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Research Article

Production Improvement through the application of Six Sigma in Small Scale Industry: ACase Study

Rahul Singh[Ȧ*]and Sumit Kumar[Ȧ]

[Ȧ]Department of Mechanical Engineering, Samalkha Group of Instituion, Hathwala- Samalkha(Panipat), Haryana

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Abstract

Small and Medium Sized Enterprises (SMEs) make an important & great contribution to increase the Indian economy at best level and are a focus of improving their efficiency and competitiveness. In this research we discuss the development of a project research to investigate the suitability of Six Sigma as an improvement methodology for Indian SMEs in the Indian manufacturing sector. Large scale industries are producing or manufacturing high quality products with help of Small and Medium Enterprises (SMEs).At this present highly competition market the main focusing of industrial region to target extra efforts to produce best to best high quality products with lowest cost. Six sigma helps to reduce the of product in suitable manner, reduce low wastages for SME of raw materials, provide best quality product for Indian market on time.

Keywords:*Six Sigma, Small Scale Industry etc.*

1. Introduction

In the early 1980's Motorola CEO apply six sigma for reduction in product failure numbers in the industry. Six Sigma methodologies to improve effectiveness in delivery of products and services will benefit the organisations, customers and all other stake holders to a great extent. Six Sigma was to focus on manufacturing processes, later marketing, purchasing, billing, and invoicing functions were also involved. The main word for any industry is " PROFIT", the main mean of word is 'P' for process excellence, ' R ' for resources management , 'O' for oriented to goal, 'F' for financially strong, 'I' for innovative to stay in competition continuously & 'T' for time based strategies .The main purpose of this research how to apply six sigma into SME industries (SME – small medium enterprise) at large no of scale, these SME industries not much used six sigma technology in large scale at present in India. By this research to improve product quality, management of product operations and also very most important customer satisfaction & reduced product failure percentage. Six sigma technologies is highly powerful management strategy to resolved PQM (production, quality and management) in easier way. At present working or used of six sigma method in SSI is very low as compared to high level mfg. Industries. In India SSI industries continuously provide great contributions in all sectors. Six sigma method first helps to grow small-medium industries at high level reduced product failure rates at low level and helps to delivered product at the time. So that six sigma helps to improves significantly for SME industries financially or economically. Methodologies and models of productivity measurement are essentially the translation of the various definitions and concepts of productivity. Most of the approaches are centered on production and production function. The effect of Business Process Management (BPM) is to increase the efficiency at higher level and effectiveness of organizational processes through improvement and innovation.

*Corresponding author **Rahul Singh** is a Research Scholar and **Mr. Sumit Kumar** is working as Assistant Professor, Department of Mechanical Engineering , SGI-Samalkha, Panipat, Haryana

2. Research Background

PrabhakarKaushik and Dinesh Khanduja, Kapil Mittal, PawanJaglan (2008) apply Six Sigmamethodology over the SMEs, the study could be a paradigm initiative towards high quality products and services at low cost for every SME. Application of Six Sigma project recommendation brought up the process sigma level to 5.46 from 1.40 by reduction in bush diameter variation in the process of bicycle chain bush manufacturing unit.

PawanJaglan, ParbhakarKaushik , Dinesh Khanduja (2011) Six-sigma a road map for SMEs &contribution of small scale industries to the Indian economy cannot be ignored as this sector is strategically placed in the industrial population of the country and in the global economy as a whole.

Rajeshkumar U. Sambhe (2012) focus on a case of provoked mid-sized auto ancillary unitconsisting of 350-400 employee and employed Six Sigma (SS) methodologies to elevate towards the dream of SS quality level. The methodology is executed on one of product assembly for trimming down defects level which are critical to customers and its implementation has had a significant financial hit on the bottom-line of the enterprise.

DharmendraTyagi, V. K. Soni, V. K. khare (2014) implementation of Six Sigma and improveunderstanding with the Six Sigma philosophy in small medium Enterprises as well as to document issues such as barriers and critical success factors and also listed benefits for implementation of Six Sigma.

