will instantly disappear from one element and instantly appear at the next downstream element. To allow the physical movement a conveyor might be used. With a conveyor the physical movement is visualized and one is able to control the time of the movement by determining the speed of the conveyor.

5.1.7 Processes

The Quest processes define what happens when a part moves through an element. Many different processes can be associated to the same element. Below follows the standard Quest processes:

1. Setup Process – The setup process is a process setting up the machine between operations. Typically being performed between batches.
2. Load process – The process of loading each part into the element. Typically used within batches.
3. Unload process – The process of removing parts after being processed by the element.
4. Cycle process – The process carried out by the element. Defines what’s needed to perform the operation e.g. raw material and a labor and the result of the operation, e.g. a refined product.
5. Repair process – The process that determine how long and what requirements are needed to repair a machine after a break down.

5.2 Quest Logic

Each element, except for accessory elements, has one or more logic expressions assigned to it. These logic elements determine when and from where one element orders a part from an upstream element, what to do with the part when it arrives (what processes to use) and where to send it when it is finished. This flow of processes within an element is shown in Figure 4.

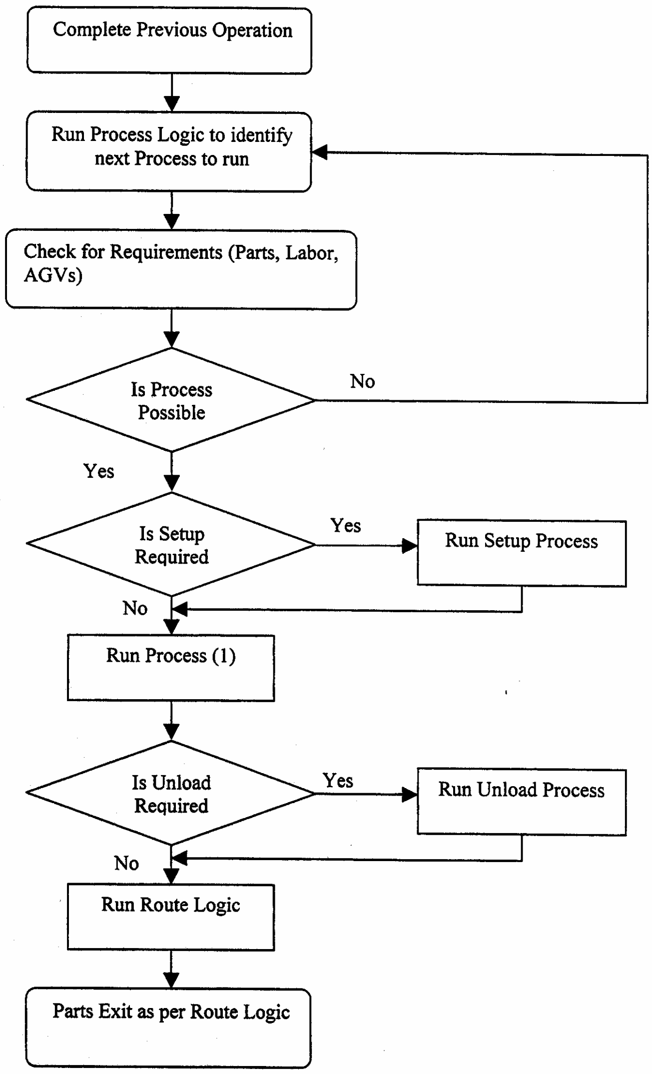

Figure 4: Flow chart of the machines process and logic in Quest

6
Data collection

In this chapter we describe what input data we use and how we use it as well as what distributions have been made for describing data.

6.1 Input

It requires a lot of input data to represent the production system. This data is mostly received from Prestando AB estimated from production data 2004 and planned production for 2005. When running Quest all kind of distributions are allowed. To get a good result from Quest or any other simulation software the input data has to be correctly estimated. Since we don't have enough data about the processes that will be run in the new plant, we have decided not to use an exponential or normal distribution. In our case we use a triangular distribution.

When exact data is not available, but the most likely and rough estimates of minimum and maximum values are known the triangular distribution can be used to provide an approximation for the desired random numbers. The probability of data values varies depending on the triangular distribution's minimum value (L), most probable value, or mode (D) and the maximum value (U). The range of the distribution from L to U is shown in Figure 5 below (Banks, 2004).

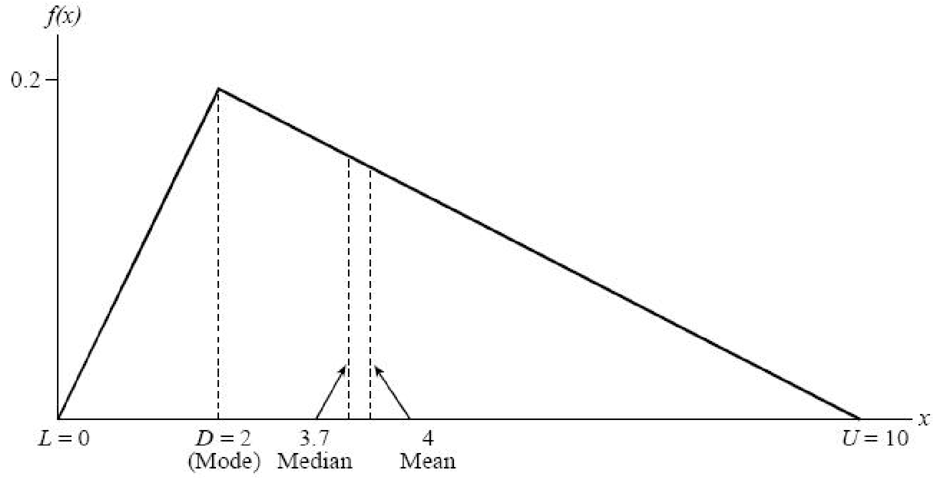

Figure 5: Triangular probability function with parameters as (0, 2, 10).

Using a triangular distribution only a maximum, a most likely and a minimum value is required. To get a more accurate distribution more data over time is necessary. The lack of information in this area will of course effect the results but they will be accurate enough to perform different tests in the model i.e. if the average repair time is shortened by x % the output will increase with y %. These kind of reactions of the model is what we need to determine whether a resource is sufficiently dimensioned or not and which parameters that effect the model in a considerable way.

