ENHANCING SUPPLY CHAIN SOLUTIONS WITH THE APPLICATION OF VMI STRATEGY: A CASE STUDY OF AN OIL REFINING BUSINESS IN THAILAND

By
AUMPORN POONPERMSUWAN

A Final Report of the Six-Credit Course
SCM 2202 Graduate Project

Submitted in Partial Fulfillment of the Requirements for the Degree of
MASTER OF SCIENCE IN SUPPLY CHAIN MANAGEMENT

Martin de Tours School of Management
Assumption University
Bangkok, Thailand

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Martin de Tours School of Management
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Assumption University
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Declaration of Authorship Form

I, Aumporn Poonpermsuwan, declare that this thesis/project and the work presented in it are my own and has been generated by me as the result of my own original research.

[title of project] Enhancing supply chain solutions with the application of VMI strategy: A case study of an oil refining business in Thailand

I confirm that:

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I confirm that this thesis/project has been carried out under my supervision and it represents the original work of the candidate.

Signed Peeratarat Ittarattanachoke

(Dr. Peeratarat Ittarattanachoke)

Date November 2011

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Aumporn Poonpermsuwan
Assumption University
November 2011

ABSTRACT

In the business of oil refinery, the perfect process of refining without any problems of breaking down or shutting down is a conceptual model that cannot be found in the real world. Therefore, the refinery has protected the accident requirement of parts by keeping all spare parts in high quantity to protect the out of stock problem. The results of the high inventory affected the inventory management cost. The strategy of Vendor Managed Inventory was considered as the appropriate model to improve the problems of inventory. The suitable replenishment model is a Max-Min model that the vendor responds in order to fulfill and manage inventory level of the buyer as in policies of VMI. The vendor has to hold a large amount of inventory costs so the solution models to balance cost are examined to keep the win-win situation along the supply chains.

Finally, the key success factors, the benefits and the difficulties to implement VMI in refinery are considered in this project.

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I, Asst. Prof. Dr. June Bernadette D'Souza, has proofread this Graduate Project entitled Enhancing Supply Chain Solutions with the Application of VMI Strategy: A Case Study of an Oil Refining Business in Thailand

Ms. Aumporn Poonpermsuwan

and she hereby certifies that the verbiage, spelling and format is commensurate with the quality of internationally acceptable writing standards for a Master Degree in Supply Chain Management.

Signed June. B. D'Souza

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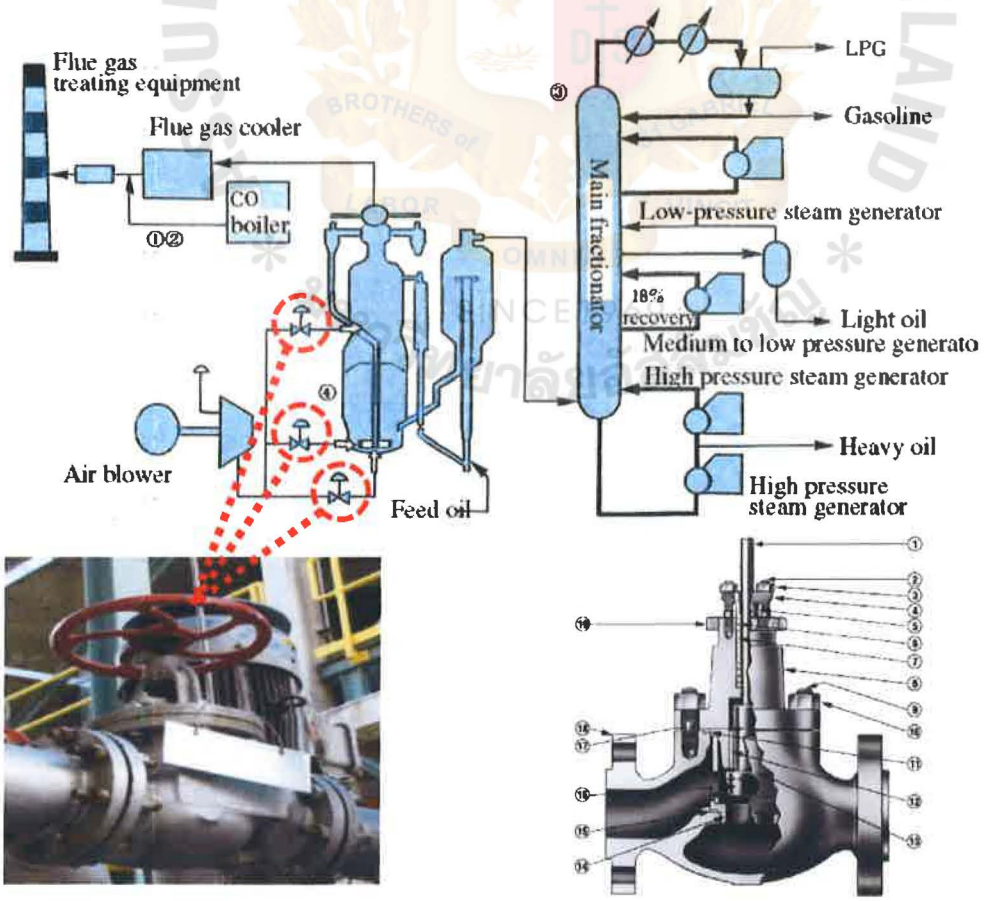
CHAPTER I

GENERALITIES OF THE STUDY

In the business of oil refinery, the maintenance cost of equipment is very high and can represent up to 15 to 70 percent of total production costs because the maintenance department has to elevate the reliability of equipment in the production process and the plant safety. The control valve is the one of equipment in the plant that which has high maintenance cost and can prevent the deteriorated of parts before failure of valve body which creates a problem in the production process. Inside of a valve there are more than 30 pieces of construction parts (plug, packing, bonnet, seat ring, gasket, etc.) which vary in size and material of valve type.

Figure 1.1: The Control Valves in Refining Process Flow



Source: Company profile

Figure 1.2: The Control Valves in Plant of Refinery

Source: Company profile

Figure 1.3: The Spare Parts for a Control Valve

Source: Company profile

1.1 Background of the Research

The company in this case study which here after will be called "ABC Company" is an owner and operator of a highly complex refinery which integrated in related, on to petrochemical production that utilizes modern processing technologies to produce petroleum products for domestic distribution. ABC refinery ranks as one of the Thailand's largest refinery, with a refining capacity at roughly 270,000 barrels per day, or about 15,000 million liters a year. ABC refinery accounts for 21 percent of the national processing capacity, meeting 35 percent of the domestic demand for refined petroleum products. ABC has equipment of operation control valve of more than 1,000 units in the plant and a cost of consumable parts of more than 30,000,000 THB every year. Normally, ABC uses purchase orders and releases note to trigger local suppliers to replenish spare parts then stocks it in the warehouse until it receives release orders from the end-users. The company has lost an amount of 50,000,000 THB per year from cost of extended shutdown or breakdown maintenance date when supplier cannot complete plan as promised in the contract because of late delivery, short ship, wrong supply and defects. The company agrees with the supplier to create more collaboration with the supply and planning so that the concept of Vendor Managed Inventory (VMI) can be used. ABC expects that VMI can reduce inventory cost, improve service levels and create more flexibility in production planning.

1.2 Statement of the Problem

Nowadays, ABC uses "The Conventional Order Management" ABC took the lead in three collaboration tasks: sales forecasting, order planning and order generation. *Sales forecasting*: end-users observe demand to consume spare parts of control valves then informed planers to design the demand. *Order planning*: the planers have to determine product ordering and delivery requirement based on the maintenance planning, inventory levels, transit lead times, and other risk factors. The planners have to make sure that spare parts will remain in stock an emergency case occurs with regard to control valves. Finally, *Order generation*: team procurement receives requirements from planners to generate order to suppliers. After suppliers deliver

goods to the site, warehouse teams have to keep all of the spare parts on shelves. ABC has to keep every item of spare parts over the safety stock which creates the high inventory holding cost and includes the physical holding cost and the cost of capital as indicated in Table 1.1.

Table 1.1: Annual Inventory Holding Cost of ABC Company

Component of Inventory Holding Cost	Annual Cost of Holding (%)	Annual Cost of Holding (THB)
Physical Holding Cost	10%	7,144,255
- *Operation Cost*		
- *Warehousing Cost*		
- *Obsolescence Cost*		
Cost of Capital	25%	17,860,636
Total Annual Inventory Holding Cost	35%	25,004,891

Source: Company profile

With the limitation of ABC's warehouse management cost, warehouse space and warehouse equipment. ABC Company enhanced a new model that can create more "collaborative arrangement" between the suppliers and ABC. The process of setting the business goals was to minimize inventory cost. ABC is interested in "VMI model". ABC has to join business plans with suppliers by sharing the information of demand. Then suppliers have responsibility to maintain the inventory level and arranged replenishment quantities to keep the spare parts available as in contractually agreed on levels.

