A Case Study on Total Quality Control Of Manufacturing Of Liners By Applying Spc Technique

Sri. T.V.S. Raghavendra[1], B.Manideep[2], R. Prem Sai[3], Y. Adi Siva Kishore Reddy[4]

[1,] Associate professor, Department of Mechanical Engineering, K L University,
[2, 3, 4] Third Year B. Tech (Mech), Dept. of Mechanical Engineering, K L university

ABSTRACT

The growing global economy has caused a dramatic shift towards Quality control and management in recent years. Efficient and effective management of quality control will have a beneficial impact on a company's ability in serving its customers properly and to keep direct and indirect costs low. Effective management of quality at each stage offers a great prospective for increasing system efficiency, customer service level and minimization of total system costs. This paper discusses analyzing and application SPC techniques of quality concept to achieve customer delightness.

Key-words: Quality, SPC, Control charts, UCL, LCL.

I. Literature survey

Statistical Process Control(SPC) is a statistical approach for assisting operators, supervisors and managers to manage quality and to eliminate special causes of variability in a process (Oakland, 2003). The initial role of SPC is to prevent rather than identify product or process deterioration, but Xie and Goh (1999) suggest for its new role to actively identifying opportunities for process improvement. The main tools in SPC are control charts. The basic idea of control charts is to test the hypothesis that there are only common causes of variability versus the alternative that there are special causes. By continuously monitoring the process, the manufacturing organization could prevent defect items to be processed in the next stage and to take immediate corrective action once a process is found to be out of control (Hairulliza et al., 2005). DoE and Taguchi methods are powerful tools for product and process development. Taguchi methods, for instance, aim at making product or process that robust to undesirable disturbances such as environmental and manufacturing variations. However, the application of these two methods by industries is limited (Antony and Kaye, 1995). Antony et al (1998) explore the difficulties in the application including improper understanding and fear of statistical concepts in the methods, thus propose a methodology for the implementation.

The findings from process capability study might require adjustment of process using other statistical technique such as SPC or DoE. Capability studies conducted by Motorcu and Gullu (2004) and Srikaeo et al (2005) show that the machine tool and process capability and production stability was evaluated and necessary steps to reduce poor quality production was carried out using other statistical techniques.

II. METHODOLOGY OF QUALITY CONTROL.

Quality control is the set of operations (programming, coordinating, carrying out) intended to maintain or to improve quality and to set the production at the most economical level which for customer satisfaction. This requires the following steps.

a) Setting up standards of performance
b) Comparing the actual observations against the standards.
c) Taking corrective action whenever necessary.

III. Case-study Analysis

3.1. About the Organization

Bharath Industries (Kusalava international ltd) is a manufacturer of cylinder liners. The products are mainly rejected due to defects arising in machining section and casting section.

- The defects in casting section are generally cracks, hard, porosity etc.
- The defects in machining section are generally, undersize of outer diameter and over size of inner diameter, collar, width over size etc.

Hence it is necessary to reduce the rework due to defects in casting and machining section and to improve the quality of product.

To improve its sales in market, Bharat industry is focusing its business strategy towards achieving the good quality products and operational efficiency by improving productivity and reducing internal costs.

Under these circumstances a case-study analysis is taken up with the following objectives.

a)To improve overall efficiency of the system in the section concerned.

b) To maximize output per section with less defects.
c) To modify the production process for better understanding and execution.

3.2. Data Collection and Analysis

The objective of SPC is to obtain a reliable and unbiased picture of how the process is performing to get the required quality of products. The success of the objective naturally based on reliable and unbiased data collected. Hence prior to SPC study, careful plan for data collection, effectiveness of operational personnel and well maintained, calibrated measuring equipment are necessary.

3.2.1. Before the Application of SPC

The data collected regarding the number of castings produced and number of casting rejected because of casting defects and machining defects as shown in Table 1 and illustrated by graphically. It is shown in Fig 1.

P – Chart was drawn using the data shown. It shows that few sample points are not close to process average, there is tolerance, but only the aim of zero defect (or) 100% acceptable items. The simplistic measure of capability can hence be provided by the relevant mean value

IV. PARETO ANALYSIS

Pareto analysis, reveals that most of rejections are due to machining defects occurring in machining section. It is shown in Table 3 and Fig 2.

4.1 DURING THE APPLICATION OF SPC :-

The data was collected regarding the parameters such as weight, mould temperature, outer diameter, inner diameter and total collar width. The above, reveals that some of the sample points are out of control. $\overline{X}$ - chart and R – chart are drawn as shown in figures . it needs further development to stabilize the process by eliminating the causes of variations, they are

- Lack of periodic training to the employees
- Deviations from specifications
- Shift generation and alteration of working hours

  These are shown in Table 2 to Table 6. They are further illustrated graphically as shown in Fig 3 to Fig 8

4.2 BRINGING THE CHARACTERISTICS UNDER CONTROL :-

By measuring and comparing the characteristics of final product generated at each section with a standard one, if it is found to be inferior and the characteristic is not under control. The parameters, which effect the characteristics of final products, are controlled to obtain the required characteristics.

4.3 AFTER THE APPICATON OF SPC

Again the data is collected regarding the number of castings produced and number of casings rejected because of casting defects and machining defects

P – chart was drawn as shown using the data as shown in table. It shows that some sample points are close to process average, $\overline{P}$
The capability $\overline{P}$ = 0.0462
= 4.62 %

It is concluded that process capabilities are improved by decreasing the rejection rate from 6.52% (before SPC) to 4.62% (after SPC). It is shown in Table 7 to Table 9 and further illustrated graphically. It is shown in Fig 9.
A pareto analysis for comparative results reveals that there exists reduction in wastage of units produced. It is shown in Table 10 and Fig 10.

