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SIX SIGMA APPROACH TO REDUCE THE TE/FE DEFECTS IN OPTICAL DISC (DVD)

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ABSTRACT

Manufacturing sector is the back bone of the economy for any country in world. The financial health of manufacturing sector plays a vital role in economic health of any country. Manufacturing sector can control the cost by reduction of defects in product. The discipline of six sigma views every business activity as a process, that once optimized and controlled, reduces cost in any organisation. Six Sigma is a customer-focused and data-driven quality strategy. It is systematic methodology that utilizes collected information and statistical analysis to reduce defect rate and improve performance. In this paper the role of Six Sigma has been analyzed through case study of optical media manufacturing industry. It is observed through the study that Six Sigma has contributed to the improved financial status,productivity and customer satisfaction on production line. However its contribution towards the welfare of the work force and growth ofthe company is not significant.

Key words:- Six Sigma, FMEA, Pareto chart, Brainstorming etc.

1.INTRODUCTION

Six Sigma was invented at Motorola in the 1980s (Delsanter, 1992).The invention was motivated by the high cost of poor quality discovered at Motorola. Motorola engineers proposed the concept of Six Sigma, which means achieving a quality standard of less than 3.4 defects per million opportunities (DPMO) for any organisation. Six Sigma has been defined as the statistical unit of measurement, a Sigma that measures the capability of the process to achieve a defect free performance. Six Sigma has the ability to produce products with only 3.4defects per million, which is a world class performance in any manufacturing or service organisation. Six Sigma has also been described as a high performance data driven approach in analyzing the root causes of business problems and solving them with positive approach.

According to Hongbo Wang (2008), statistically Six Sigma refers to a process in which the range between the mean of a process quality measurement and the nearest specification limit is at least six times the standard deviation of the process. As per Antony (2008), Six Sigma is a highly disciplined, customer oriented and bottom line driven business improvement strategy that relies on statistical methods to make dramatic reductions in defect rates in processes, manufacturing or service. Anbari (2002) pointed out that Six Sigma is more comprehensive than prior quality initiatives such as Total Quality Management (TQM) and Continuous Quality Improvement (CQI).Six sigma can be summarised as Six Sigma= (TQM + Stronger Customer Focus + Additional Data Analysis Tools +Financial Results).

A Six Sigma initiative is designed to change the culture in an organization by way of breakthrough improvement in all aspects of business (Klesjo et al. 2001). Six Sigma projects focus primarily on understanding and identification of critical characteristics to the existing customers (Harry, 1998; Dasgupta, 2003; Linderman et al., 2003; Evans and Lindsay, 2005). Maleyeff and krayenvenger (2004) have quoted the definition given by Breyfogle: Six Sigma is a comprehensive program for managing a business that emphasizes an intelligent blending of the wisdom of the organization with proven statistical techniques to improve both the efficiency and effectiveness of the organization in meeting customer needs. The term "six sigma process" comes from the notion that if one has six standard deviations between the process mean and the nearest specification limit, as shown in the graph, practically no items will fail to meet specifications; this is philosophy of Six Sigma. Six Sigma is uniquely driven by close understanding of customer needs, facts, data, and statistical analysis, and attention to managing, improving, and reinventing business processes.Today, Six Sigma is the fastest growing business management system in industry. The main aim of Six Sigma is to reduce the number of defectives to 3.4 parts per million also known as defects per million opportunities (DPMO), reducing costs and reducing cycle time which impacts the bottom line (Haikonen et al. , 2004). Six Sigma itself is a process that is often briefly described by the DMAIC, which stands for define, measure, analyze, improve, and control. DMAIC is a process for continued improvement. DMAIC refers to a data-driven improvement cycle used for improving, optimizing and control business processes and designs. The DMAIC improvement cycle is a process used to drive Six Sigma projects in any field. DMAIC is not exclusive to Six Sigma and can be used as the framework for other

improvement applications in quality management. It implements the idea of continuous process improvements. Processes are constantly monitored for possible improvement possibilities.