Process data						
	MTBF [min]			**TTR [min]**		
Unscheduled downtime	**Min**	**Mode**	**Max**	**Min**	**Mode**	**Max**
Failure stamp 2000t	20	90	240	0.8	5	150
Failure stamp 1500t	20	90	240	0.8	5	150
Failure stamp 800t	20	90	240	0.8	5	150
Failure stamp 300t	20	90	240	0.8	5	150
	MTBF [parts]			**TTR [h]**		
Schedule downtime	**Min**	**Mode**	**Max**	**Min**	**Mode**	**Max**
Tool change stamp 2000t	6000	12000	20000	1,5	2	3
Tool change stamp 1500t	6000	12000	20000	1,5	2	3
Tool change stamp 800t	3000	6000	12000	1	1.5	2
Tool change stamp 300t	3000	6000	12000	1	1.5	2
	Distribution [min]					
Load time	**Min**	**Mode**	**Max**			
Loading coils stamp 2000t, 1500t	4	5	7			
Loading coils stamp 800t, 300t	6	7	9			
Cycle time	**Constant [sec]**					
Stamp 2000t	9,8					
Stamp 1500t	9,8					
Stamp 800t	3					
Stamp 300t	3					
Package machine	15					
Finish machine	varies					
Speed	**Constant [mm/sec]**					
Forklift	1000					
Overhead crane	500					
Coil mover	150					

Table 1: Input data that are used in the Quest models.

As mention before we use the triangular distribution in most cases. Table 1 shows times that we have used in the Quest model (Production Sheet, Prestando AB, 2004). Distributions in this table are triangular if nothing else is written.

6.2 Comments about the process data

The unscheduled downtimes mean mainly failures in the various machines. A failure can for example consist of oil leakage, broken tools and breakdown of the feeder etc. These kinds of problems often occur and the repair time has a very wide distribution as can be seen in the Table 1.

The scheduled downtime is what normally would be called setup time. Since we don’t know what different processes will be run in the machines and therefore don’t know the different setup processes we have generalized the model and replaced the setup time with a scheduled failure. This scheduled failure will represent the tool changes at the various machines. The mean time between failures (MTBF) is based on part count e.g. the batch size for the different machines. Time to repair (TTR) represents the downtime caused by a tool change.

We use a triangular distributed load time to simulate the time that the overhead crane is occupied when a new coil is rigged in the machines before starting the production.

The cycle time is the time it takes producing a detail. As an example the 2000 tons stamp machine has a cycle time of 9,8 seconds which means that every 9,8 seconds a new detail will be finished.

Other data as travel speed for the overhead crane and forklift, the machines cycle time are general times taken from the existing factory.

The data that we have collected is a possible source to uncertainties. While we haven’t enough data over the time it is hard to estimate correct distributions. This will bring uncertainties to our system and model because we use distributions to describe how often e g. failures occur and for how long time the machine is down. Other data that we use is the forklifts and overhead cranes velocity which might be an additional source of uncertainty because this information is collected from the data sheet of the product and it is not always the same in the reality.

7
Designing the model layout

This chapter will describe how we have worked to design a model and how we approached the different problems we encountered. It will also handle the technical problems and possible solutions of the problems we have encountered in the progress of developing the different layouts.

When constructing a model to simulate in Quest it starts out to be very straightforward. The different elements, machines, buffers, pathways, etc. are simply placed in a 3D environment. In our case we started by describing a section of the current factory to get to know the program and to be able to verify the results with the real world model.

The segment we have chosen to describe is the press line Press99, which is the most modern press line and it is press lines similar to this that will be installed in the new plant. The material handling around this line with raw material supply and the processes being conducted afterwards was also described. The reason why we chose this particular part of the factory is that it includes many of the difficulties one is faced with in constructing a Quest model e.g. mixing push and pull connections in the same line. Another reason for this choice is that this kind of machinery will be included in the new plant as well.

To get a realistic and understandable model the first task was to describe the environment physically. To do this the CAD package ProEngineer Wildfire 2.0 (ProE) was used. All elements to be used were measured up and designed in ProE and later imported to the Quest software.

The result of this first step is shown in Figure 6 below. Here the building, press lines and the equipment around it is described.

Describing the logic of the elements and the relations between them is the next step to get a realistic representation of reality. To do this, modifications in the code governing the logics is necessary.

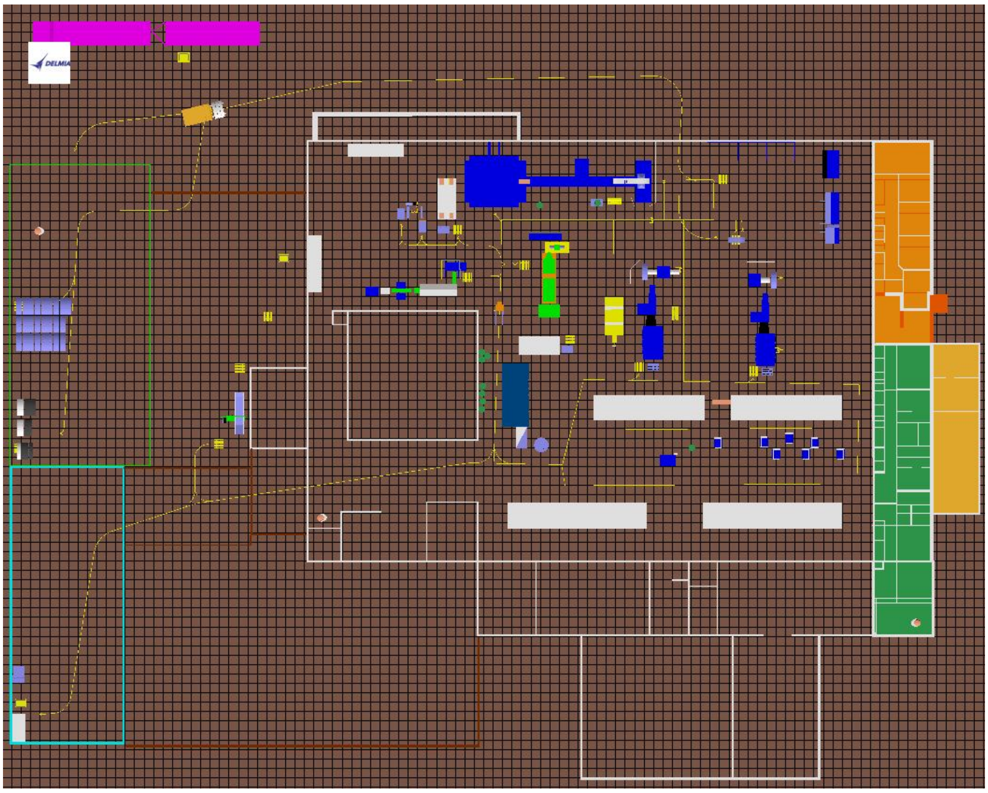

Figure 6: A top view of a Quest model of the existing plant.

After programming the behaviour of the components this element has to be connected together with either push or pull connection or a combination to get a flow through the plant. When all elements are coded and connected in the way it should be it is time to create the material that will be the flow. To visualise our unique details that will flow through the equipment, these also need to be created in ProE and imported to Quest.

After these steps the model is in a state where it could be run, but to get reasonable results all parameters that describe the behavior has to be adjusted. These parameters can be for example the repair time of the machines, the cycle times, speeds and shifts etc. From the data input a distribution could be estimated and defined with respectively value to the elements. Adjusting all these parameters is very time consuming and it had to be adjusted several times before a good result could be estimated.

