BUILDING MODEL OF BASIC STABILITY FOR PRODUCTIVITY IMPROVEMENT JOURNEY IN PT. DOW AGROSCIENCES INDONESIA BY UTILIZING VALUE STREAM MAPPING (VSM) IN PRODUCTION SHOP FLOOR

THESIS

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POST GRADUATE SCHOOL
NORTH SUMATRA UNIVERSITY
MEDAN
2009
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To obtain Master in Sciences Degree in Industrial Engineering
Post Graduate School – North Sumatra University

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ABSTRACT

Dow AgroSciences is one of the biggest international chemical companies. As global competition become tightens everyday, there is an urgent need for manufacturing operations to continually striving to increase productivity and output of their operations. Improvement on production scheduling activity is one of areas improvement that PT. Dow AgroSciences Indonesia identified and became an important component in production shop floor.

Title of this thesis is “Building Model of Basic Stability for Productivity Improvement Journey in PT. Dow AgroSciences Indonesia by Utilizing Value Stream Mapping (VSM) in Production Shop Floor”.

The topic of this master thesis originates from practical problem that company faced which are difficulty in production scheduling activity and instability of MPS metric performance due to instability and inaccuracy of information that used to develop production schedule due to variations in production schedule execution. In other words, there is no standard works that used in each production shift as one of basic stability in lean manufacturing operation.

The purpose of this study is to improve production scheduling activity by building model of basic stability in production shop floor. Model of basic stability in this thesis will be represented as Standard Operations Sheet (SOS) that will help the company to standardize their production activity and eliminates most of wastes by using Value Stream Mapping Methodology. Value Stream Mapping (VSM) tool will lead researcher to define the current state and to develop the future state of the process flow, and finally develop standard work that applicable align with future state for Tracer120SC product family.

It has been concluded from the constructed current state map of Tracer120SC value stream that the most common reasons for the wastes were the requirement of minimum quantity of raw material to be purchased from supplier, the minimum lot size of formulation tank and the unavailability of direct line from formulation tank to filling line. The future state map suggests that a 42.49% lead time reduction could be achieved, mainly thru eliminating large batch production and install direct line from formulation tank to filling line.

Standard Operations Sheet (SOS) as the model of basic stability developed using information from future state map, including information about takt time, effective process sequences and standard WIP between processes. It has been recommended to follow this Standard Operations Sheet as standard production schedule execution for each shift to achieve standard output per shift, which finally will improve production scheduling activity as the main objective of this research.

Keywords: Value Stream Mapping (VSM), production schedule, standard work, Standard Operations Sheet (SOS), current state map, future state map.
ACKNOWLEDGEMENT

Completing this thesis has been challenging and exciting journey in my life, for which I have to say Alhamdulillah and thankful to Allah SWT who has given HIS guidance in every step that I made until finally I can complete this thesis. This achievement also would not have been possible without the support of numerous people. I would like to take this opportunity to thank them.

I wish to thank to Ayah, Bunda, my Sister Desi Ariyanti Ningsih, SSi, Apt., and my big family member that I can’t mention their name one by one, without whom this would not have been possible. Their unconditional love, constant support, great advices, and prayer over the years are something that I cannot thank them enough for. I also thank them for having faith in me and my capabilities, its become energy and spirit for researcher to complete this thesis.

My deepest appreciation goes to my advisor, the Chairman of my committee, Professor Dr. Ir. Sukaria Sinulingga, M.Eng, for his valuable assistance, guidance, and encouragement in bringing this research work to a successful completion.

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I will cherish this period greatly for the rest of my life.

Medan, December 28, 2008
Devy Adhriany Rahayu
CURRICULUM VITAE

Devy Adhriany Rahayu was born on October 10, 1981, in Indrapura, North Sumatera. In 1999, researcher completed her senior high school from SMU Negeri I Medan, after which she started her study of Chemical Engineering at University of Sumatera Utara and graduated on 2004. In September 2006, she continued her study to get Master Degree in Industrial Engineering at University of Sumatera Utara and graduated on January 2009. From December 2004, Devy is employed as a staff in PT. Dow AgroSciences Indonesia, subsidiary of The Dow Chemical Company.

Since four years ago, Devy has held various roles in Manufacturing and Supply Chain area. Currently researcher holds roles as Site Logistic Leader and ASEAN Distribution Resources Planner (DRP). Researcher ever hold role as Detail Production Scheduler (DPS) for Medan Site and Contract Manufacturing Site, Material Planner for Medan Site and Production Data Analyst in the same company PT. Dow AgroSciences Indonesia.


Medan, December 28, 2008

Devy Adhriany Rahayu
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CHAPTER I
INTRODUCTION

1.1 Research Background

Growth of business world these days created tighter market competition, because the existing industrial market become more global and have penetrated the inter-states boundary. In competition which progressively tightens like this, every company claimed to own the excellence and competitiveness so that probabilities to win the competition become greater.

Those conditions forced manufacturing operations to continually striving to increase productivity and output of their operations. Their goal is to satisfy the customer with the exact product, quality, quantity, and price in the shortest amount of time (Tinoco, 2004). It can only be achieved if the company is able to create and to implement effective and efficient processes in each of its line of their business.

PT. Dow AgroSciences Indonesia as one of MNCs Company that operating in Indonesia, direct subsidiaries of The Dow Chemical Company based in Indianapolis-United States, is committed to continually improve their process and find the way to run the plant better every day and able to create and implement effective and efficient processes in each of its line of their business.

PT. Dow AgroSciences Indonesia is a producer of liquid pesticide products including herbicides, insecticides and fungicides and become the source that supply
pesticides product for the nations of ASEAN, Taiwan, China and Korea. This company currently produced more than 141 types of products from 50 ml until 200 liter pack size with many types of packaging, and more new product will be produced in the next coming years to serve global demand.

With that kind of business nature, Master Production Schedule (MPS) is playing a big role to the successful of manufacturing operation and to ensure high service level to their customers. The MPS supports all business objectives and is one that the business can reasonably expect to achieve based on available materials, capacity and resources. It reflects the plan of what plant expects to make, where, and when. MPS metrics are used to continuously improve the supply chain performance.

The master production scheduling process translates a business plan into a dynamic and comprehensive product manufacturing schedule. Production scheduling is an essential part of the management of production systems: it lies at the very heart of the performance of manufacturing organizations. Effective scheduling can lead to due date performance that results in meeting the company’s customer service goals, and reducing work–in–process inventories and production lead times. “The priority planning and shop floor control and scheduling elements ultimately determine the performance of the production system” (cited from Wiers, 1997).

In industrial manufacturing, practically, there are dozens problem that intervening production activity included in the phase of production planning or scheduling it self. In PT. Dow AgroSciences Indonesia particularly, there are some
phomenon gathered that indicating they also face some problems in their production scheduling, which are:

1. Master Production Schedule (MPS) metric having fluctuate performance, some of them achieve performance targeted, some of them below or above the performance targeted. MPS metric performance can be shown in Table 1.

<table>
<thead>
<tr>
<th>Metrics</th>
<th>Target</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
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<th>Jan</th>
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<tr>
<td>MPS</td>
<td>&gt;95%</td>
<td>96%</td>
<td>99%</td>
<td>96%</td>
<td>99%</td>
<td>98%</td>
<td>100%</td>
<td>98%</td>
<td>99%</td>
<td>96%</td>
<td>96%</td>
<td>97%</td>
<td>99%</td>
<td>92.4%</td>
<td>85.5%</td>
<td>97%</td>
<td></td>
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<tr>
<td>PtP</td>
<td>95-105%</td>
<td>107%</td>
<td>120%</td>
<td>99%</td>
<td>103%</td>
<td>103%</td>
<td>105%</td>
<td>98%</td>
<td>102%</td>
<td>100%</td>
<td>100%</td>
<td>96%</td>
<td>102%</td>
<td>98%</td>
<td>96%</td>
<td>107%</td>
<td>94%</td>
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<td>12</td>
<td>13</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>2</td>
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<td>5</td>
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<td>1</td>
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Source: PT. Dow AgroSciences Indonesia

From the table we can see that there are three performance indicators that measured, which are MPS, PtP, and MPS Stability. MPS metric is measuring plant ability to meet the ‘time and volume’ targeted in production schedule, we can see that there are some months below targeted performance. Produce to Plan (PtP) metric is measuring ‘actual versus planned volume’ that production able to deliver in one week MPS frozen zone, some of the performance are below and above performance targeted. The last metric that measured is MPS Stability, this metric is powerful metric that can tell us the overall performance and effectiveness of Master Production Schedule (MPS), including ability to meet schedule, instability of production schedule execution, changes to the frozen zone - creating new schedule or canceling schedule in frozen zone and some other problems that could be the focus for improvement. The higher number of MPS
Stability, the worst performance of Master Production Schedule metric, means a lot of variety and instability in production shop floor execution that made production team can not meet the schedule planned.

2. Production scheduler having difficulties to get accurate information about standard manpower required, standard routing to produce the product, shift arrangement and scenario that available, capacity in line production, reliability of filling and formulation line. That situation is directly impacting his ability to create accurate production schedule and ensure smooth execution in production shop floor and in the end will impacting the MPS metric performance as well.

3. Inability to meet committed target date to load the product into container and ship to customer. This situation is impacting logistic performance and directly will influence customer trust level to company.

4. Difficulties to define optimum capacity that available, to define effective sequence of operations within process and to identify earlier constraints in the manufacturing plant that required in order to response customer demand that continually growing and vary.

Problems in their production scheduling that indicated by those phenomenons surely have to resolve, otherwise their manufacturing performance will be impacting and hard to improve. One of ways that they can take to improve their production scheduling activity and in the same time achieve high stability of their MPS performance is creating basic stability in their production shop floor activity.
Talking about basic stability, one of the important elements is Standardized Work. Standardized Work is one of the most important and familiar components of the Toyota Production System (TPS). Standardized Work in production shop floor is required to resulting accurate information about production activity, output per shift and to resolve most of the phenomenon that we identified.

There are some benefits of Standardization: Helps maintain and improve quality, stabilizes the work conditions, increases the level of safety, allow for easier judgment regarding “normal” versus “abnormal” situations, enables cost reduction, and stabilizes operating time (if takt time included).

Knowing the importance of this standardized work especially in manufacturing plant and in the goal to smoothing production scheduling activity and stabilize their MPS performance, PT. Dow AgroSciences Indonesia start to focus themselves in this year 2008 to the concept of Lean Manufacturing and Standardized Work by using some tools that available, which one of them will be used in this research is Value Stream Mapping (VSM).

The focus of this research is to identify and eliminate the wastes in the production process by define the current state and develop future state that can be used by this company to build their basic stability focusing in standardized work in a journey of their continually productivity improvement and to become a manufacturing plant with cost competitiveness that align with company’s strategic plan globally.
1.2 Problem Statement

The research problem formulated in the thesis originates from practical problem that company faced which are difficulty in production scheduling activity and instability of MPS metric performance.

Preliminary discussion with company in the project formulation phase revealed that there are some variations in production schedule execution, where production team using **different** work method, production sequencing, manpower arrangement, resulting different output of product in each shift although available time is the same. Instability and inaccurate information of production output per line per shift made difficulty to create accurate production schedule and in the end will create instability of MPS metric performance.

Some of those problems drove to another basic question “what can we do to improve this production scheduling activity and MPS metric performance?” Of course, the basic answer given would be “eliminate those variations and make standardization to the work in the shop floor”. The decision made was to visualize and analyze the process flow on production shop floor and then propose model of improvement using lean manufacturing methodology especially mapping tools which had proven as powerful tool to identify wastes, improve and standardize work flow.

1.3 Research Objectives

The objective of this research is to improve production scheduling activity and MPS metric performance by building model of basic stability in production shop
floor. Model of basic stability in this thesis will be represented as Standard Operations Sheet (SOS) that will help the company to standardize their production activity and eliminates most of wastes by using Value Stream Mapping Methodology. Value Stream Mapping is one of Lean tools that will help researcher to define the current state and to develop the future state of the process flow, and finally develop standard work that applicable align with future state.

1.4 Research Benefits

This research hopefully can give benefit as follow:

1. For the company, this research can be used as guidance in developing model of basic stability for productivity improvement in production shop floor by using lean manufacturing concept resulted in manufacturing cost competitiveness, by reducing lead time, reducing WIP, floor space saving, increasing productivity, improving quality of the products produced, and overall cost reduction.

2. For the researcher, this research gives a wide learning journey about lean manufacturing and its application in manufacturing plant. This research also consider as one of a media to implement some knowledge already taken from school focusing on productivity improvement in the manufacturing plant.

3. For the institution, this research hopefully become valuable references for another researcher lead to another deeper research about Lean Manufacturing and Value Stream Mapping as one of the tools in manufacturing environment.
1.5 Research Limitations

To solve the problems in this research, the scope of the research need to be defined so that this study not become too wide, more focus and go to the right direction. The limitations of the project as below:

1. The results of this research are limited to manufacturing process and production scheduling activity in PT. Dow AgroSciences Indonesia, will not discuss about financial aspect and the impact to management structure.

2. The study only includes the development of work standardization model based on future state developed for a value stream selected and recommends ways to improve the process.

3. The value stream map is a model that is intended to help pin-point areas of improvement that limited to one product family selected based on value stream mapping product group criteria.

4. The study does not include examination or validation of the model that developed in order to see the improvement in production scheduling activity.

5. The study does not direct company how to implement improvement proposal resulting by this research.

1.6 Research Assumptions

This research is based on the following assumptions:

1. No changes to the design or technology that used in production.
2. No changes to the organization structure that lead to the changes on the policy’s company or production scheduling activity.

3. No changes on the data of volume production that used for calculation.

4. Type of products that selected for the research will continuously produced.

1.7 Thesis Outline

The content of this thesis is organized as follows: Chapter I give a brief overview of a research background and an introduction to the problems faced in production scheduling activity in production shop floor. It also describes the objective, limitation and assumption of this study.

Chapter II is a literature review that compiled and organized information about lean manufacturing, value stream mapping and standardized work that used as theoretical tools during the analysis. Continue with Chapter III, presents company profile where this research is conducted.

Chapter IV presents methodology that used for this research. Describes how this research should be conducted, clear and systematic steps to guide researcher in the process of completing the research. Data collecting and processing also discuss in this chapter.

Chapter V titled as ‘model development’. Present calculation, data processing, waste identification in value stream, and solutions to reduce waste that lead researcher closer to the objective of this research which is work standardization –
model of basic stability. In this chapter reader will get more understanding in how to develop current state and future state map using value stream mapping methodology.

Chapter VI titled as ‘problem solving’ which presents the model of work standardization as the objective of this study. Work standardization – model of basic stability visualized as Standard Operations Sheet (SOS) that developed based on future state map that has developed in Chapter V.

Finally, Chapter VII provides conclusion from this study and recommendations for further research and improvement project for company.
CHAPTER II
LITERATURE REVIEW

This chapter compiles and organizes information about lean manufacturing, value streams and standardized work that will aid the reader in understanding the specifics of the study.

2.1 Definition of Lean Manufacturing

The term “Lean Manufacturing” was firstly introduced in the book “The machine that change the world” written by James Womack in 1990. According to Womack, Jones, and Roos (1996), the term “lean” represents a system that utilizes fewer inputs in order to create the same outputs than those created by a traditional mass production system, while increasing the range of different finished goods for the end customer. The term lean manufacturing is synonymous with different names, such as agile manufacturing, just-in-time manufacturing, synchronous manufacturing, world class manufacturing, and continuous flow (cited from Tinoco, 2004).

