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An Application of Lean Six Sigma (LSS) in Small and Medium Enterprises (SMEs): Cement bags industry

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Abstract— In today's world, business has become more competitive. All industries and organizations have to perform well in order to survive and be profitable. The lean six sigma (LSS) methodology is being applied extensively to tackle many quality related issues in many processes of today's industries. Various companies have benefited greatly from the adoption of six sigma and lean engineering concepts since their initiation. A paper cement bags is a packaging sack made of paper high quality and usually craft virgin fiber, which usually consists of several layers to provide strength, with high elasticity and high tear resistance, and are designed for packaging products with high demands for strength and durability.

This study is interested in implementing the lean six sigma (LSS) methodology in SMEs. The LSS proposed in this study is not only study LSS framework but also focus of LSS implementation in SMEs. The contribution of this research is using LSS methodologies to reduce waste of time, reduce of defects, and increase the level of sigma.

The obtained results after implementation LSS methodology in the application of the cement bags industry indicate that the production rate could be increased about 4.25 % and also could be in save of around $ 8,952 from reduction of waste time and $ 12,730.61 from defects reduction; the total is $ 21,682.61 per year. In addition, the preparation time could be reduced by about 4.57 %, and increase the level of sigma from 3.91 to become 4.00.

Index Terms— *Lean, Six sigma, Lean six sigma (LSS), DMAIC, SMEs, cement bags.*

1.INTRODUCTION

The companies look for ways to improve their production and manufacturing processes in order to remain competitive in the market to reduce production cost, enhance productivity and improve product quality. Therefore, companies must utilize all the available resources efficiently in order to cater their customers with high quality products at a low price.

The lean six sigma (LSS) emerging with the combination of lean manufacturing processes in the early 1960s and the six sigma generated by Motorola is the last evolution step in the manufacturing history. Both applications provide to achieve operational effectiveness. This means to apply changes adding value, to process right at the first time and to act quickly and efficiently. Lean manufacturing focuses on eliminating loss in process and reducing the complexity [1-2].

LSS aims to develop solutions by using the minimum amount of resources (human, material and capital) and to make the products reach customers on time. Six sigma provides quality philosophy and is a statistical tool to monitor process performance. It aims to reduce the variability in the process and to eliminate defects. Lean manufacturing and Six Sigma work together successfully. While detecting lean tools, the problems in flow and worthless activities, six sigma increases the proficiency of each step adding value and forms a second entry in lean manufacturing techniques. Especially in non-production processes, both merging six sigma with lean tools and correctly differentiating the application, tools and educational content for the service sector and support processes are critical [3-4].

The integration of both (LSS) technique will facilitate the achievement of zero defect manufacturing in organizations complemented by the elimination of non-value added activities, which leads to greater results than either system can achieve alone [3][5].

This study focuses in implementing the lean six sigma (LSS) in SMEs. The LSS proposed in this study is different from other LSS framework based on other initial studies in terms of the focus of LSS implementation in SMEs only. This study contributes the application of LSS techniques in SMEs to reduce time waste, defects and increasing the level of sigma.

2. LEAN SIX SIGMA (LSS)

Lean six sigma (LSS) is an approach focused on improving quality, reducing variation and eliminating waste in an organization. It is based on the concepts of combining two improvement programs, six sigma and lean manufacturing, also known as lean enterprise. Six sigma is both a quality management philosophy and a methodology that focuses on reducing variation, measuring defects and improving the quality of products, processes, and services[1][6-7].

Table 1 presents the survey of lean six sigma LSS studies and presents the topic and the sector of each research [8][4].

