SOLID WASTE MANAGEMENT APPLYING VALUE STREAM MAPPING. A SMALL AND MEDIUM SIZED ENTERPRISE CASE

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Abstract: Lean Management is an approach that can be used in order to improve the environmental performance of the Small and Medium Sized Enterprises (SMEs), identifying the source of Solid Wastes (SW) and proposing strategies to reduce or eliminate them. In this study a methodological approach based on the application of Value Stream Mapping (VSM) and the literature review about Solid Waste Management (SWM) is proposed including the building of the current situation map, analysis and the building of the desired situation map in order to identify and implement improvement actions for the SWM in one pilot unit of the plastic sector in Colombia. The results confirm some advantages of the proposed VSM methodology as a practical redesign tool of waste and materials flows in the value stream.

Keywords: Lean Management, SME, Solid Waste, Solid Waste Management, Value Stream Mapping.

Resumen: Lean Management es un enfoque que puede ser usado para mejorar el desempeño medioambiental de las pequeñas y medianas empresas (PYMEs), identificar la fuente de residuos sólidos (RS) y proponer estrategias para reducirlos y eliminarlos. En este estudio se propone un enfoque metodológico basado en la aplicación del Mapa de la Cadena de Valor (VSM, Value Stream Mapping) y en la revisión bibliográfica sobre la Gestión de Residuos Sólidos (GRS) incluyendo la construcción del mapa de la situación actual, análisis y la construcción del mapa de la situación deseada, con el fin de identificar e implementar acciones de mejora para GRS en una unidad piloto del sector plástico en Colombia. Los resultados confirman algunas ventajas de la metodología propuesta del VSM como una herramienta práctica de rediseño de flujos de residuos y material en la cadena de valor.

Palabras claves: Lean Management, SME, Residuos Sólidos, Gestión de Residuos Sólidos, Value Stream Mapping.

1. INTRODUCCIÓN

According to Serrano Lasa [Serrano Lasa, 2007] the VSM technique was developed within the paradigm of Lean production and it was presented as an innovative graphical technique to help professionals to diagnose and redesign the production systems. This tool was developed by Toyota and known as "Mapping of material and information flow"[Thorsen, 2005], originally developed to diagnose and redesign value streams of production and distribution systems. Moreover, Rother & Shook [Rother and Shook, 2003] defined VSM as the illustration of all processes (value-added and non-value added) that are required to bring a product from the raw materials to the customer; besides VSM helps to identify all types of waste (eight waste of lean) in the value stream and target specific areas for improvement. However, the study of the VSM as a tool for environmental practices has relatively little theoretical background.

In Colombia, the business sector is classified into micro, small, medium and large sized enterprises; this classification is regulated by Law 590 of 2000, known as "Mipyme law". The term SMEs refers to the group of small and medium sized enterprises with total value assets greater than 500 and up to 15,000 minimum Colombian wages. Currently, it has been an important issue the incorporation of materials or products that have accomplished their life cycle or diminished their value, back in the productive cycle; for that reason it is included in corporate strategies [Díaz Fernández et al., 2004] and SMEs are acknowledging its importance because they represent between 96 and 98 percent out of the total Colombian enterprises [Latinpyme, 2013]. Moreover, SMEs face the challenge of competing with large enterprises to improve productivity and include environmental issues as key factor to success in a highly competitive market.

Even though SMEs have potential to compete with low prices and high quality, it is still difficult to achieve the environmental conservation with the design and development of environmental friendly products, because it is a costly process which is more suitable for large enterprises. However, the innovation process is undertaken by SMEs in order to develop new products, improving existing products, creating new ways to organize, manage, produce, and distribute them, while making better use of the SW generated in their production and logistics processes.

In this research an application of VSM to improve the solid waste management is implemented at one SMEs operating in a region of Colombia. The SW generated in the production processes of the enterprise come from processing of raw materials, work in process, finished products, packaging and returns, forming the so-called industrial solid waste. Therefore, this work focuses on the application of a methodological approach to improve the SW management at SMEs based on the Value Stream. Description of suggested conventions and indicators for mapping the SWs value stream is consolidated from a literature review of environmental lean management as well as the steps to drawing the VSM of current state and future state at one plastic sector SMEs of the Valle del Cauca department in Colombia. Therefore, the scope of this research validates the use of the VSM technique as an approach that significantly contributes to improve the SWM in SMEs. In next section the methodology is described followed by the literature review. In section fourth the design of the methodological approach is presented. Finally the application of the methodological approach in a pilot productive unit is described.