7.1 Model description – New plant

There are several conditions given for the simulation work of the new plant. There is a restricted area for the new plant and there is a condition that about 850 m^2 of the factory should be assigned for the tool workshop which is to be relocated to the expansion. The offices should be in line with the current office area. As a result there are two main layouts that we find interesting considering the material flow through the plant. The two possible solutions will have either the tool workshop facing the office area or the tool workshop located towards north, away from the existing factory. We will also investigate the possibility of first building a plant with room for two press lines later to be expanded to house two additional press lines and other equipment such as finish machine, packaging machine and a tool splitter.

7.1.1 General notes

The new plant will house press lines similar to some of the existing press lines. A press line is constructed in a manner that a coil, a roll of steel, is hung up and loaded through a rolling mill. The steel is then refined through cutting, stamping and drawing in the different tool stages finally to be washed and placed on a pallet. Now the product is either ready for shipment or further refining.

Figure 7: Picture of raw material, coils.

7.1.2 Model 1

Model number one is shown in Figure 8. The office is located in the same direction as the current office. The office is built on an area of 400 m^2 in one or two floors. The workshop will be located next to the office with an area of about 850 m^2. All equipment from the current workshop, located on the other side of town will be moved into this new building. Next to this section the main production building will be located. This building will have an area of about 2000 m^2. Depending on the price of the building, more or less roof will be built at a height of 11 meters. 11 meters is required for the overhead crane to be able to pass over the presses, which is necessary to be able to conduct service on the presses.

Inside the production building the four main machines are placed in a line with the coil feeder against the current building. The layout of equipments is shown in Figure 8.

With this layout the trucks will deliver coils and an overhead crane placed between the current and the new building will unload the trucks. This overhead crane will move the coils to a coil carrier that transports the coils into the production. In the production area an overhead crane moves the coils to the storage place of raw material. The same crane will deliver the coils to a machine on request. After the stamping procedure all details pass through a washing machine. Finished there, forklifts transport pallets with details either directly to the packaging machine or to the finish machine depending on whether the detail should be further refined or not.

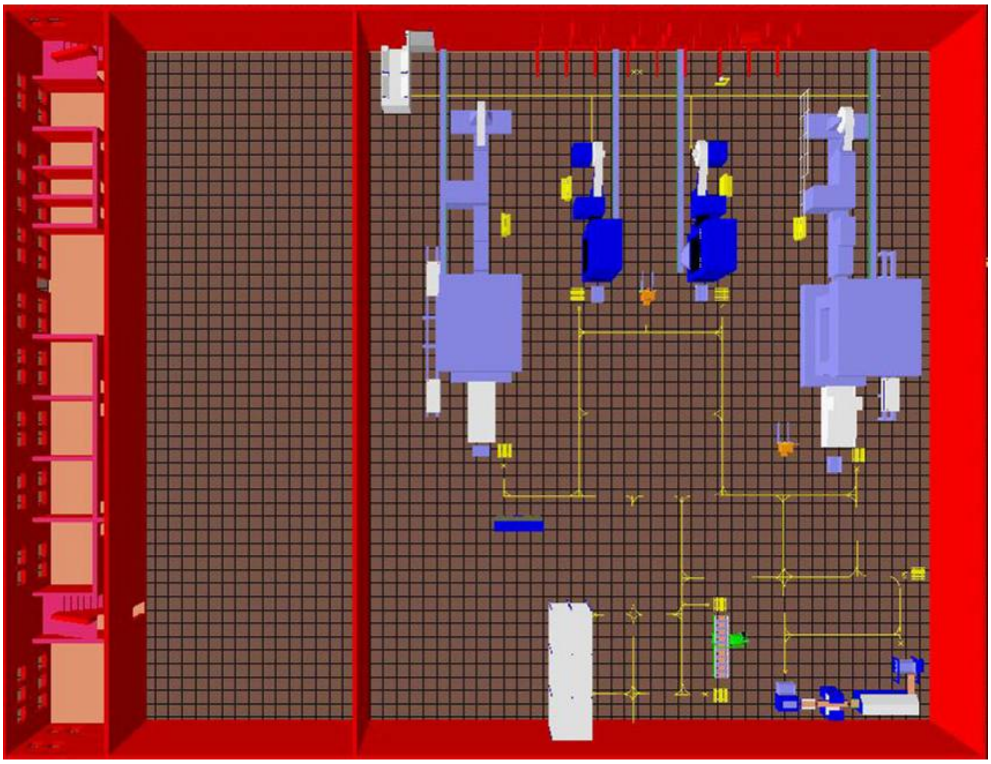

Figure 8: Top view of the new plant where the work shop is next to the office.

7.1.3 Model 2

Model 2 is almost the same as model 1. The office area is located at the same spot as in model 1 that is situated in line with the current office building. The office will still be barely 400 m^2 in one or two floors. The main difference is that the workshop is now placed in the north part of the building instead of being next to the office. The area is the same but is now thinner and broader. The production area is almost the same, but the shape is modified. Figure 9 illustrates the division and the layout of equipment.

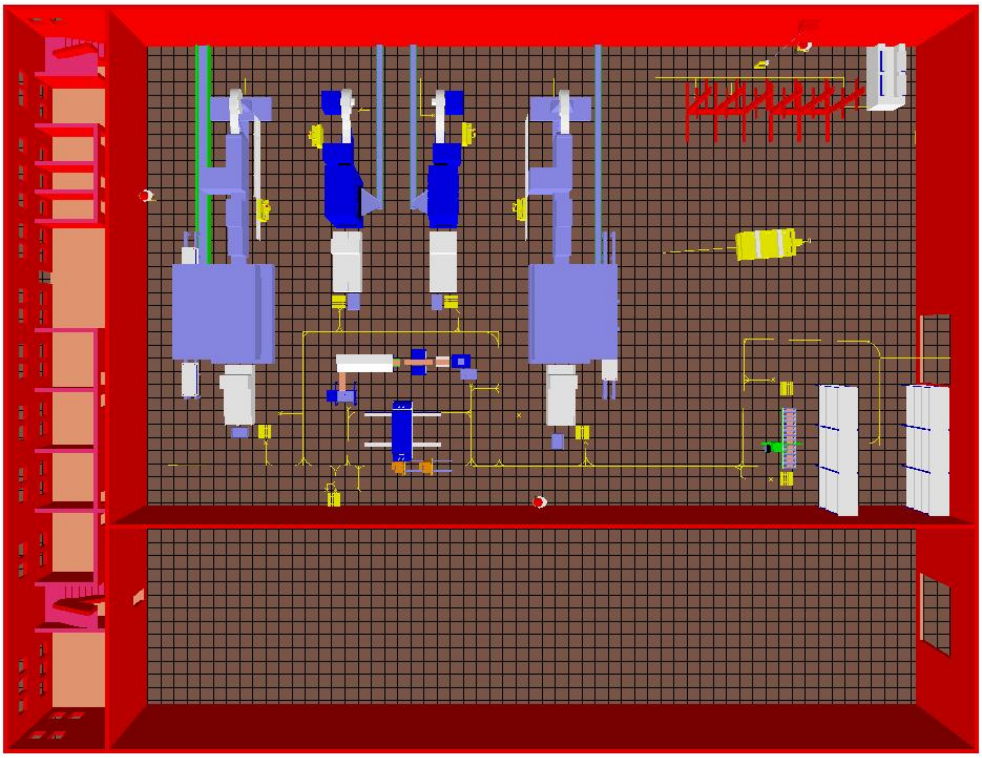

Figure 9: Top view of the new plant where the work shop is facing north.

