International Journal of Emerging Engineering Research and Technology
Volume 2, Issue 6, September 2014, PP 18-23
ISSN 2349-4395 (Print) & ISSN 2349-4409 (Online)

Application of Six-Sigma Approach to Motor and Pump Manufacturing Industry – A Case Study

U. Shrinivas Balraj[1], P. Anitha[2]

[1]Assistant Professor, Department of Mechanical Engineering, Kakatiya Institute of Technology and Science, Warangal, Telangana, India.
[2] Assistant Professor, Department of Mechanical Engineering, Kakatiya Institute of Technology and Science, Warangal, Telangana, India.

Abstract: *In this paper, a case study is presented on the six-sigma approach that is applied to the quality assurance department of motor and pump manufacturing company located in Maharashtra state in India. The objective of this study is to reduce the number of defects in total products (semi finished/finished) manufactured daily. The necessary data is collected for a number of total products manufactured during the one month period of study. The analysis of defects is done using Pareto analysis and causal analysis. The parts per million is calculated for each cause of the defects. The necessary corrective actions are suggested for the most prominent three causes. Subsequently upon implementation of these suggestions, the generation of defects has been further monitored. Based on these statistical considerations, the study reveals that the approach is very effective and has shown positive results.*

Keywords: *Six sigma, Parts per million, Defects, Pareto analysis, Cause and effect analysis*

1. Introduction

Six- Sigma is several things. First, it is a statistical measurement. It tells us how good our products really are. The six-sigma method allows us to draw comparisons to other similar or dissimilar products. Most importantly, we see where we need to go and what we must do to get there. In the sense, the six-sigma scale of measure provides us with a “goodness micrometer” for gauging the adequacy of our products. Second, it is a business strategy. It can help us gain a competitive edge. The reason this is very simple as you improve the sigma rating, the product quality improves and costs go down. Naturally the customer becomes more satisfied as a result. Third, it is a philosophy. Essentially, the philosophy is one of working smarter, not harder.

The term “sigma” is used to designate the distribution or spread about the mean (average) of any process or procedure. By combining the mean and standard deviation, the sigma of a process can be calculated. The sigma value indicated how often defects are likely to occur. The higher the sigma value, the less likely a process will produce defects. As sigma value increases, costs go down, cycle time goes down and customer satisfaction goes up. The sigma of a process tells us how capable it is.

In the concerned company, systems are there which are focused on the cost of quality rather than quality of products. The company’s target was to keep overall cost of quality below 5% of annual inventory carrying cost and to attain the same each department was given some target for cost of quality. But actual cost of quality was found around 15-20%. In fact, the cost due to internal and external repair was exceeding 6-8%. This was not at all affordable. Also every department was bothered about their own targets and there was no benchmark to interlink all. The answer was found in Six-Sigma approach because when we say the product is at 6-sigma level, it is best in class and such a level of capability will only yield 3.4 defects per million opportunities for non conformances. When it is at 4-sigma level, we are saying it as average and this translates to about 6200 defects per million opportunities for non conformances. Thus it gives us crystal clear image of our products or processes. Also Six-Sigma method allows us to reduce things to a common denominators - defects per unit and sigma value.

In this paper, a case study is presented wherein the six-sigma approach is applied to the quality assurance department of motor and pump manufacturing company to reduce internal defects only. The important terms involved in the study are clearly defined in the table I.

2. Data Collection

For precise and accurate data collection, a daily data collection sheet is prepared as shown in annexure Table II. The data is collected daily for all defective products as well as total production of motors and pumps for a period of one month. All the possible causes of defects (mechanical & electrical) are identified based on the past experience and recorded in the daily data collection sheet. The PPM is calculated daily as well as at the end of the month. The causes are prioritized using a Pareto diagram (Figure. 1).

Table I. *Definitions*

No.	Important terms	Definition
1	Department	Quality Assurance
2	Project	To reduce the number of defects in total products (motors and pumps) manufactured daily i.e., < 10000 PPM
3	Defect	A defect is the one, which is not in conformance with the specifications of the design.
4	Product	Product can be finished product or semi-finished product.
5	Defects per unit (DPU)	DPU= total defects / total products manufactured
6	Opportunity	The opportunity is the one, which may cause the product defective and it can be measured. Here opportunities =1
7	Defects per opportunity (DPO)	DPO = DPU / number of opportunities
8	Defective parts per million (PPM)	PPM = DPO * 10,00,000
9	Methodology	If a products is found defective after testing, it will be kept in quality assurance department for repair / rework / concession / rejection and total number of defective products represents total defects daily.

