Simulation Study of Cooking Stove Production

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Abstract

This paper presents a case study of a cooking stove liner production in a particular company in Myanmar. Due to the high demand, the company needs to increase its production output using the automated molding system. Manual production of stove making process requires more time than the automated production line. This study deals with Simulation study of a cooking stove industry, Myanmar. A simulation model has been developed and implemented using Tecnomatix Plant Simulation - Siemens PLM Software. The models for the traditional (current) process and the semi-automated process were built and results are compared. The implemented models have been verified and validated. The performance measures are the production size and processing time.

Keywords: *Cooking stove production, productivity improvement, simulation, discrete event simulation*

1. INTRODUCTION

Stoves have been used for cooking many years ago. Stove models have been developed due to their necessity. Currently cooking stove production is manual. The industry needs around 37 to 40 days to make a stove manually. The stove manufacturing industries prefer semi automation to increase their production quantity with improvements and quality products. They are trying to reduce the cost and production time and increase the productivity. Therefore, companies are planning to make the stoves using the automated mold for increasing the production rate. In this regard, automated molding system is considered to integrate the existing traditional production line. The manual process of the stove production is more fatigue for the labors too. Production flow and layout have always been of major concern in the production line. They directly affect the productivity of a manufacturing plant [1] [2]. Figure 1 shows the current manual process of stove production line. Discrete event simulation (DES) has been recognized as a powerful tool that is available to predict overall system performance, such as the throughput of a system [3]. The industries use computer simulation such as Discrete Event Simulation, Plant simulation and Excel to calculate the production time and costing for the products. Simulations show the graphical solutions which makes the decision making process much easier. Production time analysis, cost analysis and process mapping are very important things for a successful new product development. Simulation tools offer users the ability to investigate many diverse process systems for production plants, without spending large amount of money on testing in real assembly plants [4]. One of DES software that widely used in industry is SIEMENS Technomatrix Plant Simulation [5]. In the past, a number of case studies have been conducted by implementing DES techniques in order to enhance productivity. A case study about Cost and Benefit Analysis of the Installation of Improved Cooking Stoves has been studied by [6]. The reproduction of a real system with its dynamic processes in a model is known as Simulation. The

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ultimate goal is to reach transferable findings for the reality. Simulation in a broader sense is the process of preparing, implementing and evaluating specific experiments with a simulation model. Moreover, simulation run is where the image of the behavior of the system in the simulation model within a specified period.

The main objectives of this study are (i) To construct a work flow diagram for stove production, (ii) To implement process simulation model using SIEMENS plant simulation software, (iii) To apply the simulation model in the evaluation of different scenarios to improve performance of the system, (iv) To provide a tool that can be used in the planning of the production system of the company.

