Chapter 3

The Case Study

3.1 Introduction

3.1.1 General Information

The case study of this thesis is an automotive parts manufacturer, which is a joint venture between Thai and Japanese automotive part manufacturers. This company mainly produces special water and oil pumps for engines. The production activities consist of the Production Control and sequential process as primary, intermediate, and final process. In this case, primary process is "Die-Casting", intermediate process is "Machining", and final process is "Assembly". At present, the total number of staffs from the Production Department is 140 persons. The production capacity for each product type is summarized in table 3-1.

Table 3-1: A list of production capability in 1995

Product type	Product category	Quantity (sets/year)
Water pump	Engine part	800,000
Oil pump	Engine part	600,000
Temperature coupling	Engine part	156,000
Water drain cock	Engine part	120,000
Oil pressure release valve	Engine part	120,000
Shaft assembly rocker	Engine part	58,000
Compressor part	Compressor part	360,000

3.1.2 Organization

This company is organized as shown in Figure 3-1. The organization chart explains the work position and the authority of each level. The Manufacturing Division is composed of the Production and Engineering Departments. This division focuses on production processes, engineering, and quality management. The study is concerned on the Production Department comprising of the Production Control, Die-Casting, Machining, and Assembly Sections as shown in figure 3–2.

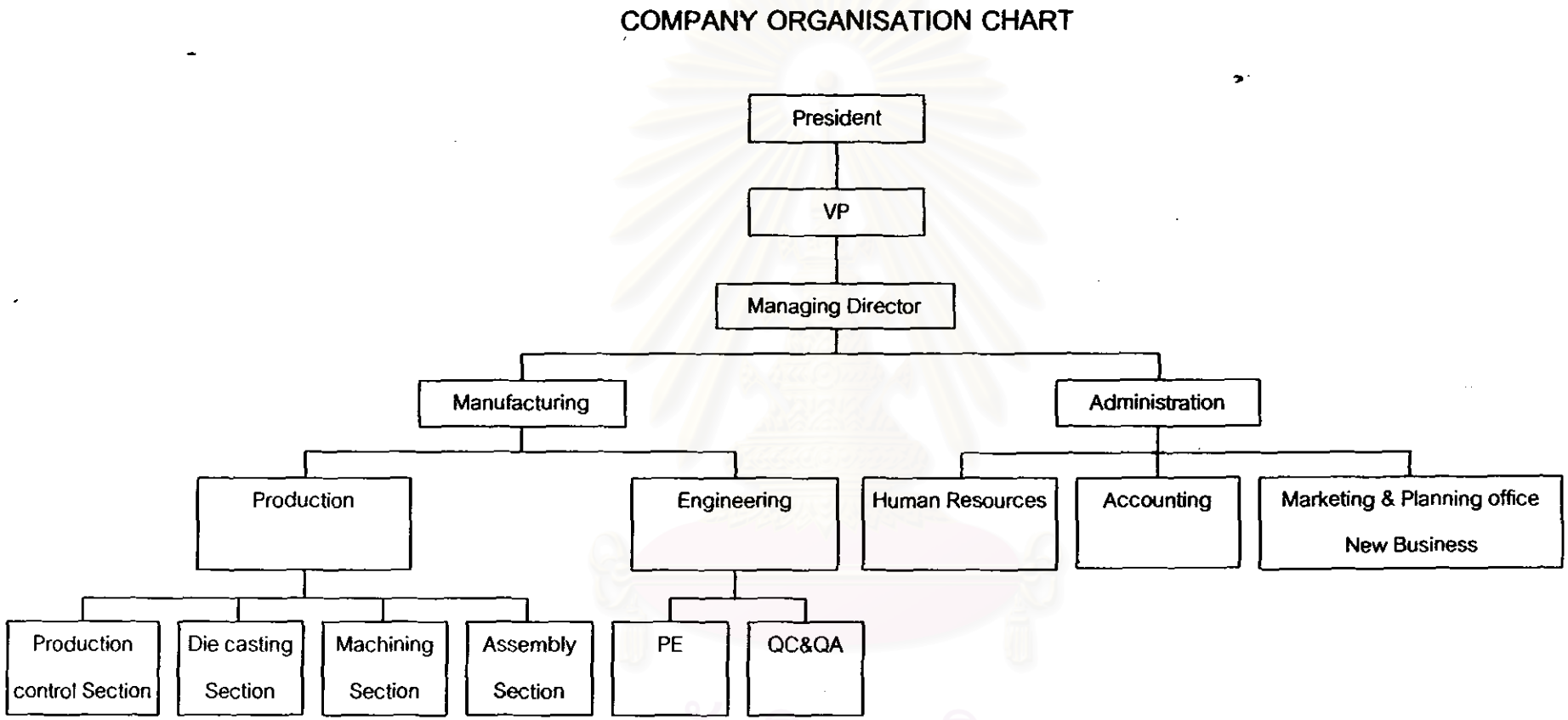


Figure 3-1 : The Company Organisation Chart of the Case study

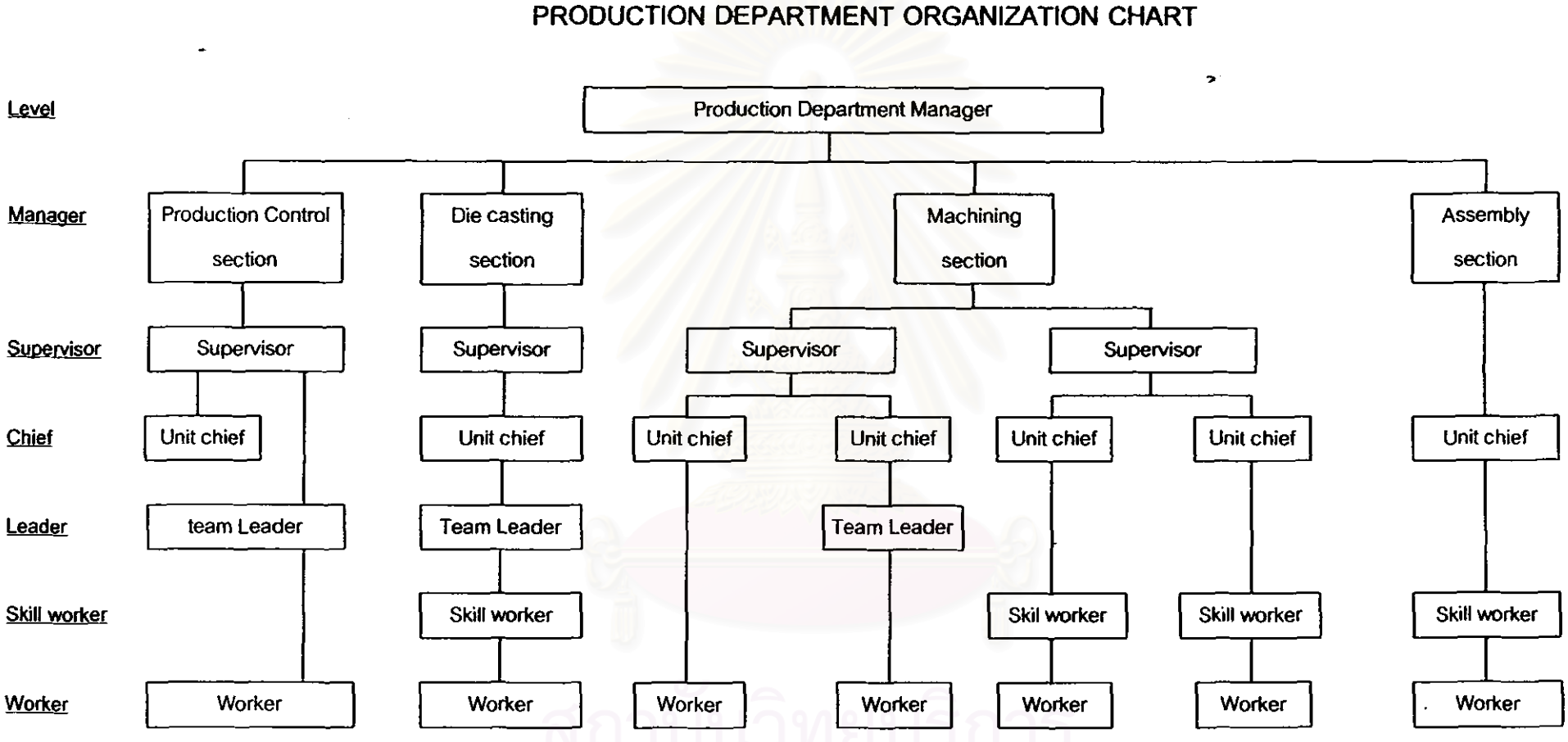


Figure 3-2 : The Organisation chart of Production Department

3.1.2.1 The Production Control Section

The *production control* section works very closely with customers and suppliers. This section uses customer orders to make Final Assembly Schedule (FAS) and purchasing plans. The FAS is sent to the Production Department to make detailed plans for production activities in the Die-Casting and Machining Sections. Purchasing plans are sent to the Accounting Department to issue purchase orders.

