PROCESS CAPABILITY STUDY OF A REFRIGERATOR MANUFACTURING INDUSTRY: A CASE STUDY

Mr. Vishal Thakur*

Dr. D. R. Prajapati**

ABSTRACT

The main objective of this paper is to conduct process capability analysis for abnormal sound of compressors of a refrigerator; using statistical process control and their tools. The process capability gives us the three different views of capability measures. The normal curve is applied generally on the product's percentage which is out of specification. Process capability indices are calculated to provide single number assessment of the ability of a process to fulfil the specification limits on quality characteristics of interest. Thus; the quality and productivity of products may be improved. Over last decade; the level of significance on process capability analysis has been considerably increased but the literature findings reveal the importance of understanding the concepts, critical assumptions and methodologies; while implementing in various manufacturing process. It is found that sound of compressor of the refrigerator is an important cause of rejection; which leads the wastage of money and time of industry.

Key words: The $\overline{X}$ & R Control charts, Process capability index, capability Ratio, Refrigerator manufacturing industry

* Post Graduate student (TQEM), Production & Ind. Engg. Department, PEC University of Technology (formerly Punjab Engineering College), Chandigarh (India)

** Associate Professor in the department of Mechanical Engineering, PEC University of Technology (formerly Punjab Engineering College), Chandigarh (India).

1. INTRODUCTION

Dedication to constant improvement in quality and productivity is needed to prosper in today's economic climate. Yesterday's standards are not good enough. A company's product has competition from companies throughout the world because modern communication and transportation have created a world marketplace. The process capability was firstly given by Juran (1999) with the introduction of capability ratio. Now 45 years have been passed and many indices such as C_p, C_{pk} are developed for measuring the process performance. Process capability is a method of combining the statistical tool developed from control chart and normal curve for the interpretation and analysis of the data representing the process. The use of process capability study is the integral part of quality engineering function and the result of process capabilities study is used for new design applications, inspection, planning and evaluation techniques. Process capability is the type of statistical tool that can be used during the production cycle to prevent the defects. How well a process meets specification or the ability of the process to produce parts that conform to engineering specification is evaluated by process capability study.

Before calculating the process capability, the process must be under statistical control i.e. under the influence of only chance causes of variation the process is operated and the resultant data of a process is normally distributed and the observations are independent. A large number of pieces that do not meet the specifications is produced by the process but the process is statistically controlled. This happen may be due to the lack of centering of the process, i.e. the actual mean value of the parts being produced may be incomparably different from the specified nominal value of the part.

1.1 Basic capability indices (C_p and C_{pk})

The process capability (C_p) can be specified by the specification range and it does not describe the location of the process with respect to the specifications. The process is adequate to meet the specifications; if the values of C_p exceeding 1.3 and when the value of C_p lies between 1.33 and 1.00; the process may be considered under the specified limits but a closed control is required. The values of C_p below 1.00 indicate that the process is not able to meeting specifications. If the process lies on the mean of the control chart then the process is approximately "normal" then C_p = 1.00 results in a fraction nonconforming of 0.27%. It is also called as process potential.

Process capability index (C_{pk}) evaluates the process spread with reference to the process is really located. The value of C_{pk} relative to C_p is a direct measurement of how far the mean value for the process. It is assumed that the process is under normally distributed. If the characteristic or process variation from its mean value between its specifications limits then the calculated value for C_{PK} is equal to the value for C_P. But as soon as the process variation moves away from the specification centre, the value of C_p and C_{pk} are changed.

CPK is very beneficial and very widely adopted. The process is capable only when the C_{PK} is greater than 1.33 in the short term. If the values of C_{pk} are less than 1.33 then the variation is too much wide compared to the specification or that the location of the variation is offset from the mean of the specification. It can be a combination of two wide points on location. The C_{pk} measures the distance between the process and the nearer specification limit in terms of 3σ . The C_{pk} works for the bell-shaped "normal" (Gaussian) distribution. It is an approximation that C_{pk} = C_p only when the process lies on its mean value. C_p represents the highest possible value for C_{pk}. Table 1 shows that the values of C_{pk} and C_p for various stages of the process.

Table 1: Values of and C_p and C_{pk}

Capability index	Estimation of the process
$C_{Pk} = C_P$	Process is placed exactly at the centre of the specification limits.
$C_P < 1$	Process is not adequate.
$1 \leq C_{Pk} < 1.33$	Process is adequate.
$C_P \geq 1.33$	Process is satisfactory enough.
$C_P \geq 1.66$	Process is very satisfactory.
$C_{Pk} \neq C_{Pk}$	Process is inadequate, new process parameters must be chosen.

2. LITERATURE REVIEW

Statistical process control can be used by both management and production people because it includes statistical methods that utilize the expertise of all employees of the company for problem solving. Management can use SPC as an effective tool for reducing operating costs and improving quality by using its methods for organising and implementing the quality effort. The control chart is a graphical tool for monitoring the activities of a manufacturing process. It plays an important role in SPC. The application of statistical method in SQC has a long history.

