QATAR UNIVERSITY

COLLEGE OF ENGINEERING

APPLICATION OF VALUE STREAM MAPPING FOR IMPROVEMENT OF EFFICIENCY IN PURCHASING PROCESS FOR A CHEMICAL COMPANY IN QATAR

BY

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ABSTRACT

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Title: Application of Value Stream Mapping for Improvement of Efficiency in Purchasing Process for a Chemical Company in Qatar

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Lean management methods have been used to improve productivity and performance in organizations. As one of the lean management methods, value stream mapping (VSM) uses the process flow map to analyze current processes so that process bottlenecks can be analyzed for streamlining or elimination. The procurement process of a chemical company is studied in this project. Current state map is drawn to display the procurement activities and flow of information from time a material need is triggered and a purchase requisition is raised by the end user to the final release of the purchase order, to enable delivery of the materials by the supplier. Secondary data was collected to determine the average number of PRs converted into POs every month and the order processing rate was calculated. Inefficiencies along the procurement process were identified and marked. A desired future state map was drawn excluding the inefficient steps or with reviewed steps. Improvement program is established and implemented to eliminate the inefficiencies along the process. After the implementation of the improvement program, the number of PRs being converted to POs improved by 50.8% from an average of 600 to 905; order processing rate improved by 33.8% from 80 to 53 minutes.

DEDICATION

I would like to dedicate this project to professionals worked with me in procurement division for their valuable and professional inputs and support throughout the project.

ACKNOWLEDGEMENT

I am thankful to God for good health and enabling me to successfully complete this study. I extend my heart of gratitude to my family members for their support throughout the project. I thank Qatar University for the opportunity to pursue this course. I appreciate the division of my work for the support during the study.

I thank my supervisor Prof. Shaligram Pokharel for his valuable contributions and objective challenges, without which this study could not be a success. Special thanks for the excellent guidance, availability, inspiration and tireless effort to ensure that I successfully complete my studies.

I am grateful to engineers in the procurement team of the company for their support throughout the study period. I acknowledge friends and course mates for their support and encouragement.

I firmly acknowledge that the study mentioned in this project is done by myself only. I have used some of my company based data solely for a part of this work to demonstrate the VSM application. The data have been disguised to avoid identification. All the analysis, outcomes, and recommendations are the sole responsibilities of the author.

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LIST OF ABBREVIATIONS

3C	Concern, Causes, Countermeasures
5W1H	What, Where, When, Who, Which (pattern), How much / many
BOM	Bill of Materials
CT	Cycle Time
DO	Direct Out
ERP	Enterprise Resource Planning
IMF	International Monetary Fund
IUPAC	International Union of Pure and Applied Chemistry
JIT	Just in Time
IT	Information Technology
LT	Lead Time
MRP	Materials Requirement Planning
OPR	Order Processing Rate
PO	Purchase Order
PR	Purchase Requisition
PVSM	Procurement Value Stream Mapping
RFQ	Request for Quotation
SAP	Service Application Platform
TT	Takt Time
USD	United States Dollar
VSM	Value Stream Mapping
WIP	Work in Progress

CHAPTER ONE: INTRODUCTION

Organizations in the service industry are under pressure to meet the continuous needs of their internal and external customers. In procurement sector, faster response, delivery on time and at the lowest cost are the most important factors valued by the customers yet many companies are still using the older methods of procurement, which have not proved to be significantly effective. Therefore, there exists an opportunity to use tools that can identify and eliminate wastes along these processes. This study explores the impact of VSM as a lean management tool, on the procurement process of a chemical company in Qatar.

A holistic evaluation of the purchasing processes is necessary because improvement is not only attributed to major changes like business reengineering but also business process reengineering activities which lead to incremental improvements and thereby leading to competitive advantage. The competitiveness of a company stems from its capacity to produce the highest quality product at the most affordable price and with increased efficiencies (Nallusamy, 2015). Lacerda et al., (2015) noted that companies that succeeded through economic crises in Europe implemented cost-saving management philosophies such as lean management to create value for customers while reducing the financial strain in their organizations.

While most organizations only focus on the actual manufacturing and process related aspects, the less technical elements are important too in operations. Those on the production floor expect a timely delivery of the relevant inputs that will ensure their production schedule is executed as planned. As evidenced in Toyota's Just-in-Time principle, having the right amount of inventory for a specific production cycle is crucial for business (Chiu et al., 2017). Toyota's production model focuses on waste

elimination by ensuring that the company does not have excess inventory, which adds to unnecessary production costs. It requires providing every section of the production line with exactly what it needs, in right quantities, and when it is needed. Toyota's inventory management system works best with fluctuations in market product demand. When there is a slight delay in the procurement process, a firm without extra inventory will have to delay its production by waiting for such materials, which again, is a form of major waste in a production setup. Therefore, there is need to evaluate the entire procurement process in a company to ensure that it becomes as efficient as possible.

1.1 Problem Statement and Justification

Many companies use traditional purchasing processes due to the comfort of using the same process and the investments made for the establishment of the processes. Yet they face the customer with changing requirements, and the traditional system may not be able to orient itself to such changes. Therefore, reexamination of the current process becomes important.

Qatar, for example, relies heavily on its oil and gas reserves for economic growth, hence there is a need for quicker procurement processes to support many chemical and petroleum companies to continue their production processes. Alfadala & El-Halwagi (2017) noted that a nation's chemical industry need to focus on increasing the value of its natural gas and oil reserves, however, the industry is quite fickle as it often has fluctuations in demand. The authors further reveal that the biggest organizations in Qatar are also some of the largest companies in the world, which means, they supply a global clientele in a market environment with multiple uncertainties. Therefore, the chemical and petroleum companies need to meet the global

and local demands in a timely and effective way. Missing on opportunities due to procurement delays has reduced profitability of the chemical industries.

Application of the VSM has been predominantly used in manufacturing setup to shorten the processes and reduce wastages. However, the optimum efficiency of the manufacturing function cannot be entirely realized without efficient procurement processes. Tools that have been proven to enhance efficiencies of production can also be applied in the service sectors like procurement to improve on the processes. Attention to qualitative aspects in the VSM of procurement process has become important (Alaya, 2016). Laburo et al. (2008) also recommends the investigation of the critical factors of VSM to achieve the highest possible performance.

1.2 Objectives

Objective of this study is to establish the impact of application of value stream mapping on the efficiency of procurement process in a chemical company. The specific objectives for the study include:

1. To investigate the main challenges or leakages affecting the purchasing processes in a chemical industry.
2. To determine the impact of applying value stream mapping on purchasing processes for a chemical company.

1.2.1 Study Questions

In order to achieve the objectives, two research questions are developed:

1. What are the current procurement steps and inefficiencies in the chemical company?
2. Is there a relationship between the applicability of VSM and improvement in efficiencies in the purchasing process?

1.3 Organization of the Report

This project report is organized in five chapters. The background, objectives and the study questions used in the report are given in the first chapter. Literature review is given in the second chapter, which focuses on the applicability of VSM in a procurement process. Chapter 3 focuses on the methodology adopted in this report followed by the implementation of the proposed method procurement process. Finally, Chapter 5 provides conclusions and recommendations.

CHAPTER TWO: LITERATURE REVIEW

This chapter focuses on the discussions related to the traditional processes, lean procurement and value stream mapping. Summary of the review is provided at the end. The search of the literature is based on content analysis of published literature available in the digital databases available in the Qatar University Library. The analysis of literature content helped in developing the knowledge that is required for assessing the importance of VSM, its applicability in procurement and analysis that needs to be done to improve the procurement processes. This type of content analysis to search for the papers are also done in Rebeeh et. al. (2019) and Al-Sobai et al. (2020).

2.1 Typical Procurement Process

A typical procurement process involves finding and negotiating the terms and obtaining goods or services externally through a tender or a bid. An efficient procurement process is healthy for a company's finances as it helps secure materials and services at competitive prices, improves delivery lead times and ensures quality of materials and services delivered by suppliers.

The process starts with identification of materials needed by the organization. Procurement staff assess the entire process and evaluate the needs of each department, as this will provide the visibility of the projected expenditure for the entire organization.

The second step entails development of a list of potential suppliers from which a competitive vendor would be selected from. The selected supplier has obligation to deliver as per materials specifications, offer competitive pricing and meet timely delivery schedule. The supplier must be accountable, have required capabilities, should

be ethical, have ease of communication and prioritize building of long-term relationships.

The third step is negotiating the contract terms with selected suppliers to agree on price, terms and conditions and timelines for deliveries. It is necessary to retrieve and analyze previous similar contracts to avoid paying more or compromising on the quality of the material or service.

Next stage is creation of purchase order to outline the description of materials, total costs, quantity required and delivery dates. Once a purchasing order is issued to the supplier, invoice is received from the supplier and the finance department processes the payment. The invoice contains the details of the order, payment terms and dates to make the payment. The goods, materials or services delivered and records maintained for the transaction. A consolidated framework of VSM procurement process obtained from Chen et al. (2010) is given in Figure 1.

