A new steps of Value Stream Mapping For the Moroccan Artisanal Enterprise

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***Abstract*—This paper discusses the Lean methodology of Value Stream Mapping (VSM) in a handicraft enterprise with Make to order environment. Within a case study of a wood craft company, the method is applied and improved. The purpose of VSM is to initialize the lean transformation and to understand the value streams of a company as a basis for further improvements. The paper explores the current literature about VSM and also discusses the specific characteristics of an MTO environment and its limitations regarding the application of the current VSM methodology. Based on this, an adapted VSM procedure with a special focus on MTO or ETO small and medium craft enterprises is presented. This paper contains a simple guided steps to build a current VSM in this environment with a new formulation to calculate the metrics point such as cycle times and setup times.**

***Index Terms*—Craft production, Moroccan handicraft, VSM steps, value stream mapping, woodcraft, woodworking.**

I. INTRODUCTION

Every LM Implementation starts with a Value Stream Map [31,17,18]. The VSM is a flowchart method to illustrate, analyze and improve the steps required to deliver a product or service. It reviews the flow of process steps and information from origin to delivery to the customer. This methodology was detailed by Rother and shook in their workbook for lean enterprise institute « learning to see » [25]. The VSM aims to analyze the organization of the shop floor and the allocation of resources to tasks in order to eliminate waste and have a significant impact on job lead time.

The application of this methodology was the object in a lot of research project especially in large enterprises and it's well adapted in the context of a high-mix small-lot size environment. However, in small and medium-sized enterprises especially in those working in craft production with a make to order philosophy where the customer order defines the product and consequently the production, the ordinary lean tools and methods as VSM known from repetitive production does not fit [24].

In fact, there are few studies combining VSM and handcraft SME in the world but no one treat in Moroccan environment;

Research objectives:

The main purpose of this paper is the adaptation of the VSM for a craft production enterprise especially those working with the Make to Order philosophy. We search how to change some parameters in the current VSM form to fit it to the parameters of the handicraft enterprise and give the steps to follow to build a current VSM with new parameters.

Research Methodology:

This research is a case study in a woodworking small enterprise. This case study is based on the use of both published literature and the cooperation with the working team in the shop floor to extract the essentials adoptions to make to the VSM.

The research Methodology is fragmented in the following steps:

A literature review to understand the VSM and searching similar application in this field.

An observation of the Shop-floor activities to understand all production activities in woodworking and searching the main characteristics of this type of enterprise.

An adaptation of all steps of the building of the current VSM with a new quantification of the parameters.

Findings:

The research shows that the VSM is a valuable tool for this type of companies searching to converts their old product system to a lean system. We elaborated a new step adapted to artisanal production system characteristics.

Research limitations:

It's just one application in only wood working company. The result will be more significant if we develop this research in more companies.

Practical Implications:

The result is useful for future practitioners who are searching to use VSM to improve their project. It's can be useful too to academic researchers working on VSM approach to enhance it.

Originality:

The case stay shows that the lean system tools used in industry can be adapted to the artisanal systems.

II. A LITERATURE REVIEW

A. Definition of the value Stream mapping

First In recent years, the VSM is considered as a key method to implement lean concepts. It's used and popularized in many companies since the publication of the book Learning to See: Value-Stream Mapping to Create Value and Eliminate Muda [25].

Rother and Shook says that "A value stream is all actions currently required to bring a product through the main flows essential to every product: the production flow from raw material into the arms of customer, and the design flow from concept to launch."A value stream can be defined as a sequence of activities required to design and manufacture or

provide a product or service. The Value stream maps were in the beginning « a material and information flow maps" presented as one-page diagrams defining all the activities of the process used to make a product [31]. Not only the material flows are mapped, but also information flows that control these material flows[25]. Value stream maps is a pencil and paper visualization tool that shows the flow of material and information associated to the activities used to produce [31]. Therefore value stream maps help users to see waste that exists in process [9] that adds cost but does not add value.

Monden [20] classified operations in three categories non-value adding (NVA), necessary but non-value adding (NNVA) and value adding (VA).

The value stream mapping is usually considered as an excellent method to begin the lean journey because it helps to understand the big picture of the business enterprise. It's very useful for the visualization, the analysis and the redesign of the production including material flow as well as information flow [25,31]and help to identify and eliminate or reduce waste[29].