TABLE 1

LEAN SIX SIGMA (LSS) STUDIES IN SECTORS AND TOPICS[9-10]

References	Sector	Topic
Furterer 2004	Service- financial	Implementation - reduce the cycle time
Stephen 2004	Industry	Implementation -reduced the defects
Chen et al. 2005	Industry-Automobile	Improvement of manufacturer's quality
Kumar et al. 2006	Industry- casting	Reduce the defect occurring in the final product
Cronemyr 2007	Industry (service) Electronic	Implemented to problem solving in Siemens
Ramamoorthy 2007	Industry- Aircraft	Implementation - reduction the rework time
Koning 2007	Service – investment	Implemented - reducing operational cost
Chandler 2007	Industry	Improvements both time and money savings
Nuce et al. 2008	Service- pharmacy	Implementation -waste reduction
Martell-rojas 2010	Service - Hospital	Implementation -to be better services
Kellogg 2010	Service- health care	Implemented -investigate the financial benefits
Alyamoor 2010	Industry- wear factory	Implementation -reduced the costs of defects
Barnala 2011	Industry- Recycle	Implementation - optimizing process and remove errors
Hale 2011	Industry-transformation	Implementation- reduce waste
Atmaca et al. 2011	Industry- Dishwashers	Increase profit
Patel 2011	Industry-Small packaging	Implemented -improve Lean Six Sigma standards to meet USA
Basavaraj et al. 2011	Industry- steel	Reduce variation and improve yield
Sabeeh et al. 2012	Industry- Medical Syringes	Increase sigma level, reduce damaged product
Cournoyer et al. 2013	Service-environment	Improve make decisions
Abdullah, 2013	Industry- drugs	Implementation -reduced the defects
Mandahwi et al. 2012	Industry- printing	Application LSS- increase effectiveness
Ren Jie et al. 2014	Industry- printing	Implementation -reduced waste and variation

3. LEAN SIX SIGMA (LSS) FRAMEWORK

The LSS framework has five phases as shown in Fig. 1 with each phase providing a structural guide towards root-cause identification of a problem, hence proposing and implementing cement bags to eliminate the root cause through preparation time and reduce defects. It should be noted that this framework is the technique that can be used in LSS adoption [11-12].

The LSS framework as shown in Fig. 1 is actually a simplification of the six sigma's DMAIC odology with guided steps on utilizing certain lean tools in each phase. The framework utilizes data driven and guided standard approach of the six sigma DMAIC methodology while utilizing lean tools in each phase to determine improvement opportunities and further analyze the problem(s) [13-14].

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3.1. Phase 1: Define the problem

In this phase of a lean six sigma (LSS), the outlines of the cement bags industry case study and its objectives must be clearly identified.

The SIPOC (suppliers, inputs, process, outputs, and customers) process map is one of the most valuable tools. By using a standard SIPOC diagram, to understanding the flow of information, supplier, input, process, output and costumer requirement of manufacturing system. Fig. 2 shows the SIPOC diagram of cement bags manufacturing, the supplier craft roll paper, ink, and glue to identify the flow processes to produce the cement bags.

In order to have an insight into the current state of the preparation time, a current Value Stream Mapping (VSM) is created which gives a closer look at the process so that opportunities for improvement can be identified. Fig. 3 shows the VSM, which shows the movement of materials through different manufacturing processes.

S	I	P	O	C
Supplier	**Input**	**Process**	**Output**	**Costume**
Craft paper	Craft paper	Handling raw paper from inventory to production line and remove cover of roll	Cement bags	Cement factory
Glue	Glue	First stage of production (printing, tubing, cutting, separation)		
Ink	Ink	Handling the product from first stage to second stage		
	Human resources	Second stage of production (opening, valve installation, gluing, closing)		
	Ropes	Collect product in second stage		
		Transport pallet to temporary storage area		
		Inspection the product		
		The product drying process		
		Transport final product from temporary storage area to inventory		

Figure 2: SIPOC diagram of cement bags

before every stages. Preparation one is 48 sec which include transportation raw craft paper by fork lift, remove cover and set roll in machine while preparation two is 36 sec which include collect semi-product and handling to second stage and the last preparation time is 147.8 sec, transportation final product to temporary inventory.

The preparation two between first stage and second stage cause to stop working about 45 min at start of shift until the product in first stage for 45 min or more to produce two pallets. The following table 2 shows the number of stops because of this case.