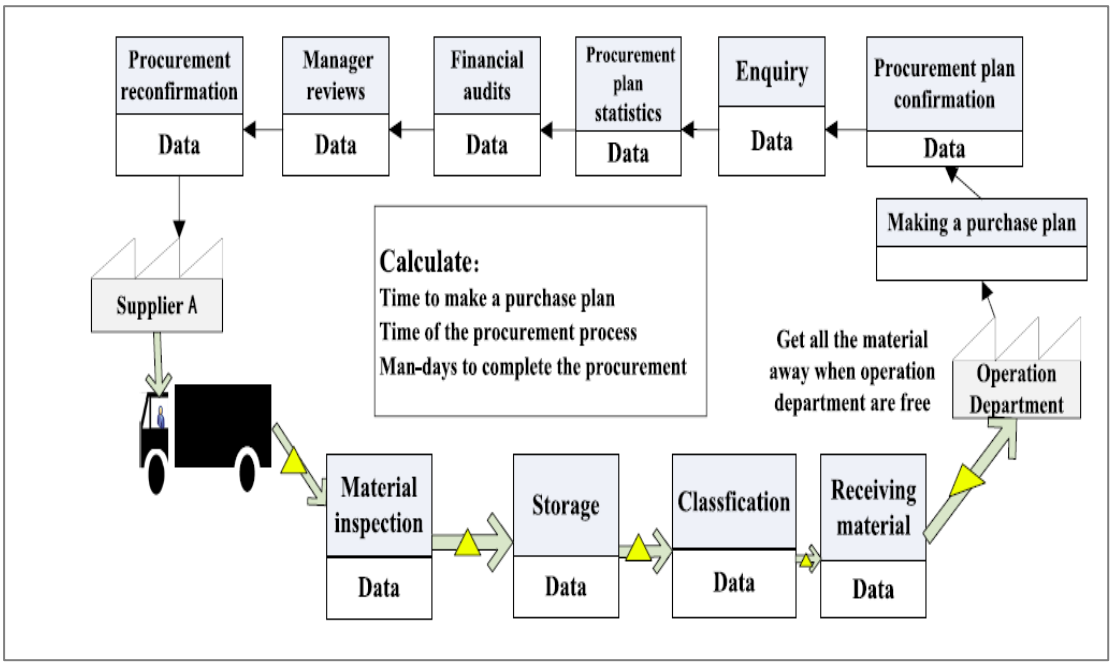

Figure 1: Procurement value stream map

2.2 Lean Procurement

Anderson et al., (2012) noted that a purchasing process is vital in manufacturing setup because costs make up a bigger percentage of total expenditure. He adds that the quality of products depend on quality of raw materials and that the stocks comprise the biggest part of overall cost of production, and therefore, the costs associated with purchasing process is crucial because it eventually adds to the expenditure. The purchasing process creates value and benefit the production process by making available all production inputs e.g. raw materials and focus on lean procurement processes to save the overall cost of production, which leads to increase in profitability of the company.

Through VSM, companies can minimize unnecessary losses by reducing non-production costs that arise from re-release of products, as well as stagnation of production equipment and workers. By reducing the inventory, the company reduces the size of storage facilities, which also reduces unnecessary costs. Resources are made available when they are required for production cycle. Eliminating wastes through application of lean procurement leads to Just-in-time approach of production. Companies that use lean procurement approach have significant advantages over their competitors, who use more traditional approaches. Lean procurement entails involving every employee in optimization activities and maximizing customers focus. The goal of lean procurement is to build a purchasing system capable of quickly responding to changing customer requirements and maximizing on profit. It focuses on the creation of an efficient system that deliver the required products upon receipt of the order, without the accumulation of intermediate stocks. A starting point is the transition from centralized, vertical management to horizontal, based on the involvement of all employees in the process.

Various tools can be applied to enhance the efficiency of procurement process in an organization. However, these tools have not been systematically and consistently implemented and most time they are ineffective in eliminating wastes and delays that exist in purchasing processes. The wastes in the current procurement process include delays and inaccuracy of data. Jing et al. (2020) noted that VSM can be used to identify wastes, therefore, the company can plan on the ways to reduce or eliminate them from the processes. There is no known research on the application of VSM in a chemical company, thus it is not clear to what extent will the application of VSM be impactful on the efficiency of the entire purchasing process.

2.2.1 Lean Procurement Approaches

There are various approaches that can be applied to eliminate wastes and thus bring improvements. Lean management tools include Just-in-time, Lean Supply Chain Management (SCM) method, six sigma, Kanban approaches and VSM. This research will focus on VSM, and its applicability in purchasing processes for a chemical company and the impact of application on the efficiency of the purchasing process. Myerson (2020) indicates that the flow of materials and information from customer to supplier is important in understanding the underlying wastages along the processes. He concludes that VSM can lead to a streamlined future state of the process.

2.2.1.1 The Just-in-Time (JIT) Concept in Procurement

Just-in-Time concept, is based on organizing the movement of material flows to ensure that all materials reach the subsequent process steps in right quantity and time (Lai & Cheng, 2016) (Figure 2). By implementing this concept, the entire procurement process is optimized, which in turn improve its reliability. The main characteristics of the Just-In-Time concept are: minimum reserves; short supply chains; small volumes

of production and replenishment of stocks; procurement relationship with a small number of reliable suppliers and carriers; effective information support; high quality of finished products and logistics services (Memari et al., 2018).

Figure 2 shows outline of the flow of materials and information in a Just in Time production setup.

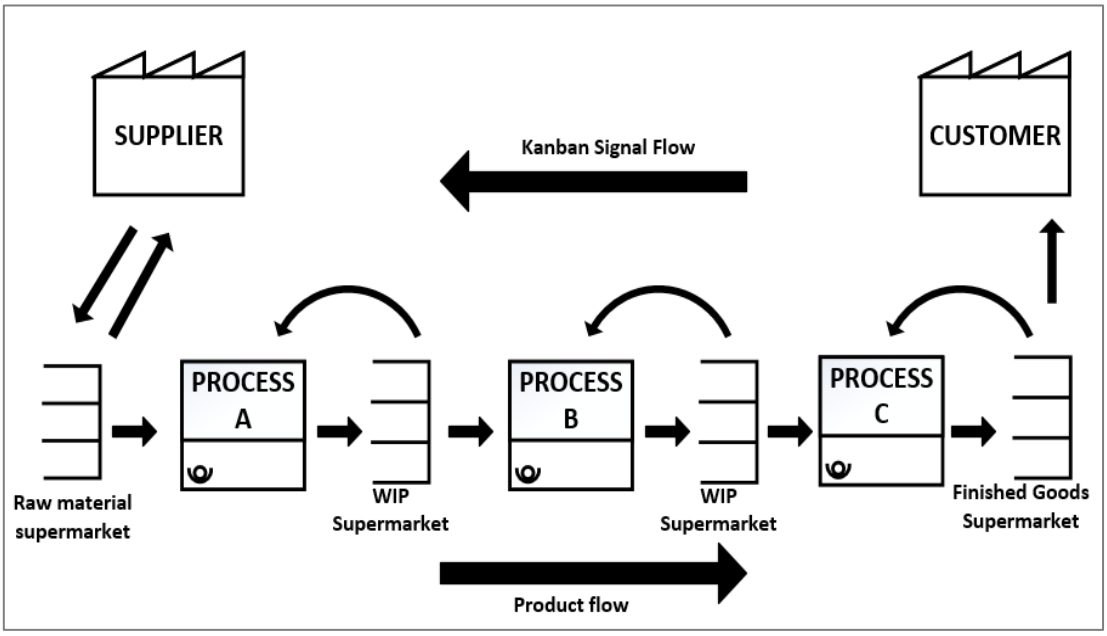

Figure 2: Just-in-Time Approach in Procurement Management

The analogy of Just-in-time approach in procurement process is that inventories result from poor coordination of workflow and management. Therefore, it is necessary to investigate the causes of inefficiencies in procurement and supplying departments. The result of the implementation of Just-in-time approach in procurement would be the elimination of excessive stocks (Pinto et al., 2018). The company seeks zero reserves,

solving the problems leading to them. Quality management, based on an integrated approach, should exclude defects. The company must fully trust the suppliers, their quality and reliability, on the basis of this it is necessary to enter into long-term partnerships, which should completely eliminate interruptions in the supply of materials. It is vital to find ways to reduce the volume of one batch of resources, to strive to reduce the production period, which will lead to a decrease in the volume of finished goods inventories. It is necessary to shorten lead-time to mitigate the uncertainties that can make a difference during long deliveries.

The goal of Just-in-time concept is to balance the procurement process. A procurement process capable of providing the fastest possible delivery of the necessary resources. The main idea is to carry out the shortest possible work cycle using resources in an optimal way. To achieve the task, it is necessary to understand how the following auxiliary tasks are resolved: interruptions in the production process, the exception of stopping; flexibility of the production system; reducing production time and minimizing the preparatory cycle; minimize inventory; and elimination of unnecessary costs. In Just-in-time approach, unreasonable expenses comprises overproduction; waiting time; unnecessary transportation; storage of inventories; marriage and waste; inefficient working methods; and product defects (Bandyopadhyay, 2004).

2.2.1.2 Kanban Method in Procurement

Application of the Kanban method in procurement will allow synchronization of the system for production and supply. Kanban is a production model based on needs, usually in the form of cards, baskets, pallets or boxes. Lean thinking implements Kanban as a way to reduce inventory management costs. The implementation of these concepts in procurement process ensures materials are available for production when

required (Zeng et al., 2019). It is based on the use of unique filled-in cards to coordinate procurement processes with each other by synchronizing them in time and the number of objects of labour in production (Cimorelli, 2016). Correct filling of cards allows an employee to implement the principle Just in Time when making buying decisions. It contributes to downtime elimination and the reduction of the volume of work in progress (WIP). Each line delivers only those items that are needed by displaying them on the Kanban card, hence the number of parts, assemblies and finished products do not exceed the planned level (Papalexi et al., 2016). This allows not only to synchronize their movements between the lines, but also to save on storage facilities, as well as eliminating unnecessary paper works. Figure 3 shows layout of a typical Kanban system in a manufacturing setup.

