REDUCTION OF KICK FORCE IN FOUR STROKE MOPED USING COMBINED APPROACH OF DMAIC AND SHAININ SYSTEM

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Abstract - In today's highly competitive globalized market, to remain competitive and successful, the companies must focus on their process efficiency as well as defect free products. The companies have initiated different quality improvement methodologies to improve their quality of processes as well as products. The present study was aimed to reduce the kick force from 280N to 210N as the high kick force is the major customer complaint in four stroke two wheeler moped. Six sigma DMAIC methodology and Shainin system have been adopted to reduce the kick force by controlling the process variations and optimizing the design. In each phase of DMAIC methodology, different tools and techniques were used for problem solving. The Shainin experimentation was used in the analysis phase to identify the dominant causes for the problem. The process capability improvement in critical parameters and the optimization of diameter of pin decompression, the kick force was reduced and the average value of 200N was achieved. The sigma level was improved from 2.49 to 3.55

Keywords - Kick force, Shainin system, DMAIC, dominant causes, process capability, sigma level, Paired comparison

I. INTRODUCTION

The first, Customer satisfaction is the key in any business for survival and improving the business performances. The present study was aimed to reduce the kick force from 280N to 210N as the high kick force was the major customer complaint in four stroke two wheeler moped at one of the leading two wheeler manufacturing company [1]. The customers were expecting that the kick force to be equal to two stroke moped as the target customers for the four stroke mopeds are the same as two stroke moped [2].

II. PROBLEM DEFINITION

The Kick force in the four stroke two wheeler is depend on the combustion pressure, compression ratio, gear ratio and camshaft profile. Apart from these major parameters, there were certain parts parameters have been designed to lower the kick force. The variations in these parameters would result into increase in kick force. The study aims to identify the critical parameters, reduce the process variations and optimize the design parameters to reduce the kick force to 210N from the existing level of 280N.

III. METHODOLOGY

The combination of six-sigma DMAIC approach and the Shainin experimentation were used to reduce the kick force in four stroke two wheeler moped. A detailed literature review had been carried out on DMAIC and Shainin system for problem solving. Various tools and techniques of the six-sigma and Shainin system had been used to identify and improve the process performances. The improvements suggested were implemented and standardized for sustenance.

3.1 Define phase: The Customer complaints on any new product launched in the market would have a serious impact on the future of the product. It affects the brand image of the company for long term if the complaints are adverse and if not resolved in a very quick time without affecting the customers. The average customer complaint percentage for the high kick force was around 9.25%.

3.2 Measure phase:

3.2.1 Data collection:

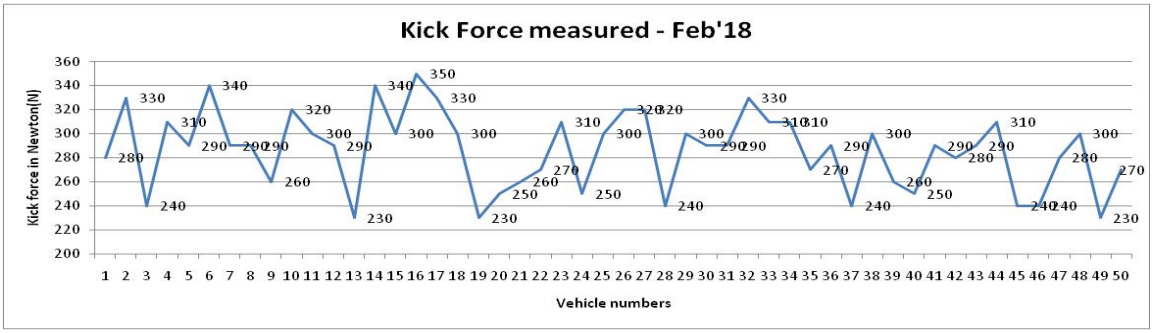


Fig. 1: Kick force measured in Feb'18

The check sheets were used for the data collection. The data collection was carried out in four levels such as in vehicle level, engine level, sub-assembly level and part level. The sample size used for the data collection was 50 numbers. The kick forces measured in the vehicles are shown in figure 1. The sigma rating for kick force variation in the current assembly line is calculated as 2.49

3.2.2 Data verification: The collected data were verified using six-sigma tools such as Run-chart and probability plot. From the run chart the P>0.05, no mixtures, clusters, trends, oscillations present in the data. From the normality test, P>0.05. Hence the data is normal and the process is stable without special causes.