Therefore the VMI model is considered as a strategy to create the win-win situation between ABC and suppliers by improved highly performance of the inventory management of the ABC and create a solution that is benefits to the suppliers. This research aims to answer the problem of "How does the ABC Company apply the VMI model for the inventory of spare parts?".

1.3 Research Objectives

1.3.1 To study the strategy of Vendor Managed Inventory model that optimizes the inventory cost of spare parts in an oil refinery.

1.3.2 To study the benefits and difficulties of applying the VMI strategy into the refinery business.

1.4 Scope of the Research

This project aims at examining the suitable VMI strategy in an oil refinery by mainly considering the win-win situation with suppliers. The scope of this project examines a quantitative and qualitative framework. The quantitative framework studied the results before and after implementation of the VMI model by comparing the cost of inventory. The data of annual inventory cost and annual consume spare parts in the year 2010 is used as the database for analysis the results. A qualitative framework studied the critical factors to create VMI collaboration and study the benefits and the difficulties of implementation of VMI in the ABC by concluding the results of the investigated data from the research questions. The questionnaire is used to find the opinion of the general manager of ABC.

Finally, the conclusion from the results and analysis will wrap up the pros and cons of the implementation VMI model in the refinery business.

1.5 Significance of the Research

This research aims to study optimization methods on the expansion of VMI strategy in inventory of control valve spare parts for ABC Company and the suppliers. The research analysis results that can be used as a guideline for ABC and suppliers by considering the application of this strategy in the inventory management. This research not only studies the concept and implementation of VMI strategy but also studies the benefits and limitations in this strategy which can be used for further

study. Furthermore, this research can be applied in any other business which is considering the implementation of VMI strategy.

1.6 Limitations of the Research

This project examines only the key supplier of product spare parts that control valves as the representative for all suppliers in ABC and studies only the fast moving parts that will be represented as the pilot group for all SKUs in inventory. Some data such as cost of holding inventory that cannot be found from historical data will get from estimated by the warehouse manager and others who are involved.

1.7 Definition of Terms

ABC analysis	The divided inventory to three groups based on the portion of inventory value (group A, B and C) (Angulo, Nachtmann, & Waller, 2004).
Inventory holding cost	A financial cost of carrying inventory which is composed with two parts; the cost of physical holding and the cost of capital (Waller, Johnson, & Davis, 1999).
KPIs (Key Performance indicators)	The measurement of critical success factors (Disney & Towill, 2002).
Lead time	A range of time after the issue of purchase orders to the time that goods are received completely (Pamela, 2005).
Supply chain collaboration	A coordination between the suppliers and the company to increase efficiency in managing

	inventory and service levels (Disney, Naim, & Potter, 2004).
VMI strategy	A process in which the supplier collaborates with the customer to maintain the inventory levels at the customer warehouse and plan replenishment quantities to keep the levels (Disney & Towill, 2002).

CHAPTER II

REVIEW OF RELATED LITERATURE

In this chapter, the details about Vendor Management Inventory (VMI) will be explained, followed by the benefits and difficulties of the VMI implementation, the theoretical foundation of VMI concepts like the method to find optimal replenishment solution model and the factors supporting and blocking VMI implementation.

2.1 Vendor Management Inventory (VMI)

VMI is a coordinated relationship between customer and supplier where the supplier takes responsibility of inventory for customers on behalf of the customer and decides the suitable inventory level of each product and policy to replenishment the inventory (Pamela, 2005).

The roles of supplier under the VMI strategy includes (1) monitoring the buyer inventory level, (2) forecasting sale, (3) making periodic replenishment, (4) deciding order quantities, (5) shipping, and (6) timing (Waller et al., 1999).

VMI is also known as continuous replenishment or supplier management inventory. This strategy is one of the most famous topics about information sharing and collaboration among partners (Angulo et al., 2004).

2.2 Benefits and Difficulties of the VMI Implementation

After applying the VMI model, step in the information chain was eliminated and the supplier can create better demand visibility through actual demand (Kaipia, Holmstrom, & Tanskanen, 2002).

The benefits of VMI that are mentioned in literature (Blatherwick, 1998; Kaipia et al., 2002; Disney & Towill, 2003; Smaros, Lehtonen, Appelqvist, & Holmstrom, 2003) as below;

1. Reduce the bullwhip effect
2. Reduce the inventory level
3. Reduce the stock out number and frequency
4. Increase flexibility in production planning and distribution
5. Improvement of customer service

Earlier studies of VMI in the retail supply chain indicate that the uncertainty in customer demand substantially reduces (Waller et al., 1999; Gavirneni, 2002; Lau, Huang, & Mak, 2004). According to Lee, So, and Tang (2000); Zhang and Zhang (2007) explained that information sharing strategy has more influence at higher levels of demand uncertainty. Kasim (2007) showed that the higher level of demand uncertainty will definitely increase the information sharing in the chain as type of information shared such as upcoming promotion, sales and inventory data can resolve the uncertainty observed in customer demand.

De Toni and Zamolo (2005) suggested the data for transfer in VMI collaboration such as Sales forecasts, stock levels, incoming orders, and promotions. As Angulo et al. (2004) adviced that Inventory levels and position, sales data and forecasts, order status, production and delivery schedules and capacity, and performance metrics should be transferred between customers and suppliers. Smaros et al. (2003) recommended that sell- through information is requested to shared in VMI strategy. McBeath (2003) was concerned with Point of Sales (POS) data from actual demand of customer transfer to supplier site. While, Harrison and van Hoek (2002) agreed that customer sales and inventory levels are the key points to share information in VMI. Mattson (2002) studied that inventory levels, current sales, forecasts and promotions are required in VMI collaboration. Achabal, McIntyre, Smith, and Kalyanam (2000) indicated that the sale forecasted is required in VMI. Kulp (2002) also suggested that inventory levels, stock withdrawals, POS data, purchase orders and production schedule are necessary for VMI. Christopher (1998) specified that actual sales or

usage, inventory levels and promotion are involved in data transfer in VMI. Finally, Holmstrom (1998) advised that transfer data in VMI should have data of free stock and cumulative goods receipt.

2.3 Theoretical Foundation of VMI Concepts

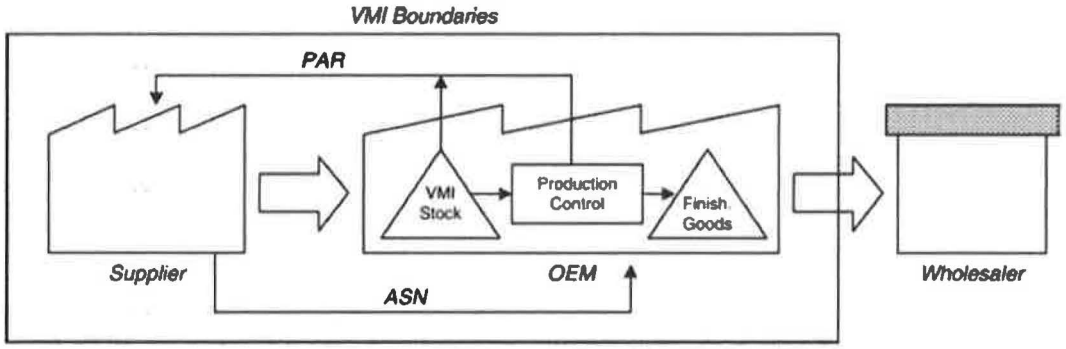
The foundation of VMI model started from the collaboration of customer and supplier in technology that lead to the implementation of these strategies which are: 1) Sharing information to supplier on real-time views, such as actual stock, demand forecasts, current and future production plans, special promotion, and order commitment. 2) Showing the status of inventory position among supply chain members so this information can trigger the supplier to get ready for replenishment. 3) Letting the customer to track the status of shipment (Aberdeen, 2004)

Hall (2001) suggested that the concept of VMI is the customer's inventory was managed by the supplier who received demand information from the customer. The effects of implementation of VMI are the decrease steps in the information chain and create a visibility demand. The supplier can plan the process to match with actual demand (Kaipia et al., 2002).

The core process of VMI model is information sharing that is based on two transactions as shown in Figure 2.1 (Hall, 2001; Pohlen & Goldsby, 2003).

The first transaction is the advance ship notice that is sent by the supplier to customer when shipment occurs. The ASN will contain the information of goods description and shipping instructions. The second transaction is the production activity record (PAR) that is periodically sent by the customer to the supplier which informs about the useful information for replenishment planning such as current stock levels, point of sale and/or incoming orders and stock withdrawal (Francesco, Marcello, & Marco, 2009).