Womack and Jones state in their Lean action plan [31] that to start directly with identifying the current value streams and mapping by product family. Rivera (Rivera and Frank Chen, 2007) presents VSM as the initial tool to start a Lean implementation which complies with the Lean implementation procedure presented by Womack and Jones.

B.A brief review of studies describing the adaptation or application of VSM in craft production

The VSM was First implemented by the automotive industry with a strong focus on low-mix series production [4,29], it was expanded too to various applications[31] and to other industries [10,5] and was enriched by others tools and techniques.

Many researchers have described the application of VSM in various type of production system (such as project, job, batch, mass or continuous production systems). Gurumurthy [16] had encompassed the studies describing the application of VSM. Table I show a review of papers describing the application of VSM developed by [16]. We added some authors speaking about the application of VSM in SME.

N°	Authors and years	The studies
1	Hines & Rich (1997)	The seven value stream
2	Dhandapani (2004)	Applying lean thinking: a case study of an Indian steel plant
3	Emiliani & Stec (2004)	Using value-stream maps to improve leadership
4	Seth & Gupta (2005)	Application of value stream mapping for lean operations and cycle time reduction: an Indian case study
5	Braglia et al (2006)	A new value stream mapping approach for complex production systems
6	Parry & Turner (2006)	Application of lean visual process management tools
7	Grewal (2008)	An initiative to implement lean manufacturing using value stream mapping in a small company
8	Quesada & buehlmann	Lean Thinking: Examples and Applications in the Wood Products Industry
9	Gurumurthy & Kodali (2011)	Design of lean manufacturing systems using value stream mapping with simulation
10	D.T. Matt (2013)	Adaptation of the value stream mapping approach to the design of lean engineer-to- order production systems: A case study

TABLE 1: APPLICATION OF VSM IN SME

From Table I, we can see that VSM has been used in both manufacturing and service industries; but, its application is more predominant in manufacturing. It's used mostly for productivity improvements but it's also used in various domains. However, the number of case studies describing the application of VSM in small-and medium-sized enterprise(s) SMEs oriented in craft production is very less. Only three papers are available, which specifically mentioned the adaptation and application of the VSM in craft small and sized enterprise.

[5] mentioned that VSM cannot be used directly for manufacturing processes with merging flows. Thus, the research team defined a procedural approach: first the part families are identified, and then the machine sharing among the targeted families is determined identifying and optimizing the critical value stream. A key issue in all research activities involving VSM technique in a manufacturing environment is that suitable part or product families can be identified. However, in an ETO environment as it can be typically found for example in construction industry [11, 21] the tools and methods known from repetitive production usually do not fit or have to be limited in use for lean improvements in simple processes[21]. Another shortcoming of applying the traditional VSM approach in an ETO environment is that it fails to map multiple products with different routings and that it lacks suitable economic measures for value or other typical manufacturing performance parameters [5]. Thus, a large number of small and medium-sized companies which are mainly focusing their activities on craft-production still cannot fully take advantage of the efficiency gains that can be obtained by VSM[21].

III. THE CASE STUDY

A.The traditional procedure of VSM

After a literature review searching how to build a value stream map, we found a lot of complicated steps to follow. The mapping becomes more difficult and the result is a complicated map very difficult to analyze which divert from the ultimate objective of the VSM. In this paper we tried to extract just the necessary information and presenting them in a simple way.

the general steps

The first step before starting the mapping is to identify the product families, groups of products that go through the same processing steps, to be investigated from the point of ordering raw materials until the point of final product delivery to the customer.

The second step Womack emphasizes to determine the current problem(s) with the value stream. Afterwards the development of the current state map is ideally conducted by a multidisciplinary team where participants should be from the whole value stream.

The final step of mapping the current state is measuring the throughput time of the value stream.

The essential data to collect

The essential data needed for building the current state map 25] are:

Product family steps of process: Definition of the production processes the selected product family goes through, e.g., cutting, assembly, finishing, etc.

Production information: Information about changeovers, frequency of raw material delivery, number of shifts the plant works, working time and breaks for each shift, etc.

Ordering: Customer requirements for each product of the family investigated, e.g., 100 products of type A and 300 type B needed every week. Packaging requirements for the orders, e.g., number of products per pallet or box.

Production Control: Forecast data received from customers and sent to different internal processes and to suppliers.

The symbols used in the map

VSM symbols vary in different places, but they fall into these four categories: process, material, information and general.

