Document Name:	Production Methods
Project Name:	Production Technology
Project Number:	2012-2
Course:	SFHO 03200 – H11 – Bachelor Thesis with project control
Availability:	3. year, Bachelor in Engineering at BUC – Buskerud University College
Supervisor:	Kjell Enger, BUC
Contracting Entity:	Kongsberg Protech Systems
Group:	
Halvor Eide, Ørjan Ohm, Sander K. Trandem, Knut Anders Lia and Alexander Svendsen	

Document History		
Rev.	**Changes**	**Date**
-		2012-01-16
1	Spell check and changes on document layout	2012-02-20
1.1	New layout	2012-04-30
2	Template update, print prepared	2012-05-27

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1 Introduction

Production Technology is a Bachelor Thesis taken on by five mechanical engineering students from Buskerud University College in Kongsberg.

The Scope is limited to five study credits for the first semester (fall 2011), then 15 study credits for the second semester (spring 2012). This is estimated to 550 work hours per group member. There will be a higher priority on documentation then in a normal industry. This will give a better basis for evaluating the project.

The purpose of this project is to evaluate production models for Kongsberg Protech Systems (KPS). Kongsberg Protech Systems has developed a new product called Protector Medium Caliber that is going into production. To make the production effective they need to develop a specific production model that they can integrate in all their locations, and in different production scale.

The company has other similar products that are already in production. In the existing production there are used several Lean tools to make the production as efficient as possible. The difference between these products and the new one is the size and weight. The existing products are of smaller caliber and therefore smaller in size and easier to handle, than the new Protector Medium Caliber. Due to the size and weight of the product they need to develop a completely new assembly process. The production process is the backbone in the company and it is vital for the company to compete with others.

Our assignment is to make a main study that evaluates different production models and create concepts for the production of Protector Medium Caliber. The production is divided into two cases with different production rate, where Case 1 handles high rate production and Case 2 handles low rate production. For both cases, we will consider the need of cranes, lifts and other equipment to make the assembly as easy and effective as possible. In the production of Protector Medium Caliber there will be a need for a jig or a fixture to hold the product while assembling and testing. This jig will be designed in SolidWorks and integrated in our production model.

To be able to make a good analysis, we need to learn about production technologies and Lean manufacturing. By learning the basics of these subjects, we will ensure effective manufacturing of quality products and a safe and good environment for the workers. To accomplish this, two generic pre-studies will be produced as supporting literature. One study for production technologies and one study for Lean manufacturing. The two studies will be used as a support for arguments for the different choices and conclusions we make in our main study.

This Bachelor Thesis is a theoretical study and takes form of a written report with drawings and illustrations. The sources used are internet, personnel of KPS and literature in form of books. Project expenses are literature and printing of reports and poster.

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1.1 Document Overview

This document is one of many reports in the Bachelor Thesis 2012-2.

The Figure below will give an overview and placement of the reports and documents for the Bachelor Thesis 2012-2. The textboxes represents documents and the green box is representing this document. The Appendix documents are not listed.

