Planning of a production facility for a component manufacturer

- In view of logistics and risk management

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May 2012

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This article is based on a master thesis [1] conducted at a successful component manufacturer in Sweden. The manufacturer has set a goal to redouble its turnover within next 5-10 years. As the existing plant is not deemed sufficient for the future development, additional facilities on the company's site will be necessary. The main purpose of the thesis was to develop a few appropriate layouts for a new plant building and to investigate its placement on the site in order to obtain as efficient production as possible. The resulting five layout alternatives of the study were generated with the SLP procedure.

1. INTRODUCTION

Every year large amounts of capital are invested in new property projects. Facility planning has increased its value and is now seen as a long term strategy for a manufacturing company, as it determines how the properties and buildings can adapt to future production. [2] The flexibility of production however will be limited by the building structures; therefore forward thinking is required when planning form and size of a new building in order to achieve future goals.

This thesis has been conducted in cooperation with the company Advanced Component AB.

2. PROBLEM DISCUSSION AND PURPOSE

Advanced Component AB has set a goal to redouble their annual turnover within 5-10 years. Hence it is necessary to increase the production capacity in order to ensure this growth. The existing plant is however not deemed sufficient for their future expansion and additional facilities ought to be planned. The aim of this study is to develop layout proposals for the plant where new buildings shall be located within the company's site and adjacent to the existing. The proposal consists of two layouts related to each other; the design of a new building, and the interior layout.

In the development process, different aspects were taken into consideration, such as the flow of material and staff, future possibilities for expansion and risk management. The main questions investigated in this work are:

- Where should new buildings be placed in relation to the existing?
- What should the interior layout, for all buildings look like?
- How big shall the new building be?
- What possible risks are there for the company in general and during the implementation of this property project?

3. METHOD

Qualitative data collection is central in this study that has been executed through semi-structured and unstructured interviews with responsible staff and open observations at the plant. Literature studies within relevant fields have been conducted throughout this work, in order to find inspiration and guidelines. The selected fields are among others facility layout planning, plant layout, material handling, construction- and project-process, space requirement calculation, risk management and relevant regulations concerning construction etc.

A Systematic Layout Planning method, called SLP has been used to generate layouts for the industrial plant. The working procedure contains eight steps [3]:

1. Gather input data and identify flow of material
2. Identify activities and establish space requirements
3. Chart relationships between activities
4. Create a space relationship diagram
5. Draw a space relationship layout
6. Develop layout alternatives
7. Evaluate alternative arrangements
8. Detail the selected layout plan

4. EMPIRICAL RESEARCH

Advanced Component AB, hereafter referred to as AC AB, is a small manufacturing company in Småland region who owns an industrial site of about 20 000 square meters, where their current 3 000 square meter plant is located. Today the company has around SEK 80 million in annual turnover. AC AB is specialized at manufacturing small components with high precision requirements, which are often made of complex materials. They do not have products of their own; components are only produced according to customer specifications. The manufacturing process can vary between different products. They are applying a functional layout in the production facility; it corresponds well to their complex production. Because of the complexity of the products, setup times are rather high.

Today, there are approximately one hundred machines in the plant and the utilization rates for different machine groups vary, between 1 and 90%. This because of the main machines having higher occupancy while the supporting ones have limited utilization as the flows to these machines varies between different products. Some components will pass many of the supporting machines, while others are ready for packing and delivery after the main operations. At the moment, 75 % of the total production space is utilized and based on the current free space the company can install no more than 2-3 new lathe machines, which increases the lathe capacity by approximately 15 %.

The components AC AB produces are rather small with lengths between 10 and 150 millimeters. The most heavy ones have a weight under 350 grams. Work-in-process goods are stored in baskets and are normally transported between activities by staff without the use of large material handling equipments. The size of the products also determines space requirements for buffers in the production, which is more or less negligible. The larger buffers require less than 1 square meter of floor area as the baskets can be stacked and in some cases they are stocked on shelves.

The raw materials used consist of 2-3 meter long metal bars with different diameters. In total, they keep about 350 different materials in stock and use about 5 600 ton per year. Each batch of metal bars arrives from the supplier to AC AB in wooden boxes. Today, there are two locations where raw material can be stored: a store-room in the main production building and a garage outside the production building. Where and how the materials are stored, depends on the size of the batch. The company applies the principle of first-in-first-out, which means that the batch arriving first shall be used first. Staff responsible for the storage uses a forklift truck to handle the boxes that can weigh from 80 to 500 kilograms. The boxes are put on wagons and are transported to the production by hand. Several of these metals are similar in appearance, but they have very different qualities, therefore, it is of utmost importance that the correct material is used for each product.

