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THE USE OF SIMULATION FOR PROCESS IMPROVEMENT IN METAL INDUSTRY – CASE HT-LASERTEKNIIKKA

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ABSTRACT

Companies in the metal industry want to find solutions for increasing the quality of service and productivity of the operation, but it is not an easy task to do, especially if the company is large (has several different production units) and in addition uses many different metal types as material. This paper examines the centralization of special metal production into a single unit instead of several units. The research method is simulation and the main concentration is on finding out the effects and the possible benefits of the centralization scenario. Two different simulation models are constructed for the study. The results of the simulation runs showed that the centralization would increase the utilization of a selected unit only 3,12 % which means that it could be easily carried out. The results also indicated that the centralization scheme could improve the operation significantly (elimination of operational and logistics phases).

1 INTRODUCTION

At the moment the need to improve the operation is in the spotlight in the metal industry. Companies want to increase the quality of service as well as maximize the productivity, but it is not an easy task to find a way to make the process more efficient without appropriate and effective tools. This kind of a tool is simulation which can provide information on the effects of different solution proposals beforehand, without implementation. There are lot of studies where simulation has been used to examine metal cutting processes, but they are mostly concentrated on cutting or casting processes instead of examining the operation of the whole production line. There are, however, few publications where the productivity issues and the whole production line have been under examination. Mamalis et al. (1990), for example, used simulation to study the effect of the batch size and the carrying capacity of the pallets on the utilization of the machine tool and the throughput times of the orders. Taplin et al. (2004) on their behalf focused on monitoring the amount of scrap, dross and carbon dioxide emissions from both energy consumption and transportation, productivity and costs during the metal material cycle. These studies are, however, mainly examining the operation of a single production unit.

In this study the approach is just a little bit wider. The focus is on the operation of a large metal cutting company which consists of several different production units (factories). The company under examination is a Finnish company called HT Lasertekniikka. It is specialized in laser and water jet cutting and has nine factories around the country which all operate as individual units, serving the clients in a certain area of Finland. Although each factory posses enough capacity and resources to serve all the clients in the area, the operation is not necessarily as effective as it could be, especially when it comes to material handling and organizing the production from the whole company's point of view.

At the moment all the units are mostly responsible for their own material handling and production. Most of the material used in these units is regular metal but in some cases there is a demand for special metals as well. The demand for special metals is not as vast as it is for regular metals but there are still variable amounts of orders in each unit every year which require special metals. Special metals are quite expensive compared to regular metals and they are usually purchased based on the demand. Sometimes the raw material has to be transported from one unit to another, in case there is not enough metal available in the storage. The main goal of this study is to find out if it's useful and cost-effective for each unit to handle their own special metal orders individually or would it be more convenient to centralize the special metal production into a single production unit.

In this article the possibilities and benefits of centralization is examined. The examination is divided into two parts. First the effects of centralization is studied. The main objective of this phase is to find out how much the centralization would increase the utilization of the selected production unit and whether or not it's possible, in general, to centralize the production into a single unit. The second phase of the article concentrates on finding out if this kind of an approach could really improve the operation from the whole company's point of view and if so, in what scale.

2 THE METAL CUTTING PROCESS

The metal sheets cutting process consisted of four different phases. These phases were the following:

1. Programming
2. Placement of the metal sheet
3. Cutting
4. Transportation of the finalized product to storage

The process starts with programming. Every order is individual and the cutting machine has to be programmed in order to cut the shapes required and wanted. After the programming phase the metal sheet is fetched from the storage and placed on the machine. When the metal sheet is properly placed, the cutting process can be started. The last phase of the process is transportation of the finalized product and of course the waste material. The whole production process is presented in Figure 1.

3 EXAMINATION OF THE EFFECTS OF CENTRALIZATION BY USING SIMULATION

Simulation was a natural choice for a research method due to its capability of giving numerical information on the operation and showing the effects of alternative scenarios without implementing them first. In this case the main focus was on the centralization of special metal production and five of the most common special metals were taken under closer examination. In the model construction the production of all nine factories were combined. At this point any specific existing factory was not chosen as the main location for the centralized special metal production. The main assumption was that there was no other production in the factory yet, in other words.This kind of an approach made it possible to examine the utilization rates at different phases of the process caused by the centralized production.

