Design the Value Stream Mapping for the Green Manufacturing

A Case Study:

Scancom Vietnam Limited Company

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Abstract. In recent years, green manufacturing has gained more awareness among both manufacturers and customers. As one of the most approaches, lean principles and techniques are becoming very useful to improve the productivity by reducing the wastes. Thus, it is very necessary to explore more applications of lean manufacturing into increasing the environmental performance of the systems. In this paper, the case of recycling system in Scancom Furniture Company is considered for improving the flow of material through the systems. It takes an important part in company to utilize the unused pieces of wood which are reused and recycled for the main production. By the reason, the main purpose aims to improve productivity for this system. After that, there are two lean techniques: Eliminate Rearrange Combination Standardization (ERCS) and line balancing applied for system improvement. The main contribution provided significant improvement by reducing 45% of WIP and 41.37% of total waiting time for the systems.

Keywords: Green manufacturing, Lean production, Value stream mapping (VSM), Line balancing, Work design

1. INTRODUCTION

In manufacturing, increasing efficiency of working, designing and developing a good production system in factory is an important role. A green production system is the solution for this concern. This philosophy aims at reducing production cost and reduce environmental impact by reusing and recycling defective products. By this practice, the amount of material intended for throwing back to the environment are used to produce the new products.

This paper will take a case study of a company, named Scancom, which producing a wide range of furniture made of wood and wood plastics composite. Scancom has a recycling system that using defect embryos recycle to the new curve embryos. These embryos are used for long leg part of Folding Armchair model. However, there are some problems in this system. Firstly, unused pieces of wood are not reused effectively. The fact that these pieces are finally disposed to the environment makes the company suffers lost for not utilizing available resource and incurs lost for waste treatment activities. Secondly, the high number of

work in process (WIP) in some processes creates bottleneck and make the whole system work inefficiently. Furthermore, workers at Scancom are faced with many health risks due to their wrong motion.

The contribution of this paper includes reducing the WIP, reducing the movement and reducing the unnecessary motion for workers in Workshop 2 of which main tasks are cutting, jointing and assemble wood.

2. LITERATURE REVIEW

In the recent years, the approach of a lean production is not enough, the enterprises have realized that green manufacturing has contributed an important part to the system. It is mainly because customer needs become more and more increasing. They require products with lower cost and high quality but also be friendly with user and environment.

2.1 Green manufacturing:

Initially (Rothenberg, Pil, & Maxwell, 2001) it required some company present their way how to reduce emission. The results collected are increasing recycling and reuse, changed processes and materials and restore energy. The organization developed should be concerned two aspects environmental performance and business performance. (Sezen & Wang, 2011) The study is presented that culture management system needs established to promote the objectives of sustainability. In the manufacturing, the issues are such as material using in the production process, emission generated, wastewater, the life of the product and finally are important factors to remanufacturing approach the successful. (Hartini & Ciptomulyono, 2015) the presented about the relationship between lean and sustainable manufacturing. That is lean, bringing the many benefits of a sustainable production system. The main purpose is to identify the gaps between lean and sustainable manufacturing.

2.1 Lean production:

Lean manufacturing is used less of source such as: haft the time, haft the manufacturing space to design new products, haft the investment in tools. In addition, it also is haft inventory, defects fewer, produces greater and products variety (Krafcik, 1988). A final conception claimed by (Naylor, 1999) that lean manufacturing is designed and developed value stream to eliminate waste types in the process. Even though it defined with many of different conceptions, it aims to simplify the operation process by reducing waste and emission to the environment. The resources such as time, transportation, inventory, process. It is a tool that helps the enterprises recognize and eliminate non-value adding in the production process. A final conception claimed by (Dankbaar, 1997), lean techniques have support to continuous improvement, it produces product variety, make lower cost and high quality.

2.3 Lean Production and green manufacturing

(Rother & Shook, 2003) showed that value stream mapping (VSM) can help manufacturers identify wastes in the production system. Hence, Lean production has effects on reducing the impacts to the environment. The table of environmental impacts linked with manufacturing waste is quoted in EPA. Lean Extended Value Stream in 'Seeing the whole mapping the extended value stream' book by (Dan & Jim, 2013) is presented that when the mapping at the facilities, the problems should be the best concerned such as overproduction, transportation and inventory. There are many concepts and evidences about the relationship between lean and green manufacturing and methods adoption of Lean tools in reducing energy waste and emission. However, it is not clear about the relationship between them. Specially, there is not any case study is adoption in wood company that apply lean tools to support for green manufacturing. Therefore, the purpose of this thesis is making good the gaps and carry the mutual support between lean and green into the fact-case study.