When customers request changes in deliveries the Production Control make adjustments to the FAS without notifying the Production Department. Therefore, activity plans the Machining and Die-Casting Sections may not be adjusted with FAS.

3.1.2.2 The Die-Casting Section

The Die-Casting Section performs primary process (Die-Casting) according to the plans made by the Production Department. This process is a type of *casting* process, which consists of many complex processes. The main body is formed under the specified processes. Then, it is inspected and distinguished into either a forming main body or a defective one. The trimming main body is sent to the Die-Casting stock area and the defected part is disposed into scrap area.

3.1.2.3 The Machining Section

The Machining Section consists of a group of machines. The production process starts when an operator withdraws the forming main body from Die-Casting process and passes to intermediate process (Machining), which has some specific machines to produce the main body. Number of products to be obtained from machining process is based on the WOS from the Production Department. The output of this process is defined as the finished main body. At present, the Machining Section consists of twenty machining groups ranging from M01 to M25.

3.1.2.4 The Assembly Section

The Assembly Section is the final process in the Production Department to be mentioned. In this case final process is called "the assembly process," which is categorized with water and oil pumps. Each production process consists of a group of specific machines, same as in the intermediate process. The input of the process is the finished main body from the intermediate process, and other items are bought from suppliers. Output from this process is a finished product, which is moved to the delivery area for delivery to customer.