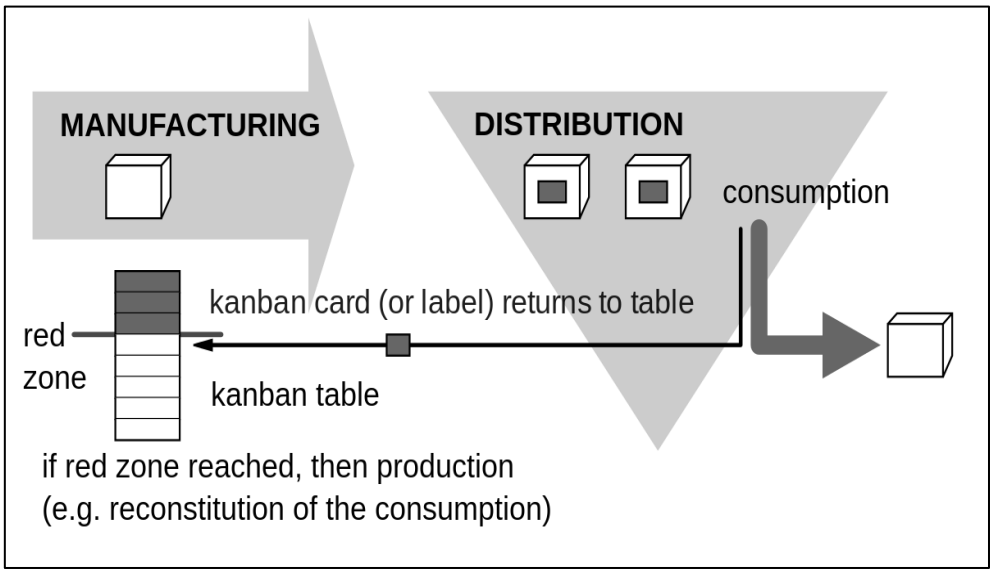

Figure 3: Kanban Approach in Procurement

The essence of Kanban system is to create a continuous in-line multi-subject procurement, in which the sites, and workplaces located at the subsequent stages of the

technological cycle, “pull” materials they need from the previous sites when they need it. The system assumes the execution of orders not by weeks, but by days and even hours.

2.3 Value Stream Mapping

Value stream mapping is a tool predominantly applied in manufacturing sector to identify and eliminate wastes along production stream or value chain processes. Singh et al. (2010) noted that VSM captures the value add or non-value add information at individual processes. It is used to measure machine cycle time, change over time, inventory, crew size and general information flow from start to end of the transformation processes. It is key in evaluating important process steps in an organization (Dinis-Carvalho et al., 2019). The VSM method enables documentation of the relationship between each process and the controls such as production scheduling and information. They also noted that VSM documents the flow of data within the process and advised that it is key to carry out VSM in lean management journey.

The current VSM map is evaluated, wastes identified and categorized. Inefficient processes are marked with Kaizen bursts that denote possible improvement opportunities. The current state map is re-drawn without these activities to achieve the future VSM state map. The difference between the two maps could result in more profitability, improved efficiencies, improved costs, and more output. Operation tasks are evaluated and categorized into three groups namely value adding, necessary non-value adding and unnecessary non-value adding tasks. Unnecessary non-value add activities do not carry any value to the end user. They are eliminated from production or information flow processes. When it is not possible to fully eliminate unnecessary non-value adding tasks, they are either bypassed or overridden to shorten the entire

process. Necessary non-value add activities are those tasks that the customer does not consider as important and not willing to pay for, yet we cannot do without them in our processes. These activities indirectly add value to the process. Good examples include training of the production machine operators, product sampling activities in the manufacturing process, machine maintenance, quality control and quality assurance just to name a few. Since these activities cannot be eliminated, they are often combined, reviewed or simplified to improve efficiency and reduce costs. Value adding activities a long value chain are those tasks that directly add quality to the process such as improvement in yield, making the product itself, and product fortification. These activities are maintained and continuous evaluation and improvement is done to improve their efficiencies. Singh et al. (2010) carried out an experiment to evaluate the effectiveness of VSM and in his conclusion, he noted that costs resulting from materials storage were significantly reduced making those processes leaner.

Value stream mapping ensures firms succeed in determining information and material flows hence revealing potential and present weak points. It provides a company with clear picture of business process, communications, and interfaces in both individual portions of processes and offer the basis of deriving opportunities for process optimization throughout the value chain (Patty & Denton, 2010). A VSM process uses flowcharts to document all steps in procurement process. It combines material processing phases with data and information flow to ensure firm efficiency. In this regard, it remains a crucial tool for any company that prioritizes identifying wastes, reducing procurement process cycles, and implementing process improvement (Patty & Denton, 2010). Furthermore, it is vital for a firm focusing on planning, implementing, and improving operations.

Value stream maps are always specific to a product category or a line of service and most of the times it is not done for a group of products or services.

2.3.1 Value Stream Metrics

There are various metrics used to evaluate the effectiveness of VSM. Their applications depend on the type of product and process offered. Some metrics add more value in manufacturing setups while others fit well in service industries or in different functions for example in procurement department. Key VSM metrics in include lead-time (LT), cycle time (CT) or order processing rate (OPR) and takt time (TT).

2.4 Summary of Literature Review

Although there are common approaches to optimizing purchasing processes, companies in the chemical industry still face significant challenges in their procurement processes. The challenges may be attributed to the nature and complexity of chemical materials and products in the value chain. Procurement efficiencies in most chemical enterprises are indeed related to the complexity and duration of the procurement cycle. The longer the cycle, the greater the number of auxiliary and servicing suppliers involved in it, the less efficient the procurement as a whole. One of the ways to solve this problem is the introduction of the lean procurement system, which is designed to optimize procurement processes, constantly improve product quality while continuously reducing costs. The main goals of lean procurement include reduction of amount of labor and time, costs of moving materials and transporting products (cross-docking, consolidating orders and minimizing the empty load during delivery, optimal vehicle selection, route optimization, packaging products), optimal placement of products in stock, minimizing stocks and reducing storage space, delivery of products

to the customer (on time in full quantity), minimizing losses during transportation and general improvement of the entire process.

Effective procurement process is fundamental in profitability of chemical companies. The goal of lean procurement is fast response to customer demand through reduction of inventory, time taken by products reaching the market and production design with efficient and economical manufacturing of quality products. Lean procurement is an element of lean production as a concept of managing a manufacturing enterprise based on continuous work to eliminate all categories of losses that inevitably occur in procurement process. The introduction of lean procurement principles in the supply chain allows companies to analyze their processes and implement measures to speed up the provision of procurement services, by accelerating those that add value while decelerating those that are wastes in the products or services. Even though researches have been done on the application of VSM to identify the state of procurement processes, the applicability in the procurement process in chemical industry is still in the emerging state.

CHAPTER THREE: STUDY METHODOLOGY

VSM is a valuable tool used in lean procurement to identify and eliminate wastes in processes where wastes and other forms of leakages lead to high costs and delayed deliveries. However, the impact of VSM application in a petro chemical company, is not well understood. This project was carried out to determine the impact of application of VSM in a procurement process for a chemical company. The project was carried out in one of the biggest chemical companies in Qatar.

3.1 Case Study Area

The petro-chemical companies in Qatar are the major suppliers of chemicals and other petroleum products, to the rest of the world. The study was done in one of the biggest chemical companies in Qatar. The company has 650 permanent employees and some other 350 employed on contractual terms. Because of the huge production volumes of chemicals, the company consumes large amounts of raw materials which are outsourced both locally and internationally. The average total spend on raw materials purchases is about a cumulative amount of USD 400,850,000.00 in a year. The company uses traditional methods of procurement whereby a request is made by the user through SAP or manually filling the requisition form, RFQ sent to potential suppliers followed by the bidding process, evaluation is conducted and the purchase order released and sent to selected vendor to make deliveries. The process has many shortcomings including delays due to wrongly assigned purchase requisitions, incomplete or poorly written purchase requisitions, inaccurate vendor information in the SAP system, delayed communication reaction time from suppliers and outdated material descriptions in the database.

3.2 Study Methodology

The current procurement process was entirely observed and translated into the current state VSM. To fully understand the current state, staff were interviewed and their responses recorded, to verify the details of the information. The collected data and information were analyzed to identify the non-value add activities along the entire procurement process. The same map was then drawn without the identified wasteful steps to give a picture of the future condition post the implementation of the improvement programs. Company staff were engaged through various focus groups to brainstorm on possible solutions that could be put in place to eliminate or reduce the wastages in their processes. The proposed next actionable steps were transformed into an improvement program detailing what needs to be done, responsibilities and target completion dates. After the implementation of the actions, both current VSM and future state VSM maps were evaluated and compared upon calculation of VSM metrics, to determine the level of impact that the application of the VSM tool, had on the processes.