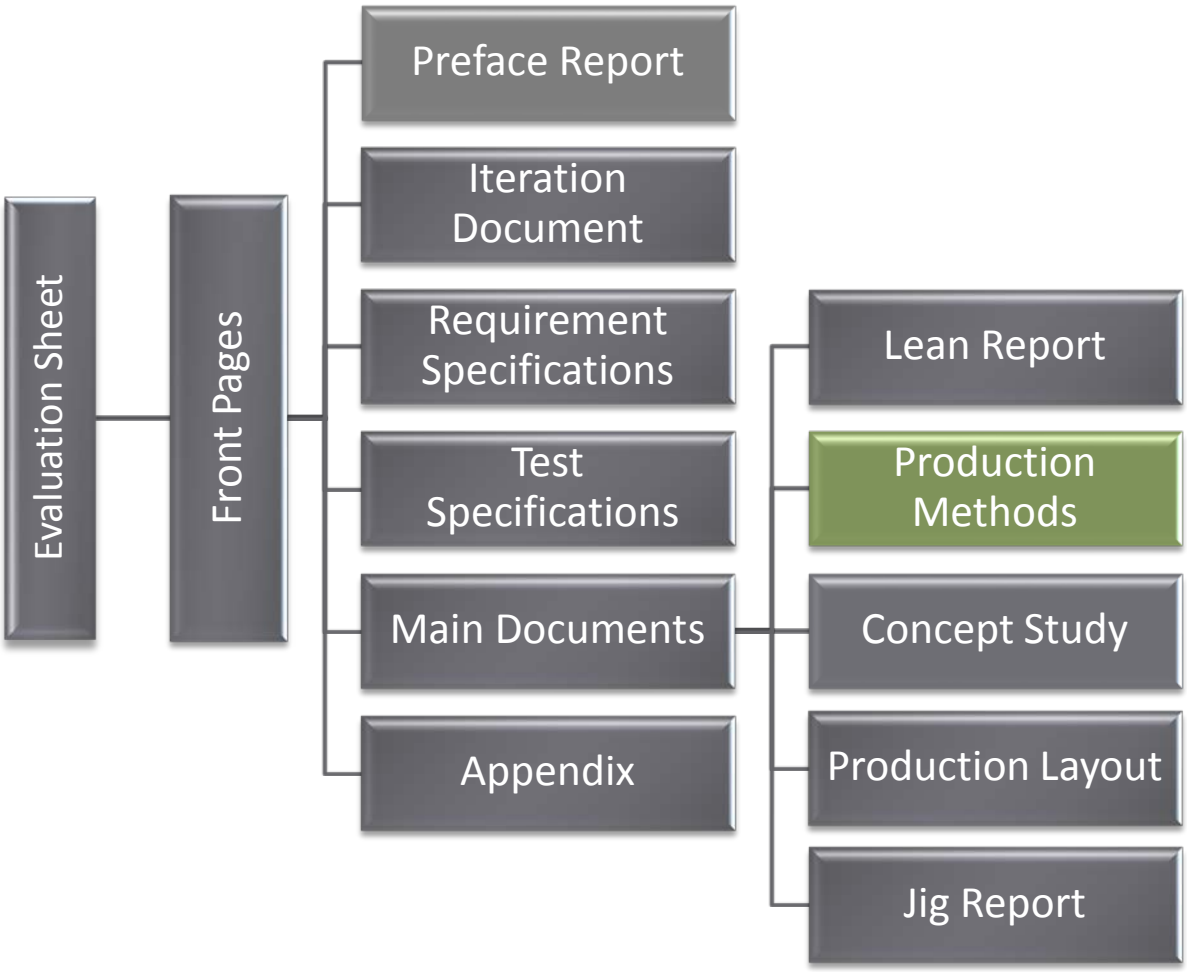

Figure 1 - Document Relation

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1.2 Document Purpose

In this document we will have a closer look on various types of production and how a new production process is planned.

One definition of a process can be “any transformation that converts inputs to outputs”. By means, in an organization, a process can be a single step in the production, the whole production or any other part of the organization that produce some kind of work. In our study we will focus on the process of producing physical goods which we will call process planning.

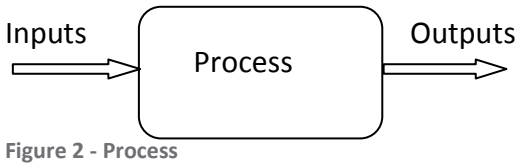

Figure 2 - Process

The main goal of this study is to get knowledge about how the planning of a new process is executed and which factors that affects the design of the process. This is a requirement from KPS (Req. K02.2). This document will be used as a reference in our main study, when we develop our production concepts.

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2 Process Planning

When the design engineers have designed the product, assembly and work drawings of the components are made. The process planners can determine how the requirements of the product will meet the specifications mentioned in the part drawing.

Process plan is the detailed instructions for making a part or a component. It includes such information as the operations, their sequence, machines, tools, dimensions, tolerances, inspection procedures and time standards e.g. cycle time.

Process planning is determination of the processes and sequence of operations required to make the product. It consists of devising, selecting and specifying processes, machine tools and other equipment to transform the raw material into finished product to satisfy the requirements of the drawings.

The purpose of process planning is to determine and describe the best process for each job so that:

1. Specific requirements are established for which machines, tools and other equipment can be designed or purchased.
2. The efforts of all engaged in manufacturing are coordinated.
3. A plan is made to show the best way to use the existing or proposed facilities.

Figure 3 - Process Planning [2]

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2.1 Steps Involved in Process Planning

The following steps are involved in carrying out the process planning manually.

1. The finished product is analyzed so that its sub-assemblies and individual components are identified from manufacturing point of view.
2. Prepare a Bill of Materials (BOM) for all components of the product which forms a basis for purchase of raw materials.
3. Decide which parts are to be manufactured in the plant and which parts are to be purchased from the market depending upon the facilities available in the plant, in example decision with regard to “make” or “buy” to be taken.
4. Choose the appropriate blank size in example raw material size and select the most economical process to be followed to manufacture components of the product. This is done by comparing the various possible methods of obtaining the final product. The basic factors of volume to be produced, in example production quantity, required quality of the product and the capabilities of the equipment available are carefully considered in this step.
5. Decide the sequence of operations to be performed on each component in the process selected.
6. Each operation is assigned to the type and size of machine or work station that will perform the job most economically.
7. Depending upon the accuracies called for by the drawings; determine the machine tools to do the operations.
8. Determine the need for any special equipment like jigs, fixtures, cutting tools etc.
9. Determine the inspection stages and instruments required and the need for designing any inspection devices (gauges, etc.).
10. Estimate the standard time for performing the job.
11. Determine the type of labor (skilled, semi-skilled or unskilled) required doing the job. Process planning has been traditionally carried out by methods engineers, manufacturing engineers, industrial engineers or by process planners.