Table : Rejection Trends Before SPC

Sl. No	Produced Quantity	Rejected Units	Proportion of rejections	UCL	LCL
1	742	51	0.068	0.095	0.04
2	424	41	0.097	0.14	0.053
3	725	35	0.048	0.538	0.427
4	866	81	0.094	0.123	0.064
5	911	69	0.076	0.102	0.049
6	862	56	0.065	0.09	0.039
7	511	28	0.055	0.085	0.024
8	855	27	0.032	0.05	0.013
9	930	79	0.085	0.112	0.057
10	917	52	0.057	0.079	0.034
11	893	63	0.071	0.096	0.045
12	894	23	0.023	0.038	0.007
13	1012	83	0.082	0.107	0.056
14	1020	78	0.076	0.1	0.051

15	979	68	0.069	0.09	0.024
16	887	48	0.054	0.076	0.031
17	924	12	0.013	0.024	0.001
18	734	80	0.109	0.143	0.074
19	873	53	0.061	0.085	0.036
20	906	95	0.105	0.135	0.074
21	990	78	0.079	0.104	0.053
22	903	47	0.052	0.074	0.029
23	874	46	0.053	0.075	0.03
24	964	45	0.047	0.067	0.026
25	883	52	0.059	0.082	0.035
TOTAL	**21479**	**1390**	**0.0652**	**0.1084**	**0.05488**

Table : Rejection trends in machining section (before spc)

Sl. No	Total defects	OD defects	ID oversize	ID die mark	Collar dia-tool mark	Crack
1	15	1	6	0	0	4
2	17	0	10	2	0	0
3	28	2	10	8	3	0
4	41	7	17	2	0	5
5	35	0	9	8	3	6
6	26	4	8	5	2	3
7	2	0	1	0	0	1
8	24	6	9	3	0	2
9	44	1	23	8	3	5
10	27	0	5	8	6	6
11	29	2	13	6	1	3
12	21	4	12	1	0	3
13	27	8	11	2	0	3
14	30	0	6	11	4	2
15	36	0	2	8	18	2
16	38	3	8	7	11	2
17	9	3	2	1	0	1
18	42	6	7	11	10	2
19	47	6	9	9	7	2
20	47	2	9	7	6	4
21	41	1	3	13	2	3
22	38	4	12	5	12	1
23	18	2	6	0	22	2
24	41	7	9	4	10	2
25	49	5	6	7	14	3
TOTAL	772	74	213	136	134	67