Table 1 -Key Steps of DMAIC Processes

Steps	**Key Processes**
Define	Define the requirements and expectations of the customer Define the process by mapping the business flow Charter, teaming, project management
Measure	Develop a data collection plan Collect and compare data to determine issues and shortfalls Process map, cause and effect matrix, MSA, process capability
Analyze	Analyze the causes of defects and sources of variation Determine the variations in the process FMEA, multivariance, Anova, regression etc.
Improve	Improve the process to eliminate variations Develop creative alternatives and implement enhanced plan DOE, response surface methods, evolutionary operation
Control	Control process variations to meet customer requirements Develop a strategy to monitor and control the improved process SPC, control plan, poke yoke

The main benefit of DMAIC is that it contributes to the creation of a conceptual framework for consistent performance measurement, improvement, and control of any process. A DMAIC project typically runs for a relatively short duration versus product development projects. It is systematic, scientific and fact based approach. The six sigma methodology is a funnel that reduces variations or waste.

2. LITERATURE REVIEW

The Six Sigma program was first launched at Motorola in 1986, thanks to the joint efforts of some key figures, among which are; Mikel Harry (Senior Engineer of the Government Electronics Group), Bill Smith (VP and Senior Quality Assurance Manager) and Bob Galvin(CEO).‘‘Motorola invented the Six Sigma quality improvement process in 1986.Six Sigma provided a common worldwide language form assuring quality and became a global standard.’’(Source: www.motorola.com; other sources frequently report that the official launch of Six Sigma took place in 1987)”. The Corporate Policy Committee of Motorola then updated their quality goal as follows:

“Improve product and service quality ten times by 1989, and at least one hundred fold by 1991. Achieve Six Sigma capability by 1992. The statistical representation of Six Sigma describes quantitatively how a process is performing. Six Sigma’s goal is the near elimination of defects from any process, product or service far beyond where virtually all companies are currently operating (Plotkin, 1999).Six Sigma has been defined as an improvement philosophy, particularly by GE. GE claims that Six Sigma is its business strategy, corporate culture, company DNA and value, and “the way we live” (GE, 2002). In order to reduce process variation and the associated high defect rate, Six Sigma focuses on improvement methodology application, then the DMAIC is mentioned most frequently now and a lasting improvement method (Starbird, 2002). Defining Six Sigma as an improvement philosophy is very inspiring and it could lead to major cultural change and performance improvement in an organization. Process improvement has often been accomplished through an integrated approach, using problem-solving techniques such as total quality management (TQM) and classic statistical analysis (Wiklund and Wiklund, 2002). The numerical goal of Six Sigma is reducing defects less than 3.4 parts per million (PPM), also known as defects per million opportunities (DPMO)., reducing cycle time and reducing costs dramatically which impact the bottom line (Haikonen et al., 2004). The Six Sigma program was launched in Fiat Services in the second half of 2005, with the aim of improving internal processes, pursuing quality and efficiency.The Black Belts work under the guidance of Master Black Belts to apply Six Sigma on specific projects, leading the Green Belts. Their work is focused on implementation of projects. The SKF Group is the world leader in the supply of products, solutions and services in the fields of rolling bearings, seals, mechatronics, services and lubrication systems. Six Sigma is a disciplined, data driven approach and methodology for eliminating defects (driving towards six standard deviation between the mean and the nearest specification limit) (Desai and Patil, 2006). A good definition of Six Sigma is given by Schroeder et al. (2008): Six Sigma is an organized, parallel-meso structure to reduce variation in organizational processes by using improvement specialists, a structured method, and performance metrics with the aim of achieving strategic objectives. (Ying-Chin Ho et al. 2008) determined critical factors for aircraft maintenance, repair, and overhaul companies during the initial incorporation stage of Six Sigma