3.2 The Existing Processes

3.2.1 Structure of the existing proceses

The existing processes in this study consist of the production control and sequential processes that can be divided into three activities as follows:

- Order Planning Activity
- Operation Scheduling Activity
- Production Reporting Activity

3.2.1.1 Order Planning Activity

This activity is a part of the production control process (the Production Control Section) that will gather the customer orders to form the Final Assembly Schedule (FAS) and purchasing plan for suppliers. This activity starts when the Production Control section receives customer orders and selects some essential information such as product item number and detail of order shown in figure 3-3.

Order Description

Delivery type	: LOCAL	Ref P/O	: ABC 98/067
Part Number	: ABC – 012345 – MC	Date	: 15/04/98
Part Name	: Front Cover	Page	: 1/7
Model	: MC	Revision	: 000

Lot Number	Quantity	Delivery Date	Remark
010	70	02/04/98	
011	80	03/04/98	
012	75	06/04/98	Night delivery

Figure 3-3 : A sample of an order description from the customer

The essential information is applied to form the FAS of each product. The FAS from this activity consists of product item number, detail of order from each customer, and delivery detail. A sample of FAS is shown in figure 3-4

Final Assembly Schedule

Description		01	02	03	04	05	06	...	28	29	30
Part Number :	Order Plan		70	80			75		60		
ABC-012345-MC	Deli (Normal)		70					REV:003			
Part Name :	Deli (Night)						75		60		
Front Cover	Export										
Model : MC	Spare part										

Remark : Deli (Normal) : Delivery at normal operation
Deli (Night) : Delivery at night operation
Export : Delivery for export center
Spared part : Delivery for spared part center

Figure 3-4 : A sample of Final Assembly Schedule in the existing system

The Production Control Section also prepares the purchasing plan for each supplier. This process uses the detail of FAS and the details of product structure to analyze the order description. Then, the purchasing plan is passed to the Accounting Department to make a purchasing order.

3.2.1.2 Operation Scheduling Activity

This activity is based on the Production Department. First, the Production Department analyzes the details of the FAS, which is received from the Production Control Section. Each detail of the FAS is an input of this activity. The Production Department makes a detailed report of operation and prepares the Work Order Schedule (WOS) for Assembly, Machining, and Die-Casting Section. A description of WOS in each section is summarized in table 3-2.

Table 3-2 : A description of Work Order Schedule (WOS) in each process

Process	Description
Assembly (Final process)	- Preparing the plan for assembly the finished product (Refer to the Final Assembly Schedule)
Machining (Intermediate process)	- Preparing the plan for machining the main body (Refer to the WOS for Assembly Section)
Die-Casting (Primary process)	- Preparing the plan for forming the main body (Refer to the WOS for Machining Section)

The production process in each section has different condition. For example, the Assembly Section combines the main body with other items to make a finished product. The WOS of this section focuses on the balance of the main body and other items. But the Machining and Die-Casting Sections produces main body with a specific process that takes time to produce. The WOS of Machining and Die-Casting focus only on the requirement of the main body in WOS for Assembly. Thus, the relationship of each WOS is very important. A sample of WOS is shown in figure 3-5.

Work Order Schedule For Assembly Section												
Description		01	02	03	04	05	06	...	27	28	29	30
Part Number	Order Plan		70	80			75			60		
ABC-012345-MC	Assy Plan	70	70	70	-	70	-	...	70			
Part Name	Stock Plan	100	100	90	-	160	85	...	155	95		
Front Cover	Assy Actual											
Model : MC	Stock Actual											

Figure 3-5 : A sample of WOS for the Assembly Section

Remark : Order Plan : is the detail of order from FAS
Assy Plan : is the number of finished product (plan)
Stock Plan : is the stock level in "the Assembly Stock" (Plan)
Assy Actual : is the number of finished product (Actual)
Stock Actual : is the stock level in "the Assembly Stock" (Actual)

3.2.1.3 Production Reporting Activity

This activity is related with the Assembly, Machining, and Die-Casting Section. It starts when the Production Department distributes the WOS to supervisors in each section for preparing details of production resource in each daily operation. At the end of the day, each supervisor collects the result from each production process and makes the Work Order Report (WOR) to inform the Production Department. A sample of Work Order Report (WOR) is shown in figure 3-6.

Work Order Report for Assembly Section (Normal Operation)

Part Number : ABC – 012345 – MC Date : 03/04/98
Part Name : Front Cover Reported By : SS
Model : MC

Order Plan	Period	Pass	Scrap	Reject	Remark
70	08:30 – 10:00	18	1	-	Set up machine
	10:20 – 12:00	20	-	-	
	12:40 – 14:00	19	-	2	
	14:20 – 17:00	23	1		

Figure 3-6 : A sample of Work Order Report from the Assembly Section

Remark: Order Plan : is the detail of order from WOS
Pass : is the number of finished product
Scrap : is the number of defected product from process
Reject : is the number of defected product from parts (Main body & Components)

The WOR from each section consists of item number, details of data item, and the production result. Each data item is used for comparing with the details of the WOS.