Lean manufacturing is an operational strategy oriented toward achieving the shortest possible cycle time by eliminating waste (Liker, 2004). It is derived from the Toyota production system and its objective is to increase the value-added work by eliminating wastes and reducing unnecessary work. The technique often decreases the time between a customer order and shipment, and it is designed to improve
The benefits of lean manufacturing generally are lower costs, higher quality, and shorter lead times (Liker, 2004) and a “house” is often used to visualize and describe the Toyota Production System as the root of lean manufacturing (Figure 1). The term lean manufacturing is created to represent less human effort in the company, less manufacturing space, less investment in tools, less inventory in progress, and less engineering hours to develop a new product in less time (cited from Tinoco, 2004).

![Figure 1 Toyota Production System “House”](image)

Figure 1 Toyota Production System “House”
2.2 Types of Wastes

According to Tapping (2002) “the ultimate lean target is the total elimination of waste. Waste, or *muda*, is anything that adds cost to the product without adding value” (p. 41).

Wastes can be classified into seven categories (Tapping, 2002):

1. Waste of *overproducing*: producing components that are not intended for immediate use or sale.
2. Waste of *waiting*: idle time between operations or during an operation due to missing material, an unbalanced line, scheduling mistakes, etc.
3. Waste of *transport*: moving material more than necessary. This is often caused by poor layout.
4. Waste of *processing*: doing more to the product than necessary. This is the single most difficult type of waste to identify and eliminate. Reducing such waste often involves eliminating unnecessary work elements (including inspection through implementation of *jidoka*).
5. Waste of *inventory*: excess stock in the form of raw materials, work-in-process, and finished goods.
6. Waste of *motion*: any motion that is not necessary to the successful completion of an operation. Obvious forms of motion waste include back-and-forth movement in a workstation and searching for parts or tools. A more subtle form of motion waste involves any change in a worker’s center of
gravity. Thus, any time a worker stretches, bends, or twists; it is a waste of motion.

7. Waste of defects and spoilage: producing defective goods or mishandling materials. This includes the waste inherent in having to rework parts not made correctly the first time through. It also includes productivity losses associated with disrupting the continuity of a process to deal with defects or rework.

2.3 Definition of Value Stream

A value stream is all the actions (both value added and non-value added) currently required to bring a product through the main flows essential to every product: (1) the production flow from raw material into the arms of the customer, and (2) the design flow from concept to launch (Rother & Shook, 2003).

Cited from Tinoco’s research paper, value streams bring a specific good or service through three critical management tasks: problem solving (figuring out what needs to be changed), information management (improving information flow), and physical transformation (implementing changes). Tapping (2002) stated that, “There are many value streams within an organization, just as there are many rivers flowing into the ocean” (p. 27).

2.4 Value-Added versus Non-Value-Added Activities

The process of transforming raw material into finished goods is the objective of any manufacturing company (Tapping, 2002). The processes that make that
transformation possible are the result of two different activities: those that add value and those that do not. Value-added activities are considered the actions and the process elements that accomplish those transformations and add value to the product from the perspective of the customer (e.g., tubing, stamping, welding, painting, etc.). Non-value-added activities are the process elements that do not add value to the product from the perspective of the customer such as setting up, waiting for materials, and moving materials.

The customer, as far as Lean is concerned, is the person or entity who is the recipient of the product or service you produce. For many, the customer is another business. For others, the customer is someone inside their own business. Sometimes the customer is a specific individual; other times, the customer is a group or team. But in any case, the customer is the one who places the value on your output (Sayer & Williams, 2007).

In the past companies have been focused on the value-added steps. The goal was to reduce the value-added component of lead time and not pay too much attention to the non-value-added activities. Today, lean manufacturing strives to improve as much as possible the value-added component of lead time, but focus first on reducing the non-value-added component of lead time.

2.5 Value Stream Mapping

Value Stream Mapping (VSM) is a visualization tool oriented to the Toyota version of Lean Manufacturing (Toyota Production System). It helps people to
understand and streamline work processes and then apply certain specific tools and techniques of the Toyota Production System (Lee & Snyder, 2006).

Value stream mapping is a pencil and paper tool that helps us to see and understand the flow of material and information as a product makes its way through the value stream. Value stream mapping provides a common language for talking about manufacturing process (Rother & Shook, 2003).

The value stream mapping process will likely reveal that a significant amount of non-value-added activities are present in your current processes. These activities consume financial and human resources and make longer lead-time without adding value. However, some of these activities are really necessary in the process; therefore the idea is to minimize their impact (cited in Tinoco, 2004).

Tapping (2002) stated the following:

Mapping material and information flow will allow you to visualize the entire manufacturing material flow, instead of a single, isolated operation (such as fabrication, welding, or assembly), visualize how operations currently communicate with production control and with each other, see problem areas and source of waste, locate bottlenecks and WIP, spot potential safety and equipment concerns, provide a common language for all manufacturing personnel, and gain insight into how the operation truly is running that day. (p. 80)

Value Stream Maps reflect a broad view of the process, usually from external supplier to external customer at a given facility. Extended Value Stream Maps take an
even broader view and often incorporate tier two and tier three suppliers and distributors (Lee & Snyder, 2006).

Like Process Mapping, VSM is most valuable in a group setting. Many of the problems it exposes reach across organizational lines of responsibility and expertise. When a mapping team has representation from all the different functions and specialties, it gains a common understanding of the process and a better position for developing and implementing good solutions (Lee & Snyder, 2006).

Value-stream mapping can be a communication tool, a business planning tool, and a tool to manage company change process (Rother & Shook, 2003). Creating a value stream map will allow the company to document current production lead time, inventory levels, and cycle times in order to determine the ratio of value-added to total lead time of the product family being analyzed, creating a vision of an ideal value flow. Value-stream mapping initially follows the steps shown in Figure 2.

Rother & Shook in his book “Learning to See” said that, the first step is drawing the current state, which is done by gathering information on the shop floor. This provides the information we need to develop a future state. Notice that the arrows between current and future state go both ways, indicating that development of the current and future states are overlapping efforts. Future-state ideas will come up as we are mapping the current state. Likewise, drawing future state will often point out important current-state information we have overlooked.

The final step is to prepare and begin actively using an implementation plan that describes, on one page, how we should plan to achieve the future state. Then, as
our future state becomes reality, a new future-state map should be drawn. That’s continuous improvement at the value-stream level. There must always be a future-state map (Rother & Shook, 2003).

Selecting a Product Family

Before starting the value stream mapping, it is important to choose a particular product or product family as the target for future improvement. Not all the product can be selected to map the flow that passes through the factory. Value stream mapping means walking and drawing the processing steps (material and information)
for one product family selected door to door in a factory. It is recommended to choose one product family, a group of products that pass through similar processing steps and over common equipment in downstream process (Rother & Shook, 2003).

According to Tapping, there are two reliable methods that can employ to help decide which value stream(s) to target for improvement:

a. **Product-quantity (PQ) analysis.** Start with PQ analysis first to see if some part numbers are run in volumes high enough to make the choice an obvious one.

b. **Product-routing (PR) analysis.** Use product-routing analysis if results from PQ analysis are inconclusive.

*Current State Map (CSM)*

After selecting a particular product or product family, the next step is to draw a Current State Map to understand how a workshop currently operates. Developing future state also begins with an analysis of the current production situation (Rother & Shook, 2003).

In order to observe and understand the value stream from customer perspective, it is suggested to start from the closes point to the customer and work the way upstream through the various processes. When it comes to the drawing of current state, it should be conducted by the common CSM procedure. According to Tapping and Shuker (2002) the steps of the procedure are the following, and be guided by Figure 3.
1. To begin with, draw the external (or internal) customer and supplier and list their requirements per month, e.g. in items, pieces, etc.

2. Next step is to draw the basic processes in the sequencing order in the value stream by listing the process attributes, i.e. cycle time, changeover time, quantity of operators, available working time, etc.

3. Then, to draw queue times between processes, e.g. how many days or hours components wait until the next process.

4. The following step is to draw all communications that occur within the value stream, i.e. information flow.

5. And finally, to draw push or pull icons to identify the type of workflow, i.e. physical flow.

Figure 3 Mapping Procedure of CSM
Figure 4 shows the value stream symbols used to describe each process of manufacturing or assembly. Detail definition of each symbols presented in Appendix A.

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**Future State Map (FSM)**

Mapping the future state requires knowledge of Lean Manufacturing principles and tools (Lee & Snyder, 2006). It also requires an understanding of reasonable expectations for success. There may be several future state maps each depicting a stage on the Lean Manufacturing journey. The future state map is subject
to change as work progresses. Some ideas will prove un-workable; other ideas will come to the forefront. Figure 5 shows an example of a value stream map.

Figure 5 Example of a Value Stream Map

According to Quarteman Lee and Brad Snyder in their book “The Strategos Guide to Value Stream Mapping & Process Mapping–Genesis of Manufacturing Strategy”, there are 9 general steps available that can assist researcher in designing the future state. Each of these steps will require considerable detailing before they can be put into practice.

1. Review the present state map.

   Present State that has mapped previously should be reviewed within the team.

   This review should answer three questions: 1. Is the map essentially correct? ;
2. Does everyone on the team understand the map in all its detail?; 3. Where are the major opportunity areas?

2. Calculate Takt Time.

   Calculate the Takt time based on customer demand. Compare the Takt Time to Process Time for each process box. If any process time is longer than the Takt Time, there is a capacity problem with this process. In this step, team can discuss further the possibilities for resolving the capacity problem.

3. Identify Bottleneck Process.

   The bottleneck is the process that with the longest cycle time. It determines total system throughput and is the primary point for scheduling. We want to pay much attention to the bottleneck process.

4. Identify Lot Size & Setup Opportunities.

   The size of lots or batches should be a function of the setup and storage costs. The larger the setup cost, the larger the lot size. Smaller lots are desirable because the make scheduling easier, reduce inventory and enable kanban. However, they lower limit for lot sizing is determined primarily by setup cost. If setup cost and time can be reduced, it allows smaller lots and frees capacity for additional production and for scheduling flexibility.

5. Identify Potential Workcells.

   Generally, it is best to combine all processes, from start to finish, in a single workcell dedicated to the product or product family being mapped. However, several factors may limit the feasibility of this. The purpose here is not to
design the workcell but establish its feasibility. Workcells appear simple but are, in fact, complex socio-technical systems that require careful consideration of many factors.

6. Determine Kanban Locations.

In Step 6, identify likely locations for Kanban and FIFO and add the appropriate icons to the Future State Map. For the Value Stream Map, we will not attempt to identify FIFO and Kanban stockpoints (Supermarkets) within a workcell.

7. Establish Scheduling Methods.

With the basic processes, handling and inventory methods in place, we now establish the overall scheduling method(s). Some of the internal methods have been already established when we set Kanban and FIFO points.

In general, the more frequently and the more quickly scheduling information is transferred, the better the performance and the lower the inventory.


The total lead-time comes from adding all values on the timeline. The total cycle time comes from the totals of all process boxes. Compare the (nearly) complete Future State Map with the Present State Map and calculate improvements in lead-time, cycle time, inventory and productivity.


In developing the Future State Map we have made many assumptions about the changes that might be made. In several areas such as the workcell design,
kanban system design and setup opportunities, we have ignored the details of how these will be designed and implemented. Kaizen bursts indicate areas where future work is necessary to design and implement these features.

2.6 Lean Manufacturing Tools and Techniques

The 5S System

According to Tapping (2002), The 5S system is designed for organization and standardization of any workplace, including offices. It is a prerequisite to the implementation of any other improvement method. By implementing 5S, we will: teach everyone the basic principles of improvement, provide a starting place for eliminating all waste, remove many obstacles to improvement (with very little cost), and give workers control over their workplace.

The 5S system consists of five activities:

1. **Sort** – sorting through the contents of an area and removing unnecessary items.
2. **Set in Order** – arranging necessary items for easy and efficient access, and keeping them that way.
3. **Shine** – cleaning everything, keeping it clean, and using cleaning as a way to ensure that your area and equipment is maintained as it should be.
4. **Standardized** – creating guidelines for keeping the area organized, orderly, and clean, and making the standards visual and obvious.
5. **Sustain** – educating and communicating to ensure that everyone follows the 5S standards.
5S system will have a positive impact on performance that will be reflected in the following metrics: reduced total lead time, elimination of accidents, shorter changeover times, improved worker attendance, value-added activities, and more improvement ideas per worker.

**Kanban Systems**

In Japanese, *kanban* means “card”, “billboard”, or “sign”. Kanban refers to the inventory control card used in a pull system. Kanban also is used synonymously to refer to the inventory control system developed for use within the Toyota Production System (Tapping, 2002).

Kanbans are cards attached to containers that store standard lot sizes. When the inventory represented by that card is used, the card acts as a signal to indicate that more inventory is needed. In this way, inventory is provided only when needed, in the exact amounts needed (Tapping, 2002).

Kanbans manage the flow of material in and out of supermarkets, lines, and cells. In Tapping (2002), there are three types of kanban:

a. A *production kanban* is a printed card indicating the number of parts that need to be processed to replenish what customers have pulled.

b. A *withdrawal kanban* is a printed card indicating the number of parts to be removed from a supermarket and supplied downstream.
c. A *signal kanban* is a printed card indicating the number of parts that need to be produced at a batch operation to replenish what has been pulled from the supermarket downstream.

*Total Productive Maintenance (TPM)*

Preventing equipment breakdowns is good, but even better is squeezing the ultimate potential from equipment. That is the purpose of *Total Productive Maintenance (TPM)*. The ultimate potential of piece equipment depends on its unique function and operating environment, and, in particular, on how well the equipment meets requirements such as availability, efficiency, and quality. Briefly, *availability* means that equipment is in operational (working) condition when it is needed; *efficiency* means that it performs at its standard or rated speed; and *quality* means that it produces no nonconformities or defects. TPM moves beyond preventing breakdowns and includes equipment restoration and redesign. A goal of TPM is to upgrade equipment so it performs better and requires less maintenance than when it was new (Nicholas, 1998).

Equipment responsibility in TPM is spread throughout many departments such as production, engineering, and maintenance, and to a range of people, especially equipment operators and shop workers. In TPM, operators performs basic equipment repairs and PM; meanwhile, teams of maintenance staff, engineers, machinists, and operators redesign and reconfigure equipment to make it more
reliable, easier to maintain, and better performing. TPM is another never-ending facet of continuous improvement in manufacturing (Nicholas, 1998).

TPM aims for greater manufacturing competitiveness through improved equipment effectiveness. By tailoring equipment to better suit a particular production environment, and by making it better-than-new, TPM increases production capacity and process reliability and reduces the costs of lost production time, defects, repairs, shortened equipment life, and inventory (Nicholas, 1998).

**Quick Changeover (QCO)**

Increasing the variety of products flowing through the cells requires tooling changes that do not disrupt continuous flow. The means for achieving this goal is the quick changeover (QCO). Quick changeover (QCO) originates from a methodology called single-minutes exchange of die (SMED) that was developed by Shigeo Shingo at Toyota (Tapping, 2002).

Tapping (2002) stated that, SMED is a theory and set of techniques that makes it possible to set up or change over equipment in less than 10 minutes. SMED begins with a thorough analysis of current setup procedures. It is applied in three sequential stages:

a. Distinguish between *internal setup* tasks than can be performed only while the machine is shut down and *external setup* tasks than can be performed while the machine is running.
b. Convert internal tasks to external tasks when possible; improve storage and management of parts and tools to streamline external setup operations.

c. Streamline all setup activities by implementing parallel operations (dividing the work between two or more people), using functional clamping methods instead of bolts, eliminating adjustments, and mechanizing when necessary.