2. METHODOLOGY

The first stage of this research involved a literature review of scientific articles and academic reports, to explore theoretical foundations related to the environmental approach of VSM and SWM at SMEs. This stage was aiming at achieving more detailed overview about previous work and exploring different perspectives to propose an approach adjusted to the local conditions. Once the articles of interest were identified, the most relevant contributions were registered according to foundations of SWM and mapping of materials and SW streams by VSM. Also it was identified the conceptual strategies to improve the flows in SWM.

The second stage was the design of the methodological approach, considering the literature review and the basic concepts of VSM (fully described in Lean Management literature). Some excerpts were taken from theoretical work developed by Ross & Associates Environmental Consulting [Ross and Associates, 2002] and Hu & Lu [Hu and Lu, 2011] as a basis for designing the methodological approach. The approach was adapted to the conditions of the SMEs in order to improve the flow of materials and SW. In this sense, the graphical conventions, the steps and the measurement

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indicators were defined for mapping the SW. Finally, the methodological approach was applied to the Pilot Study Unit (PSU).

3. LITERATURE REVIEW

The Asia-Europe Meeting [E.I.C., 2012] in cooperation with UN Organizations, Global Consulting Firms and environmental experts has allowed ASEM SMEs Eco-Innovation Center to launch its first "ASEM SMEs Eco-Innovation Project Consulting". The project was developed to offer customized services in process, system, marketing and management innovation, helping SMEs to improve their overall environmental performance. In this project the materials flow analysis (MFA) was used as a tool of material management, waste minimization and established methods like resource optimization, reuse of scrap material, improved quality control, process monitoring and waste exchange as strategies to achieve a good environmental performance.

On the other hand, Hu & Lu [Hu and Lu, 2011] suggested that the VSM is readily extended to the environmental issues adding appropriate metrics, such as material used, material waste generated, energy and water consumption, which is very compatible with organizational features that include environmental management systems. The authors also compared the life cycle assessment (LCA) with the VSM in several respects, highlighting the advantages of VSM for this type of application. According to them, "VSM proves to be a better prototype of the visualization tool needed, because it can show the map of whole production process and is user-friendly while LCA shows a limited process view".

The United States Environmental Protection Agency (EPA) presented the publication "Lean & Environment Toolkit"[Ross and Associates, 2002] as an environmental approach guide for Lean practitioners, providing a theoretical basis and some examples of application of VSM with an environment perspective. In this research, the authors stated that "Value stream maps typically examine the time to produce a product and the proportion of that time that is value added, but they do not focus on the resources consumed and wasted in the development of that product". From this the EPA establishes the "line of material" as a way to adapt VSM to track the route and quantities of material used. On the other hand the work published by Wills [Wills, 2011] proposed a theoretical framework that identifies, describes and approximates the way to manage what he calls the seven green wastes. Among the contributions of the author is a general approach for using the VSM as a tool for improving the management of materials, including solid waste.

The activities related to the recovery of materials exposed in the work of Eco-Innovation-Center [E.I.C., 2012] and Dekker et al. [Dekker et al., 2004] provide strategies to improve SWM as resource optimization, reuse of scrap material, improved quality control, process monitoring and waste exchange that serve as potential actions to execute against the SWM weaknesses found with mapping. Reverse logistics is an alternative to redesign logistics flows in the future state VSM. As stated by Dekker et al. [Dekker et al., 2004], the activities of reverse logistics include collecting, inspecting, sorting, separation, recovery or reprocessing and redistribution. Moreover, Monroy & Ahumada [Monroy and Ahumada, 2006] identified potential reverse logistics supply chains, both, in-enterprise and out-enterprise business which are closely related to SWM. Therefore, the strategy of reverse logistics supports decision making for SWM and it complements the VSM technique to plan the logistics network configuration for SW: inventory, transportation and distribution.

4. DESIGN OF THE METHODOLOGICAL APPROACH

The methodological approach proposed in this research was designed based on previous works on VSM with environmental focus, however, we considered characteristics from both the application of VSM in manufacturing and the solid waste management in SMEs, so that the definition of flows, conventions, indicators and other aspects of the proposed approach are a robust framework for Lean practitioners requiring a validated and specified conceptual framework for solid waste management.