The main idea was to find out how much the centralization of the production of all five selected special metals would increase the utilization rates in the factory. This was meant to ease the selection of an appropriate factory for the centralization.

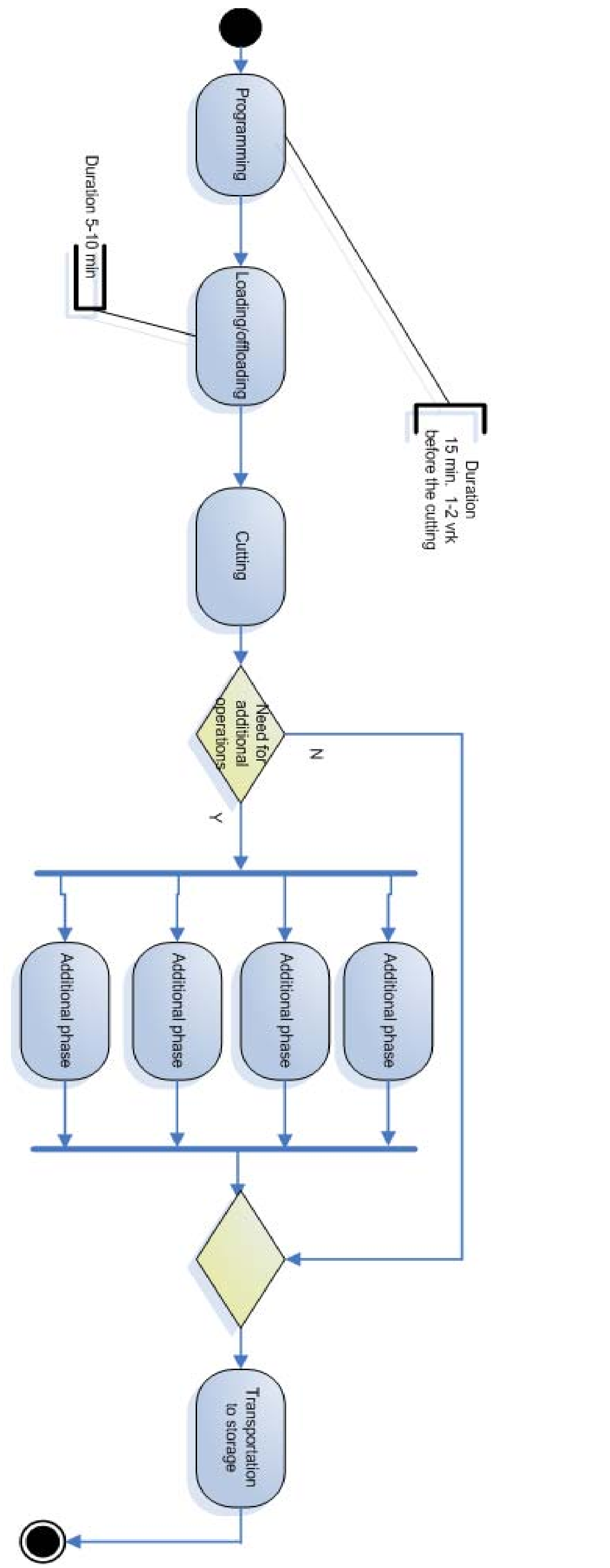

Figure 1: The metal handling process of the production units

3.1 Structural Definitions of the Simulation Model

The model was developed using the simulation software Service Model <see http://www.promodel.com>. The model development was started by doing the structural definitions. Structural definitions consisted of four different phases starting with the location definitions. All the operational areas were defined in the model using the graphical elements of the Service Model software. After the creation of the operational areas, the paths for the entities in the model were created. The path network included all the possible paths which the metal sheets and resources could use when moving from one point to another in the factory. The process of metal sheet cutting was very straight forwarded which made these definitions quite simple. There were no branches in the process but only a one possible route where to move the metal sheets from the previous phase in the model.

Besides operational areas and path network definitions, structural definitions included also a definition of entities which in this case meant five different types of metals (special metals). These five different metals included in the model are presented in Figure 2.