During processing, the filings of some materials are highly flammable and there is a high risk for overheating and fire. In average, there have been three fires each year, however, there has been no serious damages. The fire usually only affects the machine it starts in.

AC AB differentiates themselves from their competitors by offering high quality products. One of the key elements to assure quality is traceability. It should be possible to follow a finished product through the plant to the specific batch number of the raw material. It should also be possible to track the operator responsible for the operation. To ensure this, a consignment note follows the raw material. After a product is processed in the first machine, it is placed in a basket. Each basket has a packing slip which follows it till it arrives at the inventory of finished goods. On each packing slip, there are details of the operations, employee number of the operator, number of items in the basket and the batch number.

The company divides the products into three groups with different business areas. Their strategy is to obtain a balance between these business areas, preferably equally distributed. Today there is no such balance.

The current layout in the plant is shown in Figure 1. Both the parking and the area for arriving trucks are located on the south side of the plant. The production flow, which is very complex, starts and ends on the south side. It often enters the small building at least once for each product.

5. ANALYSIS AND RESULT

As mentioned in section 3, the SLP method was used to obtain a clear structure for the design of a new building and new production layouts.

The first step was to gather input data and to identify the flow of material. Since there are many products with different operation processes, the material flow is complex. It was discovered that products with high turnover often had a long production time. Therefore it was considered appropriate to assume that the total machining time will increase with almost the same trend as for revenue growth, a 10% deduction was used. The CEO of AC AB has predicted three scenarios of future revenue growth: a maximum, a medium and a minimum growth scenario. With these scenarios, future demands for different machine groups can be calculated. This is presented in the formulas next.

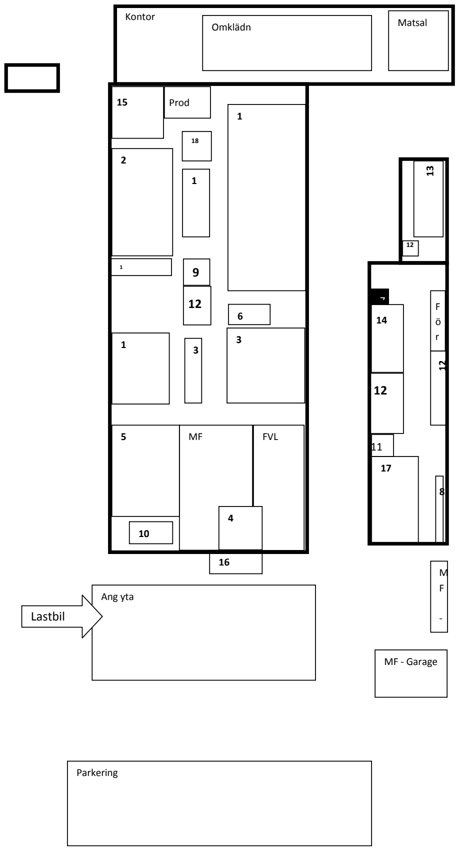

Figure 1: The current plant layout.

APG (Annual production time growth) = annual revenue growth * (100%-10%) (1)

FMT (Future machine time for machine group A) = Current machine time for group A * APG (2)

Demand for machines in machine group A = FMT / Available production hours per year per machine (3)

It is assumed that the downtime and setup time remains the same and that the future products have the same manufacturing procedures. Around 15 new machines will be required to facilitate the redoubling of the annual turnover.

In the second step two approaches to divide production has been identified. The production can either be planned as a functional workshop, which the factory currently is, or as a flow-oriented production. Space requirements for each activity were then analyzed based on the two production principals. To avoid shortage of space, the estimated space growth follows the CEO's future scenario with maximum growth. If the production is flow-oriented, the total required space for production increases by 80 %. If the production is functionally oriented space increases by 70 %. The increase of space doesn't only include new machines, but also workshops for staff and space for warehouse. Beyond production, space requirements will increase for offices as well for parking lots etc.

In the third to the fifth step, relationships between different activities in the plant are established in form of charts and diagrams. The evaluation of how activities shall be connected is based on flow of material, communication and staff movements. For example, noise level and sensitivity to dust must be considered for activities that require concentration or pure air.