7.2 Technical solutions

Problems concerning the material flow are how to get the raw material into the factory and how to get the scrap iron out of the building. These have been the main areas where we have investigated different solutions. Other areas that we have looked at are possible solutions for storing coils and changing the tool in the presses.

7.2.1 Coil delivery

The steel coil that is the raw material arrives by trucks and should be unloaded with an overhead crane due to its weight. Two different solutions for the transport of coils into the factory are presented below:

1. At a visit at Lindab we saw a solution that could be interesting also for Prestando AB. Lindab unloads their coils onto a special designed carrier that is depressed into the ground. The carrier transports the coils into the factory later to be unloaded with another overhead crane inside the factory.

   We have made contact with the company that delivered this carrier to Lindab, Br. Bengtsson Allmän Tekniska AB (BBAT), and made an inquiry about a system similar to the one at Lindab but adjusted

Figure 10: Solution of a coil carriage that Lindab use today.

for Prestando AB´s needs. A carrier with a max capacity of 15ton, enough for transporting a package of three coils, will cost 645.000 SEK, some extra expenses for installation and safety equipment will be added (BBAT offer).

2. A similar solution is to use a railroad with a specially designed wagon for transporting coils. In search for this kind of solution we came in contact with BS Mekaniska in Falköping. They can offer a solution with a capacity of 15 ton for 73.500 SEK installation and electrical equipment excluded. According to BS Mekaniska the electrical equipment needed would cost about 2.000 SEK (BS Mekaniska offer).

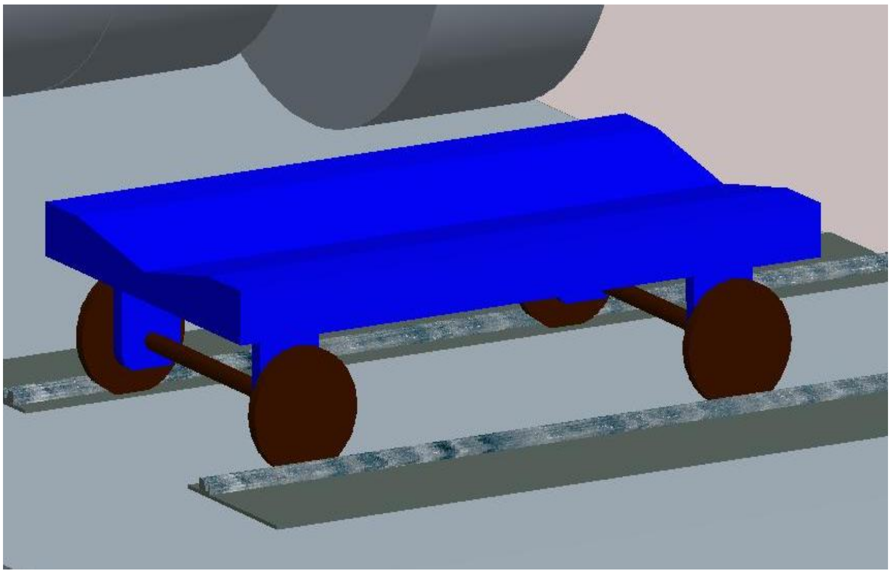

Figure 11: A coil carriage designed to carry a maximum load of 15 tons.

7.2.2 Scrap iron removal

At Press99, the pressline most alike the ones to be installed in the expanded area, the scrap iron is transported out by convoyer belts to large containers outside of the factory. This is a solution that is appreciated at Prestando AB. A problem is although the belts being used. At Press99 those are made by plastic and are wearn down or simply teared apart by the sharp edges of the scrap iron with large repair costs as consequence, about 75.000 SEK a year (Interview employess at Prestando AB).

At a visit at Euroblech in Hanover, Germany which is the largest fair regarding the steel business we contacted several company that develop and manufacture conveyors with hinged steel belts as seen in Figure 12 below.

These conveyors are more expensive to purchase in comparison with the plastic belts that are used today, but the repair cost and repair time will be reduced.

Figure 12: Hinged steel belt to conveyors.

It is of great importance that the production is not disturbed by the removal of the scrap iron. When a container outside is filled up it should be possible to route the scrap to another container without putting a stop to the production. For this we have two solutions represented by the offer from Mayfran and Tryfab.

From both companies we have inquired one 23 meters horizontal hinged belt conveyor to get the scrap from the machines and out of the building. Outside the scrap should be evenly distributed in the first container and then routed to another container.

1. One possibility is to have a turning chute, turnable by hand at the end of the conveyor as shown in Figure 13. The conveyor belt is here 762 mm wide and the frame width and height is 912 mm respectively 520 mm. The total cost of this system is euro 45.540, which equals 414.000 SEK. (Mayfran offer, Exchange rate 9.1 SEK, 2005-03-15, www.svt.se)

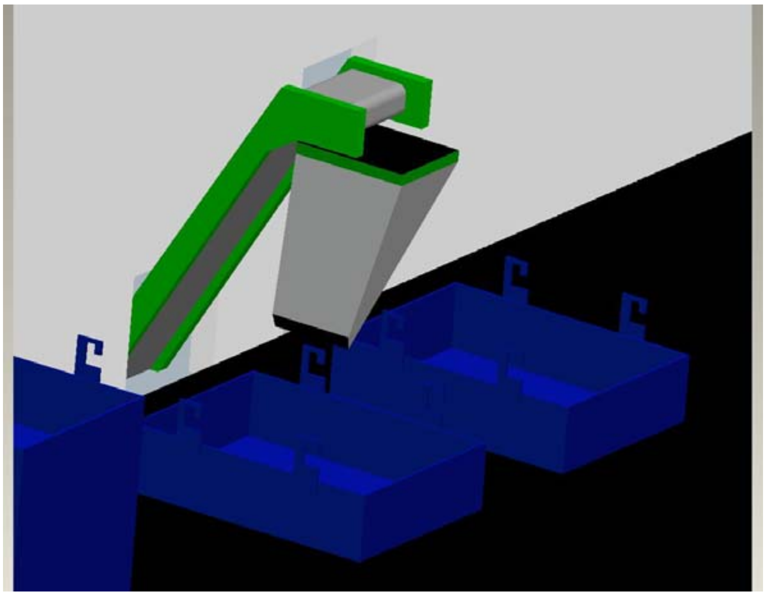

Figure 13: Turnable chute as equipment for scrap iron handling.