Symbol	Name	Description
	Customer/Supplier	Represents customer in upper right or supplier in upper left.
	Dedicated Process Flow	A fixed activity flow within a department.
	Shared Process	A process shared by other parts of the value stream.
Data 1 Data 2 Data 3	Data Box	Data about the process step, such as cycle time, change over time and uptime.
	Workcell	Indicates that multiple processes are being integrated in a manufacturing workcell.

Figure1: The process Symbol

Symbol	Name	Description
	Inventory	Inventory between two processes.
	Shipments	Movement of the raw materials from suppliers to the factory and then to customers.
	Push Arrow	Pushing material from one process to the next.
Resource 1 Resource 2 Resource 3	Supermarket	An inventory "supermarket" (also called a kanban stockpoint).
	Material Pull	Removal of materials in a supermarket to downstream processes.
FIFO	FIFO Lane	First-In-First-Out inventory.
Stock Stock Stock	Safety Stock	Inventory "hedge" against production problems.
	External Shipment	Shipments from suppliers or to the customers.

Figure 2 :The material symbol

Symbol	Name	Description
	Production Control	A central production scheduling or control operation, department or person
Daily	Manual Info	Shows the general flow of info from memos or conversation.
	Electronic Info	Such as EDI (electronic data interchange), the internet, WANs (wide area network), LANs (local area network) or intranets.
	Production Kanban	Triggers the production of a predetermined number of parts. This signals a supplying process to provide the parts to another downstream process.
	Withdrawal Kanban	A device or card that informs a material handler to transfer parts from a supermarket to the receiving process.

Figure3: The information symbol

Symbol	Name	Description
	Kaizen Burst	Attention-getting symbol highlights improvement needs to achieve the future state Value Stream Map.
	Operator	Number of operators required to process the VSM family for a particular workstation.
	Other	Other useful information.
	Timeline	Shows cycle times and wait/down times. Used for calculating Lead Time and Total Cycle Time.

Figure 4: The General symbols

The indicators to calculate

In fact, there is some ratio which helps to define the percentage of the operation with an added-value. These ratios are:

The Takt time is the production rate that matches the customer buying rate. It is the division of the system's available work time per shift by the customer demand rate per shift.

The non value-added (NVA) times which are the inventory point (raw materials, finishing, packaging, and finished products) levels. Because the inventory levels are shown in units, this needs to be translated into time units (for example days). Therefore, the daily demand is used for doing this calculation.

The value-added times: There are just the processing times for each of the three processes (machining, packaging, finishing). These times are expressed generally in seconds (sec).

The total lead time: It's the sum of all value expressed in the timelines.

The process time: It's the sum of all operations with added value which are cycle times.

Express no value-added time and value-added time as a percentage of total lead time. Calculations are made using days as the baseline; therefore, the process time or VA time needs to be expressed in days, instead of seconds.

B.The characteristics of the product system in a make to order in woodworking

The chosen company is a small sized Moroccan enterprise specialized in the woodcraft. It's specialized in the furniture of professional offices and schools with a turnover of 2 millions Dhs and 20 employees (with 10 artisan).

This company is working by project with make to order. Every product is unique and consequently, designs and production is made to the specific customer order (batch-of-one production). The project can contain a various article such as desks, counters, chairs, files drawers, etc. Usually the final product can involve some common materials or standard parts and same operations works, but every customer order requires individual bills of materials and production routings to complete the final product within an agreed deadline.

The Demand is irregular. The process typically consists of cutting, assembly and finishing. However, designing is become very important in the craft production. The customer demands a 3D conception to choose the better design. Consequently, the company integrates this step and became an engineer to order. ETO extends the make-to-order (MTO) strategy by a stage in which a product is designed to order according to individual customer needs. The logics and sequence of the main processes in the ETO model is very similar to the MTO case; however, the products tend to be highly influenced by the interaction with customers even after production order release and start of production [22].

In this case, the company works by project. The majority of theirs projects are furniture for offices. They are usually composed of a desk, a counter, a base table, a file drawer, cabinet). The products are manufactured in environments similar to manufacturing job-shop conditions. After a designing of the items, the product manager produce a file which we found all the raw materials needed for the production. The design must be valid by the customer to the commercial to start the process of production. The observation of the production area and all the steps of the production permitted to notice that even if the company works with ETO, it usually produces the same articles with customization. 90% of their projects are composed of a desk, a counter and a file drawer.