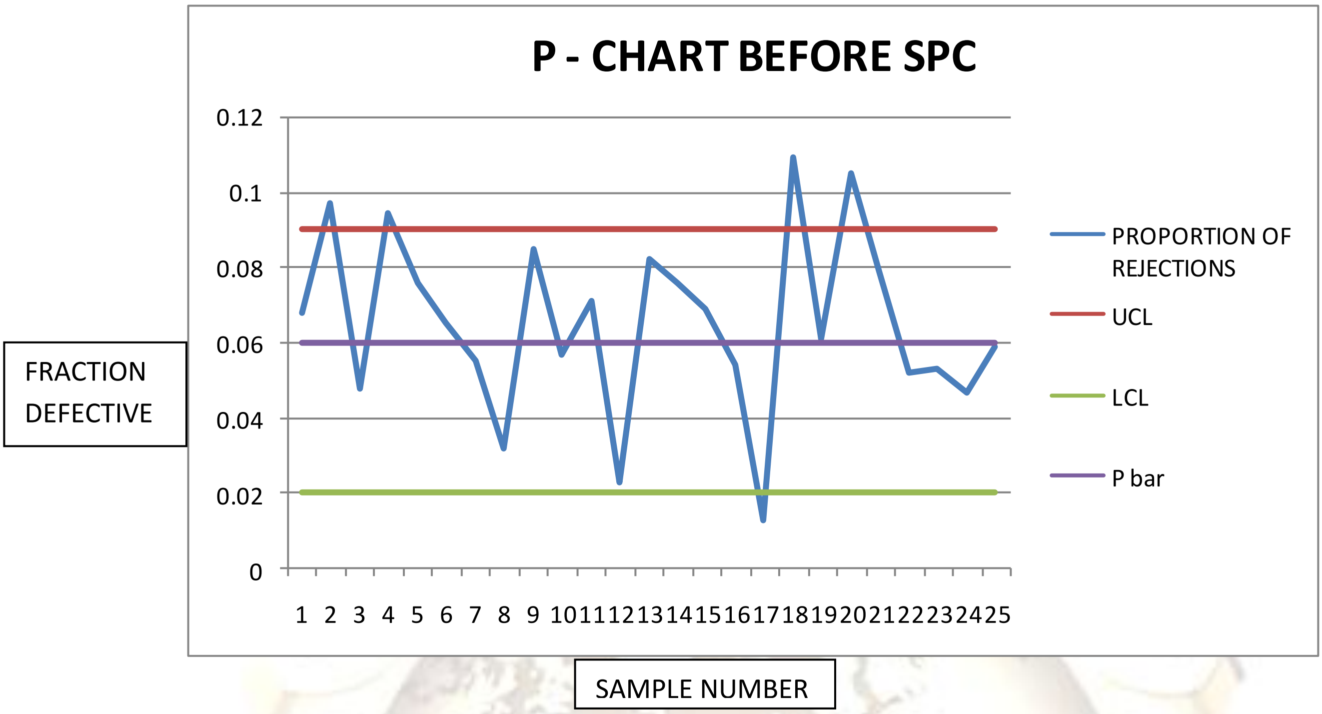

Fig : 1 P – Chart before SPC

Table : 3 Rejection of Trends before application of SPC

Types of defects	01-nov	02-nov	03-nov	04-nov	05-nov	06-nov	07-nov	08-nov	09-nov	09-nov	10-nov	11-nov	12-nov
A	1	0	2	7	0	4	0	6	1	0	2	4	8
B	6	10	10	17	9	8	1	9	23	5	13	12	11
C	0	0	3	0	3	2	0	0	3	6	1	0	0
D	0	0	2	0	1	1	0	0	0	0	0	0	2
E	0	2	0	0	0	0	0	0	0	1	0	0	0
F	0	0	0	0	0	0	0	1	1	0	0	0	1
G	2	0	0	0	1	0	0	0	0	0	1	0	0
H	1	3	0	1	2	1	0	0	0	1	0	0	0
I	4	0	2	5	6	3	1	2	5	6	3	3	3
J	0	0	1	3	3	1	0	0	1	1	2	1	0
K	0	0	0	0	1	1	0	3	0	0	1	0	0
L	0	0	0	0	0	0	0	0	0	0	0	0	0
M	0	2	8	2	8	5	0	3	8	8	6	1	2
REJECTIONS	**14**	**17**	**28**	**35**	**34**	**26**	**2**	**24**	**43**	**27**	**29**	**21**	**27**

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Types of defects	16-nov	18-nov	19-nov	20-nov	22-nov	23-nov	24-nov	25-nov	26-nov	27-nov	29-nov	30-nov	TOTAL
A	0	0	3	3	6	6	2	1	4	2	7	5	74
B	6	2	8	2	7	9	9	3	12	6	9	6	213
C	4	18	11	0	10	7	6	2	12	22	10	14	134
D	0	3	2	0	1	4	2	4	3	0	1	11	37
E	0	1	0	0	0	0	1	0	0	0	0	1	6
F	0	0	0	0	1	0	0	0	0	0	0	0	4
G	1	0	0	0	1	0	1	4	0	3	3	2	19
H	4	1	3	1	1	0	5	6	1	0	2	0	33
I	2	2	2	1	2	2	4	3	1	2	2	3	69

J	2	1	2	1	1	3	2	2	0	0	1	0	28
K	0	0	0	0	1	5	3	3	0	0	2	0	20
L	0	0	0	0	0	2	5	0	0	0	0	0	7
M	11	8	7	1	11	9	7	13	5	0	4	7	136
REJECTIONS	**30**	**36**	**38**	**9**	**42**	**47**	**47**	**41**	**38**	**35**	**41**	**49**	**780**

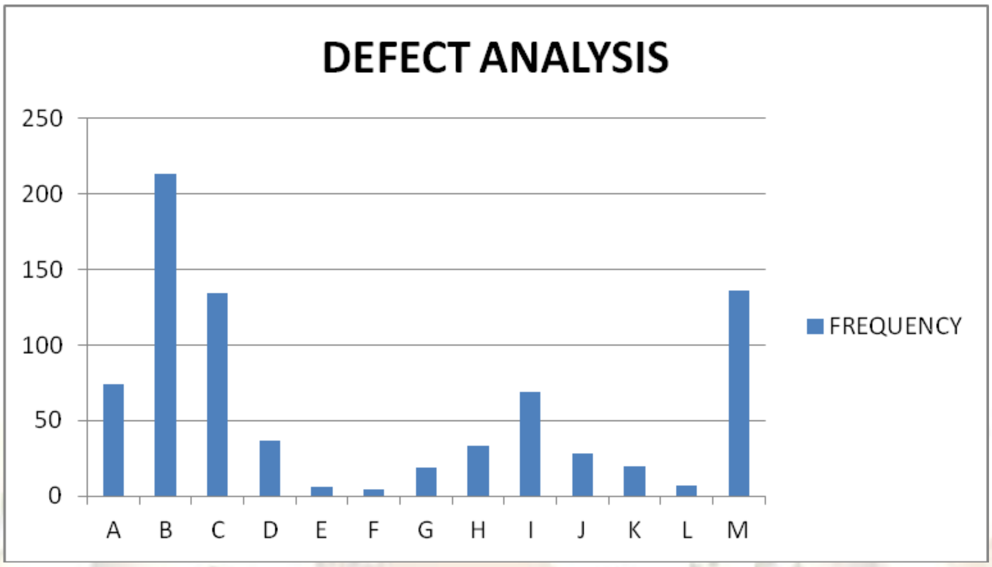

Fig : 2 Pareto – Analysis before application of SPC

NOTATIONS :-

- **A.** OUTER DIAMETER UNDER SIZE.
- **B.** INNER DIAMETER OVER SIZE.
- **C.** OUTER DIAMETER/COLLAR DIAMETER TOOL MARK.
- **D.** COLLAR WIDTH UNDER SIZE.
- **E.** INNER DIAMETER VIBRATIONS.
- **F.** COLLAR/WHEEL TOOL MARK.
- **G.** UNDER CUT SIZE DIAMETER UNDER SIZE.
- **H.** DAMAGE.
- **I.** CRACK.
- **J.** COLLAR DIAMETER UNDER SIZE.
- **K.** OLD MARK.
- **L.** TOTAL LENGTH UNDER SIZE.
- **M.** INNER DIAMETER TOOL MARK.