3.3 Current Procurement Process

The procurement process is initiated twice a month under two main activities which relay purchase requisitions to the procurement team. The purchase requisitions are received through Material Requirement Planning (MRP), which is an automated process while other PRs are received directly as written by the requesting departments, also referred to as Direct out (DO) purchasing requisitions. The MRP PRs constitute 70% while Direct out PRs make 30% of the total purchase requisitions (PRs) received in a month. A purchase requisition refers to a request that a staff generates or writes to request for material for their departments. A filled out PR form does not constitute actual purchase of materials but signals the commencing of purchasing process in its entirety. When PR is successfully generated, the procurement team starts collecting

relevant procurement information and submits the same to the relevant managers for assessment and validation. Both PRs received from the MRP system which make 70% of total PRs, and those raised manually by end users, are consolidated and assigned to buyers for processing.

The senior buyer takes up to three working days to distribute to buyers, the PRs from both DOs and MRP. The distribution of the PRs to the buyers is done concerning the departments that the buyers are assigned to. The procurement process moves to the bidding stage, where the buyers review every PR received in their baskets. Besides the buyers checking the completeness of all information required, they also check the history of each line item, whether they had been purchased before or whether they are new materials requests which are not contained in the materials database. The verification of the quality of PRs is quite rigorous as it also entails the buyers calling or meeting with respective users to make sure that all information is provided correctly.

The buyer sends a Request for Quotation (RFQ) to the chosen suppliers. Request for Quotation (RFQ) is a form of invitation that is sent through SAP to the selected suppliers for them to submit their offers including prices for all the required items, lead time, delivery terms, payment terms, and terms and conditions. The RFQs are sent on the same day of PR approvals.

A successful bidding stage ushers in the evaluation phase, where the company receives offers from the selected suppliers. The respective buyer searches for the end-user who raised the requisition, to review technical information and specifications provided in the offers by the selected suppliers and revert to the respective buyer with confirmation or rejection of the specifications if not meeting the requirements. If the suppliers' offers are confirmed, the buyer starts negotiating the prices and lead-time

with the suppliers to agree on the best competitive prices and delivery schedules. In case the offers are not confirmed, the buyer communicates with the supplier to review and offer the correct specifications. The evaluation phase comprises four critical steps: technical evaluation, commercial evaluation, negotiation, and purchase order (PO) creation. PO is issued by the purchasing department after the approval of the offer with the best price, delivery schedules, and acceptable terms and conditions for both parties.

The final step is release of a purchase order by the supervisor in purchasing department. Once the PO is released, it is automatically generated and relayed to the suppliers who prepare and make deliveries as per the agreed schedule in the PO.

3.3.1 Direct out Purchasing Process

All PRs go through the same process whether they are Direct out PRs or they are generated through the MRP runs except the initial review stage which is not necessary for the MRP PRs. For DO PRs, request is manually written by staff in different departments by filling a requisition form. Once all the details are collected regarding the specific material required, bidding is carried out to select the best competitive supplier. Suppliers are selected and purchase orders released to allow for the deliveries by the supply. The entire direct-out purchase requisition process is outlined in Figure 4.

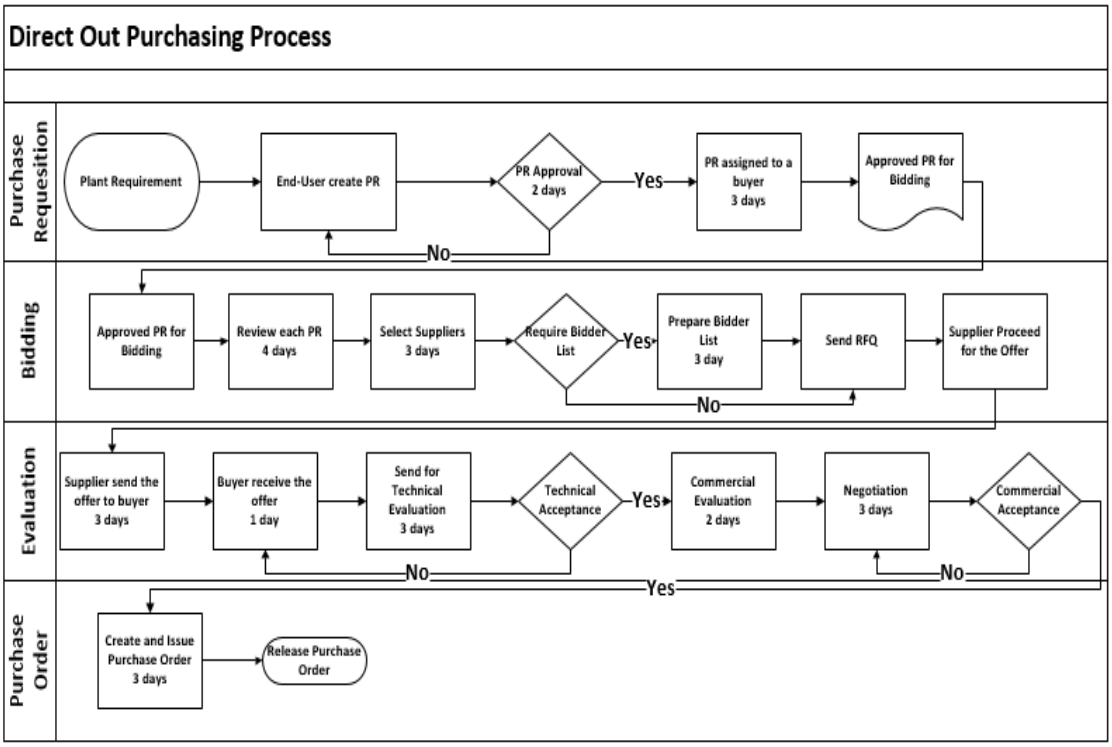

Figure 4: Direct out Purchasing Process Flowchart

3.3.2 Material Requirement Planning (MRP) purchasing process

MRP system consists of three main features: a production schedule, bill of materials (BOM) and inventory level database. The production schedule entails planning needs, including the capacity of production, predictions, alongside orders. The bill of materials (BOM) comprises all components and materials needed to produce the final product, while the inventory file keeps stock of records that enable the production manager to adjust gross requirements to net requirements.

MRP PRs are those purchase requisitions that are generated during the system run twice every month. They consist of 70% of total PRs generated during the month. Once generated, the PR goes through the normal processing stages, that is, the bidding stage, evaluation, and release of the purchase requisition. Steps involve in MRP generated PRs are outlined in Figure 5.

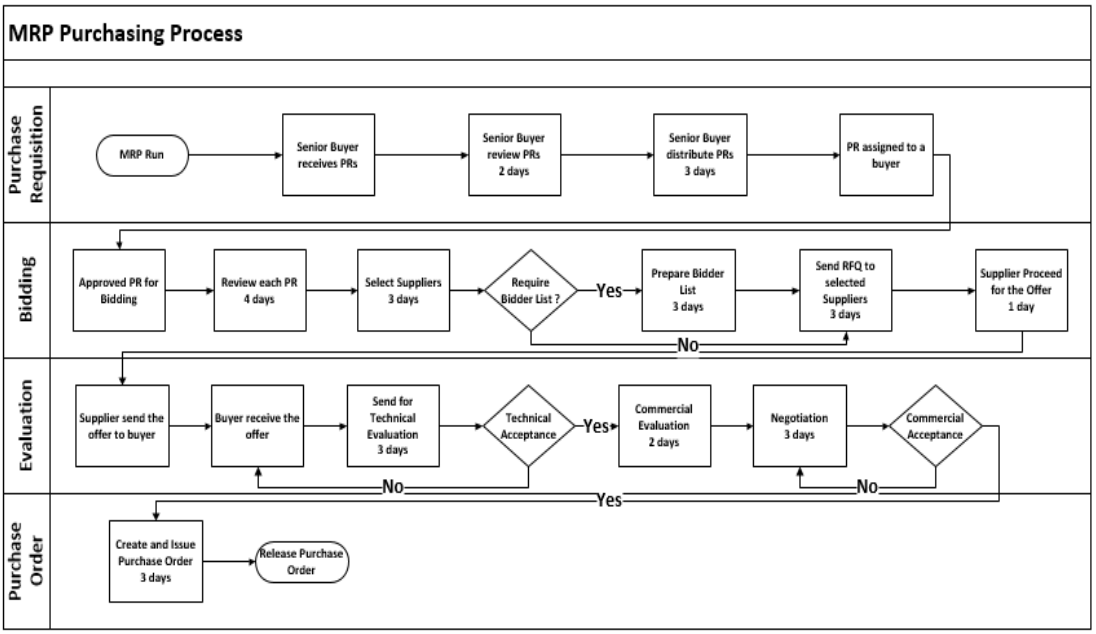

Figure 5: MRP Purchasing Process Flowchart

3.4 VSM Current State

The procurement process goes through steps, starting from identifying all business units' needs until the receipt these requirements, inspecting them, and proceeding for payment. Every requirement is identified through acknowledgement of a Purchase Requisition (PR) in the SAP system. They are created for materials required from engineers working in the non-stock items of the plant. The MRP PRs are mainly received from the warehouse while DO PRs are mainly written by the production and engineering teams. The MRP PRs are auto-generated by the system depending on the reorder quantities defined in the inventory management system. It usually comprises regular stock items. Figure 6 shows how the purchasing process is triggered and how information moves from the first step of purchase requisition to bidding, evaluation, and finally to the purchase order release. So far, the system shows that the company is well organized with all the relevant checks and balances.