4.1 *Flows and conventions*

Originally, the flows considered in the VSM refer only to the flow of materials and products through a series of steps in the Value Stream. In the same way, the environmental VSM reviewed in the literature follows the same guidelines, it allows to track the raw material used by the process, therefore, it just maps the materials finally incorporated into the product. In this research it is suggested as convention the flow of materials finally incorporated into the product, defined as ***value added material flow***. Additionally, it is proposed three relevant flows to take into account in the VSM for SWM. First, the raw material that is not incorporated into the final product is identified as ***non-value added material flow***; which is generated in the form of defective products, returns, waste, etc. It is convenient to draw out the flow of SWs in the VSM since it can reveal future opportunities to apply reverse logistics or the recovery strategies. Waste can be recovered within and outside the organization [Monroy and Ahumada, 2006], therefore the second

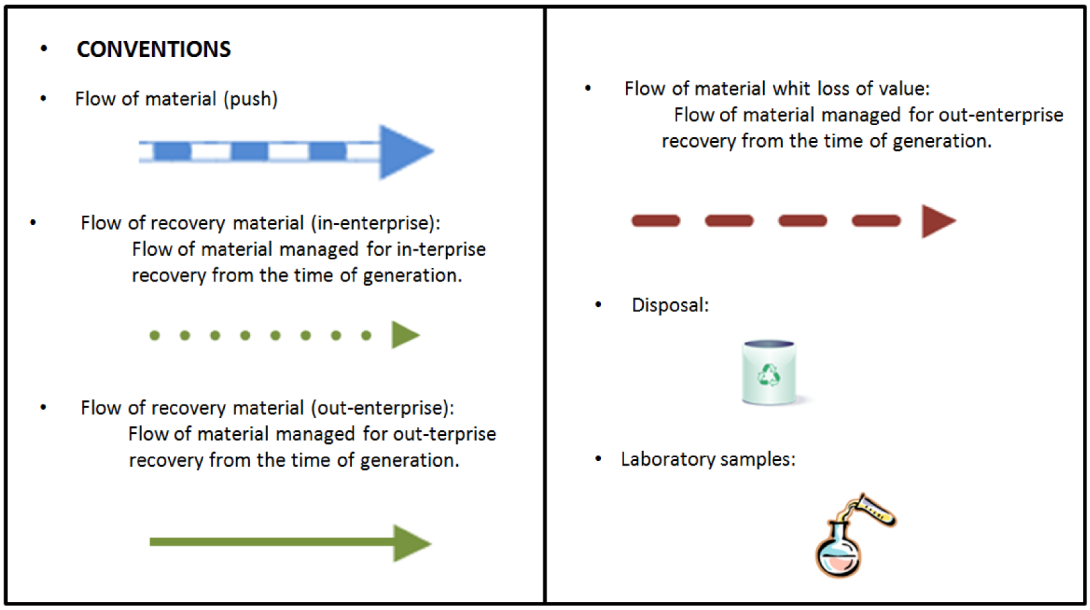

Figure 1. Flows and conventions of the VSM for SWM.

and third flows were identified as ***material flow recovered in-enterprise*** and ***material flow recovered out-enterprise***. Figure 1 summarizes the conventions proposed in this approach.

4.2 *Definition of indicators to measure the Value Stream of SW*

Three indicators (ratios) were defined to measure the flows in the mapping; these indicators were relevant for the line of materials:

- Value added material: Total value added (cumulated) in the last process / Total raw material used by all the processes, where the total value added (cumulated) in the last process is the total amount of material consumed and finally incorporated in the finished product.
- Non-value added material: Amount of non-value added material/ Total raw material used by all the processes, where the amount of material that does not add value is the total amount of material consumed and it is not finally incorporated in the finished product.
- Solid waste recovered: Solid waste recovered (in sales, repairs, remanufacturing, etc.) / Amount non-value added material.

4.3 *Steps defined for the methodological approach*

The methodological approach resulting from this research is summarized in six steps:

1. Characterization of the PSU
2. Selection of material to study and scope definition
3. Mapping and of the current state and data collection
4. Analysis of flow and data collection
5. Selection of the most appropriate waste management actions and mapping of the future state
6. Implementation of the agreed waste management action

4.4 *Waste management actions*

Eco-Innovation-Center [E.I.C., 2012] suggests different strategies to improve the environmental performance of SMEs once the weakness points of the productive processes have been identified. In this research few of these strategies are taken as the options for the step five in the methodological approach. These strategies are:

- Resource optimization, minimizing the amount of waste produced by organizations or individuals goes hand-in-hand with optimizing their use of raw materials.
- Reuse of scrap material, scraps can be immediately re-incorporated at the beginning of the manufacturing line so that they do not become a waste product.