TABLE 2

NUMBER OF STOPS FOR SECOND STAGE

Month	Number of stops	Total shift	Ratio
January	13	45	28.89 %
February	11	49	22.49 %
Average	12	47	25.69 %

The preparation time before second stage (valve installation) will be analyzed further to determine the root causes of its high setup time in the analyze phase.

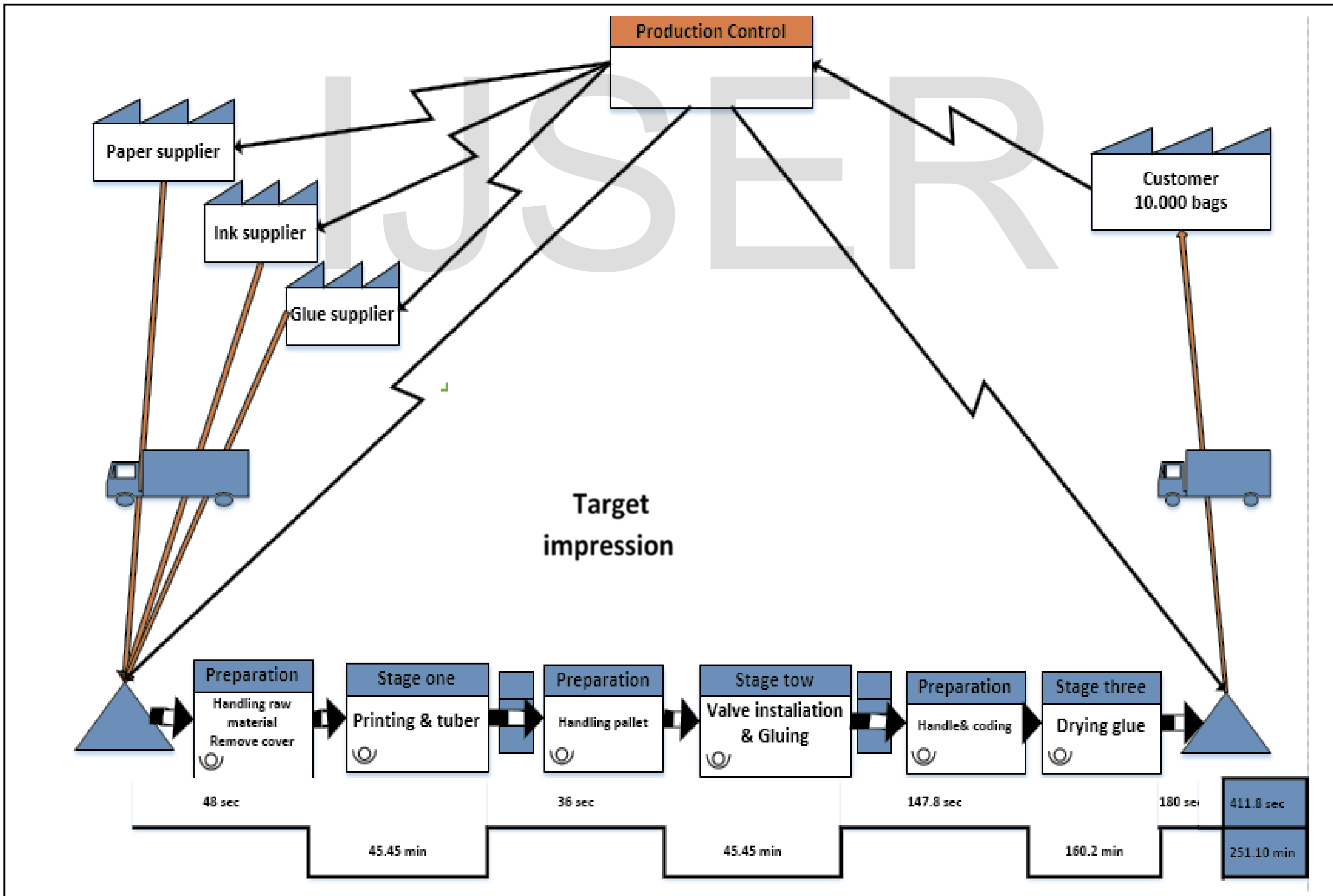

Figure 3: Value Stream Mapping VSM of cement bags

In addition, VSM in fig. 3 shows three preparations time

In this phase, the current performance of the process is measured to find the Key Process Variables and identify the

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critical points in the cement bag length and width from the measurement points that are regularly measured by the enterprise.

