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Reduction of run out specification in tractor rear wheel through DMAIC approach

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ABSTRACT:- *Reduction of run out specification in tractor rear wheel using DMAIC methodology, It encompasses various phases namely Define, measure, analyze, improve and control. Scope of project is to reduce the lateral run out specification from 5mm to 3mm in tractor rear wheel 12"x28" size. The scope confined to run out reduction in front side of the tractor rear wheel as the rear side already within 3mm specification. The run out specification is becoming more stringent in order to reduce the internal rework and thereby improving the productivity and customer satisfaction. Statistical tool like frequency plot, process capability and sigma level applied to justify the project scope during base line data collection on run out. In order to make sure that the run out pattern is uniform, data collected in various part sizes. Those data clearly indicated two facts that the rear side wobble in the wheel not exceeding 3mm*

Keywords:- DMAIC, PFMEA, PPM, Process Capability, Run Out Andshainin DOE.

I. INTRODUCTION

DMAIC Methodology basically instituted in six sigma approach to reduce variation in processes particularly in engineering and automobile industries. Reduction of variation is ultimately leads to waste elimination through methods namely problem solving and process optimization. Especially analysis phase is helps to identify the root cause for the problem. Design of experiments conducted in shainin way to pinpoint the exact root cause in analysis phase. DMAIC refers to define, measure, analyze, improve and control.

1.1. Define phase

Define phase consists of preparing the project charter, defining the SIPOC and identifying the critical to quality characteristics. Project charter explains detail about the project title, business case, and opportunity statement, goal statement, project scope, project plan and stake holders of the project. SIPOC is acronym of supplier, input, process and output matrix to identify the process and its associated input and output. Critical to quality issue is funneling the causal factors associated with the process for the underperformance of response factor. Problem definition is the most vital and has to be captured before going to measure and analyze phase. Following are the aspects to be brainstormed and captured in problem definition.

SIX SIGMA PROJECT CHARTER		REV	0
PROJECT NAME: REDUCTION OF RUN OUT SPECIFICATION IN TRACTOR REAR WHEEL THROUGH DMAIC APPROACH		DATE	20/08/2013
		PROJECT CODE	MIT/ME/2013
BUSINESS CASE		**OPPORTUNITY STATEMENT**	
The firm can retain the business share 100 percent		30 percent run out falls under within 3 to 4mm	
GOAL STATEMENT		**PROJECT SCOPE**	
Run out of the rear wheel specification is 5mm has to be brought to 3mm		W12x28 inch is the the fast runner wheel and therefore the scope limited to all the wheel codes	
PROJECT PLAN		**STAKE HOLDERS**	
ACTIVITY	**AUG SEP OCT NOV JAN FEB MAR APR**	S NATARAJAN	PROJECT FACILITATOR
Finalize team and charter		R NARASIMHAN	PROJECT SPONSOR
Gather data		T SOWRIRAJAN	CO SPONSER
Analyze data		RS RAMAEH	CO SPONSER
Select solution		FELIX AROKIARAJ	PROCESS OWNER
Develop plan to implement		THIRUVENGADAM	METHODS OWNER
Implementation as pilot		KALAISELVI	GREEN BELT
Finalize solutions		MUTHUKUMARAN	GREEN BELT
Final implementation		NIRMAL KUMAR	GREEN BELT
Closure and report		MANAVALAN	GREEN BELT
		V MEERAN MOHIDEEN	BLACK BELT

Table 1 Project charter

CRITICAL TO QUALITY		
NEED Y	DRIVERS	CTQ X
WHEEL WOBBLE VISIBILITY ELIMINATION	WHEEL RUN OUT	RIM RUNOUT DISC FACE OUT LUG WELDED RIM RUN OUT
Y=RESPONSE	Y=f(x)	X=CASUAL FACTOR