Three vital few to attack [5] causes are selected as follows,

1. Bearing noise
2. Less speed
3. Wrong assembly

The project review [2] [5], comments, motor or pumps type (HP) wise cause distribution and quantity are discussed in Table II. The analysis of causes is done using causes & effect analysis [1]. Each cause is examined to determine why each one could have occurred. The comments of these causes are given in Table III. The necessary corrective actions are taken as shown in Table IV. Also the expected PPM after implementation of the corrective actions is shown in Table IV

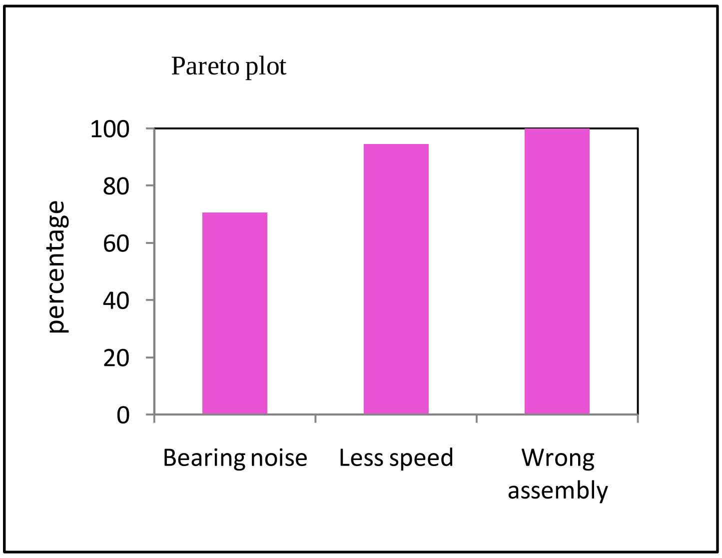

Figure 1. *Pareto plot of top three causes*

3. RESULTS AND DISCUSSIONS

The corrective actions taken are monitored continuously and found that a dramatic reduction in the defects has occurred from the day of implementation. The next month data is collected using the same daily data collection sheet. The three causes are compared PPM wise and are shown in Table V. The comparison of Pareto plot of these causes in Figure 2. shows that the defects due to these three causes are reduced to a large extend after implementing all the corrective actions successfully.

Table III. *Causes and comments*

Cause	Comments	Type (HP)	Quantity	PPM
1.Bearing Noise	Bearing Noise is mainly occurred in low HP motors & pumps. Two bearings are mounted at a time on shaft, as a result excess load is acting on the bearings & in some products, fits are not as per specifications of suppliers (SKF & AG).	0.16	28	24435
		0.25	19	
		0.5	56	
		0.75	22	
		1	16	
		1.5	2	
		2	3	
		3	3	
		Others	10	
		Total	159	
2.Less Speed	It is mainly due to blowholes present in the rotors & it is a supplier's problem. In some rotors skew lines are not correct. There is no system for skew line inspection.	1	2	8298
		1.5	1	
		2	3	
		3	4	
		5	14	
		7.5	4	
		10	19	
		25	4	
		40	3	
		Total	54	
3.Wrong subassembly	It is due to following two reasons - Wrong selections of impellers & casings for assembly. Impellers & casings are not having proper identification codes. -New workers not properly mounted impellers on shafts.	1	5	1844
		1.5	4	
		2	2	
		3	1	
		Total	12	

Table IV. *Corrective Actions*

Cause	Corrective Action	PPM	Expected PPM (next month)
1.Bearing Noise	The process sheet of bearing mounting procedure is revised for single bearing mounted to avoid excess load coming on bearings & fits are changed, assured by informing the suppliers.	24435	< 5000
2.Less Speed	The process sheet of bearing mounting procedure is revised for single bearing mounted to avoid excess load coming on bearings & fits are changed, assured by informing the suppliers.	8298	<1000
3.Wrong assembly	Identification codes are inbuilt in impellers and castings to avoid wrong selection of parts; also training is given to new workers for perfect assembly by Quality assurance & Design departments.	1844	0

Table V. *Comparison of PPM*

Cause	**PPM**	
	First month	Second month
Bearing noise	24435	7668
Less speed	8298	1142
Wrong assembly	1844	489

4. CONCLUSION

The case study here emphasizes the importance of Six Sigma technique implementation to a motor and pump manufacturing industry. Pareto analysis and cause-effect analysis are used in this case study. It is observed that the three top causes i.e. bearing noise, less speed and wrong assembly problems are reduced drastically after implementation of corrective actions successfully. Bearing noise is reduced from 24435 PPM to 7668 PPM, less speed reduced from 8298 PPM to 1142 PPM and wrong assembly problems reduced from 1844 PPM to 489 PPM. This is the evidence that it can bring out radical positive change in the processes and products. Thus, it is a continuous improvement process to improve the quality of the processes and products. It can be a good benchmark for the organization. In the author`s view, it is the creation of synergy between people and techniques that ensures maximum and continuing benefits from a Six- Sigma initiative.