The dimensions for cement bag are length × width = 60 × 50 cm, valve width side and width other side = 9.50 cm. The measurements the dates and evaluate using the statistics software MINITAB 17. Graphical results of the length, width and valve width two sides of cement bag measurement are presented in Fig. 4 to Fig. 6.

As shown in fig. 4, the sample average value of cement bag length (59.997cm) is close to USL = 60.20cm and LSL= 59.73cm. The total value of PPM in the right confirms with the probably of 102.40. Since the CPK (1.43) value is quite over the target value (CPK > 1.33). Whereas, the sample average value of cement bag width (49.997cm) is close to USL = 50.20cm and LSL= 49.80 cm. The total value of PPM in the right confirms with the probably of 124.49. Since the CPK (1.41) value is quite over the target value (CPK > 1.33).

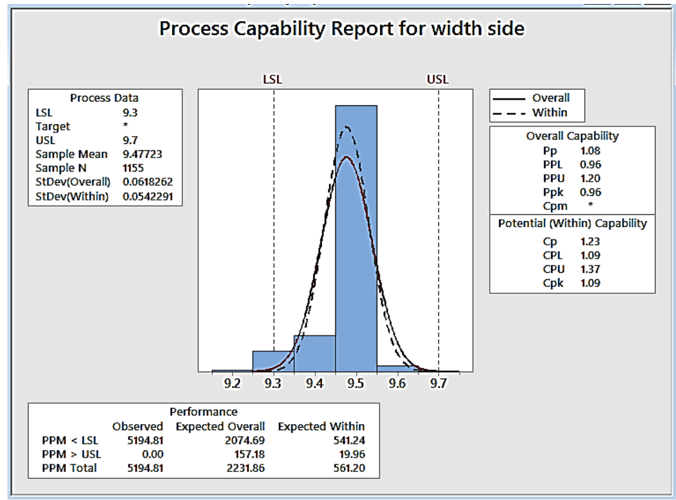

Figure 5: Process capability of cement bags valve width

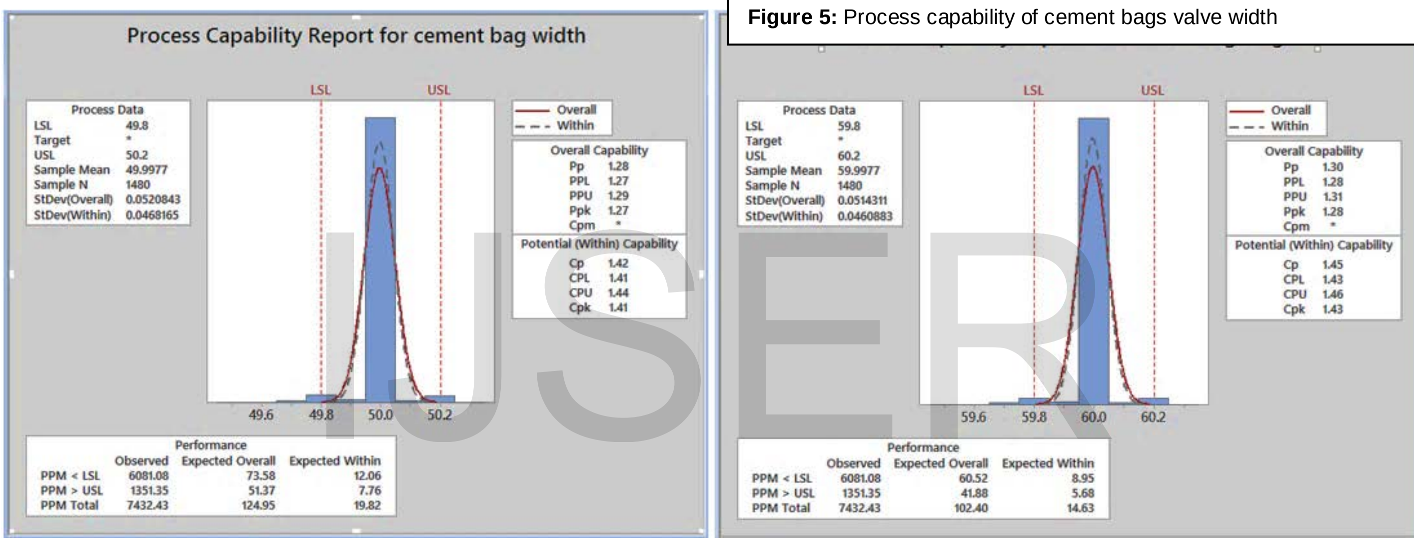

Figure 4: Process capability of cement bags Length and width

Fig. 5 shows the process capability of cement bags valve width that sample average value (9.477cm) is close to USL = 9.70 cm and LSL= 9.30 cm. The total value of expected within PPM approximately 561.20 out of a million will not meet the specification limits. Since the CPK (1.09) value is quite lower the target value (CPK > 1.33).