3. METHODOLOGY:

The current state of Value Stream Mapping interact with simulation that support to identify the wastes in the system. The results from simulation run is used to draw the value stream mapping for exposing the wastes of the process and then apply lean tools to improve the problem by reducing the wastes. After that, the interaction of simulation and the future state of VSM is applied to take results from the improvement step.

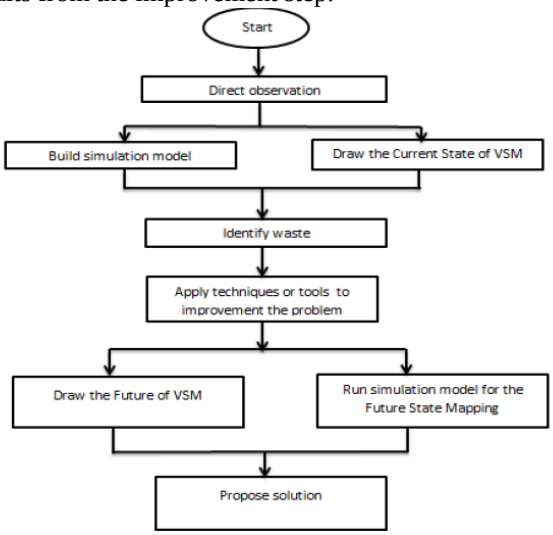

Figure 1: Research framework

3.1 The Current State Mapping

There are three main parts in the study. Those are drawing the current value stream mapping (VSM) of the considered area, implementing the improvement techniques of lean tools and generating the future value stream mapping. In the first part, after the current state map is determined, a simulation model is conducted to check that result with the data in reality. The output of this part is the number of WIP, waiting time, resource utilization of each work station from the result of the Arena. In the second part, it will employ on work design & standardization and line balancing, optimizing Kanban system for system improvement. The proposed solutions are validated by simulation prior to the third part, which is future state mapping.

- No workout occurs suddenly (machine breaks down, maintain...)
- There is no changed in human resources (leave or sick)

Input data, are processing time in each workstation. Input Analyzer is used to analyze the data of period time of each process, determine the most appropriate distribution for input of simulation modeling, which solution is in appendix 1. Then, independent t-test is used to test the similarity between the result of the model and the real system.

The Current state mapping (figure 2) includes the following steps:

- Define the information flow:
- Map basic production processes:
- Define data to be collected: demand, product family, working time, cycle time, processing time, number of operation and number of machines (table 2).