**Kaizen**

From an article in Wikipedia, explained that Kaizen (Japanese for "improvement") is a Japanese philosophy that focuses on continuous improvement throughout all aspects of life. By improving standardized activities and processes, Kaizen aims to eliminate waste.

Kaizen is a daily activity, the purpose of which goes beyond simple productivity improvement. It is also a process that, when done correctly, humanizes the workplace, eliminates overly hard work ("muri"), and teaches people how to perform experiments on their work using the scientific method and how to learn to spot and eliminate waste in business processes. To be most effective kaizen must operate with three principles in place:

a. Consider the process and the results (not results-only) so that actions to achieve effects are surfaced;

b. Systemic thinking of the whole process and not just that immediately in view (i.e. big picture, not solely the narrow view) in order to avoid creating problems elsewhere in the process; and
c. A learning, non-judgmental, non-blaming (because blaming is wasteful) approach and intent will allow the re-examination of the assumptions that resulted in the current process.

People at all levels of an organization can participate in kaizen, from the CEO down, as well as external stakeholders when applicable. The format for kaizen can be individual, suggestion system, small group, or large group. At Toyota, it is usually a local improvement within a workstation or local area and involves a small group in improving their own work environment and productivity. This group is often guided through the kaizen process by a line supervisor; sometimes this is the line supervisor's key role.

2.7 Basic Stability

First step in creating process that lean is reaching the elementary level of stability process. First level of stability generally defined as ability to produce the consistent result a number of minimum percentages from time. Simpler indicator is ability to fulfill requirement of customer for product with high quality at the first time punctually. In most cases, "customer requirement" not defined clearly and become one of first duty in stability step (translated from Liker & Meier, 2006).
Indicator of Instability

Translated from “The Toyota Way Fieldbook” by Liker & Meier, 2006, says, developing stability of the process is not an end from anything. Even it is more looking like creation of a foundation for the aspect of hereinafter from process lean.

Through direct observation, an unstable process distinguished by condition following:

1. High variation in performance measurement – variation in number that produced and also total production per hour labor.
2. Frequently alter the "plan" when problem happened. Including relocating labor or let an empty position when there is an absence, removing product to other machine when there is a damage (and in consequence can not produce the planned product), and stop working in the middle of process to change to other order.
3. Almost impossible to perceive the pattern or consistent work method.
4. Corps or goods heap in process (WIP) which vary - sometime a lot of, sometime a few.
5. Sequencing of operation that run independently (island process).
6. Inconsistent stream or no stream (also distinguished by heap WIP which vary).
7. Words use usually, basically, normally, generally, most of the time, when describing operation, followed with unless, like in "Normally we do this……unless……happening, hence we do this........." (According to the character, unstable operation is often not experiencing “normal” condition in
the case of consistent method. Even, abnormal circumstance becomes normal).

8. Statement like, "We trust the operator to take the decision about how work to be done" (this is part of wrong employees utilization understanding).

Stability is not just conditions from process that flows, however developing process that flow will assist to motivate the approach which discipline to stability - both of them are interconnected (translated from Liker & Meier, 2006).

**Objective of Stability**

The main objective of stability phase is creating base for consistency so that "fact" is visible and non value added activity can be eliminated, and then create the foundation for the real improvement. This include reducing variability of level customer demand (before specifying takt time, level of customer demand) and create the production process with flatten daily volume. A stable process also will have high level of flexibility and ability to fulfill demand from customer which varies (translated from Liker & Meier, 2006).

**2.8 Standardized Work: The Power of Consistency**

Standardized work is a foundational element of lean manufacturing methodologies. Without it, the gains made from organizing work cells, creating flow
production, and starting continuous improvement teams will only be temporary (cited in Krichbaum, 2008).

*Standardized Work: The Principles*

Krichbaum wrote in his white paper that, standardized work is a detailed, documented and visual system by which associates develop and follow a series of predefined process steps. It should be used whenever the work requires completing a series of tasks. Production workers, shipping departments, and warehousing teams all can benefit from implementing standardized work.

The detailed process steps which we call standardized work represent the best practices for workers to follow in the completion of their jobs. They are designed to minimize process variation introduced by the worker and to eliminate unnecessary motion. This reduces waste, eases problem solving and enhances productivity within a particular job or set of jobs.

Without standardized work, continuous improvement activities are not manageable because processes which are in a constant state of change cannot be improved. Detailed understanding of the steps needed to be taken to complete tasks is necessary to eliminate root causes and permanently resolve issues. When workers utilize various methods to complete their work, it is not possible to develop this understanding. Therefore, standardized work provides the baseline required for continuous improvement.
Like everything in lean manufacturing, standardized work is focused on what workers need to do to satisfy the customer. Unlike the routers developed by engineering, which focus on the part and how it is processed, standardized work focuses on the workers and what steps they must take to produce the part. Maintenance and improvement of the standardized work documentation is the responsibility of the work teams.

With standardized work implemented, production workers, supervisors, and engineers no longer have to work from memory. The process documentation provides a baseline, a standard which is referenced whenever someone new is trained on the job. The standard provides consistent training results even if different managers or operators are used to train new workers.

The same principles apply even when new operators are not being trained to do the work. Over time, employees will develop shortcuts to the process, sometimes developing bad habits. But with the baseline of standardized work, it becomes straightforward and easy to complete regular process audits, following up by reinstructing workers on the proper and desired techniques or perhaps institutionalizing the improvement workers have developed.

The Toyota production system includes in its standard operations three elements (cited in Pereira, 2008):

1. Takt Time: Time to produce one part or unit of production.

2. Work Sequence: The order of operations in which workers process a product.
3. **Standard Work in Process (SWIP):** The minimum necessary in process inventory (work in process or WIP) to maintain Standard Work.

Implementing standardized work is never easy. The detail requirements and information have to be uncovered, revealing questions and new concerns. Time observation is time consuming, and often an unpopular activity on the plant floor. Standardized work activities are never finished. Lean manufacturing strives, but never achieves perfection, and with every new step towards perfection, the standardized work changes. But the hard work and the constant striving to improve are worthwhile. Improved quality, productivity, safety and customer satisfaction is the reward (cited in Krichbaum, 2008).

**Summary**

This chapter identified some concepts regarding lean manufacturing such as its background, application, tools, and techniques as well as value streams, basic stability and standardized work that are important for understanding later parts of this paper.
CHAPTER III
COMPANY PROFILE

3.1 Company History

PT. Dow AgroSciences Indonesia is one of agrochemical manufacturing in Indonesia that produced pesticide products. Initially this company founded as PT. Pacific Chemicals Indonesia in August 1973 by letter approval from BKPM No. B/56/Press/5/73. In 2002 this company changes the entity name became PT. Dow AgroSciences Indonesia to represent a 100% owned by The Dow Chemical Company. Indonesia head office located at Wisma GKBI Fl. 20-Suite 2001 Jl. Jenderal Sudirman Kav. 28 Jakarta 10210.

Plant construction began in 1974 located at Jl. Sisingamangaraja Km. 9.5 Medan and commercially start production in 1975 with product name Dowpon*M and Delapon herbicides. At that time PT. Dow AgroSciences Indonesia was one of 4 Dow Company which producing Dowpon*M. Other Dow manufacturing that produce the same product located in Midland USA, King’s Lynn in UK, and Shah Alam in Malaysia. In 1997 this factory started to produce Dursban which is a very famous product in farmer’s eyes until today. Dowpon was discontinued in the year 1988 and extended portfolio introduces liquid herbicides formulation and packaging.

PT. Dow AgroSciences Indonesia is a subsidiary from The Dow Chemical Company based in USA and recognized as the biggest chemical company operate in
more than 175 countries with total sales whole over the world achieved 46 Billion USD.

PT. Dow AgroSciences Indonesia Plant Medan produce various herbicide product, those are: DMA, Starane, Tordon, Garlon, Clincher, Topshot, Penoxsulam, Goal, and for insecticide products: Dursban, Nurelle, Success, Tracer, Lorsban3E, Lorsban40EC, etc. PT. Dow AgroSciences Indonesia is one of the company in Indonesia actively contribute to increase Indonesia agriculture products from vegetables, fruits, plantation, and community health. Quality is always become priority but safety and environmental protection is given as top priority as a basic principle of Dow Operation.

3.2 Organization and Management

Organization Structure

Word organizing come from word organism or organ, with the meaning is a structure with integrated components which each component has a cross link interaction, influencing each other and influencing a whole structure. Organization chart show the relation pattern among parts of the positions, showing position, duty, authority, and different responsibility.

PT. Dow AgroSciences Indonesia is the company that more focuses on functional structure in the company organization. Dow uses a bi-layer organization, reduce hierarchy or layer of administration reporting, encourage empowered
employee in the organization aim to achieved maximum productivity and employee satisfaction.

Job Description

PT. Dow AgroSciences Indonesia Manufacturing site in Medan consist of departments that interact, influence each other and dependent each other. One unit fail to perform well will automatically impact to other department.

Job title, department and responsibility exist in the organization describe as follows:

1. Site Leader (Plant Manager)

Duties and responsibilities are:

a. Lead manufacturing team to design vision and mission, develop short and long term plant objectives to be aligned with corporate strategy.

b. Lead manufacturing team on the continuous plant improvement operation.

c. Accountable to operate safely, protect environment and maintain harmonization with social community.

d. Represent organization in country management team.

e. Responsible to coach, mentoring and developing people.

2. Plant Office Professional

Duties and responsibilities are:

a. Execute activity of company general administration

b. Assist plant manager in day to day activities
3. Manage Production

Divided become 3 sub-work groups, those are:

A. Produce to Plan Record Production Data

Duties and responsibilities are:

a. Production preparation
b. Record production data
c. Analyze production data

B. Operate Plant

Duties and responsibilities are:

a. Execute planned production
b. Ensure production run safely and meet production objectives

C. Manage Product Quality

Duties and responsibilities are:

a. Incoming quality control, analyze raw and packaging material before used.
b. In process quality control, analyze product during formulation and after filling line.
c. Outgoing quality control, ensure product leaving warehouse has met quality standard.
d. Analytical check as needed.
e. Ensure product integrity policy executed and maintain the compliance.
4. Purchasing

Duties and responsibilities are:

   a. Develop purchasing strategies to ensure gain most benefit to company from purchasing activities
   b. Develop purchase agreement with approved supplier
   c. Create and release purchase order
   d. As company interface to communicate with suppliers
   e. Addressed supplier issues as required

5. Maintain Facility

Duties and responsibilities are:

   a. Responsible for machineries and equipments preventive maintenance to ensure production line run smoothly.
   b. Responsible for plant machineries trouble shooting.

6. Supply Chain

Duties and responsibilities are:

   a. Responsible for material planning and scheduling
   b. Responsible for production planning and scheduling
   c. As focal point to interact with commercial group in balancing demand and supply
   d. Export Import-Custom Focal Point
7. Logistic

Duties and responsibilities are:

a. Managing material incoming including import
b. Responsible to optimize warehouse capacity
c. Responsible to ensure smooth material flow to production line and vice versa
d. Responsible for products distribution local or export.

8. Improve Asset Utilization

Duties and responsibilities are:

a. Responsible for analyze asset utilization and create opportunity to improve by using approved technology
b. Responsible to plan and execute capital project.

9. Environmental Health and Safety

Duties and responsibilities are:

a. Responsible to ensure all company safety standards are implemented and utilized
b. Deliver new safety regulation to other team members
c. As focal point to communicate with environmental health and safety corporate function.

Other functional group operate from head office Jakarta such as Marketing and Sales, Human Resources, Accounting and Finance, Legal and they are
independently reporting to each functional leader. As entity Dow AgroSciences Indonesia is led by President Director based in Jakarta office and eventually he is also as Commercial Leader. Medan Plant Organization Chart is shown in Figure 6.
Figure 6 Organization Structure PT. Dow AgroSciences Indonesia – Medan Plant
Labors and Company Working Hours

Dow always believes that their employees are key assets for the company. High talent workers, high quality employees will become a key contributor to company to achieve its’ objectives and helping company on it’s continue growing. That’s why it is very important for company thru people leaders to have the right employee in the right position within the right time.

In Dow organization the job family divided into 4 groups, each of job family will have different sets of competencies, they are:

1. Functional Specialist/Functional Leader (FS/FL)
2. Technician Technologist
3. Administration
4. Global Leadership

There are two types of workers in PT. Dow AgroSciences Indonesia which are permanent labors and contract workers.

1. Permanent Labors

Medan Plant has 26 Dow permanent employees that each of them plays key roles within the organization.

2. Contract Labors

For labor contract, PT. Dow AgroSciences Indonesia cooperates with PT. Sarana Persada Nusantara which is a registered labor supply company. Contract labors are mostly working in filling and formulation line and another non-core job in the plant. They are also seasonal workers that can be added or reduced base on production
activities or commercial demand that changes dependent on weather seasons.
Currently Medan Plant hired 143 contract workers and 12 persons as security guard.

Employee working hours at PT. Dow AgroSciences Indonesia divided as follows:

1. Office hours for daily employees.

   Working days from Monday – Friday 8 hour per day, with schedule as follows:
   08:00 – 12:00 : Working hours
   12:00 – 13:00 : Lunch break
   13:00 – 17:00 : Working hours

   Weekend and national holidays will consider as working overtime as applicable.

2. Office hours for shift manage employees.

   Will follow shift work arrangement will depend on production lines scenario, production may run on 2 shift or 3 shift. Department that has to follow work shift arrangement are: production, maintenance, utility, laboratory and security.

   Table 2 shows normal working hours arrangement which divided into 3 shifts.

   Company also respects praying time where the time is flexible as reasonable. Overtime charge will be given as government regulation if employee or workers work more than standard working hours or working in weekend or in national holidays.
Table 2 Arrangement of Working Hours

<table>
<thead>
<tr>
<th>Shift I</th>
<th>Shift II</th>
<th>Shift III</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>08:00 – 16:00</td>
<td>16:00 – 18:30</td>
<td>24:00 – 05:00</td>
<td>Working</td>
</tr>
<tr>
<td>12:00 – 12:30</td>
<td>18:30 – 19:00</td>
<td>05:00 – 05:30</td>
<td>Resting</td>
</tr>
<tr>
<td>13:00 – 16:00</td>
<td>19:00 – 24:00</td>
<td>05:30 – 08:00</td>
<td>Working</td>
</tr>
</tbody>
</table>

*Source: PT. Dow AgroSciences Indonesia*

Employee Benefits

Employee will have monthly salary and some variable pays from the company. The amount of salary will depend on personal level meanwhile the variable pay such as bonus, performance award, short term incentive six sigma achievement bonus will depend on criteria that have been designed by the company and level of achievement.

As referred to company policy, employee also eligible to have annual leave depend on year service to the company. Other type of leave also recognized such as maternity leave, pro-long illness leave, etc. Company provides medical services and life insurance and also supports employees to have social activities, family gathering and sports.
3.3 Production Process

Production Facilities

PT. Dow AgroSciences Indonesia Medan Plant produces herbicide and insecticide products. The production facilities also separate between those products to prevent cross contamination between insecticides and herbicides.