For a better understanding of the specific characteristics of this environment, we did a gemba walk for a month with a comparison with standard environment. The following table regroups all the characteristics where a difference was identified. These characteristics were determined during observations of the shop-floor activities, a detailed process analysis, and interviews and informal discussions with all the team from the top management to the artisans.

	The difference
Takt time	It's very difficult to define it. It's due to the various products and their uniqueness. Also the numbers of commands and theirs types is not fixed per months
customer requirements	It vary from product to product. Every customer chose his specifications such as colors, models, wood, forms…
Number of components	The uniqueness of the articles and their variety engender a big numbers of components even if some components are standard with variation of the woods and colors.
cycle times	The variety of the components affects the cycle times.

	The difference
Setup times	In this case is a change tools time or searching tools time. the artisan have to search the tools every time he want to do an other operation.
material flow	No clear material flow.
information flow	No electronic information flow. Only a physical information flow between commercial and production and accountant services. Between work station the information is verbal.
Workflow	There is no defined workflow. The top management says that it's difficult to define a workflow of every articles.
Collect of data	It's a big problems. There is no enregistration of the data.
Scheduling	Because the demand is irregular and the variation of the number of articles, the product manager say that it's difficult to planify a production program
Work units or pitches	We can't fixe a duration per articles.
Shipment date	Fixed in the majority of times by the customer.

TABLE 2: THE CHARACTERISTICS OF MTO PRODUCT SYSTEM

Another constraints were found generally in all craft SME are less resource and several functions are held by one person.

C.Adaptation of VSM to craft company requirements

Because of these differences, the VSM approach has to be adapted to fit to this new requirement. In this case, the project can be composed of several articles. Every article is an object of VSM with its leads times. The number of component by articles is little and there is no merge activity.

The new quantification of parameters

According to these requirements, we redefined new metrics parameters that help to see the percentage of added value task. The following parameters were defined in Arabic language.

The cycle times CT: The time when value is added to the article. To calculate this time we suggest listing all the operations doing by every artisan in every step. This list constitutes all the operations with added value. We found that this time is approximately the same by type of article. So the type by process is the sum of the time by ever task or operation. These operations are long so their units can be by minutes sometimes hours.

In Process Time PT: in this case is hours of continuous work it takes to do the task.

The changeover times (setup time) CO: It's the time needed to the artisans to change his tools, to search his tools or waiting that the tools is free.

The waiting time W: It's the time in the opening hours when the article is waiting to pass to the other workstation or process.

The rework ration RR: the number of time we repeat a task to have the best job.

The lead time: is time needed to complete an article from the commands to the delivery.

The lead times of the project can be defined in two ways:

The first way is if the articles are launched at the same time. The lead time of the project is the max of the lead times of all the articles.

The second way is if the articles are launched one by one, the lead time is the sum of the max of each process of articles.

We have to notice that the lea time of the project and the delivery time were calculated arbitrarily and the statistics of the project shown that it's not respected.

The new building steps of VSM in craft enterprise

On a big whiteboard or paper with a pencil or a marker, we build our VSM. We use post-it to refer to a process with its value CT, CO, W.

Step 1

Identify the project and the essentials articles to be studied and improved. You typically put together a team to do the mapping and analysis.

Identify the customer, the suppliers for this project. Calculate the time of the purchasing of the raw materials and the time.

Step 2

Bound the process, which means determining the limits or scope of your map. Define the scope of your chain. For example: if your chain include just production task like cutting, assembly and finishing, or that includes design and raw material buying too.

Step 3

Do your Gemba walk or process walk and note information about the type of material flow, the type of information flow, the communication method used, and your type inventory.

Step 4

Define the process steps, keeping within the information you've just defined as you do your walk. In this case, all of the steps might take place in a single location that inventory enters and then leaves. For each process, you have to identify a list of tasks needed to achieve this process. Then record time needed for every task. It's vital to record the reality of your observations, and not rely on information from employees who may have a vested interest in explaining away a problem. The purpose is to document each significant step required to create the product's value.

Step 5

Collect process data on your walk. This is where you start evaluating the performance of each step of the process. cycle time C, change-over time CO, waiting time between process W, number of workers, shifts, and available working hours. All of these could result in finding efficiencies and cutting

waste. Add that process data to the data boxes of your Value Stream Map.