TejaskumarS.Parsana, Dr.Darshak A. Desai (2014) review and examine the advancement andencounters of six sigma practices in Indian manufacturing SMEs and identify the key tools for each step in successful Six Sigma project execution.

3. About the Case Study

Present study was carried out in a Multi Task Trading company, a SSI unit manufacturing laser machine at Dwarkapuri, dabri- palam road, New Delhi (India). The main product of unit is CO2 laser machine from 1400*900 mm2 bed size and its component are CO2 glass tube, chiller, air compressor, lens & mirror etc, as shown infigure.

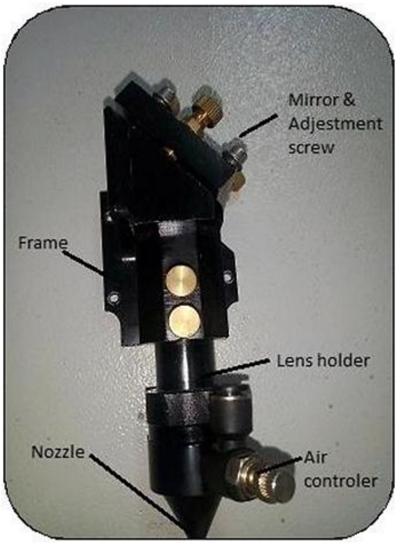

Fig.1 Laser machine

The initial observation showed very high rejection rates during manufacturing of Laser nozzle head due to diameter variation. As the initial observation showed very poor results and the staff and management was willing to reduce the rejection rate and was cooperative in implementing the change, so a small scale industry was chosen for exhaustive study on implementing Six Sigma. The entire study was focused on main component of Laser Machine is laser nozzle head.

4. Application of Six Sigma with use of DMAIC Methodology

Laser Nozzle head is the main component of Laser machine assembly. The tolerance limit of laser head nozzle hole diameter is 1.8 - 2.2 mm. The initial observations had been showing very high rejection rate of Laser nozzle head due to nozzle diameter variation. So, there was a great need to reduce rejection rate of laser head by reducing defects inherent in different processes. Six Sigma DMAIC methodologies were used to solve nozzle head rejection problem to achieve the quality Z-bench sigma level of 5.64 PPM from the present level of 2.21 PPM.

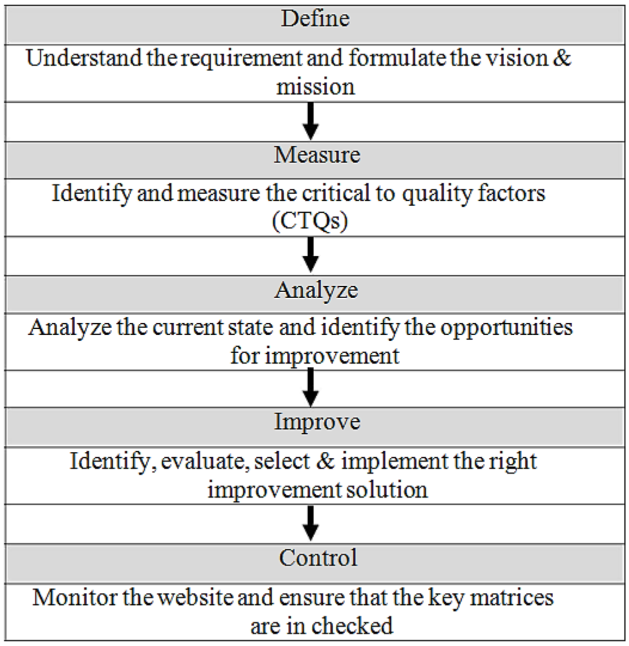

Fig. 2 DMAIC Methodology in SMEs Industry

The project registration was the first activity, which showed formal approval from the management to initiate the project, without their backing it was never possible to involve people and implement suggestions. The high rejection problem of laser head was studied in depth and all the five phases in Six Sigma methodology i.e. DMAIC (Define, Measure, Analyze, Improve and Control) (as shown in figure.2) have been successfully implemented to achieve the sigma quality level of 5.64 from 2.21 .