There are 3 lines filling for herbicides products which are:

a. Line 1: dedicated to produce DMA
b. Line 2: share facility to produce Oil Based Herbicides
c. Line 3: share facilities to produce water based herbicides

There are 3 lines filling for insecticides products which are:

a. Line 1: dedicated to produce Durban200EC
b. Line 2: share facility for water based insecticides products
c. Line 3: share facilities for oil based insecticides products

In each production process the activities is divided into formulation and packaging lines.

1. Formulation

Formulation process is a process of blending and mixing of raw materials including an active raw material. There is a standard operating procedures and recipe for each product. The recipe will give information about which materials that have to charge in, how many, how long the agitation process and what are specification target to achieve.
Equipment for formulation processes are tanks, agitator, pumps, piping and electrical panel control, etc.

2. Packaging Lines

Packaging lines is a process where products after formulation are packed into specific small container. The packaging line is start from empty bottles, filling machine, capper machine, induction sealing, labeling machine, weighing, cartonizing and palletizing.

To support formulation and packaging lines, plant also have utilities unit such as water treatment, diesel generator, compressors, nitrogen generator. Raw materials and finish products stored in dedicated warehouses.

**Raw Materials**

Materials to support formulation and filling activities supplied from local Indonesia suppliers and also imported from outside Indonesia like United States, Europe and other ASEAN countries. Materials can categorize as follow:

1. Active Raw Materials

Active raw materials are raw materials that have a very important effect to the products. Impact to efficacy or knock down of target is one of measurement of pesticides products. That’s why the pesticides manufacturer must register the active material content on each product to government thru Agriculture Department. Active material usually made in other Dow technical plant in over the world
2. Special Raw Materials

Special raw materials mean this raw material has a very specific function in the product formulation such as emulsifier, thickener or anti bacteria materials.

3. Addition Raw Materials

Addition raw materials usually only have a very small percentage in the pesticides formulation with a very small impact to product quality such as color agent.

4. Packaging

Packaging is material to pack the product in for customer use. Packaging materials are bottles, carton box, closure cap, drum, labels, etc.

Products Quality and Specification

Dursban 200EC and DMA6 are two products that very popular in market, both of them have a brand image in farmer’s eyes. To maintain brand image, it is very important for company to keep maintaining products quality.

Medan Plant has a comprehensive quality system that documented in “Plant Quality Manual Book” that must align and comply with “Operating Discipline Management System” a high level corporate direction.

All products specification comes from a very deep research and analysis. Dow AgroSciences has a research centre in Indianapolis USA to ensure Dow makes products that meet or even exceed customers expectation.
Summary

This chapter represents short profile of company where research will be conducted such as company history, organization and management, as well as production process that are important for reader to get a view of company’s environment for more understanding later parts of this paper.
CHAPTER IV
METHODOLOGY

Research Methodology is a procedure that describes clear and systematic steps to guide researcher in the process of completing the research. The procedures for this study have been chosen to meet each of the project objectives as illustrates in Figure 7.

4.1 Time and Place of the Research

This research has been conducted at PT. Dow AgroSciences Indonesia–Medan Plant, Jl. Sisingamangaraja KM. 9.5 Medan from April to October 2008.

4.2 Research Type

Type of this research is developmental research. Developmental research, as opposed to simple instructional development, has been defined as “the systematic study of designing, developing and evaluating instructional programs, processes and products that must meet the criteria of internal consistency and effectiveness” (Richey, 2004 – cited from online white paper). In its simplest form, developmental research could be either: a situation in which someone is performing instructional design, development, or evaluation activities and studying the process at the same time; or the study of the impact of someone else’s instructional design and
development efforts; or the study of the instructional design, development, and evaluation process as a whole, or of particular process components. Developmental research often serves as a vehicle for dissemination of model techniques and processes, especially as new technologies, new procedural changes, and new programmatic trends emerge. Moreover, developmental research can provide a basis for both model construction and theorizing, one which is rooted in the experiences of practitioners as well as researchers (Richey, 2004 – cited from online white paper).

Approach that used for this research is observing and mapping the current condition and develop future or ideal condition that expected. Gaps between current state and future state will be analyzed and become a goal for improvement. The main lean tool that will be used in this research is Value Stream Mapping (VSM). There are initial Value-Stream Mapping steps, as have described in Chapter II.

4.3 Data Collecting Method

Method that will be used in collecting data needed is observation to the activities that performed in the production shop floor. The researcher will go through the manufacturing facility and identified each operation process involved from raw materials to finished goods, identified all the places where inventory is stored between the processes, and observed how the material flowed from one operation to another. Researcher will use “attribute collection checklist”, pencil, eraser and stopwatch as the tool to collecting data from the field.
Another method for collecting data is direct data intake from production shop floor and internal company documentation, and pulled up data from company’s database (SAP). Researcher will also perform interview and brainstorming with production team, supply chain team, maintenance team, logistic team and purchasing team.

### 4.4 Data Processing and Analyzing Method

Data that has collected will be processed to solve the problem using Value Stream Mapping tool follow below steps:

1. **Selecting Product Family**

   The first step starts with selecting a product family. One point to understand clearly before starting the mapping is the need to focus on one product family. Identify product families from the customer end of the value stream. A family is a group of products that pass through similar processing steps and over common equipment in downstream processes.

   Data needed for this step is mainly production output of products that produced from 6 to 12 months period and all of the processes steps of each product go through. The tool to use for this is a PQPR (Product Quantity / Product Routing) matrix. This tool will help to identify which product or in some cases products to focus in on by creating Pareto Chart to see what products they made the most and pass through same process and machine.
2. Define Current-State Map

Once the value stream selected, the researcher observed and collected data related to the flow of information and material from raw material to finished goods. Beginning with the information flow, the researcher used the support from planner to collect information concerning the communication with customers and suppliers, the production controls orders and forecast from customers, the production controls orders and forecast to suppliers, the frequency of orders released to the production supervisor, and the frequency of orders released to each operation within the value stream.

In order to map the current state, researcher walked thru the floor door to door to collect data, this began with the receiving area and worked toward the shipping area. The researcher collected information about material flow, inventory between processes, and process attributes including:

1. Quantity of product required per month in work centre selected
2. Quantity of products shipped per day and per month
3. Number of shipping days per month
4. Supplier delivery schedule
5. Regular planned down time
6. Available production time (minus breaks)
7. Number of operators per process
8. Number of shifts per process
Also, the researcher collected the following individual metrics at each process involved:

1. **C/T (cycle time)**
   
   Cycle Time (C/T) in this observation refer to definition on ‘Learning to See’ book created by Mike Rother and John Shook which is how often a part or product actually is completed by a process, as timed by observation. Also, the time it takes an operator to go through all of their work elements before repeating them. The instrument used to gather it was a stopwatch to collect actual information, not standard time that company have.

2. **C/O (changeover time)**
   
   The changeover time was determined by manually timing how long it takes the operator to setup the work centre in order to make a different pack size.

3. **Available uptime (on-demand machine uptime)**
   
   The available uptime within a process is the percentage of time in which a machine or process is available on demand. This can be calculated by subtracting the changeover time from the total availability and then dividing by the total availability time.

   Once data has collected and ordered the researcher calculated daily requirements and takt time, and began to map the current state of the value stream selected. The first step was to become familiar with the value streams symbols and then start drawing the map following the steps mentioned in Chapter II. Main tools
that will be used for this step are stopwatch, pencil and direct observation sheet or blank sheet.

There are few mapping tips given in “Learning to See” book created by Mike Rother and John Shook as follow:

1. **Always collect current-state information while walking along the actual pathways of material and information flows yourself.**

2. **Begin with a quick walk along the entire door-to-door value stream,** to get a sense of the flow and sequence of processes. After the quick walk through, go back and gather information at each process.

3. **Begin at the shipping end and work upstream,** instead of starting at the receiving dock and walking downstream. This way you will begin with the processes that are linked most directly to the customer, which should set the pace for other processes further upstream.

4. **Bring your stopwatch and do not rely on standard times or information that you do not personally obtain.** Numbers in a file rarely reflect current reality. File data may reflect times when everything was running well, for example the first-time-this-year three-minute-die-change, or the once-since-the-plant-opened week when no expediting was necessary. Your ability to envision a future state depends upon personally going to where the action is and understanding and timing what is happening. (Possible exceptions to this rule are data on machine uptime, scrap/rework rates, and changeover times).
5. **Map the whole value stream yourself**, even if several people are involved. Understanding the whole flow is what value-stream mapping is about. If different people map different segments, then no one will understand the whole.

6. **Always draw by hand in pencil**. Begin your rough sketch right on the shop floor as you conduct your current-state analysis, and clean it up later-again by hand and in pencil. Resist the temptation to use a computer.

3. **Waste Identification and Reduction**

   The current state map of the processes revealed some wastes in the value stream selected. Before proceeding to the next step – mapping the future state, it is important to identify as much waste as it can in the current state map, make some analysis and propose solutions to reduce the influence of wastes.

4. **Develop Future-State Map**

   The next step is to look at current state map and analyze data resulted from it to seek opportunities to eliminate waste and improve the process flow. Information that available by mapping current state also used to define the future state that appropriate for this company. Future-state can be developed following steps and tools mentioned in Chapter II.
4.5 Model of Basic Stability – Work Standardization

By mapping current-state and develop future-state, the researcher has identified and analyzed most of wastes that found in the value stream and made suggestions and recommendations for company.

In the future-state, we can see the effective process flow that can be implemented as standard work process. Standardized work as the main goal of this research can be achieved by following future-state map that finally can help the scheduler to create most effective and accurate production schedule that can executed smoothly in production shop floor. Standardized work process resulted will be visualized as Standard Operations Sheet (SOS) for better execution in the production shop floor.

4.6 Conclusions and Recommendations

At the final phase of this research, researcher will describe conclusion of this research that relied on results from data processing and analysis at previous phase. Researcher will also give some recommendations for the company that can be followed up for plant improvement.
**BLOCK DIAGRAM - BUILDING MODEL OF BASIC STABILITY IN PRODUCTION SHOP FLOOR FOR PT. DASI USING VSM**

**Problem Identification**
- Preliminary Discussion and Investigation with DAS Management
- Problem Formulation

**Data Collecting**
- Interview with Production Planner
  - Work Centre Introduction
  - Data Forecast
  - Data of Actual Volume Produced
- Interview with Key Function
  - Production
  - Supply Chain
  - Logistic
  - Maintenance
  - Purchasing
- Study on DAS Internal Documentation
- Field Observation at Production Shop Floor

**Data Processing**
- Identify Value Stream/Product Family using PQPR Analysis
- Make Value Flow: Value Stream Mapping Method

**Data Analyzing**
- Current State Map Visualization
- Waste Identification
- Waste Reduction
- Future State Map Visualization

**Model Development**
- Standard Operations Sheet (SOS) Development – Work Standardization Model

**Research Wrap-Up**
- Conclusions and Recommendations

**Figure 7: Block Diagram of Research Methodology**
CHAPTER V
MODEL DEVELOPMENT

This chapter presents calculation, data processing and analysis of value stream. The main focus will be on the mapping current state of product family selected, identified waste and recommend solutions to reduce the influence of identified wastes. Furthermore, researcher will map draft of future state map for productivity improvement in plant.

5.1 Product Family Selecting

To select which value stream to be targeted for the practical mapping, the company must select a product family group where improvement will be focused on first. All of the products for the product family group had common production processes and the same pattern development. In order to perform this activity, researcher has collected all the list of products, actual production output for 6-12 months and all of the processes steps they go through. The tool that will be used for this step is PQPR (Product Quantity/Product Routing Matrix).

According to Tapping (2002), PQ analysis is used to display the product mix as a Pareto chart. A Pareto chart graphically demonstrates the Pareto principle – also known as the 20:80 rule – and helps separate the “critical few” from the “trivial many”. The chart shows how the total quantity of products distributed among
different types, with the assumption that the higher-volume products are the first that should be targeted for improvement.

If PQ analysis indicates a 40:60 PQ ratio, use product-routing analysis to help researcher identify target value stream. In product-routing analysis, we make a chart that shows which products or parts have similar process routes. Products that are processed through the same machines or operations in the same sequence are good candidates for grouping into product families.

Tapping (2002) also stated, “In general, when just getting started with Value Stream Management, you may not need to use PQ analysis or product-routing analysis. Another option is using a simplified version of PQ analysis”. The simplified version of PQ analysis is similar to the traditional version in that we list the products along the bottom axis of a bar graph by quantity (from greatest to least). Then we choose a selection indicator. For example, we might decide that any value stream producing a product family close to 20 percent of the total volume is a worthy candidate on which to focus improvement efforts.

Finally Tapping stated that, “However you decide to choose your target value stream, we recommend selecting one that is neither too simple nor too complex. Of course, the appropriate selection depends on your plant and on customer demand”.

Researcher starts with Product Quantity Analysis of 12 months production output. Presented in Table 3 is the list of products that produced in Dow AgroSciences Indonesia-Medan Plant since May 2007 – April 2008 for small pack only. Detail breakdown for each work centre presented in Appendix C.
Table 3 Volume Produced (12 months data for small pack only)

<table>
<thead>
<tr>
<th>#</th>
<th>LIST OF PRODUCTS</th>
<th>QUANTITY (Ltr)</th>
<th>Cumulative %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>DURSBAN200EC</td>
<td>1,110,753</td>
<td>32.80%</td>
</tr>
<tr>
<td>2</td>
<td>DMA</td>
<td>895,420</td>
<td>59.23%</td>
</tr>
<tr>
<td>3</td>
<td>GARLON</td>
<td>200,009</td>
<td>65.14%</td>
</tr>
<tr>
<td>4</td>
<td>NURELLED505EC</td>
<td>139,735</td>
<td>69.27%</td>
</tr>
<tr>
<td>5</td>
<td>CLINCHER</td>
<td>138,009</td>
<td>73.34%</td>
</tr>
<tr>
<td>6</td>
<td>PENOXSULAM</td>
<td>125,600</td>
<td>77.05%</td>
</tr>
<tr>
<td>7</td>
<td>TORDON</td>
<td>123,341</td>
<td>80.69%</td>
</tr>
<tr>
<td>8</td>
<td>LORSBAN3E</td>
<td>94,270</td>
<td>83.48%</td>
</tr>
<tr>
<td>9</td>
<td>TRACER</td>
<td>64,755</td>
<td>85.39%</td>
</tr>
<tr>
<td>10</td>
<td>GOAL2E</td>
<td>63,200</td>
<td>87.25%</td>
</tr>
<tr>
<td>11</td>
<td>LORSBAN40EC</td>
<td>57,160</td>
<td>88.94%</td>
</tr>
<tr>
<td>12</td>
<td>STARANE</td>
<td>54,001</td>
<td>90.54%</td>
</tr>
<tr>
<td>13</td>
<td>TORDON</td>
<td>51,790</td>
<td>92.06%</td>
</tr>
<tr>
<td>14</td>
<td>DURSBAN75+</td>
<td>49,261</td>
<td>93.52%</td>
</tr>
<tr>
<td>15</td>
<td>NURELLE10EC</td>
<td>43,660</td>
<td>94.81%</td>
</tr>
<tr>
<td>16</td>
<td>GOAL240EC</td>
<td>37,166</td>
<td>95.91%</td>
</tr>
<tr>
<td>17</td>
<td>GALLANTSUPER</td>
<td>27,080</td>
<td>96.70%</td>
</tr>
<tr>
<td>18</td>
<td>LATRON</td>
<td>23,985</td>
<td>97.41%</td>
</tr>
<tr>
<td>19</td>
<td>SUCCESS25SC</td>
<td>23,346</td>
<td>98.10%</td>
</tr>
<tr>
<td>20</td>
<td>PROAXIS</td>
<td>18,220</td>
<td>98.64%</td>
</tr>
<tr>
<td>21</td>
<td>DURSBAN40EC</td>
<td>17,242</td>
<td>99.15%</td>
</tr>
<tr>
<td>22</td>
<td>NURELLE10EC</td>
<td>13,596</td>
<td>99.55%</td>
</tr>
<tr>
<td>23</td>
<td>RUNNER</td>
<td>10,714</td>
<td>99.87%</td>
</tr>
<tr>
<td>24</td>
<td>INAR240F</td>
<td>2,424</td>
<td>99.94%</td>
</tr>
<tr>
<td>25</td>
<td>GF120</td>
<td>2,000</td>
<td>100.00%</td>
</tr>
<tr>
<td>26</td>
<td>METHYLSEEDOIL</td>
<td>40</td>
<td>100.00%</td>
</tr>
<tr>
<td>27</td>
<td>TOPSHOT</td>
<td>29</td>
<td>100.00%</td>
</tr>
<tr>
<td>28</td>
<td>DURSBAN (FORMULATION ONLY)</td>
<td>-</td>
<td>100.00%</td>
</tr>
<tr>
<td>29</td>
<td>BULK (FORMULATION ONLY)</td>
<td>-</td>
<td>100.00%</td>
</tr>
</tbody>
</table>

Source: PT. Dow AgroSciences Indonesia

We can then create Pareto Chart for Product Quantity Analysis based on above data, chart as presented in Figure 8.
Figure 8 Pareto Chart – Volume Products Produced in PT. DASI

Figure 8 shows, the combined quantity of 6 products (Dursban200EC, DMA, Garlon, NurelleD505EC, and Penoxsulam) together make up close to 80 percent of the total quantity produced. It’s also concludes that product to quantity ratio is approximately 20:80 (in other words, 20 percent of the product types account for 80 percent of the total quantity of products produced), we have a high volume, low-variety product mix on which we should focus value stream improvement efforts. In this analysis, we can see that the target value stream would be the processes that make products Dursban200EC, DMA, Garlon, NurelleD505EC, and Penoxsulam.

