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Six Sigma-An Innovative Approach for Improving Sigma Level: A Case Study of a Brick Company

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Abstract*— India is the second largest producer of bricks as brick industry is the backbone of developing country like India. Any advancement in brick industry by utilizing the effective tools of six sigma will not only benefit a single brick company but also to all brick industry in India. This paper has presented that where six sigma tools can be implemented and how these tools contribute in overall improvement and decrease overall no. of defects in Kissan Brick Company. Six sigma stands DMAIC (Define, Measure, Analyze, Improve & Control) which has been implemented step by step in Kissan Brick Company and sorted out the big problems which are critical to quality of bricks, were increasing the number of defective bricks and further resolved out these problem with improvements in the manufacturing process. This resulted the increase the overall profit of the company by improving sigma level.

***Index Terms*— DMAIC, Sigma Level.**

I. INTRODUCTION

The traditional quality management approaches, including Statistical Quality Control (SQC), Zero Defects and Total Quality Management (TQM), were implemented already for many years, while the more recent quality improvement technique is Six Sigma which is also implemented already in many industries across the world [1]. Since its initiation at Motorola in the 1980s, many companies including GE, Honeywell, Sony, Caterpillar, and Johnson Controls have adopted Six Sigma and obtained benefits of this technique [1]. Many companies, utilized features of Six Sigma and concentrate on creating higher quality products as output [2]. Brick industry in India is the second largest producer of clay fired bricks, accounting for more than 10 percent of global production and have more than 100,000 brick kilns, producing about 150-200 billion bricks annually. The present study was carried out at Kissan Brick Company. The Company was established with the objective of manufacturing bricks to satisfy the demand of growing constructional work. A case study was carried out to understand process mapping and process flow charts were prepared by studying the process in detail, which demanded several visits to the manufacturing unit. The Six Sigma methodology of (DMAIC) was used to study the manufacturing process. The focus of the case study is the each production flow process which was critical to defect in brick. The implementation of Six Sigma in brick industry not only benefits industry by increasing the overall profit but also to the environment by optimum utilization of clay.

II. METHODOLOGY OF SIX SIGMA

The main objective of Six Sigma is to reduce both the variability of process and the production of non-conforming products. Six Sigma has five phases (Figure 1) that were implemented in Kissan Brick Company with the application of most suitable Six Sigma tools at various processes.

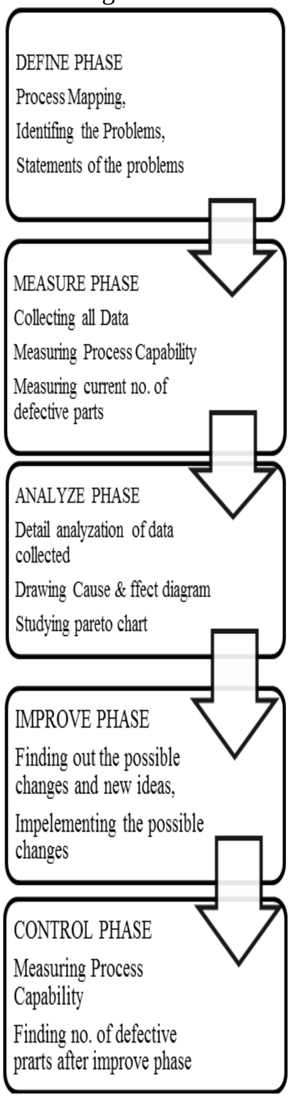

Fig. 1. DMAIC Process

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A. Define Phase

Although all stages of the DMAIC cycle are equally important, this stage will instruction the others, because it describes path, targets, critical problems and desired key parametric characteristics [3]. SIPOC process map for Kissan Brick Company was plotted (Figure 2)

Suppliers	Inputs	Process	Outputs	Customers
Land-owner from where soil is taken	Ground soil and water	Mixing of soil & water ⇨ Making Raw Bricks ⇨ Drying Raw Bricks ⇩ Carrying Raw Bricks to the Kiln ⇨ Arranging Raw Bricks in Kiln ⇨ Covering Upper layer of Brick Kiln ⇩ Start Heating in Kiln ⇨ Feeding Coal in Kiln ⇨ Take out prepared bricks from Kiln ⇨ Deliver Bricks to the Customers	Bricks	Buyers who need bricks for construction purpose.

Fig. 2. SIPOC process map of Kissan Brick Company

After the detail study of the whole process of manufacturing, the critical problem in Kissan Brick Company was that the dimensions of final manufactured bricks were out of the specification limits of dimensions, which were considered as defective bricks which was causing big financial impact on company's total cost.

B. Measure phase

In this second phase, the quality characteristics to be improved are measure. The most interesting indicators are the length, breadth and height of the brick. The process capability tool was used to measure no. of non-conforming didn't met specifications defined by the customer's needs. Capability analysis answered following questions:

- Was the process meeting customer specifications?
- Were improvements needed in the process?