a) Define

In define phase, Process Map and High Level Process Map- a SIPOC (Supplier, Input, Process, Output, and Customer diagram was drawn for pump head as shown in figure These diagrams were used to document manufacturing sequence of nozzle diameter variation identify the process or product for improvement of Co2 Laser Machine nozzle head. In laser head nozzle hole diameter variation identify as a problem in laser head rejection of Laser machine.

b) Measure

In measure phase, a measurement system analysis (MSA) was conducted which included the Gauge R&R (Gauge repeatability and reproducibility) studies. The purpose of Gauge R&R study is to ensure that the measurement system is statistically sound. Gauge repeatability and

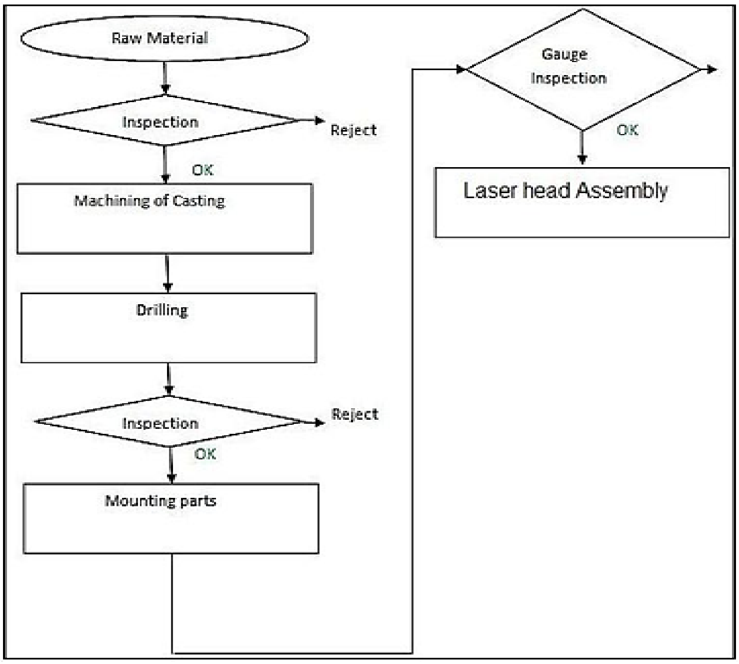

Fig.3 Flow Chart for Laser Nozzle Head

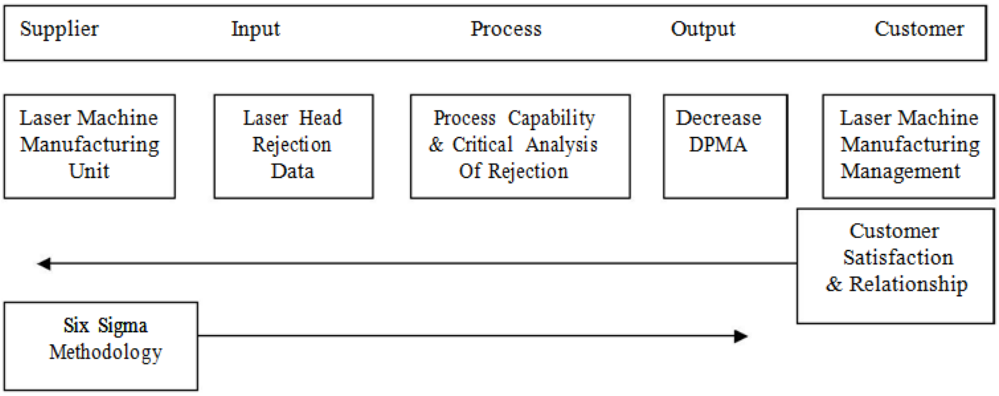

Fig.4. SIPOC Diagram

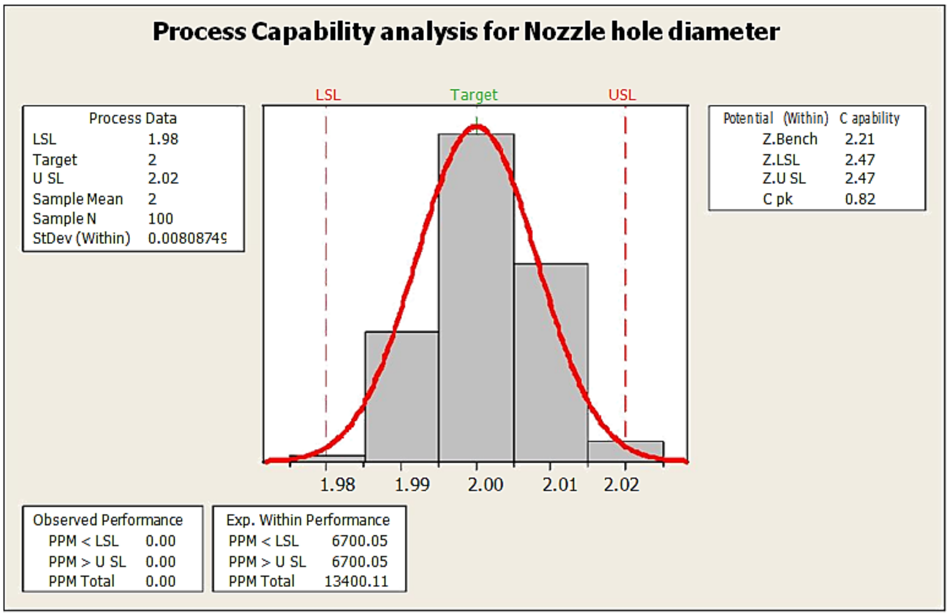

Fig.5 Process Capability analysis for Nozzle hole diameter before six sigma

reproducibility studies determine how much of the observed process variation is due to measurement system variation. Two persons are needed to perform this experiment, which in this case were the operator on line and the investigator. The sample size was 10 and two readings were taken on each sample, thereby making a total of forty readings as shown in table. The gage used for this experiment was a vernier caliper.

From the Result of Gauge R & R as shown in table, repeatability and reproducibility came out to be 22.55 percent and 0.00 percent which put the percentage study variation at 22.55 percent which is less than 30 percent, indicating that vernier caliper was correct**.**

C) Analysis

According to Kapur and Feng (2005), the analyze phase examine the data collected in order to generate a prioritized list of source of variation. Many statistical tools are used to carry out the analysis which is explained as follows.