If the quantity of WOR cannot be controlled, the Production Department will adjust the detail of WOS to solve the problem. However, WOR for the Assembly Section may directly change from the Production Control Section if the customer adjusts delivery order. The structure of existing PAC system and scope of work in each activity can be described in a list of job description in each production activity as follows;

Table 3-3: A list of job description in each production activity

Activity	Responsibility	Scope of Work
Order Planning	Production Control Section	1. Collecting the detail of customer order to prepare the Final Assembly Schedule (FAS) 2. Preparing the Purchasing Plan of suppliers
Operation Scheduling	Production Department	Preparing the Work Order Schedule (WOS) for Assembly, Machining, and Die-Casting Section
Production Reporting	Assembly Section Machining Section Die-Casting Section	1. Arranging production resource to operate each production process 2. Preparing the Work Order Report (WOR) in each production process

3.2.2 Analyzing the Structure of the Existing Processes

In this case study, the IDEF0 modeling technique is applied to study the details of the existing production control and sequential processes. This technique is building a model of the existing processes, which are preparing the structural and hierarchical relationship and analyzing the ICOM (Input, Control, Output, and Mechanism) of each activity in the existing processes. The result of IDEF0 model for the existing processes shows the system structure and the detail of system as follows;

- Workflow of the existing system (processes and activities) with the structural and hierarchical relationship
- ICOM (Input, Control, Output, and Mechanism) of each step of operation
- Relational of the processes and activities in each step of operations.

Table 3-4 : A list of documents in the Front Cover product

Type of Documents	Code	Source of Documents
Final Assembly Schedule	FAS	Production Control Section
Work Order Schedule	WOS	Production Department
Work Order Report	WOR	Assembly Section Machining Section Die-Casting Section

3.3 Problem Analysis

The details of studying the cause of the problem is to collect data and information from the representative product, which covers all processes and activities of the existing processes. In this case, the study is divided into three parts. The first part is collecting the general information of the representative product. The second part is studying the availability and utilization of production resource. The last part is analyze the cause problems as follows;

3.3.1 General Information

The representative product in this study is the Front Cover product, which consists of the following:

- *Main body*: is the main component of the Front Cover, which has highly detailed and complex process. The main body is formed at the primary process (Die-Casting). The specific operations will be later on altered at the intermediate process (Machining).

- *Component items*: are segments of the main body, where each item is bought from well-experienced and specialized suppliers in a particular field.

The main body and component items will be summed up together to obtain the Front Cover at the final process (Assembly). The details of the various parts at the present will be determined according to the components list received from customers, as shown in the table.

Table 3-5 : A component list of the Front Cover Product from the customers

No.	Level	Item number	Items name	Qty	Source of Items
1	0	AB-10000	FRONT COVER	1	Assembly Section
2	1	AB-10100	MAIN BODY (FINISHING)	1	Machining Section
3	2	AB-10110	MAIN BODY (CASTING)	1	Die-Casting Section
4	1	AB-10210	COVER-FW	1	Purchased
6	1	FP001020	TIMING PIN	1	Purchased
7	1	FP001018	TIMING PIN	1	Purchased
8	1	CD-00121	OIL SEAL	1	Purchased
9	1	CD-00513	OIL SEAL	1	Purchased
10	1	PD010010	PLUNGER	1	Purchased
11	1	PD010018	PLUNGER	1	Purchased
12	1	AB-10410	ROTOR-INNER	1	Purchased
13	1	AB-10411	ROTOR-OUTER	1	Purchased
14	1	BL010612	BOLT-HEXAGON	5	Purchased
15	1	BL010808	BOLT-MACHINE	6	Purchased
16	1	BU001010	BUSH	1	Purchased

Level 0 = The finished product

Level 1 = The finished part (Main Body (Finishing) and Components)

Level 2 = The casting part (Main Body (Casting)

3.3.2 Production Resources

Production resources, which involves the production of Front Cover, consists of "Manpower", "Production Capability" ,and "Material Availability". Each production resource refers to the design of the production process, quantity requirement from customer, and the details of each item that is applied in the production control and sequential processes

An existing production resource in each process can be summarized as follows:

Table 3-6: An existing production resource in each process

Type of production resource	Description
Additional Manpower	The additional number of management and operator level to produce the product in each section.
Production Capability	The number of part or product, which can produce in each sequential process (pieces per hour) - Main body (die-casting part) in the primary process - Main body (finishing part) in the intermediate process - Front Cover (Finished product) in the final process
Material Availability	The number of part or product, which can use in the next section (stock level). The material availability separates in two types as follows: - Main body (die-casting part) in the primary process - Main body (finishing part) in the intermediate process

At present, the details of production resources in each section, which are collected from Front Cover production processes, have set up the default of manpower, production capability, and material availability in table 3-7.

