Application of QC Tools for Total Quality Management and Continuous Improvement in Manufacturing Process of Telescopic Ball Bearing Slides

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Abstract: Seven quality control tools are a set of the QC tools that can be utilized for improving the execution of the production process, from the initial step of delivering an product or service to the last phase of production. Thus, the universally useful of this investigation is to present these QC tools. These tools has the huge roles to examine, obtain, analyze statistics for detecting and solving the problems of production processes, in order to facilitate the success of performance excellence in the organizations.

Index Terms **- Quality Control Tools, Total Quality Management, Continuous Improvement, Manufacturing Processes;**

I INTRODUCTION

Statistical equipment are 7 high-quality control tools used to resolve problems. These tools have been brought via excellent experts from Japan, such as Deming and Juran. Kaoru Ishikawa noted 90% of problems can be resolved through these 7 QC tools. This procedure had been the foundation of the surprising Japanese industrial revival after the Second World War.

For troubleshooting, the 7 QC tools used are: Histogram, Pareto chart, Control charts, Cause and Effect diagram or Ishikawa diagram, scatter charts, Graphs and Check sheets. All these seven equipment are essential tools used in manufacturing industries to reveal the standard operation and non-stop improvement of the process. These tools are used to enhance the manufacturing method through discovering the most important causes and eliminating them. The defect modes in the manufacturing line are studied by way of direct statement in the manufacturing line and statistical tools.

The principle of quality management is a beginning point for managing the organization for non-stop enhancement of efficiency over a long duration of time and for purchaser satisfaction. A quality management system is based on the integrity of all the production and assist sources of a given company. It permits an faultless system float in the success of contracts, standards and related market best requirements. The execution of a quality management system is continually section of the adjustment of the method of improvement and / or analysis of a organization processes. The PDCA cycle is a typical phase of process management and is designed to be used as a dynamic model because a cycle represents a entire step for improvement. The PDCA cycle is used to coordinate continuous enhancement efforts. Emphasize and show that improvement applications should start with cautious planning should lead to good action and have to return to careful planning in a continuous cycle: Deming's quality cycle never ends. It is a procedure used to accomplish creative upgrades as far as safety, quality, ethical quality, shipping prices and other basic business goals.

The finish of a cycle proceeds with the start of the following PDCA-cycle consists of four sequential advances or stages, as follows:

- **Plan** - Analysis of what should be improved by taking into consideration that hold opportunities for change. Choice on what need to be changed.
- **Do** - Implementation of the changes that are determined on in the Plan step.
- **Check** - Control and estimation of procedures and product in understanding to changes made in past step and as per arrangement, objectives and requirements on product. Investigate results.
- **Act** - Adaptation of new modifications in PDCA-Cycle.

II METHODOLOGY

2.1 Parts Used In KA Assembly Channel

- OC- Outer channel.
- IC- Inner or intermediate channel.
- TK- Track.
- BC- ball cage.
- End stopper.
- Ball spacer.

- Bumper.
- Rivet.
- Latch.

Figure 2.1 Outer Channel (OC) & Inner Channel (IC).

Figure 2.2 Track (TK).

Figure 2.3 Ball Cage (BC).

Figure 2.4 End stopper.

Figure 2.5 Ball Spacer.

Figure 2.6 Bumper.

Figure 2.7 Latch.

2.2 Process of Assembly

1. Insert of Ball cage in inner channel. In BC to IC machine.
2. Riveting of end stopper. In end stopper machine.
3. Install of ball spacer between IC and OC. In IC to OC machine.
4. Bending of OC and install of bumper. In bumper machine.
5. Insert of Track manually.
6. Functional Inspection.
7. Final Inspection.