Figure 2.1: Information Flows in VMI



Source: Francesco et al. (2009, p. 167)

2.4 Factors Supporting and Blocking VMI Implementation

2.4.1 Factors to Support VMI Implementation

The support factors for success of VMI model are to create a strong relationship among partnerships by using active communication, sharing the critical information, collaboration multiparty to solve the problem, and obligation to continued development (Malla, 2007)

2.4.2 Limitations of VMI Implementation

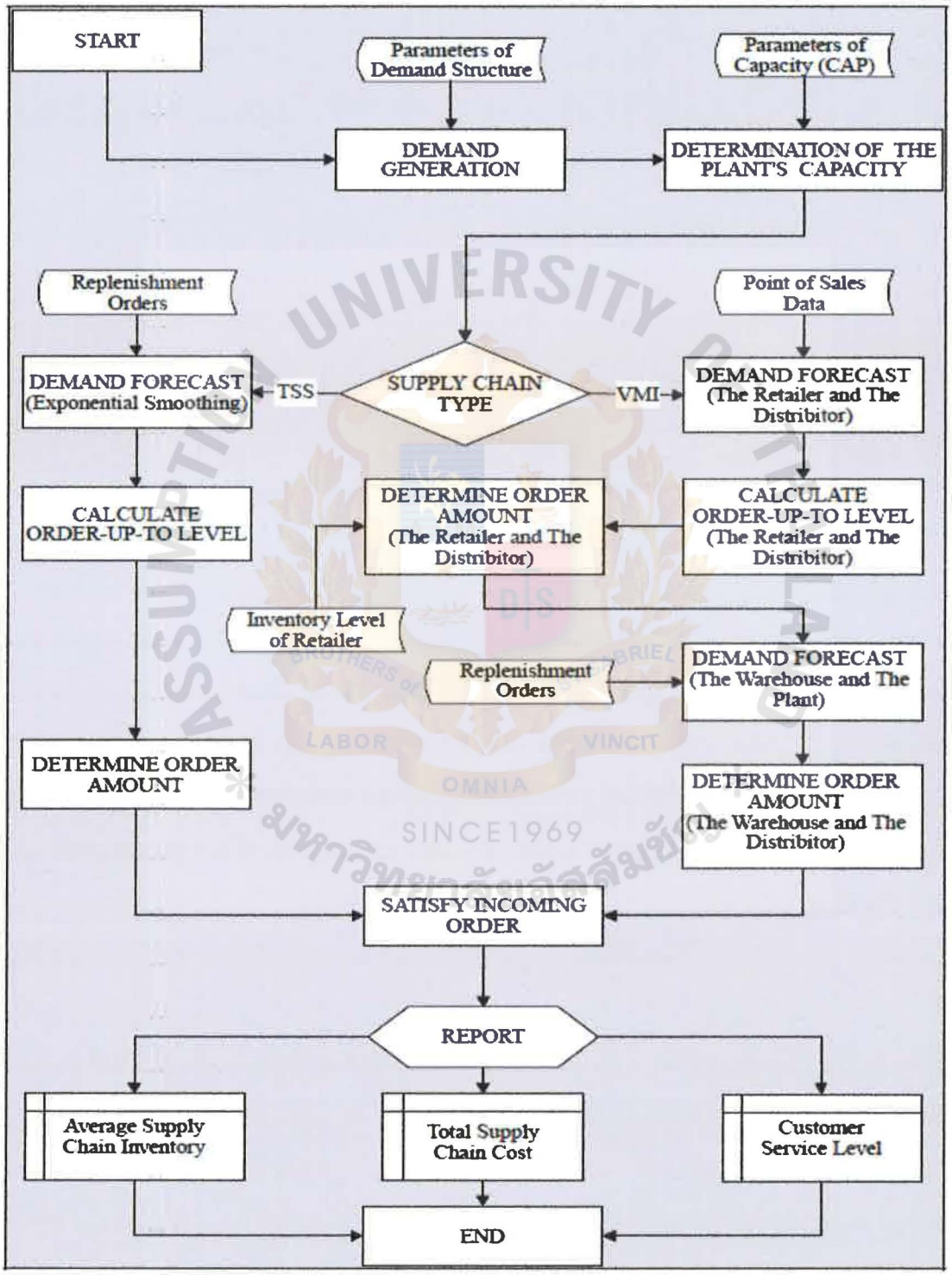
The limitations in the VMI model were considered because of conflict of goals among supply chain members and the unwillingness of the customer and the supplier to share confidential data (Simchi-Levi, Kaminsky, & Simchi-Levi, 2000).

Malla (2007) suggested that the obstacles of VMI implementation are the constraint of collaboration at all levels of supply chain, and the highs cost of initial investment of VMI implementation.

2.5 Replenishment Policy for VMI Model

Sari (2007) applied the simulation model in a spread sheet in Microsoft Excel to compare the purpose between the traditional supply chain structure model (TSS) with the VMI model under the same replenishment policy as showed in Figure 2.2 that is illustrated by flow chart of the simulation model.

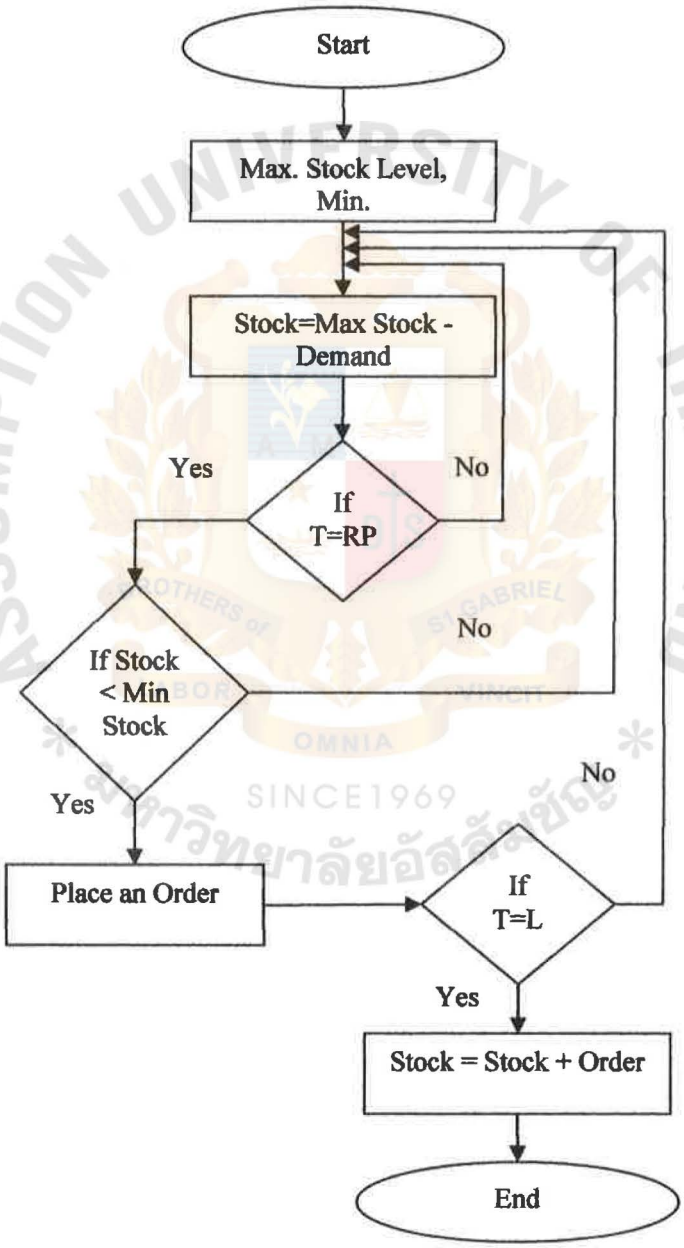
Figure 2.2: Flow Chart of the Simulation Model between Traditional Supply Chain Structure and VMI Model



Source: Sari (2007, p. 534)

Malla (2007) develop the model of VMI simulation with objective of maintaining the stock level under VMI strategy by applying the Max-Min replenishment policy (S, s) as shown in Figure 2.3

Figure 2.3: VMI Simulation Model



Source: Malla (2007, p. 85)

2.6 Performance Policy for VMI Model

The performance level will be evaluated from a set of KPI's, that was set KPI's and the corresponding threshold value under commitment of customers and suppliers to measure the overall performance in supply chain.

The penalties and benefits were set under agreement of both parties. The replication of failure can lead to terminate or decrease the collaboration levels in supply chain (Francesco et al., 2009).

CHAPTER III

RESEARCH METHODOLOGY

This research is a case study of an oil refinery which implements the VMI strategy with the key suppliers. The data for analysis here comes from historical data based on year 2010 which will be analyzed. The appropriate inventory replenishment model for VMI strategy based on the negotiation of both parties is suggested.