programs. This is achieved by examining 14 key success factors. Employees of an Asian maintenance, repair, and overhaul company are surveyed. Factor analysis is used to identify five key factors that are pertinent to successful completion of Green Belt improvement projects.(Chin Hung et al 2011) had utilized the DMAIC phase to decrease the defect rate of small custard buns by 70% from the baseline to its entitlement. At the beginning of this project, the defect rate was 0.45% (Baseline), and after the improvement actions were implemented during a six-month period this fell to below 0.141% (goal). Sebastian Koziołek (2012) presented the methodology for assessing the process of designing and constructing vehicles and machines, which implements Design for Six Sigma tools. An important purpose of this paper is to determine how defects affect the quality of the structure, based on the criteria of its conformance. Rohini et al .(2011) proposed the DMAIC Six Sigma approach of Define, Measure, Analyse, Improve/Implement and Control (DMAIC) to improve the process in the Operation Theatre of a corporate multi specialty hospital in Bangalore, India. The DMAIC approach showed a wider application and how the healthcare organization can achieve competitive advantages, efficient decision-making and problem-solving capabilities within a business context. Zhang et al. (2013) Brake judder is a brake induced vibration that a vehicle driver experiences in the steering wheel or floor panel at highway speeds during vehicle deceleration. The primary cause of this disturbance phenomenon is the brake torque variation (BTV). Virtual CAE tools from both kinematics and compliance standpoints have been applied in analyzing sensitivities of the vehicle systems to BTV. This study presents a recently developed analytical approach that identifies parameters of steering and suspension systems for achieving optimal settings that desensitize the vehicle response to BTV. Sharkawy et al. (2014) presented design methodology for automotive heat exchangers has been applied which brings robustness into the design process and helps to optimize the design goals: as to maintain an optimal coolant temperature and to limit the vehicle underhood air temperature within a tolerable limit. The most influential design factors for the heat exchangers which affect the goals have been identified with that process.

3. CASE STUDY

Being a market leader in optical storage media Moser Baer India Ltd has the always pressure to complete the CRDD (Customer Required Delivery Date). The yield of good product plays an important role in completing the CRDD. By reducing the defect in product we can increase the dispatch and focus in converting the input material into output with maximum yield. In this project, all TE-FE related defects will monitor and by using Six Sigma Methodology, we will reduce TE - FE related defects.

3.1DEFINE PHASE

TE /FE are the important parameter in manufacturing process of Digital versatile disc (DVD). Presently the rejection level is(3-6) %, which is resulting in scrap generation and minimizing the productivity of line. We have set a target to reduce the rejection level below 3%. The process elements and the interactions are indicated in the **SIPOC** given below.

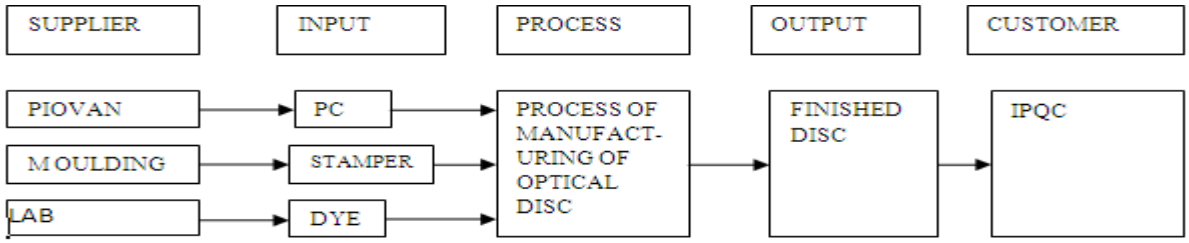

Figure-1 (SIPOC Diagram)

3.2 MEASURE PHASE

The Otari TE/FE is a tester for DVD-R/+R for General discs on Origin line. The TE/FE tester provides reliable disc handling by adopting the Otari original automatic disc loading mechanism and double-feed prevention mechanism. Day wise rejection trend on TE/FE tester is given below in figure

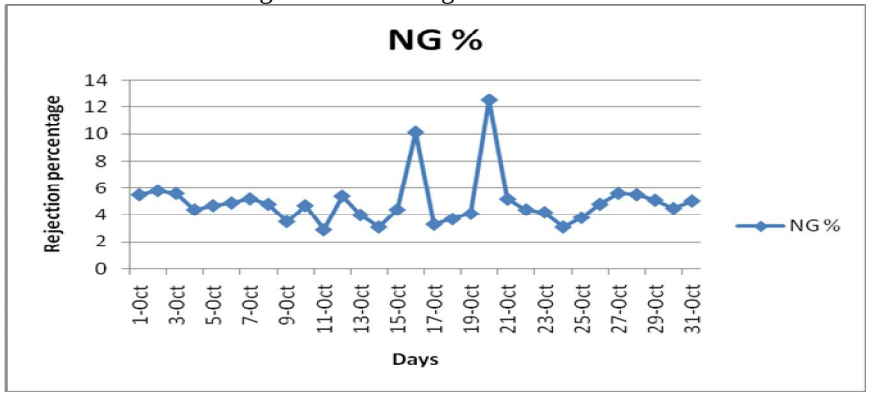

Figure-2 (Day wise rejection percentage)

From graph it is clear that the average rejection on TE/FE tester is (3-6) %.