- Improved quality control and process monitoring, steps can be taken to ensure that the number of rejected batches is kept to a minimum.
- Waste exchange, this is where the waste product of one process becomes the raw material for a second process. Waste exchanges represent another way of reducing waste disposal volumes for waste that cannot be eliminated.

5. APPLICATION OF THE METHODOLOGICAL APPROACH

5.1 *Characterization of the PSU*

The PSU of this research runs in the the plastic industry and produces a variety of molds and plastic parts made of plastic resins like polypropylene or polyethylene, as well as some special materials. The data provided by the company is modified due to confidentiality agreement; however, the proportions of the results are preserved.

The PSU is located in the industrial area of Yumbo, Valle del Cauca, Colombia and it is engaged in the manufacturing of injected plastics molds. The PSU manufactures products such as plastic caps for the pharmaceutical and food industry, car batteries components, components for the agricultural industry. The PSU had an average consumption of 116 tons of plastic resin per month during 2012 to produce all products portfolio. The production system used is characterized as “make to order”, but runs a production system “make to stock” for its main client, who demands car batteries components. The production processes of the PSU are indicated in Table 1.

5.2 *Selection of material to study and Scope definition*

In order to draw the VSM it is necessary to select the material to study (Value Stream). That selection was carried out in the PSU taking different aspects in consideration such as the main raw material of the principal products and the amount of solid waste generated in any Value Stream of materials. Likewise, the observation time was defined (day, week, month, year, etc.) from the average values of the flows studied. The plastic resins were the materials mapped (raw material) which form part of all the products studied.

The production process of injection was studied. This Value Stream was chosen for the following reasons:

1. The process is directly related to the mission (Manufacture of plastic products by injection).
2. It is the process that requires more resources such as raw materials, energy, water and personal.
3. It is the principal generator of solid waste.

5.3 *Mapping and data collection of the current state*

Through the current VSM (Figure 2) it was possible to identify the flows of materials and information involved in the process and the amount of solid waste generated and managed inside and outside the company. Also, it was established a basis for improvement suggestions and develop a VSM of the future state. In order to collect data, serveral visits to the PSU were made where the processes and flows were observed; likewise values of the defined attributes were recorded. The data were recorded using forms containing the attribute of the VSM data boxes.

5.4 *Analysis of flows and data*

In this step, the value flow analysis tool was used. This tool consists of tabulating inflows and outflows for each process that occurs in the value chain, describing, quantifying and classifying them as streams that add value or not, i.e., streams which are part of the final product or are residues respectively. Then actions conducive to reuse, recycle internally or externally, or make the final disposal of waste not recovered are defined. In the process were identified three SW flows of plastic resin that not add value, which represents the six percent of total raw material used by all the processes and also, an opportunity for improvement. Those flows originated from the injection and punching process and the returns from customers revealed weaknesses in quality control and failures in SWM due to fails in the recovery strategy. Additionally, the SW generated in the punching process involves the handling of hydraulic machines; therefore SW is contaminated and not suitable for recovering.

5.5 *Selection of the most appropriate waste management actions and Mapping of the future state*

The chemical characteristics of the materials that do not add value (plastic resin waste) allow them to be reincorporated in the process, for that reason the waste management action proposed is reuse of scrap materials". This strategy for waste management is of common use in this kind of industry. For instance, Monroy & Ahumada [Monroy and Ahumada, 2006] reported the case of a producer of batteries located in Colombia that recycles car batteries and reincorporates the different parts of the batteries (included the plastic components) into the production process. To implement this strategy it is necessary to develop a recovery process in which the SW will be milled in order to convert it in recycled resin.