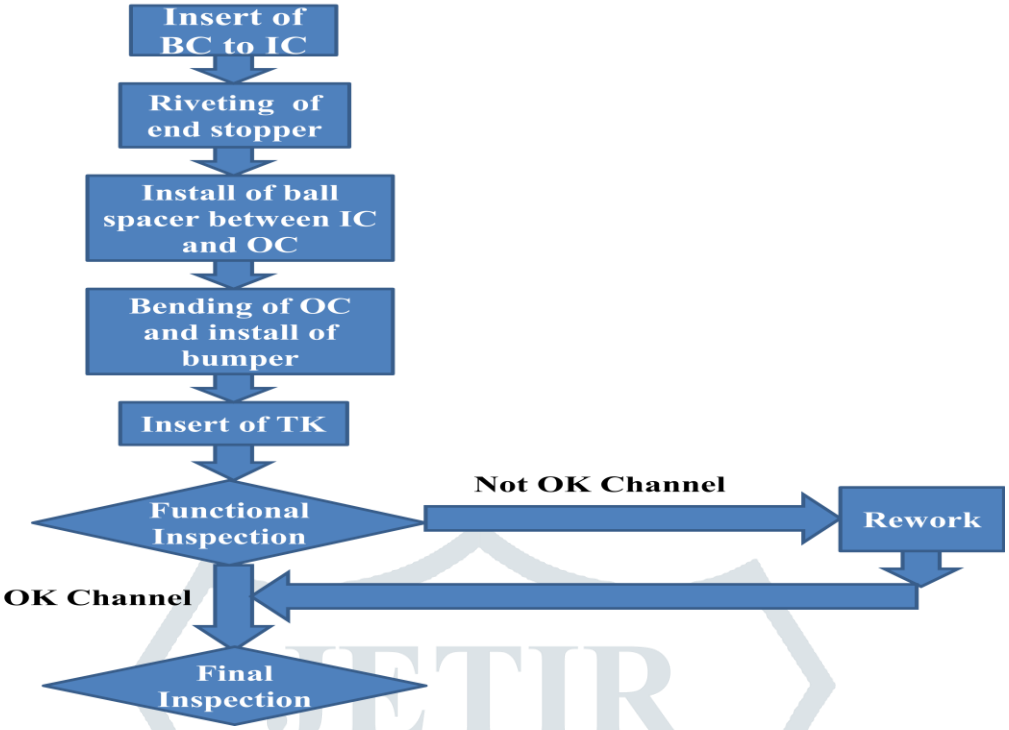


Figure 2.8 Flowchart of assembly process.

2.3 METHODOLOGY

- Data check sheet is prepared to maintain the quality of channel.
- Shift wise regular inspection is been done by quality inspector.
- Hourly inspection by quality can detect the problem in the channel.
- Main use of functional inspection in line is to check the smoothness of channel.
- Final inspection will check ball missing and extra ball in channel.
- Platting of Zinc (Zn) and Catholic Electro Deposition (CED or Black) is also checked for good surface finished product.
- Channel which required rework are kept in yellow bin.
- Channel which is not possible of rework is kept in red bin.
- Rework of channel is been done on hourly basis by rework person.
- At last all good quality channels is packed with signature of quality inspector.

2.4 Checking Parameter

- Ball cage fix well in the IC ($\geq$ 20N).
- External diameter of End stopper Rivet after Riveting $\geq$ 3.6
- Rear Bending Distance: 8$\pm$ 0.3
- Rear Bending Angle 90 $\pm$ 2^{O}
- Operating Force 0-4 N (Trembling not allowed)
- Lock Force (Pull & Push) 18$\pm$8 N
- Assembly Thickness 12.7$\pm$0.2
- Scratching between track and inner stopper
- Good stop function of Latch & End stop
- No steel Ball Missing or Extra Steel Ball
- No Damages of Components
- Daff on Running Channel not allowed
- Scratches, Oil on surface not allowed.

2.5 Study of Defects in Channel

- **Ball Missing.**

In this defect there would be no ball in ball holes of ball cage and ball spacer. Due to this defect channel life cycle may reduce. This type of defect mostly occur in ball spacer but in very rare condition there would be missing in ball cage because ball hole diameter is little bigger then ball spacer.

Figure 2.9 Ball Missing in BC.

Figure 2.10 Ball Missing in Ball Spacer.

- **Extra Balls.**

These types of defect usually occur between IC and OC at ball spacer where some balls with force stack between IC and OC surface without ball spacer. Due to these defect there will be problem in functioning of channel.(Channel will not open completely because of extra balls).