Table 3-7: The default of manpower, production capability, and material availability for Front Cover product

Production resource type		Default setting at normal operation	Source of Data
Additional manpower	Production control process	2 man/day	Production Control Section
	Primary process	3 man/day	Die-Casting Section
	Intermediate process	4 man/day	Machining Section
	Final process	2 man/day	Assembly Section
Production capability	Primary process	100 pieces	Die-Casting Section
	Intermediate process	80 pieces	Machining Section
	Final process	126 pieces	Assembly Section
Material availability	Die-Casting stock	200 pieces	Die-Casting Section
	Machining stock	200 pieces	Machining Section

Remark: **Normal operation** means the standard process from 08:00 to 17:00
Overtime operation means the additional process from 17:00 to 20:00

3.3.3 Problem Analysis

3.3.3.1 Problem Ratio

In the study of the existing processes of the Front Cover, the record of each problem is collected during July until September 1998 from the Work Order Report (WOR) in the final, intermediate, and primary processes. A number of transaction is a summary from WOR. For example, a number of transaction in July is a number of WOR in the final process (Assembly) plus the number of WOR in the intermediate process (Machining) and the number of WOR in the primary process (Die-Casting), which is 75 times.

The number of problems are collected from the detail of problem in each WOR. Some problems are effected only in the final process (Assembly) but the same problems may effect to other processes such as the number of main body. In this study, the number of problems accumulated will be classified according to the topic of problem in each process, which will appear as the "Problem Ratio." The problem ratio can be seen in the following table 3-8:

Table 3-8 : A summary of number of problems during July to September, 1998

No.	The topic of problem	Number of problems In each month				Problem Ratio (%)
		Jul.	Aug.	Sep.	Total	
1	Shortages of Parts	10	21	17	48	22.5
2	Poor Resource Utilization	9	18	18	45	21.1
3	Excessive Work-in-Process	20	19	12	41	19.3
Number of transactions		75	69	69	213	

Remark : Problem Ratio = $\frac{\Sigma \text{ (Number of Problems)}}{\Sigma \text{ (Monthly Transactions)}} \times 100$

3.3.3.2 Resource Utilization

From the number of problem in each month, the details of production resource utilization in production control and sequential processes are collected in term of the additional manpower usage, production capability, and material availability to define the cause of problem in the existing processes as follows;

- *The additional manpower usage :* will be considered from the average amount of additional working time in normal operation (8 hours) and overtime operation (4 hours) being used, both in the management and operator level of each process. At present, the type of manpower usage can be categorized as follows:

Production Control Process : consists of the staffs in management level to handle documents, which are used for controlling the Final Assembly Schedule (FAS) in the production control process and Work Order Schedule (WOS) in sequential processes.

Sequential Processes : consist of these sub-processes as follows;

- Final Process (Assembly) : consists of the staffs in operator level to prepare the finished product
- Intermediate Process (Machining) : consists of the staffs in operator level to prepare the finishing main body.
- Primary Process (Die-Casting) : consists of the staffs in operator level to prepare the casting main body.

A record of additional manpower from production control and sequential processes indicates that the production control process require a lot of additional manpower to edit and modify the Final Assembly Schedule (FAS) and the Work Order Schedule (WOS) in each sequential process (average 102.6 hrs/month). Each sequential process also requires the additional manpower to support and produce the main body. At present, the average of additional manpower (hrs/month) in the final process (Assembly), intermediate process (Machining), and primary process (Die-Casting) is 29.3, 84, and 25.3 as follows.

Table 3-9 : The additional manpower usage of production control and sequential process from July to September, 1998

Source of Manpower Usage	Actual Manpower Usage (hrs/month)				Average Usage (Hrs/month)
	Jul	Aug	Sep	Total	
Production Control Process	88	96	124	308	102.6
Sequential Processes					
- Final Process	12	56	20	88	29.3
- Intermediate Process	68	84	100	252	84.0
- Primary Process	64	44	8	76	25.3

From table, the production control process requires a lot of additional manpower to edit and modify FAS and WOS due to the changing delivery and the unbalance of actual production resource utilization in each sequential process. Same as the manpower usage in sequential processes, the additional manpower is applied to prepare the production resource, Work Order Report (WOR) in each sequential process, and overtime operation in intermediate and primary processes.

- *Production Capability* : depends on sequential processes as the primary, intermediate, and final processes. In this study, primary process is defined as "Die-Casting process", intermediate process is "Machining process" and final process is "Assembly process". That are described as follows:

Final process: Steps of operation are divided into production line. Therefore, the production capability divided will be considered from the amount of products provided in the production line.

Intermediate process: Steps of operation are divided into production lines same as the final process The production capability is considered from the amount of products manufactured in the production line.