But, considering what have been expressed by Tapping, which “appropriate selection depends on your plant and on customer demand” and after several
discussions, researcher got feedbacks from plant personnel that process steps in Dursban200EC, DMA, Garlon, NurelleD505EC, and Penoxsulam production process is quite simplified already, and looking at Tracer product group we will see the opposite one, then plant personnel proposed to focus improvement using Value Stream Mapping in Tracer product group with several considerations as below:

1. Tracer product group is having high complexity on product design and production process.
2. Several processes need to be standardized and define the optimum process sequences.
3. Tracer product group is having high fluctuation in production output (based on historical data) due to execution to production schedule that not standard.
4. Tracer product group is expensive product, then, reducing waste in this line will be worth to do.

Based on feedback from manufacturing site, researcher then decided to focus the study on Tracer product group with products Tracer 100ml IDN, Tracer 250ml IDN and also Tracer120SC formulated bulk as part of the upstream process. Value Stream Mapping can now be started on this product family selected follow next step in the mapping process.
5.2 Define Current State Map

In order to map the current state, the researcher observed and collected information about material and information flow paths, process attributes, and work-in-process inventory which helped determine metrics for each process and for the entire value stream. This information enabled the researcher to develop the value stream map of the process activities and helped to understand the movement of materials and information along the value stream selected. The resulting information could be used to identify and eliminate waste in the production process and to produce a future state map by creating a vision of an ideal value flow.

Value Stream Mapping Data Set

The Product

a. Tracer120SC is water based insecticide product with high complexity in product design.

b. Research will be focused on Tracer120SC bulk formulated, Tracer120SC 100ml and 250ml that having similar product design. Also, refer to Appendix B to see a figure of product Tracer120SC 100ml and 250ml.

c. Tracer under 100ml and 250ml is produced for local customer (Indonesia) with high growth year by year.

d. Tracer produced in plant located in Medan and finish products mostly will be shipped to Jakarta warehouse and will be distributed to all cities in Indonesia.
Customer Requirements

Average demand of Tracer 100ml and 250ml is 3.799 liters per month. This is equal to 190 liter per day.

a. 2.605 liters Tracer 100ml per month. (130 liters per day).

b. 1.194 liters Tracer 250ml per month. (60 liters per day).

Detail data presents in Appendix D

Production Processes

The material flow begins at the receiving area as raw material and travels through the plant until it reaches the shipping area as finished goods. In sequential order, production steps to produce Tracer120SC are below:

1. Melting.
2. Formulation.
3. Drumming-off.
5. Re-Circulating bulk before pumping to head tank filling machine.

Dow AgroSciences Indonesia
Tracer120SC Product Family - Production Steps

Figure 9 Tracer120SC Product Family – Production Steps
Once material arrives, it is moved from receiving area to raw material shelter until needed. One of raw materials to formulate Tracer will be moved to first operation named melting right after weekly formulation schedule created and communicated by planner. As the characteristic of this material, melting process itself is a must before Tracer formulation started. Normally, melting process will take 24 hours before it can be used in formulation. After 24 hours, raw material will be unloaded from the melter, and then together with other raw materials stated in formulation batch sheet will be moved to formulation area to formulate bulk Tracer. Formulation process is having specific SOP to guide formulator to perform the task. Tracer bulk resulted from formulation will be ready to use once declared “QC PASSED” by Quality Department.

After formulated, bulk will be drumming off to 200 liter drum and then will be transferred to purging area to get purged with nitrogen. Bulk in 200 liter drums then will be moved to bulk shelter and stored until further needed. Once weekly filling schedule released by planner to produced Tracer 100ml and 250ml, bulk that has stored in shelter area will be moved to filling area. Sometimes bulk already kept for several days in the shelter area, then another re-circulating process to the bulk is required to ensure the appearance of the bulk is within quality specification. After re-circulated, bulk will be transferred to head tank filling machine for filling purpose. In filling line itself, there are several activities conducted to produce finish products. Finish products produced per shift will be transferred and handed over from
production operator to logistic operator and stored in warehouse until shipment schedule available.

From discussion between researcher and plant personnel, understand that, drumming off process is the only way that plant have currently to transfer Tracer bulk to filling line. Purging and re-circulating bulk are performed to prevent bacterial issue and to maintain appearance of bulk that tend to create separation as the characteristic of Tracer bulk if keep in long period. Plant personnel said that those production steps are avoidable if bulk formulated can be consumed no later than one day and Tracer bulk can directly transfer to filling line. In the process of value stream mapping, this concerns will be one of points that researcher will be focused on.

Another point that researcher need to highlight about current production process that, each production steps has their own specific SOP (Standard Operating Procedures), but only listing detail steps that operator must follow while performing their task. SOP does not direct operator with detail “time” allocated to perform each step. This concern also one of the reasons that lead researcher to study about work standardization and seek most suitable recommendation that can implement in Medan Plant.

Work Time
a. Twenty (20) days in a month.
b. Three shifts operation in all production departments.
c. Eight (8) hours every shift, with overtime if necessary.
d. One time break for 75 minutes during each shift.

(45 minutes for lunch, 30 minutes for hand over)

Production processes stop during breaks, except Melting process.

**Master Scheduler and Production Planner Department**

a. All communications with customer and supplier are electronic.

b. Receives 30/60/90-day forecasts from commercial thru MRP.

c. Replenishment orders placed thru MRP with 14-30 days lead time to support customer order in warehouse level, placing on weekly basis by country Distribution Resource Planner to support WFC target.

d. Issues 30/90-day forecasts to vendor via MRP, email, phone, fax and PARS.

e. Issues material order to vendor based on lead time set on MRP. Mostly monthly firm orders.

f. Master Production Schedule (MPS) creates on weekly basis via MRP for production shop floor execution and having alignment between product readiness and shipment schedule issued by logistic coordinator.

g. Issue weekly shipping schedule to warehouse department.

**Supplier Information**

Dow AgroSciences Indonesia has internal and external suppliers with lead time vary from 60 days to 14 days.
Tracer Process Attributes

Melting

a. Cycle time = 24 hours

b. Changeover = 1800 seconds

   1) Melter changeover (from last usage) = 900 seconds

   2) Material and dedicate container and pallet preparation = 900 seconds

c. Availability = 24 hours = 1440 minutes = 86400 seconds per shift

d. Uptime = (available time – change over time)/available time = 97.92%

e. Working in 3 shifts

f. WIP between Melting and Formulation observed = 0 day

g. Operator = 2 workers

Formulation

a. Cycle time = 10 hours 30 minutes

b. Changeover = 4200 seconds (detail task captured in SOP, including formulation
   tank preparation and changeover, material preparation and safety tools
   preparation)

c. Availability = 24300 seconds per shift

d. Uptime = 82.72%

e. Working in 3 shifts

f. WIP between Formulation and Drumming-Off observed = 14.74 days

g. Operator = 2 workers
Drumming-off

a. Cycle time = 1 hour

b. Changeover = 2100 seconds (for 1400 liter Tracer bulk)

   1) Drum request and transferring = 600 seconds

   2) Drum rinsing with chlorine dilution = 1500 seconds

c. Availability = 24300 seconds per shift

d. Uptime = 91.36%

e. Working in 3 shifts

f. WIP between Drumming-Off and Purging observed = 14.74 days

g. Operator = 2 workers

Purging

a. Cycle time = 35 minutes

b. Changeover = 600 seconds

   1) Product (bulk in drum) transferring to nitrogen purging area = 300 seconds

   2) Setting purging hose = 300 seconds

c. Availability = 24300 seconds per shift

d. Uptime = 97.53%

e. Working in 3 shifts

f. WIP between Purging and Re-Circulating observed = 14.74 days

g. Operator = 2 workers
Re-Circulating before pumping bulk to Head Tank Filling Machine

a. Cycle time = 12 minutes
b. Changeover = none
c. Availability = 24300 seconds per shift
d. Uptime = 100%
e. Working in 3 shifts
f. WIP between Re-Circulating and Filling observed = 5.26 days
g. Operator = 1 worker

Filling

a. Cycle time = 420 seconds (per bottle) = 7 minutes
b. Changeover = 7800 seconds
   1) Setting F/M from previous pack size = 7200 seconds
   2) Packaging preparation and transferring = 600 seconds
c. Availability = 24300 seconds per shift
d. Uptime = 67.9%
e. Working in 3 shifts
f. WIP between production and warehouse observed = 5.23 days
g. Operator = 11 workers
Warehouse Department

a. Receive shipment schedule from logistic coordinator that has booked with shipped out schedule twice a week.

b. Removes from finished-goods from production department to warehouse area and stages them for vessel shipment to customer.

c. Inform customer on detail shipment information three days before ETD at Belawan port.

Supplier Information

a. Dow AgroSciences Indonesia has internal and external suppliers

b. Order released and communicated via email, phone, fax and system called PARS (Purchasing Automatic Releasing System)

Current State Map

In the next page, Figure 10, researcher present current state map for product family Tracer120SC using data collected above following guidelines from book titled “Learning to See: Value-Stream Mapping to Create Value and Eliminate Muda” by Rother M. & Shook J. (2003).
Figure 10 Current State Map for Tracer120SC Product Family
**Current State Map Analysis**

From the current state map, we can see the Total Production Lead Time is 124.11 days. We consider a day as the net working day, which has 6.75 working hours. Total Processing Time of the current process that implemented in the plant is 2184 minutes, that is, the value added time. Thus the difference between total production lead time and the total processing time is 118.72 days. It means that it takes only 5.39 working days (2184 min) to produce 190 liters of Tracer120SC product family. In other words, the value added time is 5.39 days and the non-value added time is 124.11 days. Figure 11 shows the value added and non-value added time expressed in percentage.

![Value added vs. Non value added activities](image)

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**Figure 11 Value Added vs. Non-Value Added Time in the Current State of Value Stream Mapping**
The value added activities amount to 4.16% and the non-value added activities amount to 95.84%, see Figure 11. Thus, there are quite many resources spent to the non-value added activities, while only a small part of activities adds value to the products. The non-value added activities also involve the necessary but non-value added activities.

5.3 Identification and Analysis of Wastes in the Flow of Tracer120SC

The current state map of the processes revealed some wastes in the flow of Tracer120SC product family. It was found that the total product cycle time for the value stream was 2184 minutes, however, the total lead time, which is the time to make a raw material into a finished product, was 124.11 days. This indicates that there is much opportunity for improvement.

We identified the wastes of Tracer product family flow by visualizing the current state map and analyzing wastes. In the process of Value Stream Mapping the following methods were applied: interviews with Dow AgroSciences Indonesia (DASI) management, interviews with DASI key partners, study of DASI internal documentation and direct observations in the production area and warehouse. As the result of application of the mentioned methodology, we were able to identify the following wastes: 1) overproduction, 2) waiting, 3) transportation, 4) over processing, 5) inventory, 6) movements, and 7) defects.
5.3.1. Overproduction

Waste of overproducing means producing components that are neither intended for stock nor planned for sale immediately (Tapping, 2002).

Overproduction is the production or acquisition of items before they are actually required. Overproduction is highly costly to a manufacturing plant because it prohibits the smooth flow of materials and actually degrades quality and productivity (DAS Training Material, 2008).

Waste of overproducing occurs in WBI filling line. Observer found there was some volume produced over than targeted, and that only realized after filling activity done. With tight allocation of raw material to produce Tracer120SC product, overproduction is not acceptable especially when specific pack size already determined in the beginning of the month. Overproduced quantity normally will be stored in production room until further notification by production planner.

Filling activity was done in semi automatic filling line, human still the biggest contribution in the filling activity. Overproduction might happen due to miss counting of physical finish products that has produced and only realized after filling line stopped and filling activity done.

5.3.2. Waiting

Waste of waiting refers to the idle time between operations (Tapping, 2002).

Waiting is whenever goods are not moving or being processed or whenever searching occurs, the waste of waiting occurs. Unlike waste of overproduction, waste
of waiting is easy to identify. It takes many forms, including waiting for orders, parts, materials, items from preceding processes, or for equipment repairs (Nicholas, 1998, p. 79).

Waiting for the SOP (Standard Operating Procedure) to be prepared

The waste of waiting occurs when key operator of formulation and filling line waiting for the procedure to be printed out in the production room. Before starting any tasks in the formulation and filling line, the operator must hold the SOP in their hand. SOP is critical procedure that they must follow to execute any task. SOP always printed out in the operator room by production shift leader. Once they have production schedule to execute Tracer products, operator have to go to operator room and ask for the shift leader to print out the SOP. This activity is taking time longer that it should be due to shift leader sometimes in the middle of something and operator must wait until shift leader available. Usually, operator will just stand behind the printer or sit waiting in the production room for the SOP to be prepared.

Waiting for raw and packaging material to be transferred to production line

Waiting occurs in the production line while production operator waiting for raw and packaging material that need to be processed transferred from logistic department to production line. Raw material and packaging material is stored in logistic area and only authorized logistic operators who get access and responsible to transfer material to production line.
Production operator normally will give the request form of raw material and packaging material that has to be processed to produce Tracer120SC finish products to logistic operator. Logistic operator need some times to prepare the material, match the material code with physical material, count the quantity to be matched with the request and then transfer it to production line using forklift. Those detail activity took time, and while logistic operator perform those activities, some of production manpower will only wait in their line waiting for the material to be proceed. Activity like making carton box, labeling bottle, making case print, will only be able to perform if material already transferred to production line.