Step 6

Map the movement of the product and information flows. Count the inventory. Inventory and overproduction can be an extensive cause of waste. Take special note that inventory may be scattered in a makeshift manner.

Step 7

Create a timeline. Map out process times and lead times for inventory through our process steps. By monitoring inventory levels at each step, we can find inefficiencies and non-value-adding items in our production.

Step 8

On the map, calculate the lead time and the process time. Calculate the ratio process time/ lead time which refers to the % of added value of your process.

The following figure it's a scheme to follow to map easily the value stream.

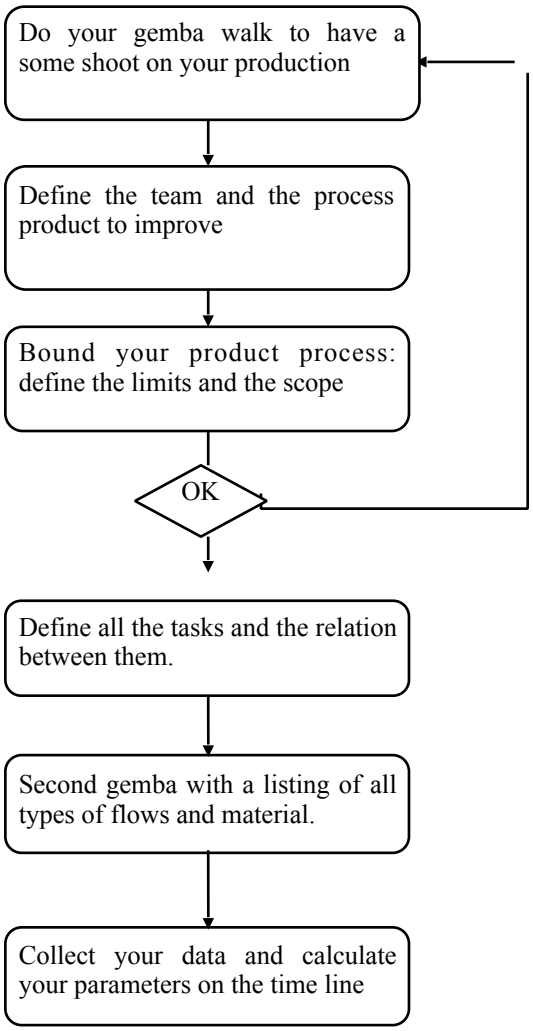

Figure 5: Scheme to build easily the VSM

IV. Creating the current Value Stream Map

Now, it is time to map out the process. To start our process, we create a team with the manager, the coordinator and the designer.

We asked the managers on the different type of product they produce. After a Pareto analyze, we found that 60% of the turnover is desk and counter.

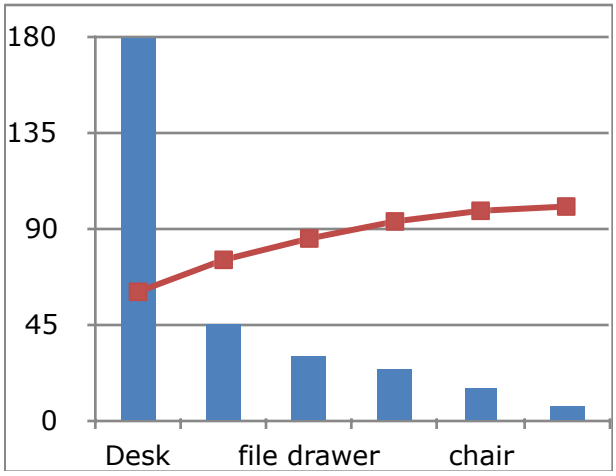

Figure 6: Pareto Analyze to select the product

The team decided to work on the desk process to work and we selected five projects to collect their data production.

A. The Current state map

The data to collect are the cycle time, the changeover time and the waiting time or inventories.

The working hours are 8 hours per day. They work 6 days per week. When we asked how much take a desk they respond generally about 3 working days equivalent to 24 hours. The reality is very far to this.

In the make to order, the projects are unique. Every desk is unique but we stated that generally all the desks are produced by the same process. We stated also that all the operations take the same time to be done.