Fig. 6 shows the process capability of valve width other side, the sample average value (9.507cm) is close to USL = 9.70cm and LSL= 9.30cm. The CPK (1.93) value is quite over the target value (CPK > 1.33), the total value of expected overall PPM approximately 2.33 out of a million will not meet the specification limits, this process is fairly capable.

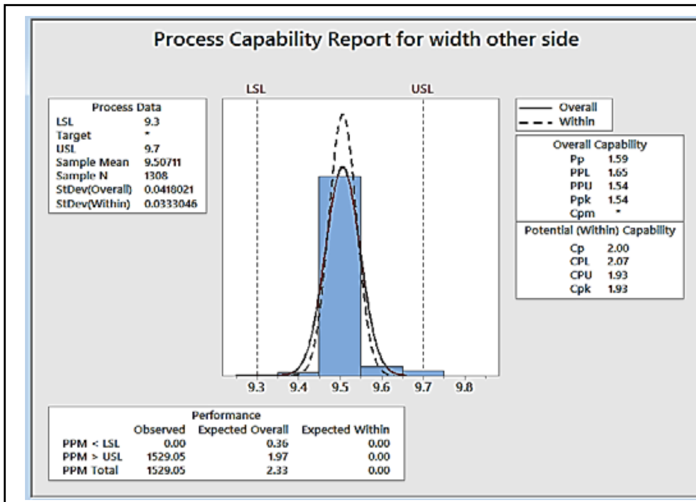

Figure 6: Process capability of cement bags valve width other side

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The operator cannot repair the cement bags outside the control limits. These bags become scrap after registration, but this problem does not have a classification of these defects and their causes. Defects of the cement bags are given in table 3.

TABLE 3

THE DEFECTS OF CEMENT BAGS

Month	Production	Defects	Defect ratio
January	7792640	62040	0.796 %
February	8005980	64109	0.801 %
Average	7899310	63075	0.799 %

Evaluation of sigma level:

DPMO = 63075*106 / 7899310 = 7984.88 defect with defects ratio is 0.799 % and the level of accuracy in processes is 99.2 % and the sigma level in this case is 3.91.

3.3. Phase 3: Analyze

Based on the observation in the production line of each preparation and setup, preparation time before second stage, which include collect semi-product and handling to second stage. The objective of this phase to determine the root causes of waste in preparation time and defects and identify the significant process parameters causing the defect.