Waiting for Start-up equipment

Waiting occurs in filling and formulation line, while key operator starting up the machine together with maintenance operator, other workers just waits for the line to be ready to be run. From the observation, setting filling machine itself could take approximately 2 hours and take 1 hour in formulation line before ready to run normal. But the speed of the process could be different depends on the skills of each operator.

The reason for waste of waiting due to not every workers are able to perform all key activities, only trained operator could set up the machine, in other words, there is lack of cross-skilled workers who can perform some of activities by himself instead of waiting for other worker. The workers that already allocated in one line are also tend to just do or execute work that has instructed by their shift leader, rather than initiate to do something that useful while machine is setting up.
5.3.3. **Transportation**

*Waste of transport means moving material more than necessary* (Tapping, 2002).

*Transportation of product between processes is a cost incursion that adds no value to the product. Excessive movement and handling can cause damage and are an opportunity for quality to deteriorate.*

Observer found that raw material transferred from shelter area where the material kept to formulation area using forklift, after used for formulation, partial raw material will transfer back to shelter area for further store. Same with semi finish product (bulk), after formulated, bulk would be stored in the drums and transfer back to shelter area before one day will be used in filling line. There is waste transportation also during purging process. Once bulk drumming off to 200 liter drum in formulation area, those drums will be transferred to purging area using forklift. The transportation of raw material from warehouse to production area, observer consider as necessary but non-value added activity that can be eliminated, mostly due to poor layout.

5.3.4. **Over-processing**

*Waste of processing is doing more to the product than necessary and the customer is willing to pay* (Tapping, 2002).

*Over-processing is using a more expensive or otherwise valuable resource than is needed for the task or adding features that are designed in but unneeded by*
the customer. Putting more work or effort in a product than is required by the customer is also over processing.

During observation, found that waste of over-processing occur in formulation and filling line, some of them as below:

1. Drumming-off Tracer bulk after formulated even though bulk will be consumed in the same day after formulated.

2. Re-circulation bulk in drum before pumping to head filling machine. This could happen due to bulk already stored in the drum for awhile after formulated until finally using in the filling line. Operator said this circulation required to prevent sedimentation in the drum since already kept for days before using in filling line.

3. Re-weighing net weight of bottle even though equipment already facilitate with technology to set net weight desired. This inspection also must be done to prevent customer complaint if plant delivers product that has volume less than net weight desired.

4. Re-purging partial bulk that not consumed completely in filling line before stored in warehouse.

5. Too many bulk transferring activities during filling process. From observation found that Tracer120SC bulk experienced at least three (3) times transferring,
   a. From drum to pail, due to hand pump can’t pumping small volume of bulk that still left in the drum, bulk must be transfer to open pail.
   b. From pail to drum, small volume of bulk in pail from previous drum then must be transferred again to another full drum of bulk.
c. From drum to head tank filling machine, this process must be done before filling process continue.

5.3.5. Inventory

Waste of inventory is excess of stock from raw materials to finished goods (Tapping, 2002).

Inventory, also known as Work in Progress (WIP), is a direct result of overproduction and waiting. Excess inventory tends to hide problems on the plant floor, which must be identified and resolved in order to improve operating performance. Excess inventory can increase lead times. This large excess inventory is a result of over production. Excess inventory incurs added costs in handling and storage, as well as an increased likelihood of obsolete (or out-of-date) inventory. From the customer’s point of view inventory is non-value added.

From the current state conditions obviously it is seen there is an excess inventory in raw material and finish products between processes. Excess inventory in raw material is mostly due to MOQ (minimum order quantity) that agreed between Purchasing and Suppliers. High inventory of finish products between processes is due to batch sizes of production that implemented as the result of equipment capability to process products.

Raw material purchased from Internal DOW Plant in US with lead time 2 months and MOQ 3000 liter equal to 61.92 days inventory, this is the basic reason of high inventory in warehouse. Moreover, another reason for unnecessary of raw
material is the policy of safety stock level which is set based on customer requirement trends and lead time to get the material to support high seasons demand.

Batch size that requested by planner also gives contribution to high WIP inventory. During research, found that mostly planner ask 1400 liter bulk to be formulated, which is equal to 7.36 days inventory. Finish products that need to be produced also higher than daily customer demand and creating high WIP inventory, this is mostly due to planner intent to optimize volume produced in time available in one shift.

5.3.6. Motion

Waste of motion means any motion that is not necessary to the completion of an operation (Tapping, 2002).

Excess motion is the waste related to ergonomics and is seen in all instances of excess bending, stretching, walking, lifting, and reaching. Excess motion can be caused by poorly laid-out facilities.

Unnecessary motion in pumping raw material into formulation tank

Researcher found that worker performs motion that necessary to the job but should be eliminated. Worker in formulation line always need to push and pull the full and empty drum using their hand in roller conveyor during formulation. Worker also has to bringing raw material about 12 kg and 18 kg manually to second floor using stairs to formulate in specific tank before finally pumping to main tank to
formulate Tracer120SC. Those activities if perform for several times in sequence can cause back pain and other ergonomics issues.

*Unnecessary motion in checking the raw material*

From observation, researcher noticed that formulator need to walk from one area to another area for several times. The identified reasons mostly due to poor plant lay out. Detail wastes of motion that observer found are:

1. Firstly, formulator needs to walk to production room to get instruction and batch sheet to formulate Tracer120SC by production shift leader.
2. After got formulation batch sheet, formulator must walk to logistic department to give the batch sheet to logistic operator to prepare the materials in formulation area. Specific to main raw material to formulate Tracer120SC, formulator need to get the lot number that stated by supplier in the drum’s label.
3. Then, once formulator got the lot number of the main raw material, formulator need to walk back to production room and give the lot number to production shift leader for further check on quality specification like active ingredient and specific gravity of raw material that required to making final batch sheet formulation. Once final formulation batch sheet made, formulator need to walk back to formulation area to start formulation of Tracer120SC.
Unnecessary motion in the production process

In addition, researcher identified the waste of unnecessary movement of workers during production process. Each working area actually is equipped with set of tools. While the work in progress, or during setting up the machine, operator often walk from one area to another looking for the tool that he needs. It happens that tool is missing or using by another work group and the worker need to find it or take it form the other working area. This implies the waste of motion.

5.3.7. Defects

Waste of defects and spoilage is defective parts that are produced and need to be reworked (Tapping, 2002).

We identified the waste of defects in filling line of Tracer120SC product family and created relatively big scrap of packaging material. Defects occur in induction seal burner equipment, during observation, found that operator has to perform random inspection to ensure performance of induction seal is within specification to prevent leaking product from the cap. If the induction seal not burnt properly, operator must rewind the process, by clean up the bottle first, put the new cap and re-burn the induction seal. Damaged cap and induction seal, by the end of the filling activity will be scrapped and written off from the inventory or adjusted to production order and created bigger consumption than BOM proposed.

In the current state conditions, inspections play an important role due to the high loss that could occur if an entire batch would be missed. Even this activity is
essential but created a lot of waste during the process. If an unconformity was not
detected the entire batch could receive many hours of processing before mistake is
caught. For defective items that must be scrapped, all of the labor, material, and
resource expense of producing them are wasted. Defects in products hold up
production and increase production lead times.

5.4 Solutions to Reduce the Wastes and Their Influences

In this chapter researcher propose the ways to eliminate or reduce the
identified waste in the flow of Tracer120SC product family. A draft of future state
map will be created to suggest solutions to the inefficiencies that have been identified
in the current state map. In order to improve the entire production process for the
value stream selected, the researcher made the following recommendations.

5.4.1 Overproduction

Standard operations sheets could be used for the line’s operator to eliminate
unnecessary inventory due to overproduction and to eliminate accidents and defective
production. These sheets measure all three elements (cycle time, a standard operation
routine, and a standard amount of work-in-process) every certain period of time.
Digital display panels are another recommendation which would normally be used to
show the pace of production (Takt time), the day of production and the number of
units that has been produced during the day. This would inform every person at the
plant about exactly at what rate they must be working in order to satisfy customer
demand. Standardized work provides a basis for consistently high levels of productivity, quality and safety (Tapping, 2002).

### 5.4.2 Waiting

**Waiting for the SOP (Standard Operating Procedure) to be prepared**

Researcher propose to have SOP printed out by local printer vendor as standard form that put in the formulation or filling area rather than printing out one by one in the production office by shift leader. We can safe significant number of time rather than to wait SOP to be printed out in production room. Researcher also propose to review the SOP again to be more practical while still maintaining the EH&S aspects of company.

**Waiting for raw and packaging material to be transferred to production line**

Waiting for raw and packaging material to be transferred to production line can be reduced by utilizing Kanban systems. As mentioned, a Kanban is a tool to achieve just-in-time. It consists of a card containing all the information that is required to be done on a product at each stage along its path to completion and which parts are needed at subsequent processes. By the utilization of this tool the parts can be moved quickly from one work center to another, improving the material flow and reducing the work-in-process between processes.
**Waiting for Start-up equipment**

Cross-training of workers needs to be utilized to reduce waste of waiting due to lack of cross-skilled workers. Cross-training is helping to balance load in workstations and improve product flow, eliminating the problem of poor worker utilization. Cross-train workers would allow them to contribute to most operations in order to achieve the continuous flow in the workshop.

In order to reduce setting and change-over time at the filling and formulation line, the researcher suggested the application of quick changeover (QCO) method. QCO originates from methodology called single-minute exchange of die (SMED) that was developed by Shigeo Shingo at Toyota (Tapping, 2002). SMED is theory and set of techniques that makes it possible to set up or change over equipment in less than 10 minutes. The systematic process includes analyzing a changeover, then applying quick changeover techniques and strategies to reduce the machine and/or line downtime. Some examples that could be utilized in this situation include:

a. Setting tools close to the work center, reducing the time that the operator spends looking for the tools.

b. Standardization of the setup operations, so each operator must perform the setup in the same way and must run the work center similarly.

c. Establishing a standard time to perform a setup. By this approach every operator must perform the setup of the work center in the same period of time.

d. Setting clocks at each work center in order to determine how much time an operator is spending to set it up would be beneficial.
5.4.3 Transportation

To reduce waste of transportation, researcher suggest to re-locate the warehouse that store raw/packaging material and other facility (like purging facility) next to formulation and filling area to shorten the time needed to transfer and processing material. Thereby, not only waste of transportation would be reduced but also the waste of motion and waiting.

5.4.4 Over-processing

Waste of over-processing that has identified mostly can be resolved by installing direct line from Tracer120SC tank formulation to head tank filling line. This action can reduce waste of over-processing number 1, 2, 4 and 5 that already identified previously. Direct line from formulation tank to head tank filling machine can reduce lead time around 34.74 days as it will reduce drumming-off, purging and re-circulating process.

Re-weighing activity is also over-processing and one of the root causes is the reliability of equipment. Researcher suggested the implementation of total productive maintenance (TPM), which is a process to increase the efficiency as well the useful life of the equipment involved. Basic element of total productive maintenance is autonomous maintenance or employee involvement, so each operator must take care of the work center he or she operates, maintain it, and report any damage as it occurs. Autonomous maintenance focuses on maintaining optimal conditions to prevent
equipment-related losses such as breakdowns, speed losses, accuracy, and quality defects by addressing the abnormal conditions that lead to such losses.

5.4.5 Inventory

In order to reduce waste of inventory, researcher suggests to reducing batch size into minimum batch size of formulation tank when planner creating production schedule. Maximum lot size of formulation tank is 1400 liter which equal to 7.36 days of inventory, and minimum lot size where formulation tank still able to formulate Tracer120SC is 900 liter which equal to 4.73 days of inventory. Minimum tank lot size actually still creating WIP and not meeting daily customer demand, but from the tank specification, researcher understood that we can’t do too much to reduce it as it’s part of the rule to perform work while still maintaining EH&S and Quality aspects.

To reduce waste of inventory due to MOQ that stated in MRP system, researcher propose for purchasing to approach supplier, if possible, to reduce the MOQ, shorten the lead time and implement VMI model. Thereby, the safety stock would also be lowered and production processes will be more efficient.

5.4.6 Motion

*Unnecessary motion in pumping raw material into formulation tank*

In order to reduce motion in pumping raw material, researcher suggest to install chain conveyor then unnecessary movement push and pull of full and empty
drums can be eliminated. And to reduce unnecessary movement to bringing material to second floor manually, researcher suggested installing bucket elevator which can be used for vertical lifting of non-critical and non-sticky solids.

**Unnecessary motion in checking the raw material**

The suggestion to reduce unnecessary motion in checking raw material prior to formulation will be plant re-locate out. Researcher thought would be beneficial if production room re-locate closer to the formulation area and logistic can tighten their FIFO process and maintain online database that capture detail information like lot number of technical, then walking back and forward logistic department and production department can be reduced.

**Unnecessary motion in the production process**

Researcher identified the unnecessary motion of workers in their working area. As mentioned previously, each working area is equipped with a set of tools required in production process. The unnecessary motion occurs when a worker has to search the missing tools. Researcher suggests making standardization of workstations and arranging them in the way that a worker can easily find what they needs to perform a task. System called ‘5S’ is worth to implement in this situation. The 5S system is designed for organization and standardization of any workplace, including offices (Tapping, 2002). By implementing 5S, it will give workers control over their workplace.
5.4.7 Defects

In order to reduce waste of defects, suggest to conducting deepest analysis to find the real root cause. If the root cause related to quality of cap and induction seal, suggest to involving quality and purchasing department to figure out the best specification and ask supplier to improve the performance. If the root cause related to reliability of equipment, same with waste of over-processing, researcher suggest to implementing total productive maintenance (TPM) to increase the efficiency as well as the useful life of the equipment involved. If those issues resolved, not only defect products and reworking process can be reduced but also inventory of cap and induction seal can be reduced since planner do not have to allocated so many quantity for scrap packaging due to damaged in production process.

5.5 Develop Draft of Future State Map

Having visualized the current state map, identified the wastes and associated problems, some of the necessary changes in the value stream of Tracer120SC product family were outlined in the draft of the future state map, as shown in Figure 13.

In the beginning of the value stream, researcher propose to purchase material only according to MOQ set, while still continue analyzing possibility to reduce MOQ and safety stock set in the plant. By reducing MOQ, we can reduce lead time about 7.48 days from the current state. We also propose to start analyze possibility of VMI (Vendor Managed Inventory) implementation, the concept in purchasing where vendor keep inventory or consignment for us in their warehouse according to our
monthly or weekly consumption. Material will only bring in to the plant while production planner ready to release production order to the shop floor. By this concept we can tremendously reduce WIP in the warehouse.

In the effort to reduce waste of motion in checking raw material, researcher suggest to implement FIFO and online database of material and lot number that can tell every one which lot number that will be processes next. FIFO will also enables to shorten lead times and aids in the continuous flow of the components through the process.

Next significant changes we propose that can reduce most of the waste is eliminating process drumming off, purging and re-circulating bulk by installing direct line from formulation tank to head tank filling machine. Installing direct line means lead time can be reduced around 34.74 days and also will improve the process flow of Tracer120SC product.

With current facility that Medan Plant have, which each equipment have their own minimum lot size to process product, supermarket model or pull system can not really be implemented. But plant still able to reduce WIP between processes and reduce lead time by only formulate and pack finish product according to minimum lot size which is 900 liter and equal to 4.73 days lead time.

