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Productivity improvements at small manufacturing company's shop-floor

Master's Thesis in
Industrial Management

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ABSTRACT

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ABSTRACT:

An effort to increase and improve the productivity has been started by the case company at which this thesis was conducted. Various productivity measures and improvements are being currently being studied to achieve a leaner production and easy material flow.

In productivity improvements the ultimate goal is to seek out new production manufacturing processes that can increase the company's overall efficiency in order to stay competitive in the market. This could be accomplished by the reduction or total elimination of losses that occur mechanically or through a bad operational process.

The aim of this thesis is to develop a simple productivity measuring of the manufacturing machine and also to make a bidding calculator or sales tool to be used to speed the rate at which they set bids.

By using literature from previous studies, unstructured interviews of managers, supervisors and employees the tasks to be performed were set. A recording sheet was created to record the rate at which the machines at the shop-floor were being utilized and this study we named as machine hour study. This study is to help us to understand the current state of utilization so as to figure out measures to increase the productivity. The second task was to modify the bidding calculator or sales tool to be more user-friendly. Lastly, the author was to recommend other projects that could help in the improvement of productivity at the shop-floor.

The significant result is the fact that the machines being used in manufacturing were being underutilized which was agreed by the supervising managers at the shop-floor. Some of the reasons pertaining to this result are too much setup in a working day, long searchers for tools, not enough work, etc.

KEY WORDS: Productivity, set-up, shop-floor, bidding process

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CHAPTER ONE: INTRODUCTION

In today's economy, small enterprises are on the brink of collapse because of very high competitive markets. A small enterprise that inhibits the characteristics of producing at a high quality and low cost is being sought after by customers all the time. This also gives a challenge to small enterprises to seek out for new production manufacturing processes that can increase their overall efficiency in order to stay competitive all the time.

Unlike large manufacturing companies that have the resources and skills to adopt and apply well known philosophies to achieve high productivity gains, small manufacturing enterprises in order to succeed needs certain "tools" or methods which have to be created that requires little budget. Small enterprises face problems in capital, manpower and resources to improve their operations. These tools or methods needs to be in such a way that is easy and quick to implement and must have a very significant impact upon the enterprise efficiency upon implementation.

One way of in which small enterprises can stay competitive is to reduce production cycle by employing lean manufacturing methods and part of these is set-up reductions which has the potential of reducing production costs in a short term. The reduction of set-up time is not a new concept and it has existed for quite a long time, in fact Henry Ford in 1926 was using lean manufacturing in their manufacturing process. Set-up time could be described as the time taken to change a machine from last production lot to the first good part of the next production.

Another improvement that could be adopted by small manufacturing enterprises is in the process of bidding. Bidding is a very important business process in those successful bids is what gives the enterprise capital and henceforth growth in order to survive in the manufacturing environment. The estimation of product cost is a very challenging task for small enterprises but yet very crucial to the financial success of the company. Using parametric estimations will enable such companies to quickly respond to customer demands and provide a versatile and better cost estimates to products.

1.1 Research background and objectives

This thesis is a constructive case study of small manufacturing enterprise situated in the municipality of Vörå, Finland. The case company is currently facing major challenges in both manufacturing processes and sales. Being a typical engineer-to-order enterprise which is a company that designs and manufactures products based on customer orders, it relies heavily on its ability to be fast at production and with a low cost.

The purpose of the master thesis is to help the company in developing an interactive productivity measuring of their manufacturing machines and also making a bidding calculator to set competitive bids at the shortest possible time in order support the sales department of the company As a result this thesis will highlight some well proven tactics for improving productivity at the initial effect of having these developmental tools in the company to enhance their competitive advantage.

1.2 Structure of the study

The structure of the study will proceed as follows. The thesis will start in chapter one by giving a brief introduction to the manufacturing industry, a little background of the case company and the objectives of the study. Chapter two describes the case company in detail to further understand the improvement tactics suggested in the study. The next chapter which is three addresses the research methodology used in this study. Chapter four goes on by looking at the literature review which forms the theoretical framework of the study to understand well known theories and studies in this field to know which ones are suitable to apply in the case company. The empirical part of the study are chapter five and six which looks at the As-Is and To-Be proposed models and the construction of sales tool respectively. The thesis ends with a conclusion and limitations of the study and suggested further research that could be done in chapter seven.

CHAPTER TWO: COMPANY PROFILE

The case company was founded in 1971 producing machining parts and part-assembly in the metal industry. In 1988, the sister company was also founded which was involved with trading of manufacturing equipments. The company has now been bought by a larger group in the year 2009. The business activities has grown and is now involved in manufacturing of various specialized tools and components for example the ship and power plant industries, building industries, wind and other special industries.

The vision of the company is to be one of the three leading manufacturers of various maintenance tools world-wide. This vision statement is backed by a mission to provide high quality maintenance tools optimizing the value for their clients. The case company has grown over the years, mainly because their clients are satisfied with their performances. Their success can be linked to the strong values of the company:

- quality;
- delivery accuracy;
- trustworthiness;
- flexibility.

Figure 1. Some maintenance tools manufactured at the case company

In fulfilling customers' needs and demands, the company has chosen to co-operate with many companies world-wide within the selected industries in order to have the possibility to serve the customers with full lifecycle services.

The case company has 24 employees. Six of these employees are in the administration and the rest are shop floor personnel. About 90% of the personnel are highly trained and can be considered as specialists. Employees with such attributes could be described as professionals according to Mintzberg (1980). It can therefore be said that the case company employees are professionals.

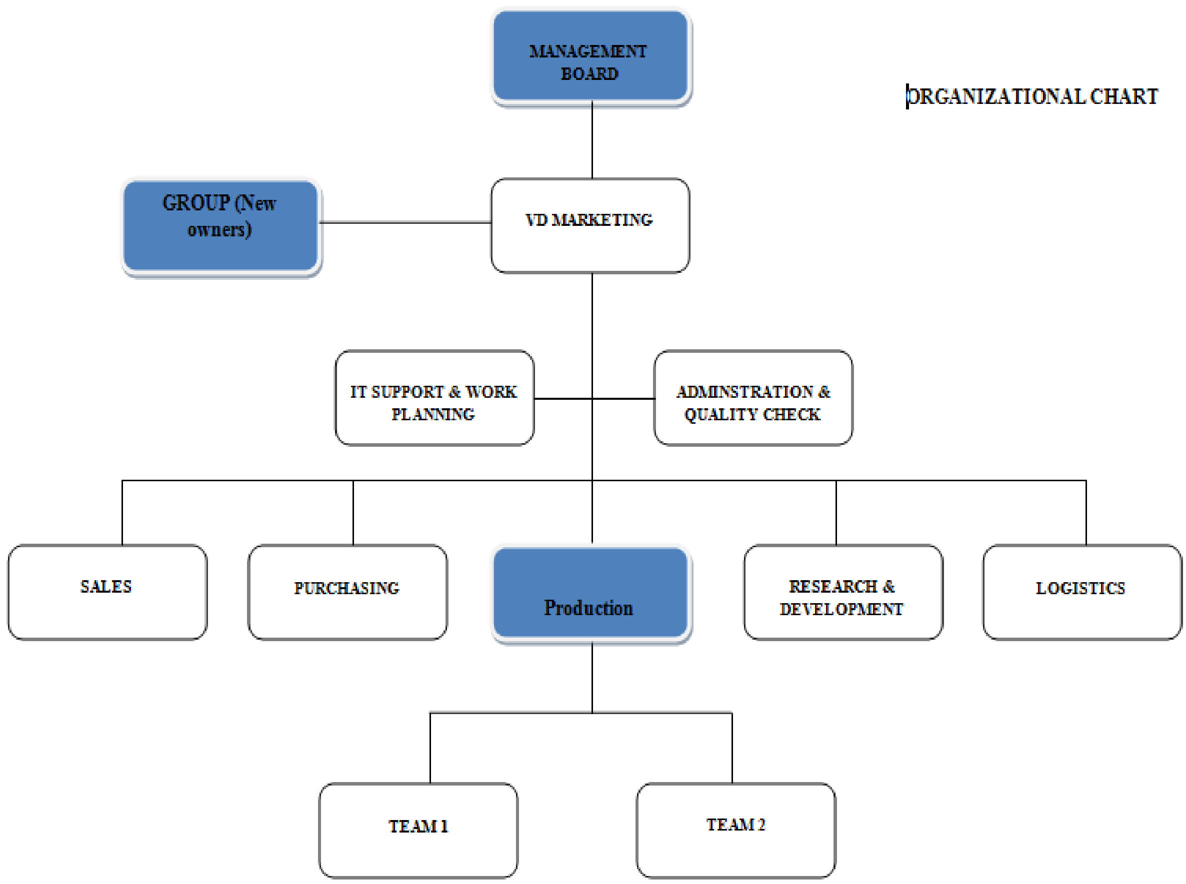


Figure 2. Organizational chart of the case company

According to the European Commission (EC) the case company could be described as a small enterprise. The EC definition states "Enterprises employing fewer than 50 persons having either an annual balance-sheet total not exceeding 5 million EUR or an annual turnover not exceeding 7 million EUR." (Statistics in focus, 2002)

The case company can be described also as a company moving from the collectivity stage to formalization and control stage as stated by Quinn and Cameron (1983). The main characteristics of this life cycle stage are high commitment, collectivity and informality. Concerning the formalization and control stage the characteristics are mainly productivity, control, emphasizing on goal settings, stability, information management and proper communication.

Table 1. Case company characteristics

Year started	2009
Number of employees	24
Organizational type	Small Enterprise
Activities	manufacturing of specialized tool sets and maintenance tools
Vision	To be in the best three of manufacturers of various maintenance tools world-wide
Organizational life cycle	Gradual shift from collectivity stage to formalization and control stage
Core competences	highly skilled personnel, on time delivery and delivery of what was promised and flexibility to adapt to customer requirements and demands
Type of employees	Professionals
Clients	Power, marine and energy industries
Markets	National and International
Competition	Slightly heavy

CHAPTER THREE: RESEARCH METHODOLOGY

This chapter is to provide the different methods, designs and approach used to understand the processes and steps arrive at the various conclusions in this study.

3.1 Research Design

A research design gives a layout framework for collecting data and analyzing them. Ghauri and Grønhaug (2005) describe the research design as the total plan to showcase conceptual research problem to an important and practical empirical research.
There are three main categories of research design; they are exploratory, casual and descriptive research. Casual research is used to determine mostly cause and effect relationships whereas descriptive research has to do with the description of characteristics and functions.

For this research the author decided to use an exploratory research with the main aim of discovering new ideas and insights of the study concerning productivity improvement and developing profitability models. This method is most useful when considering projects or subject with high level of uncertainty or simply when there is lack of understanding of the subject in question. This is the description given to exploratory research according to authors' like Philips & Pugh., 1987 and Ghauri et al, 1995. This kind of research design provides flexibility for the author and there is no formal structure to follow.

3.2 Methodology Approach – Case Study

Exploratory and descriptive research most of time is conducted in a case study. In a case study research, there is a need for enough information of the subject being studied to be able to explain its features and the ability for the research to be performed in different independent coordinates.
Yin (2003) describes a case study as an inquiry into an empirical research intended to investigate existing occurrences within a reality context. The type of case study used by the researcher is a single-case study. From the research, the company represents a case that provides an exploratory nature. Some other characteristics are its uniqueness and the ability to test well formulated theories (Yin 2003). On the other hand, a multiple case study is difficult to employ because it requires extensive resources and time.

From this thesis, the author employs extensively a single case study. Although there are three research objectives, all of them are totally different from each other, they are productivity improvement, developing productivity models and creating a bidding calculator or a sales tool to make offers.

3.3 Data Collection Methodology

This thesis gives a mixture of both qualitative and quantitative research methods being used. With qualitative research, Yin (2003) identifies six main characteristics. They are interviews, archival records, direct observations, participant-obeservation, documentation and physical artefacts. The thesis important sources of data were interviews and direct observations. The interviews were done through the use of questionnaires modeled based on the 7S model developed by McKinsey organization (Waterman, Peters & Phillips, 1980).

3.3.1 Exploratory interviews

Interview questions used in this research were unstructured, they are more of casual questions formulated to suit the needs of the research. The questions were directed to seek insights of productivity improvements or in other cases to address performance measurements. This method violates the validity of the interview questions. Both employees and managers were interviewed.

The interviews were conducted in a more casual way to avoid any skepticism. Two or more employees were interviewed at the same time normally during coffee breaks and after lunch break. This provides some discussions among employees on better ways of doing things and so on. Some limitations to this method was the fact that some of the employees were not able to express their opinions very clearly because the way they might be viewed by other employees.

Notes taken through this interview were analyzed with the senior employees like the production supervisor

3.3.2 Spending time with the production supervisors

To quickly understand the production process of the company and get a general overview of how work is done in the company, the author had to spend time with the production supervisors for about a week and also with the management/administration department of the company to also understand how their work affect the production at the shop floor of the company. The tasks of the production supervisors include:

- Decide the production time of new orders. This is normally done by estimations based on experience
- Programming of the CNC machines for new orders
- Conduct control checks of products and also measurements for new orders (first and last produced items)

All of these duties have to be documented and stored for future reference; hence the production supervisors also spend some of their time at the desk.

Time spent with the management team/administration also helped to understand the link between their work and the actual production of materials. The author was introduced to the whole administration team with considerable time being spent with the production manager who is in charge of providing work drawings to the production supervisors, planning production schedules, and also acting us a strategic purchaser for the company. The author was also introduced to the sales manager to understand how the company makes and receives orders from clients. This was an essential investigative meeting because one objective of the thesis is to design and create a bidding tool for the sales manager to enhance the speed and accuracy of sending offers or tenders for new projects. The rest of the administration team met are, administration manager, research and development manager and lastly the logistics manager.

CHAPTER FOUR: THEORETICAL FRAMEWORK

4.1 Cost Estimation

Looking at the competitive nature of business today, it has become an upper hand for organizations that are able to estimate the costs of products early both in design and development stages of the product cycle (Zhang, Xin; Zhang, Jianwu, 2011). Manufacturing organizations having an accurate cost estimation of their products are able to control their costs, succeed in bidding and hence have a strong competitive advantage over other manufacturing organisations. There are three main ways of cost estimation, they are estimations based on past experience (variant cost estimation), estimation based on explicit cost computations and parametric cost estimation (Ben-Arieh, D. 2000) which is further discussed in subsequent section (4.3.1). Manufacturing organisations do cost estimation based on different reasons. The most and popular reason is to address the question "Should the product be produced?" By answering this question manufacturing managers have to make detailed cost estimate on what is to be produced before starting to produce it.

- Importance of doing cost estimation (Kesavan, R; Elanchezhian, C. & Vijaya, B., 2009)

Cost estimating can be described as the process of making an expenses forecast on a manufacturing product that can be incurred. Cost estimation makes it possible for managers to perform:

- ✓ Cost control

Cost control involves cutting down on wasteful activities to increase savings and to ensure a sound competitive advantage. Care must be taken when considering cost cutting measures because this has the tendency of decreasing quality of product and poor morale of employees.

- ✓ Determine the selling price of a product

The selling price of a product is usually determined by the sales/marketing department. But before the sales department can make any correct estimation they will need the input of the shop floor manager to simply to know the process cost of the product in order to make his/her estimation.

- ✓ Make purchasing analysis

Cost estimation helps organizations to determine the cost of using third party manufacturers for their outsourced work, also to compare prices between their suppliers of raw materials and other related products for manufacturing. Cost estimation will provide them with the view of knowing the right vendors to contact in manufacturing a certain product.

- ✓ Make-or-buy decision

Cost estimation makes it possible for manufacturing companies to compare prices from different sources on whether to purchase or buy a product or service. Examples include material costs, vendor quality and delivery, tooling cost, etc.

The rest of the significance of cost estimation has been provided in the list below:

- To determine the most profitably and economical way of manufacturing and tooling of a product.
- To make a production budget for the organization.
- To be able to send tenders/bids quickly.
- To be able to look at other alternate designs of a product.
- To do feasibility studies of possible future products.
- To determine the marketability of a certain product.
- To determine the amount of investment required for equipment.
- To bring into subjection the operating costs by introducing new systems into the plan of cost accounting.
- To introduce new programs of cost reduction in the manufacturing department or shop-floor to be precise.
- To help in long term financial planning of the organization.