3.1.1. Assuming in the model

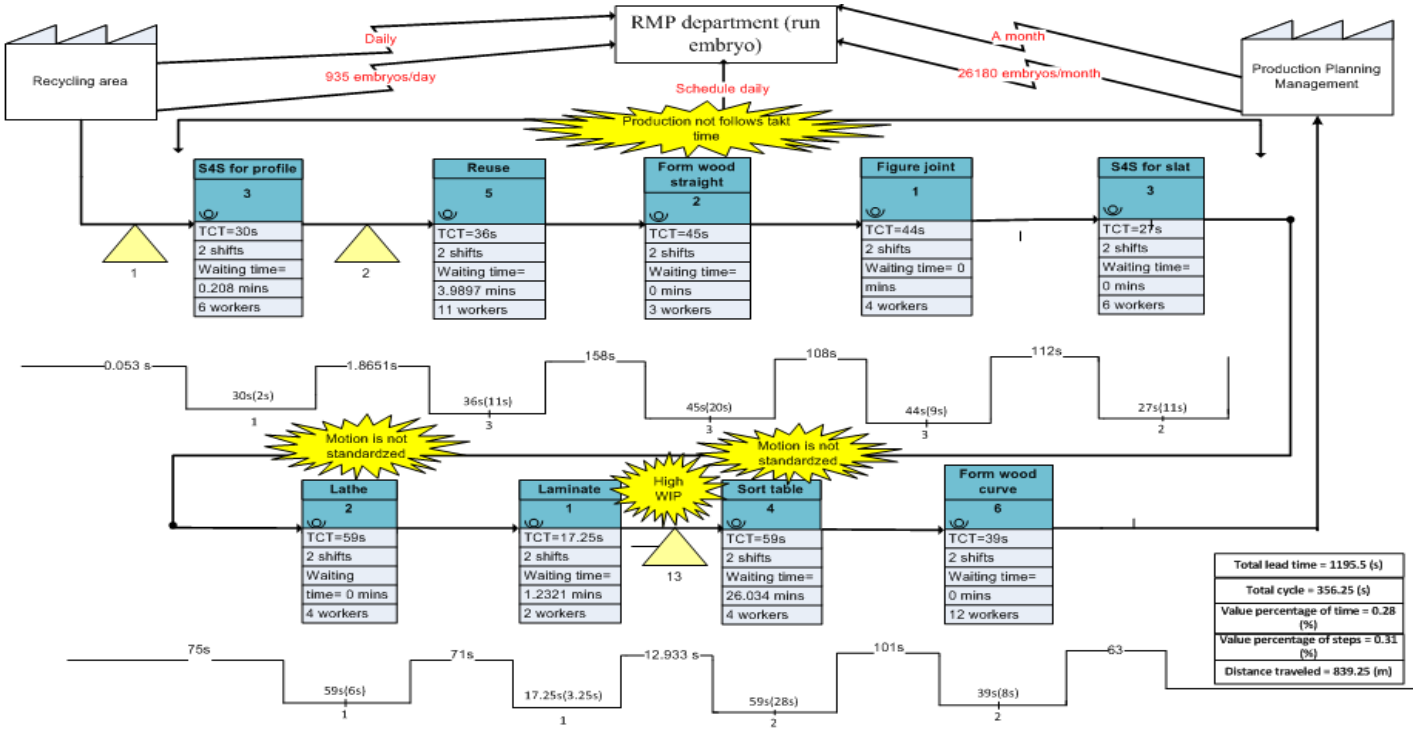

Figure 2: The Current State Mapping

We complete the timeline segment with number step of value added, the total value added time in each workstation, the total cycle time and the time of distance traveled. And then, we signal Kanban burst to identify problem needed to improve.

According to the Value Stream Mapping, the line is unbalanced, the production does not follow takt time, the process still exists extra motion in the non-value added activities. And easy to see that the cycle time of each work station smaller than the total lead time is 1195.5 (s), total time of value percentage 28%, value percentage of steps 32%. Besides that, there are some workstations no waiting or time low waiting time while some workstations long waiting time. So, we propose some techniques and tools for improving.

3.1.2. Identify problems:

Using the Fish bone chart to analyze reasons cause the extra motion (figure 3), movement (figure 4) and high WIP (figure 5) in the production process. There are 4 reasons are by machine, man, material and method.