2. Another possibility is to have a transverse conveyor outside that distribute the scrap in the two containers as seen in Figure 14. The widths of these conveyors are 725 mm and the length is 23 m and 2,7 m respectively. A stand that moves the smaller conveyor is also included in the offer from company Tryfab that sums up to euro 45.755, about 416.000 SEK. (Tryfab offer, Exchange rate 9.1 SEK, 2005-03-15, www.svt.se).

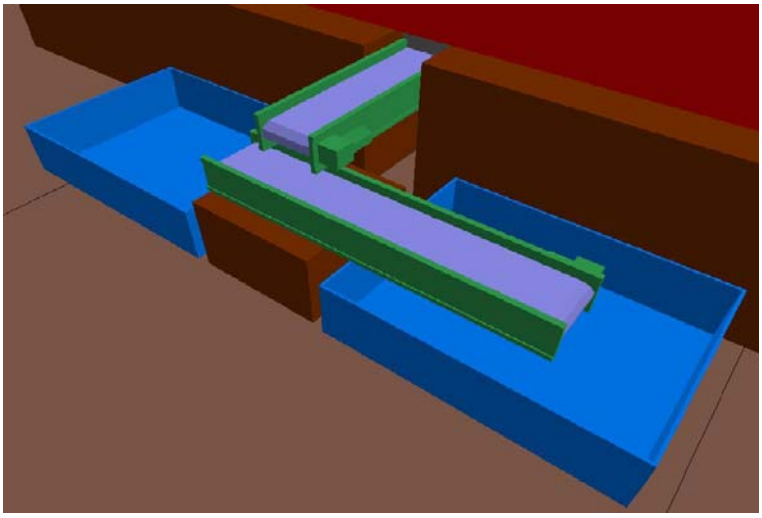

Figure 14: A technical solution to divide the crap iron into two containers.

3. A completely different solution is to have the containers, instead of the scrap iron on the conveyer. The system we designed allowed for one container to be evenly filled directly under the press and then sent outside and an empty container would arrive simultaneously without disturbing the production. This system would allow the operators to have better control over the filling process since it is conducted directly by the press and not outside of the building.

   This solution is however a great deal more expensive than the other solutions. The offer from the American company Automated Solutions Inc. summed up to \$481.801, about 3.400.000 SEK, installation excluded (Automated solutions offer, Exchange rate 6.98, 2005-02-16, www.svt.se).

7.2.3 Coil storage system

Today coils are stored on the ground in a tent, some outside of the tent and in some buffer inside by the press lines.

The total annual turnover at Prestando AB is today 11.000 tons of steel. And at any given moment there are about 500 coils in different sizes located on the premises. One of the larger coils (Ø1800 mm, width 600 mm, 4,5 ton) take up about 1 m^2 of ground space. The area that the coils absorb can be reduced by the use of different storage system. We have evaluated two systems for storing coils:

1. The company Ohra has a system where coils are hung on arms that can support a maximum load of 15 tons, see Figure 15. The arm length is restricted to 1000 mm implying, at Prestando AB with coil width of up to 600 mm and a weight of almost 5 tons it is possible to store 52 coils on an area of about 24 m^2. When storing with this system one coil will take up 0,45 m^2. The system from Ohra, including the stands and a c-hook to be used with an overhead crane cost euro 21.639, which corresponds to 197.000 SEK (Ohra offer, Exchange rate 9.1 SEK, 2005-03-15, www.svt.se).

Figure 15: A storage solution from Ohra that could be useful to Prestando AB

2. For a fully automated storage system the company Vollert has a complete system containing an overhead crane that can handle both coils and pallets so that both large coils and those stored on pallets can be handled.

   The system we have inquired has room for 418 coils, from which 56 are stored on pallets. The area that this system will occupy is about 350 m^2, this equals 0,83 m^2 per coil with all the passages included. If we only consider the coils not stored on pallets and only measure the area of the actual stands to get a comparison with the Ohra system the 362 coils take up an area of 100 m^2 – 0,28 m^2 per coil.

   The overhead crane with a maximum capacity of 5000 kg, complete with 2 x 60 m running path, costs euro 395.500 – 3.600.000 SEK and the rack system delivered and installed euro 315.000 – 2.867.000 SEK. It all sums up to 6.467.000 SEK (Vollert offer, Exchange rate 9.1 SEK, 2005-03-15, www.svt.se).

7.2.4 Tool changing process

The tools that are used in the larger press lines weigh up to 10 tons and therefore require special equipment for the change process. The tool changing process is today conducted with a special constructed carriage that is driven by electricity and compressed air. One carriage is used to remove the previously used tool and another carriage that has been prepared with the tool to be used in the next batch is used to load the new tool.

Figure 16: Carriage for loading press tools.

7.2.5 Tool loading beam

An alternative way to load and unload the tools is to use tool loading beams. With this system the special carriage won’t be necessary. The change can be conducted with the overhead crane instead. When preparing for a tool change the tool to be used will be placed on the tool loading beams to save time at the change and to create a visual buffer so that the operator is assured that the tool is in complete order and ready for production. When the tool needs reparation in the middle of a run the lower part of the tool can be pulled out to simplify and also shorten the repair process.

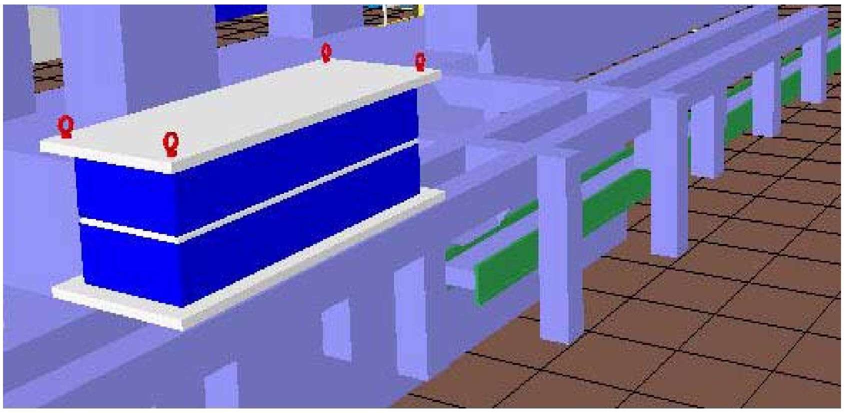

Figure 17: Loading beams used for tool loading.

7.3 Simulation technical problems

During this project, especially in the initial phase, we have encountered some problem using the simulation software Quest. These problems were sorted out with the help of the computer technical team at LTH, the support at Delfoi, distributor of Quest in Sweden and extensive use of the trial and error method. Some of these problems are presented below.

7.3.1 Saving computer power

One problem we encountered was the fact that the model produced large magnitudes of parts, parts that the computer needs to recalculate at every moment. This obviously causes the computer to slow down and became hard to work with. To get passed this problem we constructed the out buffer after the washing machine as a machine instead of a buffer. This machine was then programmed to take for instance 200 flanges and turn them into one full pallet, reducing the number of parts by 199, saving computer power when the full pallet is stored waiting to be processed or delivered. If the flanges is to be processed the machine downstream will need to "unwrap" the pallet and deliver 200 flanges. The process of compressing and decompressing the flanges is similar and conducted editing the process logic of the machines in question.