4.3 Bidding Process

Many manufacturing companies work are done by involvement in a bidding process to obtain contracts from client in competition with other manufacturing companies. It is the primary objective of each manufacturing organization to prepare bids that are accurate, whilst increasing profit and adding value to the customer (S. Parekh, R. Roy and P. Baguley, 2009). Cost estimation techniques are of a prime importance in winning bids. In a bidding process, fixed price bids are in requested from manufacturers (contractors) for a specific piece of work or product. The manufacturer that submits the lowest bid and all other things being equal that is meeting all other standards such as high quality, fast delivery time, etc. is awarded the contract to produce the piece of work.

Setting low bids increases the chance of winning contracts but reduces the profit margin, however setting bids at an acceptable level increases your investment returns but also decreases your chance of winning the bid (S. Parekh, R. Roy and P. Baguley, 2009). Uncertainty about the total costs associated with performing contract bids makes it very difficult for manufacturers to estimate the probability of winning a particular bid (Chapman, C.B., Ward, S.C. and Bennell, J.A., 2000)

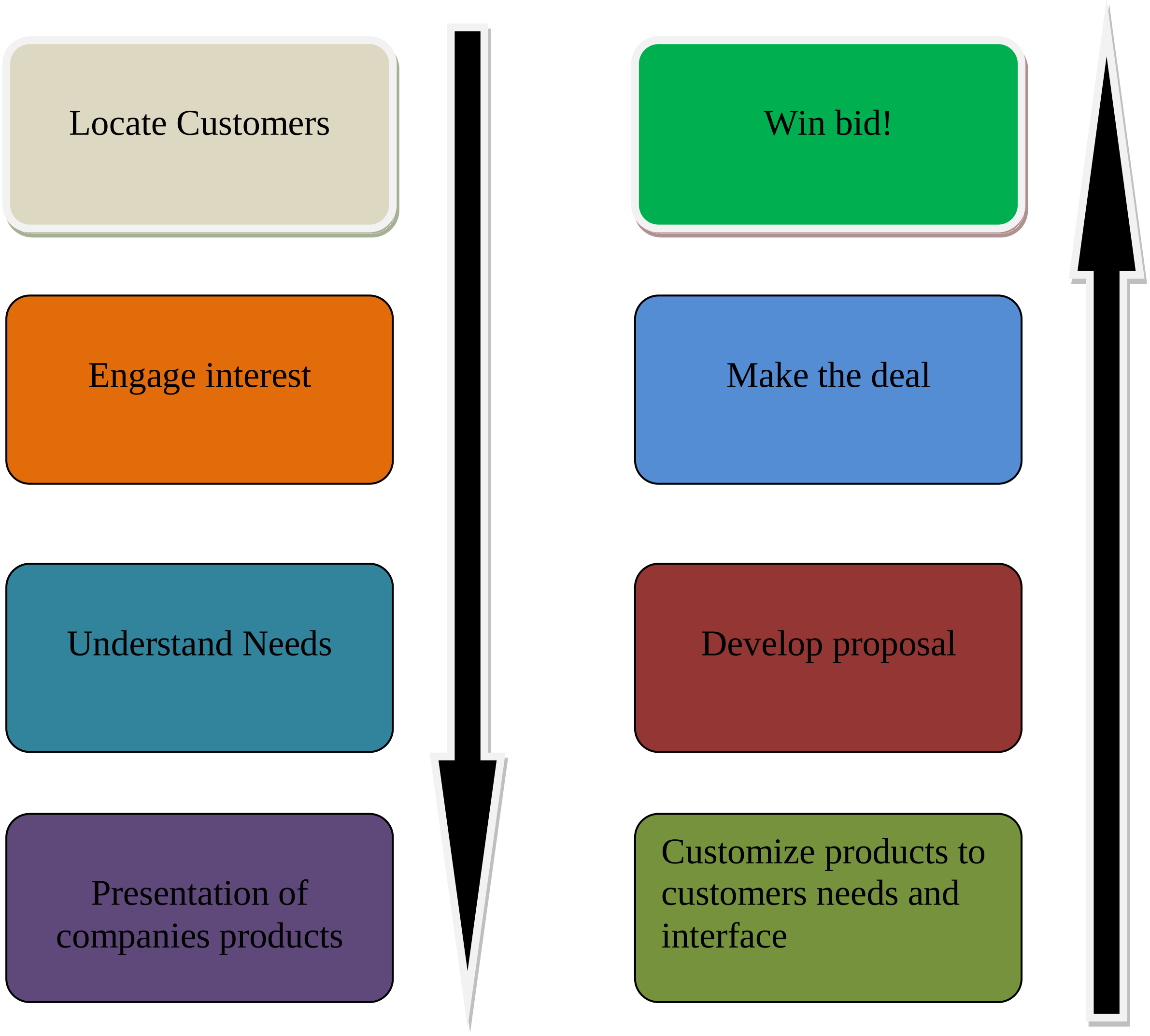


Figure 3. Bidding process (Behrens, 2003)

The figure 3 above shows the normal process of bidding. The process starts normally with the manufacturer locating possible customers. This first step can also be the other way round where customers find manufacturers who can meet their needs. The next step involves manufacturers showing interest in working with the customers and by so doing they make presentation of their products to the customers. When an understanding is reached the customers can now present their needs to the manufacturer and customization of products is developed. The most important part of the bidding process is the development of proposal and this is where cost estimation is required. When the estimated cost of the project is accepted by the customer, a deal is then reached and the project or product is awarded to be produced.

In the preparation of cost estimation for bids there is the need to consider also uncertainty management. Uncertainty can be compared to risk but is quite different. Uncertainty can be described as not possessing a definitive knowledge around an activity or task; uncertainty does not differentiate between positive and/or negative (S. Parekh, R. Roy and P. Baguley, 2009). As time progresses, uncertainty begin to reveal itself but the problem is the inability to know the actual consequences of the uncertainty. The figure 4 below shows a graphical representation of the process of uncertainties and certainties during cost estimations

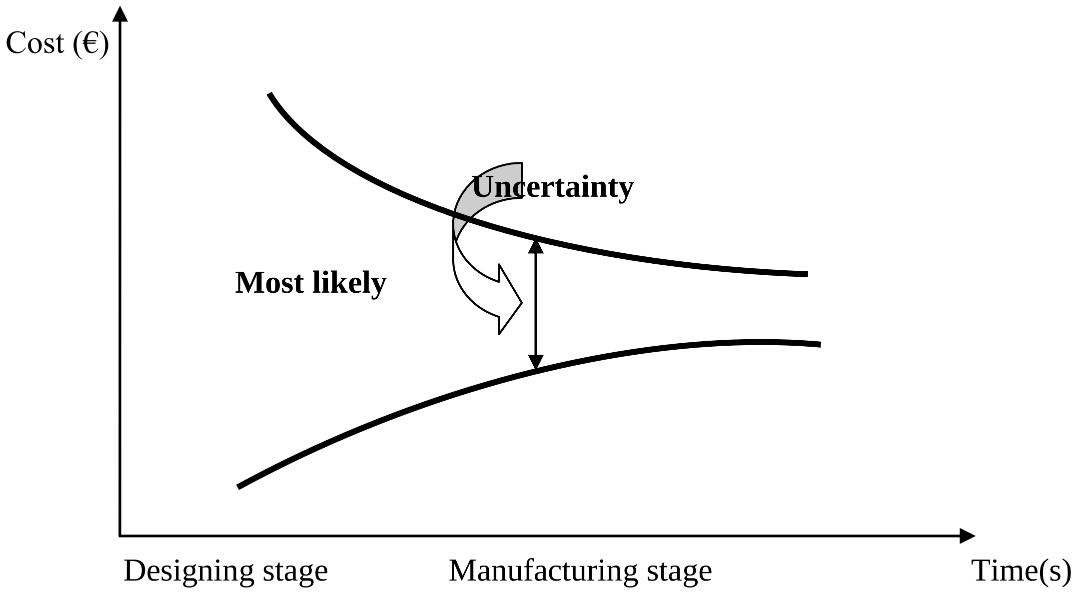


Figure 4. Uncertainty in a cost versus time perspective

Uncertainties can be seen in concept stage as well as the production or manufacturing stage. The table 2 below gives a brief description of examples related to this thesis of the uncertainties manufacturers tend to face during the preparation of bids. Table adapted from S. Parekh, R. Roy and P. Baguley (2009).

Table 2. Design and manufacturing uncertainties

Uncertainties at the designing or concept stage	Uncertainties at the manufacturing or production stage
Inadequate basis for design	Skilled labor
Design specifications	Labor shortages
Ambiguous requirements	Third party delays e.g. late material deliveries
Change of requirements	Health and Safety e.g. accidents
Budget cuts	Availability of manufacturing tools
Lack of skilled personnel	Availability of spare manufacturing tools or parts
Availability/affordability of raw materials during production	Premature design
New design (higher uncertainty)	Site costs and availability
Design delays	Machine failure e.g. Breakdown, maintenance overrun
Defective design errors	Machine overload
Approval delays	Idle machine waiting for labor, materials, tooling, etc.
Insufficient information	Scrap/Rework; due to labor error, defective raw materials, machine error
Terminology differences	Design changes
Types of metrics used	Requirements change
New design standards	Late delivery
New environmental standards	Product qualification
Poor assumptions	Unforeseen emergent properties e.g. incompatibility with other systems or parts
Failure definitions	Change in operation procedures
Test specification	External regulations e.g. environment, government
Test trials and reports	Change in schedule
Documentation	Change in quantity
Communication with customer	Documentation procedures
Validation	Obsolescence

Verification	Delays caused by environmental factors such as climate change
Rise in competition influence changes	

4.3.1 Preparing faster bids

Bids are normally prepared in a defined time frame given by the customer. Normally request proposal is sent to manufacturing company and a submission date and time is included. Using analytical detailed, bottom-up methodology each work manager is asked about their opinion on the correct cost estimation of their work. Likewise they are also asked for a detailed work description, risk assessment, technical text and many more. All of these requirements make a cost estimate a slow process, tedious and labor intensive (Shermon, D., 2009). One way to determine the cost estimate quickly is to use parametric estimating.

- Parametric estimating

Parametric estimating is a technique employed to develop cost estimates based upon the examination and validation of the relationships existing between project's technical, programmatic, and cost characteristics as well as all other resources used during its development, manufacture, maintenance, and/or modification (ISPA, 2008). There are three types of parametric cost-estimation that has been found. They are methods cost-estimation formulae (CEF), method of scales and statistical methods (Duverlie and Castelain, 1999).

✓ Cost-estimation formulae (CEF)

In cost-estimation formulae, basic mathematical are used to relate the cost of a product to a small number of parameters such as physical and dimensioning values. This method normally takes into consideration two to five parameters and this method could be employed during the design stages of a product.

✓ Method of scales

The method of scales is the simplest among the three estimation methods. The user has to identify the most important technical parameter of the product analyze and relating it to the cost of the parameter. Example, the significant parameter is weighed, the ration of the cost to weight (€/Kg) is then developed. The disadvantage of this method although of it is very straight forward is that they usually produce inaccurate results because of the assumptions made in the value of the chosen parameter and the cost.

✓ Statistical methods

Statistical parametric cost estimation takes into consideration past data collected over a period and are then organized using statistical techniques or models such as exponential, linear, polynomial models, etc. and relating this information to the estimated cost. One disadvantage of this method is that it cannot be used at early development stages due to insufficient previous data or information.

The most important sought after characteristic of parametric estimating is the speed without any loss of accuracy. The first developed parametric estimate may not be accurate as the subsequent detailed estimate, but it helps in managerial decisions to be proactive to decide on what to do in a logical manner. The advantage of parametric estimation could be illustrated in the figure 5 below (Shermon, D., 2009).

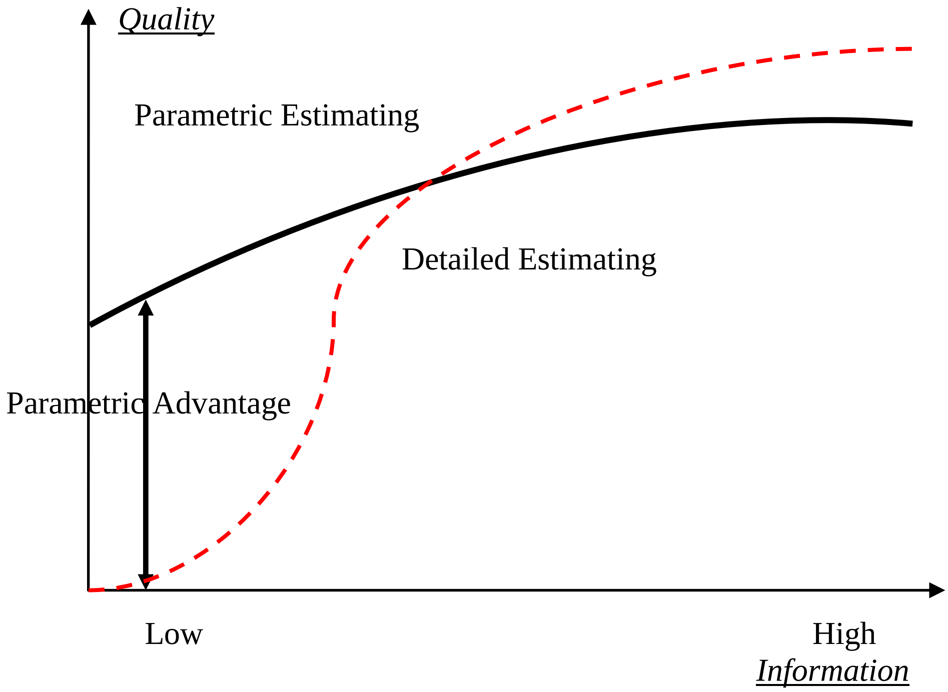


Figure 5. The advantages of using parametrics

- Using parametrics throughout the organization

Parametric models have a variety of applications. Senior management use it to solve problems for decision makers by quickly and conveniently considering costs that has an influence on the decision. Moreover, other uses such as market strategies can also be assessed alongside productivity, competitor analysis and productivity tracking. There are other possible applications. Only the imagination of the organization can limit the number of applications (ISPA, 2008). Below are selected examples of applications of parametric models applications related to this thesis

- ✓ Forward Pricing Rate Models

Forward pricing rate models uses bottoms-up to forecast indirect expense rates. The bottoms-up method is a traditional method used in collecting detailed departmental budget data. The preparations of these forward pricing rates are usually cost and time intensive.

- ✓ Bid/No Bid analysis

Parametric models are very important in the bid/no bid analysis. An organization decision on whether to make a bid for a project or not is very strategic and hence requires more analysis and also the reason is not only about making a gain. There are many reasons organizations bid for a project example might be the organization want to introduce a product in the market place. Organizations may also be willing to make a loss on a project in order to make profitable gains in the future if they are able to realize the opportunity.

- ✓ Conceptual estimating

This is the ability to fashion in mind products and by so doing the parametric models can give a fast cost estimate. Example, a program manager needs a new software application, and that this application can be conceptualized, concepts such as platform, application, programming language, source line of codes, etc are normally available at time of conception and hence the use of parametric costing tools to perform cost estimate can be done at this early stage.

- ✓ Budget planning analysis

Parametric tools are also important and useful in making budgets. Every good organization makes or must make a budget. A systematic plan for expenditure is usually drawn on questions such as: what products will be offered for sale? How will the organization go about to fulfill their duties? What best product mix should the organization indulge in to maximize profit? All such questions are important to consider in budgeting.

- ✓ Make-buy analysis

The make or buy analysis gives the organization the general overview of the important decision making process of either to make a product themselves or to purchase it from another organization based on cost analysis. Parametric models are useful in such analysis to give decision-makers fast and easy decision.

4.3.2 Using Microsoft excel in bidding process

There are inexpensive ways to do cost estimating. One way is the use of spreadsheets which can be found on any portable computer in an organization. The spreadsheet is simply a computer application that is used to replace a paper accounting worksheet. This application has reduced the dull work of doing estimating and at the same time reducing the error rate (Christofferson, 1999). The advantages of using a spreadsheet in estimating are:

- ✓ They are easy to use
- ✓ They are very cheap when compared to some estimating computer programs
- ✓ They are fast in performing tasks
- ✓ They are customizable to suit the work environment of the organization
- ✓ They are powerful.