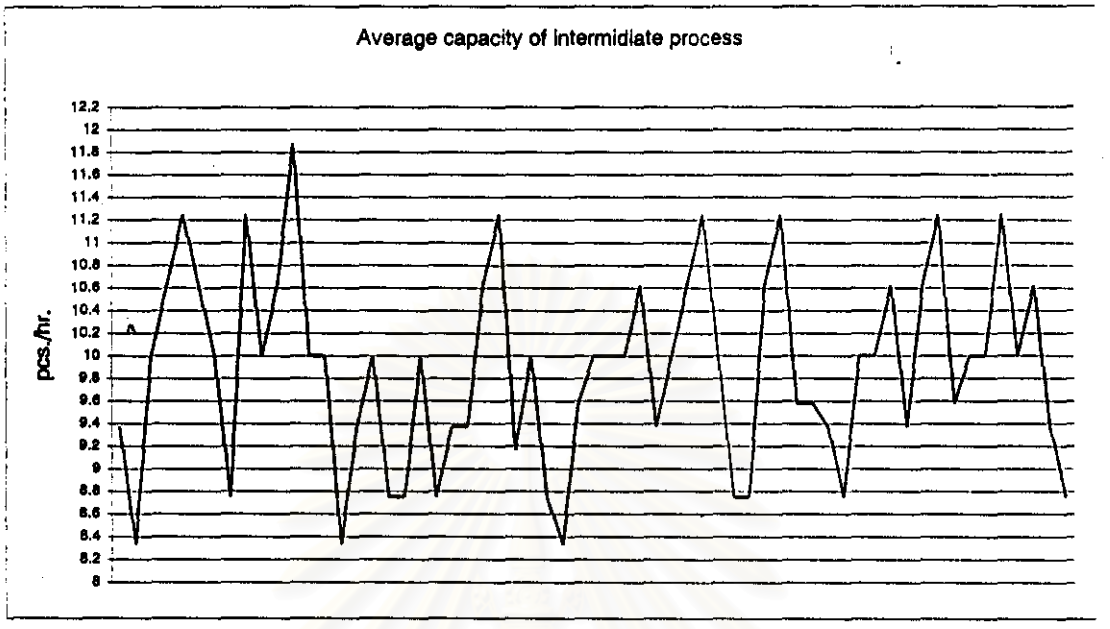
Primary process: Steps of operation are divided into processes. The production capability is considered from the casting process, which has the longest cycle time in the production process.

Production capability in each sequential process is collected by the number of item per hour (pcs/hr) that can be produced within a given amount of time. However, the amount produced will be less than the amount previously determined, due to the random events such as absent of worker, machine breakdown, and material problem that cause the amount of item to be unmatched with the Work Order Schedule. Furthermore, the modification of manpower usage in each process may have an effect on the amount of item to decrease.

A result of actual production capability from Work Order Report (WOR) in each sequential process shows that the production capability (pieces per hours) has not constant and meet with the planned schedule from Work Order Schedule (WOS). The average of production capability is calculated to recognize the effect of problems in each month as shown in table 3-10.

Table 3-10 : The summary of actual production capability (pcs/hour) during July to September, 1998

Type of sequential processes	Actual production capability (pcs/hour)						
	Jul	Aug	Sep	Average	Max.	Min.	Diff.
Final process	10.7	11.1	11.1	10.9	13.0	9.0	4
Intermediate process	9.8	9.8	10.0	9.8	12.0	8.0	4
Primary process	10.7	10.2	10.7	10.5	13.0	8.0	5



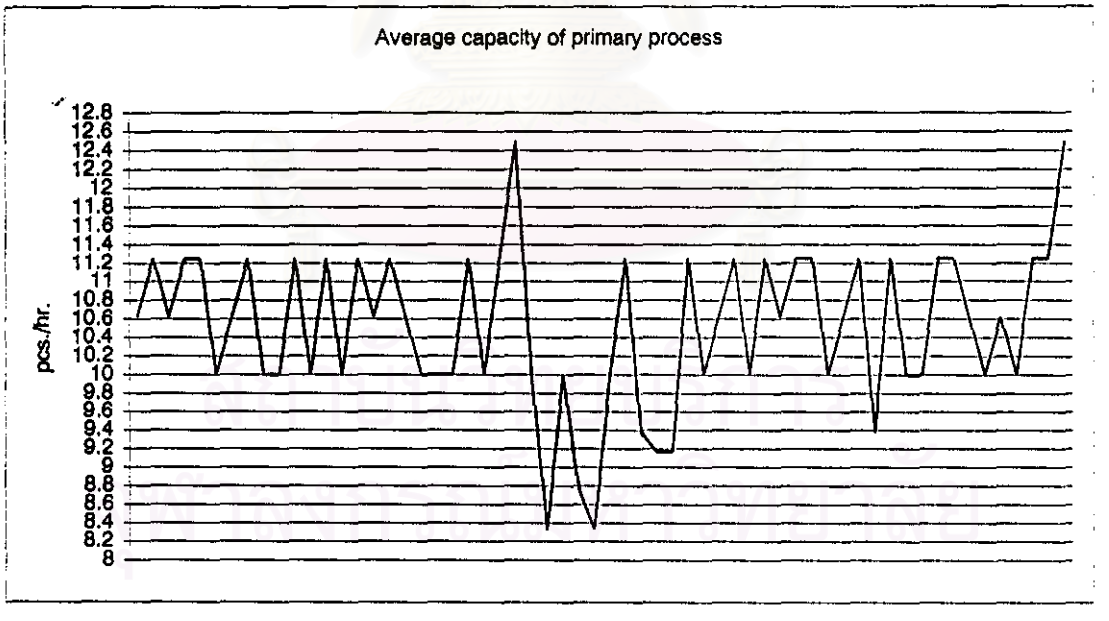


Figure 3-7 : The records of production capability in final, intermediate and primary processes during July to September, 1998

