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Simulation of production setup changes in an SME

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Abstract

This case study demonstrates how a simple simulation model can help Small and Medium Size manufactures to identify current and future possible problem areas and assist management in taking the best possible decisions regarding future production strategies

Keywords: Key Performance Indicators; Production Setup; Simulation; Customer Order Decoupling Point; Postponement; Mass Customisation.

1. Introduction

This paper focuses on a case study in a global Danish SME producing advanced machinery with an increasing level of customization thus having a complex logistic and production setup. The demand is characterised by seasonal fluctuation which has lead the company to pursue a level strategy. A large inventory

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of finished products has therefore been built up over the last years, but the development toward increased customization has made it difficult to predict which products to store.

The goal of the present study is to find new ways of leveling the manufacturing and introducing mass customization techniques. Simulation was used to analyze the effect of moving the customer order decoupling point forward in terms of inventory level and resource consumption in the pre- and final assembly areas (as described by Hoekstra & Romme [1]. Discrete-event modeling and simulation is a popular tool in widely varying fields for identifying and answering questions about the effects of changes on processes [2].

2. Case Company description

The company produces large modular industrial machines consisting of standard units, standard equipment and special parts. The design is modular to achieve maximum individual customization while minimizing cost through creation of modular components that can be configured into a wide variety of end-products and services [3,4,5].

A typical machine consists of 6-7 modules of which 95 percent are based on standard components and units while 5 percent are customized. The production is thus a combination of batch and order production, both at the level of components, units and finished goods.

Under periods of stable demand the company would pursue a conventional postponement strategy as described by Hoek et al. [6] where generic modules are pushed and customized configurations and components are pulled which in Lample and Mintzberg's framework [7] can be described as standardized customization. However, there are significant variations in demand.

And when demand is low, generic machines are being configured and produced to stock according to the sales department’s estimation of future orders. The movement of the decoupling point presents a challenge as the product and the manufacturing system is designed for a specific level of assembly and once this level is surpassed a number of decisions are made which will define the capabilities and hence limit the number of potential customers.

The number of modules and variants has increased significantly during the last years which further complicate building machines for inventory. The company operates with 12,000 items divided equally between purchased and in-house manufactured. Standard delivery time is 6 weeks of which 2 weeks are for order specification and 4 weeks remain for assembly and test. If a high degree of customization is requested the delivery time is prolonged.

The company differentiates from competitors through leading edge technologies and a high degree of customization. The strategy is to be 1-2 years ahead of competitors, which again means that the products are in a high price range.

2.1. Production and assembly

Planning takes place at four levels involving varying planning horizons:

- 1 year horizon (S&O plan) based on forecasted sales per month
- 3 month horizon (unit plan) based on actual orders and the S&O plan
- 6 week horizon (standard and customized parts) based on actual orders
- 1 week horizon (detailed materials and capacity plan)

In addition, daily meetings are held where operation managers, head of planning and foremen discuss the current situation. The planning department launches approximately 500-600 orders per month of which 5% are rush orders. The planning department is in serious need of one overall/integrated information system to obtain a total picture of customer orders, material requirements, planned production and purchase orders, available machines and man-hours, etc.

2.2. Manufacturing and assembly

The shop floor is divided among four areas: engineering shop, module assembly, electronic assembly and final assembly. The engineering shop produces customised components for unit assembly where units are singly mounted according to final assembly needs. In the electronic assembly, control boxes and control units are pre-mounted as preparation for final assembly.

The rate of capacity usage in the engineering shop and at the assembly line is high. Actually, the main assembly lacks space in periods. Unit assembly is preferably planned according to orders. However, when orders are scarce, standard units are produced to stock, which means that the work load for unit assembly is almost evenly distributed over the year. Final assembly is also preferably planned according to orders, but likewise the unit assembly, machines are assembled to stock when orders are scarce. Unlike the unit assembly, the chance of producing the right (needed) finished machines to stock are somewhat low, and the process of re-configurating finished machines takes an extra 50% workload.

3. Simulation

The basis for running the simulations is the order book presented in the table 1 below. The week numbers illustrate the week of delivery, the numbers in brackets are the order numbers.

Week	Model B20	Model B28	Model F24	Model F28
19		7 units (91)		
18				8 units (70)
17	6 units (10)			
16				2 units (66)
15		5 units (89)	6 units (75)	
14			6+7 units (65+71)	
13	6 units (08)		6+6+6+5+5 units (54+55+67+69+73)	
12			6+8 units (57+59)	
11			6+3 units (61+63)	5 units (87)

Table 1. The order book for the simulation.

Model F24 can be produced at the F28 assembly points and inversely. Likewise Model B20 and B28 units can be produced at the same assembly points. In unit assembly electrical and mechanical assembly takes place in parallel. On the final assembly line the electrical assembly takes place when mechanical assembly is approx half finished. In the simulation model the main assembly is therefore divided into three activities:

- Mechanical assembly 1
- Electrical assembly
- Mechanical assembly 2

Electrical assembly is separated from mechanical assembly to enable management of staff in the electrical department.

Table 2. Master data for the electrical department.

Employees	Control point	Assembly lines
1	Electrical unit assembly, F-models	1
1	Electrical unit assembly, B-models	1
3	Unit assembly, F28	3
4	Unit assembly, F24	4
4	Unit assembly, B.models	4
5	Main assembly, F-models	5
3	Main assembly, B-models	3

The following lead times are used:

Table 3. Lead time for the different activities in the simulation.