Examples of spreadsheets are Microsoft office excel, OpenOffice.org Calc, Lotus 1-2-3, Gnumeric, KSpread, etc. The following notes and examples are adapted from Christofferson J. (1999) book.

- Making a summary sheet
- Making a detail sheet
- Using formulas
- Making a link on different sheets
- Information lookup methods

4.4 Clarification of Productivity, Performance, Efficiency, Profitability and Effectiveness

Improvement and measurements are mostly performed by companies as a general rule for staying competitive. However, most often there is not a clear understanding of what is being improved or measured. The terms are sometimes considered the same or they are interchanged such as efficiency, effectiveness and profitability. Stefan Tangen (2005)

- Productivity

Productivity is can be described as a multidimensional term, meaning it will depend on the context it is being employed. Björkman (1991) states that the objectives of a productivity measurement is often based on an individual’s opinion rather than a collectively opinion. In summary Björkman (1991) suggests that:

- There are both verbal and mathematical definitions and approaches to productivity
- The term productivity is rarely defined
- Individuals who use the term lack the awareness of its multiple meanings as well as the consequences

The mathematical definitions of productivity can be used as a performance measure with the aim of improving productivity but not to explain productivity. Examples of mathematical definitions are as follows:

*Productivity = Efficiency * Effectiveness = Value adding time/Total time* (Jackson and Petersson, 1999)

Productivity = Units of output/Units of input (Chew, 1988)

Productivity = Actual output/Expected resources used (Sink and Tuttle, 1989)

A verbal explanation of productivity gives the meaning of a shared view of an organizational goal. They can be used to describe and specify the strategic objective of an organization (Björkman, 1991). Examples of verbal explanation of productivity:

Productivity is defined as the ratio of what is produced to what is required to produce it. Productivity measures the relationship between output such as goods and services produced, and inputs that include labour, capital, material and other resources (Hill, 1993).

Productivity means how much and how well we produce from the resources used. If we produce more or better goods from the same resources, we increase productivity. Or if we produce the same goods from lesser resources, we also increase productivity. By "resources", we mean all human and physical resources, i.e. the people who produce the goods or provide the services, and the assets with which the people can produce the goods or provide the services (Bernolak, 1997).

- Performance

Because of the lack of understanding in the difference between the terms productivity and performance, most individuals discussing productivity actually will be describing performance. Performance is a term with the objective of competitiveness and achieving manufacturing feature of high quality, fast production speed, low cost, flexibility and dependability. The type of performance an organization aims to achieve is very case specific. Slack *et al.* (2001) provides a high-performance operational description that most organizations targets:

- High-quality operations which involves the ability to do work ones without any re-do's and by doing so not wasting time and effort by causing inconvenience to customers

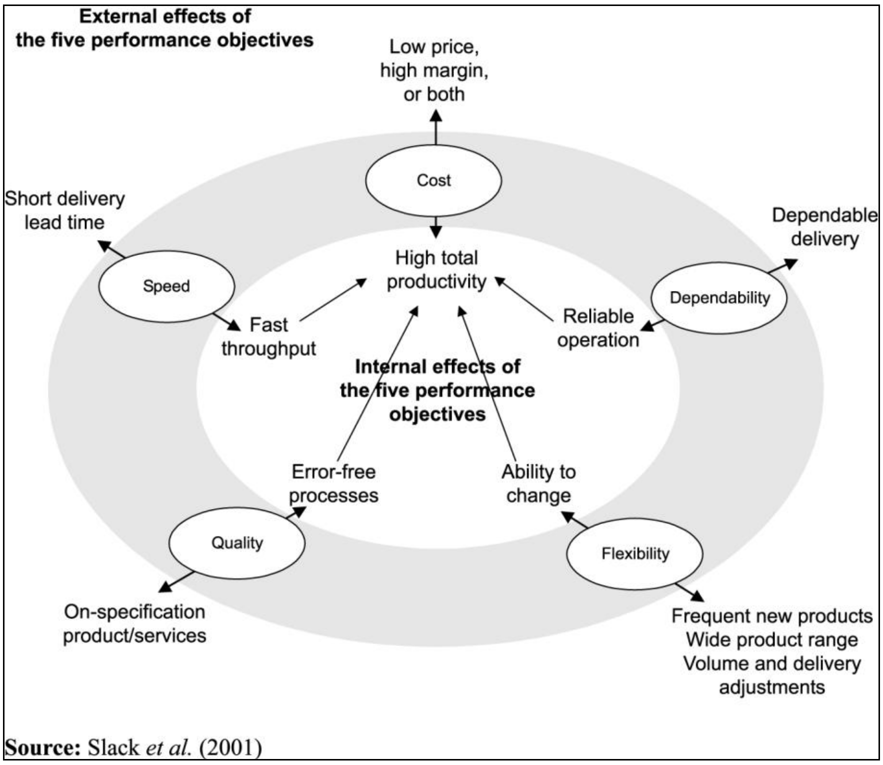
- Fast operations tends to reduce in-process inventory between manufacturing operations and by so doing reducing administrative overhead or expenses.

- Low cost of operations tends to increase profits and ability for organizations to sell at competitive prices.

- The organizations ability to change to meet unforeseen circumstances describes the level of flexibility of the organization in its operations. The ability to change to meet customer demands.

- Using dependable operations to deliver products and services as planned decreases wasteful operations and increases efficiency.

The figure 6 shows the five external and internal effects of performance objectives in an organization which are cost, speed, quality, flexibility and lastly dependability.

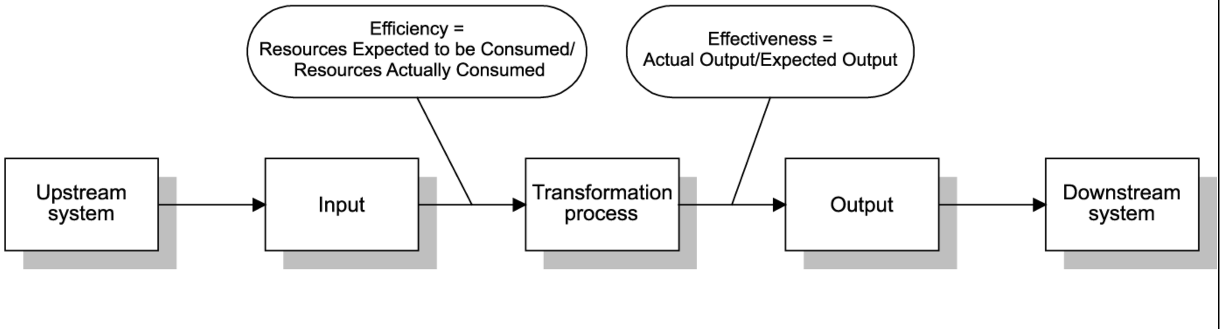


Source: Slack *et al.* (2001)

Figure 6. Organizational performance objectives (Slack et al.**,** 2001)

- Efficiency

Efficiency is connected to resource utilization and it influences the productivity ratio input. In other words in manufacturing, it describes the minimum usage of resources theoretically required to run a process compared to the actual requirement of resources (Sink and Tuttle, 1989). Another definition of efficiency is the economical measure of organizational resources employed in providing a certain level of customer satisfaction (Neely *et al*, 1995). Jackson (2000) also describes efficiency as a ratio of ideal system dependent time to total time. In summary, as stated by Sink and Tuttle, efficiency means "doing things right". The figure 7 below shows the relationship between efficiency and effectiveness.



Source: Sink and Tuttle (1989)

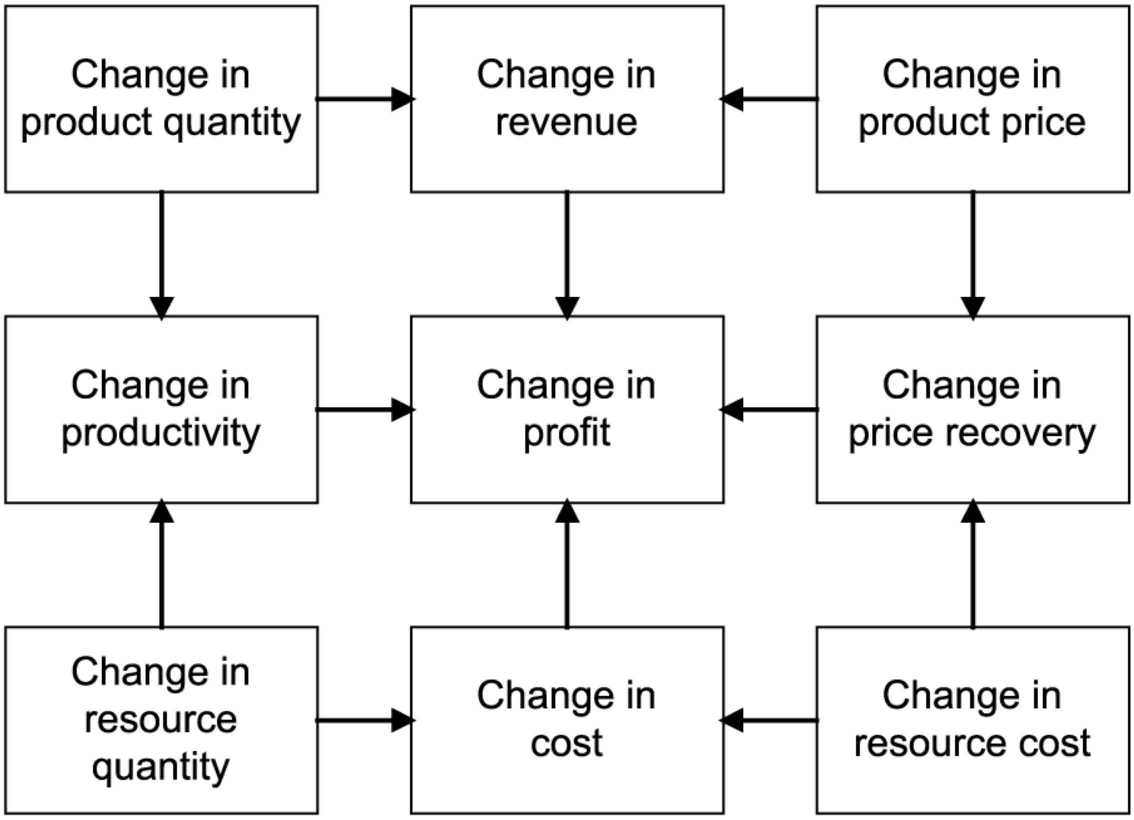
Figure 7. Relationship between efficiency and effectiveness (Sink and Tuttle, 1989)

- Effectiveness

Effectiveness is the ability for an organization to attain a desired goal. This means there is no limitation to the level of effectiveness within an organization (Stefan Tangen 2005). It can be very high or low depending on how it is defined within the organization. Sink and Tuttle define effectiveness as doing right things at right times with good quality, etc and can also be described as the ratio of actual output to expected output.. Another definition is the level of attained goals and showing how well a set of results were accomplished (Sumanth 1994).

- Profitability

Profitability and productivity terms are somehow interdependent but they do not coincide (West, 1999). Profitability can be defined as the ratio of revenues to costs. This ratio however considers the initial needs of shareholders as being the main interest group. It should be noted that, there can be a change in profit and that will not have anything to do with productivity increase or decrease, example cost or price inflation (Bernolak, 1996). An increase in productivity does not lead to profitability increase in short term but in a long-term, it is likely to do so (Tangen, 2002a). Price recovery can be used to separate profitability from productivity. The price recovery is the ratio of unit prices related to unit costs (Miller, 1984). Figure 8 shows the relationship between productivity, profit and price recovery. Figure adapted from Stainer (1997)



Source: Stainer (1997)

Figure 8. Relationship between productivity, profit and price recovery (Stainer, 1997)

4.4.1 How to improve productivity

The fact that productivity is a complex concept, improving it depends or varies from one organization to the other. In manufacturing organizations, the factors that influence an improvement in productivity may include technology, good machine or equipments, energy efficiency, hiring of skilled labour, using benchmarking and world class business tools, etc.

- Using or investment in high technological equipment (ICT)

Information and communications technology (ICT) has many meanings relating to different purposes. It is a technology, not only a piece of hardware. ICT investment not only comprises of the selection of hardware components or software but rather it includes the investment into management systems, organizational skills, strategies and structures that has the tendency of providing a return to the investor (Anderssen, H. 2006). Management systems may include solutions such as customer relationship management (CRM) and enterprise resource planning (ERP) tools. Hardware such as printers, computers, etc. and software may also include sophisticated ones such as computer-aided design (CAD), accounting software solutions, etc. Good back-up systems is an example of the operational support that can be implemented.

The composite nature of ICT can be seen from the figure 9 below.

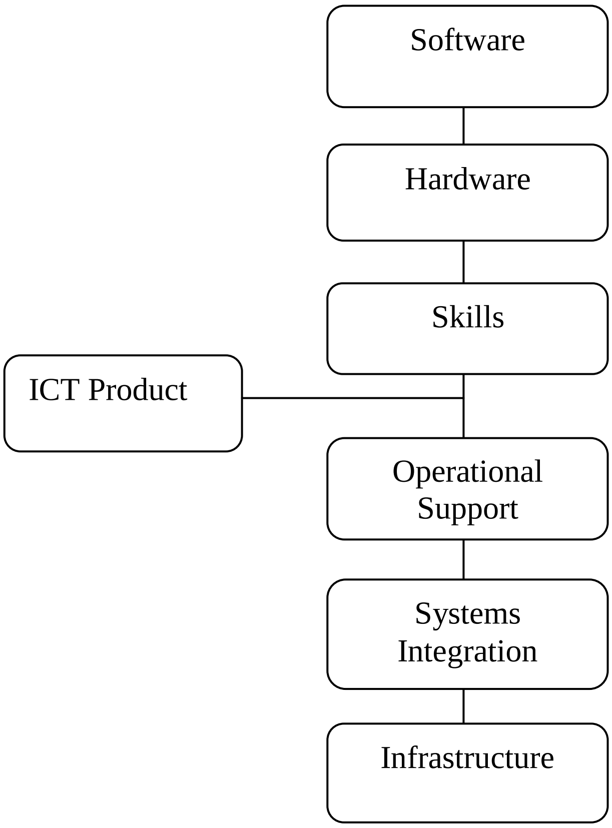


Figure 9. Composition of Information and Communication Technology

- Efficient energy utilization

Improving energy efficiency could provide a significant shot in the arm for your overall productivity. What's more, positive environmental messages, such as a reduction in the company's carbon footprint, will increase customer awareness of your company's responsible practices and generate goodwill.

- Hiring skilled labor

To increase productivity, companies have to increase the number of skilled labor. Skilled labor is the greatest asset a company has and the investment in training both on the job and off the job will provide a big impact on productivity. Quality training needs to be given to employees especially in areas where the company has identified a gap in knowledge. Furthermore, investment in management development is also very important.

- Using benchmarking and proven world class business tools

Benchmarking is the process whereby a company compares itself to another company in the same industrial category on the basis of its business processes and performance. It allows companies to understand and know how well they are doing in comparison to their competitors and thus will help in their improvements over time (Keegan, R and O'Kelly, E., 2004)

4.5 Contract Manufacturing

Many well known industrialized companies have resorted to outsourcing their manufacturing activities with the view of reducing cost and to go global. Companies such as Motorola, HP, etc have cooperated with foreign firms with the capacity of producing products at low cost but with a high quality standard (L. Feng-Hsu; L. Heng-Yih; L.Ting-Ling, 2008). Contract manufacturing can be described as an outsourcing process whereby a client outsources their product to be manufactured by a capable manufacturing company on agreed terms. Nowadays there are many contract manufacturers that originally were part of original equipment manufacturers (OEM). The contract manufacturer is known to be a specialist in producing a desired product and because of this core competencies, it has paved way for OEMs to outsource their products to contract manufacturers (source here).