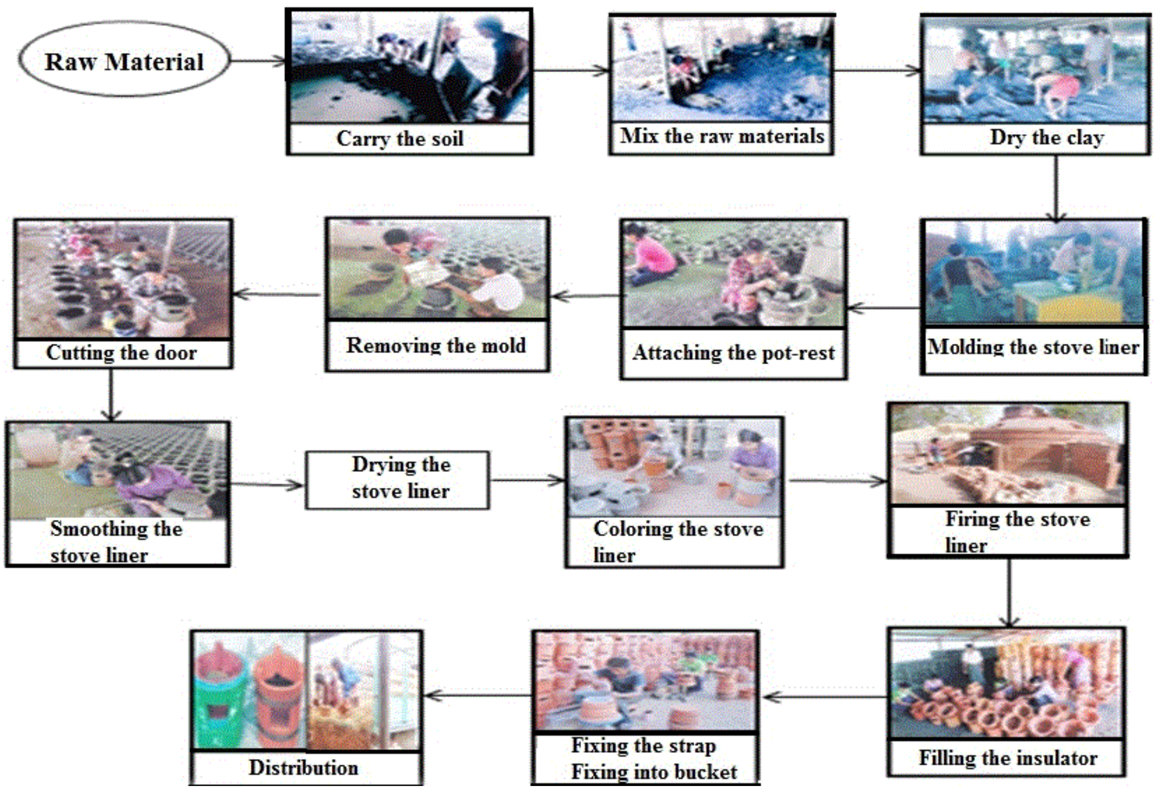

Figure 1: Current manual process of stove manufacturing

2. Simulation Model

The simulation model of the selected stove production line (Figure 1) was built in Siemens Plant Simulation software.

2.1 Case Study

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The case selected for this study is that of cooking stove manufacturing company in Myanmar. The following data for the current process has been provided by the stove manufacturing company;

- Total number of workers= 85
- Number of shifts = 2 shift/day for two types of stove design
- Working hours / shift = 8 hours/shift
- Number of stoves / day = 240 for each type of stove design
- Raw materials cost / stove = US$ 0.126/ stove
- Raw material cost for total production / day = US$ 62.5/ day
- Transportation cost / day = US$ 36.67/day
- Electricity & other utility cost / day = US$ 80/ day
- Defects is occur 3% per day for the current process of the stove production.

The table 1 shows the total number of workers and the Average process time for each process in current production system of the stove manufacturing company. The workers include total number of staffs and total number of laborers. The process time for each process has been mentioned in “day: hour: minute: second: millisecond” because the plant simulation software requires the data to be in that format. Moreover, Set-up time and Recovery time for each process is around 5-10 seconds. It will vary depending on the workers experience of the specific process.

	Average Process Time				
Process	**Day**	**Hour**	**Minute**	**Second**	**Millisecond**
Carry the Soil	0	0	1	31	25
Mix the Raw material	0	0	10	0	0
Dry the clay	1	0	0	0	0
Molding the stove liner	0	0	2	22	0
Attaching the pot-rest	0	0	0	52	8
Removing the mold	0	0	0	8	0
Cutting the door	0	0	1	10	4
Smoothing the stove liner	0	0	10	28	93
Drying the stove liner	1	0	0	0	0
Coloring the stove liner	0	0	1	35	87
Firing the stove liner	3	8	0	0	0
Filling the insulator	0	0	0	53	79
Fixing the strap / Fixing into bucket	0	0	0	58	88
Distribution	0	8	0	0	0

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Total number of workers	85

Table 1: Average time data of the current process

2.2 Semi-automation process of stove manufacturing

Figure 2 presents the semi-automation process of stove manufacturing. The automated molding process integration is considered in the current existing production line. Two different molding systems are designed, implemented and integrated in the simulation study.