3.3 ANALYSIS PHASE

3.3.1 For root cause analysis of TE/ FE NG, brain storming and FMEA analysis is given below

Table-2(Brain storming)

Brain Storming on TE/FE NG problem		
	Defect	**Cause**
1	TE-FE Drive problem	m/c
2	TE-FE V-arm alignment problem	m/c
3	Tray /Signal error	m/c
4	PC	material
5	Stamper problem	material
6	Blank thickness variation	method
7	Blank mechanical parameters	method
8	IMM process parameters	method
9	OD variation	method
10	Blank visual defects	method / material
11	Dye	material

FMEA Analysis **Table -3** (FMEA Analysis)

	Function failure	**Failure mode**	**Failure effect**	**Severity**	**Cause of failure**	**Occurrences**	**Current controls**	**Detection**	**RPN**
TE / FE NG	HIGH PICOUNT	TE/FE Drive problem	Ok disc got NG ,	6	Drive calibration problem	5	Drive calibration schidule defined	2	60
		TE/FE v-arm alignment problem	Rubbing / scratch problem	7	Operational failure	3	Regular pm	1	21
		Tray /Signal error	M/C stopped	2	Loose power connection	2	Checking of drive connection once in a shift	1	4
		PC	Visual defects	3	Contamination of PC	1	Blank disc inspection in every 2 hours	10	30
		Stamper problem	Visual/ high PI count value	8	Manufacturing defect in stamper	3	Blank disc mechanical / visual checked whenever stamper changed or cleaned	6	144
		Blank mechanical parameters	High PI count	8	Blank disc parameters not checked	8	2 Blank checked in every day	10	640

		OD variation	High PI count	2	Temperature & humidity variation & scanner calibration	6	OD checked in every shift	4	48
		Blank visual defects	Disc rejection	2	Visual inspection failure	2	6 disc checked by operator in every 2 hours	6	24
		Dye	OD variation	2	contamination during preparation	1	OD checked in every shift	4	8

3.3.2 RPN Pareto of FMEA analysis

Table-4

DEFECT	RPN	% DEFECT	%COMMULATIVE DEFECT
Blank mechanical parameters	640	65.4	65.4
Stamper problem	144	14.7	80.1
TE/FE Drive problem	60	6.1	86.2
OD variation	48	4.9	91.1
PC	30	3.1	94.2
Blank visual defects	24	2.5	96.7
TE/FE v-arm alignment problem	21	2.1	98.8
dye	8	0.8	99.6
Tray /Signal error	4	0.4	100.0

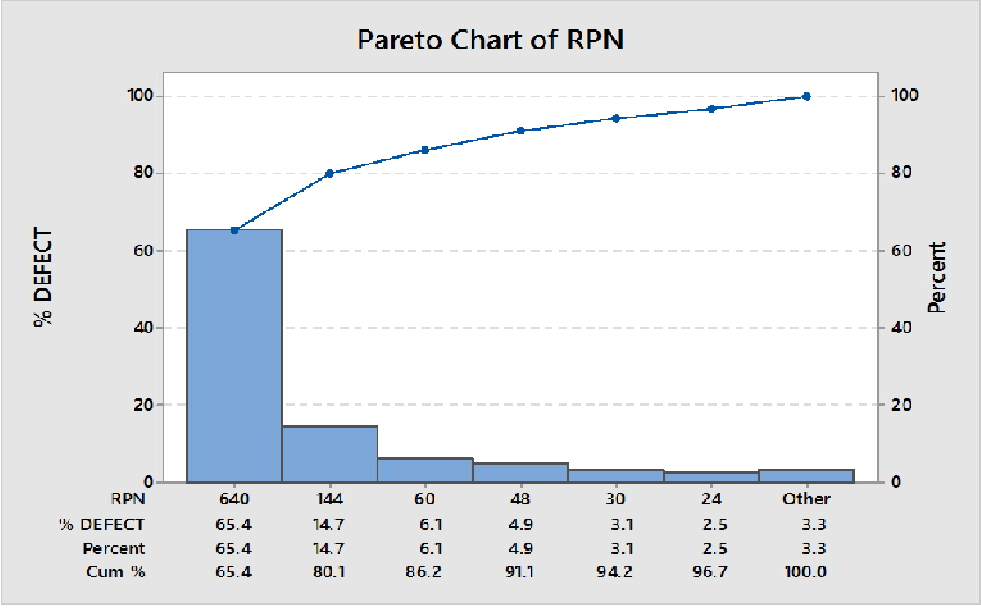

Figure-3 (Pareto chart of RPN)