Table : 4 Outer diameter before SPC

Sl. No	1	2	3	4	5	Mean (X)	Range (R)
1	129.41	129.476	129.445	129.45	129.43	129.442	0.066
2	129.425	129.445	129.44	129.45	129.452	129.442	0.027
3	129.385	129.42	129.38	129.4	129.399	129.399	0.04
4	129.442	129.432	129.452	129.436	129.435	129.44	0.017
5	129.435	129.436	129.451	129.438	129.442	129.441	0.016
6	129.38	129.395	129.4	129.421	129.398	129.398	0.041
7	129.382	129.376	129.395	129.4	129.402	129.391	0.026
TOTAL						129.421	0.033

FOR $\bar{X}$ - CHART
MEAN ($\bar{x}$) = 129.421
UCL = 129.44
LCL = 129.401

FOR R - CHART
MEAN ($\bar{R}$) = 0.033
UCL = 0.0698
LCL = 0.00

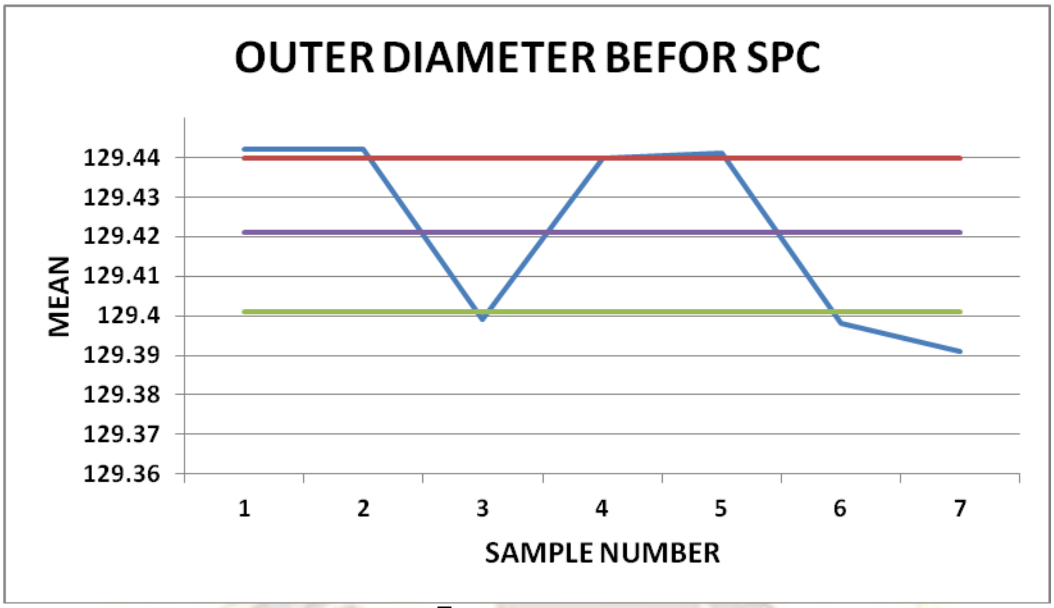

Fig : 3 $\bar{X}$ - chart (outer diameter)

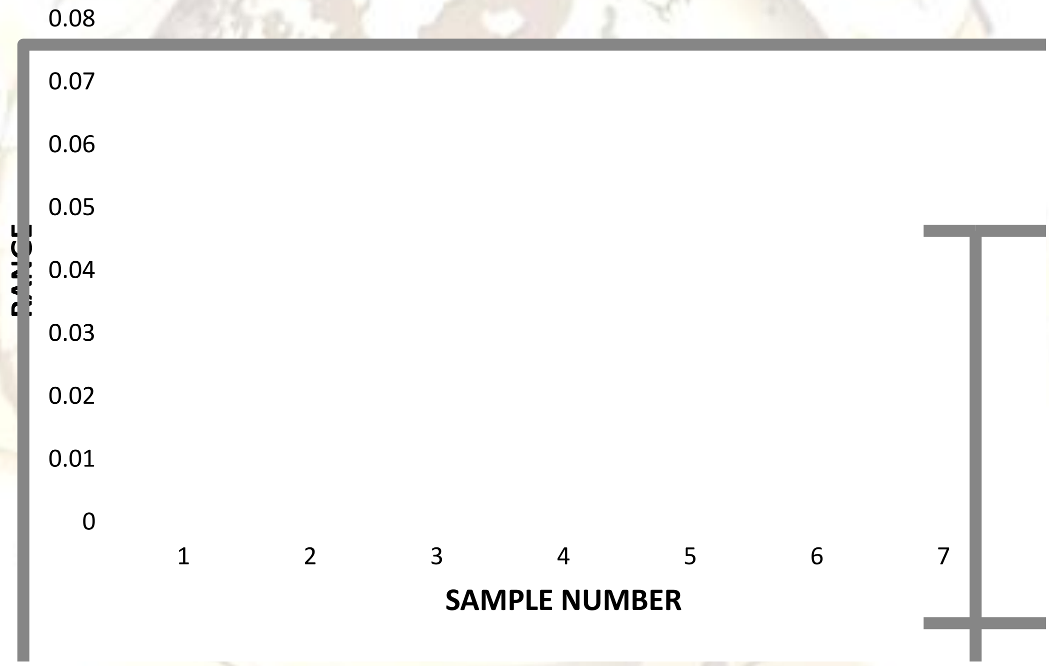

Fig : 4 R – chart (outer diameter)

Table : 5 Inner diameter (before SPC)

Sl. no	1	2	3	4	5	Mean ($\bar{X}$)	Range (R)
1	123.876	123.889	123.873	123.862	123.87	123.877	0.019
2	123.863	123.874	123.869	123.856	123.871	123.867	0.018
3	123.831	123.825	123.815	123.838	123.83	123.829	0.023
4	123.871	123.869	123.856	123.874	123.863	123.867	0.018
5	123.862	123.873	123.869	123.826	123.83	123.852	0.047
6	123.838	123.83	123.815	123.825	123.831	123.829	0.023
7	123.856	123.867	123.883	123.88	123.869	123.871	0.027
TOTAL						123.856	0.025