According to the Process Capability measurements for Length of Brick obtained, it could be said that Process mean (23.83) was slightly larger of the target (23.5) and length of some bricks greater than the upper specification of 26 cm (Figure 3). This larger length of brick than required, increased the cost of clay used for making the raw brick because even one or half centimeter increase in length of one brick directly increase total cost of clay used for making of bricks

The Ppk index indicates whether the process will produce units within the tolerance limits. Here, the Ppk index was 0.66 (Figure 3), indicating that the manufacturer must improve the process by reducing variability and centering the process on the target. Apparently, the large variation in the process was a much more severe problem for this production line compared to the process not being centered on target.

Likewise, the PPM Total (Exp. Overall Performance) was the number of parts per million (33038.79) whose characteristic of interest was outside the tolerance limits. This means that approximately 33000 out of 1 million bricks did not meet the specifications.

The company was not meeting customer's requirements and there was a need to improve its process by reducing the process variation.

Schimdt and Launsby formula [4]

This formula is a basic formula for calculating the sigma level. It just needs the variable i.e. Defects per million opportunities i.e. DPMO. DPMO= 33038.79 (Figure 3)

Sigma = 0.8406 + Sqrt (29.37-2.221×ln(DPMO))

= 3.3425

Similarly Sigma level of breadth and height of brick obtained.

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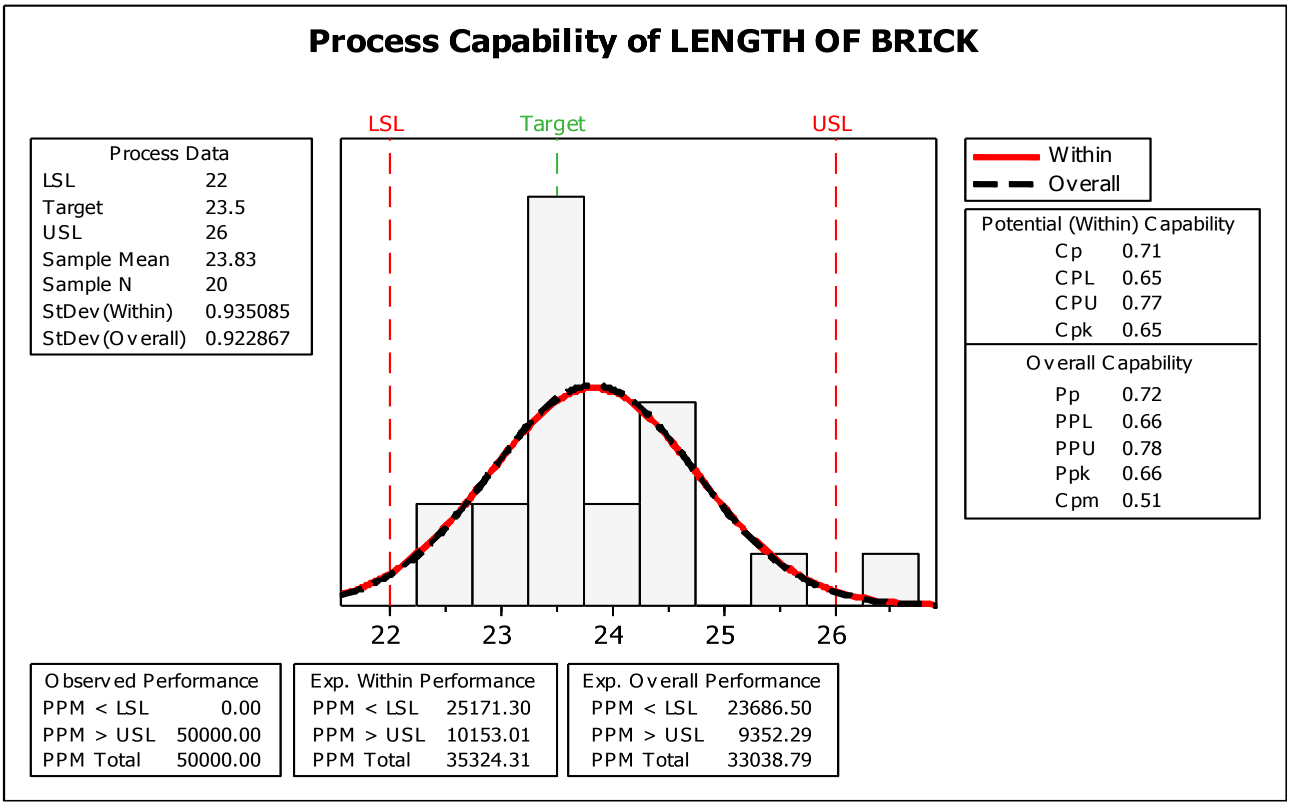

Fig. 3. Process Capability for Length of Brick (minitab result)