The sixth step involves development of layouts for buildings and production with respect to structural requirements, site conditions and work environmental aspects. Nine layout alternatives were created. These alternatives were then measured and evaluated in a systematic way in order to select a few options to pursue. Evaluation criteria were identified according to the requirements the new buildings must meet. Five layouts were selected. Further analysis took place in order to determine opportunities for improvement of these proposals. Figure 2 demonstrates one of the layout proposals. This combines the flow- and functionally-oriented production philosophies. The different colors represent different product groups, who all has their separate flows and machines.

The suggestion in Figure 2 will have the new production building placed on the south side and a building for some support functions are placed to the west. There are also a couple of additions to the current building. The production flows in the new building will be straight, starting at the top and exiting at the bottom. The main flow in the current building will be U-shaped.

The new building is marked with a dashed line while the current building is enclosed by a full line. The areas of the new buildings are between 2000 and 3000 square meter. Hence, the plant size will be increased with 70 to 100%. There will be some free space within the buildings, which will make it possible to expand for another two to three years after redoubling of the annual turnover.

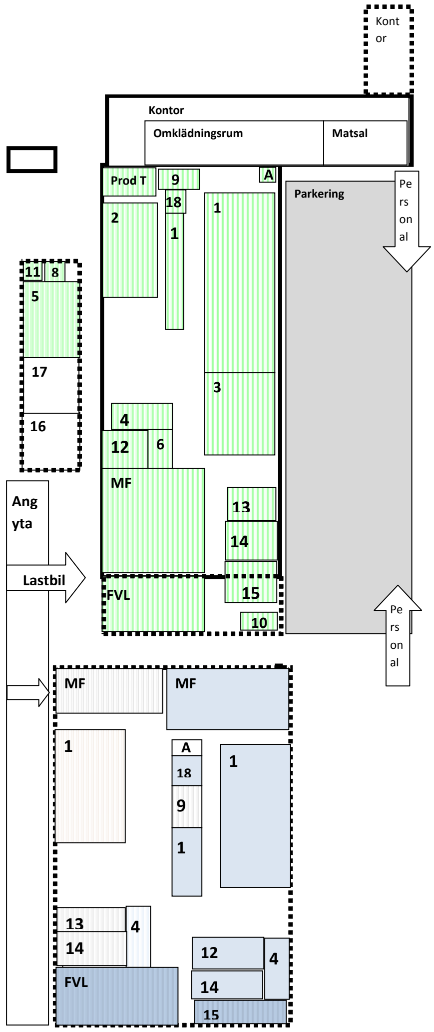

Figure 2 One of the five layout proposals.

A risk analysis has been executed where risks related to the company's production and to the facility project were identified and analyzed to find possible action plans. Examples of risks identified are usage of wrong material and fires in production, a solution for both is to divide the site in different sections. Problems with building permit and overriding budget and time plan are other risks.

5.1 Recommendations

The final step of SLP, which is to create a detailed layout, has not been executed in the master thesis. It is left as a recommendation for the company to continue to develop it. AC AB shall evaluate the five layouts and select a final proposal which they shall design in detail by placing machines and form workplaces. The final layout possibly needs to be adjusted to achieve a better organization. Meanwhile, AC AB needs to contact authorities to find out what permits and other investigations need to be prepared, handed over and approved before and during the construction process. It is also time to make decisions about procurement and construction contracts.

The company should complement the risk analysis performed in this thesis. It is essential that the company continuously executes risk analysis for their activities.

6. CONCLUSION

The five layout proposals, the recommendations for AC AB and the risk analysis constitute the result of the thesis. The goal of this work has been reached as the initial questions of this study have been answered during the work with the development of these proposals.

Although the SLP methodology has not really been developed since the 60s, it is still considered to be a good method to design a layout with, because of its systematic approach. However, the results can vary considerably depending on who is practicing the methods, for what purpose and in what condition. It depends, for instance on how thorough the authors are when developing an optimal layout and how prejudiced they are when evaluating the layout proposals. During the data collection process, it is necessary to interpret the responses in a correct and objective way. People, with different responsibilities in the company, can nonetheless have different opinions about the same question. The difficulty is then to evaluate these opinions in a right way and to make them a foundation for the analysis and proposals.

A great many factors are involved in every facility project; hence, each project is unique. Therefore, the results of this thesis are not considered to be possible to generalize to other companies or situations. However, the methods used are possible to apply to other companies and situations.

7. REFERENCES

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