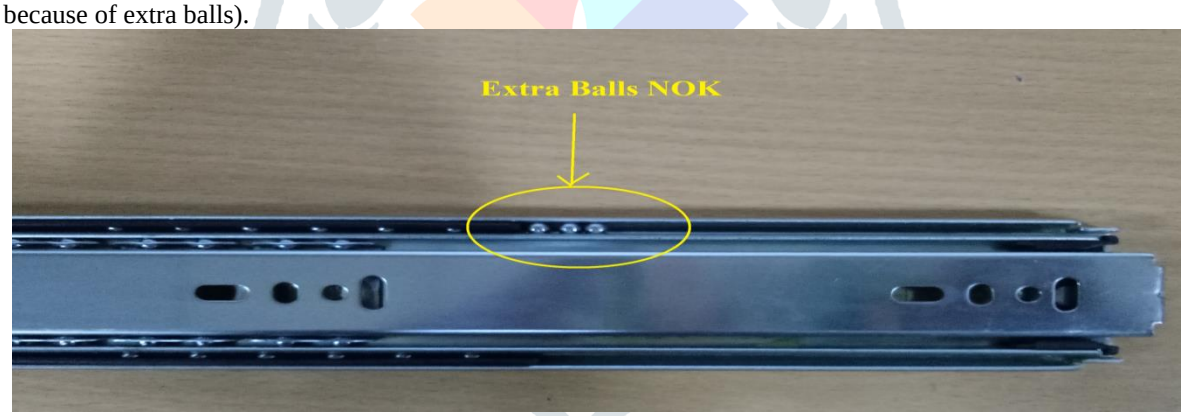


Figure 2.11 Extra Balls in channel.

- **Latch & End Stopper Riveting.**

These defect may occur due to variation in rivet hole diameter and chances of improper punching of rivet with parts increases. Sometimes because of small rivet hole diameter, rivet may not fit properly therefore chances of wear and tear increases.

Figure 2.12 Riveting of End Stopper (Ok & Not Ok parts).

- **Loose & Tight Problem.**

  These problem occur due to improper use of GO and NOGO gauges at ball profile of OC and IC in roll forming of parts. If NOGO gauge passes smoothly then loose problem will occur and if GO gauge not passes smoothly then tight problem will occur. Other reason for this problem may be the thickness of parts after plating. By the functional inspection only this defect will be detected.

- **Rubbing Problem.**

  In roll forming of OC and IC there are chances of line marks, roller impression or burr formation in ball profile of parts because of which rubbing problem may occur. By the functional inspection of channel only this problem will be detected.

- **Plating Defect.**

  There is various type of plating defects in OC, IC and TK because of chemical problem appear on the surface on the parts which are as follows:

  Zinc Plating Defects:

1. Dull Plating.
2. Yellow Plating.
3. Blue Plating.
4. Oil Marks.
5. White Marks.
6. Uncover Plating.
7. Plating Peel Off.

Catholic Electro Deposition (CED or Black) Plating Defects:

1. Blistering.
2. Brush Marks.
3. Water Marks.
4. Paint Run Off.
5. Uncover CED.

III RESULTS AND ANALYSIS

- Checked all the parameter of assembled channels on hourly basis for four months.
- Training given to operators for the proper functioning of channel and detecting defects in it.
- Training given for final inspection of channel and also inspected many channels in each lines of assembly.
- Analysis is done from dock audit and according to it Pareto chart is been plotted.
- Following check sheet is been prepared to find the defect in channel on hourly basis.

Chart 3.1 Check Sheet used in Assembly line.