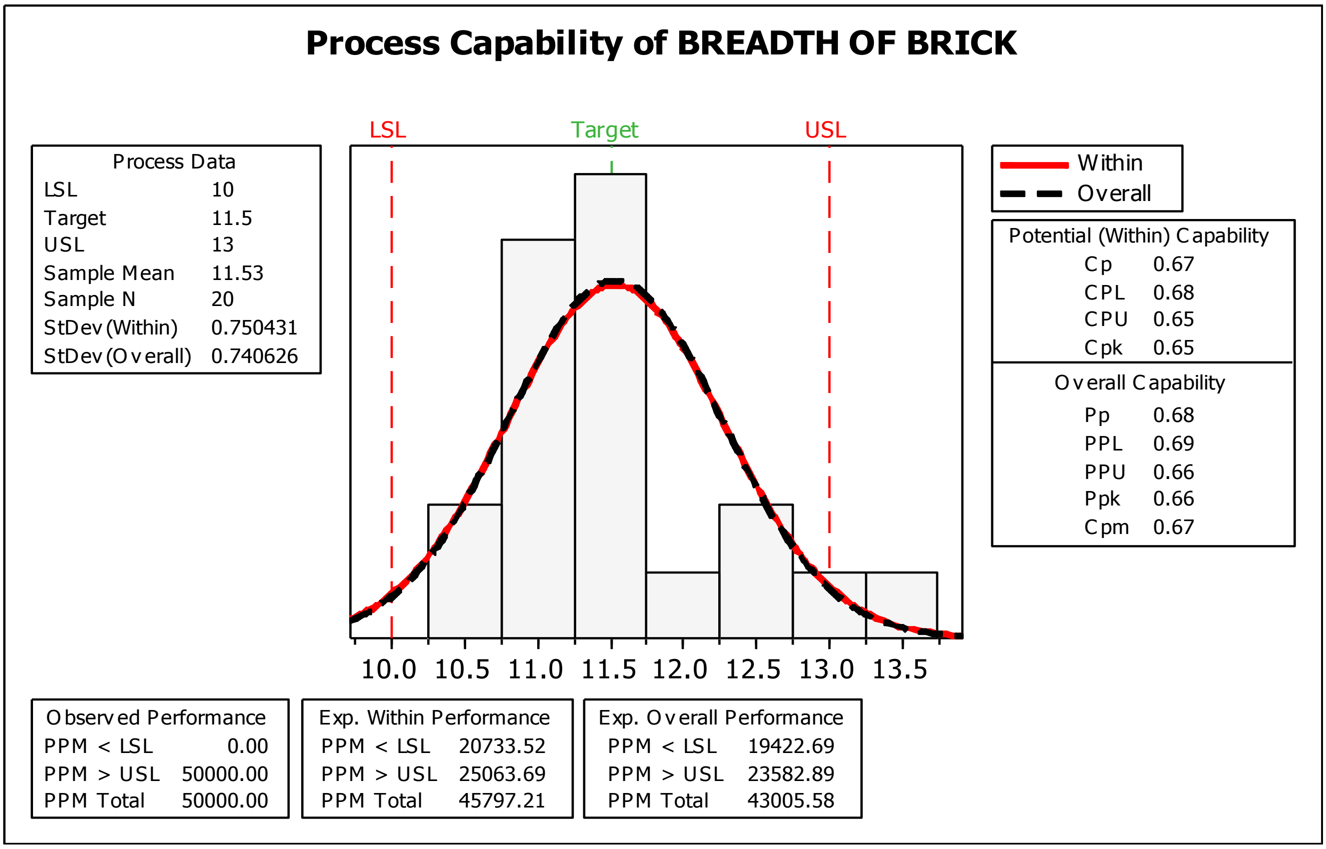

Fig. 4. Process Capability for Length of Brick (minitab result)

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As in case of length of brick, breadths of some bricks were also greater than the upper specification of 13cm. These larger breadths of bricks than required, increased the cost of clay used for making the raw brick because even one or half centimeter increase in breadth of one brick directly effects total cost of soil used for making of bricks.

The PPM Total (Exp. Overall Performance) was the number of parts per million (43005.58) whose characteristic of interest was outside the tolerance limits. This means that approximately 43000 out of 1 million bricks did not meet the specifications. The company would require the improvement in its process by reducing the process variation.