- Material Availability : is consider from the amount of main body in the intermediate and primary processes. [Those items are defined as Work-In-Process (WIP) in the Front Cover product. At present, the result of material availability from the comparison of the actual production shows a fluctuation of the amount of finishing main body in intermediate process and casting main body in primary process. The number of main body in intermediate and primary process that has been altered due to those problems of the existing PAC system can represent the effect of poor resource utilization as follows;

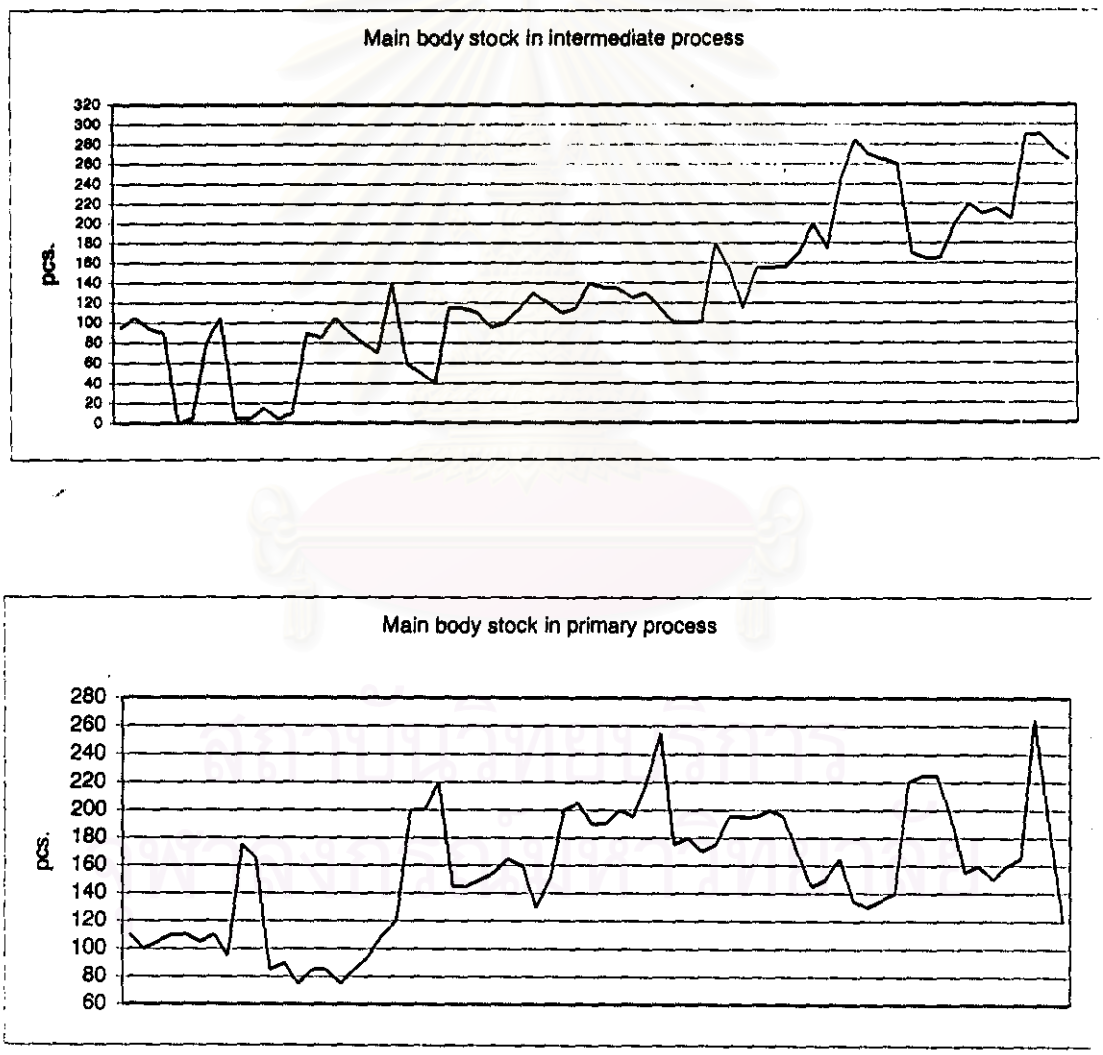


Figure 3-8 : The records of main body stock (WIP) in intermediate and primary processes during July to September, 1998

3.3.3.3 Analyzing the Existing Workflow

The cause of the problem from previous topic is analyzed in the steps of the production control system, as follows:

- Shortage of parts before the final process (Assembly)

The decomposition diagram of IDEF0 model, discovers the step of the existing production control and sequential processes, which are concerned with the problem in the production reporting activity as follows:

- *Updating the Final Assembly Schedule*: This is the monitoring job and responsibility of the Production Control Section, a production control staffs renovate the amount of delivery in the FAS to match the change of the amount demand by the customers. The FAS that has been edited is applied to the process of preparing the "Production Resources" of the "Planning Process" in the final process to modify the purchasing plan in the production preparing activity.

- *Preparing the Production Resource*: This means categorizing duties according to the responsibility of each sequential process that look after the Work Order Schedule. For the WOS in the final process, supervisors prepare the production resources and the amount of main bodies and other items that will be required in the process of assembling. Afterwards, they revise the amount of the requirement to meet with the amount that has been altered from the FAS.