Fig. 7 shows the cause and effect diagram of preparation time problem, the focus of root-cause analysis will carried out for setup of valve preparation. Fish bone diagram is developed based on each setup to assist the findings of the cause of this problem. It is developed through brainstorming and discussion. The main causes are:

1. Handling motion waste by worker
2. Collect the product in the pallet.
3. Insufficient automated system.
4. Majority of worker are semi-skilled.

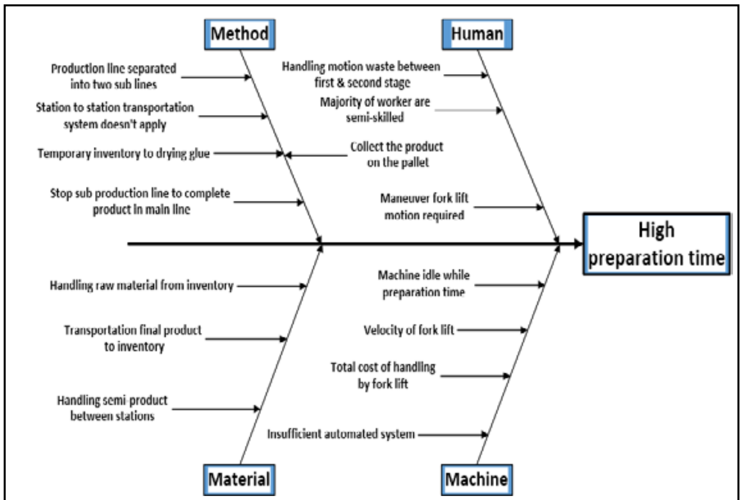

Figure 7: Cause and effect diagram of preparation time problem

In the cause-effect diagram in fig. 8 defect sources stated are examined below in order of process. The category of the defect source mentioned (Machine, methods, Man, materials) is indicated in parentheses. It is developed through brainstorming and discussion. The main causes are:

1. Only visual inspection followed.
2. No classification of defects and causes.
3. Not inspection after each stage separately.
4. Unsynchronized tuber and bottomar system.

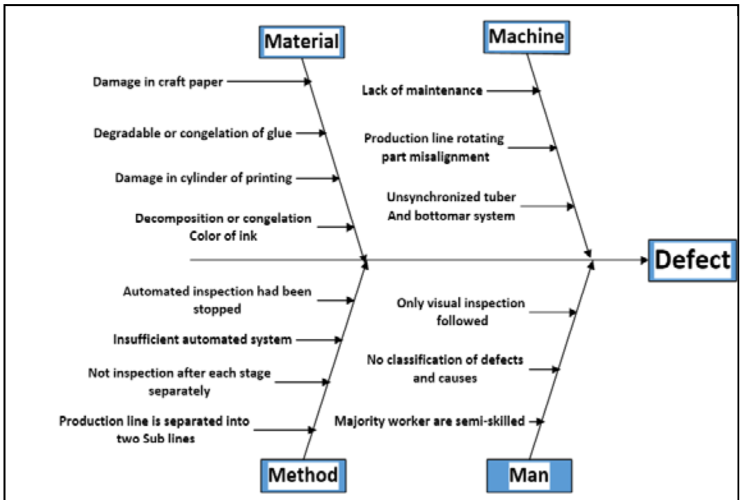

Figure 8: Cause and effect diagram of defect in cement bags

Table 4 shows the main type of preparation time in the cement bags factory, the critical factor in the current process that could be improved to minimize waste. The degree of importance preparation two is very important because the production in second stage is stop working about 45 min at start of shift until the semi-product in first stage collect on two pallets, this is a problem at the beginning of each shift.

TABLE 4

MAIN TYPE OF WASTE TIME FOR PREPARATION TIME

Type	Activities	Time (sec)	Degree of importance	Remark
Preparation one	Handling raw and remove cover of roll	48	L	By fork lift
Preparation two	Collect and handling the semi-product to second stage	36	V	Stop working stage two about 45min
Preparation three	Collect product and Transport pallet to temporary storage area	147.8	M	By fork lift

The data are collected over period 8 weeks. It has showed that stopped working in second stage because the semi-product is not available when starting work.