		KA-Quality Assurance												
		Assembly Inprocess Inspection Report												
Product Name				**Quality Inspector Name**								**Date**	/ /	
Insp.Freq		As Per quality Inspection Plan		**Shift**								**Line No.**		
			FAI	**Time**										
1. IC + Ball Cage	1.1	Enough grease on running channel												
	1.2	No steel Ball missing or Extra steel ball												
	1.3	Ballcage fix well in the IC (> 20N)												
2. End Stop riveting	2.1	End stop assembly in right position, Firm riveting												
	2.2	External diameter of rivet after riveting ≥ 3.6												
3. OC+ IC	3.1	Enough grease on running channel												
	3.2	No steel Ball missing or Extra steel ball												
4. Bending of OC and ass. Rear Bumper	4.1	Rear Bending distance: 8± 0.3												
	4.2	Rear Bending angle 90 ± 2^{o}												
	4.3	Orientation of Rear Bumper												
5. Latch Riveting	5.1	Firm Riveting (Proper flarring)												
	5.2	External diameter of rivet after riveting ≥ 3.6												
	5.3	Height of rivet after riveting (≤ 0.3)												
	5.4	Latch type and Tk length												
6. Function test	6.1	Operating Force 0 - 4 N (Trembling not allowed)												
	6.2	Lock Force 18 ± 8N Pull Out / Lock												
	6.3	Assembly thickness 12.7 ± 0.2												
	7.1	No steel Ball missing or Extra steel ball												
	7.2	No damages of Components												
	7.3	Daff on running channel not allowed												
QA Inspector Signature:		**Released**												
		No Released												
Production Supervisor Signature,If any deviation found														
QA Supervisor's Signature:														
Improvement Required :- O				**Limited Approved :- ☐**								**Approved :- ✓**		
Problem Description:-														
Corrective action :-														

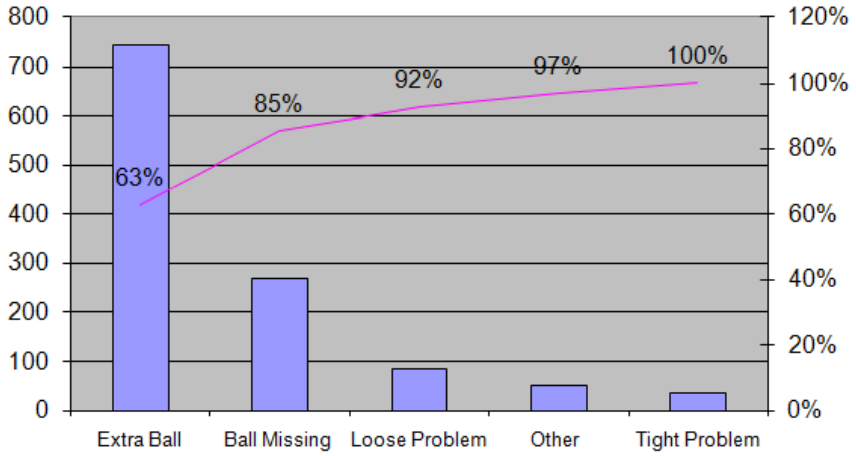
As per the recorded data of 4 months we have plot a Pareto chart and we found that mostly defects occurs in extra balls and ball missing due to improper opening & closing of shutter and improper alignment of ball feeder. These data is of 2000 sets of channels per day and according to it mean is taken.

Table 3.1 Pareto Analysis of defects in August 2018

Sr. No.	Defects	Sets	Cumulative Sets	Cumulative %

1	Extra Balls.	743	743	62.70
2	Ball Missing.	268	1011	85.31
3	Loose Problem.	84	1095	92.40
4	Other	53	1148	96.68
5	Tight Problem.	37	1185	100.0

Chart 3.2 Pareto Analysis of defects in August 2018.

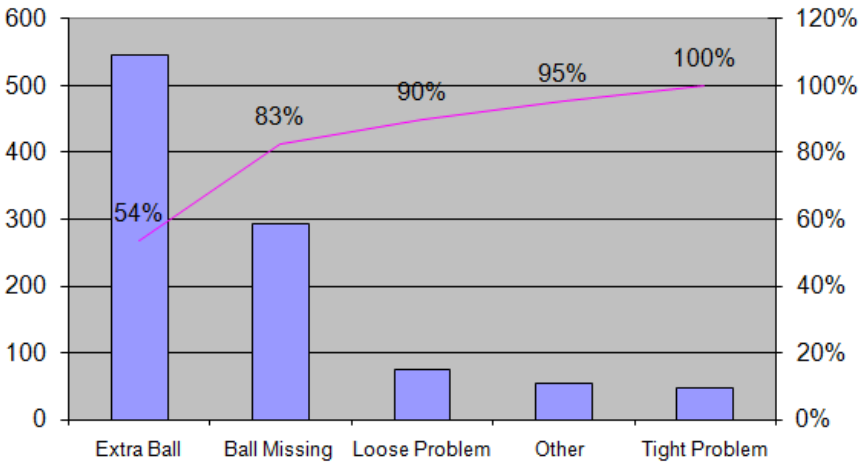


From chart 3.2 it is observed that major problem in channels are extra balls and ball missing. Other minor defects are improper lubrication on ball profile, rubbing problem, riveting and plating. Some other problems like loose and tight channels can be rework and corrected.

