Improving a New Production Process

In the previous Next, we already saw the implementation of operations research in the HagaZiekenhuis of Marleen Balvert. However, operations research can be used for many companies, cases or problems. Therefore, I will explain short my methods when optimizing the new ACV production line during the internship at Bosal Netherlands B.v. te Vianen.

Introduction

Bosal Netherlands (BNL) is plant 8 of the the Bosal group founded in 1923. Bosal is one of the worlds leading manufacturers of on- and non-road exhaust systems and it also produces precision tubes, storage racks and tow bar systems. The research focused on the ACV production plant within BNL. This line produces different king of heat exchangers, and it started at the end of 2011. The production process can be seen as an Operator-Paced Job-Shop production line, since many operators are working within the line. However, only based on the fictive machine assignments it can be seen as a Job-Shop.

Since the production of these heat exchangers has different problems with high scrap rates, low output, high reworking rates and high inventory levels, this research is conducted. On the basis of experiences within the company, talking with employees and own data measurements, a research question is proposed that covers these problems. To define the approach steps and project plan, literature is studied within different areas.

Approach

Eventually, a three step approach is developed, called planning, controlling and simulation. First the simulation part means a machine study in a static and dynamic approach. The static approach is an excel study on the basis of statistical calculation. This to check the output of the machines and utilizations of both operators and machines. The dynamic approach is actually a simulation model and it represents the total flow of the process. Besides it can gain insight in the behavior of the process, to find out what the actual bottleneck is. The controlling part covers the determination of the carrying rate, the upstream supply chain and inventory investigations. The planning part covers two mathematical models that determine a new plan, sequence and product mix for the total production line.

The Production Process

Before explaining the ideas and results, I will shortly explain the production process. As said, the research was done for the ACV plant within BNL and it produces heat-exchangers for the European and American market. I divided the production process in three different stages to simplify and define the research area. First stage is the supply chain inventory part and the second and third part covers the total production line within BNL. To understand the process, each stage should be investigated extensively. For example, one should talk with employees and operators within the production process, to understand what is going on and what the experiences are. It is important to check opinions on different levels. The division is made on the basis of characteristics within the production. In stage two, every product is processed on its own machine, which means they have a fixed machine assignment. However, in stage three each product is produced on each machine. To model the production process, certain assumptions have to be made. For example, setup restrictions and operations restrictions that do not restrict the production output. Other assumption are related to data discovered or measured.

Discovering Data

In most companies, and especially for new production processes, it is extremely difficult to discover appropriate data, which can be used for the research.

Since most of the data was unavailable at the beginning of the research, time measurement were needed within the actual production process. Besides it is, as already said, necessary to talk with employees and ask for as much information as possible. Since each employee keeps track of data within separate Excel files, it is important to understand each way of working with Excel and combine different information resources to get your own accurate data. Transforming the data in one's own preferences is favorable to get familiar with them and be able to use it in your way for the research. The time measurements were especially needed to discover clear production, reworking, and set up times. These measured times are the main input of the research. It is important to note that, one can not rely on the data available in a company, since they may not be true. Discovering the right and needed data can be time consuming, but it is necessary for every research.

Machine study

With the discovered data, first a static approach is developed. This to gain insight in the capabilities of the ACV production plant, especially the machines and operators utilization, and output. Again to simplify the production, extra assumptions are needed to model each machine separately in Excel. Since each operator spends some time on small things like writing, talking, searching for tools or going to the toilet. It is assumed that a 100% utilization within the models is impossible, but 80% is acceptable. However, since some operators utilizations were extremely low, extra combination are experienced. These new combinations already present new ideas for implementing within the production process. Besides, some problems within the process were noted.

After gaining insight in the machines and operators, a dynamic simulation model is developed. This to represent the flow within the process and understand the behavior of the system. From this, one can find the bottleneck station of the process and experiment certain cases within an optimization. First the simulation model is developed that represents the current production the best. Then, the model is optimized regarding to maximize the output of the total production. This is done for a monthly period and scheduling two production shifts per day. The decision variables of the model are the starting planned production values and the reworking times of the operators. This, since these are unstable and can differ between each operator. The operators utilizations define the constraints of the optimization. This to make sure each operator works efficiently at least a certain percentage of his time. Within the optimization, it is tested what the effects will be of assigning more activities or freedom to the operators. Also we want to know what the influence is of lowering the production times of the machines regarding to the output.