3.1 Data Collection

Data of the control valves in the ABC plant from the ABC historical database on annual maintenance report from January 2010 to December 2010. The total unit of the operation control valves has about 1,400 units under 3 brands such as X, Y and Z which shared the proportion as in Table 3.1. This project studies only brand X which has the highest proportion of consumed spare parts per year.

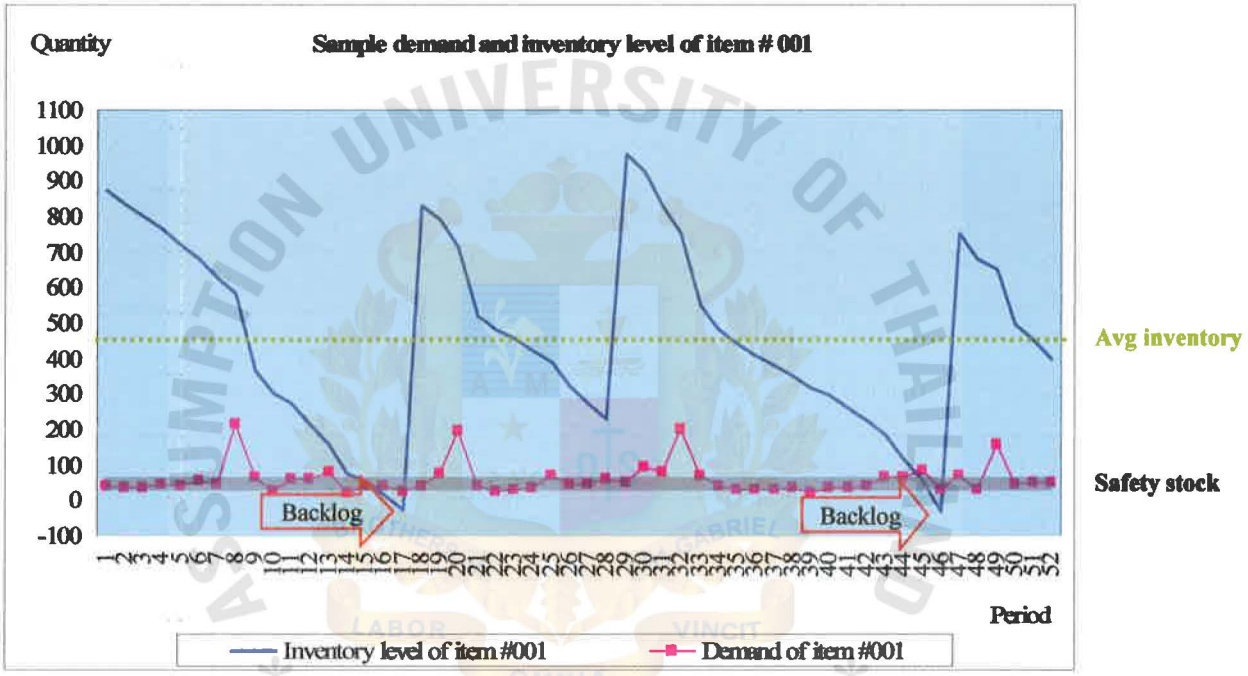
Table 3.1: The Number of Valves in ABC Plant and Cost of Spare Part under Three Brands

Brand	No. of Valves (UNIT)	Annual Cost of Spare Parts (THB)	% of Annual Cost of Spare Parts (%)
X	1,150	41,160,945.00	85
Y	200	5,775,527.00	12
Z	50	1,654,300.00	3
Total	**1,400**	**48,590,772.00**	**100**

Source: Company profile

Data of the spare parts consumption and inventory on hand is got from the ABC historical database on quarterly report from January 2010 to December 2010. The data based upon weekly demand of each item and weekly report of inventory level is demonstrated in Figure 3.1.

Figure 3.1: Graph of Demand and Inventory Level of item # 001



Source: Company profile

Data of the supplier effectiveness performance is got from evaluation of ABC to suppliers by KPIs. In the year 2010, ABC has set percentage of successful contract at 95, percent of on-time deliveries, percentage of complete deliveries at 98 and percentage of delivery with acceptable quality at 98. After evaluation, the supplier performance was lower than the target point in part of successful contract and on-time delivery as demonstrated in Table 3.2.

Table 3.2: The Supplier Effectiveness Performance

Key Performance Index (KPI)	Target Point	Performance of Supplier
On-Time Deliveries (Right Time)	95.00%	75.00%
Complete Deliveries (Right Product and Right Place)	98.00%	98.00%
Deliveries with Acceptable Quality (Right Quality)	98.00%	98.00%
Perfect Order	**95.00%**	78.00%

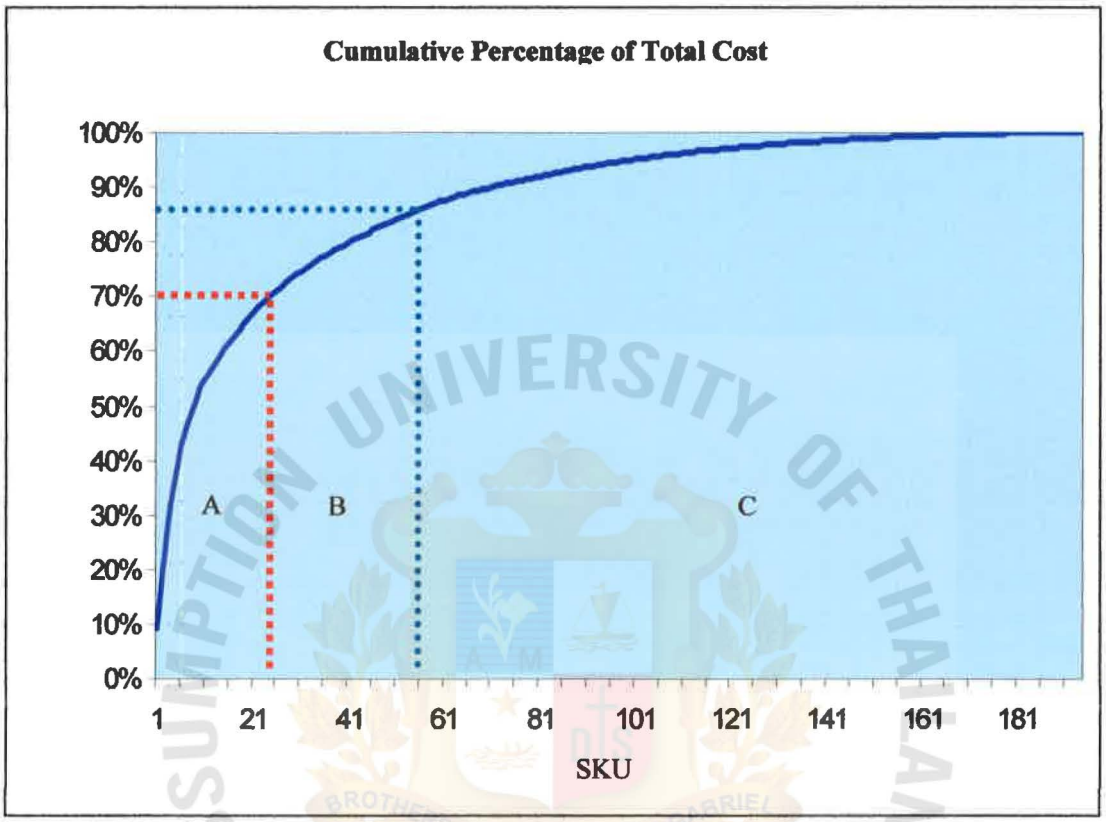
Remark: Transaction per Year = 100 Times SKUs = 194

Source: Company profile

3.2 Classify SKUs into Product Classes

ABC consumed spare parts under brand of supplier X is about 194 SKUs. It will be very difficult to classify which items highly impact the company. The recommended method is to apply the ABC classification method. The result is shown in Figure 3.2 and indicates, that 70 percent of total cost of consumed spare part was classified as group A with 25 items, group B with 28 items and group C with 141 items and both contributed around 30 percent of total cost.