Table 3.2 Pareto Analysis of defects in September 2018.

Sr. No.	Defects	Sets	Cumulative Sets	Cumulative %
1.	Extra Balls.	546	546	53.63
2.	Ball Missing.	294	840	82.51
3.	Loose Problem.	76	916	89.98
4.	Other.	55	971	95.38
5.	Tight Problem.	47	1018	100.0

Chart 3.3 Pareto Analysis of defects in September 2018.



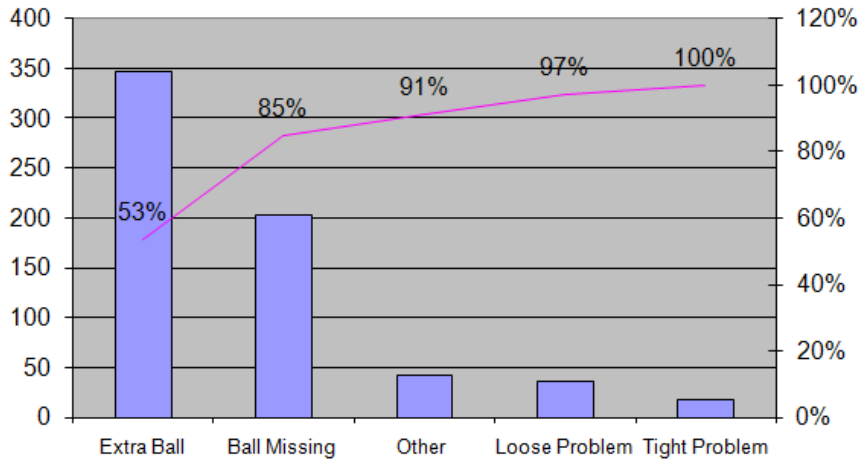
For better understanding of defects, same method of data processing and analysis has been carried out for the month of September. On the basis of data of August and September it is concluded that extra ball and ball missing are the major problem in assembly line. So to reduce defects in production final inspection is set up on each line and according to it training is given to the operators.

Table 3.3 Pareto Analysis of defects in October 2018.

Sr. No.	Defects	Sets	Cumulative Sets	Cumulative %
1	Extra Balls.	346	346	53.47
2	Ball Missing.	203	549	84.85
3	Other	42	591	91.34
4	Loose Problem.	37	628	97.06

5	Tight Problem.	19	647	100.0

Chart 3.4 Pareto Analysis of defects in October 2018.

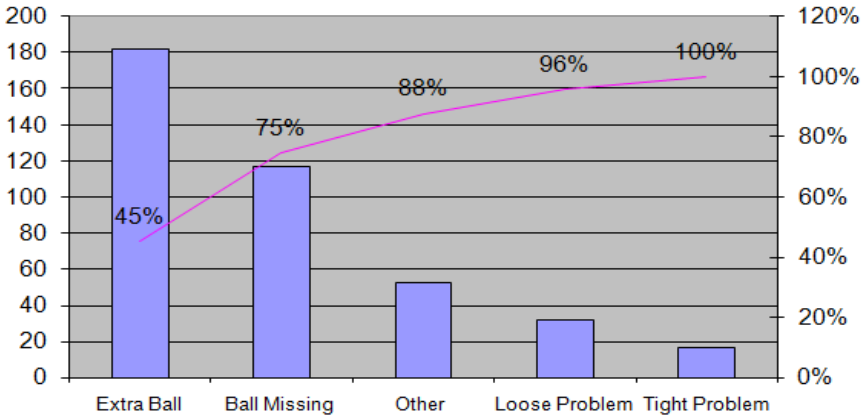


The above data has been collected after giving training to operators and collecting data on Check Sheet, it is observed that in the month of October there is minor reduction in extra ball and ball missing defects. So for further improvements rework has been done on all assembly lines and to reduce the defect of loose and tight channel, different ball size (diameter 4.70-4.82) has been used as per requirement.