3.3 Analysis phase1: In this phase the root causes of the problem were identified using brainstorming, cause and effect diagram, why-why analysis and the Shainin tools such as paired comparison and factorial experiments.

3.3.1 Cause and effect analysis: There were 19 possible causes for high kick force was identified during brainstorming. All these causes are grouped under the 4M. These possible causes were verified with respect to the current variation control at Gemba and found that there were five parameters for which the variation control is less.

3.3.2 Identification of main causes: The dominant causes were identified using Shainin tools of paired comparison. There were 5 best of best vehicles and 5 worst of worst vehicles chosen from the production. The actual values of the five parameters identified in the cause and effect analysis were measured in these vehicles. To identify the significance of the causes to the problem of high kick force, each parameter from the worst of worst vehicles were updated in the best of best vehicles and the kick force was measured. Based on the trials, it was identified that the variation of camshaft hole CD, diameter of pin decompression unit and lifter plate height were significantly contributing to the increase in kick force. The causes for variation in these parameters to be identified using Why-Why analysis. However, the average kick force measured in the best of best vehicle is 230N. If the target is to control the above parameters in-line with BOB vehicles, the kick force can be reduced to only 230N. This is not meeting the target of 210N. Hence further analysis was carried out to reduce the kick force to 210N.

3.3.3 Identification of root causes: The why-why analysis is carried out for all the main causes to identify the root cause of the problems and it is shown in the table 1

Table 1: Why-why analysis

Sl. No	Vital Cause	Root Cause
1	Camshaft hole CD variation	No rigid support available in fixture
2	Lifter plate height variation	1.Setting done in trial and error method using the fresh blank; 2.Raw material sheet not inspected
3	Diameter of pin decompression variation	1.Process carried out in Cam operated machine 2. No proper monitoring system for tool life available

3.4 Analysis phase2: The critical parameters were optimized to lower the Kick Force using Shainin DOE technique. There were three factors identified as significant parameters through Shainin Good Bad analysis in Analysis phase. Based on the review of functional requirements of the design and factorial experiments, it was identified that the design for Lifter ratchet height and Cam shaft hole are in optimized condition. The dimension of diameter of pin de-compression unit can be optimized between 7.1mm and 7.79mm. By keeping the lifter plate height and camshaft hole CD as per the specification and varying the dimensions of the diameter of pin de-compression unit, the kick force achieved was 200N at the value of 7.50mm and 7.61mm. To avoid the risk of engine not starting during testing, the dimension of the diameter of pin de-compression unit was arrived as $7.5^{+0.02}$ mm.

3.5 Improve phase: The actions identified to eliminate the root causes are as follows,

Table 2: Why-why analysis

Vital cause	Cause	Suggested actions
Camshaft hole CD variation	No rigid support in drilling fixture	1) Provide fixed Support in fixture to avoid Key Way Locator disturbance. 2) Provide Proxy interlock sensor to avoid wrong loading of cam shaft. 3) Provide receiving gauge for checking

The existing fixture without support and the fixture with support to avoid keyway locator disturbance is shown in figure 2 and the The proxy sensor provided in the fixture to avoid wrong loading of camshaft is shown in figure 3