Table 2 Critical to quality

SIPOC				
SUPPLIER	INPUT	PROCESS	OUTPUT	CUSTOMER
RIM LINE	RIM	FORMING	ASSEMBLED WHEEL	TRACTOR MANUFACTURERS
DISC MANUFACTURING PRESSES	DISC	ROLLING		FARMERS
DISC MACHINING LINE	LUG	EXPANSION		END USERS
LUG WELDED MACHINE	LUG WELDED RIM	WELDING		
WHEEL ASSEMBLY NUT RUNNER	FASTENERS	ASSEMBLY		

Table 3SIPOC

1.2. Measure phase

The measure phase includes:

Study of repeatability and reproducibility, collect baseline data on defects and their possible cause, Plot defect data overtime and analyze for special causes, Create and stratify frequency plots and Calculate process sigma, detailed process maps. Frequency plot used to justify the project scope confined to front side wheel run out of the tractor wheel.

FRONT WOBBLE in mm	COUNT	CUMULATIVE PERCENTAGE
0.50	1	2
0.6	2	6
0.70	1	8
0.80	3	14
0.9	2	18
1	1	20
1	2	24
1.3	1	26
1.3	1	28
1.4	1	30
1.4	1	32
1.4	1	34
1.5	2	38
1.5	4	46
1.6	1	48
1.6	1	50
1.7	3	56
1.7	1	58
1.7	1	60
1.8	3	66
1.8	1	68
1.8	1	70
1.9	3	76
2	4	84
2.2	2	88
2.4	1	90
2.4	1	92
2.6	1	94
2.70	1	96
2.8	1	98
3.00	1	100

N=50

Table 4 Front run out

REAR WOBBLE in mm	COUNT	CUMULATIVE PERCENTAGE
1.50	2	4
1.7	1	6
2.00	1	8
2.00	2	12
2.1	1	14
2.2	1	16
2.2	2	20
2.2	1	22
2.3	3	28
2.4	1	30
2.4	2	34
2.5	1	36
2.5	1	38
2.5	10	58
2.6	3	64
2.7	2	68
2.7	1	70
2.8	2	74
2.9	1	76
3	1	78
3.1	1	80
3.2	4	88
3.4	2	92
3.6	1	94
3.6	1	96
4.1	1	98
4.4	1	100

N=50

Table 5 Rear run out

It is obvious that the run out in other side of the wheel is not exceeding the 3mm specification whereas front side of the wheel run out exceeds 3mm specification about 22%. This justification is enough to carry out the project at front side of the wheel. Front and rear wheel run out data analyzed to find out process capability and sigma level with 3mm and 5mm as the tolerance limit. The study result given below.

STUDY OF PROCESS CAPABILITY 5 MAX VS 3 MAX			
PARAMETER	CAPABILITY PPK	SIGMA LEVEL	EXPECTED PPM
WOBBLE F 5MM	1.36	4.09	21.94
WOBBLE F 3MM	0.21	0.64	261768

Table 6Consolidated report of PPK and Sigma level

II. ANALYZE PHASE

Analysis phase encompasses the Shainin technique tools to pinpoint the causes for the problem namely component search, paired comparison test, product parameter search, process parameter search and full factorial analysis. In this phase, we will be using data based techniques to pin-point which of the Suspected Sources of Variation (SSV's) are really creating the problem and the phenomenon. Features in DOE are90% of the Engineering problems are analyzed using "*Atmospheric analysis,*" Root cause cannot be established just by "thinking", Solutions given based on judgment, engineering guesses and Opinions will make the problem recur again. DOE tool helps to pinpoint the root causes using simple data collection and analysis techniques. Collection of data could beon-line without disturbing the regular production. Analyze data could beoff-line without fancy mathematics and statistics. Finally could be concluded either the cause is creating problem or not creating problem without any ambiguity.

2.1. Component search:

Component search helps to narrow down to the components which cause the problem, Ideal for assembly problemsasthis tool can be used for assemblies where reassembly is possible without any damages. Assembly problems can be due to the assembly process or the components Interactions between components also lead to the problem. Always select one very BEST assembly and one VERY worst assembly for the study.