7.3.2 Mixing push and pull connections

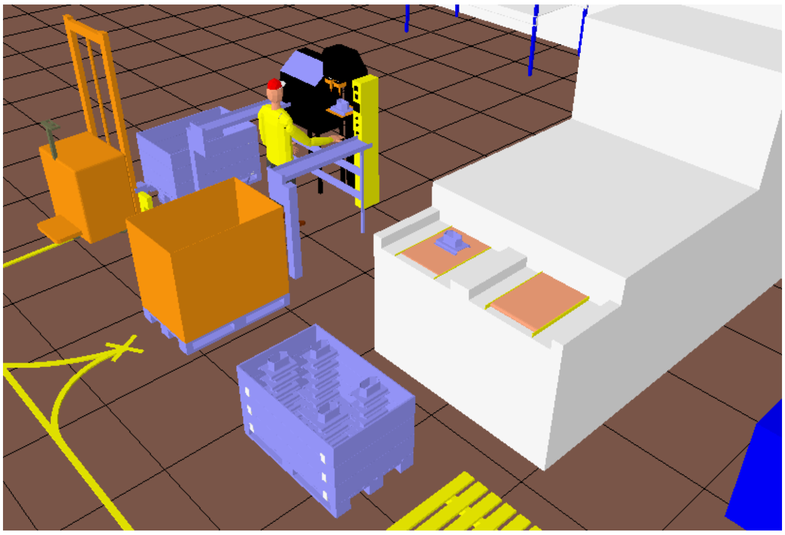

Figure 18: Animation of how push and pull connection is used in the reality. This picture is a demonstration of a situation in the current plant.

In default mode all elements have push logic. If pull behavior is desirable it is necessary to redefine the logic in the elements. This is done by adjusting the default code that governs the different processes associated with the element in question. It is necessary to get the different processes to communicate with each other. An example of an element with a pull input and a push output connection is the welding machine (see Figure 17) where the in buffer pushes parts to the weld. When the part count in the in buffer reaches zero the request logic should respond by ordering a full pallet from the storage area upstream and the forklift will collect a pallet that complies with the request and restart the counting process.

8
Analysis of the production flow

Comparisons between the solutions are made in this chapter. We will also present the advantages and disadvantages of the tests.

8.1 Output

Most information can be read directly from Quest's output statistic. Quest delivers almost all kind of output. Each machine has an output menu where data is available. As an example we can find average time, utilization, downtimes, queuing times etc. If more specific data is required, there is the possibility to program your own output files to present cost, weights and so on.

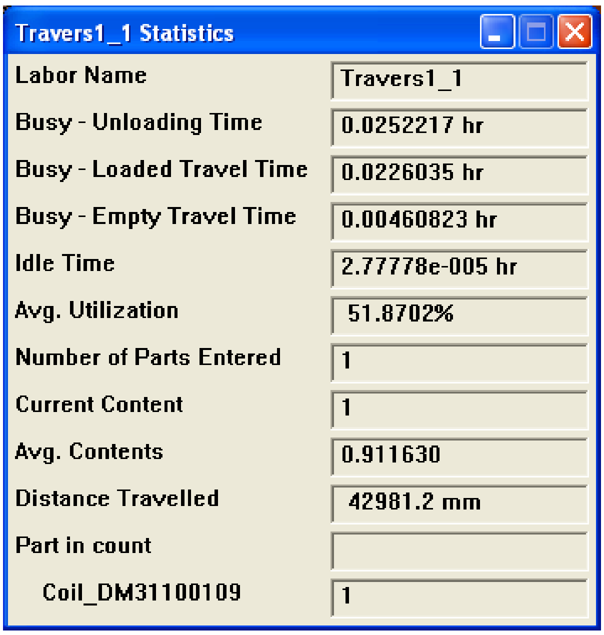

Figure 19: Shows a typical Quest output statistic window.

When performing the different simulation tests it is important to choose a simulation time and a warm up time that are long enough to avoid large deviations caused by the stochastic distributions in the model. In all of our runs presented below the simulation time is set to 21 days with 24 hours warm up time to avoid the deviations caused by the initial state of the different elements.

8.2 What if another two machines are installed?

The installation of two additional machines will of course increase the output and eventually cause problems downstream. This is however analysed in section 8.4. In this test we are more interested in the increase of raw material handling e.g. will the overhead crane used for the loading of the coils be able to serve four machines as well as two machines?

To investigate this we will look at the waiting time at the load station at the start of each press line. This is the time that elapse from the moment one coil is used up till a new coil is being loaded to the line.

The results in Table 2 below show the impact of the two additional machines. The waiting time is increased with about 12 % but this does not affect the output of the two machines in any considerable extent. One also has to remember that the total output, from all four machines, will be doubled.

	Two machines		**Four machines**		**Deviation**	
	2000	**800**	**2000**	**800**	**2000**	**800**
Parts created	53350	150057	54059	149812	1,3%	-0,2%
Wait time (min)	**5,32**	**4,37**	**6,04**	**5,01**	**11,9%**	**12,8%**
Repair time (h)	146,6	139,0	141,7	138,8	-3,5%	-0,1%
Shift break (h)	45	45	45	45	0,0%	0,0%
Avg util	60%	52,07%	61%	52%	1,5%	-0,2%
Jobs/h	444	1250	450	1248	1,3%	-0,2%

Table 2: Consequences of waiting times when adding another two machines.

8.3 What if the maximal repair time can be shortened?

One way to increase the output from the system can be to rationalize the repair process by the use of better equipment, improving the design of the repair site and to be better prepared ahead of break down.

To investigate the effect of this kind of improvement the maximum repair time will be shortened from 2,5 hours to 1,5 hours.

As the result in Table 3 show the output can be increased by about 10% with a reduction of the maximal repair time with one hour. To make every repair within 1,5 hours may be a bit optimistic but could be a goal in the production where every downtime over 1,5 hours are evaluated and followed up to reduce the repair time.

	Max 2,5h		Max 1,5h		Deviation	
	2000	**800**	**2000**	**800**	**2000**	**800**
Parts created	107454	298265	121122	329586	11,3%	9,5%
Wait time (min)	5,33	4,35	5,52	4,42	3,4%	1,6%
Repair time (h)	**145,4**	**141,0**	**100,0**	**105,1**	**-45,4%**	**-34,2%**
Shift break (h)	45	45	45	45	0,0%	0,0%
Avg util	60,9%	51,8%	68,7%	57,2%	11,3%	9,5%
Jobs/h	223	626	252	686	11,3%	8,7%

Table 3: Result of reducing the maximal repair time from 2,5 h to 1,5 h.

8.4 What if the batch size is increased with 20 %?

Increasing the batch sizes can be a way to increase the output, since the number of tool changes will be reduced. In this test we will increase the batch sizes with 20 % and see how it affects the output.