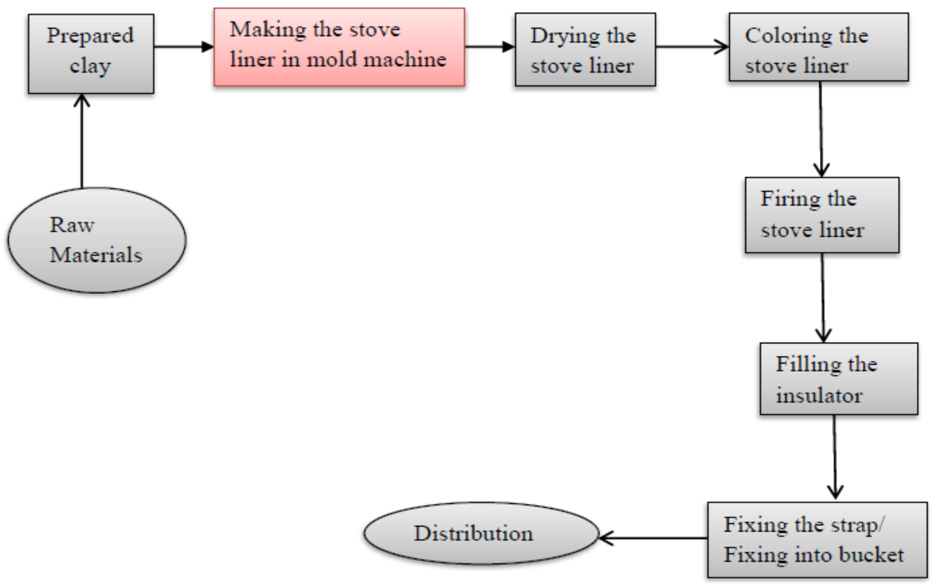

Figure 2: Semi-automation process of stove manufacturing

2.2.1 Development of Automated Molding Machines

Two different designs for automated molding process are designed and implemented. The prototypes (Machine No. 1 and No. 2) are shown in Figure 3 (a) and 3 (b).

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Figure 3(a) Machine No.1

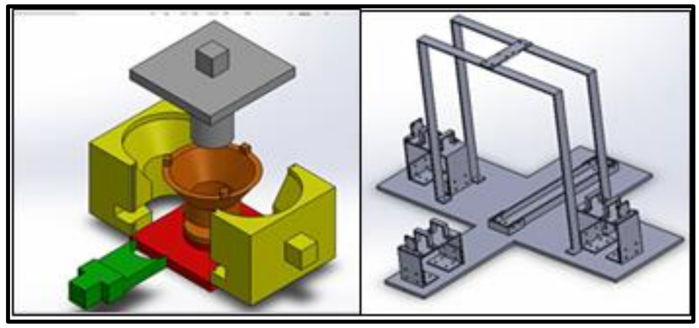

Figure 3(b) Machine No.2

The total cost of the machine No. 1 (Table 2) and parts that are used to make the machine 1. Machine 1 is working with pneumatic system and is controlled by the PLC. This machine design includes the door and pot-rest design to reduce the fatigue of workers. Only one worker needs to operate the machine in order make the stove liner. The cost of the machine is 40480.4 baht.

Description	**Machine 1**		
	Quantity	**Price/Unit**	**Subtotal**
Inside stove mold	1 pcs	2500	2500
Outside stove mold	1 pcs	2500	2500
Inside hole mold	1 pcs	1000	1000
Vat 7%			420
0010141205 Solenoid valve civil pneumatic	2 pcs	750	1500
0010141204 Solenoid valve civil pneumatic	1 pcs	350	350
1019817 Pneumatic cables	5 meter	10	50
001028167 Pneumatic Seal	2 pcs	18	36
002003341 Pneumatic cylinder	2 pcs	2,000	4,000
0020032001 Pneumatic cylinder	1 pcs	1200	1200
1RTO00087 Pneumatic valve	4 pcs	95	380
1RTO00088 Pneumatic valve	2 pcs	95	190
Vat 7%			39.9
1ACCV00005 Solenoid valve	1 pcs	350	350
Vat 7%			24.5
Vibrator holder	1 set	6,000	6000
Vat 7%			420
PLC	1 set	10000	10000
Wiring Materials			2030