i) Process Capability analysis

Capability analysis is a set of calculations used to assess whether a system is statistically able to meet a set of specifications or requirements. To complete the calculations, a set of data is required, usually generated by a control chart; however, data can be collected specifically for this purpose & used mini-tab software to draw process capability graph shown in fig.

Z – Bench sigma value of process was found to be 2.21 and existing DPMO level of the process comes out to be 13400.11, which is remarkably high and this shows that there are lot of opportunities for improvement in the process.

ii) Cause & Effect Diagram

Using process capability analysis, the DPMO level and sigma level of the nozzle hole diameter of laser head rejection was known. Now it was the time to find out the causes of laser head rejection.

iii) Two sample T- test

In two samples T-test four factors were taking for study from cause & effect diagram.

- Two sample t-test for skilled & unskilled operator

First two samples t-test for skilled & unskilled operator by taking a sample size of 50 pieces for each unskilled & skilled operator shown in table & used mini-tab for P-value.

Difference = (Unskilled Operator 1) - (Skilled Operator 2) Estimate for difference: -0.00020

95% CI for difference: (-0.00315, 0.00275)

T-Test of difference = 0 (vs. not =): T-Value = -0.13 P-Value = 0.893 DF = 97

Since the p-value for unskilled & skilled operator comes out to be >0.05 therefore this cannot be a factor for laser nozzle head rejection.

- Two sample t-test for Regrinding of Drill

Second two samples T-test for Regrinding of Drill (after 15h and 25 h) by taking a sample size of 50 pieces and again find the P- value for this test (Shown in table 1).