Days	Activities
5	Electrical unit assembly
6	Unit assembly, F24
9	Unit assembly, F28
10	Unit assembly, B-models
20	Main assembly, B20, B28, F28
15	Main assembly, F24

Focus in the model is as follows:

- In unit assembly focus is on utilizing manpower capacity
- In main assembly focus in on utilizing line capacity

3.1. Production and assembly

The current data is used for the initial simulation. To allow unit assembly time to produce units for main assembly, the simulation run starts in week 1. To avoid main assembly from starting on customer orders too early, a constraint is introduced saying that main assembly cannot begin until 5 or 6 weeks (depending on the machine type) before time of delivery. Yellow (light gray in black and white) jobs indicates that they are finished on time, whereas red jobs (dark gray in black and white) indicates that they are delayed. The histogram in the bottom illustrates the total use of assembly operators. A job is not started unless the right assembly line, the right operator type and the right materials are available.

Contrary to the expectations, the simulation indicates that unit assembly is the bottleneck, whereas main assembly has surplus resources. In a follow up analysis it is observed that main assembly takes significantly longer time than the expected 3-4 weeks, mainly because many orders are initiated but then put on hold for a shorter or a longer period due to lack of materials, lack of staff or missing order specifications. It turned out that the technical department had too few resources to cope with the growing degree of customization and therefore bill of materials were often updated too late in the manufacturing process leading to missing materials at the assembly lines. More resources had to be attached to this important job to avoid the current situation at the assembly lines.

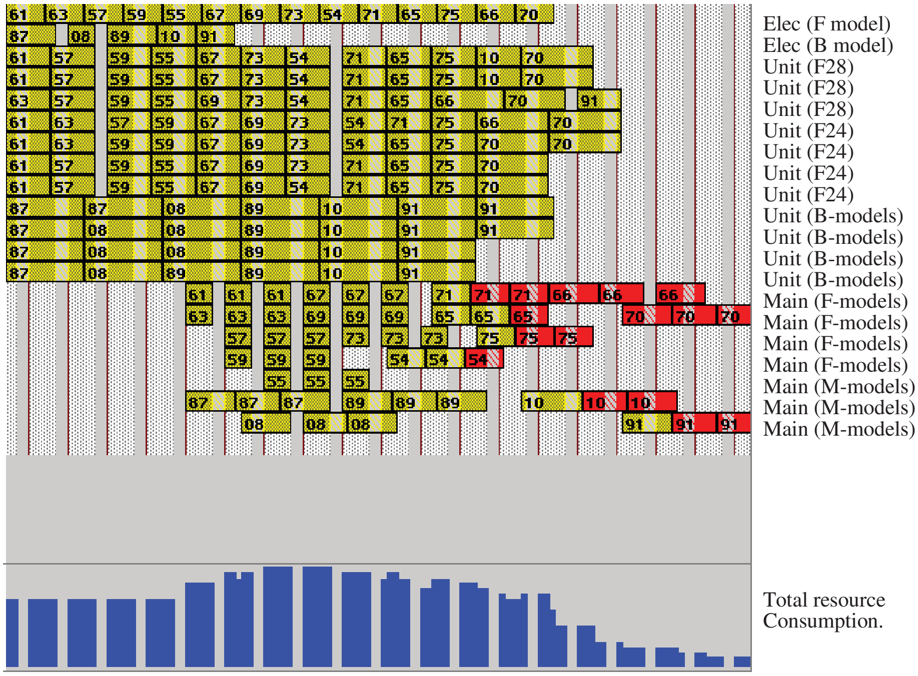

Fig. 1. The initial simulation illustrates the use of resources for a specific order mix based on the existing management concept. The picture corresponds to a Gant chart showing unit and final assembly activities. The activities are marked with order numbers. Resources can be seen at the right and the total capacity load can be seen at the bottom, represented by a histogram. Delayed activities are red.

It is demonstrated that the delivery performance is improved, although more working hours are included in the plan and the number of main assembly lines is reduced from 8 to 6. Denkena [8] suggests that random events should also be built into a simulation model. While the simulation model does not accommodate for this the practical experience shows that a significant portion of resources go into managing these event and to manage them better simulation models could provide a better understanding of scope and impact.

4. Conclusion

Simulation experiments have documented that sufficient capacity is available and that lead time can be reduced through a reorganization of resources and activities. Further, capacity can be freed for additional production. As a machine typically includes 7-8 units, the time for final assembly could be reduced with 7-8 days just by moving activities corresponding to 1 day pr unit from final assembly to unit assembly. In addition, improvements of design/construction continuously take place to reduce the number of hours for assembly, e.g. by reduction of the number of components and by further modularisation. By reducing the time for final assembly and postponing the customer order decoupling point the company can reduce customer changes during assembly.

The simulation runs imply that many resources can be saved partly with a more detailed planning, and partly by using available resources in unit assembly instead of in main assembly. Moreover, continuous improvements of design/construction, production and assembly methods could reduce the time consumption considerably. A common understanding in the company of consequences of rush orders and customer changes could be obtained by using a fine-planning tool as for example CAPS.

The use of a simulation model was considered a major breakthrough in the discussion with the company, as the simulation runs fairly accurately could demonstrate the actual status of production together with the consequence of changed planning principles and preconditions.

The experiences from this case study also shows that simulation models are more accessible than what most SME's expect. Often, SME's are hesitant to apply technologies such as simulation because they are being perceived to be time consuming and complex. Both are true if you are pursuing perfection, but often companies does not operate with a level of precision that requires complex models and even very simple models can be applied to improve the utilization of resources.

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