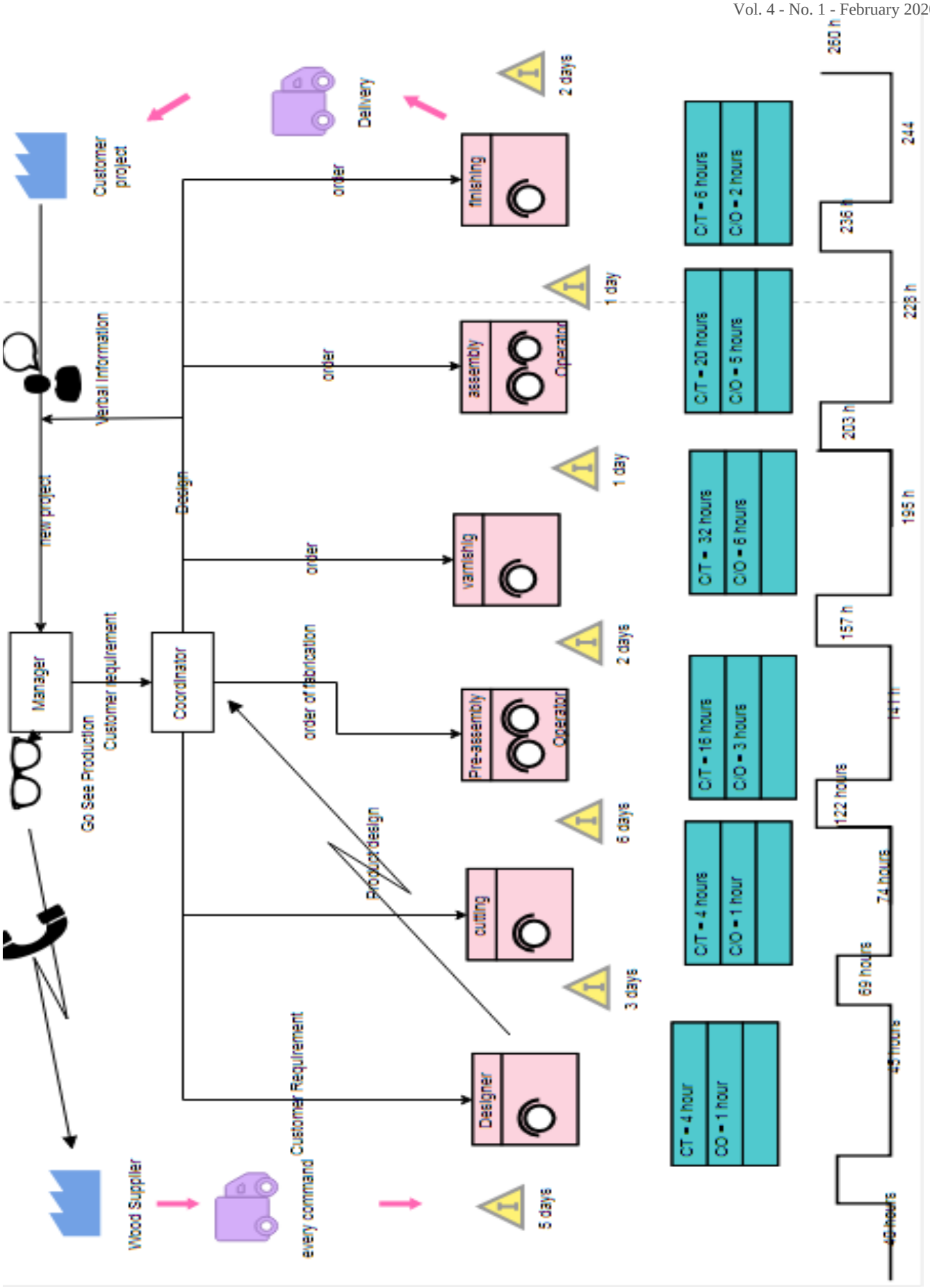

Figure 7: The current state map

B.Performance evaluation of the chain

On the timeline, we made some changes. We calculated the cumulate of times form the receiving of the command to the delivery.

The real lead time revealed by the VSM is about 260 hours equivalent 32.5 days. The value added tasks take 82 hours.

The lead time = the added time 82 hours+ the changeover time 18 hours + the inventories (semi finished product) 160 hours.