Table 3.4 Pareto Analysis of defects in November 2018.

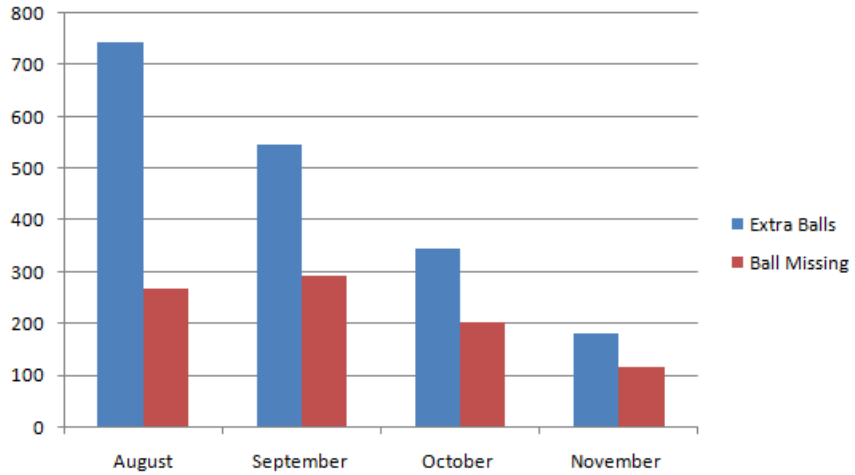
Sr. No.	Defects	Sets	Cumulative Sets	Cumulative %
1	Extra Balls.	182	182	45.38
2	Ball Missing.	117	299	74.56
3	Other	53	352	87.78
4	Loose Problem.	32	384	95.76
5	Tight Problem.	17	401	100.0

Chart 3.5 Pareto Analysis of defects in November 2018.



From chart 3.5 it is observed that extra ball and ball missing defect can be reduce and controlled by training given to functional and final operator and with rework of channels the quality of product can be improved.

Chart 3.6 Histogram Analysis of major defects.



From the several analysis it's clear that major problem in channel is due to extra ball and ball missing. To overcome these defects, the root causes are identified for the same which are listed below:

- **Causes for Ball missing in channel.**

1. Ball feeder is not set properly between IC to OC machine.
2. Track is not set accurately in ball feeder.
3. If air pressure is less, then ball missing will start.
4. Damage of shutter will lead the problem.
5. Ball spacer clip cylinder not set properly.

- **Causes for Extra Ball in channel.**

1. Ball feeder main spring damage i.e. expansion and contraction not proper.
2. Damage of body spring in the ball feeder.
3. Ball feeder not set correctly.
4. Ball feeders block damage.