Figure 3.2: Graph of ABC Classification



Source: Company profile

Group A generated around 70 percent of the total cost of consumed spare parts and items ranked in 1-9, cover 50 percent of total cost so these items were chosen for the pilot study as shown in Table 3.3

Table 3.3: Top Cumulative 50% of Total Cost from List of Spare Parts

SKUs	Annum Volume	Unit Cost (THB)	Total Cost (THB)	Percentage of Total Cost	Cumulative Percentage of Total Cost	ABC
1	603	6,245	3,765,735	9.15%	9.15%	A
2	573	6,570	3,764,610	9.15%	18.29%	A
3	518	7,240	3,750,320	9.11%	27.41%	A
4	3,020	921	2,781,420	6.76%	34.16%	A
5	2,400	880	2,112,000	5.13%	39.29%	A
6	1,417	980	1,388,660	3.37%	42.67%	A
7	587	2,323	1,363,601	3.31%	45.98%	A
8	283	3,850	1,089,550	2.65%	48.63%	A
9	539	1,930	1,040,270	2.53%	51.16%	A

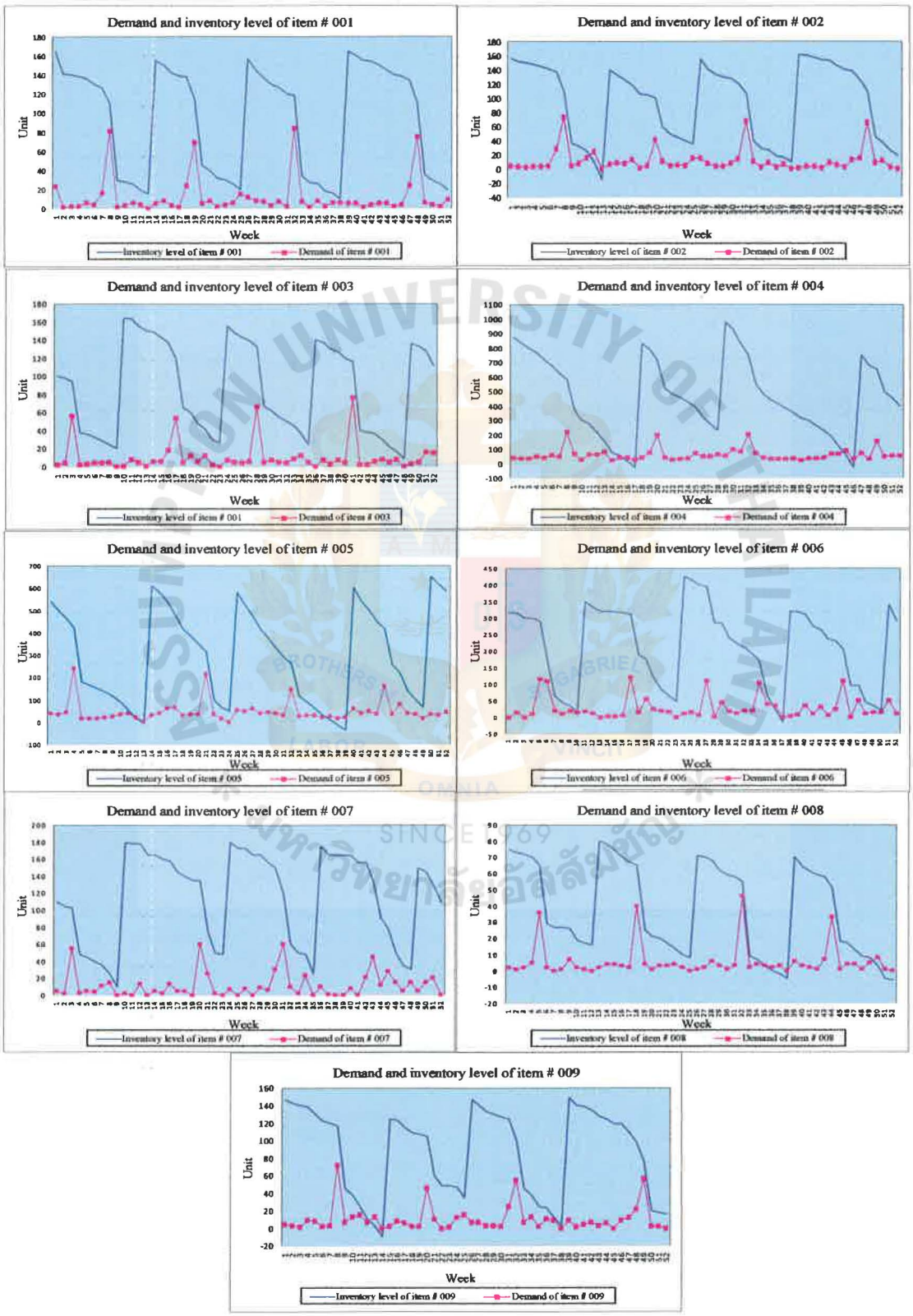
Source: Company profile

3.3 Apply Inventory Replenishment Model

3.3.1 AS-IS Inventory Replenishment Model and Inventory Cost

Currently, ABC, and suppliers have ordered and replenished inventory by simply calculating the condition of uncertain demand and lead time as illustrated in Figure 3.3.

Figure 3.3: Demand and Inventory Movement of Item #001-Item #009



Source: Company profile

The ABC Inventory Cost and Component are shown in the Table 3.4

Table 3.4: AS-IS ABC Inventory Cost and Demand

ABC						
SKUs	**Annum Volume**	**Average Inventory**	**Inventory Holding Cost/Unit/Year**	**Annum Inventory Holding Cost**	**Cost of Average Inventory**	**Annum Total Inventory Cost**
# 001	603	1,214	2,186	2,653,501	7,581,430	10,234,931
# 002	573	1,221	2,300	2,807,690	8,021,970	10,829,660
# 003	518	987	2,534	2,500,425	7,144,070	9,644,495
# 004	3,020	5,920	322	1,908,312	5,452,320	7,360,632
# 005	2,400	3,390	308	1,044,120	2,983,200	4,027,320
# 006	1,417	2,644	343	906,978	2,591,365	3,498,343
# 007	587	1,365	813	1,110,017	3,171,476	4,281,492
# 008	283	490	1,348	659,601	1,884,575	2,544,176
# 009	539	1,135	676	766,693	2,190,550	2,957,243
Total				**14,357,335**	**41,020,956**	**55,378,290**

Source: Company profile

The total cost of ABC inventory for item #001- item #009 was 55,378,290 THB per year while the total cost of supplier inventory was only 4,651,776 THB in year 2010 as showed in Table 3.5.

Table 3.5: AS-IS Supplier Inventory Cost

Supplier						
SKUs	Unit Cost	Average Inventory	Inventory Holding Cost/Unit/Year	Annum Inventory Holding Cost	Cost of Average Inventory	Annum Total Inventory Cost
# 001	4,372	146	1,530	222,894	636,840	859,734
# 002	4,599	147	1,610	235,846	673,845	909,691
# 003	5,068	118	1,774	210,036	600,102	810,138
# 004	645	710	226	160,298	457,995	618,293
# 005	616	407	216	87,706	250,589	338,295
# 006	686	317	240	76,186	217,675	293,861
# 007	1,626	164	569	93,241	266,404	359,645
# 008	2,695	59	943	55,407	158,304	213,711
# 009	1,351	136	473	64,402	184,006	248,408
Total				1,206,016	3,445,760	4,651,776

Source: Supplier's company profile

3.3.2 TO-BE Implement VMI Strategy

The ABC plant has faced the problem of high inventory cost because of high stock in every item of the spare parts in order to protect the problem of the shutdown process due to lack of stock. From this problem, the strategy of vendor-managed inventory (VMI) can improve the inventory cost by negotiation between the suppliers and ABC to create the win-win situation. The structure of agreement between ABC and supplier in the strategy of VMI is as follows:

3.3.2.1 Scope of Work

Replenishment entrusting: the core process of VMI is the responsibility of suppliers to reduce the ABC's inventory level for each of the spare parts by at least 25 percent of the present level and assure to keep inventory level in range of Min-Max stock level under the top priority to prevent the process of shutdown due to parts that are out of stock.

To share the information between ABC and the suppliers: ABC allows the suppliers to check condition of control valves at the ABC site and to share the database of control valves and all information that is necessary to create optimization VMI such as reference, design and accessories, standard of compliance, material of construction, service conditions and maintenance requirements.

Inventory owner: The supplier has to own the inventory till sold to ABC.

3.3.2.2 Service Level Agreement

KPIs : used to assess the achievement level of performance such as on-time delivery (right time), complete delivery (right product and right place), delivery with acceptable quality (right quality) and perfect order.

Penalty and benefit: the result of KPIs will bring the penalty and/or benefit to the supplier. For instance, if the supplier cannot supply spare parts as the condition, the supplier will get the penalty from ABC step by step i.e., pay a fine by calculating from cost of plant shut down per day until the contract is broken with the supplier.

The limitation of VMI strategy will affect the supplier by declining the revenue of the supplier by at least 25 percent from the reducing inventory level, creating the cost of inventory by estimated 20,000,000 baht per year and increasing risk of paying fee with the highest fee of 300,000 baht per day.