It is clear from figure is that there are three problem for rejection

1- Blank mechanical parameters
2- Stamper problem
3- TE/FE Drive problem

3.4 IMPROVEMENT PHASE:

3.4.1 Blank mechanical parameter

Table-5

Root Cause	**Solution**
Barrel Temperature	Monthly inspection of heaters and thermocouples
Clamp Force	Quarterly checking of gear/motors for proper tonnage
Air Blow	Quarterly cleaning of air filters,regulators, pipes.
MTC Temperature	Quarterly preventive maintenance of MTC.

3.4.2 Stamper problem

Table-6

Root Cause	**Solution**
Improper Groove Depths	Check the blank at the time of stamper Loading, Clean stamper at time of loading
Thickness of stamper	Thickness check before loading.

3.4.3TE/FE Drive problem

Table-7

Root Cause	**Solution**
Calibration	Calibration done quarterly.
Alignment	Quarterly TE/FE preventive maintenance
Cooling	25 deg. Temp. maintained surrounding of TE/FE
Power connections	Power connections tightened with cable ties.

3.4.4 Rejection percentage after improvement

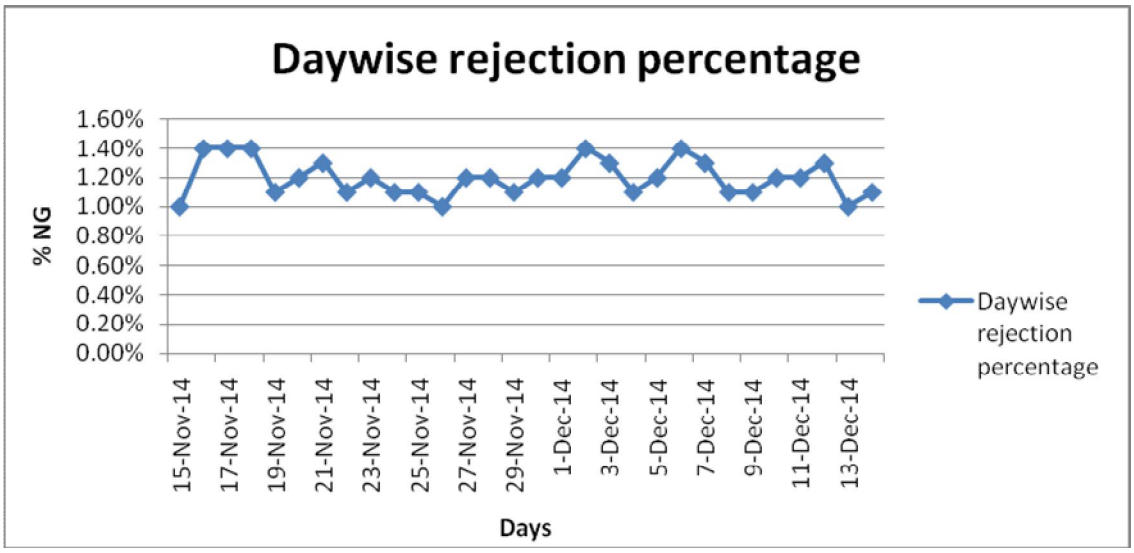

Figure-4(Day wise rejection percentage)

It is clear from figure is that after improvement the rejection percentage is (1-1.4) %.

3.5 CONTROL

In present case study blank mechanical parameter, stamper defect, TE/FE drive problem are the components which requires improvement.

- Half Yearly preventive maintenance schedule of injection moulding machine.
- Quarterly preventive maintenance schedule for TE/FE tester.
- Regular calibration of TE/FE drives.
- Blank mechanical parameters checked shift wise.

4. CONCLUSION

Initially before the implementation of Six Sigma the rejection rateon Origin line was (3-6) % due to TE/FE. But after the implementation of Six Sigma DMAIC methodology it has been reduced to a great extent (1-1.4) % due to TE/FE.Savings in cost after improvement = Approximate 420000 rupees per month on one line which is great achievement and also reduces rejection rate to a high percentage. There is also intangible savings such as reduction in consumer complaints.

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