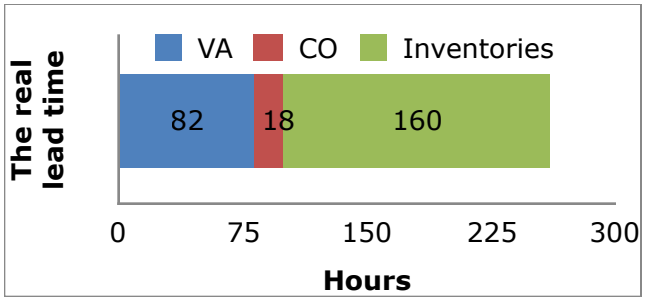

Figure 8: The composition of the lead time

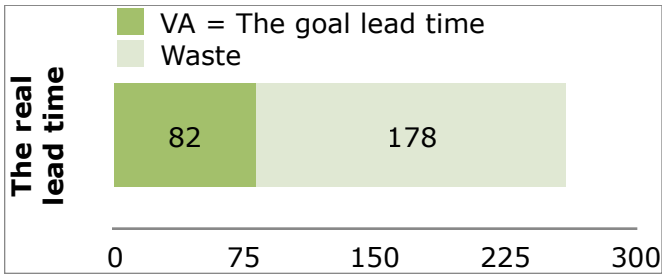

Figure 9: The real lead time and the goal time

These graphics shows that the 68% of lead time is waste and only 32%. This process needs some improvement to enhance the productivity and eliminate waste.

C.Discussion

VSM in MTO production can be done project by project. However, if the projects are the same and the products produced by 90% of the same chain value we can use VSM by products.

The main gain of VSM in this case is the analysis of the waiting time. It can be used to analyze costs too.

It is recommended to map several projects of different scopes to get a better understanding whether the complexity of a product and the necessary manufacturing processes influence the flow of components through the workshop. Although in the MTO, every project is unique, the analysis of several projects and the comparison of their current state maps stated that the results converges and we obtained the same lead time which offers a general opportunity for improvement.

Value Stream Maps in this case study offered to the manager a good basis to see the wasting time and start discussion to raise awareness about muda (waste) within the manufacturing teams.

The effectiveness of VSM is generally proved by several studies. However, in artisanal enterprise is less demonstrated. In this part, we just tested the effectiveness of the steps used to map the value chain in artisanal fields. Those steps has been done for five times by just the coordinator and artisans and they succeed regarding to their levels school.

For the effectiveness of VSM and regarding to its definition which is a virtual measure of the distance between the results obtained and the objectives, we can measure the effectiveness of our adapted VSM by two indicators:

- The numbers of the sources of waste listed from the map.
- The reduction of the lead time.

In this case, after analyzing the map according to the eight sources of wastes developed in lean approach, we find a several wastes. For example:

- Change over time is high;
- Lot of inventories;
- No electronic information flow;
- Separation between workstation;
- No continuous flow: the flow is discrete and every time the coordinator has to order to the next station which article have to do;
- No data changed between client and coordinator;
- The rework ration is very high; RR=100%: for the five projects done by the coordinator, she constated that the worker have to work many time on the circular saw to modify some measurement.

This analysis was conducted two times. The first one was done by me but the objective of my thesis is not just to do this VSM in this type of enterprise and measure the effectiveness. It's to develop a simple steps basing on different tools used in lean to guide the artisans and managers to do this VSM by themselves alone. After developing those analysis steps we asked the coordinator to do the VSM alone. The two VSM converge to the same results.

V. CONCLUSION

This work is a result of an intense work and discussion process with the working group of the company. As a result, a guided step was developed to build a current VSM of the woodworking company.

A literature review of the VSM revealed that due to the differences of an MTO environment to series or mass-production the conventional VSM approach needs to be adapted. The conventional VSM approach is designed for high volume repetitive manufacturing industries; in a batch-of-one environment it can be applied only project by project.

This paper presents the steps to follow to map the value chain. It presents graphically the value chain of the production of a desk in this company. By using value stream mapping we observed that non-value added time is caused by inventories and changeover time. Also the work in process is higher than they expect. The manager and the team approved the effectiveness of the VSM. All the team has challenge to make some change to eliminate their mudas.

Of course, there are difficulties to quantify the effectiveness of these measures in a typical MTO environment, but we succeed to develop a simple steps to do VSM that will help the working group to identify the non value added tasks and sources of wastes. The measurements of the effectiveness of

these steps was measured by the number of times the coordinator succeed to create the map. A testing of this steps in artisanal leather bag manufacture is in progress.

The next work is to develop a guided steps to guide artisans to analyse the map and presents this as a complete work to start the lean transformation.

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