After limitation is that the supplier will lose more than gain from this strategy so it is necessary to balance the situation of win-win between ABC and suppliers. The suppliers negotiate with ABC to generate revenue by implementing the software program for valves management and maintenance beneath the supplier support which includes the process of maintenance schedules, providing maintenance parts and maintenance actions for all valves. ABC has to balance the benefits with suppliers so that it should not be lower than the lost sale, cost of inventory and cost of risk.

3.4 Analysis the VMI Implementation

The main issues of VMI implementation for ABC is consideration of quantitative and qualitative analysis before implementation of the new strategy at the ABC plant.

The quantitative analysis has to calculate the index after implementation of VMI and compare it with the index of AS-IS in point of inventory cost.

The qualitative analysis has to be concerned about the benefits and limitations of ABC and the suppliers readiness to collaborate and share information.

CHAPTER IV

PRESENTATION AND CRITICAL DISCUSSION OF RESULTS

Chapter III indicates that, the VMI model has been developed to keep in check the highest impacted costs of the ABC refinery. For the quantitative analysis, the Max-Min replenishment policy has been determined to balance the inventory cost of the refinery compared with the last replenishment model. The inventory cost of supplier has been created to support the conditions under the policies of VMI strategy. Furthermore, the exchanged optimizing benefits for the supplier who carried the high inventory cost to serve ABC as required are created by revenues from replacing the competitor valves, implementing valve serviced maintenance and increasing unit price. The results of implementation in each model are studied in the following section. For the qualitative analysis, the result of in-depth interviews in topics of the benefits and the limitations of implementing VMI model in the organization of ABC are discussed in the next section.

4.1 Quantitative Analysis

4.1.1 Result of Evaluation and Analysis of Max-Min Replenishment Model

Malla (2007) suggested the formula of Maximum and Minimum stock level as follow:

Maximum stock level (S) = D*(T+L) + ST.

Minimum stock level (s) = D* ((T/2)+L) + ST.

Where, D = Average demand

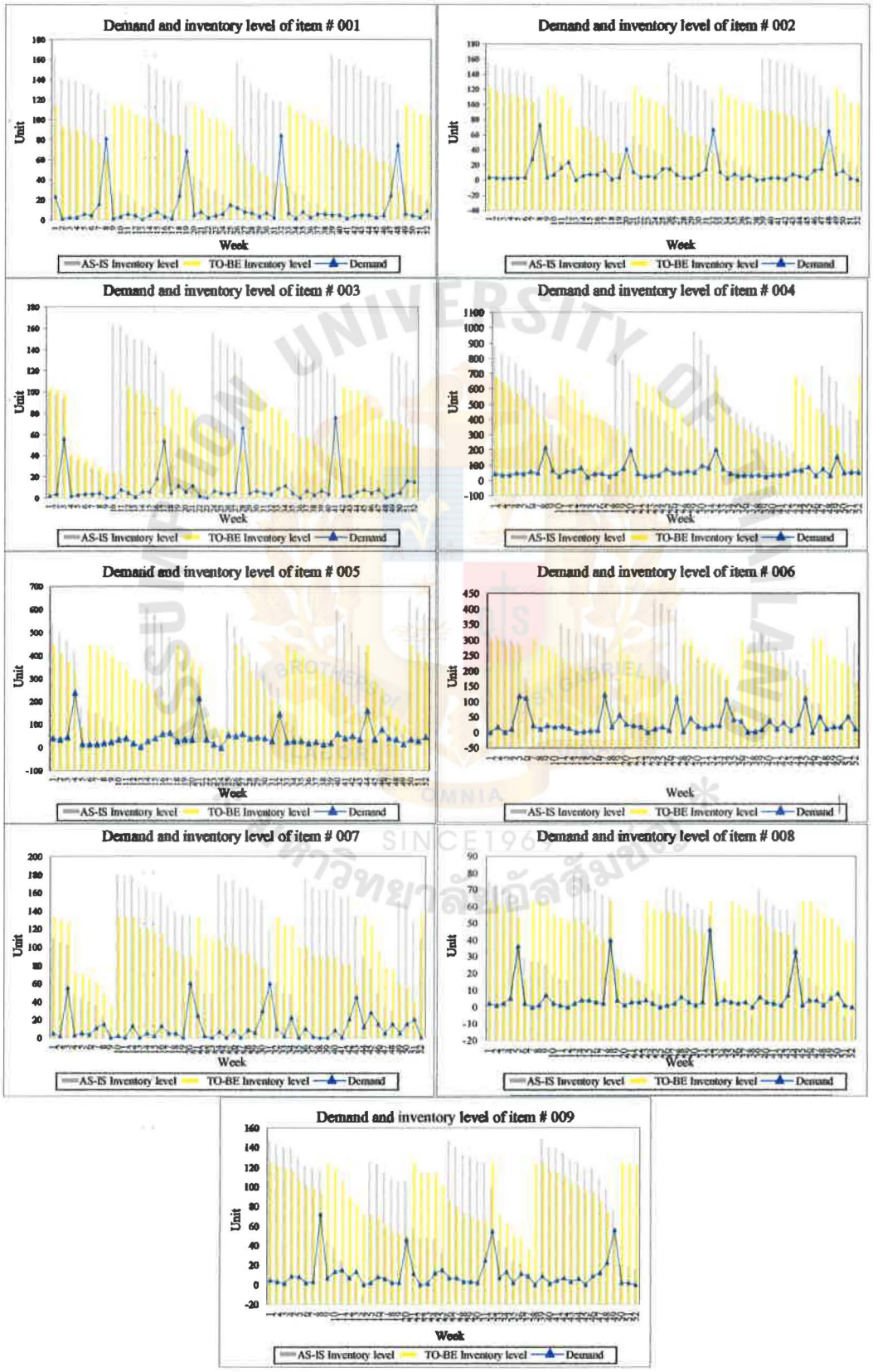
T = Review period

L = Average lead time

ST = Safety stock

The results of the Max-Min replenishment policy was calculated on the spread sheet that shows the out put of the replenishment model and is described in Figure 4.1.

Figure 4.1: Inventory Movement from Max-Min Replenishment Model of Item #001– Item #009



From the theory of VMI model, the vendor has to refill the inventory when the stock statuses lower than the minimum stock level but not fill more than maximum stock level. Figure 4.1 demonstrates the sample graph simulation of the inventory movement under the Max-Min inventory replenishment model compared with the demand and the actual stock. The result showed that the VMI model can improve the inventory level of ABC and improve the problem of shortage in item no. 002, 004, 005, 006, 008 and 009 as illustrated in the graph of Figure 4.1.

Furthermore, the Table 4.1 reveals the total inventory cost of ABC from Max-Min replenishment model in one year. The simulation inventory cost is 40,984,856 THB which can reduce cost of inventory from the actual stock about 14,393,435 THB or 26 percent of one year inventory cost.

Table 4.1: Result of ABC Inventory Cost Based on VMI Strategy

ABC						
SKUs	**Average Inventory**	**Inventory Holding Cost/Unit/Year**	**Annum Inventory Holding Cost**	**Cost of Average Inventory**	**Annum Total Inventory Cost**	**% of Inventory Deduction**
# 001	885	2,186	1,934,610	5,526,825	7,461,435	27%
# 002	902	2,300	2,074,600	5,926,140	8,000,740	26%
# 003	735	2,534	1,862,490	5,321,400	7,183,890	26%
# 004	4,409	322	1,419,698	4,060,689	5,480,387	26%
# 005	2,534	308	780,472	2,229,920	3,010,392	25%
# 006	1,968	343	675,024	1,928,640	2,603,664	26%
# 007	1,012	813	822,756	2,350,876	3,173,632	26%
# 008	362	1,348	487,976	1,393,700	1,881,676	26%
# 009	840	676	567,840	1,621,200	2,189,040	26%
Total			**10,625,466**	**30,359,390**	**40,984,856**	**26%**

Conversely, the total inventory cost of supplier in simulation model for one year is 14,730,088 THB which increased from the actual stock of supplier 216 percent as demonstrated in Table 4.2

Table 4.2: Result of Supplier Inventory Cost Based on VMI Strategy

Supplier							
SKUs	Unit Cost	Average Inventory	Inventory Holding Cost/Unit/Year	Annum Inventory Holding Cost	Cost of Average Inventory	Annum Total Inventory Cost	% of Inventory Increase
# 001	4,372	474	1,530	726,049	2,074,427	2,800,476	226%
# 002	4,599	465	1,610	749,002	2,140,007	2,889,009	218%
# 003	5,068	371	1,774	657,299	1,877,998	2,535,297	213%
# 004	645	2,221	226	501,481	1,432,803	1,934,284	213%
# 005	616	1,262	216	272,179	777,654	1,049,833	210%
# 006	686	993	240	238,514	681,468	919,982	213%
# 007	1,626	517	569	294,498	841,422	1,135,920	216%
# 008	2,695	187	943	176,075	503,072	679,147	218%
# 009	1,351	431	473	203,814	582,326	786,140	216%
Total				**3,818,912**	**10,911,176**	**14,730,088**	**216%**