Table 1 Two-Sample T-Test: Unskilled Operator 1, Skilled Operator 2

	N	Mean	St. Dev.	SE Mean
Unskilled Operator 1	50	2.0008	0.00724	0.001
Skilled Operator 2	50	2.001	0.00763	0.0011

Table 2 Two-Sample T-Test: Drill Regrinding After 15h, After 25h

	N	Mean	St. Dev.	SE Mean
After 15 h	50	1.9998	0.00622	0.00088
After 25 h	50	2.001	0.0116	0.0016

Difference = (After 15h) - (After 25) Estimate for difference: -0.00460
95% CI for difference: (-0.00832, -0.00088)

T-Test of difference = 0 (vs. not =): T-Value = -2.47 **P-Value = 0.016** DF = 74

Since the p-value for Drill Regrinding comes out to be <0.05 therefore this might be a factor for laser nozzle head rejection

- Two sample t-test for Drill Replacement

Third two samples T-test for Drill Replacement (after 35 days and 45 days) by taking a sample size of 50 pieces and again finds the P- value for this test (Shown in table 2).

Table 3 Two-Sample T-Test for Drill Replacement: 35 Days, 45 Days

	N	Mean	St. Dev.	SE Mean
35 Days	50	2.002	0.00571	0.00081
45 Days	50	2.0016	0.0065	0.00092

Difference = (35 Days) - (45 Days) Estimate for difference: 0.00040

95% CI for difference: (-0.00203, 0.00283) T-Test of difference = 0 (vs. not =): T-Value = 0.33 **P-Value = 0.745** DF = 96. Since the p-value for drill replacement comes out to be >0.05 therefore thiscannot be a factor for Laser nozzle head rejection.

- Two sample t-test for New & old job holding mechanism

Fourth two samples T-test for New & old job holding mechanism by taking a sample size of 50 pieces and again finds the P- value for this test (Shown in table 3).