The stopped working about 45 min to collect two pallets and handling by worker. Table 5 below shows summarized of stopped working and probability of occurs in this situation, the average of probability of occurs is 25.81%.

This means stopped working the second stage about 11.61 min (696.6 sec) at the beginning of shift until the semi-product is complete in the first stage, in addition to the preparation time before second stage of 36 sec in the production line.

TABLE 5

SUMMARIZED OF STOPPED WORKING AND PROBABILITY OF OCCURS

Week	Workdays	Total shift	No. of stops	Probability
1	6	12	3	25.00
2	5	10	2	20.00
3	6	11	3	27.27
4	6	12	5	41.67
5	6	11	5	45.45
6	6	11	3	27.27
7	6	12	0	0.00
8	7	14	3	21.43
Total	**48**	**93**	**24**	**25.81**

3.4. Phase 4: Improve

At this stage, the DMAIC team has recognized clearly the main causes for each type of wastes, expected solutions, required actions, time interval, and others. Corrective actions are started immediately as requested by management.

The Improve phase is where the proposed action to minimize the probability of reoccurrence for these problems. In order to improve and reduce the preparation time and the setup time between first stage and second stage and reducing the potential to stop working the second stage time, the system or process must be automatic the transporting of product from the end of the first stage to the beginning of the second stage directly using an industrial conveyor.

It is working without collect time, reduce the time required for transfer, and the eliminate stop working in shift beginning in the unavailable of semi-product from the previous stage, so the time is adjusted a transport by 50% or 18 sec the percentage of 4.57 % from NVA, whereas reduces stop working second stage of 25.81% time (696 sec) to zero.

Table 6 below shows the amount of revenue from this reduce the waste time. The increase annual production 335,700 bags with percent 4.25 %, whereas the total annual revenue is $ 8952.

TABLE 6

THE ANNUAL REVENUE OF REDUCE WASTE TIME

State	Time reduce (sec)	Ratio improvement	Production increase /day	Annual production	Percentage	Annual revenue ($)
Preparation time	18	4.57 %	55	16500	0.209 %	440
Stop working in second stage	696.6	25.81%	1064	319200	4.04%	8,512

In the current situation of the defects can be treated through the application of maintenance periodic machines and make the screening process take place after each stage of the production stages and improved to be automated, Thus defects could be reduced about 20-25%.

The following table 7 shows the number of defective products after the application of the proposed improvements.

TABLE 7

THE DEFECTS IN CEMENT BAGS AFTER APPICATION IMPROVEMENT

Month	Production	Production after reduce waste preparation time	Defects		Defect ratio	
			Before	After improve	Before	After improve
January	7792640	7818377	62040	48081	0.796 %	0.617 %
February	8005980	8033955	64109	49685	0.801 %	0.620 %
Average	7899310	896166	63075	48883	0.799 %	0.618 %

In addition, there is time waste when a defective product passes in the early stages of industrial process and continue in production line on the following industrial various stages to the sole and final inspection station.

The saving of around is (13959 def. *12 month * 0.57 cost = 95479.56 L.E) about $ 12,730.61 per year.

Evaluation of sigma level after application the proposal of improvement in the processes, the defect per million opportunity (DPMO) is 6188.26 defect with defects ratio is 0.618 %. The level of accuracy in processes is 99.38 % increase about 0.18%. However, the sigma level in this case is 4.00, the sigma level increase 0.09 with percent 2.31 %.