2.2 Process Planning Sheet

The information determined by the process planning is recorded in a tabular form in a sheet called process planning sheet. This document is provided to the manufacturing personnel for their use. The character of this sheet will vary for different organizations depending upon the production conditions and degree of details required. In general the following data is listed for each component of the product in the process sheet.

1. Information regarding the main product, of which the component being manufactured is a part, in example name and part number of the main product.
2. Name, part number, drawing number of the component and number off e.g. number of components required per product.
3. Information concerning the blank e.g. raw material used, size and weight of stock.
4. Operations are listed in proper sequence along with the shops in which these operations will be performed.

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5. Information regarding machines used for each operation.
6. Data on jigs, fixtures and other special tools required.
7. Inspection devices needed for inspection.
8. Cutting data, in example speeds, feeds & depth of cut for each machining operation.
9. Elements of standard time such as set-up time, handling time and machining time for the job.

2.3 Process Design

In the design of a process, there are a lot of standard procedures. In general these activities start with the receipt of the product specifications and ends with the final plans for the manufacture of the product.

The steps involved in process design are as follows.

1. A careful review of the product design and specifications to make sure that economical manufacture is feasible.
2. Determination of the methods of manufacture that will result in the optimum manufacturing cost.
3. Selection or development and procurement of all machines, tools, and other equipment required for the manufacture of the product at the required quality and rate of production.
4. Layout of the production area and auxiliary spaces, and installation of the manufacturing facilities.
5. Planning for and establishing the necessary control of materials, machines, and manpower to ensure economical production of the product.

The above steps may be identified as functions of various activities, such as manufacturing engineering, process engineering, process planning engineering, or tool engineering. The scope of process-design activity can be identified as all work that is necessary to arrange for the manufacture of the product by the most economical means.

Basic Factors Affecting Process Design

There is three basic factors that affect the design of a manufacturing process, namely:

1. The volume or quantity of the product to be manufactured.
2. The required quality of the product.
3. The equipment that is available, or that can be procured, for the manufacture of the product.

The volume to be manufactured must always be considered as the volume to be produced within a given period — or as the rate of production. In this manner it can be related to the capacity of the manufacturing equipment under consideration and the best methods selected accordingly. The anticipated volume should be based upon a sales forecast. This is of particular importance in the introduction of a new product. Funds should be allocated for the improvement of processes only when the forecast indicates such a volume of sales that an appropriate return on the investment can be realized. In general, the greater the volume of the

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product to be produced, the greater is the opportunity to incorporate advanced methods of manufacture into the design of the manufacturing process. The number of identical units to be produced vitally affects the selection of manufacturing methods.

The savings per unit of product or per component part, when multiplied by the total volume to be produced will give an idea of the money that can be allocated for the purchase of modern equipment. It may justify new and better machine tools, the use of numerically controlled machines, etc. It will also justify better auxiliary equipment such as jigs, fixtures, or dies, which will in turn increase the productive capacity of the existing equipment in the facility.

Methods of manufacture vary widely with the volume to be produced. The production of heavy industrial equipment and machinery involves very few units of product, requires skilled machinists or other craftsmen using general-purpose machines and tools, and assembly is by skilled labor. On the other hand, the mass production of washing machines, refrigerators, TVs, automobiles, and similar goods is accomplished with a large proportion of automatic machinery and on a planned assembly line that requires a minimum of skill.

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3 Work Measurement

Work measurement is the application of techniques used to determine the time taken by a qualified worker to carry out a specified job at a defined level of performance. Work measurement means measuring the work time, in example minutes or hours required to complete the job. Work measurement is used to reduce or eliminate all ineffective time.

The main objectives of work measurement are:

1. To determine the time required to do a job.
2. To estimate the man and machine requirements and to assess the plant capacity accurately.
3. To provide information for effective production planning and maintenance.
4. To assist in estimation of reliable delivery dates.
5. To provide a basis for fair and sound incentive schemes.
6. To standardize the rate of performance of workers.

3.1 Time study

There are different methods that are used in work measurement. The selection of a particular method depends on the job situation. One method is time study. Time study is concerned with the direct observation of work while it is actually being performed by the operator. Time study is defined as a work measurement technique. Recording the time, rate or pace of working for the elements of a specified job carried out under specified conditions. The data found from the time study are to be analyzed to determine the time necessary for carrying out the job at a defined level of performance. Time study is the most satisfactory and accurate technique for determining the time taken for completing a manufacturing operation but due to its nature it is mainly used for repetitive work.