FOR ($\bar{X}$) – CHART

MEAN ($\bar{\bar{X}}$) = 123.856
UCL = 123.869

FOR R - CHART

RANGE ($\bar{R}$) = 0.025
UCL = 0.0528

LCL = 123.84 LCL = 0.0

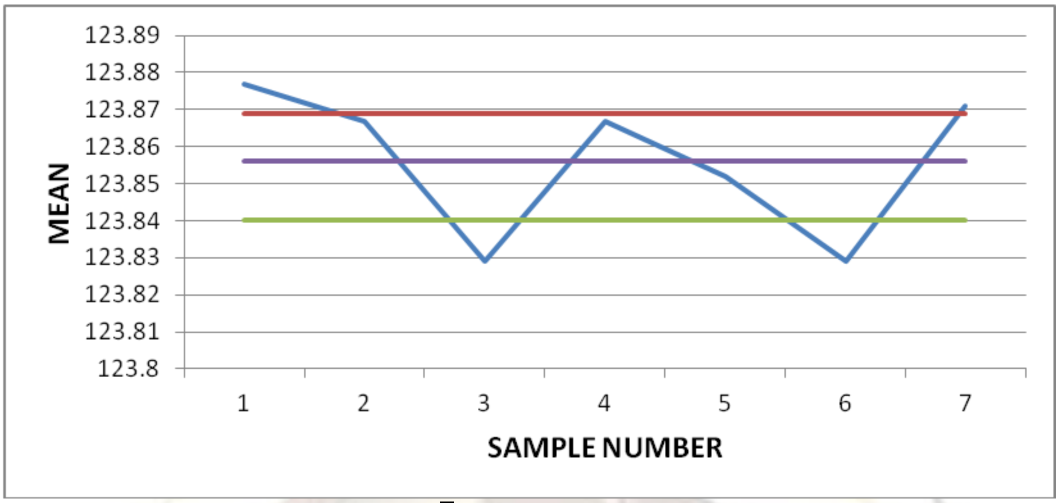

Fig : 5 $\bar{X}$ - chart (inner diameter)

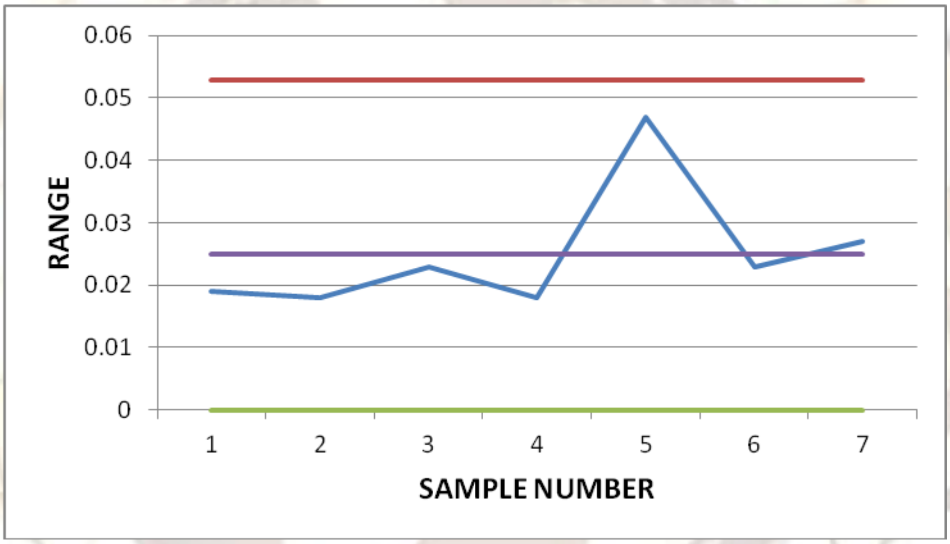

Fig : 6 R – chart (inner diameter)

Table : 6 Total collar width (before SPC)

Sl. no	1	2	3	4	5	MEAN ($\bar{X}$)	RANGE (R)
1	5.95	6.1	5.94	5.9	5.98	5.974	0.2
2	6.1	5.98	5.95	5.94	5.98	5.97	0.2
3	5.98	5.9	6.05	5.94	5.99	5.96	0.15
4	5.9	5.95	5.935	5.92	6.05	5.95	0.13
5	5.94	5.95	5.87	5.85	5.87	5.9	0.1
6	5.84	5.89	5.84	5.85	5.84	5.85	0.05
7	5.95	5.93	5.9	8.92	5.9	5.95	0.113
TOTAL						5.936	0.118