3.5 Phase 5: Control

This phase is very important in the Lean Six Sigma implementation, as LSS does not only aim to reduce waste and defects but also to be able to sustain the improvement that has been made. In order to sustain the achieved results and to prevent degradation in the process performance. Hence, the standardization of the optimal process parameters setting is required. From time to time, control charts for dimension of cement bags, to check that the product is meeting the desired specification. That to accentuate the following points in order to prevent the occurrence of other defects at different stages of production and reduction of waste time:

- Checking the defects at the first stage so that defects are not passed to after the production stage.
- Use the conveyor between first stage and second stage to reduce the waste time and eliminate stop working in second stage.
- Inspection data and analysis of defects and classification of causes these defects.
- Training people on the regarding details of production and quality issues as well as other activities such as problem solving and team building.
- Use of control charts and graphs at each processing stage to keep the employees aware of the real time performance at the respective stages of production.

4. CONCLUSION

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The following conclusions are drawn from this study:

1. Lean Six Sigma (LSS) can be applied in all business areas such as industry, design, sale, marketing, services and procures quite many advantages.
2. The implementation of Lean Six Sigma (LSS) provided an impetus for establishing best practice within the company.
3. Reduction of the preparation time by 4.57 %, the increase of annual production is over to 335,700 bags with percent of 4.25 %.
4. A significant improvement was observed in the key performance metrics (DPU, process capability, yield) after implementation of the lean six sigma (LSS).
5. The implementation of the lean six sigma (LSS) has resulted in savings of around $ 8,952 from reduction of waste time and $ 12,730.61 from defects reduction; the total is $ 21,682.61 per year.
6. Increase in the level of sigma level percentage 2.3 % from 3.91 to become 4.00, and increase in the net profit of the company.

REFERENCES

[1] Atmaca E., and Girenes S. S., 2011, "Lean Six Sigma methodology and application," Qual. Quant., 47(4), pp. 2107–2127.

[2] Fitzmaurice I., 2010, "The effects of implementing a Lean Six Sigma tool , Visual Process Controls , to improve month-end activities in a finance department – An Empirical Case Study," National University of Ireland.

[3] Mandahawi N., Fouad R. H., and Obeidat S., 2012, "An Application of Customized Lean Six Sigma to Enhance Productivity at a Paper Manufacturing Company," Jorden J. Mech. Ind. Eng., 6(1), pp. 103–109.

[4] Jie J. C. R., Kamaruddin S., and Azid I. A., 2014, "Implementing the Lean Six Sigma Framework in a Small Medium Enterprise (SME) – A Case Study in a Printing Company," International Conference on Industrial Engineering and Operations Management, pp. 387–396.

[5] Patel R., 2011, "Modeling Lean Six Sigma in the small packaging industry in India," Institute of Technology.

[6] Kumar M., Antony J., Singh R. K., Tiwari M. K., and Perry D., 2006, "Implementing the Lean Sigma framework in an Indian SME : a case study," Prod. Plan. Control, 17(4), pp. 407–423.

[7] Sosen A. A. S., Zohir A. H., and Saleh S. A., 2012, "Improvement of Production Quality by using Six Sigma Technique : Applied Study in the Medical Syringes Factory - Babylon," Tekreet Eng. Scinces, 02, p. 12.

[8] Ghaleb A. A., El-sharief M. A., and El-sebaie M. G., 2014, "Study of Tools, Techniques and Factors used in Lean Six Sigma," Int. J. Sci. Eng. Res., 5(12), pp. 1652–1658.

[9] Hale S. A., 2011, "Lean Transformation and Relocation of Jet Engine Assembly Operations by Libraries," Massachusetts Institute of Technology.

[10] Basavaraj Y., Sreenivasa P. K. V., and R. N. N. V., 2011, "Improvement of process capablity through six sigma and robust design : Case study at an Indian Steel Manufacturing," Int. J. Ind. Eng., 18(9), pp. 482–492.

[11] Ramamoorthy S., 2007, "Lean Six-Sigma Applications in Aircraft Assembly," Wichita State University.

[12] Barnala P., 2011, "Optimization of Operating Parameters of a Material Recovery Facility using Lean Six Sigma Techniques," University of Toledo.

[13] Montgomery D. C., 2009, Introduction to Statistical Quality Control, jo.

[14] Taghizadegan S., 2006, Essentials of Lean Six Sigma, Elsevier Inc.