Figure 6 above shows the current VSM map of the procurement process. A more detailed map is shown in Appendix 1.

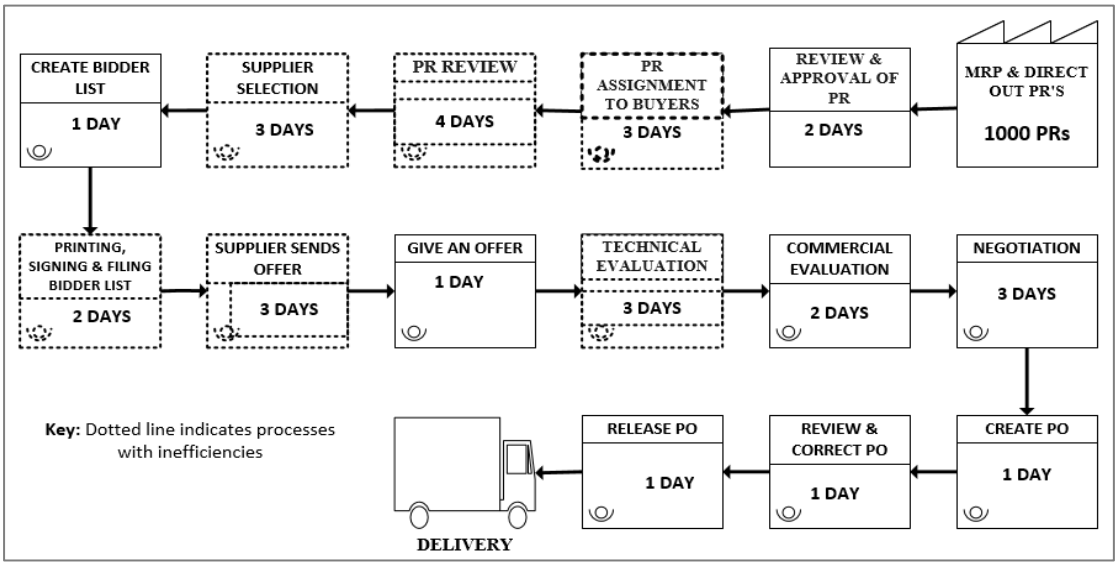

Figure 6: Current VSM state

3.5 Current VSM Metrics Performance

The current state consists of 15 key steps that a PR goes through from the time it is raised manually, until it is successfully converted into a PO. However, system generated MRP PRs do not go through all the procurement steps, they undergo one step less (review and approval by the supervisor as this had already been executed in the workflow by the time the PR was being raised at the departmental level), hence they take shorter duration to convert them into POs than those PRs which are manually written. Even though an average of 1000 PRs are available at the start of the process, it takes 30 days for a team of 5 buyers to successfully process 600 of them. Out of the 15 key steps, seven of the steps have been identified to contribute to delays and hence, are

regarded as either non value adding or partially value adding activities. Al though, these steps take longer to be executed and therefore contributing to losses along the process, they remain key and therefore a number of them cannot be entirely eliminated from the procurement process, they can only be reduced or improved to make them leaner. The seven inefficient steps take more than 50% of total time to be executed.

Not all PRs experience delays. MRP generated PRs are likely to take shorter duration to process than the Direct Outs PRs. This is because the time spent in some steps like PR reviews and finding correct material specifications, corrections of mistakes included during raising of the PRs and wrong PR assignment to buyers, is greatly reduced. Again PRs of values greater than USD 10,000 take more time to be processed than those of less than USD 10,000. This is because they require extra steps of evaluation and negotiation as more vendors are invited to bid for the same. Every step is critically evaluated for such purchase requisitions.

The inefficient steps along the procurement process include:

i. **PR assignment to buyers:** This step takes up to 3 days as opposed to the targeted zero days. When PRs are received both from the departments (for manual PRs) and from the system (for MRP run PRs), a senior buyer analyses all of them and assigns them to respective buyers to start processing them. It takes longer time due to several instances whereby the PR is wrongly assigned to a buyer, who may not have knowledge and experience of materials requested for by another department. Buyers have been allocated respective departments from which they handle the PRs. Recognizing the wrong assignment of the PR means that, re-assigning has to be done and the entire process restarts. With automation and granting system rights of execution to the requesters, this step would become redundant as the requesters

would select their respective buyers when raising the purchase requisition both manually and through SAP. Therefore, this step is eliminated in the future VSM map.

ii. **PR reviews:** This step takes 4 days while it should take a maximum of 2 days. The delays are caused by mistakes found in the written PRs which the buyers have to keep following up with the requesters for correction. When PRs are accurately raised or written with all required information, it becomes easier and faster to process them thereby reducing on the overall PR processing time.

iii. **Supplier selection:** This step takes 3 days instead of the expected 2 days. The delays occur as a result of the vendors not responding in time, to the adjustments or negotiation requests made by the buyers. The buyers keep on sending emails requesting for better offers, and it can lead to the buyers looking for alternative vendors. This means the entire step is repeated, leading to delays.

iv. **Printing, signing and filing of bidder forms**: This activity takes 2 days as the buyers spend a lot of time printing, signing, scanning and filing the bidder forms. Ideally, no time should be spent here as it is a duplicated activity. Buyers send system generated forms to the suppliers and therefore, this activity can purely be automated.

v. **Supplier sending offer**: This activity takes an average of 3 days while the target set is 2 days. The delays result from the suppliers not reading and responding to mails in time or sometimes some suppliers do not respond at all. The vendors delay to respond because they had not seen the email requests, out of stock materials from vendor's end or lack of capacity to produce the requested materials.

vi. **Technical evaluation of PRs**: This step currently takes 3 days against the targeted 2 days. The delays are caused by back and forth of matching the supplier offer with the required material specifications.

vii. **Negotiation:** this step currently takes 3 days to be completed due to delays in preparation of technical specifications, lack of critical information during negotiation time and delay in supplier selection.

The delays inherent in the above steps lead to an extra 11 days that are spent in processing the PRs. Table 1 shows current duration in each step of the procurement process.

Table 1: Duration of Current Procurement Step

No.	Key procurement step	Actual duration in days
	Raising of PR (manual or through SAP)	
1	Review and approval of PR	2
2	PR assignment to buyers	3
3	PR review	4
4	Supplier selection	3
5	Creating bidder list	1
6	Printing, signing and filing bidder list	2
7	Supplier sending offer	3
8	Giving of offer	1
9	Technical evaluation of PR	3
10	Commercial evaluation of PR	2
11	Negotiation	3
12	Create PO	1
13	Review and correct PO	1
14	Release PO	1
	Total days	30

Out of the 1000 PRs available for processing, the procurement team are able to process average of 600 PRs. VSM metrics were calculated to establish baseline condition for the procurement key performance indicators. The Takt Time and Cycle Time (CT) or Order Processing Rate (OPR) were all calculated as below:

Total MRP and DO PRs in a month	= 1000 PRs
1 day's work hours for 1 buyer	= 8 hours
5 buyers working 1 day	= 40 hours
5 buyers working 5 days a week for 4 weeks	= 800 hours

3.5.1 Takt Time

This is the time duration at which the one single PR needs to be converted into PO to meet the requester's demands.

TT = Available Time / Number of PRs raised by the end users

= (800*60) minutes / 1000 PRs

= 48,000 minutes / 1000 PRs

= 48 minutes / order

3.5.2 Order Processing Rate

This is the actual duration that it takes to convert one single PR into a PO. Out of the 1000 PRs submitted in a month, the team managed to successfully convert 60% of them into POs.

60%*1000 = 600 PRs

The team converts 600 PRs into POs within the available time of 48,000 minutes.

Therefore:

OPR = 48,000 minutes / 600 POs = 80 minutes / PO

Table 2 shows summary of the calculations of current procurement efficiency based on the current state data.

Table 2: Current Procurement Efficiency

No.	Item	Current state measure
1	Total number of PRs (70% MRP and 30% DO)	1,000
2	Working hours (per day) for 5 buyers	8
3	Average POs released (in a month)	600
4	Target PO conversion rate per month (85%)	850
5	Repeat orders PRs per month (10%)	100
6	Takt time (in minutes)	48
7	Order Processing Rate (in minutes)	80
8	Average delay between PR trigger and PO release (in minutes)	32
9	Number of buyers in the team	5

3.5.3 Other Inefficiencies in the Current VSM State

- **Lower OPR than Takt Time:** This happens due to the current delays in the procurement process. A less TT than OPR means the firm takes more time to

complete processing one PO than to create a PR from any department. From the computation, a PR is generated every 48 minutes while a P.O is released only after every 80 minutes.

- **System / software issues**: Software glitches and hanging of the system are the major causes of delays. Glitches occur due to instability of networks and internet and sometimes because of the delayed updates of the SAP software. Moreover, inadequate SAP expertise by the buyers also reduces efficiency as sometimes PRs are wrongly raised by the end users or inadequate SAP skills to process the PRs with ease by the buyers.

- **Delays in assignment and distribution of PRs among respective buyers due to misallocation of PRs to buyers:** Specific buyers handle PRs from specific departments and if this is wrongly allocated, it takes more than three days for the buyers to complete this step. Wrong assignment of PRs affect more Direct out PRs than system generated PRs. This is because the end users may not have information on which particular buyer is assigned to handle PRs from his / her department. The problem may also arise from improper screening of Bill of Materials (BOM) and inventory data, especially during cycle-count adjustments and production reports.