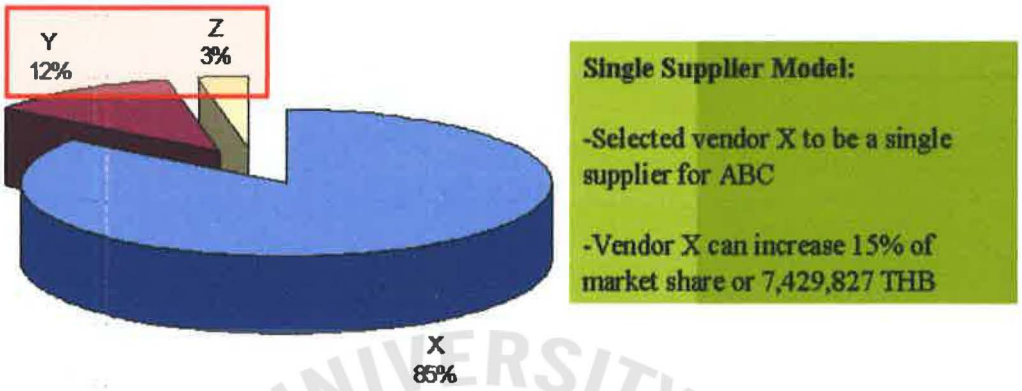
The cost of inventory directly affects the supplier therefore the incentive solution model can keep the balance between cost and revenue for the supplier. The models to create revenue for ABC were studied and three solution models were composed which are sole source model, the service maintenance model and the raising sale price model. The implementation and the results from each model were investigated as per the following sections.

4.1.2 Result of Evaluation and Analysis the Optimization Model

The result of the balancing situation model was calculated in a spread sheet and the output of each model was showed as below.

Increasing inventory cost = TO-BE inventory cost – AS-IS inventory cost
= 14,730,088 - 4,651,776
= 10,078,312 THB/ Year

Figure 4.2: Market Share of Vendor X in the Sole Source Model



First, the sole source model is the model that has only one supplier to provide all parts in the plant and replaces the competitors' market share as in Figure 4.2. The vendor X can create more income by increasing the market share from 85 percent to 100 percent. Table 3.1indicates that the total annual cost of spare parts in ABC was 48,590,772 THB and vendor X had a market share of about 85 percent or 41,160,945 THB per year, where as the vendor Y and Z hold the market share only 15 percent or 7,429,827 THB per year. In this model, ABC negotiates with vendor X to implement the sole source model so that ABC will have only vendor X to supply the whole spare parts to ABC. This can increase the revenue of vendor X from 41,160,945 THB to 48,590,772 or increase the revenue about 7,429,827 THB per year.

The next model to balance cost of inventory is the service maintenance model for all valves under responsibility of vendor X which guarantees the future of business by making a contract with ABC. This model supplier X will take action to do maintenance planning and maintenance action for valve 1,400 units. The maintenance planning includes the management schedule of planning, part planning and service resource planning. The maintenance action consists of the verifying the process of the condition found, then corrective action and submitting a report of maintenance in each unit. In the past, ABC hired the contractor to do service maintenance for all valves, and ABC paid about 8,400,000 THB or 6,000 THB per unit. After ABC negotiated with supplier X, the vendor agrees to receive this job and offer the cost of maintenance planning and maintenance action per valve starting from 5,500 THB

depending on the size of the valve. This can generate revenue to supplier X at least at 7,700,000 THB per year from valve 1,400 units.

The last model is the model of raising the product price of ABC and vendor X is designed to adjust the unit price and fix the adjusted unit price for ABC starting from the beginning of the VMI contract until the end of the contract. Normally, the supplier X increases the unit price ever year. The increased rate depends on interest rate, exchange rate and inflation rate which vary from 5-15 percent. The vendor estimated it to increase about 10 percent of the unit price and this can guarantee the constant price of spare parts over the contract period and the supplier could evaluated a revenue of about 2,105,617 THB per year.

Table 4.3: The Result of Balancing Supplier Revenue by Raised the Unit Price

SKUs	Difference Cost of Inventory Between AS-IS and TO-BE		Balanced Supplier Revenue by Raised the Unit Price 10%
	ABC	Supplier	
# 001	-2,773,496	1,940,742	376,574
# 002	-2,828,920	1,979,318	376,461
# 003	-2,460,605	1,725,160	375,032
# 004	-1,880,245	1,315,991	278,142
# 005	-1,016,928	711,538	211,200
# 006	-894,679	626,121	138,866
# 007	-1,107,860	776,275	136,360
# 008	-662,500	465,436	108,955
# 009	-768,203	537,732	104,027
Total (THB)	**-14,393,434**	**10,078,312**	**2,105,617**

The results of the three optimizing solution models can conclude as illustrated in Table 4.4.

Table 4.4: Conclusion the Revenue from the Three Optimizing Solution Models

Supplier Inventory Cost Increase (THB)	Creation Supplier Revenue		
	Sole Source Model (THB)	Service Maintenance Model (THB)	Raised the Unit Price Model (THB)
10,078,312	7,429,827	7,700,000	2,105,617

The revenue of individual optimizing solution model cannot cover supplier's inventory cost. Therefore, a combination of all models will be considered as the best solution to create win-win situation for the vendor and ABC in VMI strategy. This can generate a revenue of about 17,235,444 THB per year. The reasons to select and support the combination of three models are explained as below.

The main reason to select sole source model is because it supports the policies of VMI strategy and can increase efficiency and effectiveness of vendor X in order to manage all parts under their brand than manage with other brands. The close-up relationship of vendor and ABC can create the collaboration in chains that bring the success VMI strategy. This model can create win-win situation to both companies.

The two benefits for ABC is to accept the service maintenance model because of reduced cost of maintenance for ABC and reduced steps of work process that directly reduce the lead time and affects the efficiency and effectiveness in the VMI strategy. Because, the vendor has to coordinate with ABC to do service maintenance planning, the supplier can decide on the appropriate inventory levels of each part in each period of time by following the inventory polices of the VMI strategy. The vendor can provide parts in the emergency case faster than before the transaction of information flow is shortened. Thus, the service maintenance model beneath vendor management can bring satisfaction to the ABC than the previous version.

The key reason for ABC to accept the raising unit price model is because it is used to ensure that cost will be unchanged until the end of the contract. In the past, vendor X increased the product price in the range of 5-15 percent every year thus, to follow VMI model, vendor X agreed to freeze the unit price for ABC but vendor X requested to raise the unit price at about 10 percent from the last price. This model can create win-win situation with vendors and ABC beneath the VMI model.

Thus, the combination models of sole source model, service maintenance model and raised the unit price model were considered as the suitable models to create win-win situation with ABC and vendor X under VMI implementation. Nevertheless, ABC has to be concerned about the problem form single source model. In case of, the disaster or any problem occurs with vendor, ABC will face with problem of stock out that affects to shutdown process. Therefore, ABC has to prepare the second source instead if any problem occurs.

4.2 Qualitative Analysis

4.2.1 The Critical Factors to Create Successful VMI Strategy

From the questionnaire, the result of interview shows that the critical factors to create successful VMI model of ABC were considered as follows:

1. To create the win-win situation between the supplier and ABC is the most importance factor of concern because the VMI strategy creates benefits to the organization and forces the vendor to hold and manage inventory. Thus the ABC must think about the reimbursement to the vendor which cans be optimal cost of vendor inventory management.

2. To identify the suitable supplier who has complete capability and willingness to accomplish the VMI strategy.

3. To follow the replenishment methodology and achieve the target of inventory levels requires the collaboration of the supplier and ABC to negotiate and follow terms and conditions of replenishment policy. For example, the supplier and ABC has to set the maximum and minimum inventory control level, which is calculated according to the past inventory data.

4. To set the suitable metrics for measurement of the supplier's performance such as the service level used for measuring the capability of supplier.

1.2.2 The Benefits of VMI Strategy

The benefits of VMI implementation to ABC were studied to reduce repetitive waste in process and non-value-added labor. The benefits from the procurement process until the payment process is as follows:

1. To decrease the complexity of procurement process managed by the vendor so that it can reduce the lead time of spare parts.

2. To decrease the inventory level of ABC so that the vendor own and manage the inventory for ABC.

3. To reduce the employees to manage spare parts in the warehouse in order for employees to move to work in others parts.

4. To reduce the stock out number and frequency that occurs so that inventory will be under control of vendor to follow the Max- Min replenishment policy.