FOR $\bar{X}$ - CHART
MEAN ($\bar{\bar{X}}$) = 5.936
UCL = 5.86
LCL = 6

FOR R - CHART
MEAN ($\bar{R}$) = 0.118
UCL = 0.2494
LCL = 0.0

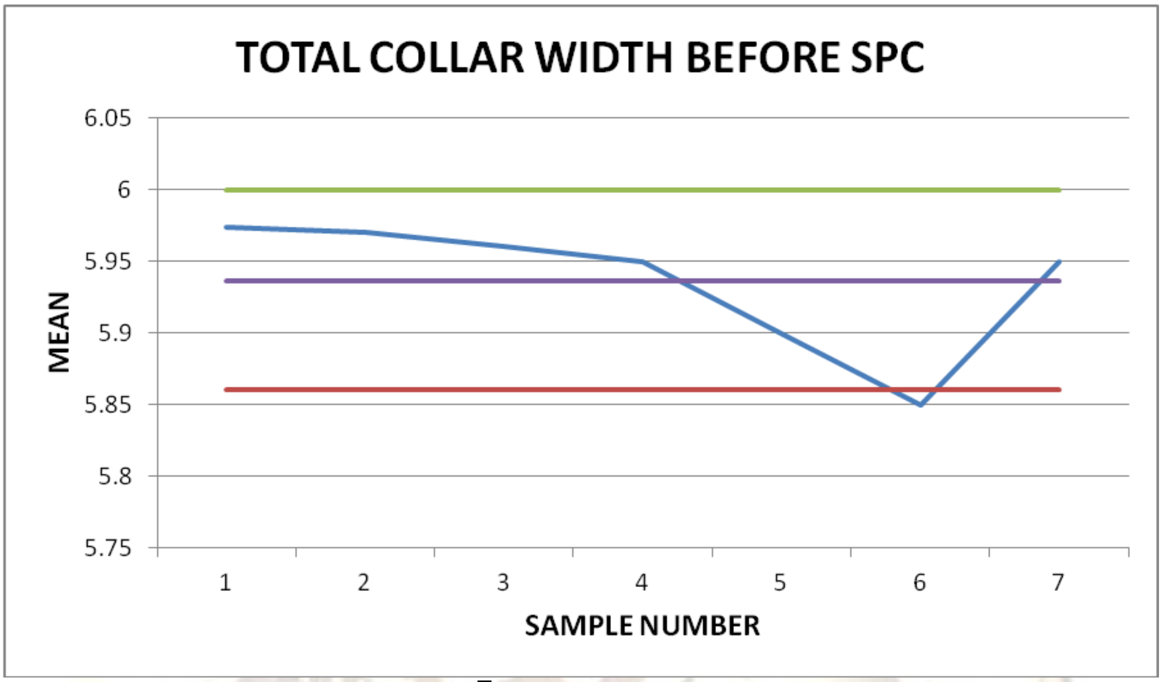

Fig : 7 $\bar{X}$ - chart (total collar width)

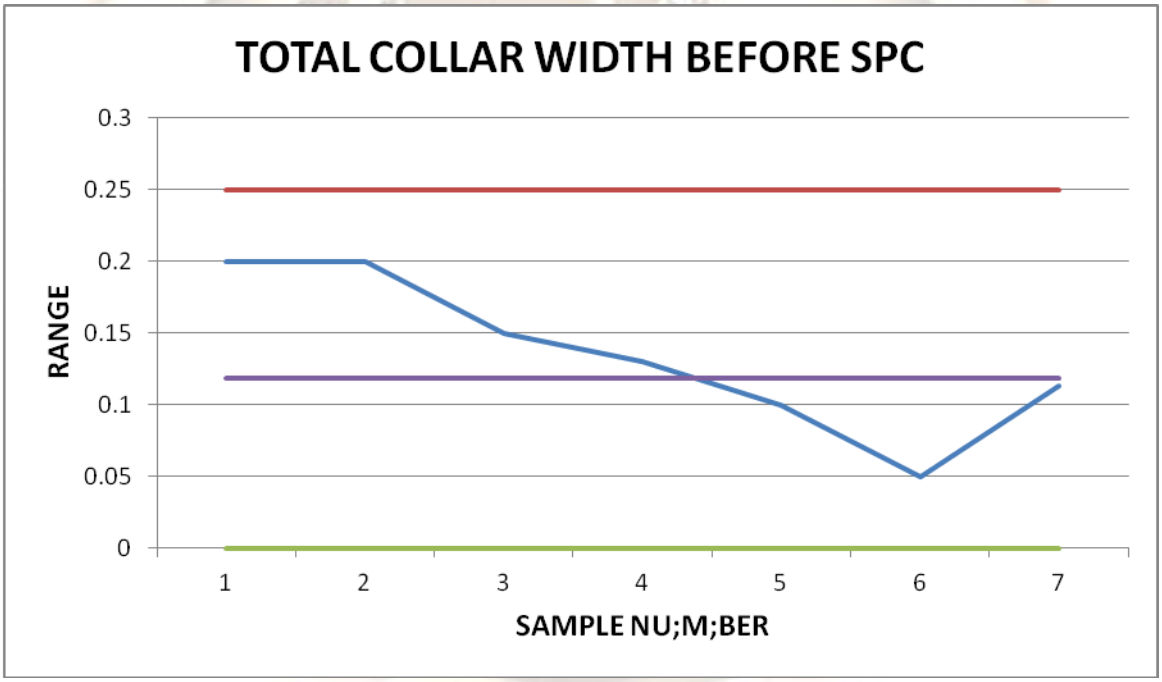

Fig : 8 R - chart (total collar width)

Table : 7 Rejection trends after SPC

DATE	PRODUCED QUANTITY	PASSED QUANTITY	REJECTED QUANTITY	% OF REJECTIONS	MATERIAL REJECTIONS	PROCESS REJECTIONS
02-JAN-13	872	826	46	5.2	29	17
03-JAN-13	950	912	38	4	25	13
04-JAN-13	872	832	40	4.5	25	15
05-JAN-13	896	857	39	4.3	11	28
06-JAN-13	985	913	72	7.3	48	24
07-JAN-13	898	846	52	5.7	3	49
01-FEB-13	870	822	48	5.5	26	22
02-FEB-13	735	704	34	4.2	14	17