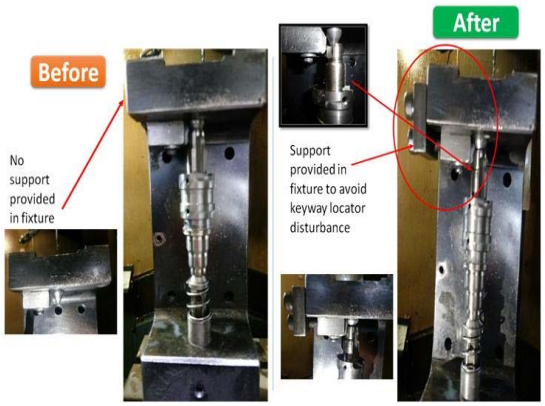


Fig. 2: Fixture with support block

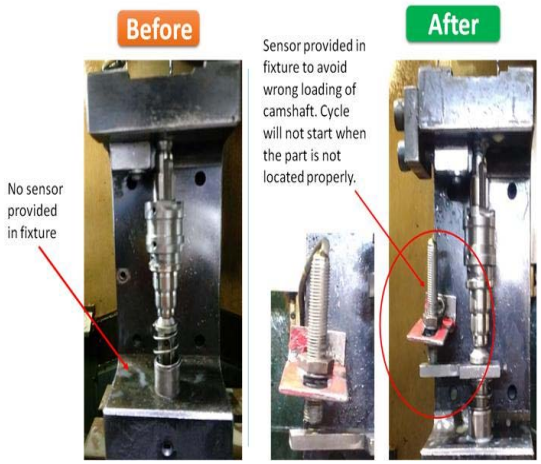


Fig. 3: Fixture with sensor

Table 3. Actions for lifter plate height variation

Vital cause	Cause	Suggested actions
Lifter plate height variation	1.Setting done in trial and error method using the fresh blank. 2.Raw material sheet not inspected	1) Stroke length to be set using the master sample. 2) Incoming inspection for the raw material sheet to be carried out

Table 4. Actions for diameter of pin decompression variation

Vital cause	Cause	Suggested actions
Variation of diameter of pin decompression unit	1.Process carried out in Cam operated machine. 2. No proper monitoring system for tool life available	1) Change the process to the MHS - 6 Axis machine for consistent accuracy. 2) Implement auto insert monitoring system in the machine

3.6 Control phase:

The actions suggested in the improve phase were implemented and the results were validated by comparing with the existing process performances. It is shown in table 5

Table 5. process performance comparison of Kick force

Parameters	Existing	Current
PPM	140534	104211
Ppk	0.36	0.28 (tolerance band reduced)
Cpk	0.32	0.42
Sigma rating	2.49	3.55

The side effects were verified with the improved parts and there was no side effects found. The kick force measured before improvements and after the improvements are shown in figure 4

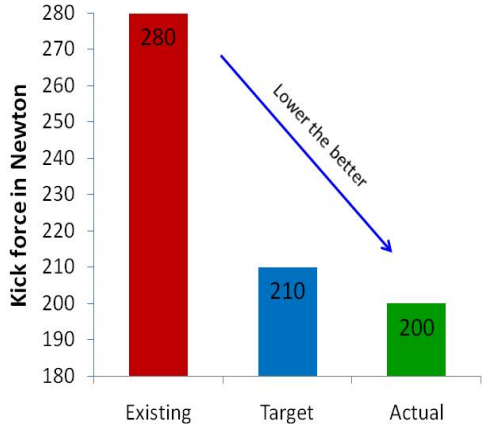


Fig. 4: Kick force target and actual

The list of documents and procedures standardized for sustenance are shown in table 6

Table 6. Standardization

Sl. No	Standardization description
1	Camshaft drilling fixture drawing is updated with additional supporting block
2	Inspection standards updated for inspection of camshaft hole centre distance
3	Failure mode directory updated
4	TPM one point lesion updated
5	Decompression unit drawing updated for pin diameter change from $7.1^{+0.02}$ to $7.5^{+0.02}$
6	System engineering standard updated for change in kick force specification from $250^{\pm 50}$N to $180^{\pm 30}$N

CONCLUSION

The aim of the study was to reduce the kick force requirement to start the four stroke moped two wheeler from 280N to 210N. Different tools and techniques of six sigma DMAIC and Shainin experimentations were helped to resolve the problem and reduce the kick force from 280N to 200N. Using statistical tools, the factors contributing to process deviations were identified and the results obtained were validated. Shainin experimentation is the powerful and simple approach to identify the dominant causes for the problem. The tools and techniques used in the measure and analysis phases determine the success or failure of the study to a large extent. In this the study, the Shainin tools have been very effectively used to pinpoint the dominant causes.

1. Suggestions for future work:

1. To improve the sigma rating of the following processes, i) Lifter plate height – From 3.25 to 6; ii) Camshaft hole CD – From 3.97 to 6; iii) Pin decompression diameter – From 3.83 to 6
2. 2) A study can be carried out to improve the Sigma rating of Kick force from 3.55 to 6
3. 3) Learning's of this study can be horizontally deployed to other products

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