Schimdt and Launsby formula [4]

DPMO= 43000

Sigma = 0.8406 + Sqrt (29.37-2.221×ln(DPMO))

= 3.223

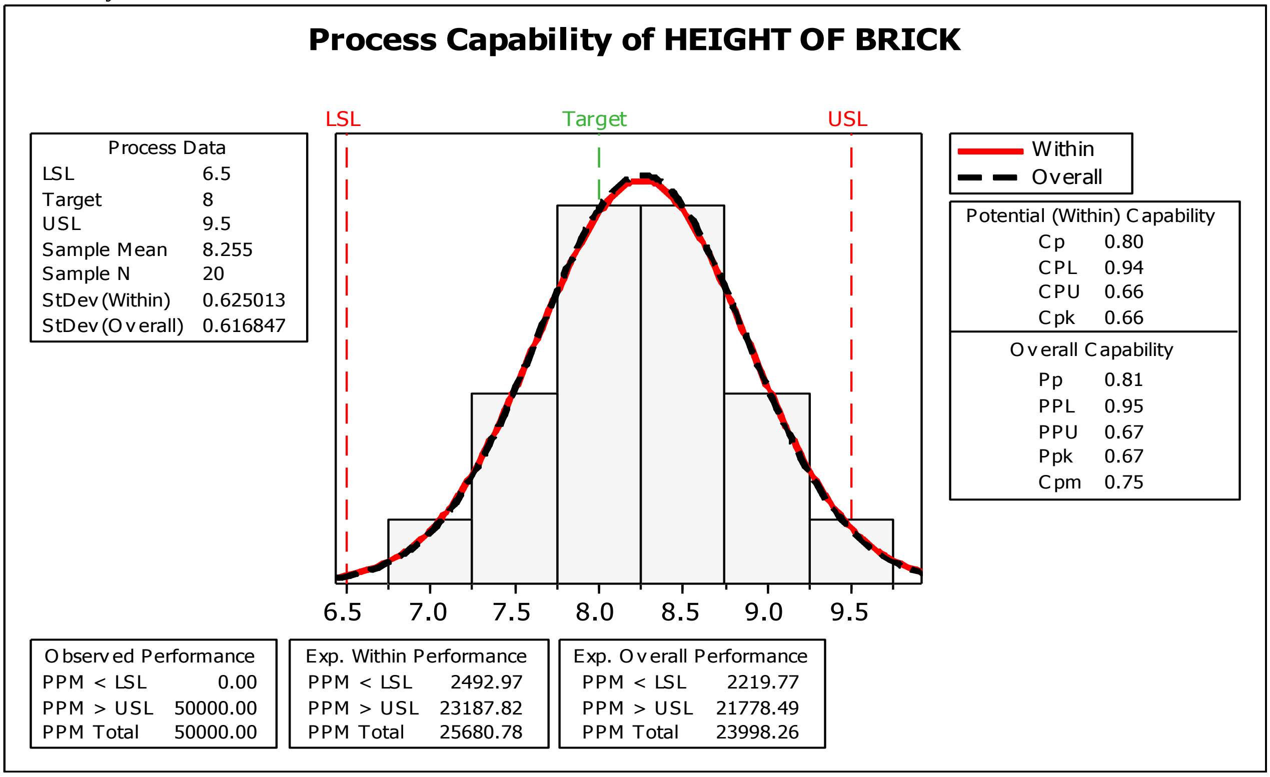

Fig. 5. Process Capability for Length of Brick (minitab result)

As in case of length and breadth of brick, heights of some bricks were also greater than the upper specification of 9.5cm. These larger heights of bricks than required, increased the cost of soil used for making the raw brick because even one or half centimeter increase in height of one brick directly effects total cost of soil used for making of bricks.

The PPM Total (Exp. Overall Performance) was approximately 24000 out of 1 million bricks which did not meet the specifications.

The company would require the improvement in its process by reducing the process variation.

Schimdt and Launsby formula [4]

DPMO= 24000

Sigma = 0.8406 + Sqrt (29.37-2.221×ln(DPMO))

= 3.48

C. Analyze Phase

In this third stage of the DMAIC cycle an analysis was made with the information obtained using quality tools, such as Cause & Effect diagram and Pareto Chart. In this stage, preliminary determined information utilized, various factors are observed and key factor is recognized that relatively more effect on final product [5].The detail study of the critical causes of the defective bricks (in size) was concluded to Cause & Effect diagram (Figure 6). The Pareto Chart concluded that the mould size was the most critical cause for the size of final bricks (Figure 7).