Another proposal to reduce lead time is to start implement QCO, TPM, 5S, and Standardize work which already shortly describe previously. By implementing those methods, most of waste that already identified can be reduced or eliminated
from the process and in the end will help to shorten lead time and eliminate non value added activities.
Figure 12 Transforming Current State Map to Future State Map for Tracer120SC Product Family

Note: Production processes in the box with dash line are the process that researcher proposes to be eliminated in the future state by installing direct line from formulation tank to head tank filling machine.
Figure 13 Draft of Future State Map for Tracer120SC Product Family
Summary of changes introduced in the future state map

In summary, we can reduce production lead time by 52.73 days by implementing some proposal which has explained previously. We condensate the proposed changes in the draft of future state map, as follows:

1. Purchase raw materials only according to MOQ, while continuously reviewing possibility to reduce MOQ. By this action we can reduce lead time about 7.48 days from the current state map.

2. Installing direct line from formulation tank to head tank filling machine. By this action we can eliminate process drumming off, purging and re-circulating bulk, which has explained previously these processes are avoidable. Installing direct line means lead time can be reduced by 34.74 days in total (14.74 days lead time between drumming off and purging, 14.74 days lead time between purging and re-circulating and 5.26 days lead time between re-circulating and filling).

3. Formulate only according to minimum lot size which is 900 liters, we can reduce lead time between formulation and filling about 10.01 days (from 14.74 days to 4.73 days lead time).

4. Producing only according to minimum lot size 900 liters, will also reduce lead time between filling and warehouse about 0.5 day (from 5.23 days reduced to 4.73 days).
Summary

Current state and future state map resulted in this chapter has revealed some wastes in production shop floor and gave proposal to reduce it. Future state map will lead researcher to the objective of this research which is work standardization for productivity improvement in PT. Dow AgroSciences. Detail model of work standardization will discuss in Chapter VI.
6.1 Model of Basic Stability – Work Standardization

Standardized work is an agreed-upon set of work procedures that establish the best method and sequence for each manufacturing and assembly process (Tapping, 2002).

Standard operations are fundamental to the process of continuous improvement. What organizations fail to realize is that without good standards it is difficult or impossible to achieve high production efficiency, to match production output with demand, to keep WIP inventories small, or to improve quality (Nicholas, 1998).

A benefit of putting standards development at the shop-floor level is that whenever changes in operations occur, the standards can be revised immediately. Otherwise, the revision must wait until a staff person gets around to it. Further, creating up-to-date standards permits staff planners to prepare master schedules that are feasible and that reflect shop-floor status and current capabilities. Standard operations also make it is easier to identify safety hazards and procedures that lead to or permit defects and then to modify them (Nicholas, 1998).

In a flexible factory, workers are rotated among jobs and responsibilities, depending on product demand. Posted standard operations, located where workers
can easily reference them, enable workers to quickly become familiar with the standards and procedures of their new work assignments. They also make it easy for workers and supervisors to periodically check actual work against the standards, which corrects backsliding and prevents workers from falling into bad habits.

The principal focus of this chapter is on the developing standard operations sheet as a model of work standardization in production shop floor by using VSM methodology. The starting point for setting standard operations is to determine the required cycle time or in VSM we call it as takt time. That’s because the quantity of something to be produced should be based upon a production output goal, and that goal is best stated in terms of the frequency that an item must be produced in the allocated time – the required cycle time or takt time. Once the required cycle time is set, operations are planned so that the timing of production output is as close as possible to that time.

In determining cycle time or takt time, no allowance should be made for waste in the process. The daily time available should not be reduced to allow for equipment breakdowns, idle time, or rework, and the required daily quantity should not be increased to allow for defective items. When the takt time includes allowances for waste, as it often does, the source of waste are never addressed or eliminated. When no allowances is made for source of waste, attention is drawn to them and they are remedied (Tapping, 2002).

Current state and future state that researcher has identified in the previous chapter is in the effort to eliminate waste, and then the takt time hopefully can be
achieved successfully in each shift. Producing to takt means synchronizing the pace of production with the pace of sales. Takt time must be followed by each production team in the effort to produce standard output in each shift as the objective of this research.

Based on data collected in the previous chapter, takt time for Tracer120SC product family can be calculated as below:

\[
Takt Time (TT) = \frac{Available \ production \ time}{Total \ daily \ quantity \ required}
\]

\[
= \frac{24300 \text{ sec}}{190 \text{ liter per day}}
\]

\[
= 127.89 \text{ sec per liter} \approx 128 \text{ sec per liter}
\]

Means, in order to achieve standard output in each shift, production crew have to produce one liter of Tracer120SC in 128 seconds.

Next step we must determine the standard quantity of work in process (WIP). WIP is the minimum in-process inventory necessary for the process to function. It consists solely of the items being processed at each operation and any items held between operations. Ordinarily it is the minimum quantity of material necessary to achieve smooth flow of work, although that quantity will vary depending on the type of machine or workstation lay out. As explained in previous chapter, the minimum lot size of the formulation tank is 900 liter, and this becomes the number of WIP that we will put in the Standard Operations Sheet.
Part of establishing the Standard Operations Sheet is establishing the process routing sequence as the order in which operations must be performed to make a part or product, that is, the route a product must follow from workstation to workstation (Nicholas, 1998).

Future state that has developed in the previous chapter, researcher consider as representation of effective process sequence which every worker should refer to when performing their task since already eliminated some of identified wastes and can be used in Standard Operations Sheet. Figure 14 is Standard Operations Sheet (SOS) that developed based on future state map that present sequence of operations within process, including operation takt time (cycle times), WIP and number of operator for each process.

Standard Operations Sheet (SOS) should be displayed at each operation and at each sequence of operations so workers can readily refer to them. According to Nicholas (1998), the SOS sheet is an important tool for three areas of visual management:

1. It serves as a guide to inform each worker about the Standard Operations Routine (SOR), completion times, and other important aspects of the operation.

2. It helps the supervisor assess whether the operations are being done according to standards.

3. It serves as a tool to evaluate performance and improvement.

The SOS sheet is always dated to indicate when the last revision occurred.
Figure 14 Model of Work Standardization for Tracer120SC Product Family
Nicholas (1998) stated that, standard operations are the work procedures, sequence of tasks, and times prescribed for production of a unit of output. They are developed in large measure by suitably trained shop-floor supervisors and workers, with assistance from planners and engineers. Putting responsibility for standards development at the shop-floor level results in standards that are more accurate, current, and accepted by workers.

According to Nicholas (1998), standard operations serve vital functions in competitive manufacturing. They are essential for communicating and training standard times and procedures, and they provide planners and schedulers with accurate, up-to-date information about cycle times and operations capacity. With standard operations, production plans and master schedules are more realistic and likely to meet production goals. They provide an important contribution in efforts to put planning and control responsibility back on the shop floor.

Nicholas (1998) also stated, the SOS should be revised regularly, since, says Monden, standard operations “are always imperfect and operations improvements are always required in a process”. Standard operations should never be considered fixed. They must adapted to reflect changing demand, worker skills, etc., and ongoing improvements in the process. Even after they have been adapted to the situation, they should be continually scrutinized for places where the process can be tightened up to improve efficiency, reduce cost, and improve quality.
In broader view, researcher is presenting Appendix H to understand the usage and linkage between Model of Basic Stability with Supply Chain and Manufacturing Operations.

### 6.2 Implementing Standardized Work

Standardized work provides a basis for consistently high levels of productivity, quality, and safety. Employees develop kaizen ideas to continually improve these three areas. Even though in this paper will not further research and discuss how to implement standardized work, according to Tapping, here are some guidelines for implementing standardized work:

a. Work together with operators to determine the most efficient work methods and ensure that consensus is attained. This may include reviewing the proposed set of revised work elements with entire group that will be using them. Do not surprise people by unilaterally imposing new standards and procedures.

b. Use the Standard Work Combination Sheet to understand how process cycle time compares with takt time. This document displays the material and human workflow for a process. It specifies the exact time for each sequence within an operation, including walk time. If cycle time is longer than takt time, operation can be “kaizened” (improved) to meet takt. This may include allocating some of the work elements into an operation that cycle faster than takt.

Standard Work Combination Sheet will not further discuss in this paper, another specific time study required in order to develop it.
c. Adhere to takt time, a critical unit of measurement for standardized work. Do not attempt to accommodate changes in takt time by making substantial changes in individual workloads. When takt time decreases, streamline the work and add employees as necessary. When takt time increases, assign fewer employees to the process.

**Summary**

This chapter proposed model of work standardization as standard operations sheet that represent process sequence, takt time, WIP and number of operator that each shift should be followed in order to produce product according to takt time. This chapter also discussed shortly some guidelines to implement standardized work that valuable for another researcher.
CHAPTER VII
CONCLUSIONS AND RECOMMENDATIONS

The purpose of this study was to develop a model of work standardization for Tracer120SC product family in PT. Dow AgroSciences Indonesia using Value Stream Mapping (VSM) tool. VSM allows company to define current state and develop future state of their production process. A current state map was created and analyzed for potential areas of improvement. Future state map that developed reduce most of wastes and will be used as basic to develop model of work standardization.

7.1 Conclusions

From data collected and analysis made, researcher concludes some points as below:

a. Work standardization is one of basic stability elements that can be achieved by defining and analyzing current state of the process and developing and analyzing future state by using value stream mapping tool.

b. Value stream mapping is an effective tool to suggest ways to reduce lead times, identify some wastes in production shop floor, recommend ways to eliminate them and provide basic information to develop model of work standardization in manufacturing process including effective process sequence and takt time required.
c. From current state map analysis found that, the value added activities amount 4.16% and the non-value added activities amount 95.84% and this mostly caused by drumming-off, purging and re-circulating process.

d. The future state map suggests that a 42.49% lead time reduction could be achieved, mainly thru eliminating large batch production and install direct line from formulation tank to filling line.

e. Takt time or required cycle time in Tracer120SC product family is 128 seconds per liter. Means, in order to achieve standard output in each shift, production crew have to produce one liter of Tracer120SC in 128 seconds.

f. Three most common reasons were found for the wastes. The first reason was the requirement of minimum quantity of raw material to be purchased from the supplier, contributing to the waste of inventory. The second reason was the minimum lot size of formulation tank that contributed to waste of inventory and over-processing. The third reason was the unavailability of direct line from formulation tank to filling line that contributed to waste of over-processing and this is the biggest contributor to long lead time of Tracer120SC value stream.

g. Work standardization model is visualized as standard operations sheet that contains main information like recommended process sequence, takt time, WIP and number of operator for each work centre that should be followed by each production crew to achieve standard execution of every production schedule.
7.2 Recommendations

On the name of continuous improvement for production shop floor in PT. Dow AgroSciences Indonesia, below some recommendations that researcher offer:

a. To eliminate most of wastes identified in value stream mapping, researcher proposed to utilize QCO, TPM, 5S and Work Standardization.

b. In order to achieve standard output for each shift, researcher recommend to follows Standard Operations Sheet (SOS) that developed and producing only according to takt time, this also will improve production scheduling activity as the main objective of this research.

c. Researcher recommends that results from this study can be used as guidance in implementing lean manufacturing especially value stream mapping in production shop floor and as starting point for continually improvement journey.

d. Researcher also highly recommends starting kaizen workshop at specific processes that are critical to achieving future state map of the value stream.

e. In addition, researcher also recommend to starting mapping other product family to create a better model of plant floor and also develop Standard Operations Sheet (SOS) for each production line.

f. Further research using time study also recommend to be conducted to develop Standard Operations Sheet (SOS) and SOP that provide more detail information and visualization of process sequence, WIP, completion times or standard times and other important aspects of the operation. Detail Standard
Operations Sheet (SOS) will help management to assess whether the operations are being done according to standards and also can be used as a tool to evaluate performance and improvement.
REFERENCES


APPENDIX A

DEFINITION OF TERMS

*Autonomation*: Automation with a human touch. The second of two major pillars of the Toyota Production System. (The first pillar is just-in-time production).

*Availability Time*: The time a production line is available for production. Availability time is measured in seconds and does not include planned downtime like lunch periods and breaks.

*Batch Size*: A technique used to run a determined quantity of parts at one operation prior to moving them to the next operations.

*Changeover Time*: The non-value added time required to convert a setup for one product line to a setup for another product line.

*Continuous flow*: The ideal state characterized by the ability to replenish a single part that has been “pulled” downstream. In practice, continuous flow is synonymous with just-in-time (JIT) production, which ensures that both internal and external customers receive only what is needed, just when it is needed, and in the exact amounts needed.

*Current state map*: The time that elapses from the beginning of a process or operation until its completion.

*Cycle time*: The time that elapses from the beginning of a process or operation until its completion.

*Demand/customer demand*: The quantity of parts required by a customer.
Downtimes: Those are considered break times. Downtimes are regular planned times and usually involve unpaid lunch and paid breaks. During a downtime the production does not run.

Electronic Data Interchangeable: It is a tool that allows companies to process the purchasing order electronically.

Finished Goods: Refers to parts that already have been manufactured and are in the completed stage waiting to be shipped to the customer.

First-in-first-out System: An inventory system used when continuous flow is not possible. WIP that is put into the system first is the first to leave the system.

Flow: The movement of information or material. The idea of flow in lean manufacturing is to have information and material move uninterrupted as little as possible.

Future state map: A diagram that suggests ways to reduce lead-times and increase throughput.

Kaizen: Small daily improvements performed by everyone. Kai means “take apart” and zen means “make good”. The point of kaizen implementation is the total elimination of waste.

Kaizen event: A team event dedicated to quick implementation of a Lean manufacturing method in a particular area over a short time period.

Kanban: A tool to achieve just-in-time which consists of a card containing all the information required to be done on a product at each stage along its path to completion and which parts are needed at subsequent processes (Monden, 1993)
**Lead Time**: The time that parts take to be transformed from raw material to finished goods.

**Lean**: Shorthand for Lean Manufacturing – a manufacturing paradigm based on the fundamental goal of Toyota Production System: minimizing waste and maximizing flow.

**Lean Metrics**: A list of measurements that will help for tracking progress toward the targets selected for improvements.

**Material Requirement Planning**: It is a tool that helps manage the production process. Basically, it is a plan for the production of the components and purchase of materials needed to make an item.

**NVA**: Non-value added.

**Operators**: Involves those individuals that provide the work hand to perform an operation.

**Product Family**: Refers to all the parts that are produced within the same value stream. All the parts for the product family group have common production processes and same pattern development.

**Raw Material**: Material that has been purchased but not changed in any way.

**Standardized work**: An agreed-upon set of work procedures that establishes the best method and sequence for each manufacturing or assembly process. Standardized work is implemented to maximize human and machine efficiency while simultaneously ensuring safe conditions.
**Takt time:** The word “Takt” comes from the German word “rhythm,” therefore Takt time determines the rhythm necessary to maintain customer demand. Takt time determines how fast a process needs to run to meet customer demand. Takt time is calculated by dividing the total time available for production by the total customer requirement.

**Total cycle time:** The total of the cycle times for each individual operation or cell in a value stream. Total product cycle time ideally equals total value-added time.

**VA:** Value added

**Value:** Information or material in the form that a customer is willing to pay for.

**Value Stream:** The set of processes, including value-added and non-value-added activities required to transform raw materials into finished goods that customers value (Womack & Jones, 1996).