4.5.1 Relationship between contract manufacturers (CM) and original equipment manufacturers (OEM)

A CM company manufactures products according to customers' requirements as stated in the sales order. Mostly, the OEM (hiring firm) contacts the CM with the manufacturing design or product. The CM is then required to produce a quote based on the manufacturing processes of meeting such an order. These include cost of materials, cost of labor, machining cost and so on. After the quotation has been sent to the OEM, they make a final decision and then a sales order is sent to the CM. The relationship between CM's and OEM can be a onetime contract to a long term contract. The table below gives the relationship types companies can engage and the amount of risk they are willing to take (Arruñada, B; Vázquez, Xosé H., 2006)

Table 3. Relationship between CM and OEM

Type of relationship	Characteristics	Level of commitment/ Cost of Control
Market agreement	Onetime engagement	Low
Renewable contract		Moderate
Framework arrangement	Agreement in principle to produce several models in a given period; payment on basis of units produced or space utilized in manufacturing facility	Moderate-High
Strategic alliance	Long-term agreement; open sharing of processes and intellectual property; adaptiveness; frequent reciprocal communication	High

4.5.2 Importance and benefits of contract manufacturers

OEMs that hire the services of CMs can reduce their direct cost considerably. Example they don't have to pay for production facility and machines needed for production. Also labor cost is not paid. CMs on the other hand also get essential investments when they work for many OEMs.

Moreover, OEMs are able to focus on their core competence also to say their most profitable business activities such as marketing, research and design (R&D), etc.

Because CMs are able to produce high quality products because of the advanced skills acquired through working with different OEMs and perhaps the relationships formed with suppliers and also acquired knowledge of production efficiency.

Lastly, the flexibility of most CMs manufacturing systems allows OEMs to replace a product with another in a very short notice. (Arruñada, B; Vázquez, Xosé H., 2006)

CHAPTER FIVE: PRESENT STATE ANALYSIS

5.1 As-Is and To-Be of the case company

The “As-Is” are identified processes or simulations that represents current situations as it is without the adding any changes or improvements. They tell or give the now picture of the case company pertaining to things of interest. The “To-Be” processes shows what could be or how a current process or situation is meant to be when certain changes and improvements are incorporated to the As-Is model. In this research it was decided by the case company to take a look at these simulations and develop an As-Is and To-Be processes. They are the manufacturing centre process, shop-floor layout and lastly most important about the machine utilization rates (machine hour study). These were the three analyses the case company is interested in finding more information about in order to help in their productivity growth.

5.2 As-Is manufacturing centre process

The manufacturing process of the case company is focused on producing in batches or as quick jobs, thus making the company a classical workshop. Some orders are very simple, as some need complex operations. The work orders move quite freely in the manufacturing process but there are some common flows that can be distinguished. (Meeting 11.2.2011, Production Supervisor). Sometimes it is deemed unbeneficial to manufacture internally which leads to buying as ready-made from a supplier, and the product going straight to the customer or the finished products storage. (Meeting 4.1.2011, Sales Manager). A description of the manufacturing process is given in appendix 2 in the form of a process chart. In this chart the manufacturing process is divided into four parts: Stage 1 - Start of the production, Stage 2- Main stage of transformation, Stage 3 - Part finishing, and Stage 4-Finishing production. In appendix 3 the corresponding machines and processes are listed and in appendix 4 the manufacturing layout is presented. Next details are given on the steps of the manufacturing function.

Stage one – Start of manufacturing

Production supervisors and production planning together give the instructions for the manufacturing of a job or batch. One of the production supervisors then inserts the necessary guidelines to the IT-system in order for the workmen to perform the manufacturing process. (Meeting 11.2.2011, Production Supervisor). The manufacturing of a batch or a quick job then proceeds in stage one with two available options:

1. As raw-material retrieved from the raw-material storage. This raw-material is basically a piece of the required metal. This raw-material needs first sawing and possibly clearing before advancing to the machining phase.
2. As semi-finished material which is bought from a supplier that prepares the material so that it goes straight to manufacturing phase two's machining. (Meeting 4.1.2011, Sales Manager & Meeting 11.2.2011, Production Supervisor).

Stage two – Main stage of transformation

In phase two the main transformations to the unfinished products are done. The CNCmachining is done in the CNC turning-lathes and the multitasking machining centres (Case company 2011a). However, the manufacturing can also be done as manual machining with older machines. The manual machines are able to grind, turn, mill, drill, and press which makes them still usable. These machines are used quite infrequently. Sometimes the manual and CNC-machining are both used. (Meeting 11.2.2011, Production Supervisor). From the machining the process sometimes continues to hardening, chroming, or to some other external service basically aimed on transforming the product properties. The hardening is almost always done, and the chroming always as subcontracted work. Very rarely the hardening is done in-house with the hardening cart. (Meeting 11.2.2011, Production Supervisor).

Stage three – Part finishing

In stage three the welding and blasting/washing are done, if needed. These steps are interdependent and change priorities often based on requirements. Sometimes the welding comes first and sometimes the blasting/washing, or sometimes neither is needed. From welding and blasting/washing the unfinished product goes to the painting room and stays there for drying. (Meeting 11.2.2011, Production Supervisor).

Stage four – Finishing manufacturing

Stage four of the manufacturing process starts with the assembly. This means combining different parts and also sometimes welding, blasting/washing, or painting for the final product to be completed. The assembly basically gathers up the parts of the previous work done and combines them to make the final product. Finishing the assembly means that the product leaves the transformational part of the manufacturing. (Meeting 11.2.2011, Production Supervisor).

After the assembly is done the work is sometimes documented. The documentation means that the production supervisors insert the needed information to the IT-systems which includes: finishing the work, taking photographs to give proof of the condition of the products, setting guidelines for the future equivalent jobs, and giving the office information to enable better management. (Meeting 11.2.2011, Production Supervisor).

From the documentation the finished products are moved on to storage. There they are either packed for delivery or stocked for future need. If the products are specified to need final testing it is mainly conducted in-house. Especially the lifting devices need to be tested for ensuring the safety of the end-customer. Also pressure tests are conducted on need. (Meeting 11.2.2011, Logistics Manager).

The current production process is good but there is still room for improvement. The above explanation of the process was provided by the Production Supervisor. Figure 10 below gives the graphical representation of the flow chart for easy understanding.

Current production process flow chart (As-Is)

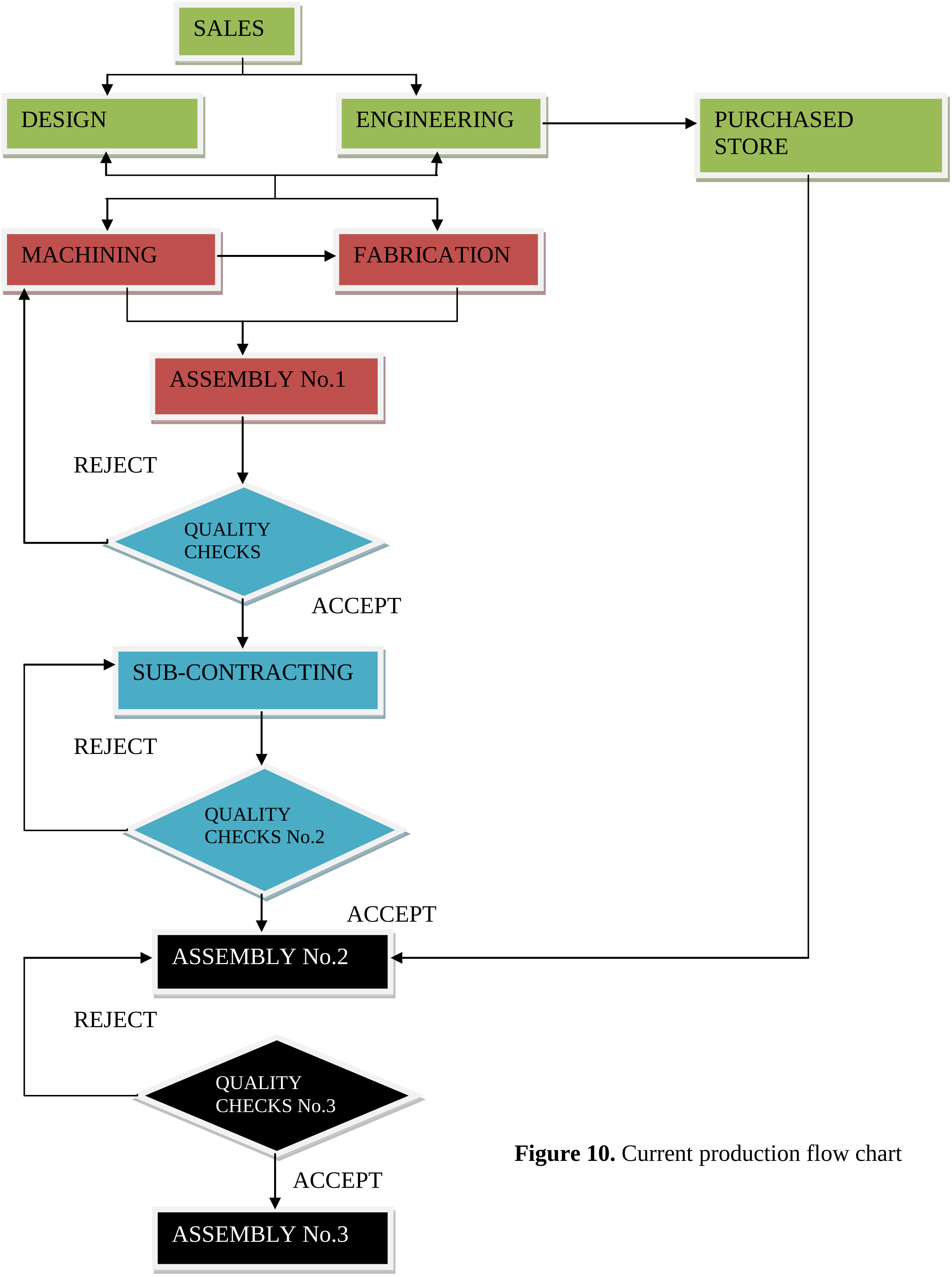


Figure 10. Current production flow chart

Stage one comprises of the sales, design, engineering and store. The sales comprises of three activities which can be performed, the sales can release an order that has come from a client/customer, and this normally involves a drawing design the second activity concerning sales could be purchasing the product from another company if they find it cheap to do so. In this case the drawing is given to another company for a fee. The third activity involving sales is to order materials or services needed to do the work if not already available. From the sales then decision is made on going into design or engineering. Design is generation of drawings for the manufacturing of the product. Engineering involves the input from the production planner to schedule the job and plan to accomplish the task. Store represents the purchasing of materials or parts to be used for the manufacturing of the product and this stage commences after the design or engineering has been completed in this stage.

Stage two involves the machining which includes activities such as bending, drilling, blanking, etc. Fabrication activities include welding, cutting, grinding, etc. From any of these processes then the product moves to the assembly stage and this is the first structural assembly of the parts if needed.

Stage three involves subcontracting and two quality checks. The first quality check is immediately after the assembly in stage two and is normally a dimensional check of parts of the product. The second quality check is after the product has been subcontracted to another company to perform operations that are not than in the case company or it will cost cheaper to perform it elsewhere. Some of the activities performed by subcontractors are hardening and heat treatment of the metals. The quality check performed after subcontracting is mainly to inspect the work done by the subcontractor.

Stage four involves the final assembly of parts after it is accepted in stage three. This is assembling the product and it is followed by an operational performance quality check to see if the product is well capable of doing the work it has been created to do. Normally a series of testing is provided to see its durability and agility of the product. Acceptance will then send the product to final assembly which is to pack and ship to the customer. After this stage documentation is done if necessary by the production supervisor.

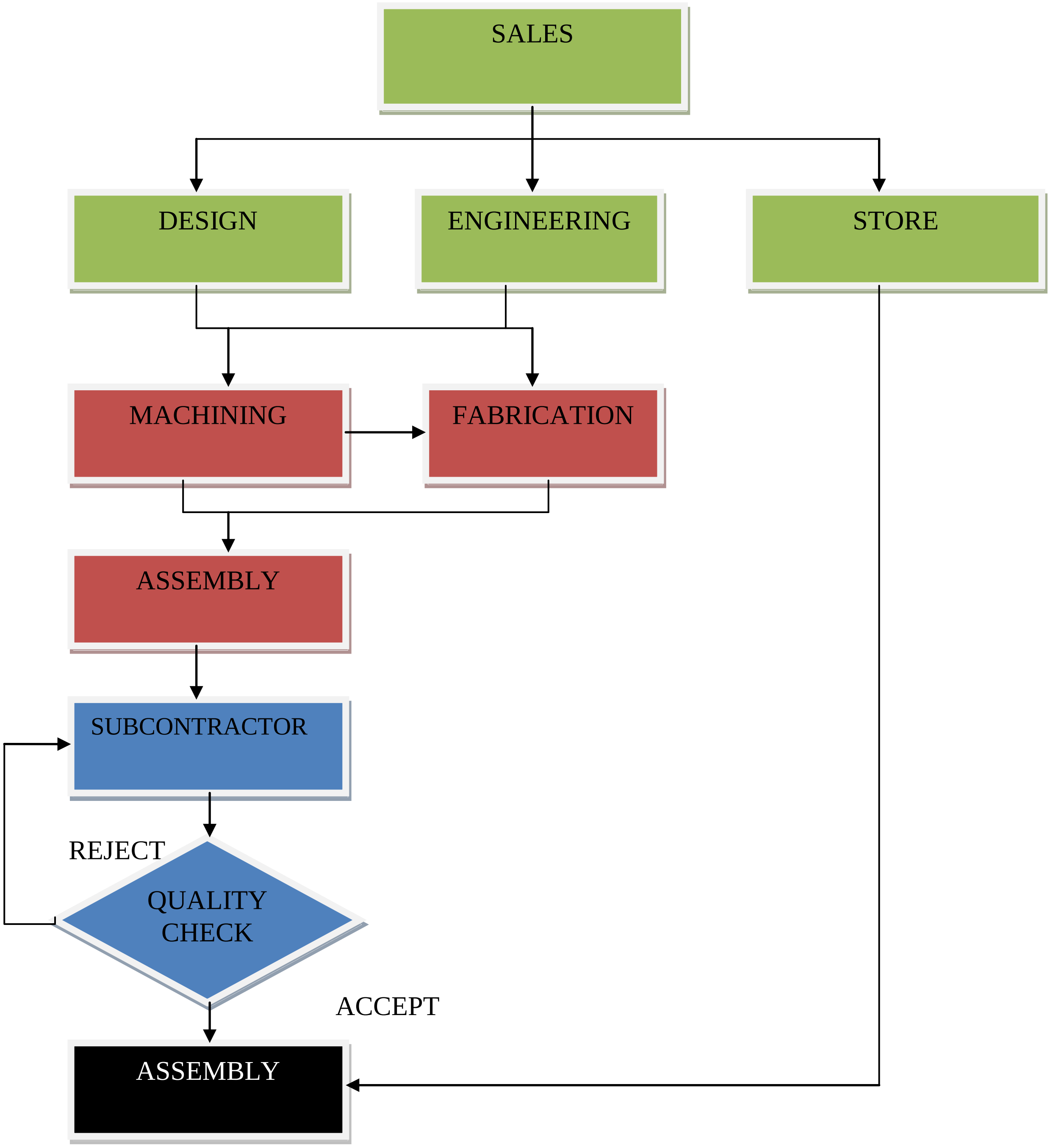


Figure 11. Proposed production flow chart

5.2.1 To-be proposed manufacturing process flow chart

Figure 11 above provides the graphical representation of the proposed flow chart or simply the To-Be model. This model takes advantage of reducing the steps involved in the production of a product. Operational activities in stages three and four of the process have been reduced to two and one respectively. Now there is only one quality check operation to be performed after the subcontracting operation and this is essential because the job has been done outside of company walls. The rest of quality checks has been incorporated into the operations in stage two (Machining and Fabrication) and lastly in the final assembly of products. The ability to do in-process quality checks at these operational activities saves time in the process flow chart and it also has the ability to spot defects quickly before moving into a different operations. It also helps the Production Supervisor responsible of documentation to keep track of each process well avoid neglecting of important notes. This proposed flow chart has the tendency to have shorter manufacturing lead time.