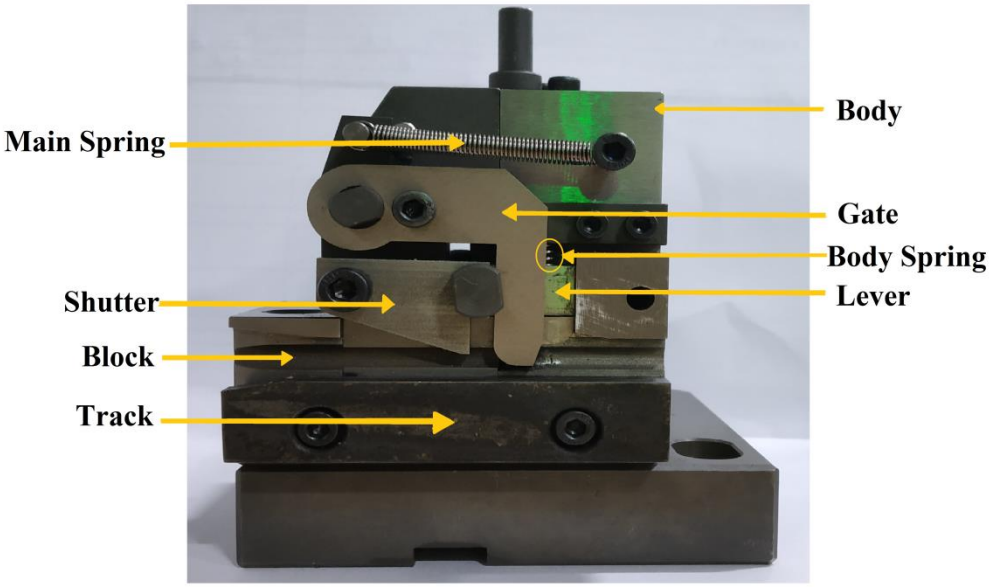


Figure 3.1 Ball Feeders.

After implementing the correction of major root causes in ball feeder, again analysis is done for two months and according to those data Pareto chart is been plotted and shown below.

Table 3.5 Pareto Analysis of defects in February 2019.

Sr. No.	Defects	Sets	Cumulative Sets	Cumulative %
1	Extra Balls.	46	46	38.65
2	Ball Missing.	27	73	61.34
3	Loose Problem.	19	92	77.31
4	Other.	15	107	89.91
5	Tight Problem.	12	119	100.0

Chart 3.7 Pareto Analysis of defects in February 2019.

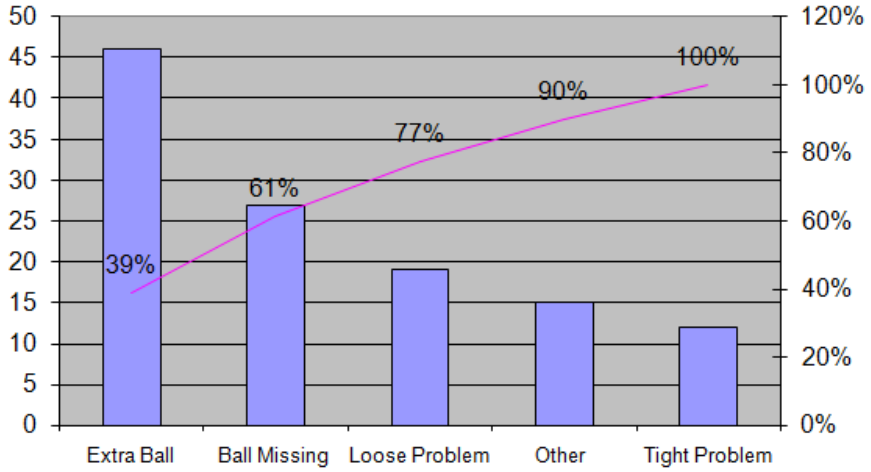
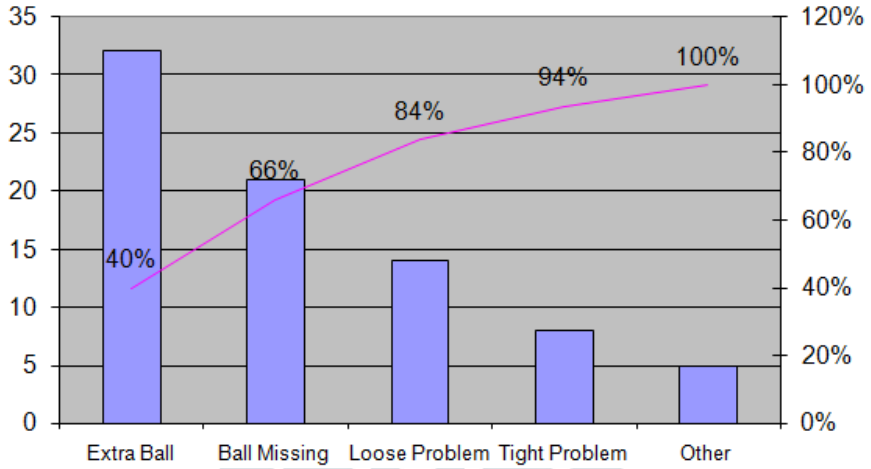


Table 3.6 Pareto Analysis of defects in March 2019.