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Base Frame and pneumatic holder with vat 7%	1 set	7490	7490
Total (Thai Baht)			40480.4

Table 2: Cost details of machine No.1

The time data for the machine 1 is shown in Table 3. The data includes processing time, recovery time, cycle time and setup time in order to do the simulation model by using plant simulation software. The unit of time is in seconds.

Time (Seconds)	Machine 1
Processing time	1650
Recovery time	2
Cycle time	1
Setup time	3

Table 3: Time data of machine 1

The table 4 presents the total cost of the machine 2 and the parts that are used to make the machine 2. Machine 2 is working with pneumatic system and is controlled by PLC. The door and the pot-rest design are included in this machine to reduce the fatigue of the workers. Only one worker needs to operate the machine in order make the stove liner. The cost of the machine is 52353 baht.

Description	Machine 2		
	Quality	Price/Unit	Sub-Total
Pneumatics	1 set	9179	9179
Mold	1 pc	22971	22971
Machine Design	1 pc	7383	7383
Wiring Materials			3000
PLC	1 set	10000	10000
Total (Baht)			52,353

Table 4: Cost details of machine 2

The table 5 shows the time data for the machine 2. Processing time, recovery time, cycle time and setup time are included in the data table in order to do the simulation model using plant simulation software. The unit of time is in seconds.

Time (Seconds)	Machine 2
Processing time	1760
Recovery time	3
Cycle time	1
Setup time	2

Table 5: Time data of machine 2

3. Results and Discussion

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3.1 Production Time Analysis for Current Process

The process mapping of current production is shown in Figure 4. The process mapping is done using plant simulation software. According to the data that was provided by the industry; total number of labors are 62 including both men and women. Approximately 31 labors are working for the charcoal stove production.

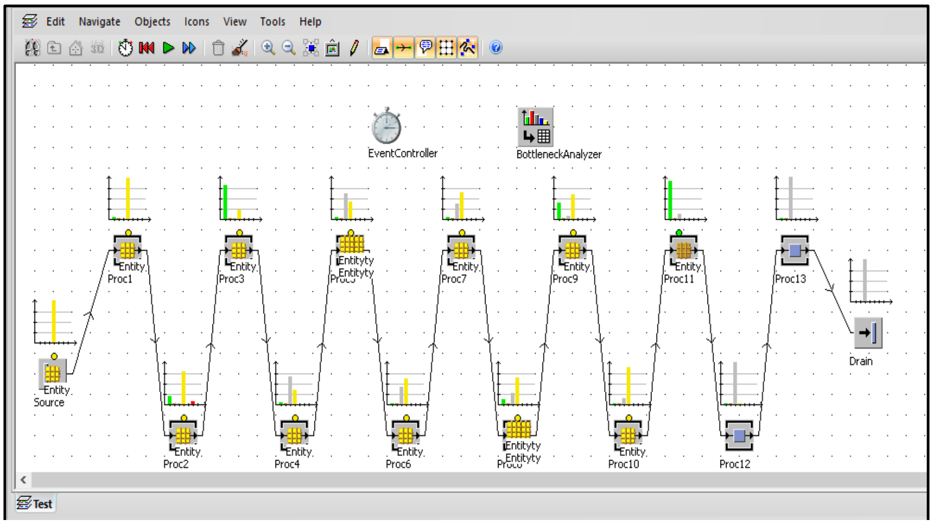

Figure 4: Process mapping for current production

The figure 5 says the result of current stove production. The result says that total throughputs per day are eight stoves and throughput per hour is 0.33 stove. Total number of stoves that can be produced by the industry is around 248 if the number of workers is 31. Moreover, the result is nearly same as the data that was provided by industry. The data conveys that 240 stoves are produced by the industry per day.