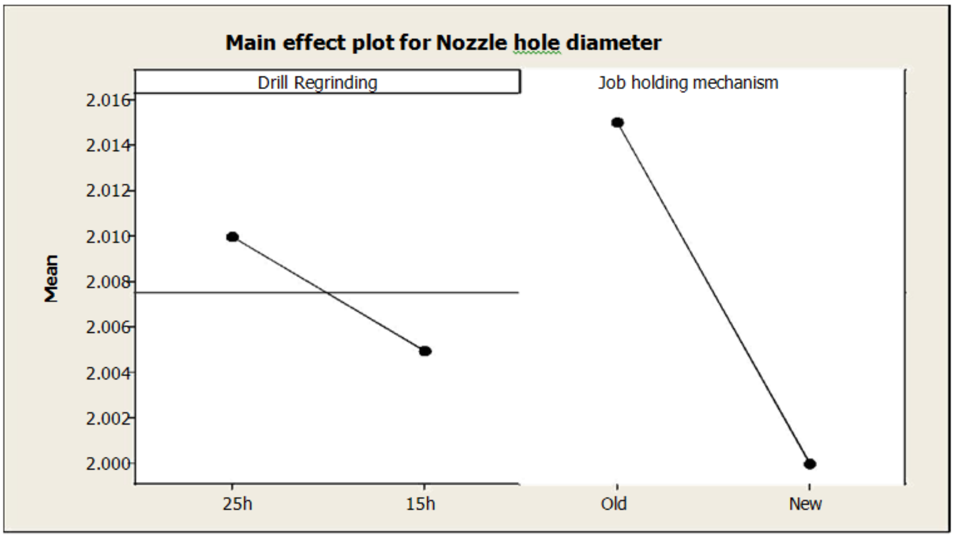

Fig.6 Main effect plot for Nozzle hole diameter

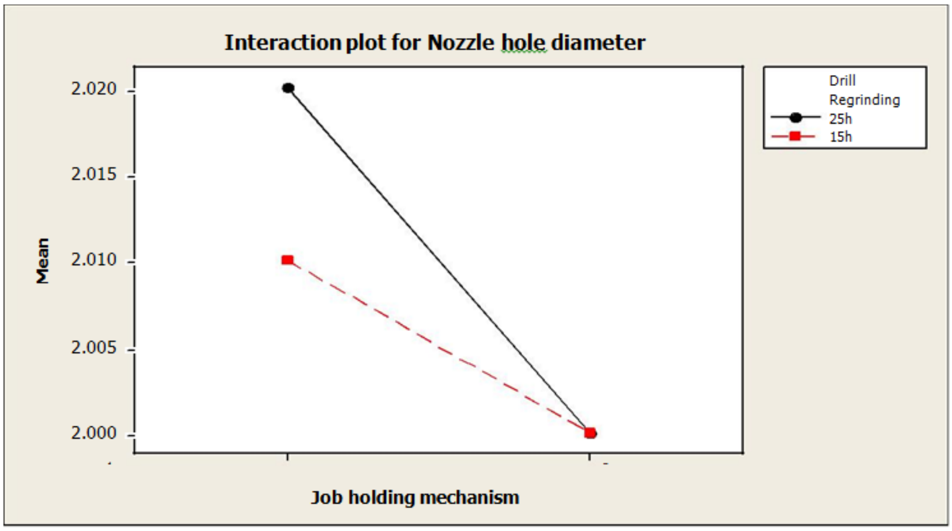

Fig. 7 Interaction plot for Nozzle hole diameter

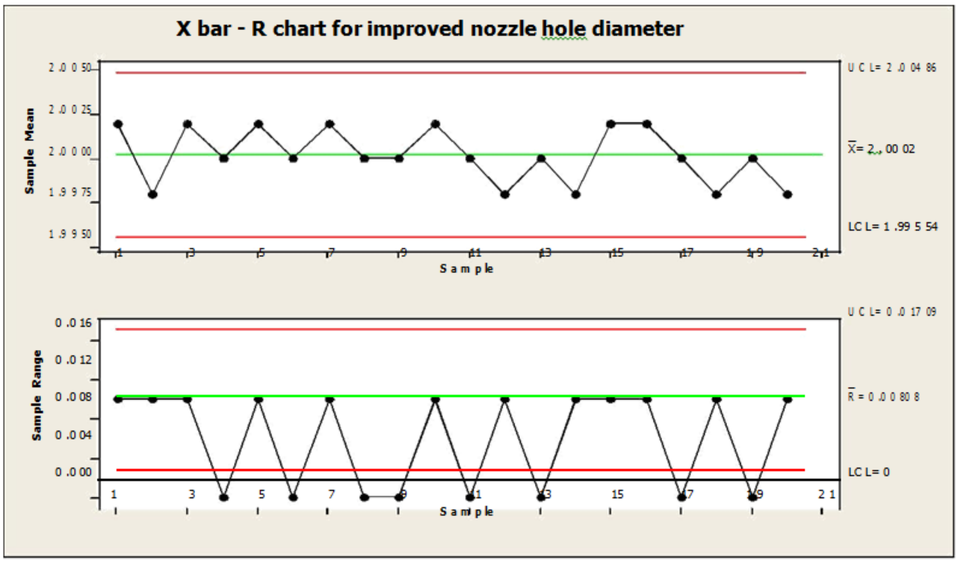

Fig.8. X bar- R chart for Improved Nozzle hole diameter variation 5.1 Result Appraisal