5.3 Shop-floor layout (As-Is)

The shop-floor layout can be seen from Appendix 1. There are three different sections where manufacturing of products take place. Layout 1 is the first manufacturing shop-floor that was created during the start of the company; we refer to it as the old side of manufacturing. Layout 1 houses most of the manual CNC machines and also we will find the painting room, welding space area and the blowing locker.

Layout 2 is the second manufacturing floor of the company and is referred to as the new manufacturing side. This side of the shop-floor was built to be able to acquire new machines for expansion. Production spaces 1, 2, 3 and 4 are part of the old building that was built during the start of the company. This area houses all the CNC machines both old and new ones. The name new manufacturing side basically refers to the introduction of CNC machines. Production space 5 however was the new space created to add a new machine to the production line. In layout 2, you will also find the testing room or space where finished manufactured products are tested and assembled for shipment.

The current layout was done without any thought of expansion in the future; no preplanning as a result new machines are just added to where there is space. And this has been done over the years. This kind of layout has a negative effect on process flow of materials during production. Some of the identified negative effects are:

- There is too much travelling on the shop-floor
- The flow of manufacturing products is not smooth and continuous
- The work environment sometimes becomes dangerous because there is not enough space for in-process products to be placed
- Lack of maximum utilization of purchased machinery and some inventories

5.3.1 Changes to shop-floor layout (Proposed new layout): To-Be

Considering the high amount of cost involved in major re-layout of the shop-floor and re-positioning of some machinery, the proposed layout doesn't take into account such design involved in the movement of CNC machines. Rather the proposed layout considers changes that involve minimum positioning of equipment in only some few areas of the shop-floor. The first major layout is to:

- Move the "Testing Room" in layout 2, where currently assemblies of products are done to the warehouse of the company. In this way, because from the process flow chart after final assembly comes storage and shipment of the product
- Relocate the computer the employees use to record work-in-process from the "Changing Room" in layout 2 to an open place on the shop-floor. We recommend moving it into the space area that will be created if "Testing Room" is relocated
- Creating a "Tool Room" where all tools can be located for easy accessibility. Suggestion: Should be located in layout 2 "Testing Room"
- In layout 1 (Manufacturing old side) unused machinery should be removed to create space for accommodation of a new CNC machine or perhaps a whole new production unit should be located there example welding unit.

This proposed layout has the tendency to increase productivity by decreasing the amount of time spent moving on the shop-floor, especially in such of tools. Also there will be a continuous and smooth flow of materials at the shop-floor. Furthermore, there will not be any hazardous operation going on in walking areas especially at the "Testing Room". Testing Room and assembly should be at a place where there is minimum movement of personnel.

5.4 Machine hour study (As-Is)

The objective of the machine hour study was to find the current rate at which the machines at the shop-floor are being utilized and to find why they are running at this rate and what corrective actions could be put in place to increase the productivity.
The machine hour study was done by developing a work sheet see (Appendix 2). This work sheet template is placed on each machine at the shop-floor so that the worker can record the activity he is performing at that time. The study was conducted into two periods, Period 1 and Period 2 each taking a capacity of 23 working days.

- Designing the template

In designing the template through discussions with the respective staff we made a template that will take less time to fill in and also easy to understand by all personnel. We identified the main processes that are done in manufacturing and represented it as the "Activity". They are: Sawing, CNC-machining, Manual machining, Painting, Welding, Hardening and Testing. The rest of the parameters to be filled in are:

Machine number- This is the name of the machine that is in use.
Date – This is day of the work being done
Setup Time – This is the time to prepare the machine for production. This include the time taken to program the machine, changing and sharpening of tools, etc
Start time - The time the actual work commences or starts
End time – The time the machine stops completely from production
Breakdown time – It is the unplanned time when the machine stops or it is deliberately stopped by the worker to address conditions beyond his control
Work number – The number assigned to the work being done on a particular product
Drawing number – The number related to the drawing sheet of the product being produced.
Amount – This is the number of articles or products worked on in a particular time frame
Other notes – This represents other information worth considering in accessing the machine hour study.

This model was developed to check the utilization and efficiency rate of the machines.
Formulas:
Machine Utilization = Actual running time / Machine available time

Machine Efficiency = Standard machine running time / Actual running time

Machine Effective Utilization = Corrected machine running time / Machine available time

Explanation of parameters in formulas:

Machine available hours/capacity Hours is *scheduled hours * number of machines*. From the case company, the capacity hour used is 8 hours / day. Therefore the whole period of the study, the machine available time is 8hrs * 23 days of study.

Management breakdown time - This is the official breakdown time for the machines. This also includes planned maintenance. In this study we use only the known official lunch and coffee breaks that is a total of 50 minutes to represent the management breakdown time.

Actual machine running hours recorded is the real running time of the machine, producing parts minus management breakdowns. In this study only the lunch and coffee breaks were taken out 50mins/day

Standard machine running time is the time you get or final capacity when you correct all breakdowns i.e. Idle machine time example: waiting for work, tools, no operator, etc and machine ancillary time example: cleaning of the machines and surroundings, set-ups, etc from the production including management breakdown time of 50 minutes in this study. For this study, due to the limitations we faced in acquiring all correct breakdown times, the only other correct ancillary time recorded was the set-ups and this was also deducted to get the standard machine running time.

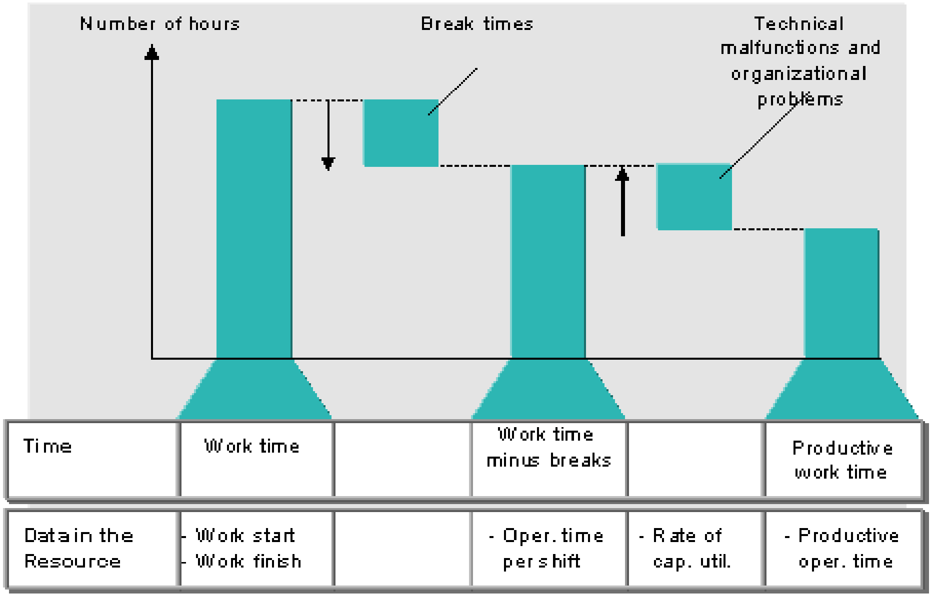


Figure 12. Shows how effective productive work is achieved from start to finish

In order to analyse the results, machines being studied were grouped into categories based on the machining processes. We grouped them into 10 different categories. They were grouped in this way to make it easier to assign process cost to them that will be used in the sales tool. Appendix 3 shows the grouped machines and processes.

5.4.1 Results of the study

- The results of the machine hour study could be found in Appenndix 4. The results focuses directly on the utilization of the machines because that results will be used in the calculation of the cost of machine usage which inturn will be used in the sales tool (bidding calculator). Looking at the results we could see that there is a low utilization percentages for the machines, especially the CNC-machines. These machines are the ones that do most of the work in the company and the most expensive too. Applying 20% corrected percentage error to the sudy the rate drops further and this result is well accepted by the shop-floor supervisor as being realistic. Theoretically this allowance consumes approximately 15-20% of machine running time (Kesavan, R; Elanchezhian, C. & Vijaya, B., 2009)

- From the results we also noticed that the set-up time for the machines is extremely high in comparison to the standard machine running time. Almost at a rate of 45% for the highest recorded.

5.4.2 Implications

With these results it is clearly to see that the machines are not running at a full capacity as it was built to do. With this in mind, to improve productivity in this area, we considered tackling what needs minimum change but would have a drastic improvement change on productivity. To answer this question of improvement we asked the question “Why is there a low utilization rate?” From discussions with the shop-floor supervisor and other employees we were able to identify some reasons. Some of the reasons suggested were:

- Sometimes there is lack of operators on a machine. From personal observation, two machines are sometimes operated by a single employee
- Machines are sometimes waiting for a job to be performed. This can be due to lack of new contracts for jobs to be performed on the machine
- Repairing activities also have an influence on the low utilization rate. When there are no fixed maintenance schedules, machines have the tendency to break down at anytime and this results in low utilization rate
- Low utilization rate also results from machines having to wait for consumables such as tooling and fixtures
- Waiting for set-up to be completed

Among the reasons discussed we realized that the set-up reduction needs attention to know how to effectively reduce it to help increase productivity. The rest of the reasons, solving it could be done by having a proper planning schedule and that is the duty of the work schedule manager.

We decided to investigate on set-up reduction processes. And this will form the bases of our To-Be of the machine hour study.

5.4.3 Machine hour study (Proposed recommendations to improve results)

In order to propose recommendation for set-up reductions, we took a look at a typical set-up process at the shop-floor for a particular machine. In our observation, we realized there are four main steps to get the machine ready for work. The first stage is the preparation stage. This involves getting the information of the work that needs to be done and in this case the drawing sheet of the product. After having the drawing, there is a little bit of studying particularly if it is a new product to know how to proceed. The tools and all necessary items to make this product are fetched.

The second stage usually involves getting rid of old parts, tools and materials that are in the CNC machine that is going to be used for the new work. Normally, machines are cleaned to remove metal shaving from previous work when the day is over.
The third stage is the setting stage. This involves the positioning, calibration and measurement of the material to be produced.
The last stage involves running trial runs and further adjustments to the CNC machine. If the trial runs are successful then work can begin with the rest of the products to be produced.

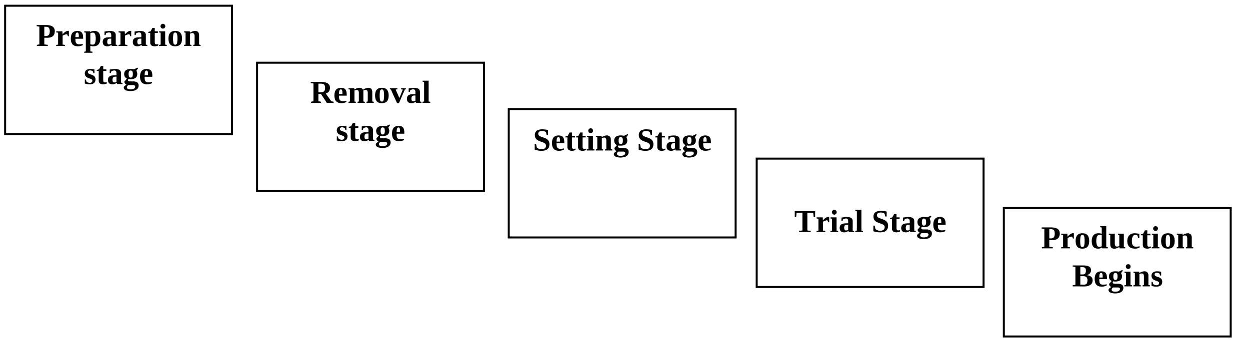


Figure 13. Set-up execution stages at the case company

After identifying the set-up process currently practiced, we asked why it takes too long to go through these stages. The following are some of the reasons that came up through personal observation and interviews:

- Programs sometimes contain errors in them. When this happens it needs to be fixed before any work can be done
- It takes a considerable amount of time for the operator to study the work to be done especially new drawings
- There is the problem of inadequate tooling. Sometimes there are not enough tools available for to be fixed in one machine for a particular job. When this happens part of the work is done and later when the tool is available the other part is done which could have been avoided if all the tools were available at the same time.
- Long searches for correct machining tools. Some of the tools are not properly labeled or marked for the operator to easily identify. This makes inexperienced operators to go around asking if the tool can be used on the job being done or not

- There are too many different set-ups in a day for a machine. This is due to few articles but long set-up times
- Only a handful of the operators know how to program the machines. So they have to wait for their machines to be programmed before they can start work.
- Operators don't have a systematic order of working. They perform tasks in any order just to get the job done, in other words they work in their own way.
- Necessary supplies are not organized well and are poorly located at the shop floor.

5.5 Using SMED to reduce set-up times

When there is a high set-up time in a manufacturing process, it means the company is being less efficient and losing money. The objective of SMED is to reduce set-up time in a manufacturing process. SMED stands for Single Minute Exchange of Die. This method was introduced by Shingo in 1950's in Japan and was adapted by Toyota. There are different steps involved in the implementation of SMED to increase productivity and reduce waste. The major steps are taken from the major books by Shingo, S on SMED System, articles and websites dedicated to lean manufacturing.

5.5.1 Set-up time reduction process

1. *Separating tasks into internal and external*

An internal task represents tasks that are performed or can only be performed once the machine is stopped from operating. Example is removing a part or tool from the machine. External tasks are performed when the machine is still running. Example is obtaining work instructions for the next task to be performed. These two different operations and processes have to be observed carefully and documented well. During documentation, all other activities that don't add value to the activities should be classified as waste. Examples are searching for tools and unnecessary walking.

2. *Convert internal to external tasks*

The main objective at this stage is to perform all external tasks while the machine is running. In other words advanced preparation has to be done for the next task. Examples include collection of tools, consumables, drawing sheets, sharpening of tools, etc. before the next activity starts.

In order to achieve this, there has to be some analysis of the processes and this could be done through video recordings. There is a need for timely recordings of hand and body movements, recording of actions and to breakdown elements/processes into internal, external and waste.

Lastly, to brainstorm about the classifications of the processes whether it is useful or not

3. *Streamline all aspects of the set-up*

This stage deals with the improvements of the grouped tasks which are external and internal tasks. Some of the improvements that could be made to internal improvements are:

- using more than one operator to eliminate unnecessary movements
- use locating pins and sockets to eliminate adjustments
- use standardized die height
- use quick-release fasteners instead of bolts and nuts
- Improved team work(Olofsson,2009)

External improvements suggestions are:

- using checklist to avoid omissions or repetitions
- using visual control principles like colors and bold text to identify tools, storage stations/materials, etc.
- organize work place to be the same at all stations so that when there is a change of operator, they will quickly adapt to the new station

4. *Eliminate adjustments*

This is one of the main time wasters in manufacturing. Operators are suppose to test and see if the they have reached the correct cutting of the job they are doing so they need to measure it all the time. The following points are some of the suggestions that will help to reduce or completely eliminate adjustments

- establishment of reference points to minimize trial and error
- fixing settings by calibration of equipment
- creating standard spacers for heights
- positioning pins and metallic dowels to locate positions quickly

5. *5S implementation (Highly recommended):* This involves implementing good housekeeping and workplace organization and lastly having a clear and precise Standard Operating Procedures (SOP) to help improve consistent setups.

The most common improvement that could be seen from the proper implantation is the reduction of downtime and the reduction of waste. There are other additional benefits that come from having a proper SMED implementation. The following as some benefits of SMED

- Higher machine utilization

- Higher production throughput
- Reduced start-up waste and rejects
- Less inventory
- Better quality
- Better safety measures due to following proper change-over procedures
- Less skill is required in operating the machines due to simplified and standardized work process

5.5.2 The 5S methodology

The 5S methodology is thinking and a way to organize and manage the workplace by removing waste. Is an effective tool to create and maintain well organized, effective, clean and high quality workable environment. This methodology was developed by Hiroyuki Hirano. The 5S methodology is also referred as the five pillars of the visual workplace. From the article by Michalska J. and Szewieczek D., (2007) they are:
Sort (organization)
Set in order (orderliness)
Shine (cleanliness)
Standardized (standardized cleanup)
Sustain (discipline)

Sort: This is a practice of keeping only important items by sorting through tools, materials and so on at the shop-floor. This practice leads to fewer hazards and much less clutter to increase productivity. Through sorting, raw material wastes and other materials, nonconforming products and damaged tools can be removed to maintain a clean workplace, increase efficiency in searching and receiving of materials and thereby shortening the running time of operations at the shop-floor. In implementing the sorting methodology certain questions needs to be answered to facilitate the process.
- Are unnecessary things causing the mess in the shop-floor?
- Are unnecessary remainders of raw materials thrown anywhere in the shop-floor?
- Are all necessary things sorted, classified, described and possess the own place?