Controlling

The second part of the research covers controlling stage one of the process. Since inventory levels are measured by hand, first it is checked if the current levels are too high. To relate these levels to cost factors, the carrying rate is determined for BNL. The 'Cost of Carry' (Carrying Costs) is the total cost of storage, insurance and financing costs that a seller of a futures contract must bear while waiting to deliver the asset that the buyer has purchased from the seller. According to the inventory levels counted by hand, one can conclude that they are too high. For some raw material parts, there is inventory for more than 40 weeks. In comparison with a four weeks ordering cycle and the lead times, this is too much. Moreover, since the carrying cost are determined at almost 40%.

With the determined carrying rate it is possible to calculated lot sizing policies, like the EOQ and Silver-Meal approach. However resulting solutions present very low ordering amounts, which are not practical. Implementing these can result in a huge bullwhip effect. Therefore, other policies are developed on the basis of the lead times and four weeks ordering cycle. Besides the most important upstream supply chain is investigated in detail. Because of quality issues, it is very irregular and has extremely high scrap percentages.

Mathematical Planning

After controlling stage one of the process, it is a logical step to control the main production line, stage two and three of the process. This planning part covers an optimization within the package AIMMS. Two mathematical models are developed on the basis of two literature papers. They are labeled as a planning and sequence model. These models are implemented and used together via a two step approach. First the planning model is solved regarding to minimizing the release, holding and back order costs. The resulting production plan is used as input for the sequence model. This sequence model present shows if the total planned production can be made within the time restrictions. Besides it results in Gantt charts that show the product sequence that has to be scheduled.

Both models are mixed integer linear programming model and can be adapted to other production processes. Operators are not included because within the ideal situation, the machine production times are restricting the output, instead of the operators itself. Therefore, the models are very general and simple to implement and also extremely effective. Again to represent the production process in a mathematical way, some assumptions have to be listed. One can think of the machine assignments or capacities restrictions. Also within this part, some cases are experimented. These are related to the inclusion of scrap percentages, idle percentages, beginning inventory levels or introducing longer shift lengths.

Results

From the different research parts, different results can be noted. In total they can be placed in two groups; Internal and external implication. A very intuitive internal result is that it is extremely important to keep producing on the machines continuously to maximize the output. Besides it is found out that lowering the processing times is profitable for the output. Moreover, it is important to note that planned demand can be met according to the production times. According to the planning models we found cyclic plans for two and three weeks with an output of more than 450 per week, which was originally planned by BNL. They best result found has an average output of almost 500 products, which is a huge improvement. Besides for a one shift production per week, the three weeks cyclic planning is the best one found. This one increases the output to almost 270 products, instead of 250. Another result is that it can be profitable to produce the large products at the small side of the machine in stage three, while this is originally not possible. This idea is advisable when there is no demand of the small products, and more demand of the medium and high products.

Also it is found that a combination of activities is advisable to investigate or introduce within the process. Ideas for this are encouraged by management and will be investigated in the future. For example, combining operators activities or assigning small operations within the process to different operators.

According to the dynamic simulation model, we found that stage two is the bottleneck of the total production process, instead of the bottleneck assumed by the company. Next to that, also reworking times are restricting the production output of stage three. However, it must be noted that the model does not represent the real production for 100%. Because real operators never do certain actions via a fixed schedule, and none of them work at the same speed, it is difficult to model operators in a program. Although, it is found that in the dynamic model, one operator less can result in almost the same production output.

Considering the external result, it is found that current inventory levels are too high and can be improved, efficiently. The carrying rate of ACV within BNL is determined, and shows more the importance of a good inventory control. Therefore, new ordering policies are determined based on a four weeks cycle. Besides a SAP or bar-code system can be implemented or introduced, since the control activities of the inventories and upstream supply chains are not fully integrated.

Recommendations

On the basis of the results found by the different methods, we can point out a few recommendations. First of all, since both the static and dynamic approach point out different combinations of activities it is advised to investigated more in such combinations within the production process. Second, it is recommend to improve the production times of the machine, especially for the machines in stage two. Another option to investigate is to not consider fixed machine assignments for the products, but introduce flexibility to produce multiple different products on different machines.

Beside operational recommendation, there are also external and software recommendation listed. Since products from the longest supply chain have a very high scrap percentage and also restriction the production, it is advised to improve the stability and increase the buffers at each station within this chain. To better keep track of the inventory level, it is advised to improve data availability via a certain new system. At least introduce for every employee a fixed layout within excel to work with. The last advice proposed is to implement the MRP-II concept within the company to improve data availability and information streams.

Conclusion

This research shows how operation research models and techniques can help to improve new production processes. Currently BNL and ACV implemented some points noted by the research. The output is improved, but still quality issues play a huge role in the limitations of the production. Besides inventory problems have been noted in order to control them better, especially since inventory costs play a big role within this plant. Therefore, improvement possibilities always have to be investigated and the role of operations research never stops after this research.