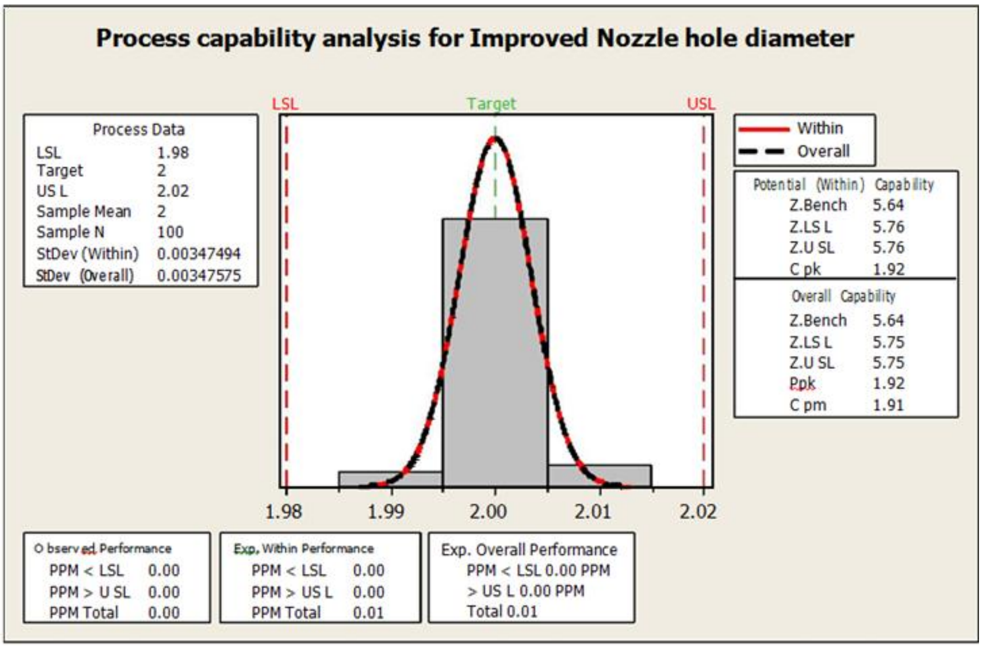

Fig.9 Process capability analysis data for Improved Nozzle hole diameter variation

Table 4 Two Sample T-Test: NEW, OLD Job Holding Mechanism

	N	Mean	St. Dev.	SE Mean
New	50	2.0002	0.00622	0.00088
Old	50	2.0048	0.0109	0.0015

Difference = (NEW) - (OLD) Estimate for difference: -0.00460

95% CI for difference: (-0.00814, -0.00106)

T-Test of difference = 0 (vs. not =): T-Value = -2.59 **P-Value = 0.012** DF = 77

Since the p-value for New & Old job holding mechanism comes out to be <0.05 therefore this might be a factor for Laser nozzle head rejection.

D)Improvement

In the improve phase, experiment of design conducted for optimum results. By T-test we found two main factors from all which affect the process are

- Drill regrinding
- Job holding mechanism

These experiments were conducted to optimize the value of the parameters drill regrinding and Job holding mechanism. A 2*2 experiment was designed, i.e. an experiment with two factors each levels. Table 1 & 2 shows the significant important factors for nozzle hole diameter variation.

Minitab was used to plot the main effects plot and interaction plot between the important factors shown in fig. 6 & 7 (Drill Regrinding and Job-holding mechanism).

The main effect plot suggests that drill regrinding is a minor factor and Job -holding mechanism is a major factor.

Table 5 Important Factor for Nozzle hole diameter variation

Important Factor	**Low Level**	**High Level**
Drill Regrinding	25 h	15 h
Job Holding Mechanism	Old	New

Table 6 Readings of factors at various levels

S. No	Drill Regrinding	Job Holding Mechanism	Nozzle Hole Diameter (mm)
1	25 th	old	2.02
2	15 th	old	2.01
3	15 th	New	2
4	25 th	New	2

Interactions plot shows that the lines are not parallel to each other so there are interactions present between the factors. The change in the response mean from the low to the high level of drill regrinding depends on the level of Job -holding mechanism.

E) Control

In control phase, draw the X bar-R control chart to check the variation in the process after improvement & it shows the process within range near the target. In this process took 100 samples from after improvement in the operation for Drawing X bar-R control chart shown in fig .8.

Improved result in form of process capability analysis graph is shown in figure 9.With the proper management of recourses & application of six-sigma in SSI help to improve sigma level up to 5.64 and total rejection level reduced to 0.01of production in PPM.

Conclusion

The results show that Six Sigma application has led to a remarkable cost saving as well as a reduction in the rejection rate of nozzle head of hydraulic laser machine. Major reasons identified for the high rejection rates were in nozzle hole diameter. After the gauge R&R study, it was found that the rejection is not due to human and instrumentation factor. Initially the process capability analysis for Sigma level was 2.21. But after implementing Six Sigma, values for process capability Sigma level were found out to be 5.64. This case study clearly discards the myth that Six Sigma is the domain of only large companies. It can be concluded that Six Sigma is not merely a simple statistical quality tool for application in large corporate companies; in fact the present work has attempted to prove that it can be successfully applied as a process improvement tool in organizations of diverse kinds.

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