These are some of the many questions that could help in the elimination of waste in the sorting process. Advantages of this methodology include stock decreasing, better utilization of floor space, and prevention of losing working tools and process improvement by reducing costs.

Set in order: To promote a smooth work flow, tools and equipments has to be orderly kept. The set in order methodology is used to achieve this productivity. This method could be used especially in visualization of the shop-floor. Examples are painting the floor to help in the identification of transport routes, storage areas for materials, drawn out shapes of tools to make it easier to place and remove and many more. Examples of questions to ask before using this methodology are:
- Is position (location) of the main routes and storage facilities and places clearly marked?
- Is anything kept in the area of devices against the fire?
- Are there any floor cracks and other irregularity that can or are causing operator's movement?

Advantages related to this rule are safety improvement, decreasing time for searching of materials and tools, increasing effectiveness and efficiency of the workers

Shine: Example of the control questions in this rule are:
- Are sources of light clean?
- Are the machines clean?
- Are the oil's stains, dust or metallic remains found around the position of the machine or anywhere at the shop-floor?

This application of this rule relies much on the operator of a given workstation to daily keep it faultless and clean. This regular cleaning permits to easily identifying faults such as leaking oil pips, blocked drainage, etc. and helps in eliminating sources that can cause disorder. Elimination of probable accidental reasons, maintenance and improvement of machines, devices, quick identification of potential sources of damage are some of the benefits of the shine methodology.

Standardize: This methodology provides control and consistency at the shop-floor. Standards need to be set for basic housekeeping so as to apply it everywhere in the facility. Developed standards should be clear, communicative and easy to understand by every worker at the shop-floor. Standards should not only be developed for operational processes at the shop-floor only but it can also be used in the administrative processes, example, customer services, management accounting (book-keeping), etc.

Sustain: This last methodology has to deal with the self-discipline of the employees to change from their old ways to adapt and maintain the new implemented rule. To maintain the focus unto the implemented 4S methodology, regular inspection, checklists for 5S activities could be developed to serve as a control tool to allow the employees not to decline back to their old ways of operating. This rule provides the advantage of increasing the awareness and morale of the employees and decreasing of the number of mistakes, improvement of communication processes within the facility and lastly inter-human relationship improvements.

CHAPTER SIX: MAKING THE SALES TOOL

6.1 Original Sales tool description

The case company has used a bidding calculator for the offering calculations. The bidding calculator is an excel-format template which consists of the controller and the calculating table. An example calculation and the template can be found as appendix 5. The offer calculation in the example has three components.
The calculator first calculates the direct labor used in the manufacturing function steps.
The set-up times are separated from the normal machine driving time, thus allowing quantity discounts with less labor costs per product. Next the direct material costs are added up with knowledge of quantities and supplier prices. The direct external services are summed up as separate fees. Some special fees can be added after this, as the calculator is made on a flexible excel –template. This signifies that the used costing method is the job order costing with no separate common cost allocations made.
The calculating table then calculates the costs per piece and the total costs for the order, which means the amount of pieces multiplied with the costs per piece. The calculating table next places a desired margin on top which covers the presumed common costs and provides the aimed profit. The above mentioned factors indicate the usage of marginal plus pricing, as the margin is aimed on covering the variable costs and the profit targets.

6.2 New designed sales tool

The new designed sales tool or bidding calculator was designed with Microsoft excel as the previous calculator. The reason for using this software is that it is easy to use as compared to other programs and it could be easily learned, and that helps when one wants to make upgrade the calculator.

In designing the new sales tool, the sales manager was interviewed to get his view of how he wants the new calculator to look like and how he wants it to function since he will be using it most of the time. The main points that were addressed were the physical outlook of the sales tool –all parts should be visible in a page with for easy viewing including the summary sheet where results are displaced. Another important task is to create dynamic detail sheets where they can easily update price changes and other necessary updating. The rest of the request concerning the new sales tool has to have an appealing look.

6.2.1 Description of different parts and usability of the new sales tool

The sales tool has been designed to function primarily as a cost estimator. It is a tool the sales manager uses to quickly and efficiently estimate the total cost of a product in order to secure a bid. The sales tool and all its necessary documents and files have been placed in one folder. Inside this folder the "Sales Tool Index" file and twelve other folders which are Bid Status Database, Budget BC20, Budget BC25, Budget BC33, Budget WC20, Budget WC25, Budget WC33, Clients Database, Direct Expense Database, Materials (Raw materials database), Operating Database and Personnel Database.

The "Sales Tool Index" file is the link to accessing the sales tool template. On opening the file, the user has the chance to select which activity to perform with the sales tool. There are three different groups of activities that could be performed by the sales tool. They are:

- Choose budget category to prepare tender/bid
- Update databases or detail sheets
- Miscellaneous workbooks

Choosing budget category to prepare tender/bid

There are currently six different budget categories the user can select in order to perform a cost estimation of a product. They are worst case (WC) budgets including 20, 25 and 33 and best case (BC) which is 20, 25 and 33. The figure below shows the different budgets to choose from.

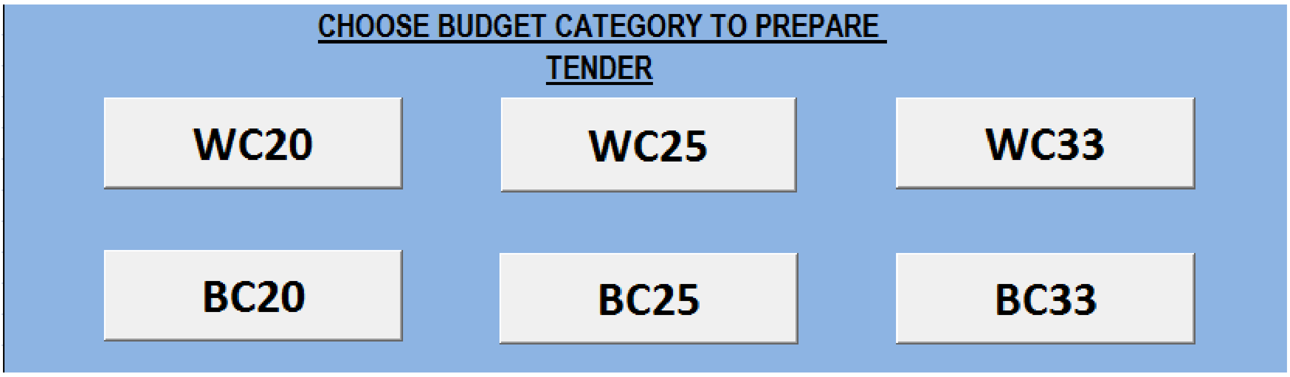


Figure 14. Index to choose budget category to prepare bid

Note: Before you can select a budget to perform the cost estimation, you must first enable the contents of this spreadsheet. By default the macros is always disabled. The arrow in the figure 15 below shows where to enable the macros.

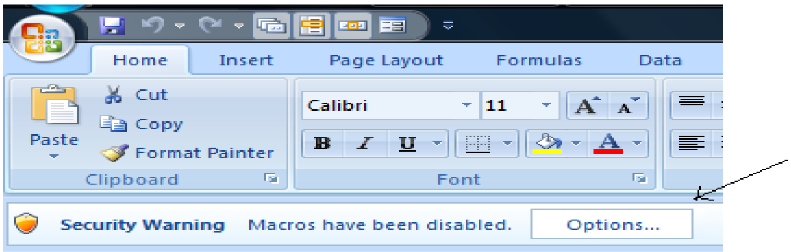


Figure 15. Showing where to enable excel macros

Making a product cost estimation (using WC20 as an example)

Upon opening the "Budget WC20" a default message in the figure below appears on the screen. This message appears because excel has detected that the worksheet contains other links which are closed or unopened. Solution: Simply ignore this message by clicking on the "close button" or "Continue".

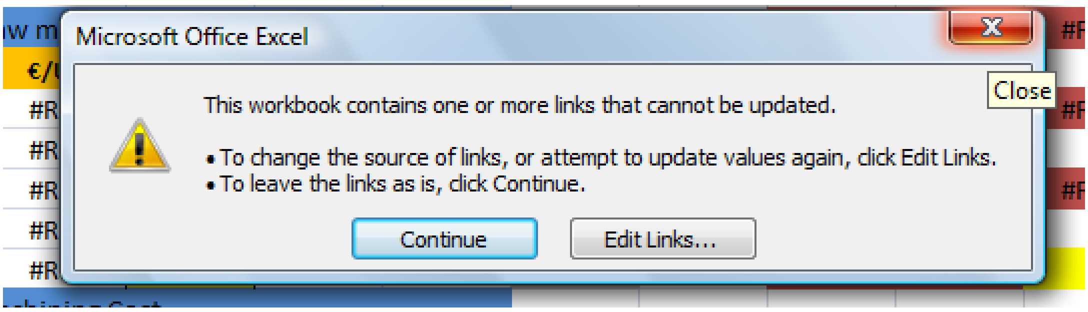


Figure 16. Message warning upon opening workbook

Different parts of the estimating sheet

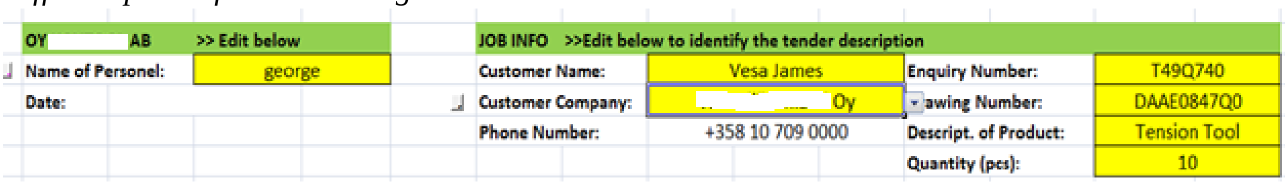


Figure 17. Bidding/tender information

The figure 17 above shows the top part of the estimating sheet. In this section the user is required to fill in some certain details concerning the tender description. They include the

Customer Name which is mostly the representative of the company offering the bid.

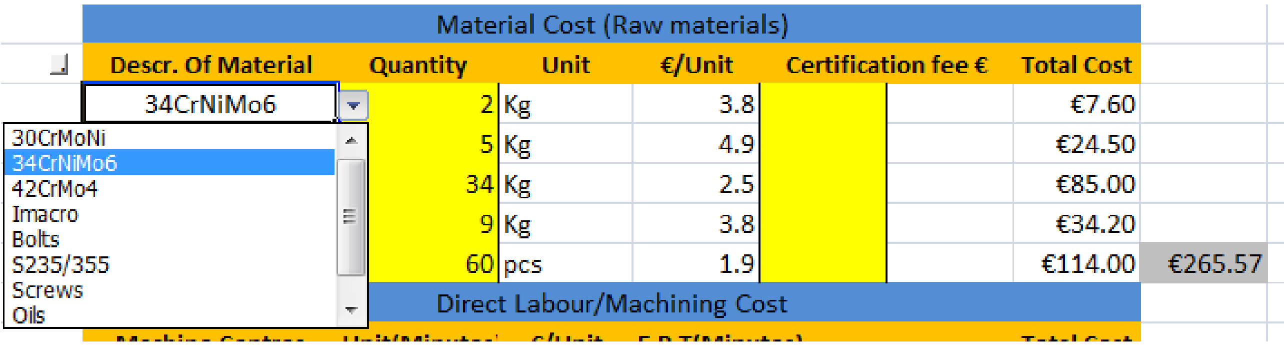
Customer Company, this is the name of the company the bid is being prepared to.

Enquiry Number is the tender/bid number which is mostly given by the client company.

Drawing number is the number of the detailed drawing of the product to be produced and in this case, tender being prepared for.

Description of Product gives the name or easy identification of the work being done.

Quantity (pcs) provides the information on how many articles or pieces the product in question.



Material Cost (Raw materials)						
Descr. Of Material	Quantity	Unit	€/Unit	Certification fee €	Total Cost	
34CrNiMo6	2	Kg	3.8		€7.60	
	5	Kg	4.9		€24.50	
	34	Kg	2.5		€85.00	
	9	Kg	3.8		€34.20	
	60	pcs	1.9		€114.00	€265.57
Direct Labour/Machining Cost						

Figure 18. Material cost section of the calculator

The figure 18 above shows the Material Cost (Raw materials) section of the estimating sheet. In this section, we have *Description of Material; this* gives the user a chance to select the material (mostly raw metals) to be used in making the product. When material is selected from the drop-down menu, it automatically provides the *Unit* and the *€/Unit* cost of the selected material. The user only has to fill in the *Quantity* based on the detailed drawing description of the product. *Certification fee* is an additional fee that may be included in the material cost. This shows the genuinely of the material in question is included if the client requests for it. Lastly the *Total Cost* which gives the cost of the different materials to be used in total and is represented in the cell with the gray color background.

The figure 19 below shows the Direct Labor/Machining Cost. This section includes the *Machine Centre* which can also be selected from drop-down menu. In selection it also provides the *€/Unit* price for each centre. The *Unit* is provided in minutes. This price is a sum of both the machining time and labor hours of the employee operating the machine. The user then have to input the time in the *Estimated Processing Time (*E.P.T*)* which is in minutes and after that *Total Cost* is calculated automatically also provided in gray colored background cell.

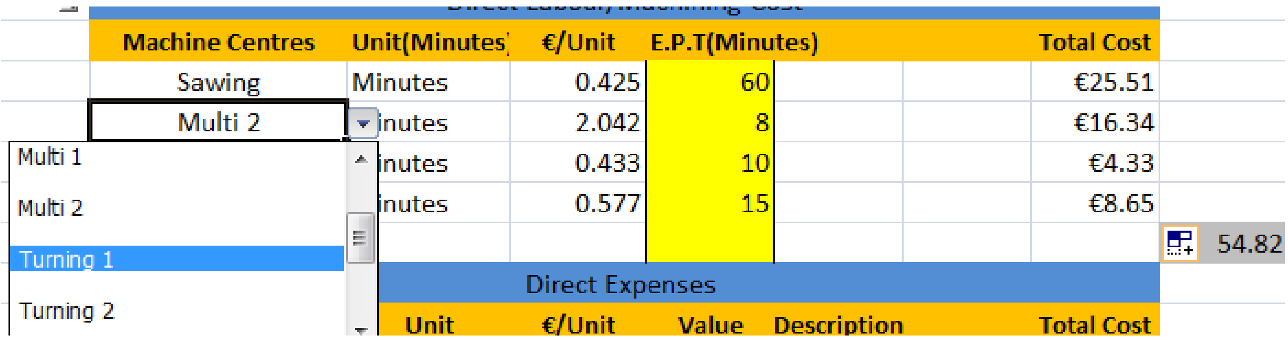


Figure 19. Direct labor/Machining cost section of the calculator

The next section is the *Direct Expenses* section. These include provision of freight services, special purchased services and tools that are not provided in house. The different *Direct Expenses* could be found from the drop-down menu in the section. The user only has to provide the *Value* of the expense type.

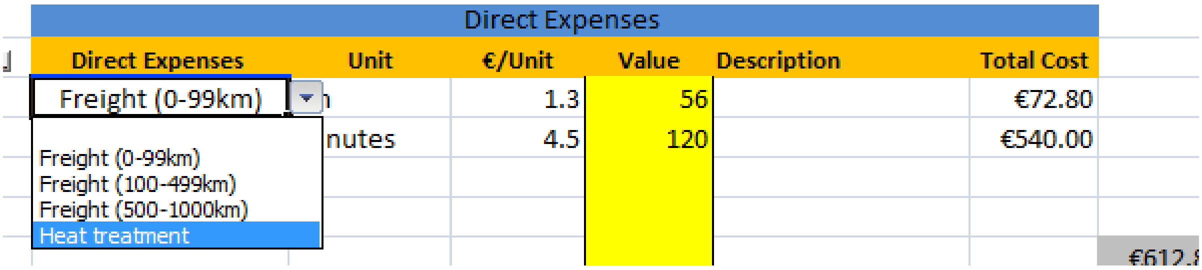


Figure 20. Direct Expenses section of the calculator

The next figure 21 below shows the *Various Overhead Expenses* section of the estimator sheet. This section includes the different expense categories like factory expenses, administrative expense, selling expenses, distribution expenses and miscellaneous expenses. Due to lack of specific value for each expense category, they have been assigned a single percentage value that has to be provided by the user.