From the process of the two activities just mentioned, the Production Control Section conveys information referring to change of delivery to modify the FAS and the amount to be produce in the final process directly. But, the change that is not referred to in the updated Work Order Schedule is the one causing deficiency of the main body and other items.

- Poor Resource Utilization

The decomposition diagram of IDEF0 model discovers about the production resource utilization, which is related with two processes in the production reporting activity as follows:

- *Production Process*: Categorized according to each sequential process. Supervisor controls the amount of item according to the Work Order Schedule. The actual production of each item will be recorded in the Work Order Report and distributed for keep in each sequential process This record depends on the amount of item from the WOS and the production capability in each sequential process.

- *Modifying the Work Order Schedule*: This means categorizing responsibility in each sequential process. The correction of the amount of item in the Work Order Schedule is verified by the supervisor in accordance with the Work Order Report. The update of the Work Order Schedule is applied to the process of "Preparing the Production Resource" to update the production quantity.

When looking at the above two activities, the existing processes do not verify and pursue the production resource utilization. The supervisor in each sequential process is the only one who can adjust resource utilization along with the amount of each item from the WOS. Therefore, when there is an updating in the WOS, the requirement of the production resources in each sequential process have to change to maintain the planned schedule.

- Excessive Work-in-Process

The decomposition of IDEF0 model indicate the workflow of existing processes, which consists of some processes from Order Planning and Production Reporting Activity as follows:

- *Preparing the Production Resource*: When the amount of finished products in final process (Assembly) has been changed, WIP in intermediate process (Machining) and primary process (Die-Casting) increase or decrease together with this

change. However, the amount of main body in intermediate and primary processes are still maintained with the planned schedule from WOS due to the schedule in the intermediate and primary processes are not update the changing from the final process.

- *Planning process for components*: The responsibility of the Production Control Section, this activity will use data from the Final Assembly Schedule (FAS) to produce the "purchasing plan" for other items. Thus, the purchasing plan for each item is related with the requirement from the FAS. However, the purchasing plan has been concerned with the lead times and amount of stock.

With the above two activities, the amount of main body in the intermediate and primary processes refer to the planned schedule from WOS from the final process while the amount of other items from supplier are referred with the FAS, which is controlled by the Production Control Section. Therefore, when the planned schedule in the FAS changes, the amount of main body in intermediate and primary processes is not matched with the amount of other items purchased according to the purchasing plan.

From the result of production resources utilization, the cause of problem can be defined in term of "Unsuitable Planning", "Workflow", "Data Communication", and "Item identification" problems. Each problem has a functional relationship to schedule and control processes. Start from the planned schedule (FAS & WOS) are objected to delivery the product at the right time, the right quantities, and meeting with the quality specifications. Thus, the workflow, data communication, and item identification are very important topics to match the customer requirements with the actual production resource.

After the planned schedules (FAS & WOS) are released to each sequential processes. Many random events such as changing delivery or machine breakdown may affect schedule adherence and force to modify the schedule. The record from each sequential process is not matched with the planned schedule that cause the adjusting of the planned schedule and production resource utilization. But, the existing processes have not a data collection and information system to communicate with the planning process. Thus, the planned schedule cannot manage.

The outcome of production resource usage in July until September, 1998 can be summarized as follows;

- *Unsuitable Planning* : is the comparing result between the production result from Work Order Report (WOR) and Work Order Schedule (WOS). Almost of the additional manpower is applied to edit and modify in the production control process. However, the actual production capability from WOR is not followed by the planned schedule in WOS.

- *Workflow* : the decomposition diagram of IDEF0 model illustrates the existing workflow of the production control and sequential processes. This diagram shows some repetitive and obstructive processes, which may cause an uncompleted of data and information in the planned schedule and the production result.

- *Communication* : the data and information in the existing system is scattered in the production control and sequential processes ,which have no standard format to exchange and communicate together. Especially, "Preparing the Work Order Schedule" and "Preparing the Production Resource" sub processes have to add double entry tasks that may cause the human error and require more additional manpower.

- *Item Identification* : Each data item in production control and sequential processes that the result has no standard format to identify the detail of items. That, cause requires some of additional manpower to analyze and identify the detail of item.

3.4 Summary

3.4.1 Workflow Problem

From the result of problem analysis, each activity in the existing production control and sequential processes is separated responsibilities and determined the limit of the activity by the holding on to the objective of the related process. The planned schedules have been changed due to many random events especially the change of delivery order from customer that effect to adjust and modify the planned schedule in each interval. Categorizing as mentioned causes the problem of updating the data and

coordination of production control and sequential processes. The steps of many small tasks are determined from the objective of related section. This study focuses on the cause of problems from the existing data collection and information system that can be summarized as follows:

1. Some processes have repetitive data
2. Some processes do not have enough information to make decisions
3. Many data items in each activity are not standardization

3.4.2 Data Communication Problem

From IDEF0 model, the data and information in the existing processes have no standard format to exchange and communicate together, especially with item identification. At present, each activity sets an internal data format to exchange each data item between processes. But they have no standard format and relationship of data exchange, which causes problems of referring and exchanging data.