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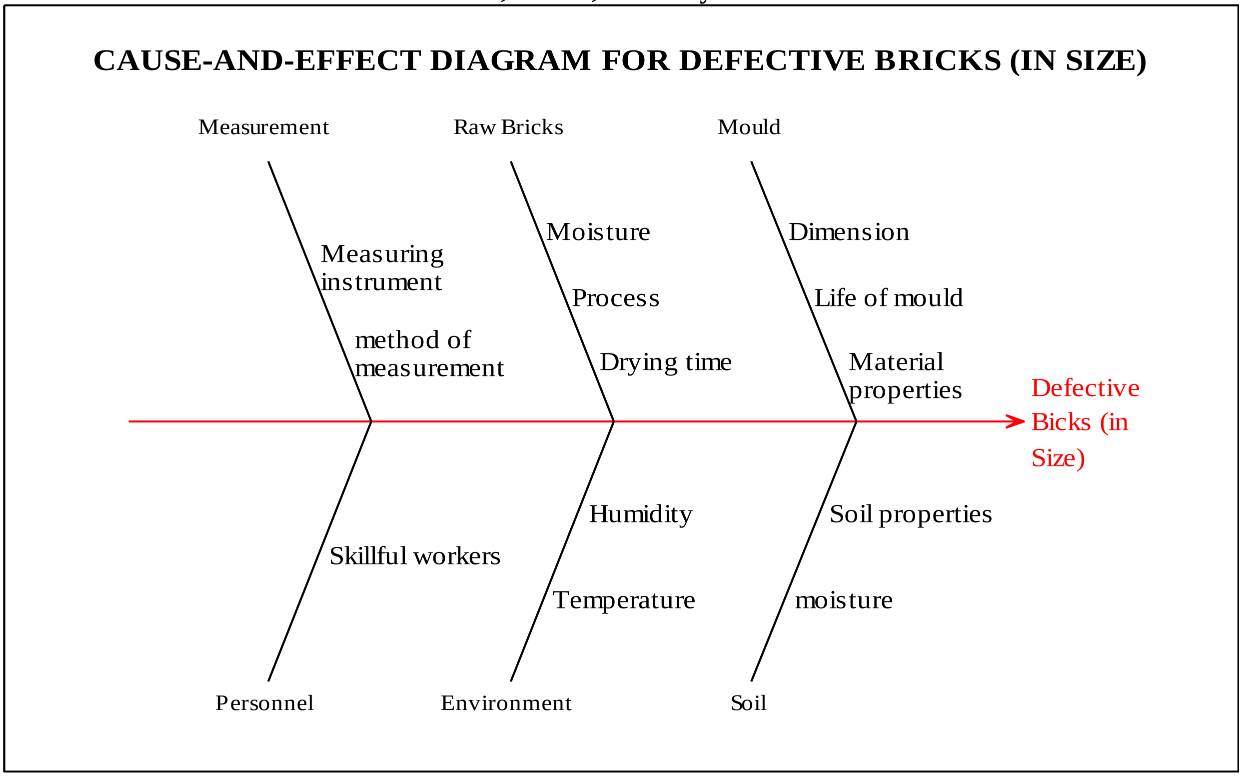

Fig. 6. Cause & Effect diagram (minitab result)