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4 Types of Production

Depending upon the type of industry and manufacturing situations, production can be divided into two types as follows:

1. From a seller's point of view, products are manufactured either to customers order or to stock. In manufacturing to customers order, production of any product is taken up only when you have customer`s orders on hand. In manufacturing to stock, the items are produced and stored and customer`s requirements are met from the stock of the finished goods.
2. From method of production point of view, it can be divided into following three types:
   - Job shop/job production which is described in Ch. 4.1.
   - Flow shop/mass production which is described in Ch. 4.2.
   - Batch production which is described in Ch. 4.3.

4.1 Job Shop

In a job shop, or job production, flexible resources are used to produce low volumes of highly customized and varied products. The design is called functional layout or process layout. Usually the job shops have many products simultaneously flowing through the process.

Because of the varied activities for each product the job shops can look a bit chaotic with large amounts of storage buffers and a lot of waiting between each activity. In short terms, job shops typically have high process flexibility that permits product customization but have high processing cost and long flow time.

Figure 4 - Job shop: Milling on Innocenti Automobile Factory [4]

Examples of job shops can be tool/machine shops as seen in Figure 4.

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In this type of production the products are manufactured directly to customer's orders and the quantity produced is also small. In many cases it may be one piece only. The work starts only when the organization has orders on hand. The main characteristics of this type of production are:

- Each job may be different from the previous one, all depending on specifications, quality and quantity.
- Flow of material may not be continuous.
- General purpose machinery is used, hence less initial investment in equipment.
- Similar types of machines are grouped together.
- Highly skilled operators are needed.
- Each work has to be planned and scheduled separately.
- Raw material inventories are high.
- Prior planning is not possible. From the above characteristics it is clear that job order production is a case of intermittent production. The examples of job order production are manufacture of aircrafts large turbo-generators, ships, chemical plants, gates, doors and windows of houses etc.

4.2 Flow Shop

The other extreme, flow shops or mass production, uses more specialized resources to perform limited tasks with high precision and speed. In this kind of production the products are more standardized and are produced in larger quantity. The quality of the products tends to be more consistent because of the specialized resources and the experience of the workers. Usually the variable process cost is low, even if the fixed costs for plant and equipment are high. This is because the cost is spread on the large quantity of products. The limit in variety of products often results in shorter process flow time than in job shops.

Figure 5 - Flow Shop: Old Ferrari Assembly Plant [3]

An example of flow shops is an automobile assembly plant, such as Ford, Toyota or Ferrari (Figure 5). An assembly line is an example of discrete flow shops where products are produced part by part.

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Examples of continuous flow shops can be steel plants, oil refineries and chemical plants, where the product is produced in a continuous manner. In short terms a flow shop has low unit-processing cost, short flow time, and consistent quality at large quantity.

Mass production is production of items in large quantity using much specialized machines and processes. Items like metal screws, nuts and bolts and plastic products are made in mass production. In this type of production there is a continuous and steady flow of materials. The different characteristics of mass production are:

- Small varieties and large volumes are manufactured.
- Product type plant layout is used.
- The flow of work is balanced in example: machine capacities are balanced.
- Specialized machines and processes are used, hence high initial investment in equipment.
- Materials can move by conveyors.
- It results in lowest cost of production.
- Easier production planning and control.
- Inventory of work in progress is small.

4.3 Batch Production

In reality all processes are some kind of mix of job and flow shop. It's common to call it batch production.

Because in the early stages of the product's life the quantity is low and uncertain, the investment cost is high and this result in that a flexible process like job shop will be appropriate. After some time the product matures, and the quantity increases the cost and response time become critical. Then it fits with a flow shop kind of process architecture. But in the end of the product's life cycle, the quantity declines and again the job shop architecture will be more appropriate.

Figure 6 - Batch Production: Forging Golf Irons at Mizuno [5]

In batch production, the products are made in small batches and in large variety (Figure 6). The orders may be repeated with intervals of time.

The characteristics of batch production are:

- Products are manufactured in batches.
- General purpose machines are used.
- Flow of material is intermittent.
- Plant layout is process type.
- In process inventory is high.
- Process and product planning is done for each batch.
- Workloads on various machines or sections are unbalanced.
- Machine operators are highly skilled.
- A very common type of production.

Drugs, chemicals, paints, sheet metal components, forgings and parts manufactured on turret/capstan lathes come under this type.

The design of process architecture are very important for an organization because it will point a finger on what kind of process that will be most suited for their products and what it should focus on. By designing a good process that satisfies the customer demands, will result in success.

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6 Abbreviations

Abbreviation	Description
BUC	Buskerud University College
KPS	Kongsberg Protech Systems
Rev.	Revision
BOM	Bill Of Materials
e.g.	For example (exempli gratia – Latin)

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