- **Delays in bidding and supplier selection** - delays are common during bidding, PR review, and supplier selection. During bidding, buyer checks with end-users on the correctness of the material specifications. A number of times the end users fail to indicate whether the materials they are requesting for are being purchased for the very first time leading to significant delays. It means that the PR is resent back to the requesters for correction. This causes further delays.

- **Lack of updated customer databases and material information:** This causes delays during the PR review. Moreover, collapsing materials of similar suppliers together, searching for the right material information and suppliers from the SAP purchase history during review also takes considerable time. Materials description could have not been done well in the SAP. Sometimes the way a material is described on the ground significantly differ from the name recorded in SAP. Moreover, a material may also have correct naming in SAP but it is not linked to the vendors. It, therefore takes a considerable amount of time to try linking them to right suppliers.

- **Delays in supplier selection:** It occurs because buyers take long to retrieve material information. Sometimes the suppliers are obsolete or the materials are first timers, and the requesters have failed to indicate where the supplier and material information is new or repeat purchases. The back and forth during specifications reviews with suppliers also contribute to a significant time lost in confirmation of specifications as well as correcting the PRs to meet the requirements.

- **Long lead-time:** Currently, five buyers working 8 hours per day process 600 orders per month out of 1000 orders. The backlog implies that there is always delays in delivery of 40% of all materials requested for by the end users. Longer lead time result from delays experienced in all the steps of PR process from the time is raised to the time a PO is being released to the supplier.

- **Materials being purchased for the first time:** When end users do not indicate whether the materials being purchased are new items hence the buyers spend a lot of time trying to retrieve such materials from the system where they are not. Upon confirmation that specific materials description is not in the system, an entire

process of its inclusion as well as looking for the vendor is re-initiated. This leads to loss of significant amount of time.

- **Lack of prior approval of PRs with value above USD 10,000:** There are delays due to small mistakes like when the requester creates a bidder list for PRs above 10,000 dollars and fails to seek prior approval by a higher level supervisor, which is a control put in place to curb unnecessary spending. When buyers notice such mistakes, they reject the requisitions and ask the requestors to recollect them for departmental approval before processing them.

- **Delayed suppliers' response to RFQs:** It should take zero-days from the day of PR approvals to send RFQs, but the process often faces communication delays, especially when suppliers delay in responding to emails or when the requestor did not provide critical information on the capability of the supplier to produce and supply the needed materials. A vendor may delay to respond to requests from the company either because they did not access the mail requests or sometimes the information contained in the requests are not accurate or incomplete. Additionally, the vendor may not be having the requested materials and are still trying to source for them, hence they become reluctant or buy time in responding to the requests.

- **Wrongly written PRs:** More delays are experienced as a result of PRs missing some critical information necessary for its processing. The respective buyer searches for the end-user who raised the requisition to review and amend the missing technical information and specifications, as provided in the offers by the selected suppliers. Offers by suppliers for wrongly written PRs are often rejected by the requestors because they do not match the exact material needed, due to misinformation captured during the requests. In case the offers are not confirmed,

the buyer communicates with the supplier to review and offer the correct specifications.

- **Outdated material descriptions:** New materials descriptions and phrases are coined by day and how a specific material was referred to a few years back may be totally different now. For example, the chemical world has often interchangeably used Carbon Dioxide and Carbon (IV) Oxide. IUPAC constantly reviews some of the names given to compounds and this scenario may mean that a new employee could use a newer and more advanced description for a commodity that may ultimately be wrong and lead to a negative result when searching the SAP. Such scenarios lead to delays in the system.

3.6 Analysis of Current VSM State

An analysis of the current procurement state reveals the need to make adjustments and changes to improve the future procurement state. Currently, the company closes 600 PRs per month as opposed to the targeted 850 PRs per month. Some PRs may take up to 6 months to be converted into POs and sent to the customer. This is a very long time and hence production is likely to be immensely affected with delays. As a result, the future procurement state should target to achieve the expected 850 PRs converted to POs by eliminating the delays experienced in various procurement stages. This can be achieved through automating PR assignment, PR review, bidding, and supplier selection.

CHAPTER FOUR: IMPLEMENTATION AND FINDINGS

Future state map was established after the implementation, data collection done and analysis for the same done using Microsoft Excel Tools. The level of improvement is proportional to the summation of improvements made in the various procurement steps. Improvements derived from application of VSM are also linked to quality of actions executed in the improvement program. The improvement program eliminated some steps while reviewing others to make them leaner and more efficient.

4.1 Implementation of Improvement Plans

Improvement plans are implemented for every step and monitoring and evaluation done for effectiveness of the activities.

4.1.1 Establishment of Regular Follow-up Structure

Some of the issues mentioned above can be solved through the improvement in communication effectiveness between the company and the suppliers. One of the key issues noted is disconnect between the organization and the suppliers. For instance, some suppliers may delay in providing the company with details on their production capacities. This issue can be resolved by adding an extra layer of communication checks. For instance, following an email communication with a phone call could assist to confirm that suppliers receive the RFQs on time.

A regular follow-up program will help the company to detect any change in the supplier information. Making extra and regular calls to the supplier may help the procurement team ascertain whether the suppliers found their emails and how soon they would respond to them. Making regular follow-ups can help the company's procurement team identify viable alternatives to the prevailing situation. Follow up is important as it will allow the company start the process of searching for alternative

vendors for the same materials required. The buyers will get information in time whether supplier discontinued a brand or not. The information such as a change in authorized dealers can effectively be shared during this communication process. Such vital information protects the company from losses and risks of purchasing poor quality commodities or stock. Additional steps to be carried out include the following:

Improve continuous checks and updates of supplier information based on previous communication exchanges. The buyer should maintain accurate supplier contact information and other details including:

a. Checking the company's history for email and phone contacts.
b. Checking the supplier's company's website and verification of correctness of information.
c. Sending out the email informing the supplier about the invitation to bid and, within the same communication, notify the supplier that the company will call to confirm the receipt of the invite.

4.1.2 Internal Reviews at the Departmental Level

Departments have the best understanding of the technical capabilities that they require for their materials and equipment. Each department should audit its PRs for completeness and correct quality. For example, once the individual in-charge or the production managers identify what they require for the continuity of their work, they need to search against the company database to confirm that the supplier details are available and select their preferred suppliers list based on the materials' specifications.

This will help in shortening the lead time for making the deliveries. The requester should therefore follow the below steps while raising a requisition to the procurement department:

1. Identification of a need
2. Raise a purchase requisition
3. Submit the purchase requisition for review
4. The purchase requisition is reviewed against company needs and existing inventory levels
5. The new information is submitted to the other steps once the requesting departments confirm that all the data is accurately recorded to avoid search glitches that may force the document to be rejected in the work flows.
6. The requester searching and checking for the respective departmental buyer through the SAP and notes on the document, the respective buyer whom the PR should be submitted to.

4.1.3 Regular Reviews and Update of Supplier and Product Information

The organization needs to establish itself as an efficient firm with well-run operations. Companies that rely on internal databases, need regularly updates to the system. Every department should regularly furnish the procurement department with all relevant information relating to all materials together with details and information of the respective suppliers of those materials and items. All stakeholders should ensure that all required and useful information are all updated in SAP to enhance efficiency of the purchasing process.

Before submitting the PRs to the procurement department, the internal managers should review them at the departmental level. They need to evaluate PR against the SAP details. Granting of SAP database access to the department to be confirming the descriptions against the current information could prevent lateness and such wastages in the system. Due to the intricacies at the procurement level, the access

level of rights shall be for a search and verification purpose only. If the departments can ensure that its materials descriptions match that which is in the system, then the information shall be accurate enough for the procurement team to proceed with the purchase immediately.

4.1.4 Staff-proposed Improvements

Brainstorming with a section of the staff presented a few recommendations on how the entire process can be improved and optimized. The staff recommended continuous internal training on SAP usage. They saw the need for everyone being empowered to be conversant with the procurement protocols especially in SAP. This approach would ensure that the members are aware about the system's changes and handle them accordingly.

They also indicated that in future, the efficacy of the proposed procurement systems should always be tested and approved before deployments to staff to ensure that everything is fully functional. Further proposals by staff included the following:

- **The time taken from the PR raising to final processing of the PO.**

Considerable time is taken for the PR to be converted to PO. Reduction of this will enhance efficiency of purchasing process.

- **The number of erroneous supply of documents to different offices**

The company can effectively reduce delays by resolving the errors as a result of inaccurate documentation.

- **The reduction of the number of PRs initiated in a month.**

This can be achieved by having representatives from various departments being responsible for all the purchase activities in respective departments. It can also be

achieved by making most materials stock items that have minimum and maximum quantity levels in the system upon which an auto purchase is triggered whenever the system raises flag when the amount of materials reaches minimum levels. Still, the number of PRs raised in a month can significantly be reduced by purchasing materials in bulk quantities that can last for some period of time. However, this depends on accurate demand forecasting and material planning.

4.1.5 Continuous Assessments and Reviews

Improvements and sustainability is achieved through regular review of activities as part of the routines. Effective review structures should be established with itemized agenda on what needs review.