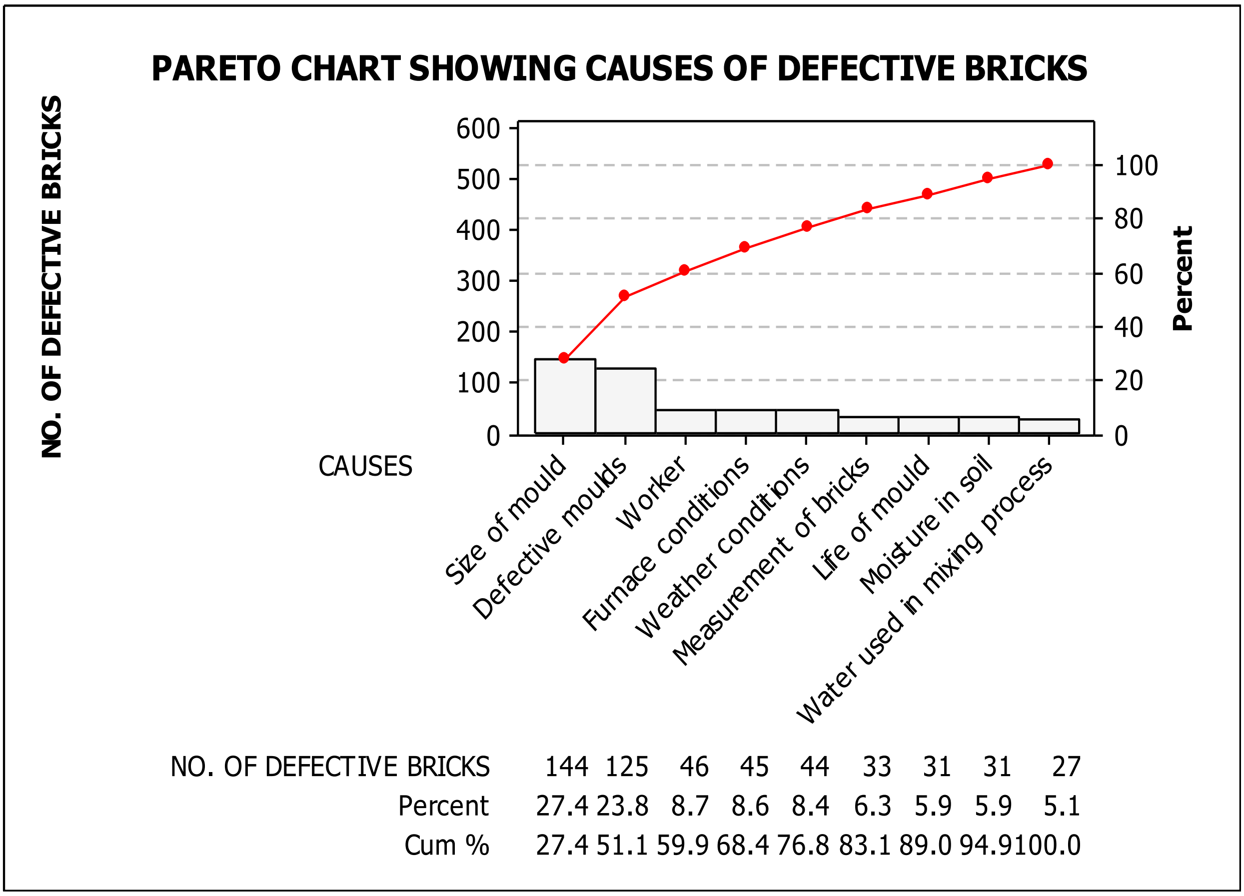

Fig. 7. Process Capability for Length of Brick (minitab result)

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D. Improve Phase-Reduction in no. of defective bricks (by dimensions):

Considering all the main reasons of defective bricks due to large difference between specification limits and target limits of length, breadth and height, it was observed that as compared to other factors, dimensions of the mould are the most critical to the defect. More the dimensional defects in moulds more would be in final product. So to remove these defects, necessary improvements were implemented in the process where mould was used.

It was inspected that some moulds were larger in size as compared to the required size. Raw bricks that were taken out from the mould had larger size due to the larger mould and ultimately these larger sizes of raw bricks were increasing number of defective bricks (by size). Thus the brick was consuming larger amount of raw material (soil) than required which lead to increase in the cost of final product. The following necessary improvement implemented:

- All the moulds which had dimensional error were removed and replaced with new accurate moulds.
- All the workers were given the strict instruction to use mould in proper way and were told about the importance of mould for the final brick.
- The moulds which were being used from very long time were replaced with new ones.
- The new workers were given training by skillful workers for the process of moulding and making raw bricks.

It was also inspected that moisture was critical to the final brick taken out of the kiln. Moisture is present in

- Soil
- Environment
- Kiln
- Raw bricks due to more water added in mixing process.

which are effecting size of final brick. The moisture present in the raw brick making process released in the kiln, due to heating which reduced the size of brick. The following necessary improvement implemented:

- Water was mixed in required proportion.
- Improved drying process.

E. Control Phase

This is the final stage of DMAIC process, in this the team must make a review of the originally stated goals, to observe if the goal is reached, otherwise, to analyze the reasons which creating the restrictions to reach the goal set and propose a new goal because six sigma is a process of continuous development, so it is not advisable to get a six sigma level at a single event, it must be at all key events to the product to reach the six sigma level [2].