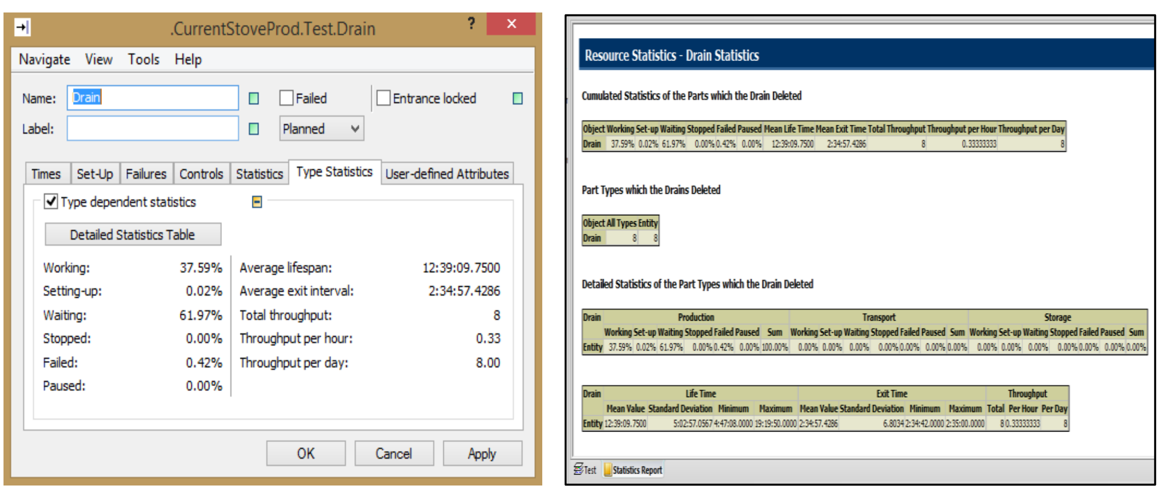

Figure 5: The result of current production

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3.2 Production Time Analysis for Machine 1

The process mapping of semi automation production (Figure 6) is shown when machine 1 is used in the production system. As per the data, provided by industry; approximately 31 labors are working for the charcoal stove production. Only one labor is required to operate the machine.

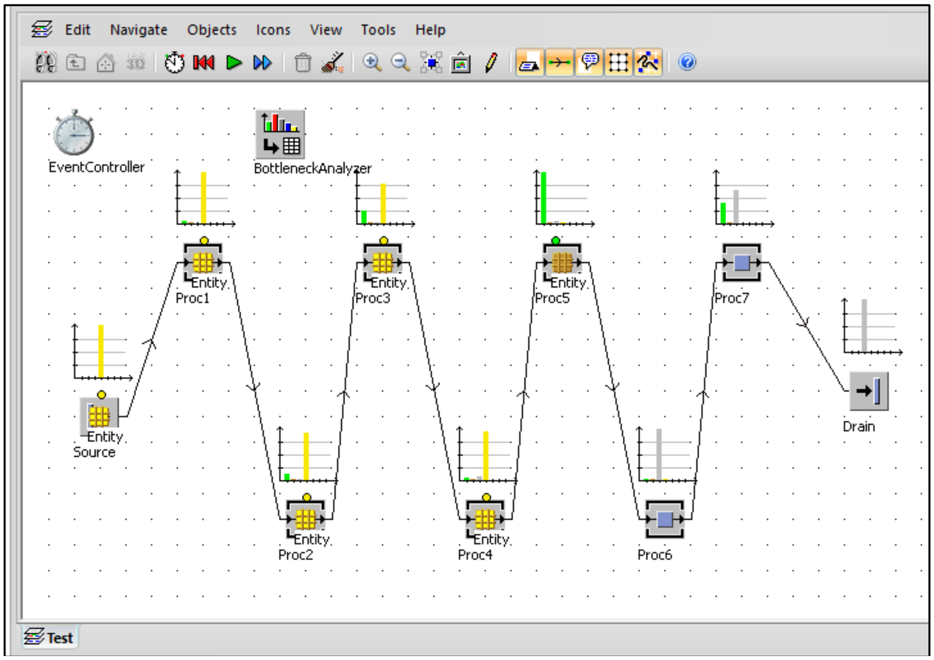

Figure 6: Process mapping of semi automation production (machine 1)