4.2 VSM for the Future State

This is a map drawn after implementation of the improvement program. It usually contains shorter steps and all the steps are more value adding than in the initial current state map. It is more efficient than the current state map due to elimination or reduction of non-value add activities. In the future state map, steps are improved and some duration of time saved to enhance the entire process. There are some key processes that were completely eliminated or their duration reduced to the minimum. Steps that were completely eliminated due to their redundancy include PR assignment (3 days) and printing, signing and filing of bidder forms (2 days). The rest of the steps had several leakages but were necessary to the process, therefore, they were reviewed and their duration reduced. The duration for PR reviews was reduced from current 4 days to 2 days, receiving offer from supplier reviewed from 3 days to 2 days, technical evaluation of PRs reviewed from 3 days to 2 days and negotiation time from 3 days to

2 days. These shortened the entire procurement process by 11 days, which is an extra available time to convert more PRs to POs.

Comparing the initial state VSM, the future state has shorter lead time and OPR as shown in Figure 7.

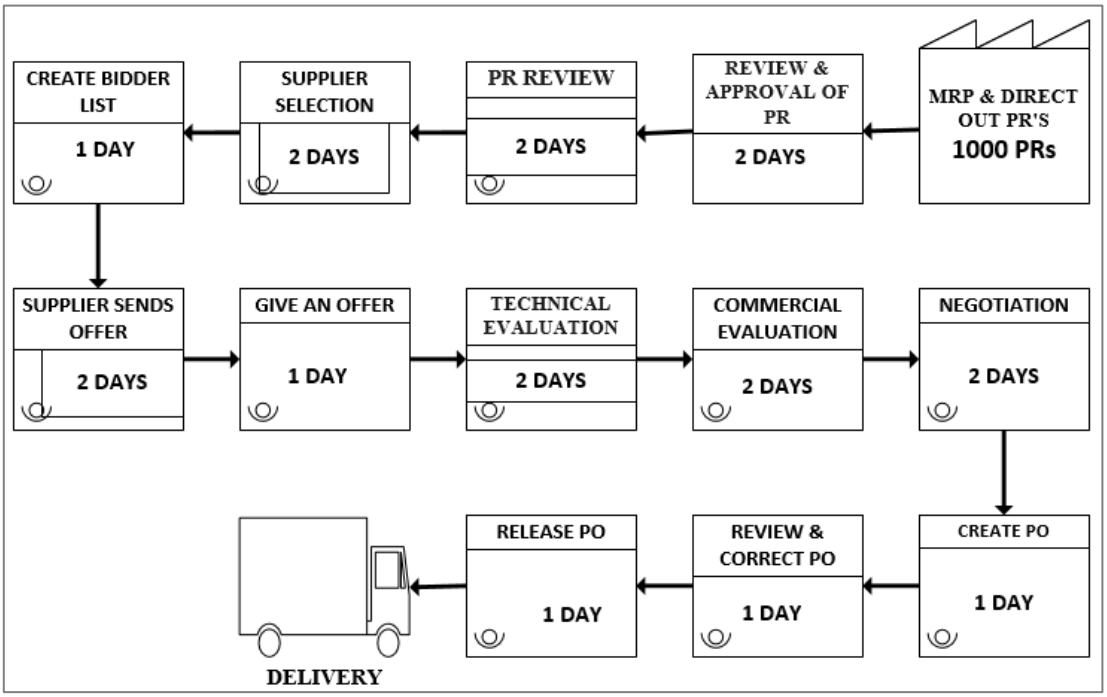

Figure 7: VSM for the Future State

Simple problem solving tool is applied in each of the steps with inefficiencies to identify their root causes, and actions taken to seal the gaps and permanently eliminate wastes in the respective procurement steps. A 3C (Concern, Causes and Countermeasures) is a 3-step problem solving tool used for addressing small operation problems.

The 3C problem solving methodology starts with detailed definition of concern / problem being addressed to enable a good understanding of the problem. The concern is defined using a template of 5W1H describing what the problem being addressed,

where the problem is happening, when the problem is happening, who is affected by the problem or stakeholders involved, which pattern the problem is portraying and how much / many showing the magnitude of the problem. The answers to these 5 questions leads to a summarized focused problem statement.

Second phases of the 3C tool addresses the causes of the problem. It starts with brainstorming on the possible causes of the inefficiencies along procurement process. The outcome of the brainstorming session are grouped into fish bone diagram to determine the direct causes. A 5-why analysis (which is a repetitive question asking technique seeking answers on why a phenomenon is occurring and it involves up to 5 whys) is conducted to arrive at the root causes of the inefficiencies in the procurement process steps. Countermeasures or focused actions are taken to eliminate specific root causes of the problems or leakages in each of the procurement steps. The details of 3C Problem Solving template is shown in appendix 2.

Key items purchased include chemicals and catalysts which make 80% of total purchases, machine spare parts (15%) and Information Technology (IT) making 5% of company's total purchases. The chemicals and catalysts make the biggest quantity of items purchase. They are consumed by production department processes for compounding substances and additives mainly used in petroleum processing companies and companies manufacturing fertilizers, oils, detergents, pesticides, herbicides and, paints and inks for painting and printing industries.

Complete elimination of 2 non value add steps, and improvement of other key procurement steps led to the reduction of the entire procurement process from 30 days to 19 days as shown in Table 3 below.

Table 3: Duration of Current Procurement Process

No.	Key Procurement Step	Duration in Days Before Implementation of Improvement Plans	Actual Duration in Days After Implementation of the Improvement Plans	Number of Days Saved
1	Review and approval of PR	2	2	0
2	PR assignment to buyers	3	*0*	3
3	PR review	4	*2*	2
4	Supplier selection	3	*2*	1
5	Creating bidder list	1	1	0
6	Printing, signing and filing bidder list	2	*0*	2
7	Supplier sending offer	3	*2*	1
8	Giving of offer	1	1	0
9	Technical evaluation of PR	3	*2*	1
10	Commercial evaluation of PR	2	2	0
11	Negotiation	3	*2*	1
12	Create PO	1	1	0
13	Review and correct PO	1	1	0
14	Release PO	1	1	0
	Total days	30	19	11

There were significant reductions in the number of days spent in each procurement step as shown in Table 3 above. To begin with, assignment of PRs by the senior buyer to other buyers was improved by re-assignment of buyers to handle PRs for specific departments. The requesters therefore select buyers and attach their names to the PRs while raising them. This was implemented for both manual and the PRs that are raised through the SAP hence leading to complete elimination of the step. Elimination of PR assignment saved the time lost in the assignment and time spent in reassignments when erroneous allocations were made. The delays as a result of PR

reviews were reduced from 4 to 2 days by simplification of the manual PR form as well as incorporating an email alert component for PRs raised through SAP. The later would notify approvers of the PR workflows that need their approval responses. This ensured that any error made during raising of PR was quickly addressed to enable continuation of the processing to the next level.

Additionally, specific staff were nominated and their roles redefined to include raising of PRs for their respective departments. The individuals were given SAP access rights to be able to digitally raise the requisitions hence minimizing on errors of at the start of the procurement process. Frequent phone calls follow up structure was established to address the leakage of delayed supplier selection from 3 to 2 days. Buyers would thereafter make phone calls after sending mails to vendors to confirm the recipts of their inquiries and request for time that responses would be relayed. Further phone calls would be made for every 4 hours that elapsed before getting responses from the vendors. Delayed supplier selections occurred due to vendors not responding on time to the proposed adjustments as requested by the buyers, hence the vendors kept on sending emails requesting for feedbacks, and in some cases when not successful, they start to source for alternative vendors which commences the whole cycle again.

The redundant step consisting of printing, signing and filing of the bidder lists was completely eliminated by automation from current 2 days to none. Online forms were created that would be filled and signed digitally by both company and the suppliers hence rendering the step paperless. This eliminated time spent in this step and still elimination of paper work hence saving on printing costs. Delays experienced due to late receipts of offer from suppliers were reduced from 3 to 2 days through implementation of regular follow ups through emails and phone calls. Suppliers did not

respond immediately due to late reading of mails or lacking capacity to deliver the requested materials. Frequent follow ups through phone calls help in early detection of delays or lack of supplier capacity to deliver the requested materials hence alternative vendors would be engaged as soon as this information becomes clear. Technical evaluation took 3 days to be completed due to un-matching specifications between what was requested and what the supplier has offered or what is in the BOM in SAP. This was reduced to 2 days after updating the material lists and description and linking them to respective vendors in the SAP system. Finally, negotiations were taking 3 working days caused by delays in preparation of technical specifications required in negotiation sessions, lack of critical information for negotiation and some delays in supplier selection. A buyer with adequate negotiation skills was nominated to be responsible in overseeing and making sure that all negotiations are done as per plan with all required inputs and output. This was successfully reduced to 2 days by ensuring prior preparation for the session days before the negotiation.

4.3 Data Analysis

After the implementation of improvement plans, VSM metrics were computed again to evaluate the impact of the activities on the procurement processes. Implementation of the improvement program resulted into more free time that the buyers utilize to convert an average of 305 more PRs into POs. There is a positive trend of more POs being released month by month, and this has subsequently improved the average POs released per month from 600 to 905. Table 4 shows data for five consecutive months collected after implementation of the improvement plans:

Table 4: Number of PRs Processed per Month after Implementation of Improvement Program

Month	Total man hours in each month	Duration in minutes in a month	Number of POs released
March 2021	800	48,000	1,015
February 2021	800	48,000	940
January 2021	800	48,000	955
December 2020	800	48,000	819
November 2020	800	48,000	794
Total			4,523
Average			905

4.3.1 Takt Time (TT)

Takt Time does not change from the current state to the future state. Customer demand remains the same, and the company has no control over it. It is not an easy task to stop end users from raising more PRs. As soon as the materials get used up, they will raise new purchase requisitions for replenishments.