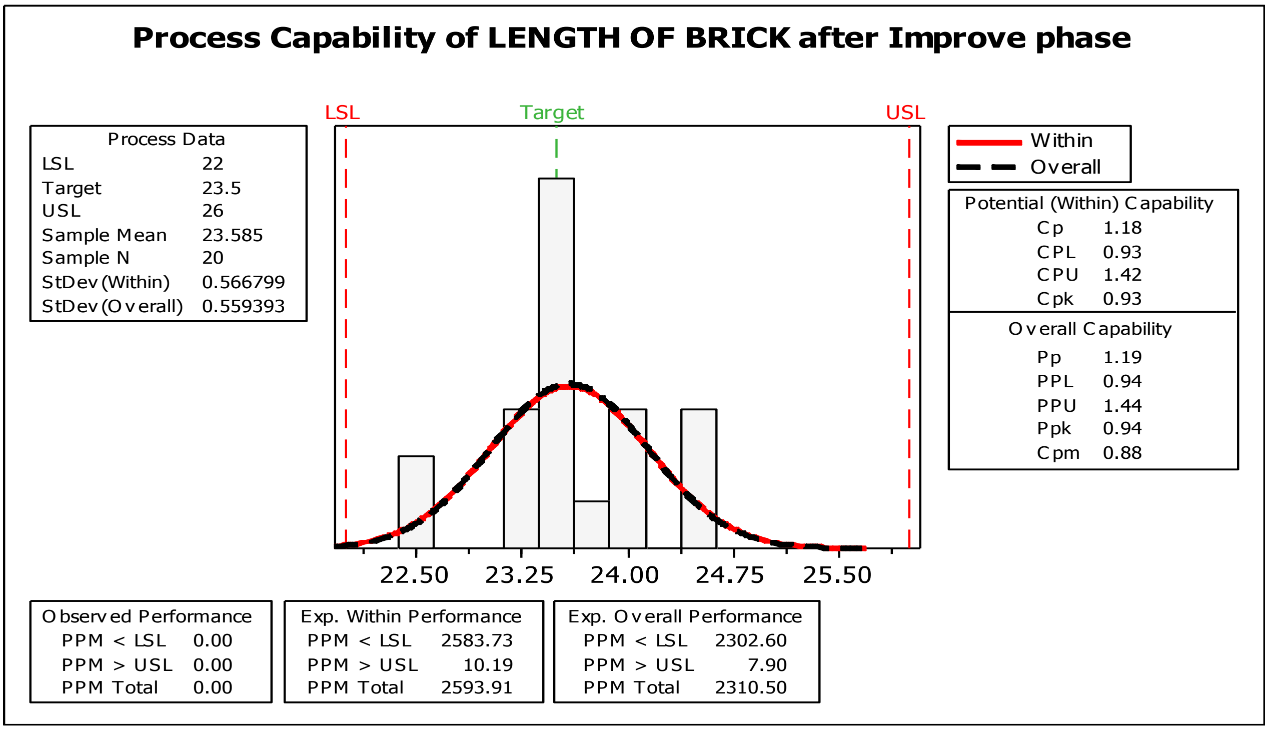

Fig. 8. Process Capability for Length of Brick after improve phase (minitab result)

The PPM Total (Exp. Overall Performance) was approximately 2300 out of 1 million bricks which did not meet the specifications (Figure 8).

The company was meeting customer's requirements and process was improved by implementing possible improvements.

Schimdt and Launsby formula [4]

DPMO= 2300

Sigma = 0.8406 + Sqrt (29.37-2.221×ln(DPMO))

= 4.33

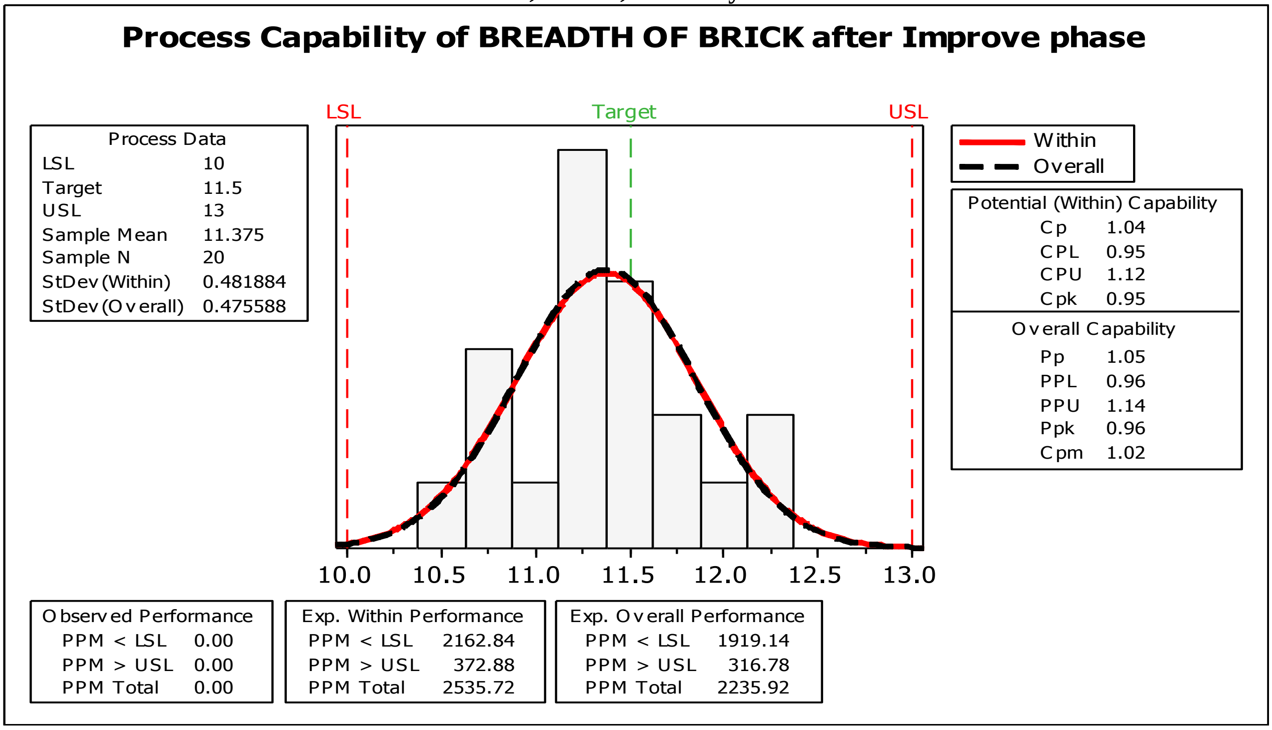

Fig. 9. Process Capability for Breadth of Brick after improve phase (minitab result)

The PPM Total (Exp. Overall Performance) wss the number of parts per million (2235.92) whose characteristic of interest was outside the tolerance limits. This means that approximately 2200 out of 1 million bricks did not meet the specifications (Figure 9).