The following figure shows the result of semi automation production if the machine 1 is in use. The result says that the total throughputs per day are nine stoves and throughput per hour is 0.38 stove. Total number stoves the industry can produce is around 249 if the number of workers is 31. The total number of stoves will increase and the human fatigue will reduce if the machine is used in the production system Moreover, the production has to go parallel in order to achieve this result. It means that 30 labors have to work manually while one labor has to work using the machine. The result is higher than the current production.

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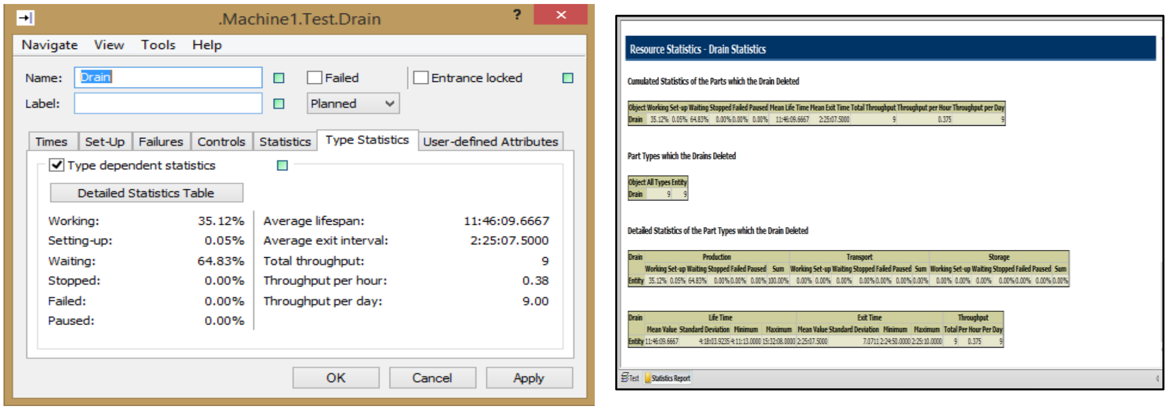

Figure 7: Result of semi automation production (machine 1)

3.3 Production Time Analysis for Machine 2

The following figure 8 presents the process mapping of semi automation production when machine 2 is used in the production system. According to the data, provided by industry; approximately 31 labors are working for the charcoal stove production and only one labor is needed to operate the machine.