Wave 1 :

List down the suspected components in the descending order, Select one Best of Best BOB, and very Worst of Worst WOW assembly, Measure the quantifier for the problem and note it down, Disassemble and reassemble twice and note down the quantifier again. If best remains best and worst remains worst , then the assembly is not the contribut or If the quantifier is variable , then proceed as below Please find below the quantifier for initial ,first reassemble and second reassembly of the wheel assembly 12x28"

TRIALS CATEGORY	WHEEL 1 RUN OUT in mm-BEST	WHEEL 2 RUN OUT in mm-WORST
BASIC CONDITION	2.03	3.55
FIRST REASSEMBLY	2.16	4.31
SECOND REASSEMBLY	2.08	3.86
MEDIAN	2.08	3.86
RANGE	0.13	0.71

Table 7Result of assembly trial

Difference between medians D= 1.78, average of the ranges d = 0.44,D/d = 1.78 /0.44 = 4.04.
If the D/d ≥ 1.25 then the assembly process is not the contributor.

WAVE 2

Bring back the assembly to the original condition before going for the next swap, ensure that best remains best and worst remains worst, Repeat the swapping till all the listed components are swapped. The data below shows the results of the component swapped and the inference

BEST Assembly with swapping	Run out result in mm	WORST assembly with swapping	Run out result in mm	Inference
Aw Ob-RwDbFb	3.53	AbOw-RbDwFw	2.21	Complete reversal
Bw Ob-DwRbFb	2.21	Bb Ow-DbRwFw	3.65	Best remains best/
AwBwOb-RwDwFb	3.81	AbBbOw-RbDbFw	2.49	Complete reversal

Table 8 Summary of swapping

Upper decision limit for best assembly = Median of best + (2.78 *d/1.81) = 2.08 +0.68= 2.76
Lower decision limit for best assembly = Median of best - (2.78 *d /1.81) = 2.08 - 0.68 = 1.40
Upper decision limit for worst assembly = Median of worst + (2.78 *d /1.81) = 3.86 + 0.68= 4.54
Lower decision limit for worst assembly = Median of worst - (2.78 *d /1.81) = 3.86 - 0.68= 3.18

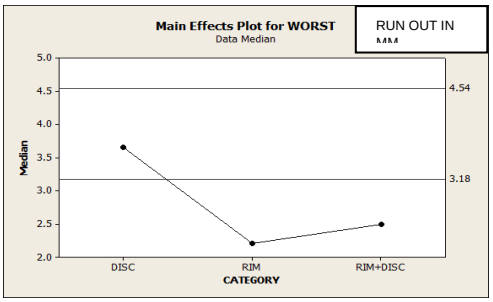

Figure 3 Interaction chart for best

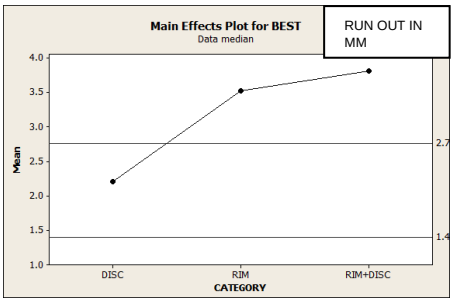

Figure 4 Interaction chart for worst wheel

WAVE 3

The purpose is to quantify the main effects and interaction effects of the components under study Interaction is quantified in terms of both magnitude as well as direction

	Bw-Discw	**Bb-Disc b**
Aw-RIM w	3.55,3.81,3.86,4.31 Median = 3.83	3.53,3.65 Median =3.59
Ab-RIM b	2.21,2.21 Median = 2.21	2.03,2.08,2.16,2.49 Median = 2.12

Table 8 Interaction summary

A	**B**	**AB INTERACTION**	**Result**
-	**-**	**+**	**3.83**
+	**-**	**-**	**2.21**
-	**+**	**-**	**3.59**
+	**+**	**+**	**2.12**
-3	**-0.33**	**0.15**	