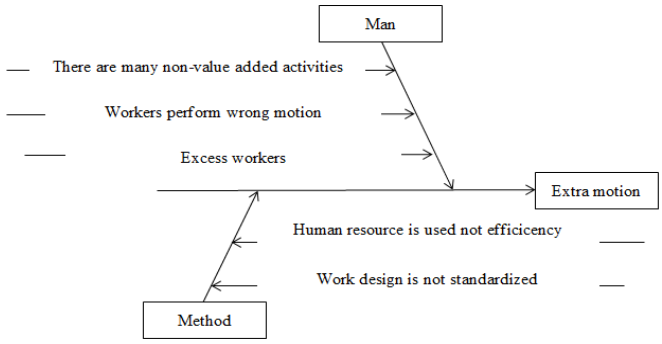

Figure 3: The cause of extra motion

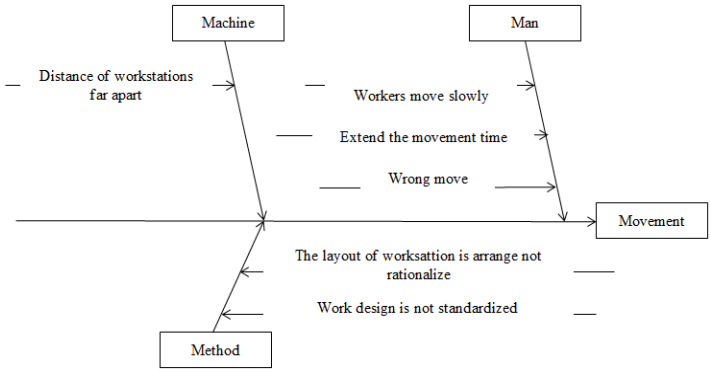

Figure 4: The cause of long movement

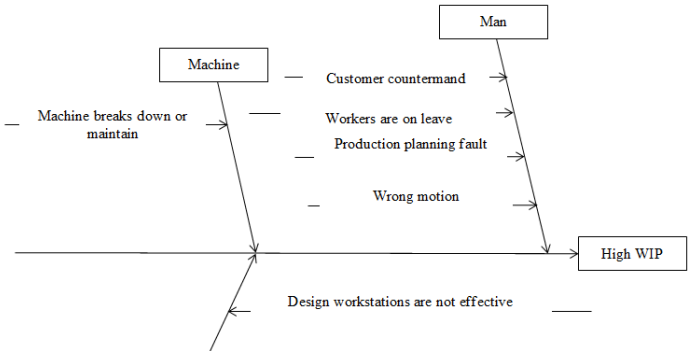

Figure 5: The cause of High WIP

3.2. Solution for improvement:

3.2.1 Operation Balance Chart:

According the Operation Chart we see that the cycle time of each work station are not equal (figure 5). There are some workstations have a cycle time exceed the takt time, it means that the production process is unbalanced. In the Recycling system, there are two workstations had a cycle time exceed takt time are Lathe and Sort table.

The efficiency of line balancing is 67.09%. This means he productivity of production line is not efficiency. Therefore, we will redesign the production line to reduce waste in time.

3.2.2 Design and standardize motion:

Process flow chart is a chart included symbols that represent the treating is performed operation various processing operations are performed on a part of the job.

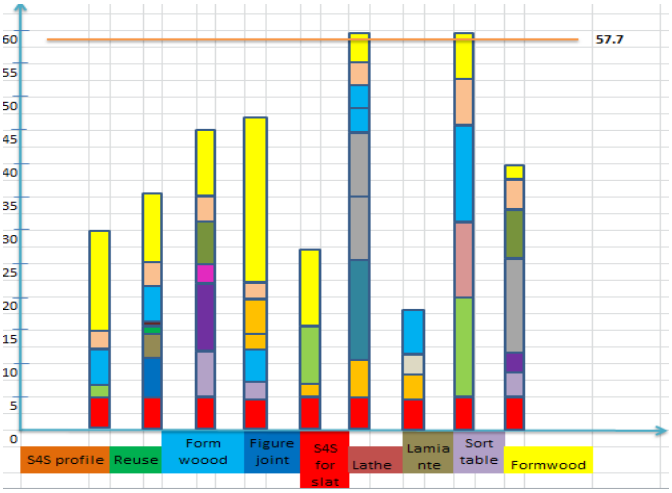

Figure 5: The Operation Balance Chart

The symbols used in the process flow chart shown in the appendix 1

The time to worker complete a pallet (300 embryos) is 4 hours 92 minutes (17700 seconds) before improving. After improving, 1 embryo is performed in 49 seconds. The productivity of the 'Lathe' work station = (17700s/ 49s) = 361.22 embryos/ pallet. This means that productivity increase 61 embryos/ pallet compare with before improving.

The 'Lathe' work station:

The work at the Lathe workstations is being arranged as shown in the Process flow diagram ECRS Figure. However, according to visual observations can be seen that waiting time of worker when one embryo ran out of machine is 9s, and then, workers get embryos down pallet took 11s. Thus, time of embryo ran out of machine is quite slow compared to the time of worker needed to get embryos down pallet. This means that if only one worker working at the workstation can still be completed to schedule. Currently, there are two workers at the workstation, this leads to

Before improving				After improving		
	Take embryos from the pallet	5		Take embryos from the pallet	5	
	Work 1 puts embryos to machine	7		Work 1 puts embryos to machine	7	
	Worker 2 waits embryos	11		Worker 2 wait and take out embryos	11	
	Worker 3 waits embryos	11				
Lathe	Worker 2 arranges embryos in the pallet	9	59	Worker 2 arranges embryos in the pallet	9	39
	Worker 3 arranges embryos in the pallet	9		Lifting the pallet	3	
	Lifting the pallet	3		Remove pass step 'Laminate'	4	
	Remove pass step 'Laminate'	4				

Figure 7: Before and after improving the workstation "Lathe"

increased cycle time and work arrangements have not been standardized. Moreover, the position of the workers standing on the machine and the location of pallet too far apart, that led to the workers to crouch over to influence their health in (figure 7).