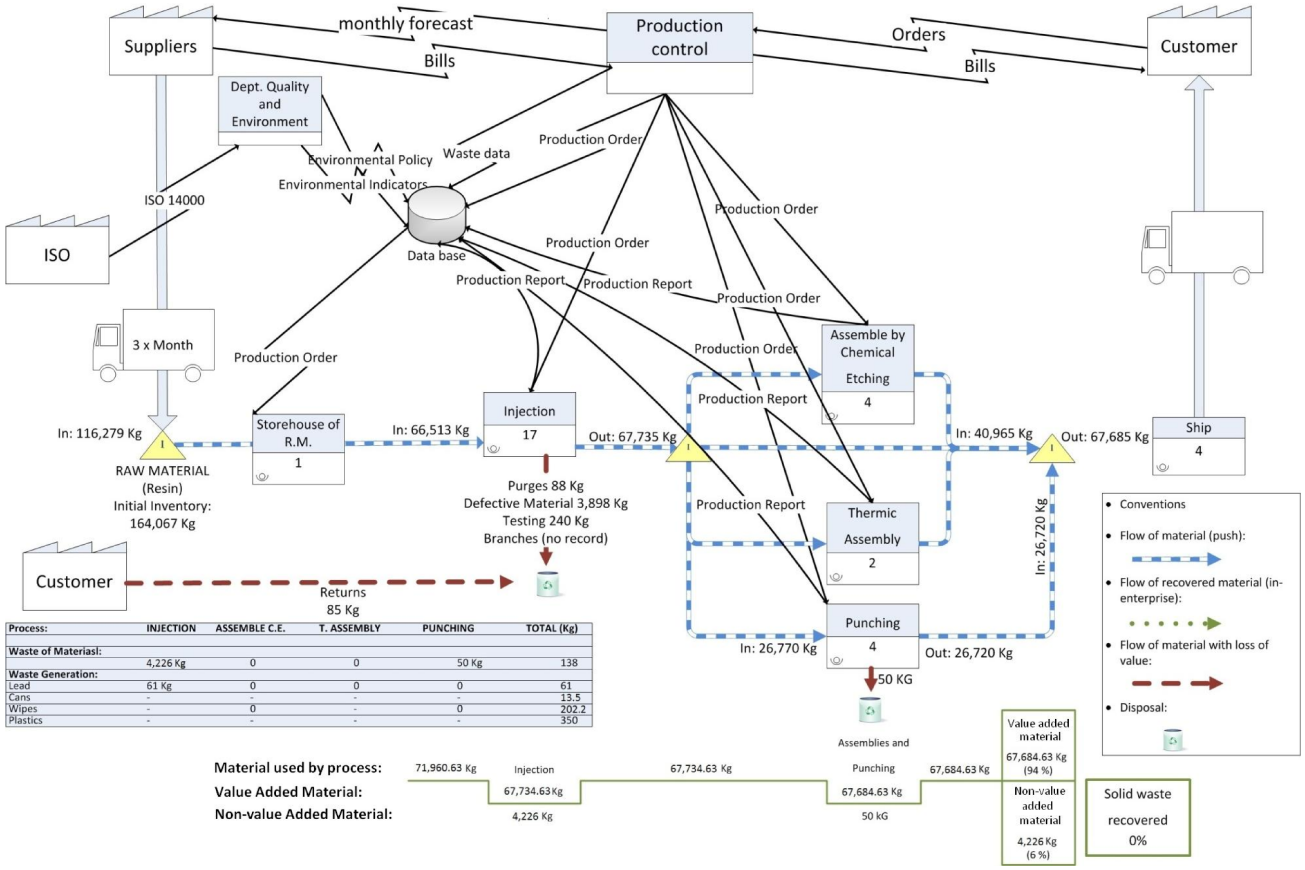

Figure 2. Current VSM for SWM. Source: the authors.

Some SW from the injection process can be reincorporated immediately avoiding a possible inventory accumulation of recycled resin. This is possible for some products like the covers of some SKUs, while others require the storage of the recovered resin generated before milling it. This is the case of the recovered resin from the production of larger products such as batteries. As a result, the VSM of Future State were consolidated (Figure 3) suggesting the material flows that can be improved.

The expected results are summarized in Table 2, in which it is shown an improvement in the SW recovered indicator as proposed by the chosen strategy.

5.6 *Implementation of the agreed waste management action*

At the end of this research, the PSU already was applying the methodological approach described in section 4.3, and developing an implementation plan for the proposed actions described in section 5.5.

6. CONCLUSIONS

This study validates that VSM becomes a way towards solid waste management in order to identify and decide about the solid waste in the value stream. This study provides an approach to help the SMEs in a region of Colombia to achieve control of their value stream leading to future improvements. VSM has been perceived as a valuable planning tool and can be used for developing and implementing solid waste management projects. Eventually, it enables SMEs to move towards an active role in developing environmental practices, resulting in future success.

On the other hand, it should be noted that the suggestions built in the future state map should be complemented by other studies related to characteristics of the materials and the organizational structure of the enterprises. Additionally, it should be considered in a future work other uses of the solid waste in an inter-enterprise recovery model as a strategy to reduce costs, gain earnings and mitigate negative environmental effects.