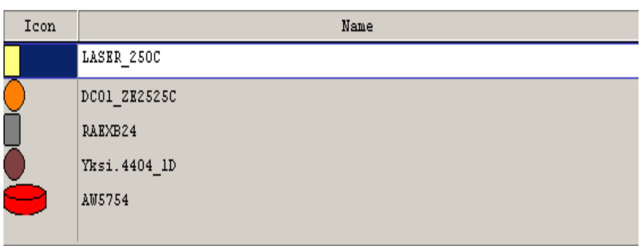

Figure 2: Entities of the developed simulation model

Usually when developing a simulation model there is also a need for resource definition. However, in this case it was not necessary. The process was very straight forward and there was only one person taking care of the operation in each phase all the time, which made separate resource definitions unnecessary.

3.2 Operational Definitions of the Simulation Model

After the structural definitions, it was time to define the model logic and behavior, in other words do the operational definitions. The operational definition was started by defining the production days in the model. The time period under examination was 1/1/2006-1/12/2007. All the production dates defined in the model within that time period were based on the real values gathered from the real data. In order to make the production dates add up between the real data and the simulation model, the calendar feature of the simulation software was used. The production dates acted as arrival definitions, in other words defined the time when a certain metal sheet were created in the model. Together with metal sheet creation definition, the quality definitions for the metal sheets were made as well. Basically this meant the size of the metal (weight).

In order to make the model fully functional, operation times for each phase of the process had to be defined as well. Without proper time definitions it would have been impossible to calculate utilization rates. The time definitions were the following:

- Programming: estimated value 15 minutes
- Placement of the metal sheet: 5-10 minutes. Because every value between the minimum and maximum values were equally possible, the uniform distribution U(7.5,2.5) were used.
- Cutting: the duration of the operation was depended on the maximum cutting speed of the cutting machine. The estimation for the maximum cutting capability was 6000 kg/24 h, 250 kg/h. It meant that the size of the metal sheet defined the exact operation time in this phase of the process.
- Transport of the finalized product was not relevant in this case so any definitions concerning the transportation was not made.

Last operational definitions which had to be made before the model was ready for use and fully functional were the attribute definitions. Because the model was quite simple and the process straight forwarded, there was a need only for two different attributes definition. These attributes were the weight and operation time (based on the weight and estimated cutting speed).

3.3 Simulation Run and Results

Before the actual simulation runs the following parameter definitions were made.

- Simulation time: 1/1/2006-1/12/2007
- Operation time of the factory 24 h/day, except on weekends when all the factories were closed
- Number of replications: 10

Knowing that the cutting speed/capability was 6000 kg/h and the total amount of metal was 97 601 kg, the amount of 24 h production days were approximately 16. The results of the simulation run showed that it would cause 3,12 % utilization rate for the selected factory, if the production of all special metals under examination would be centralized into a single unit. The most of the utilization is caused by the cutting phase but also loading and offloading the material has a small effect on the utilization.

Mostly the production happened in quite small batches, except for few larger orders. Because of this the utilization during the whole time period was quite small. Only few orders in the beginning of the year 2007 caused a temporary peak. This meant, however, that it is possible to centralize the production as long as the current utilization of the selected unit is under 96,88 %.

4 EXAMINATION OF THE BENEFITS OF CENTRALIZATION

The benefits of the centralization was examined by analyzing the effects of combining orders from different units into one single order. The key idea was that one order rarely uses all the material which is fed into the cutting machine. Every single handled order includes different phases such as programming, material loading and offloading as well as logistics operations, no matter how small the order is. Although the company needs to match often tight supply schedules to the customer, it is possible to keep the "window" open for new orders which require the same material than the first order of the window and run the combined orders together to minimize the costs, for example material handling causes.

4.1 The Construction of the Simulation Model

Simulation model for the examination was built by using Microsoft Excel and Visual Basic scripting languages. The decision variable was the order window.
Key points and rules of the model were the following:

- All orders requiring special metals were concentrated into one simulated production facility
- The daily production capacity was set to 5000 kilograms
- Order window was a changing variable (measured in days, values 4-14)
  - If order window expired or the next order was too large, the combined order was forwarded to the production facility and a new order window was opened
  - Otherwise orders were kept and finished as they originally were

Unfortunately the exact measures (height, width) of each order were not available so we assumed that every order could be combined with each other as long as the summed weight is lower than the daily production capacity, 5000 kilograms. We discovered that given special metal types were not used too extensively - only orders requiring LASER 250C type of metal were large enough to end previous window and force to open a new one.