The 'Sort table' work station:

The motion Sort table of worker at present is performed as follows the table below. However, there are some extra motion can change as follows: in the left-hand of workers put available a beautiful wooden leaf, in the right-hand side is the place where selects the standard color of wood. The good wood leaf will place on the beautiful wood leaf on the left-hand side so as to enough 11 leaves, and thin rim more a beautiful wood. This operation following the visual observation will save more time. We will eliminate a stage is "Get down the pallet" that happening after the stage 'Select color of wood as follows the standard'. This one is

Before improving				After improving			
Workstation	Activities	CT	TCT	The left	The right	CT	TCT
Sort table	Take embryos from the pallet	5	59	Take embryos from the pallet		5	49
	Select color of wood as follows the standard	15		Select color of wood as follows the standard	Rim alternately good wood pieces and bad wood pieces	24	
	Get down the pallet	6		Get down the pallet		7	
	Count and rim alternately good wood pieces and bad wood pieces	13		Lifting the pallet		4	
	Get down the pallet	7					
	Lifting the pallet	4		Remove pass step 'Formwood (glue curve wood)'		9	
	Remove pass step 'Formwood (glue curve wood)'	9					

Figure 8: Before and after improving the workstation "Sort table"

simultaneous eliminated the crouch over motion that causes to the health of workers in (figure 8).

3.2.3 Line balancing:

According the Flexible Line Balancing software, we realized that can be grouped two workstation Lathe (6) and workstation Laminate (7) together in (figure 9).

The inital efficiency of line balancing is 67.09%, the efficiency after improving is 72.5%. Hence, the efficiency increase (72.5%-67.09%) /(67.09%) = 8%.

The initial bottleneck is 59s in workstation 'Lathe' and workstation 'Sort table', cycle time is exceeded takt time standard. After grouping workstation together, the bottleneck is 56.25 in workstation 'Lathe' and 'Laminate', cycle time is underlying takt time standard.