03-FEB-13	920	909	11	1.1	9	2
04-FEB-13	885	843	42	4.7	12	30
05-FEB-13	980	935	45	4.5	33	12
06-FEB-13	1005	937	68	6.7	29	39
07-FEB-13	995	941	54	5.4	41	13
08-FEB-13	856	831	25	2.9	13	12
09-FEB-13	876	817	59	6.7	33	26
10-FEB-13	920	874	46	5	29	18
12-FEB-13	930	892	38	4	26	12
13-FEB-13	849	820	29	3.4	25	4
15-FEB-13	515	495	20	3.8	13	7
16-FEB-13	857	820	37	4.3	9	28
18- FEB-13	900	845	55	6.1	30	25
19- FEB-13	883	857	26	2.9	3	23
20- FEB-13	745	717	28	3.7	26	2
22- FEB-13	424	412	12	2.8	3	9
23- FEB-13	742	694	48	6.4	10	38
TOTAL	**21360**	**20351**	**1009**	**4.604**	**525**	**485**

Table : 8 P - chart (after SPC)

Sl.no	PRODUCED QUANTITY	REJECTED QUANTITY	PROPORTION OF REJECTIONS	UCL	LCL
1	872	46	0.052	0.074	0.029
2	950	38	0.04	0.074	0
3	872	40	0.045	0.066	0.023
4	896	39	0.065	0.063	0.023
5	985	72	0.062	0.097	0.048
6	898	52	0.055	0.08	0.033
7	870	48	0.042	0.078	0.032
8	735	31	0.025	0.064	0.019
9	920	11	0.047	0.021	0
10	885	42	0.045	0.068	0.031
11	980	45	0.066	0.065	0.025
12	1005	68	0.054	0.09	0.043
13	995	54	0.029	0.075	0.032
14	856	25	0.065	0.046	0.011
15	876	59	0.05	0.092	0.041
16	920	46	0.04	0.071	0.028
17	930	38	0.034	0.059	0.02
18	849	29	0.038	0.053	0.015
19	515	20	0.043	0.063	0.012
20	857	37	0.061	0.063	0.022
21	900	55	0.026	0.085	0.037
22	883	26	0.037	0.046	0.012
23	745	28	0.029	0.057	0.016
24	424	12	0.064	0.052	0
25	742	48	0.043	0.09	0.037
TOTAL	**21360**	**1009**	**0.04628**	**0.06708**	**0.02356**

Table : 9 Rejections in machining section (after SPC)

Sl.no	TOTAL DEFECTS	OD UNDERSIZE	ID OVERSIZE	ID DIE MARK	COLLAR DIA- TOOL MARK	CRACK
1	17	3	4	5	3	2
2	13	2	1	1	4	5
3	15	3	2	4	3	3

4	28	9	15	2	1	1
5	24	0	8	14	1	2
6	49	0	25	8	14	2
7	22	9	12	0	0	1
8	17	6	7	0	3	1
9	2	0	0	0	1	1
10	30	2	8	2	16	2
11	12	4	0	6	0	2
12	39	5	22	6	2	4
13	13	1	3	2	4	3
14	12	0	6	4	2	0
15	26	4	10	5	3	4
16	18	6	4	5	0	3
17	12	2	0	7	3	0
18	4	0	1	1	0	2
19	7	3	1	0	1	2
20	28	1	3	2	17	5
21	25	2	7	3	9	4
22	23	0	14	3	1	4
23	2	0	0	1	0	1
24	9	1	2	5	0	1
25	38	0	3	22	5	2
TOTAL	**357**	**57**	**145**	**100**	**93**	**55**

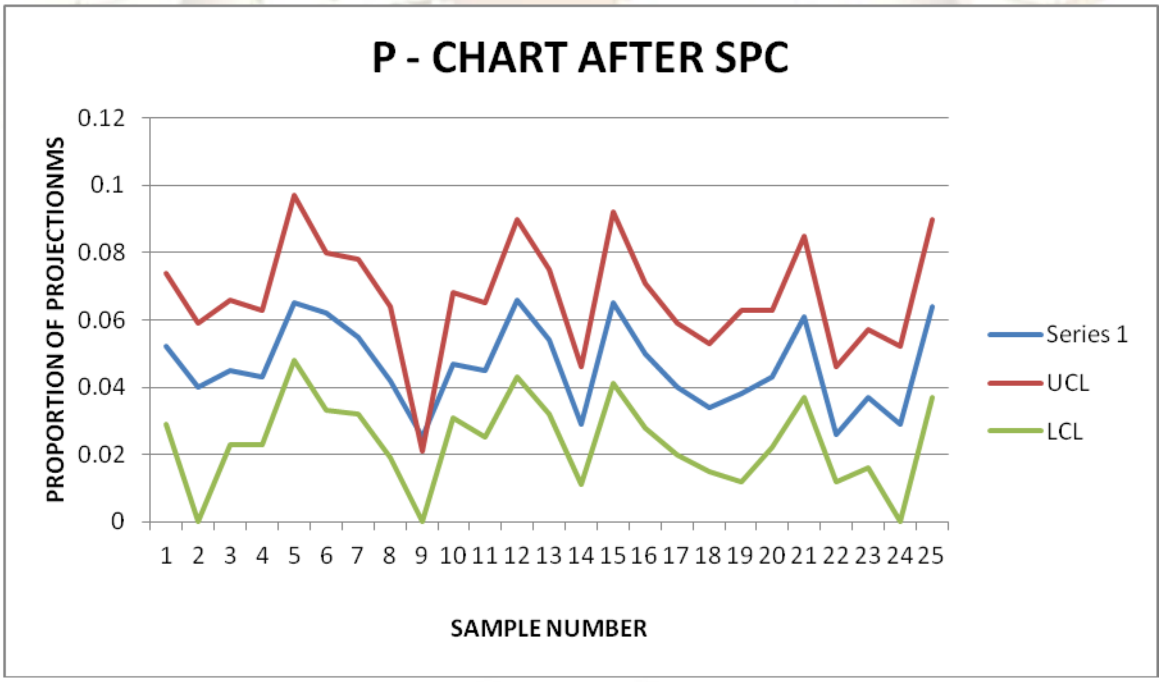

Fig : 9 P – Chart (After SPC)