The company was meeting customer's requirements and process was improved by implementing possible improvements.

Schimdt and Launsby formula [4]
DPMO= 2200
Sigma = 0.8406 + Sqrt (29.37-2.221×ln(DPMO))
= 4.344

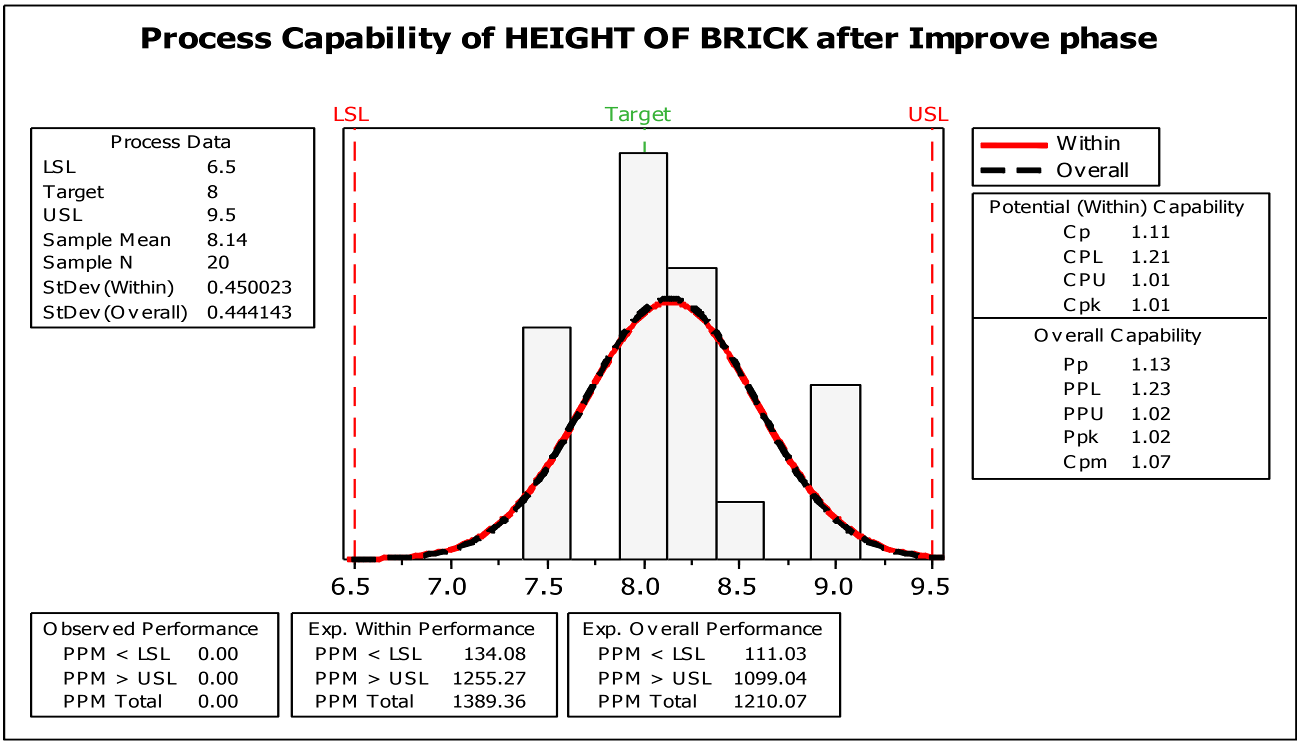

Fig. 10. Process Capability for Height of Brick after improve phase (minitab result)

The PPM Total (Exp. Overall Performance) was the number of parts per million (1210.07) whose characteristic of interest is outside the tolerance limits. This means that approximately 1200 out of 1 million bricks do not meet the specifications (Figure 10). The company was meeting customer's requirements and process was improved by implementing possible improvements.

Schimdt and Launsby formula [4]
DPMO= 1210.07
Sigma = 0.8406 + Sqrt (29.37-2.221×ln(DPMO))
= 4.529

III. CONCLUSION

With the successful implementation of Six Sigma in Kissan Brick Company, sigma level was improved by reducing number of defective bricks (Table I).The improvement of sigma level resulted the overall profit to the company.

Table I. Result of application of Six Sigma in Kissan Brick Company

characteristics (Variables)	Sigma level before application of six sigma technology	Sigma level after application of six sigma technology	Improvement in sigma level	Defective bricks per million before application of six sigma technology	Defective bricks per million after application of six sigma technology	Reduction in Defective bricks per million
Length of brick	3.3425	4.330	0.9875	33000	2300	30700
Breadth of brick	3.223	4.344	1.121	43000	2200	40800
Height of brick	3.480	4.529	1.049	24000	1200	22800

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