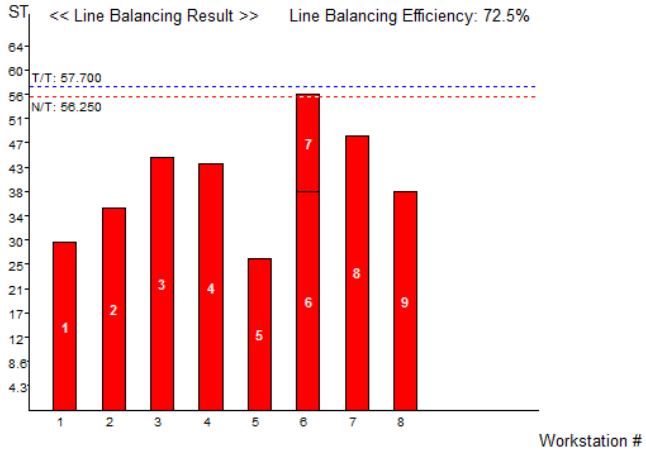

Figure 9: The line balancing efficiency after balancing

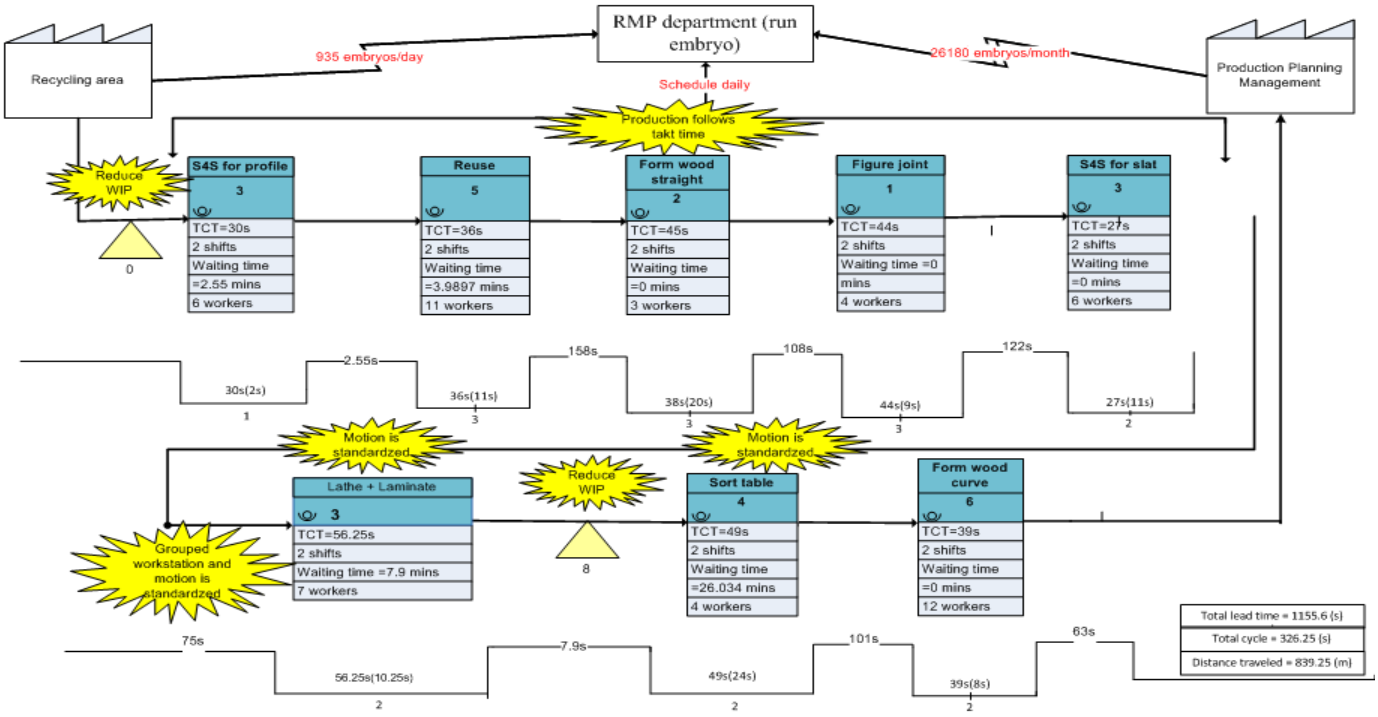

Figure 10: Future State Mapping

3.1 The Current State Mapping

The total cycle time of workstation 'Lathe' and 'Laminate' decrease by grouping. The motion on workstation 'Lathe' and 'Sort table' is more standardized and the production line produced follows takt time. Sum of improvement above, the total lead time reduced 1155.6 (s). We draw the future state of value stream mapping (VSM)

After applying Line balancing method to grouped workstation, we again simulate for the workstations, the processing time is changed after applying the way of grouped workstations and is present in (figure 10)

4. SOLUTION:

After running Arena for the improvement result, we can see that the value added time increase, the waiting time and the total time decrease clearly, the number of WIP in workstation has also decreased much compared with before improving. Specifically, we have a summary table of the result before and after improving that run by simulation in table 1.

5. CONCLUSION:

This study applied lean tools to improve the resource recovery systems (Green system) at the Scancom company. Thus, it takes part in narrow the gap between lean and green production. In this study, the integration of two methods, simulation and value stream mapping is effective to identify waste and validate the solution from improvement tools. A good solution of this work has reduced significantly total lead time, decrease amount of WIP in systems, improve the system utilization.

Elements change (embryo)	Before improving	After improving	Improvement percent
The numbers in	484	484	
The numbers out (embryo)	454	462	Increase 1.76%
The value added time (s)	5.1407	5.1416	Increase 0.02%
The waiting time (s)	14.8670	10.5162	Decrease 41.37%
The total time (s)	20.0077	15.6578	Decrease 27.28%
Total of number WIP (embryo)	16	11	Decrease 45.45%
The lead time (s)	1195.5	1155.6	Decrease 3.45 %
The total cycle time (s)	356.25	326.25	Decrease 9.20%
Human resource	55	54	Decrease 1.85 %

Table 1: the result before and after improving that run by simulation

APPENDICES

	S4S profile	**Reuse**	**Formwood (glue straight part)**	**Figure joint**	**S4S for slat**	**Lathe**	**Laminate**	**Sort table**	**Formwood (glue curve part)**
Number of machines	3	5	2	1	3	2	1	4 tables	6
Number of workers	6	9	6	4	6	6	2	4	12
Capacity (embryo/shift)	497	430	498	501	495	495	487	499	499
The total time available for per month	29820	25800	29880	30060	29700	29700	29220	29940	29940
Total cycle time(embryo/second)	30	36	45	44	27	59	17.25	59	39
Number of shifts	2	2	2	2	2	2	2	2	2
Distance traveled of workers (meter)	4.6	5.2	4.6	5.8	2.8	0.2	0.1	1	1.4
The time of distance traveled (s)	110	158	108	112	75	71	41.25	101	63
Waiting time (min) (per day)	0.208	3.9897	0	0	0	0	1.2321	26.034	0

Table 2: The data collection in each workstation support to complete the data box in Value Stream Mapping

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