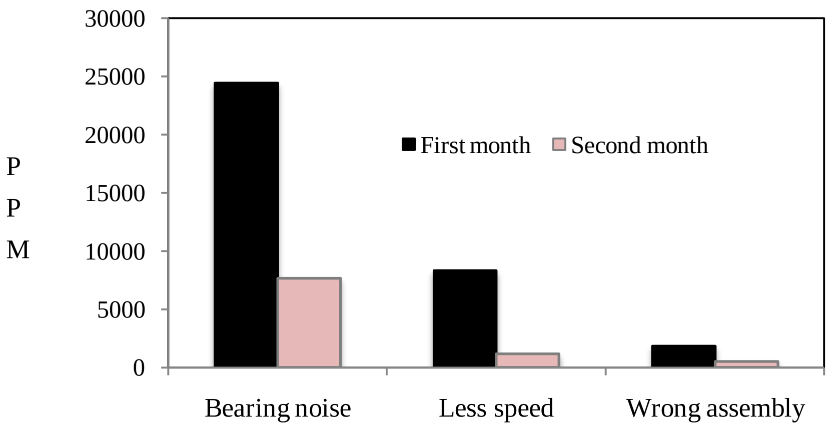

Figure 2. *Comparison of PPM*

REFERENCES

[1] J. Prasad, “Six Sigma in Bulb Manufacturing”, Productivity Journal of National Productivity Council, vol.43, No.2, pp. 192-195, 2002.

[2] P. Kumar, “Six Sigma In Manufacturing”, Productivity Journal of National Productivity Council, vol. 43, No.2. pp. 196-202, 2002.

[3] George Eckes, Making Six Sigma Last: Managing The Balance Between Cultural & Technical Change. Int. ed., Wiley & Sons, Singapore, 2001.

[4] Arnold V. Feigenbaum, Total Quality Control, McGraw Hill, 3rd ed, Singapore, 1991.

[5] http//www.issixsigma.com

[6] http//www.isss.com

Annexure

Table II. *Daily Data Collection Sheet*

	SIX SIGMA DATA/DAYS	1	2	3	4	5	6	8	9	10	11	12	13	15	16	17	18	19	20	22	23	24	25	26	27	29	30	31	Total
A	Total defective products	20	27	15	8	12	11	9	15	9	13	16	11	5	14	11	10	8	3	26	24	9	12	10	4	13	5	15	335
B	Total products manufactured	230	235	240	238	247	252	36	45	243	248	241	237	249	230	233	250	249	244	231	243	233	245	242	248	235	242	241	6507
C	DPU = A/B	0.087	0.1149	0.063	0.034	0.049	0.044	.038	.061	0.037	.0524	.0664	0.046	.02	.0609	0.047	0.04	0.032	0.012	.1126	0.099	0.039	0.049	0.041	0.016	0.055	0.021	.0622	.39899
D	PPM=C* 1000000	86957	114894	62500	33613	48583	43651	3136	1224	7037	62419	66390	46414	20080	60870	47210	40000	32129	2295	112554	98765	38627	48980	41322	16129	55319	20661	62241	1409000
E	Causes																												
	A) ELECTRICAL																												
	less current	1												1				1							1				4
	less resistance		2	1			1									1				1				1			1		8
	excess current			2				1			1			1		2						1							8
	excess resistance					2			3		2									1									8
	unbalance current		2	1			1				1						1				1	1			1				9
	unbalance resistance			1								1						1											3
	less speed	2	3		1	2		3	3		3		2	2	3	2	1		1	4	3	2	7	3		3	1	3	54
	less torque	3																											3
	starting problem		2								1	1			1			1						1					7
	humming noise				1		1									1						1				1			5
	less efficiency			1					1				1					1					1					1	6
	lead connections	1			1					1					1		1												5
	B) MECHANICAL																												
	bearing noise	9	13	7	4	8	5	4	8	5	1	12	5		7	4	5	3	1	19	15	1	2	4		8	2	7	159
	dimension problem	1		1											1														3
	less discharge						2					1					1		1			1				1			7
	excess discharge	1								1			1			1	1				1			1					7
	priming time is more		1				1				2							1			1				1			2	9
	starting problem			1							2				1						1	2	1						8
	less efficiency		2		1			1		1			1							1	2						1		10
	wrong assembly	2	2							1		1	1	1									1		1			2	12
	less head																												
	Total	20	27	15	8	12	11	9	15	9	13	16	11	5	14	11	10	8	3	26	24	9	12	10	4	13	5	15	335

AUTHOR'S BIOGRAPHY

U. Shrinivas Balraj is working as Assistant Professor in the department of Mechanical Engineering at Kakatiya Institute of Technology and Science, Warangal, India. He has teaching experience of 12 years and industry experience of 2 years. He has 14 publications to his credit in reputed international journals, national and international proceedings. His research areas include design of experiments, response surface methodology, electrical discharge machining, optimization methods, quality engineering etc.

P. Anitha is working as Assistant Professor in the department of Mechanical Engineering at Kakatiya Institute of Technology and Science, Warangal, India. She has teaching experience of 5 years and worked as design engineer in industry for 2 years. Her interested research areas are tribology, metal matrix composites, finite element analysis and optimization methods.