TYPE OF DEFECTS	NO OF UNITS REJECTED BEFORE SPC	NO OF UNITS REJECTED AFTER SPC
A	74	57
B	213	145
C	136	100
M	69	55

Table : 10 Comparative Analysis

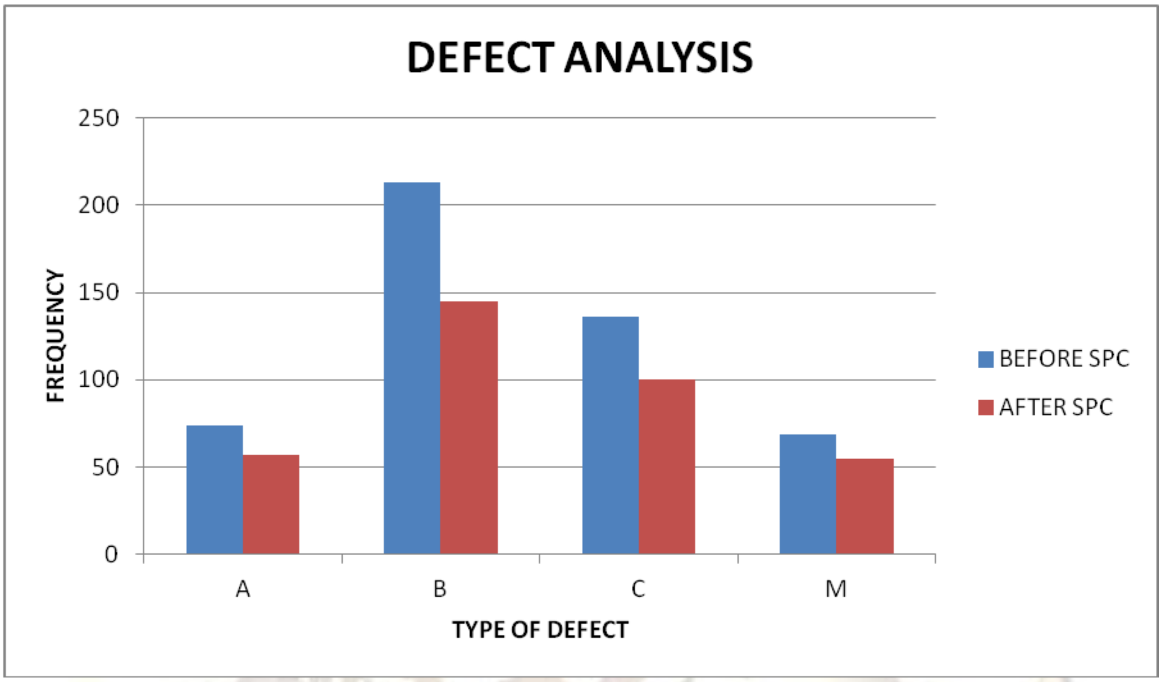

Fig : 10 Comparison of rejection trends

NOTATIONS:-

A – OUTER DIAMETER UNDER SIZE
B - INNER DIAMETER OVER SIZE
C – OUTER DIAMETER TOOL MARK
M – INNER DIAMETER TOOL MARK

V. Results & Discussions

5.1. STATISTICAL PROCESS CONTROL :-

The objective of SPC is to obtain a reliable and unbiased picture of how the process is performing to get the required quality of products. The success of the objective naturally based on reliable and unbiased data collected. Hence prior to SPC study, careful plans for data collection, effectiveness of operational personnel and well maintained, calibrated measuring equipment are necessary.

5.2. BEFORE THE APPLICATION OF SPC

The data collected regarding the number of castings produced and number of casting rejected because of casting defects and machining defects.

P – Chart was drawn using the data shown. It shows that some sample points are not close to process average $\bar{P}$, there is tolerance , but only the aim of zero defect (or) 100% acceptable items. The simplistic measure of capability can hence be provided by the relevant mean value $\bar{P}$.

The capability $\bar{P}$ = 0.0652
= 6.52 %

5.3. DURING THE APPLICATION OF SPC

The data was collected regarding the parameters such as weight , mould temperature , outer diameter, inner diameter and total collar width. The above, reveals that some of the sample points are out of control. $\bar{X}$ - chart and R – chart are drawn as shown in figures . it needs further development to stabilize the process by eliminating the causes of variations, they are

- Lack of periodic training to the employees
- Deviations from specifications
- Shift generation and alteration of working hours

5.4. BRINGING THE CHARACTERISTICS UNDER CONTROL :-

By measuring and comparing the characteristics of final product generated at each section with a standard one, if it is fond inferior, the characteristic is not under control. The parameters, which effect the characteristics of final products, are controlled to obtain the required characteristics.

5.5. AFTER THE APPICATON OF SPC :-

Again the data is collected regarding the number of castings produced and number of casings rejected because of casting defects and machining defects.

P – chart was drawn as shown using the data as shown in table. It shows that some sample points are close to process average, $\bar{P}$

The capability $\bar{P}$ = 0.0462
= 4.62 %

VI. CONCLUSION

It is concluded that process capabilities are improved by decreasing the rejection rate from **6.52**% (Before implementation of SPC) to **4.62**% (after Implementation of SPC). A pareto analysis for comparative results reveals that there exists reduction in wastage of units produced.

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