Also the order information included only the special metal orders so we could not calculate if the production capacity was available or not. Here we assume that all needed production capacity is available.

4.2 The Results of the Simulation Run

The key finding was that the longer an order window is open the larger the average order is. In the case of rarely used metal types such as Raex B24 the number of orders were too small or too dispersed to benefit the operation remarkably from even 14 days long order window, but in the case of the most often used metal types like 1.4404 1D and AW 5774 the improvement was substantial.

For example the number of orders was reduced 30-40 percent and the average order weight increased 55-60 percent while the order window was extended from 4 to 10 days.

Tables 1-5 show how the length of the order window affects to the number of runs and average order weight when using five different metal types during the time data was gathered.

Table 1: Metal 1.4404 1D

1.4404 1D — Number of original orders: 88

The length of the order window	4	6	8	10	12	14
Average order weight	92	104	129	147	165	194
Number of runs	71	63	51	45	40	34

Table 2: Metal AW5754

AW5754 — Number of original orders: 115

The length of the order window	4	6	8	10	12	14
Average order weight	68	81	91	107	123	146
Number of runs	94	79	70	60	52	44

Table 3: Metal LASER 250C

LASER 250C — Number of original orders: 51

The length of the order window	4	6	8	10	12	14
Average order weight	1671	1826	1916	1963	2123	2123
Number of runs	47	43	41	40	37	37

Table 4: Metal DC01 + ZE 25/25 C

DC01 + ZE 25/25 C — Number of original orders: 25

The length of the order window	4	6	8	10	12	14
Average order weight	99	103	108	108	118	125
Number of runs	24	23	22	22	22	19

Table 5: Metal Raex B24

Raex B24 — Number of original orders: 12

The length of the order window	4	6	8	10	12	14
Average order weight	313	313	313	313	313	313
Number of runs	12	12	12	12	12	12

5 DISCUSSION AND FUTURE WORK

The main goal of this study was to find out what would be the effects of the centralization of the production of special metals into a single factory instead of nine and would it really benefit the whole company. In order to find answers to both of these questions, two different simulation models were constructed. First simulation examination concentrated on studying whether it would be possible to centralize the production or not and what would be the effects of the centralization for the selected production unit. The results of this simulation run showed that the production of specials metals can be centralized into a single factory as long as the utilization rate (production of other metals) of the selected production unit is currently lower than 96,88 %.

When the first simulation concentrated on finding out how much the centralization would increase the utilization of the selected unit, the second simulation focused on examining the benefits of the centralization for the company. This was done by examining the orders and the production days of different units. The main idea was to find out if combining orders from different units into one single order were useful and more efficient. The results of the simple simulation showed that extending the order window from 4 to 10 days and combining all the orders within that window would improve the efficiency remarkably if the metal type is used often and typical single order is relatively small. When the number of the orders reduce 30-40 %, it means that a lot of extra phases is eliminated and the process improves remarkably. The less orders the less programming, material loading and offloading as well as logistics operations there are in the process. If part of the orders can be processed from a single metal sheet instead of using several different metal sheets as well, the efficiency would increase even more. In the ideal situation this kind of an improvement could shorten the delivery time for the customer, which means improvement in quality from the customers point of view as well.

Unfortunately, due to given data, it was not possible to calculate exact financial gains caused by the centralization. Although the detail level of the data was relatively low, it can be shown that centralizing the special metal orders into a one production facility is a reasonable idea.

Although we received good results and the centralization seems to improve the operation of the whole company, there is still a lot of future work to do before it can be said exactly how much the operation would improve and what unit should be selected as the production unit for all the special metals. In order to get the exact calculations of the effects of the centralization, the use of material and metal recycling have to be taken under closer examination in the future. This means optimization of the use of a single metal sheet before and after the cutting phase.

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