Table 9 Magnitude and direction of interaction

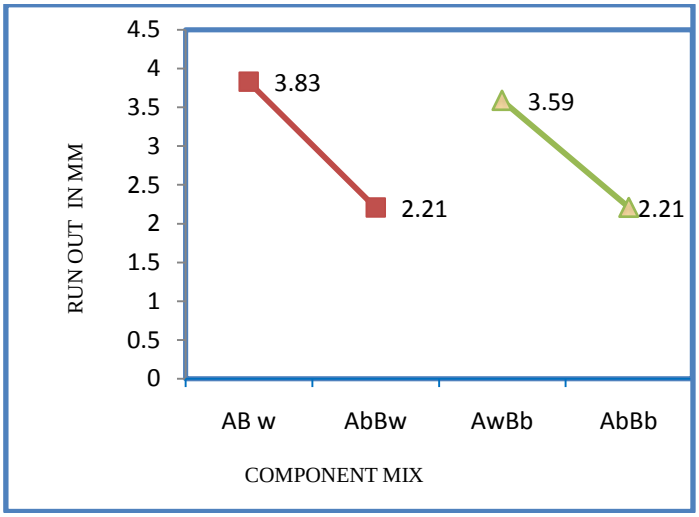

Figure 10Component interaction graph

Component search technique used to find out the suspected source of variation from the most contributing component out of all constituent part. Rim of the wheel has been identified as a major contributor based on the best and worst wheel's components swapping.

2.2. Product characteristic search

Product characteristics identified as a causeof the problem based on engineering judgment. Lug inset variation in Lug welded rim, Weld distortion in Lug Welded rim, Kink due to valve hole piercing and Non homogeneous expansion in Rim expansion. Paired comparison test used to determine whether the lug inset variation is suspected source.it is proved that lug inset varation more than 0.5mm in rim is contributor for the excess run out.Full factorial analysis result shows no significant effect due to lug welding distortion.

1. IMPROVE PHASE

As a corrective action lug planishing, valve hole piercing tool profile correction and expander block bad modification have been taken to reduce the run out reduction.

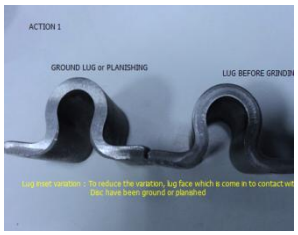

Figure 6 Lug planishing

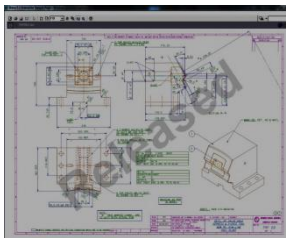

Figure 7 Valve tool correction

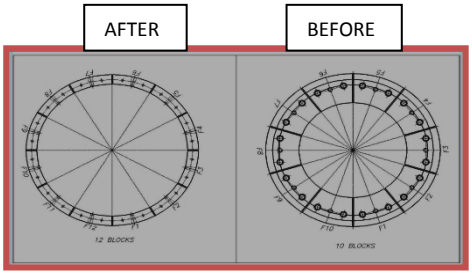

Figure 8Expander block modification

2. CONTROL PHASE

To sustain the performance, controlling the cause of the problem is vital and therefore the controlling parameters are updated in the PFMEA, control plan, work instructions, tool drawing, product drawing etc. Product drawing amended with specification 3.5mm as an initial commitment to customer instead of 3mm.Set up instruction incorporated with point to ensure the lug planishing operation have been carried out. Introduced x-bar r chart to monitor the performance of the quantifier continuously to track time to time variation for bring back to the stability.

III. RESULTS AND DISCUSSIONS

1. Component search experiments concluded that the main effect due to the run out in the rim and no other component contributing to run out problem
2. Component swapping trials concluded as clear as crystal that worst rims reverse the run out value of best rim completely.
3. Sigma level improved from 0.64 to 1.24 and subsequent rework reduced to 261768 ppm to 65800 ppm.

IV. CONCLUSION

1. Shainin way of design of experiments helpful to identify the suspected source of variation without ambiguity.
2. Further analysis with paired comparison to identify the product and process characteristics contributing to the run out.
3. Full factorial analysis is another tool in shainin DOE to optimize the process parameter

ABBREVIATIONS

DMAIC: Define Measure Analyze Improve control, PPM: Parts per Million.

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