4.3.2 Order Processing Rate (OPR)

Order Processing Rate (OPR2) was computed. For this case, the average 905 of POs released from November to end of March.

OPR is the actual duration that it takes to convert one single PR into a PO. Out of the 1000 PRs submitted in a month, the team managed to successfully convert an average of 905 into POs in a month.

Total MRP and DO PRs in a month	= 1000 PRs
1 day's work hours for 1 buyer	= 8 hours
5 buyers working 1 day	= 40 hours
5 buyers working 5 days a week for 4 weeks	= 800 hours
Total number of POs released	= 905

The duration of time in a month remains the same (30 days) hence our calculations are as below:

905 / 1000	=	90.5% of total PRs.
OPR2	=	48,000 minutes / 905
	=	53 minutes / PO

After the implementation of the improvement plan, data shows that, it takes a new average of 53 minutes to complete a whole cycle of one PR processing from the time it is raised to the time it is released.

4.4 Results

Comparison of the order processing rate for current state versus future state shows that there is a significant improvement from 80 minutes to 53 minutes for each PO. This means the buyers are able to process more POs within the same duration and thus leading to improvement of the overall efficiency. Table 5 shows the comparison of VSM metrics of current state versus those computed after the implementation of the improvement initiatives.

Table 5: Comparison of VSM Metrics before and after Implementation of Improvement Plans

No.	VSM metric	Current state VSM (1)	After implementation of improvements (2)
1	Takt Time (TT)	48 minutes	48 minutes
2	OPR	80 minutes	53 minutes

The table shows a significant improvement in OPR after implementation of improvement plans compared to the same before the implementation. OPR improved from 80 to 53 minutes, an improvement of 27 minutes.

It is recommended to have a less cycle time than takt time, hence there is need for further evaluation to establish a new future state, improvement programs developed to ensure that cycle time matches or is below the takt time. The rationale behind this is that the rate at which orders are closed should be faster than the rate at which new orders are being generated.

4.4.1 Impact of Application of VSM on Order Processing Rate

Data at current VSM mapping showed that the procurement team was able to create 600 POs within a month that is 60% of total PRs raised. However, within similar duration, this number significantly increased to 905 POs within a month, 90.5% of total raised PRs. It was an increase by 50.8%. OPT was 80 minutes at current VSM map when the project commenced and after implementation of improvement plans, OPR reduced to 53 minutes. This was a reduction by 27 minutes equivalent to 33.8% reduction in OPR. However, 53 minutes OPR is still higher than TT which is 48 minutes. This means that a new purchase requisition is generated every 48 minutes while, a PO is released every 53 minutes. This means PR backlog will always be available and the team needs to look for other ways of bridging the 5 minutes' gap so OPR can match with TT. Alternative ways may include working additional minutes or temporary addition of workforce whenever there is need. In ideal situations, OPR should always be greater than TT so that we are able to deliver faster than the customers' demands.

CHAPTER FIVE: CONCLUSION AND RECOMMENDATION

5.1 Conclusion

VSM is useful in viewing the entire process from beginning to the end with main purpose of identifying gaps or wastes. This is achieved by drawing a current state map outlining all the steps in a process, and a future state map without the steps considered to be non-value add. These wastes are eliminated or reduced to minimum levels. The long-term benefits of VSM include reduction of costs, improvement of lead times, increased yields and improvement in quality of products and services in an organization.

This report studied the current procurement processes and converted them to the VSM to understand the wastes inherent in processes and to implement a better system for procurement function. Analysis of the steps was conducted with the potential changes made based on the outcome of the 3C problem solving tool that was applied to determine the root causes of the inefficiencies. Afterwards, future VSM map was established after eliminating and minimizing the non-value added steps. The results of the implementation shows that the new process increases the efficiency of the procurement processes by 33.8%. The study suggests that application of VSM helps to understand the processes that can be changed, apply the changes, and improve the order processing rate.

5.2 Limitation of the Report

The study was carried out in a particular company working in the petrochemical industry. Although the company is one of the largest ones in Qatar, this report focused only on the procurement processes related to chemicals and catalysts. However, the

timings mentioned here are based on the particular case. Therefore, study of the processes for other types of purchases becomes necessary by using the VSM.

5.3 Future work

This study focused on the internal factors affecting efficiency of purchasing process for a chemical company. Further study can seek to establish the external factors that directly contribute to the delays and hence lead to inefficiencies along procurement processes for companies. External factors could be related to the company but outside the procurement department or external to the company.

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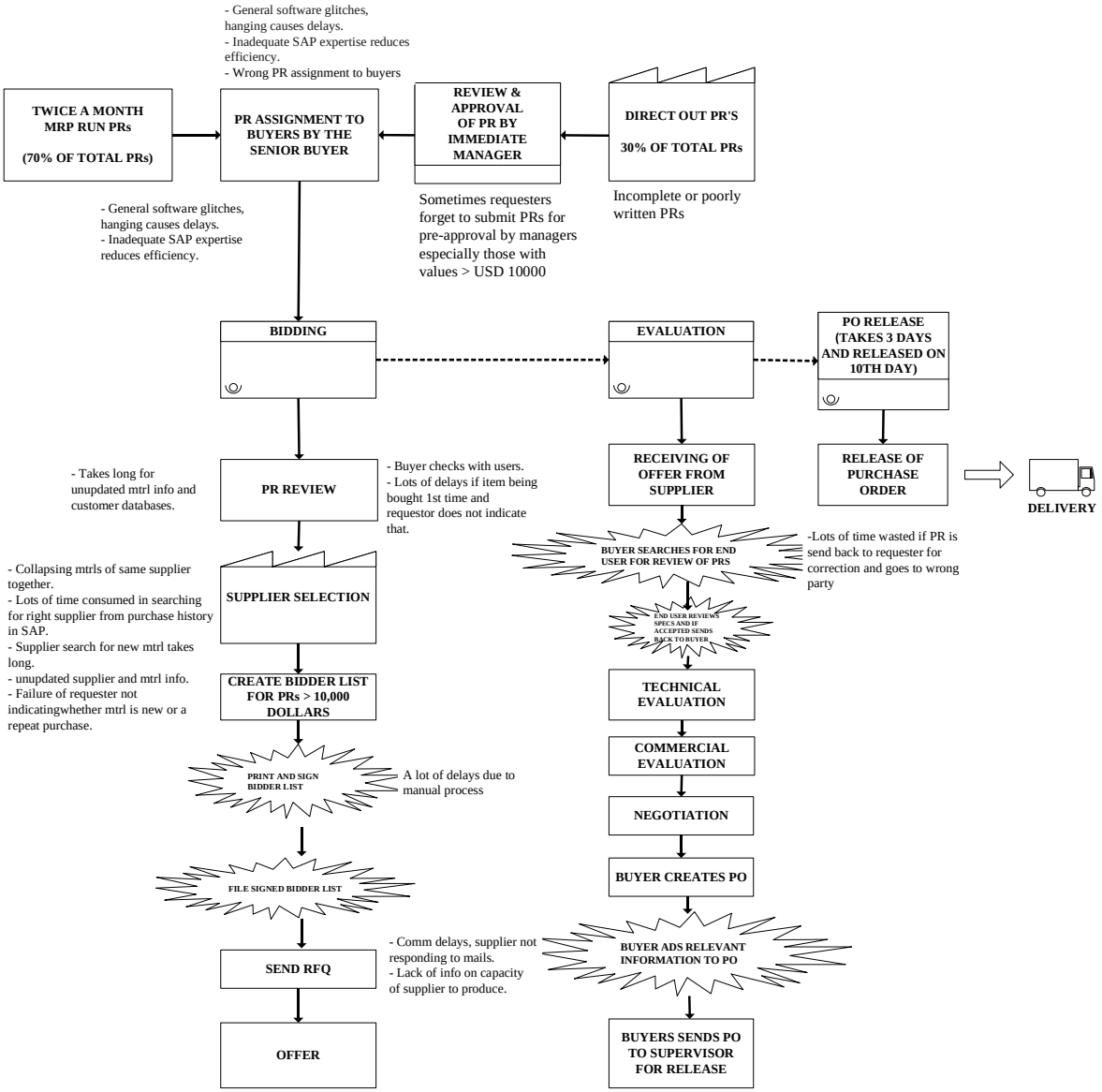
APPENDIX A: CURRENT VSM STATE FOR PROCUREMENT PROCESS

Current VSM State for Procurement Process



APPENDIX B: 3C PROBLEM SOLVING TEMPLATE

3C Problem Solving Tool	
Problem as Reported:	
1. CONCERN - Define the problem	
What is the problem?	
Where is the problem detected?	
When is the problem happening?	
Which pattern can be seen?	
Who is involved?	
How much / many	
Focused Problem statement:	
2. CAUSE - Identification and Investigation	
2a) Brainstorming:	**2b) Fishbone Diagram:**
2c) Direct Causes:	**2d) 5-Why Analysis:**
2e) Root Cause:	
3. COUNTERMEASURES	