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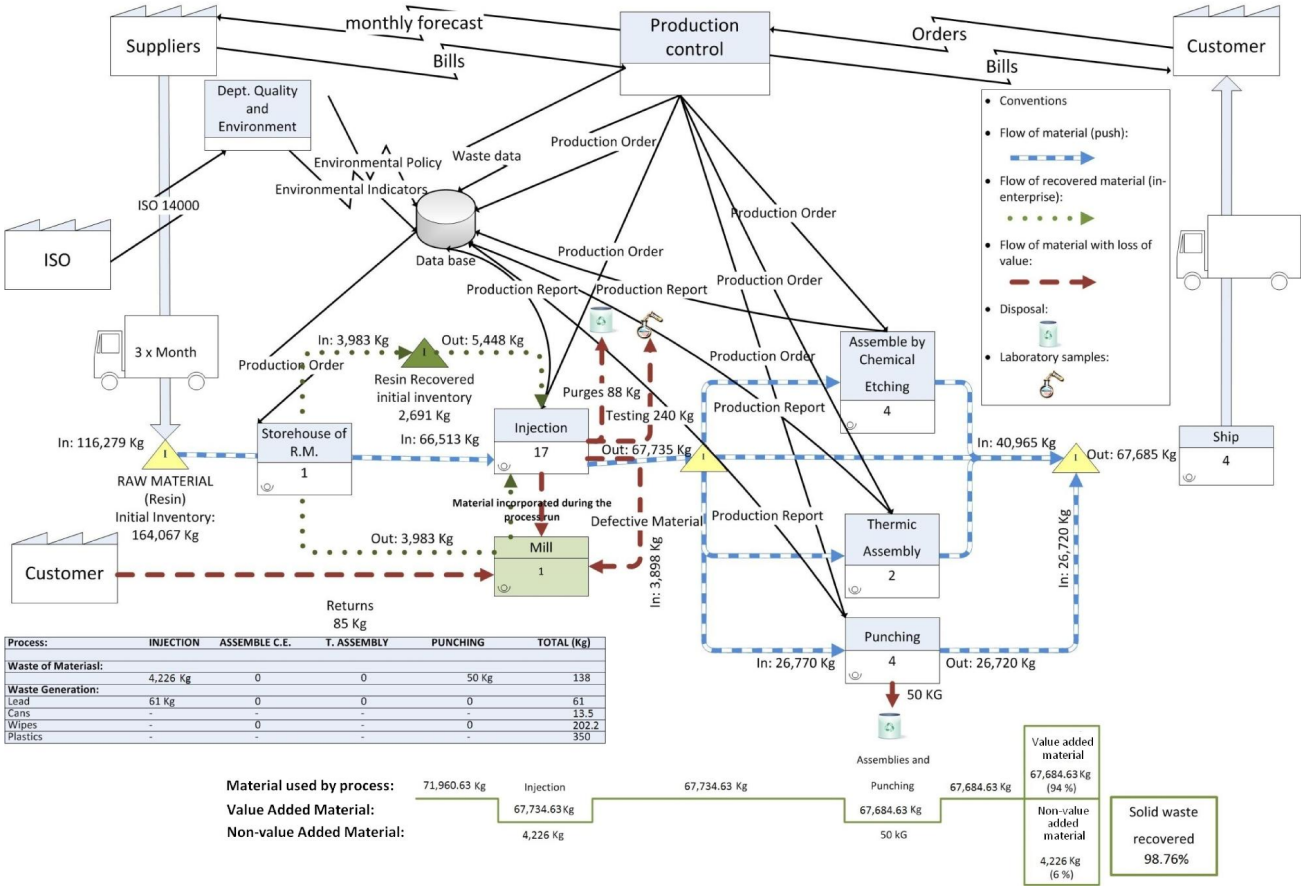

Process:	INJECTION	ASSEMBLE C.E.	T. ASSEMBLY	PUNCHING	TOTAL (Kg)
Waste of Materiasl:					
	4,226 Kg	0	0	50 Kg	138
Waste Generation:					
Lead	61 Kg	0	0	0	61
Cans	-	-	-	-	13.5
Wipes	-	0	-	0	202.2
Plastics	-	-	-	-	350

Figure 3. Future VSM for SWM. Source: Authors

Table 1. Processes of the PSU

Process:	Manual Assembly	Assembly by Chemical Etching	Thermic Assembly	Mold Making	Injection	Punching
PSU	X	X	X	X	X	X

Table 2. Expected results after applying of the proposed methodology.

Indicators	Current state of the Value Stream	Future state of the Value Stream
Material Adding Value	94 %	94 %
Material that does not add Value	6 %	6 %
SW Recovered	0 %	98 % (from the 6 %)

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