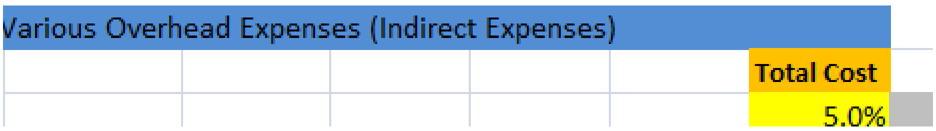


Figure 21. Various overhead expenses (Indirect expenses)

The next section in the estimation sheet is the cost overview where the calculated value of the product is being displayed. In this section, we have the:

The Prime Cost which is the total of *Material Cost*, *Direct Labor Cost* and *Direct Expenses.*

Total Cost per piece is the *Prime Cost* + *Various Overhead Expenses*

Total Cost of Job is the cost per piece multiplied by the quantity of articles (pieces) to be produced.

Profit Margin/Mark-up % this is the proportion of total cost represented by profit. Note: the profit margin percentage should not go below twenty percent (20%). There is a notification that pops up anytime the user wants to set the profit margin. The next figure 22 shows an example of this.

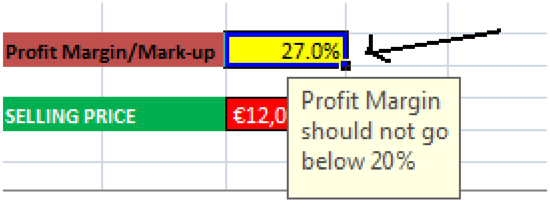


Figure 22. Profit margin section/selector

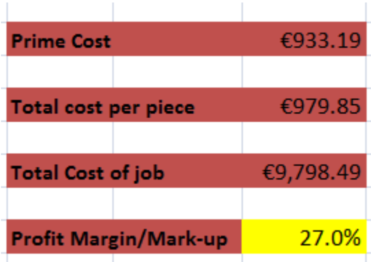


Figure 23. Cost overview of the estimation sheet

The next important section of the estimation sheet is the *Selling Price*. This gives the final amount of the overall job estimate. The formula: **Selling Price = Total Cost x (1 + Mark-Up Percent)** (Holland R,1998) Notes: The background color of the selling price cell turns "red" whenever the amount exceeds €10,000.00 This is an indication that the CEO has to be noticed for approval of tender/bid price.

The last part of the estimation sheet is a pie chart that shows the cost proportion of the tender/bid. This helps the user to quickly view the prices of each area of the total cost estimation.

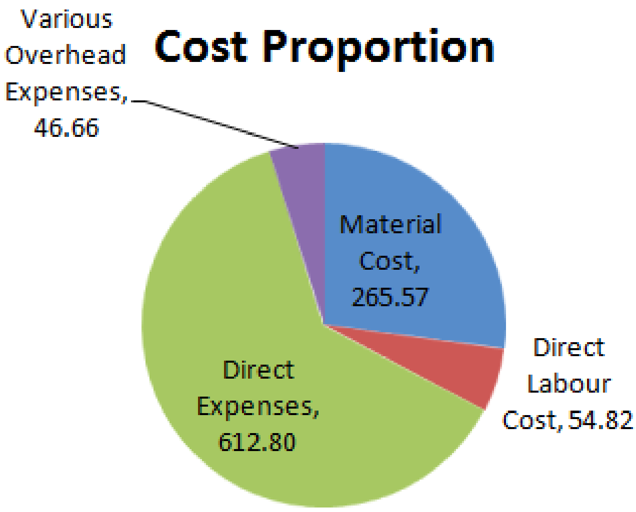


Figure 24. Pie chart showing cost proportion of the calculated bid

Additional Notes:

- The user of the cost estimator has to fill in only the yellow colored marked cells.
- There are linked buttons next to each estimation section in order to compute the cost. Excel cannot access closed sheets so every time the user wants to compute in a particular section, he/she has to click on the button to open the file in order for estimation sheet to do the computation. The figure shows where the button is located (where arrow is pointing to!).

Figure 25. Link buttons to open closed sheets

Update database or detail sheets

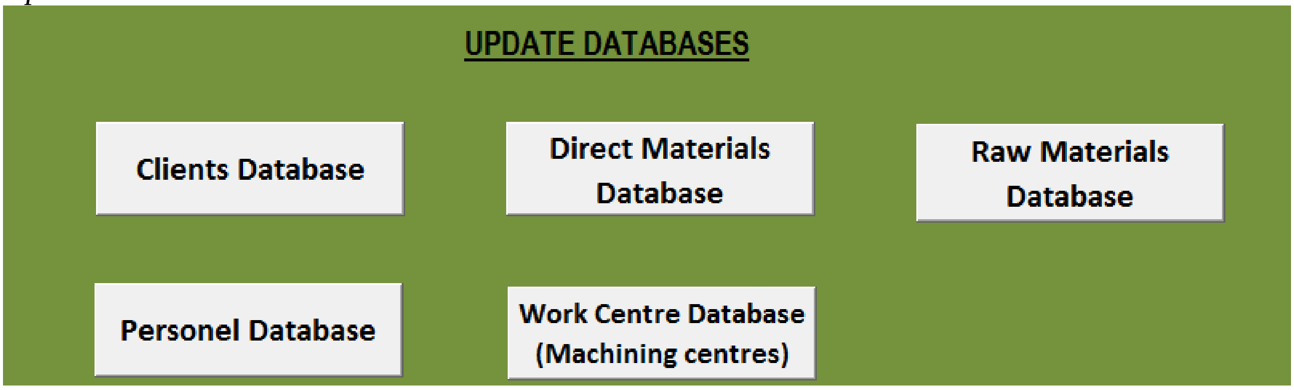


Figure 26. Updating index of the bidding calculator

The figure 26 above shows the different databases that are needed for the cost estimation sheet to function well. They are the client database, direct materials database, raw materials database, personnel database and work centre database.

How to update the data (using raw materials database as an example)

The database has been created in a dynamic form which makes it easy to use in the cost estimation. Any changes made in the database will reflect automatically when the cost estimation sheet is used. The values in this database are not real values! The figure 27 below shows the database for raw materials and prices.

Database for Raw Material (metals) and Price list

Raw Materials	Unit	Unit Price €	Description	Cost Category	Certification Price
30CrMoNi	Kg	€4.90	Raw material	Direct Material Cost	€20.00
34CrNiMo6	Kg	€3.80	Raw material	Direct Material Cost	
42CrMo4	Kg	€2.50	Raw material	Direct Material Cost	
Imacro	Kg	€5.20	Raw material	Direct Material Cost	

Figure 27. Database for raw materials

If you want to update the database, simply click on any part of the table you want to update and then you click on the form button shown in the figure 28 below with an arrow.

Figure 28. How to access the database form from excel

When the form is clicked it brings out the sheet for you to fill to update the table. This is the easiest and convenient way in case you have so many data to input. Below is an example of the form.

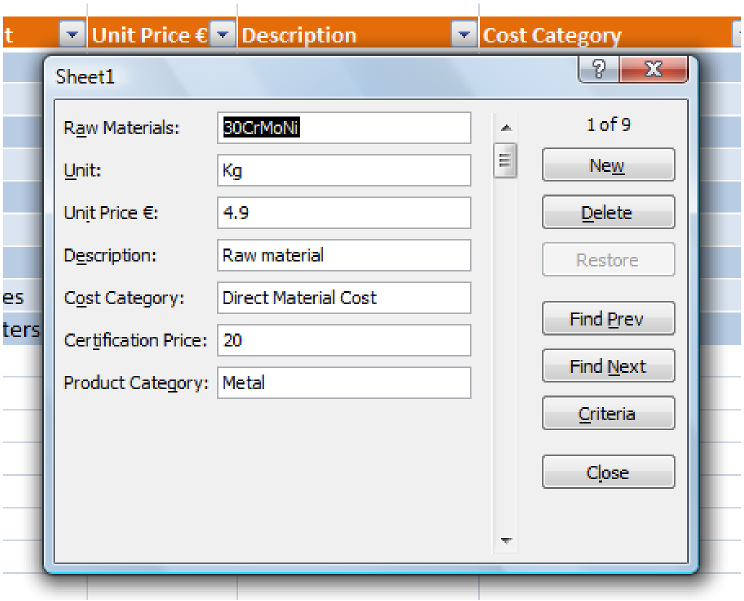


Figure 29. An example of microsoft form for easy updating

Miscellaneous workbook

This workbook is where the user stores tenders/bids that have been sent and the status of each bid. It includes the *date bid is received,* that is the date the client asked for a priced quote.

Date bid sent; that is the time the bid is prepared and sent to the client for review.

Preparer: name of the person who prepared the bid.

Bid enquiry number: the number to identify the bid (normally comes from the client).

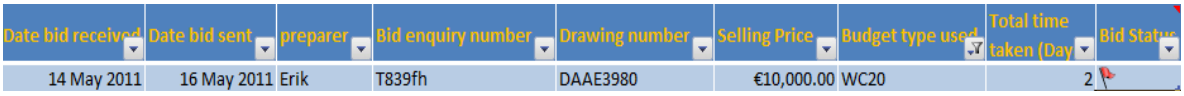
Drawing number: this provides at least the description of the product.

Selling Price: this is the final cost quoted for the product.

Budget type used: this shows upon which budget the bid was prepared.

Total time taken: this is the number of days it took for the bid to be prepared

Bid status: this is whether the bid was "won", "lost" or is still "waiting". These statuses are represented by flags of green represented won and value "2" is used to enter, yellow representing waiting "1"and red representing lost "0".



Date bid receivd	Date bid sent	preparer	Bid enquiry number	Drawing number	Selling Price	Budget type used	Total time taken (Day	Bid Statu
14 May 2011	16 May 2011	Erik	T839fh	DAAE3980	€10,000.00	WC20	2	

Figure 30. Miscellaneous workbook

CHAPTER SEVEN: CONCLUSIONS, LIMITATIONS AND FURTHER RESEARCH

7.1 Conclusions

In conclusion, this study has highlighted the immediate threats faced at the shop-floor which when solved will have a tremendous effect on productivity improvement. These problems could be grouped into two main areas: the first one being the low utilization of the CNC machines and the second one being the disorganization in the job distribution. The solutions to these problems are explained in chapter six of the study.

In trying to solve the problem of low machine utilization, elements that constitute the problem were lack of operators on a machine. From personal observation, two machines are sometimes operated by a single employee, machines sitting idle throughout the day reason being lack of new contracts for jobs to be performed on the machine. These problems could be addressed by proper production planning activities such as management making a strategic decision on the kind of production mix they want to engage in, should they continue produce in batches which in the case company is good because of seasonal products and difficulty in forecast demand.

Furthermore, too long searches were made in finding correct tools to perform manufacturing operations. This leads to the second problematic area of disorganization in the job distribution. First of all the current manufacturing process should be checked well to see how they could it could be streamlined and a proposed solution is given in this thesis as the To-Be production process flow chart. Also applying SMED in conjunction with 5S methodology will help in solving this problem area of job disorganization. These proposed solutions intend to be done at a minimum cost and a short possible implementation time and it is well known to improve set-up by reducing the time and also improve the work flow in respect to 5S methodology.

Lastly, the creation of a much more user friendly bidding tool to help speed up cost estimation calculations also gives the case company the upper hand in maintaining a competitive position. The sales tool built upon an easy to use program, Microsoft excel will give the operators less problems in modification of the tool in the future.

7.2 Limitations

Limitations to the machine hour study

What are some of the things that inhibited the study?

1. Some of the timings were not recorded right. Example some of the workers recorded the time they came to work to the time they close from work instead of the time they start machine to produce parts to the time they stop producing parts.

2. Not all the required timings were recorded especially time losses.

Below is a table showing the big time losses that should/could have been recorded to widen the scope of productivity measurement.

Table 4. Time losses that should/could have been recorded

Losses	Group the loss belongs to	Example of activities in this group	Observations during the study
Setups and Adjustments	Downtime Loss	• Setups/Changeovers • No operator to program the machine • No materials • New and big adjustments especially new products • Warm-Up time especially on Monday mornings	It was observed that a considerable amount of time is spent in setting the machine up for production. Few programmers are available in the facility and many machines to setup. Adjustments of tools also takes much time
Breakdowns	Downtime Loss	• Managerial breakdowns example lunch, coffee times and general breakdowns example power cuts • Malfunction of	During the study there were some days we experienced power failures at the shop floor.

		equipments • Tool failures and lack of tools • Unplanned maintenance	Also lack of adequate tools, this could have been prevented if work is planned ahead
Small Stops	Speed Loss	• Cleaning and checking of machine for next product • Sensor blocks • Components jamming in the machine • Obstruction of production flow	These are normally stoppages of about five minute's maximum time. They are normally does not involve the supervisor or maintenance personnel being present to solve the situation
Reduced Speed	Speed Loss	• Equipment wear • Lack of efficient operators • Running under maximum effect	From observation, operators normally reduce the working speed due to tiredness or idling so they refuse to run the machine at its theoretical speed. Others are due to wear down of the machines
Startup Rejects	Quality Loss	• Incorrect Assembly • Scrap • Rework	These happen due to wrong setups, warm up periods, etc. and they are rejects that happen in the early phase of production
Production Rejects	Quality Loss	• Scrap • Rework • Incorrect Assembly	These normally occur during a steady production.

	There could be rework due to not checking measurements well, considering scrap for example a wrong whole is drilled etc

3. The quantity of articles produced was also recorded poorly. Example, operators recorded the whole quantity of articles they are supposed to produce instead of the quantity they actually produced during a time period. Because of this limitation, it is difficult or not possible to calculate the productivity based on pieces produced to working hours.
4. There is no standard time for each operation as well as the required quantity to be done at a forecasted standard time.
5. Work overload that makes operators not having adequate time to properly fill the time sheet template. They normally finish the work before filling the template.
6. The study time period started too early, this resulted in not really understanding the production process of the shop-floor.
7. The research was conducted at a peak production period where the work needs to be done to satisfy customers so there is not enough planning into how effective it has to be done.
8. Language barrier between the study conductor and the employees.

7.3 Further Research

The case company needs a lot of changes that will assure them to stay competitive in the manufacturing market. Some of measures proposed for further study are through personal observation of the current situation they find themselves in. First of all, there would be a need for the company to look into industrial robotics. The installation of robots will replace the human operators. The use of industrial robots will accomplish work at a high speed, correct precision and can endure more by working 24 hours. This has a chance to increase the company’s utilization; there will be more consistent production and an efficient use of labor.

Secondly, the case company must do continual study of the machine usage by employing OEE to effectively evaluate manufacturing operation. And thanks to technology, the gathering of data for the calculation of OEE could be done with special equipments and software that will installed on each machine so that operators will not have to worry about writing down anytime. Automatically, while machines run, one will be able to know the effective usage of resources.

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MEETINGS

17.12.2010: First visit to case company. Meeting participants: CEO, Sales Manager, Development Manager and Professor Marja Naaranoja.

4.1.2011: Meeting with Sales Manager. The topic was to get understanding of the enquiry-offer process in other words the bidding process.

4.1.2011: Meeting participants: CEO, Development Manager, Production planner and Production Supervisors. The topic was to discuss the study to be conducted at the shop-floor

25.1.2011: Meeting with Sales Manager. The topic was the forecasting of sales and advanced price setting.

25.1.2011: Meeting with Production Planner. The topic of the meeting was to get detailed information of the purchasing and production planning operations.