As can be seen in Table 4 a 20 % increase of the batch sizes do not affect the output in a considerable way. This can partly be explained by the relatively short simulation time of 20 days but the main reason is that a tool change does not affect the total downtime. Although the number of tool changes has been decreased by circa 30 % this have a very limited affect on total repair time, which represents both the repair of failures as well as the tool changes. Therefore the output is relatively unchanged.

			20% larger		Deviation	
	2000	**800**	**2000**	**800**	**2000**	**800**
Parts created	107454	298265	109392	297241	1,8%	-0,3%
Wait time (min)	5,33	4,37	5,56	4,60	4,1%	5,0%
Repair time (h)	**145,4**	**141,0**	**139,6**	**141,2**	**-4,2%**	**0,2%**
Shift break (h)	45	45	45	45	0,0%	0,0%
Avg util	60,9%	51,8%	62,0%	51,6%	1,8%	-0,3%
Jobs/h	447	1243	455	1238	1,8%	-0,4%
Failures	**152**	**130**	**151**	**134**	**-0,7%**	**3,0%**
Tool changes	**4**	**22**	**3**	**17**	**-33,3%**	**-29,4%**

Table 4: Result of increase the batch size with 20 %.

8.5 What if 50% of the details needs further processing?

Another test of the flexibility is running two machines where each produces 50 % that will go to further refining. The result based on 20 days production with 3 shifts, shows that the refining machine with a cycle time of 9 seconds will be a bottleneck. The maximum buffer size in this run reached 108 pallets and the average size about 55 pallets, where each pallet includes 300 flanges. A run of 20 days is not long enough to decide if the buffer size is correctly estimated, but it provides a rough estimate of the average buffer size and in what directions the buffer size tends to be.

A solution to avoid the bottleneck is to have a faster refining machine, but the question is how much faster. The second test we did was to reduce the cycle time with 20 % to 7 seconds. As Table 2 shows the average buffer size decreases to 0.7 pallets, which corresponds to a reduction with 98 %. This indicates that a refining machine with 7 seconds cycle time will be able to serve two machines without causing any larger bottlenecks.

Next question is what will happen if all four machines are producing details where 50 % go to further refining. It is easy to realize that a cycle time with 9 seconds is not possible. As in Table 2, 7 seconds is not enough either. Investments in a machine with 5 seconds will result in that the buffer size is decreased but will still not be enough. A time around 3.5 seconds is sufficient for avoiding bottlenecks, but reducing it that much is probably impossible and if it is possible it will be very expensive. It is probably better from a financial perspective to invest in two machines instead of one. This argumentation is based on that 50 % of the details will go to further refining. Since we don't know what will be produced in the new plant it may just be

25 % or less that will be further refined and then it is enough with one machine with a cycle time of 7 seconds. This test is very speculative but is shows the strength in using a simulation software when planning further production processes.

Buffer size (Pallets)					
	2 Machines		4 Machines		
Cycle time bear.	**9**	**7**	**9**	**7**	**5**
Sim. Time	504	504	504	504	504
Max	108	4	-	94	20
Avg.	55	0,7	-	29,4	6,2
Cur.	108	2	-	86	13

Table 5: Illustrate the level in the buffer, placed before the refining machine, with different cycle time in the refining machine.

8.6 Logistical problems

Figure 19 shows an overview of Prestando AB. The picture shows both the current production plant and the new possible plant. Our discussion is based upon this layout.

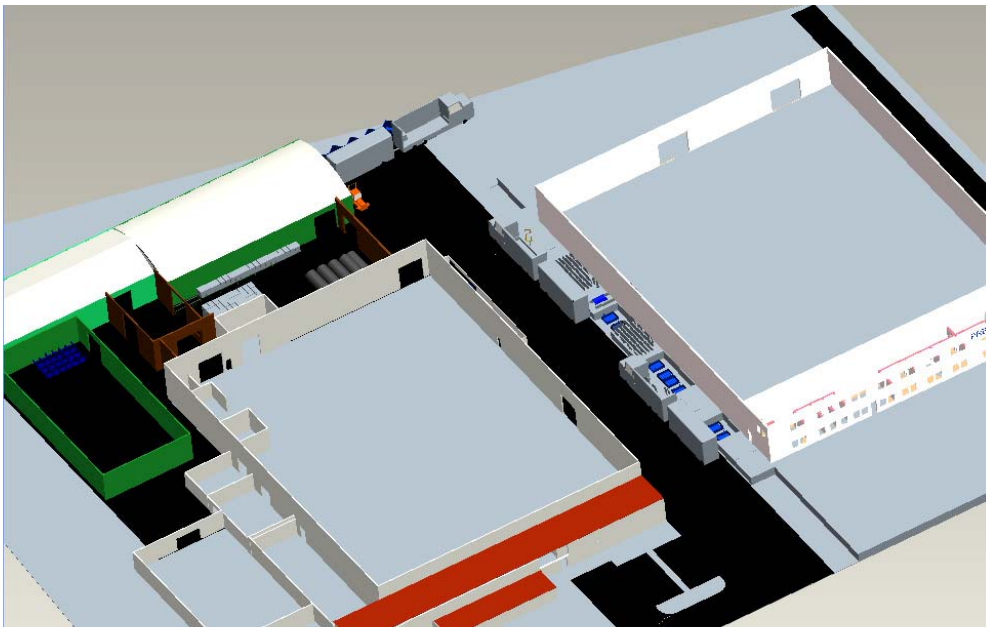

Figure 20: An illustration of the total plant after an expansion.

Unloading area
The idea is to organize the logistic in a way that the material mostly goes in one direction to avoid collisions and unnecessary transportations. The thought is that trucks will arrive to the gate between the buildings and then be unloaded in the unloading area shown in Figure 20.

As mentioned above an expansion of the production will result in an increased material flow. With about 50 % more material the number of incoming trucks will also increase. Today about 10 trucks arrive per day where 6 of them are larger trucks and the other are smaller trucks. The unloading of incoming coils takes from half an hour to one and half hour depending on the material and how the distributor has loaded the trucks.

We suggest that the majority of the incoming coils should be unloaded with an overhead crane. This will reduce the unloading time considerable. The safety will also be improved with an overhead crane, since the risk of a coil dropping will be reduced. Another positive issue is that the employees will have a more comfortable working environment as e.g. less bad working positions and less pollution.

Next to the unloading area we have placed a dock which we will use as a smaller storage place and it can also be used as a loading dock for goods from the new plant. This system will decrease the number of transports in the passage outside.

Loading area
The area to load trucks is located in the left part of the Figure 20 and at the end of the dock. The parts that are produced in the new building will be loaded and shipped from the end of the dock. The advantage with the use of dock to load the truck is that we can use the smaller electric forklift and the traffic in the passage is minimized. Using the electric forklift also makes the loading faster and easier for the employees. A disadvantage of this is that the dock has to be of the same height as the truck. But a solution of this is to use some kind of movable plate that allows the truck to drive insid the trucks.