5. To create the relationship between the key supplier and ABC so that the supplier can understand the business and tradition of ABC.

4.2.3. The Difficulties of VMI Strategy

ABC and the key supplier will face some difficulties and complications while implementing the VMI model so ABC and supplier has to clearly understand and accept the following items.

1. The vendors and ABC have to set the same goals, clearly understand the teams management, the process right up to the officers level, before implementing VMI model to protect the contrasting goals among the supply network.

2. The incentive system for the vendor was considered as a key support to maintain the success VMI model. The vendor will be losing from cost of inventory so the vendor has to balance cost of inventory with the incentive system from ABC to have win-win situation.

3. The cost of investment support system is a fixed cost for ABC and the supplier has to invest in support equipment and support systems which are used for interchanging data among both companies.

In conclusion, the appropriate strategy of Vendor Managed Inventory model that optimizes the inventory cost of spare parts in ABC was the Max – Min replenishment model in which the inventory was managed and owned by the supplier. This model revealed that can reduce the inventory cost of ABC by 26 percent compared with the past data and out of stock does not occur in this model. The Max-Min replenishment model can save the ABC inventory cost but for the vendor, the considerable amount of inventory cost was 216 percent compared with the past data. The supplier will not accept the enlarged inventory cost because of implementing the VMI strategy if it does not have proper incentives to offer. Thus, the solutions to generate the incentive for vendors were considered in three models. The first solution model was the sole source model which generated the income of about 7,429,827 THB per year but not enough to balance with cost of inventory. The second model was the service maintenance model which created the revenue of more than 7,700,000 THB per year.

The result of the second model not only optimize the inventory cost of vendor but also support the supplier operation process beneath the VMI strategy. Whereas, the last model was the raising sale price model that added unit price of spare parts for ABC about 10 percent when compared with the past data. Although, the revenue of this model, created was about 2,105,617 THB per year for supplier, it can also guarantee to ABC that the unit price will be fixed until end of contract which synchronizes with the policies in VMI strategy. Thereby, the appropriate incentive solution model that created win-win situation is examined and the combination of sole source model with service maintenance model and raised the unit price model which generated the benefit to ABC and vendor was suggested.

The conclusion of interview showed that the critical factors for successful VMI strategy must be concerned with selection of the suitable vendor, create the win-win contract, built the collaboration to follow the goal, and set the suitable metrics for measurement the supplier's performance. The benefits of implementing of VMI strategy for ABC were studied so as to decrease the complexity of procurement process, to reduce lead time, to decrease the inventory level, to reduce the employees, to reduce the stock out number and frequency, and to create the relationship between the key supplier and ABC. The difficulties of implementing VMI strategy for ABC were discussed as the conflict of goals among the supply network, the properly incentive system for vendor, and the cost of investment support system

Apparently, the conclusion of this project satisfied the objectives of study and demonstrated that ABC can practically implement the Max-Min replenishment model to apply as the appropriate replenishment inventory policy for VMI strategy. While as, the appropriate incentive solution model that the vendor can apply was the combination model of sole source model, service maintenance model and raised the unit price model to balance the occurred cost from VMI strategy. Initially, ABC has to select the key supplier who has a strong relationship with ABC and after that set up the scope of work such as replenishment entrusting which calculates the Max-Min replenishment model based on the terms and conditions, and set up the service level

agreement. Because of implementing the VMI strategy the key vendor has to understand and follow the scope of work and service level agreement. The vendor has to calculate occurred cost then balance it properly with the incentive solution model. The company should emphasize on creating a win-win situation and have close relationship with the vendor and adjust the attitude of the staff to collaborate with the supplier. In the future, the company should consider on the applicable support system to support the information flow which is a critical factor to improve the effectiveness and efficiency in the vendor managed inventory.

CHAPTER V

SUMMARY FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

The findings, conclusions and recommendations of this paper were explained as follows:

5.1 Summary of the Findings

The objectives of this paper are to study the strategy of VMI which can minimize the inventory cost of the spare parts as well as the benefits and difficulties of applying the VMI strategy. The results of this study are useful and appropriate to support the decision of company to implement VMI strategy. As the result, the summary of findings and conclusions of this project are that:

1. The project study began with by collecting historical data of control valves quantity, selecting key suppliers to study the VMI model, gathering number of consume spare parts and stock data of spare parts from the company profiles and applying the ABC classification to arrange the high demand items. Therefore, the top nine items in the total cost of spare parts were selected to be considered.

2. The scope of work and service level agreement for the vendor and the company were set up based on agreement of partners to follow the policies of VMI strategy. The selected items were plotted on a graph of demand pattern and inventory movement of each item was identified to define the appropriate demand pattern. This project used the pattern of Max-Min replenishment model for comparing the inventory cost against the actual historical data.

3. The result of Max-Min replenishment model showed that it can reduce the inventory cost of the refinery which can hit the target point as in policies. For

the vendor, the result of Max-Min model increases the inventory cost and three optimizing solution models was used to assess the revenue against occurred inventory cost of the vendor achieve the win-win situation for both companies.

4. The result showed that combining the model of sole source model, service maintenance model and raised the unit price model can generate the highest revenue which covered the inventory cost of the vendor and created the benefits for the company by increasing the effectiveness of VMI strategy, reducing the cost of maintenance control valves and constraining the unit price of parts.

5. The refinery has to concentrate on the critical factors to create successful VMI strategy and create the win-win situation, select the suitable supplier, set the replenishment methodology and target of inventory level and set the suitable metrics for measurement. The benefits of VMI implementation are considered as decreasing the complexity of procurement process, decreasing the inventory level, reducing employees, reducing stock out number and frequently creating the relationship between the key supplier and ABC. The difficulties and complications of the VMI model are examined as setting the same goal of both companies, creating the incentive system for the vendor and costing of investment support system.

5.2 Conclusions

The application of successful VMI strategy in an oil refining business make it necessary to examine the suitable supplier to collaborate with the company then set up the scope of work, terms and conditions that bring to find the optimal replenishment policy for VMI strategy.

Finally, the company has to measure the result after implementation and think about the results that affect with the supplier then find the solution to balance the win-win situation.

5.3 Theoretical Implications

The research described that the prototype of VMI model was used in a tyre and describes how VMI model can improve the performance of the company by minimizing the inventory costs. The optimal replenishment policy was applied and the model (s,S) policy was used to keep inventory levels low and cut the inventory costs. Furthermore, the support factors to create the success of VMI model are considered to create a strong relationship among vendors with active communication, to share the critical information, to collaborate between multiparty to solve the problem, and to be obligated to continued development (Malla, 2007).

This project as in previous research studies studied the model of Min-Max replenishment to maintain the low inventory levels as estimated in VMI policy. In this project the solution to balance cost of vendor's inventory, effected from reduced inventory level of the refinery, with exchanged benefit models is studies which is different from previous studies. Consequently, this project expected to create successful VMI strategy in the refinery business which can create win-win situation in the chains.

5.4 Managerial Implications

From the conclusion in this research, the refinery manager can use the methodology from this project as the guideline to implement VMI model in business. The manager can implement the Max-Min replenishment policy as a suitable inventory management and can reduce cost of inventory and reduce repetitive waste in a process that improves the process lead time.

The results of qualitative analysis shows that this research can be applied to the company in which mangers can select the key supplier to collaborate in VMI model, to create the policy of VMI and to set the suitable KPIs.

Finally, the balancing situation models for supplier were suggested as a guideline for the manager to create the win-win situation with the key supplier that can implement or advise or create the new appropriate model which depend on the company and key vendor.

5.5 Limitations and Recommendations for Future Research

This case study may not be suitable to implement in other refineries because the limitation of policy of VMI model. The key suppliers are specific for the ABC refinery. Therefore, the other refineries or other businesses can use this as a guideline to implement VMI strategy in business only.

The suggestion for the future research recommends exploring the impact of risk compared with the benefit of vendor managed inventory. The company, interested to implement VMI, can make a decision to implement VMI or not from this information and can use the information from research to design the appropriate VMI policy.

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APPENDICES

APPENDIX A

Research Tool

Interview Questionnaire

Overview of the interview guide

The questionnaire in this interview is designed to get information from general manager of ABC refinery's perspectives towards the VMI trading partner and the benefits and limitation related to the studied VMI model. This research material is a partial fulfillment of the graduate project for the Degree of Master of Science in Supply Chain Management, Assumption University. The information from this questionnaire will used as a reference and for education purpose only.

1. What are the critical factors to create successful VMI model in ABC refinery after studied VMI model?

2. What are the expected benefits for ABC refinery after studied VMI model?

3. What are the expected limitations for ABC refinery after studied VMI model?

4. What can be exchange between ABC refinery and supplier?