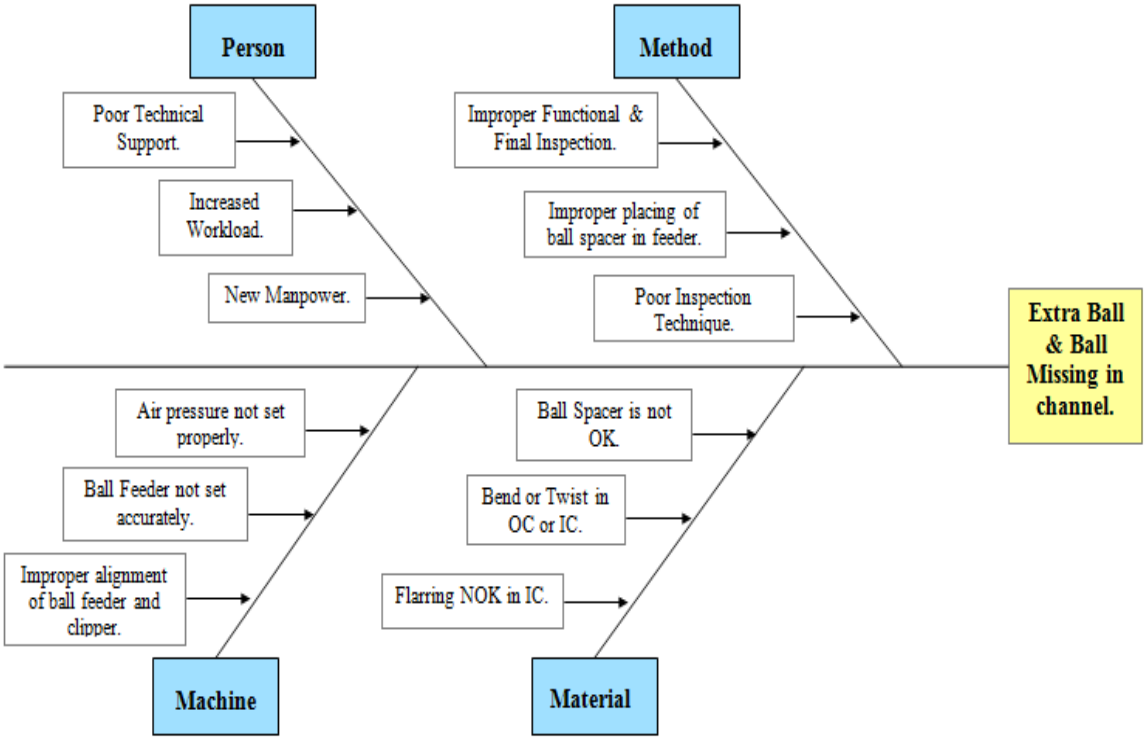
Sr. No.	Defects	Sets	Cumulative Sets	Cumulative %
1	Extra Balls.	32	32	40.00
2	Ball Missing.	21	53	66.25
3	Loose Problem.	14	67	83.75
4	Tight Problem.	08	75	93.75
5	Others.	05	80	100.0

Chart 3.8 Pareto Analysis of defects in March 2019.



From chart 3.7 and 3.8 it's conclude that ball missing and extra ball defect can be reduce by regular inspection and maintenance of ball feeder parts, before the production shift get started. So Cause and effect diagram of extra ball & ball missing in channel is been plotted below.

Chart 3.9 Cause and effect diagram of extra ball & ball missing in channel.



IV CONCLUSION

- For the continuous improvement of the process, check sheet data collection on hourly basis is most reliable tool to control all the quality parameters and makes detection of problem easier.
- Continuous utilization of these tools helps to improve the personnel characteristics of the people involved. It enhances their ability to think and developed new innovative ideas, which in turns help them to solve problems in a better way with proper planning.
- Chart 3.9 interprets the major causes for defect in channel with the help of cause and effect diagram.
- Under current research work, after implementation of various QC tools such as Check sheet, Pareto chart, Histograms and Cause and effect diagram the quality of final product produced got improved as shown in the analysis part.
- Approximate 8% defects have been reduced in the current process after successful modification of old process parameters.

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