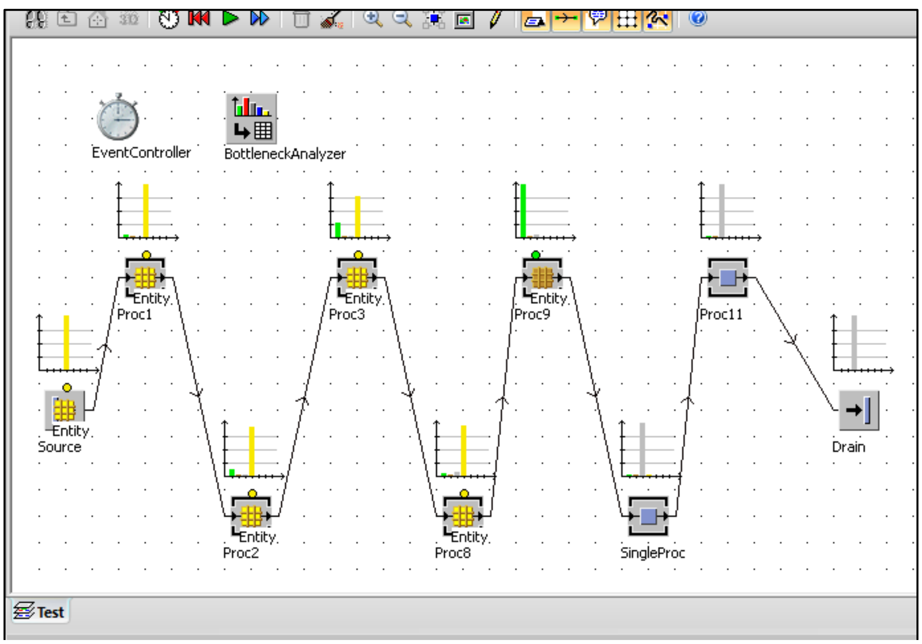

Figure 8: Process mapping of semi automation production (machine 2)

The result of semi automation production (Figure 9) is shown if the machine 1 is in use. According to the results, total throughputs per day are nine stoves and throughput per hour is 0.38 stove. Total number stoves, the industry can produce is around 249 given the number of workers is 31. The total number of stoves will increase and the human fatigue will decrease if the machine is used in the production system. Moreover, the production has to go parallel to obtain this result.

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It means that 30 labors have to work manually while one labor will work using the machine. Again, the result is higher than the current production.

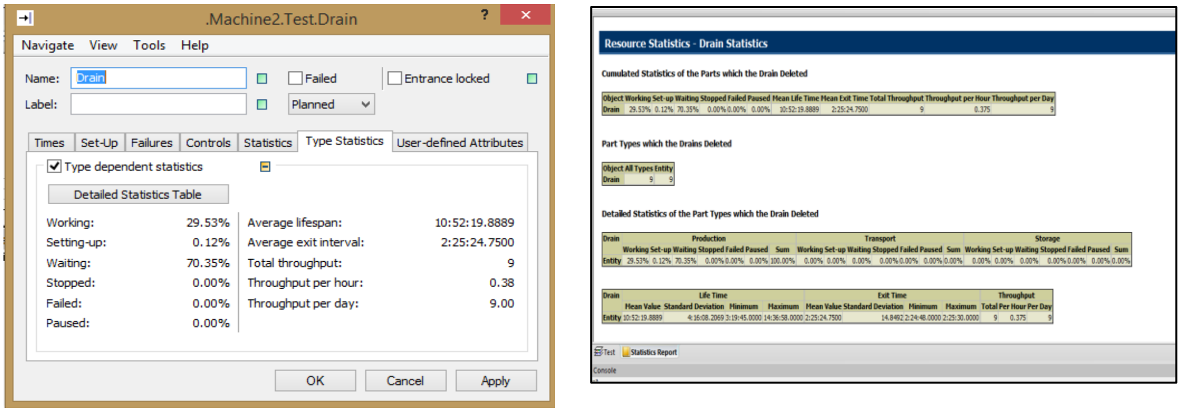

Figure 9: Result of semi automation production (machine 2)

Table 6 shows a comparison of factors between current production system and semi automation production system.

Factor	Current Production	Semi automation Production
Human fatigue	Higher	Less
Production size	Less	Higher
Profit	Less	Higher

Table 6: A Comparison table

4. CONCLUSION

This paper presents a case study on increasing productivity in a cooking stove liner production line. The process time analysis for the current production and the semi automation production is done using plant simulation. The semi automation analysis considers two types of machine. Total throughput of current production is 248 stoves and 249 stoves can be produced by both machines in the semi automation system. These results are from the simulation model. But the actual production size per day is 240 stoves according to the current production. So the final result says that if the industry uses the machines for the production; the production will increase and at the same time fatigue of the labors can also be reduced. Quality of the product will increase when the human fatigue is less. Moreover the industry can earn more money if they use the mold machines for the production. In future, the industry can invest money for more machines if the semi automation production system produces success. Result can get quickly from the plant simulation software.

5. ACKNOWLEDGEMENT

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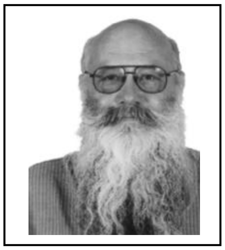

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