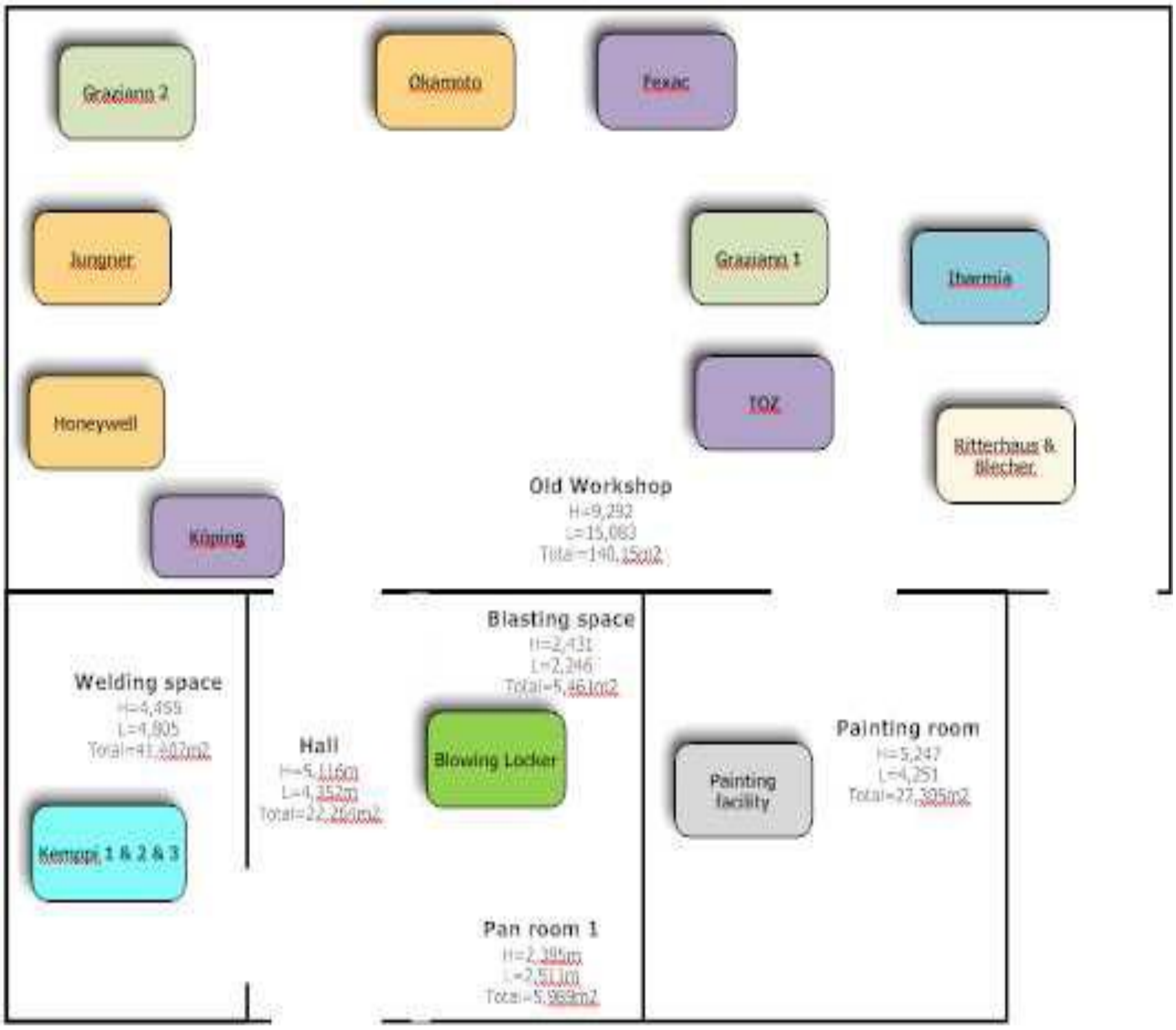
28.1.2011: Kick-off meeting with CEO, a guest from sister company and Professor Maria Naaranoja. The topics related to the basic plans of the researches.

11.2.2011: Meeting with production supervisor. The topic was to open the manufacturing process and draw a process chart. The machine operators work stations were also discussed

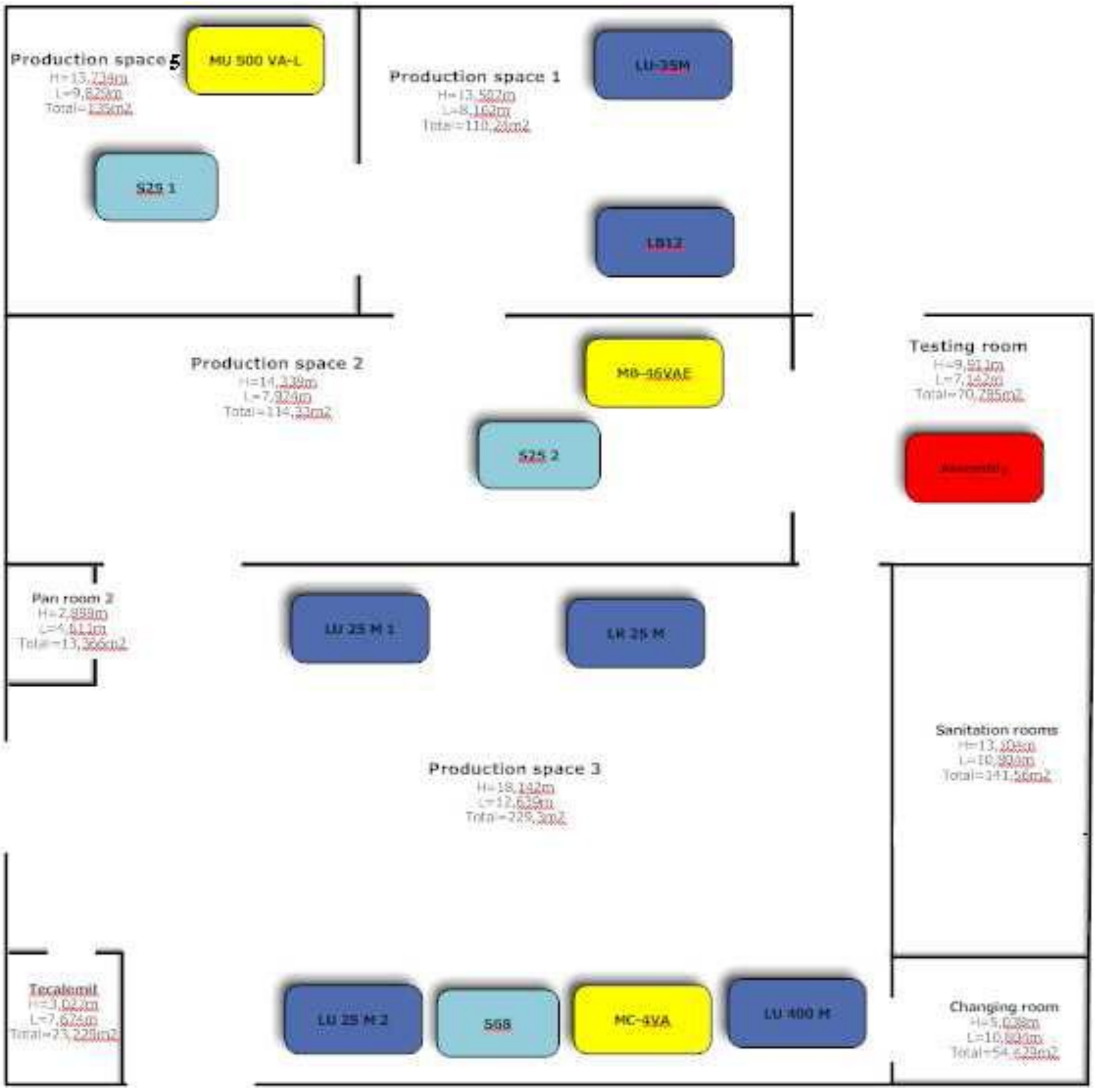
11.2.2011: Meeting with Logistics Manager. The topics were the functions and personnel of the warehouse.

11.2.2011: Meeting with Production Manager. The topic was to find out the main machines the operators use and some barriers they are facing during production.

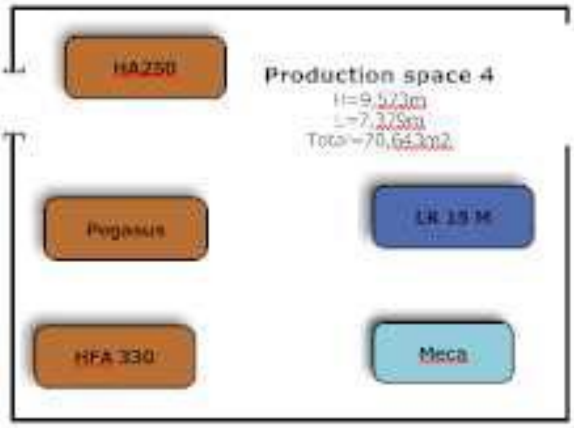
APPENDIX 1. Manufacturing floor layout



Layout 1 Manufacturing old layout



Layout 2 Manufacturing new side



Production Space 4

APPENDIX 2. Machine hour study template

KGN TOOL

Machine name

Person	Date	Setup time	Start time	End time	Breakdown time	Work number	Writing number	Amount	Activity

Other notes:

Activity / Process Name

1 = Sawing, 2= CNC-working, 3=Manual working, 4=Painting, 5=Welding, 6= Hardening, 7=Testing

APPENDIX 3. Manufacturing machines and processes

	#	Name	Model	Serial #	Machine series	Processing dimens.	Origin
CNC-Turning	1	LB 12	1988	6312.0897		D200 * L350	Japan
	2	LR 15 M	.08.1993	2158		D 240 * L 600	Japan
	3	LR 25 M	1991	0303.0376		D 340 * L 850	Japan
	4	LU 25 M 1	1995	.0083		D 420 * L 1250	Japan
	5	LU 25 M 2	1997	.0199		D 420 * L 650	Japan
	6	LU 400 M	2007.05	1313.4		D 420 * L 650	Japan
	7	LU 35 M	1998.07	.0202		D 740 * L480	Japan
CNC-Milling	1	MC-4VA	1986	6110.0714		X 650 Y 400 Z 460	Japan
	2	MB-46VAE	2002.02	95		X 560 Y 460 Z 460	Japan
	3	MU 500 VA-L	2007.09	131830		X 1250 Y 660 Z 540	Japan
CNC-Sawing	1	Pegasus			235 * 315 A-CNC	4-100	Czech
	2	Amada			HA 250	40-250	Japan
	3	Amada			HFA 330	20-330	Japan
Manual Grinding	1	Okamoto	1986	7421		X 600 Y 300 Z 250	Japan
	2	Jungner		US-2305	NR:2133		Sweden
	3	Honeywell					
Manual turning	1	Graziano 1		9220	Tortona	D 640 * L 1400	Italy
	2	Graziano 2			Tortona	D 480 * L 800	Italy
Manual milling	1	TOZ	1996	23700098	FGS 32/40 T	X 1200 Y 500 Z 500	Czech
	2	Fexac				X 1000 Y 500 Z 500	
	3	Köping	1942	NR:102		X 800 Y 400 Z 400	Sweden
Manual drilling	1	Ibarmia					Italy
	2	Strands	1980	41677	S68		Sweden
	3	Strands	2004	355107 B	S25		Sweden
	4	Strands	2007	359952 B	S25		Sweden
	5	Meca					
Manual Press	1	Ritterhaus&Blecher		73135	Barmen		
Welding	1	Kemppi 1	1.2.2002	1013894L	PROMIG 501	MIG	
	2	Kemppi 2	11.2.2008	1545324	PROMIG 511	MIG	
	3	Kemppi 3	2007	S/N 1372731 U	MINARCTIG 180	TIG	
	4	Hardening cart					
Assembly	1	Testing room				70,785m2	
Painting	1	Painting room				22,305m2	
Material clearing	1	Blowing locker				5,461m2	
	2	Aqua Clean AC-1.3		2 893 213 001			
Testing	1	Pressure					
	2	Lifting					
	3	Measurement					
Testing Bench	1	Test Bench	2011				

APPENDIX 4. Results of the machine hour study

Machines	Machine Effective Utilization Period 1	Machine Effective Utilization Period 2	Average Machine Utilization for the cost centres	Corrected based on Error Approximation of 20%		
				Machine Effective Utilization Period 1	Machine Effective Utilization Period 2	Average Machine Effective Utilization
CNC-Multitasking centers						
MU 500 VA L	63.7%	37.7%	**51%**	51.0%	30.2%	**40.6%**
MC-4VA	83.5%	83.5%	84%	68.8%	66.8%	
MB-46VAE	95.9%	82.3%	89%	76.7%	65.9%	
			86%	71.8%	66.3%	**69.1%**
CNC-Turning-Lathes						
LB 12	50.4%	51.3%	51%	40.3%	41.0%	
LR 15 M	60.6%	65.6%	63%	48.4%	52.5%	
LR 25 M	61.9%	69.3%	66%	49.5%	55.4%	
LU 25 M 1	91.3%	76.0%	84%	73.1%	60.8%	
LU 25 M 2	66.8%	70.8%	69%	53.4%	56.6%	
LU 35 M	78.5%	92.1%	85%	62.8%	73.7%	
			70%	54.6%	56.7%	**55.6%**
LU 400 M	59.7%	85.4%	**73%**	47.8%	68.3%	**58.1%**
CNC-Sawing						
Pegasus	58.3%	43.2%	51%	46.7%	34.5%	
Amada 250	22.8%	38.1%	30%	18.2%	30.4%	
Amada 330	53.3%	63.5%	58%	42.7%	50.8%	
			47%	35.9%	38.6%	**37.3%**
Manual Grinding						
Okamoto						
Junger						
Honeywell	15.0%		15%	12.0%	0.0%	
Manual Turning						
Graziano 1	2.5%	4.8%	4%	2.0%	3.9%	
Graziano 2						
Manual Milling						
TOZ	18.0%	0.0%	9%	14.4%	0.0%	
Fexac	2.4%	0.0%		2.0%	0.0%	
Köping						
Manual Drilling						
Ibarmia	4.0%	8.5%	6%	3.2%	6.8%	
Strands s68						
Strands s25						
Strands s25						
MCCA						
Manual Press						
R&B	15.3%	6.0%	11%	12.2%	4.8%	
			9%	7.6%	5.1%	**6.4%**
Welding						
Kemppi 1	69.8%	94.2%	82%	55.8%	75.3%	
Kemppi 2						
Kemppi 3						
Hardning Cart						
			82%			**65.6%**
Painting						
	6.6%	2.6%	**5%**	5.3%	2.1%	**3.7%**
Aqua Cleaning						
Blastering						
	20.2%	7.7%	**14%**	16.2%	6.2%	**11.2%**
Assembly						
	76.0%					

APPENDIX 5. Old sales tool/bidding tool of case company

Date	30.12.2010, ED
Enter values in yellow boxes	
Basic Values	€/minute
Sawing	0,05
Turning and positioning time	1,00
Milling and positioning time	1,00
MU 500 (multitask centre)	1,20
Blasting	0,60
Welding	0,60
Painting	0,60
Assembling	0,60
Logistics and packing material	Discussible
Purchased programming	Discussible/Offer
Measurement,Pressure&Lifting test	Discussible
Costs	
Amount	10
Cost per piece	330,00
Total costs	3300,00
Selling price	
Selling price/piece	462,00
Total selling price	4620,00
Profit	
Margin %	40 %
Margin (€/piece)	132,00
margin (€ total)	1320,00

Number	Description	Supplier	Amount/pieces	Material / Purchased	Sawing mm / Price	Turning Time / Price	Milling Time / Price	MU 500 (Multitask centre)	Blasting	Welding	Painting	Assembly	Measurements, Pressure&Lifting tests	Logistics	Other costs		Cost per Piece	Total costs	Total selling price	Selling price per piece	Total margin	Margin per piece
DAAE077368		KGN	1	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	10,00	0,00	10,00	10,00	0,00						
				0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	10,00	0,00	10,00	10,00	0,00	30,00	300,00	420,00	42,00	120,00	12,00
DAAE077369	Grinding Wheel		1	45,00	0,00	200,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00						
				45,00	0,00	200,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	245,00	2450,00	3430,00	343,00	980,00	98,00
OTHER COMPONENTS	BOLTS AND NUTS		1	15,00	0,00	40,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00						
				15,00	0,00	40,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	55,00	550,00	770,00	77,00	220,00	22,00

APPENDIX 6. New sales tool/ bidding tool for case company