**Value Stream Management:** A sequential, 8-step process used to implement Lean concepts and tools derived from Toyota Production System. The purpose of Value Stream Management is to minimize the waste that prevents a smooth, continuous flow of product throughout the value stream.

**Value stream mapping (or value stream process mapping):** The visual representation of the material and information flow of a specific product family; Steps 4 and 6 of the Value Stream Management process.

**Waste (also muda):** Anything within a value stream that adds cost or time without adding value. The seven most common wastes are 1) waste of overproducing, 2)
waste of waiting, 3) waste of transport, 4) waste of processing, 5) waste of inventory, 6) waste of motion, and 7) waste of defects and spoilage.

**Work-in-Process**: Any product in the production process than began as raw material, but is not a finished good yet.
APPENDIX B

TRACER120SC PHOTO REFERENCE

Tracer120SC pack size 100ml
## APPENDIX C

### VOLUME PRODUCED IN ONE YEAR (MAY 2007 – APRIL 2008)

<table>
<thead>
<tr>
<th>LIST OF PRODUCTS</th>
<th>QUANTITY (Ltr)</th>
<th>Cumulative Quantity (Ltr)</th>
<th>%</th>
<th>Cumulative %</th>
</tr>
</thead>
<tbody>
<tr>
<td>DURSBAN200EC</td>
<td>1,110,753</td>
<td>1,110,753</td>
<td>32.80%</td>
<td>32.80%</td>
</tr>
<tr>
<td>DMA</td>
<td>895,420</td>
<td>2,006,173</td>
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<td>59.23%</td>
</tr>
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<td>GARLON</td>
<td>200,009</td>
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<td>65.14%</td>
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<tr>
<td>NURELLED505EC</td>
<td>139,735</td>
<td>2,345,917</td>
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<td>69.27%</td>
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<tr>
<td>CLINCHER</td>
<td>138,009</td>
<td>2,483,925</td>
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<td>73.34%</td>
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<td>PENOXSULAM</td>
<td>125,600</td>
<td>2,609,525</td>
<td>3.71%</td>
<td>77.05%</td>
</tr>
<tr>
<td>TORDON</td>
<td>123,341</td>
<td>2,732,866</td>
<td>3.64%</td>
<td>80.69%</td>
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<tr>
<td>LORSBAN3E</td>
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<td>2,827,136</td>
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<td>83.48%</td>
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<tr>
<td>TRACER</td>
<td>64,755</td>
<td>2,891,891</td>
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<td>85.39%</td>
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<td>GOAL2E</td>
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<tr>
<td>DURSBAN75+</td>
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<td>NURELLEE10EC</td>
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<tr>
<td>GOAL240EC</td>
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<td>95.91%</td>
</tr>
<tr>
<td>GALLANTSUPER</td>
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<td>3,275,209</td>
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<td>96.70%</td>
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<tr>
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<td>99.87%</td>
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<tr>
<td>INDAR240F</td>
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<td>99.94%</td>
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<tr>
<td>GF120</td>
<td>2,000</td>
<td>3,386,736</td>
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<td>100.00%</td>
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<tr>
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</tr>
</tbody>
</table>

*Source: PT. Dow AgroSciences Indonesia*
## APPENDIX D

### CUSTOMER REQUIREMENTS

Reporting by Months for Y2008

<table>
<thead>
<tr>
<th>GMID</th>
<th>PRODUCT DESCRIPTION</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Average Monthly Requirement</th>
<th>Average Daily Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>213899</td>
<td>TRACER120SC BTLPET50X0.10L IDN</td>
<td>950</td>
<td>-</td>
<td>1.690</td>
<td>2.000</td>
<td>1.575</td>
<td>7.385</td>
<td>400</td>
<td>1.646</td>
<td>5.500</td>
<td>2.143</td>
<td>2.900</td>
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<td>130.00</td>
</tr>
<tr>
<td>213901</td>
<td>TRACER120SC BTLPET24X0.25L IDN</td>
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<td>180</td>
<td>540</td>
<td>606</td>
<td>780</td>
<td>2.510</td>
<td>323</td>
<td>1.113</td>
<td>2.400</td>
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<td>1.950</td>
<td>2.436</td>
<td>1,194</td>
<td>60.00</td>
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<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>3,799</strong></td>
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</tbody>
</table>

Devi Adhriany Rahayu : Building Model Of Basic Stability For Productivity Improvement Journey In PT. Dow Agrosciences Indonesia By Utilizing Value Stream Mapping (VSM) In Production Shop Floor, 2009
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APPENDIX E

VSM PROCESS SYMBOLS

<table>
<thead>
<tr>
<th>Icon</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outside Source</td>
<td>This icon represents the Supplier when in the upper left, the usual starting point for material flow.</td>
</tr>
<tr>
<td>Customer/Supplier</td>
<td>The customer is represented when placed in the upper right, the usual end point for material flow.</td>
</tr>
<tr>
<td>Process</td>
<td>This icon is a process, operation, machine or department, through which material flows. Typically, to avoid unwieldy mapping of every single processing step, it represents one department with a continuous, internal fixed flow path.</td>
</tr>
<tr>
<td>Dedicated Process</td>
<td>In the case of assembly with several connected workstations, even if some WIP inventory accumulates between machines (or station), the entire line would show as a single box. If there are separate operations, where one is disconnected from the next, inventory between and batch transfers, then use multiple boxes.</td>
</tr>
<tr>
<td>Shared Process</td>
<td>This is a process operation, department or work center that other value stream families share. Estimate the number of operators required for the Value Stream being mapped, not the number of operators required for processing all products.</td>
</tr>
<tr>
<td>Data Box</td>
<td>This icon goes under other icons that have significant information/data required for analyzing and observing the system. Typical information placed in a Data Box underneath FACTORY icons is the frequency of shipping during any shift, material handling information, transfer batch size, demand quantity per period, etc. Typical information in a Data Box underneath MANUFACTURING PROCESS icons: C/T (Cycle Time) – time (in seconds) that elapses between one</td>
</tr>
</tbody>
</table>
part coming off the process to the next part coming off. C/O (Changeover Time) – time to switch from producing one product on the process to another.

Uptime – percentage time that the machine is available for processing. EPE (a measure of production rate/s) – Acronym stands for “Every Part Every _____”. Number of operators – use OPERATOR icon inside process boxes. Number of product variations. Available Capacity Scrap rate. Transfer batch size (based on process batch size and material transfer rate).

This symbol indicates that multiple processes are integrated in a manufacturing workcell. Such cells usually process a limited family of similar products or a single product. Product moves from process step to process step in small batches or single pieces.

**VSM MATERIAL SYMBOLS**

These icons show inventory between two processes. While mapping the current state, the amount of inventory can be approximated by a quick count, and that amount is noted beneath the triangle. If there is more than one inventory accumulation, use an icon for each.

This icon also represents storage for raw materials and finished goods.

This icon represents movement of raw materials from suppliers to the Receiving dock/s of the factory. Or, the movement of finished goods from the Shipping dock/s of the factory to the customers.

This icon represents the “pushing” of material from one process to the next process. Push means that a process produces something regardless of the immediate needs of the downstream process.
This is an inventory “supermarket” (kanban stockpoint). Like a supermarket, a small inventory is available and one or more downstream customers come to the supermarket to pick out what they need. The upstream workcenter then replenishes stocks as required.

When continuous flow is impractical, and then upstream process must operate in batch mode, a supermarket reduces over-production and limits total inventory.

Supermarkets connect to downstream processes with this “Pull” icon that indicates physical removal.

First-In-First-Out inventory. Use this icon when processes are connected with a FIFO system that limits input. An accumulating roller conveyor is an example. Record the maximum possible inventory.

This icon represents an inventory “hedge” (or safety stock) against problems such as downtime, to protect the system against sudden fluctuations in customer orders or system failures. Notice that the icon is closed on all slides. It is intended as a temporary, not a permanent storage of stock; thus, there should be a clearly-stated management policy on when such inventory should be used.

Shipments from suppliers or to customers using external transport.

---

### VSM INFORMATION SYMBOLS

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Super Market" /></td>
<td>This is an inventory “supermarket” (kanban stockpoint).</td>
</tr>
<tr>
<td><img src="image" alt="Material Pull" /></td>
<td>Supermarkets connect to downstream processes with this “Pull” icon that indicates physical removal.</td>
</tr>
<tr>
<td><img src="image" alt="FIFO" /></td>
<td>First-In-First-Out inventory. Use this icon when processes are connected with a FIFO system that limits input.</td>
</tr>
<tr>
<td><img src="image" alt="Safety Stock" /></td>
<td>This icon represents an inventory “hedge” (or safety stock) against problems such as downtime, to protect the system against sudden fluctuations in customer orders or system failures.</td>
</tr>
<tr>
<td><img src="image" alt="External Shipment" /></td>
<td>Shipments from suppliers or to customers using external transport.</td>
</tr>
<tr>
<td><img src="image" alt="Production Control" /></td>
<td>This box represents a central production scheduling or control department, person or operation.</td>
</tr>
<tr>
<td>Icon</td>
<td>Description</td>
</tr>
<tr>
<td>------</td>
<td>-------------</td>
</tr>
<tr>
<td><img src="image" alt="Straight Arrow" /></td>
<td>A straight, thin arrow shows general flow of information from memos, reports, or conversation. Frequency and other notes may be relevant.</td>
</tr>
<tr>
<td><img src="image" alt="Wiggle Arrow" /></td>
<td>This wiggle arrow represents electronic flow such as electronic data interchange (EDI), the Internet, Intranets, LANs (local area network), WANs (wide area network). You may indicate the frequency of information/data interchange, the type of media used ex. Fax, phone, etc. and the type of data exchanged.</td>
</tr>
<tr>
<td><img src="image" alt="Production Kanban" /></td>
<td>This icon triggers production of a pre-defined number of parts. It signals a supplying process to provide parts to a downstream process.</td>
</tr>
<tr>
<td><img src="image" alt="Withdrawal Kanban" /></td>
<td>This icon represents a card or device that instructs a material handler to transfer parts from a supermarket to the receiving process. The material handler (or operator) goes to the supermarket and withdraws the necessary items.</td>
</tr>
<tr>
<td><img src="image" alt="Signal Kanban" /></td>
<td>This icon is used whenever the on-hand inventory levels in the supermarket between two processes drops to a trigger or minimum pint. When a Triangle Kanban arrives at supplying process, it signals a changeover and production of a predetermined batch sizes of the part noted on the Kanban. It is also referred as “one-per-batch” kanban.</td>
</tr>
<tr>
<td><img src="image" alt="Kanban Post" /></td>
<td>A location where kanban signals reside for pickup. Often used with two-card systems to exchange withdrawal and production kanban.</td>
</tr>
<tr>
<td><img src="image" alt="Production Kanban Batches" /></td>
<td>This icon telling us that Kanban arriving in batches</td>
</tr>
<tr>
<td><img src="image" alt="Sequenced Pull" /></td>
<td>This icon represents a pull system that gives instruction to subassembly processes to produce a predetermined type and quantity of product, typically one unit, without using a supermarket.</td>
</tr>
<tr>
<td>Icon</td>
<td>Description</td>
</tr>
<tr>
<td>------</td>
<td>-------------</td>
</tr>
<tr>
<td><img src="image" alt="Load Leveling Icon" /></td>
<td>Load Leveling: This icon is a tool to batch kanbans in order to level the production volume and mix over a period of time.</td>
</tr>
<tr>
<td><img src="image" alt="Go See Icon" /></td>
<td>“Go See” Production Scheduling: Gathering of information through visual means.</td>
</tr>
</tbody>
</table>

**VSM GENERAL SYMBOLS**

<table>
<thead>
<tr>
<th>Icon</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Kaizen Icon" /></td>
<td>Kaizen</td>
</tr>
<tr>
<td><img src="image" alt="Operator Icon" /></td>
<td>Operator</td>
</tr>
<tr>
<td><img src="image" alt="Timeline Icon" /></td>
<td>Timeline</td>
</tr>
<tr>
<td><img src="image" alt="Weekly Schedule Icon" /></td>
<td>Weekly Schedule</td>
</tr>
</tbody>
</table>

(Source: Rother & Shook, 2003)
Appendix F
Current State Map for Tracer120SC Product Family

- **Dow Internal and External Suppliers**: Monthly Firm Order

- **Master Scheduler and Production Planner**: Weekly Replenishment Order

- **Customer**: 190 liter/day
  - Tracer 250 ml = 60 liter/day
  - Tracer 100 ml = 130 liter/day

- **MRP**: 90/60/30 day Forecasts

- **Weekly Schedule**: 1x/2 months

- **Weekly Ship Schedule**: 5x/month

- **Dow Internal and External Suppliers**
  - 1x/2 months

- **Melting**
  - Cycle Time: 1440 Mins
  - Cycle Time: 630 Mins
  - Changeover Time: 30 Mins
  - Melted: 113 kg
  - Uptime: 97.92%
  - 3 shifts
  - 2 operators
  - 8440 sec. avail.

- **Formulation**
  - Cycle Time: 630 Mins
  - Changeover Time: 70 Mins
  - Formulated: 2800 liter
  - Uptime: 91.36%
  - 3 shifts
  - 2 operators
  - 24300 sec. avail.

- **Drumming off**
  - Cycle Time: 35 Mins
  - Changeover Time: 0 Mins
  - Drummmed off: 2800 liter
  - Uptime: 97.53%
  - 3 shifts
  - 2 operators
  - 24300 sec. avail.

- **Purging**
  - Cycle Time: 10 Mins
  - Changeover Time: 0 Mins
  - Melted: 2800 liter
  - Uptime: 100%
  - 3 shifts
  - 1 operator
  - 24300 sec. avail.

- **Re-Circulating**
  - Cycle Time: 12 Mins
  - Changeover Time: 0 Mins
  - Re-Circulated: 1000 liter
  - Uptime: 79.9%
  - 3 shifts
  - 11 operators
  - 24300 sec. avail.

- **Filling**
  - Cycle Time: 7 Mins
  - Changeover Time: 0 Mins
  - Production Lead Time: 2184 mins

- **Warehouse**

---

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1. Forecasting and Material Planning

1.1 Enter 30/60/90 days forecast into ForDE

1.2 Generate dependent requirement of raw material and packaging material

1.3 Releasing Purchase Orders to supplier follow lead time and MOQ set

1.4 Materials available for production scheduling

2.1 Creation of Weekly Production Schedule

Rule/Measurement

Follow Purchasing Work Process

Propose to purchase only according to MOQ while regularly revisit lead time and check possibility to reduce MOQ

Other Process Related

Other Process Related

SAPS/MRP

SAPS/MRP Medan

Material Planner

Material Planner

Country CSR/DRP

Country CSR/DRP

Medan-DPS

Medan-DPS

Production Dept.

Production Dept.

DAS Medan Logistic

DAS Medan Logistic

Commercial

Commercial

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Linkage between Model of Basic Stability with Supply Chain and Manufacturing Operations

2. Creation of Weekly Production Schedule

2.1 Tracer120SC orders created into SAP with detail RDD following lead time set

2.2 Finish Product Tracer120SC availability check in SAP

2.3 Stock available

2.4 Deliver to Customer

2.5 Weekly MPS created to schedule production of Tracer120SC following process & information proposed in future state map

2.6 Execute production schedule following Standard Operations Sheet (SOS) for Standard Output

3.1 End

Follow DRP Work Process

Follow Material Flow Work Process (MFWP)

Follow MPS Work Process

Follow MPS and PIP/RPD Work Process

On Time Shipment Metric

MPS Metric Performance

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