Another loading area is located beside the tent. The thought of this is that the truck will park as in the Figure 20 since it makes it easier for the forklift to turn around and more importantly it will free up space to allow other trucks to pass by and avoid traffic jam.

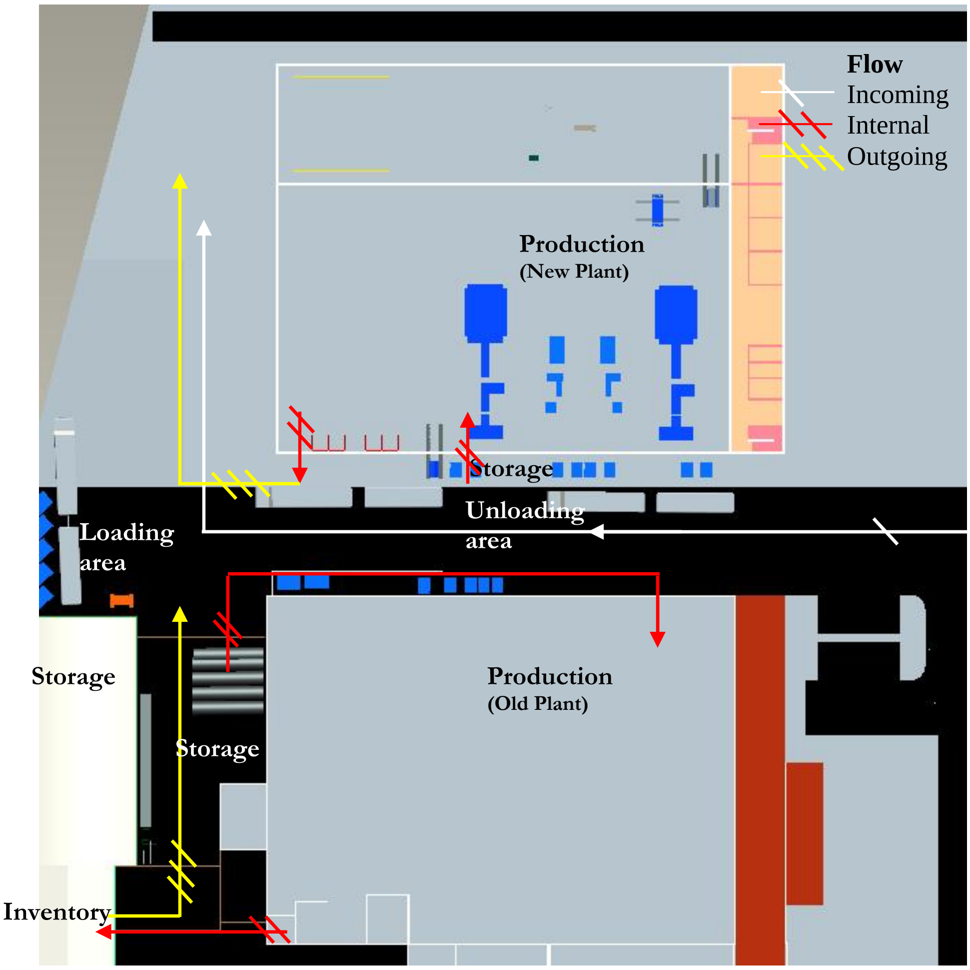

Figure 21: Describe the material flow after an expansion.

The flow after the expansion will be more straight ahead than before. The colour of the lines still have the same meaning, which means that white line describe the arriving flow and the red is the internal flow and finally the yellow that express the outgoing flow.

As mentioned in the two parts above, unloading and loading parts, our intention is to have a straight flow though the plant. Figure 21 shows an internal flow with start in the storage place with direction against the main direction to the old production plant. The flow in this direction are decreased compared to the current situation, this because a lot of material will come from the storage place at the dock and less from the old raw material storage. But a part of all coils are relatively thin and will still be stored in the tent and therefore will this flow still be in this direction. Since the old plant still will produce like today it is almost impossible to avoid some crossing traffic.

9
Conclusions

This final chapter sums up the project in terms of what we recommend Prestando AB to do to expand the organisation with a new manufacturing plant.

We can realize that today the production capacity is a bottleneck at Prestando AB and an expansion would be preferable. According to us model 2, described in chapter 7, is the best alternative. Although there are no differences in the output, model 2 have other issues that make it a winning concept. Model 2 has advantages especially if the building should be built in several steps. This model is a lot more flexible in this case. It also has advantages if it is necessary in the future to expand even more than the four machines we have considered in this report. This solution can handle five or maybe six machines which model 1 can not. Another advantage of this model is the production flow pattern. Both models use the dock to unload arriving trucks but in model 2 the dock can also be used when loading outgoing trucks.

We have presented a number of technical solutions to improve and simplify the material handling at Prestando AB. To import the raw material into the new plant we suggest that Prestando AB invest in the coil carrier provided by BS Mekaniska. This kind carrier can also be used to transport the heavy tools between the production department and the tool workshop for service and maintenance work.

To remove the scrap iron from the production lines we will recommend hinged steel belt instead of the plastic belts that are used today. Which solution, from Tryfab or Mayfran is a matter of taste. The great advantage using steel hinged belts is that it will reduce the repair cost and repair time.

We will also advice Prestando AB to replace the conveyer system used at Press99 today with this type of solution. Besides the reasons presented above this will also make a lot of space available outside that will lead to better logistical conditions outside the building.

To further improve the logistical situation outside we suggest that the coils are unloaded with an overhead crane and stored on the dock outside the new plant. This will reduce the traffic considerably.

Initially there will be plenty of space inside the new plant and the coils can be stored directly on the floor. As more machines are installed less floor space will be available to store gods. To store the coils in a more efficient way the solution with a racket system from Ohra is recommended.

We will also like to recommend, based on our simulation analysis, that Prestando AB try to focus more to improve the repair process and to make it more efficient, since this would affect the output considerably.

Finally we hope this report will be helpful to Prestando AB in their future work with this possible expansion

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References

Banks, J. 2004. *Getting started with AutoMod*, Second Edition May 2004

Dudás, C. 2003, Flödessimulering av Produktion, Master Thesis 2003, KTH (Oakshott, L. Business Modelling and Simulation)

Olsson, G. Rosen, C. 2005, *Industrial Automation*, Department of Industrial Electrical Engineering and Automation, Lund University.

Solding,P. 2001 Diskret händelsestyrd simulering av produktion av vindkrafttorn hos Enercon Windtower Production AB, Master Thesis 2001, Department of Robotics, LTH.

Quest 1995. Deneb Robotics Inc, Digital Manufacturing, User Manual Quest V5, 1995

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Vollert, No. AN1993_01, Oliver Wolschinski, Stadtseestrasse 12 74 189 Weinsberg Germany, 041217

Inside information:
Product catalogue, Prestando AB, 2004

Productivity sheets, Prestando AB, 2004

Internet
www.abus-kransystem.se

www.svt.se/texttv/index.html, Exchange rate, 050316

Other sources (Visits, interviews)
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