The book of economic control of quality of manufactured product by Shewhart (1931) is generally considered as a beginning of statistical quality control. The control chart consist of three lines; an upper control limit (UCL), a lower control limit (LCL) and a centre line (CL). These limits are arbitrarily established at three times standard deviation above and below the centre line. The Shewhart charts are useful for quickly detecting large shift in the mean. Chaudhry and Higbie (1989) examined the implementation and use of statistical process control in a chemical and plastic firm. They studied the factors which are associated with the practical implementation of statistical process control, and discussed their effects on the output. They discussed the important components of SPC process in context of their achievements at a manufacturing facility. Wu (1996) presented an approach to determine the optimum control limits of the x-bar chart for skewed process distributions. The approach takes both the control limits of the x-bar chart and the specification limits of x-bar into consideration, and relates the out-of-control status directly with the nonconforming products. He suggested that proposed approach may be applied to industries to reduce the average number of scrap products, without increasing the type I error in statistical process control (SPC). Goh (2000) outlined the functions of statistical tools and examined the steps in which they are adopted by non-statisticians in industry. A "seven S" approach is explained, highlighting a strategy for the effective deployment of statistical quality engineering. With respect to information utilization, statistical tools are particularly essential for optimizing product and process performance. Chen and Ding (2001) proposed a new index S_{pmk} for any underlying distribution, which takes into account process variability, departure of process mean from the target value, and proportion of non-conformity. They first reviewed C_p, C_{pk}, C_{pm} and C_{pmk}, and their generalization, CN_p, CN_{pK}, CN_{pm} and CN_{pmk}. Then they proposed a new index S_{pmk}.

Prajapati and Mahapatra (2007) discussed a very simple and effective design of proposed X-bar and R chart to monitor the process mean and standard deviation. The concept of the process chart is based upon the sum of chi-square ($\chi2$) to compute and compare Average Run Length Values (ARLs).They compared the performance of the proposed chart with VSS, VSI and VSSI joint scheme proposed by Costa (1999). Jose et al. (2010) demonstrated the relationship between the overall equipment effectiveness (OEE) and process capability (PC). These measures however are traditionally applied separately and with different purposes. They investigated the relationship between OEE and PC, how they interact and impact each other, and the possible effects that this relationship may have on decision making. They reviewed the OEE and PC background. Then a discrete-event simulation model of a bottling line is developed. Using the model, a set of experiments are run and the results interpreted using graphical trend and impact analyses. Das (2012) discussed the use of generalised lambda distribution to handle non normal data .Traditional control chart has been established based on the assumption of normality. In many practical situation assumption of normality is violated. Under these situations, the use of traditional control chart gives erroneous conclusion. But for handling non-normal data one approach is use of non-paramatic control chart which are not to efficient. Wanare and Gudadhe (2013) stated that the process capability is the ability of the combination of the equipment to produce a product that will consistently meet the design requirements and the customer expectation. The analysis ensures that processes are fit for industrial specification and limiting the process variation is important in achieving product quality characteristics. Prajapati and Singh (2014) computed ARLs (average run length) at various sets of parameter of the X-bar chart by simulation, using MATLAB. The performance of the chart is measured in terms of the average run length, which is the average no. of sample before getting an out-of-control signal. They proposed various optimal scheme of different level of correlation. Moreover they compared these optimal schemes of modified X-bar chart with Derman-Ross (1997) and Klein (2000) schemes at various level of correlation. Erameh et al. (2016) proposed the use of control charts for the turning process of a combination of the spindle speed and feed rate as a subgroup size for a total subgroup of thirty. The diameters (representing the quality characteristics) were used to generate control charts and capability histogram for the process. They found that the process was within statistical control but found incapable of meeting up .to specifications because the capability index (Cp) was less than 1 and the machine capability for industrial application was not adequate.

3. Products and Industry

This industry is one of the largest refrigerators manufacturing industries of India and producing many products by this industry. Being one of India's foremost brands & business house, this industry is also an extremely responsible corporate citizen. This is best manifest in its stewardship of one of the world's largest privately owned Mangroves Reserve.

There are many products which are manufactured by this firm, like Aerospace Appliances, Batteries, Construction, Electricals & Electronics, Interior (Furniture), Locks, Material Handling, Precision Engineering, Process Equipment, Security Solutions Storage Solutions, Tooling, Vending etc.

3.1 Refrigerator compressor plant

Compressor is very important part of refrigerator. Assembly of compressor is takes place at very adequate environment. Compressor is consisting of compressor shell; which is constructed from a steel sheet with atop cover is being welded together with housing at bottom. The connection is sealed such that the refrigerant can't leak to the outside. The mechanical unit of compressor remains within the center of its housing. Four springs are used for keeping the mechanical unit to its central position. There are two base plates which are used for mounting the compressor within the appliance. The motor is the most important part of the compressor and the motor consists of stator, rotor and a power cable. The motor is mounted on the spring so that the vibration because of stator is reduced. The stator is constructed from metal sheet and it contain stator stack which is made up of winding of two copper wires together. Iron core is used as a rotor and casted in aluminum. Figure 1 shows the various components of the compressor of a refrigerator.

Figure 1 Components of the Compressor of a refrigerator

The details of various components are as follows:

1. Housing with connectors and base plates 2. Top Cover 3. Block with stator bracket
4. Stator (with screws) 5. Rotor 6. Valve unit (screws, cylinder cover, gaskets, valve plate)
7. Crankshaft with grommet 8. Connecting rod with piston 9. Oil pick-up tube
10. Springs with suspensions 11. Internal discharge tube (screw, washer, gasket) 12. Start equipment

Standard sound of compressor is 72 ±25% DB

4. Methodology of using control charts

In this paper; the $\overline{X}$ and R charts are used to know the status of the process. The data are collected from in-line process. The observations are taken from the manufacturing line of 100 samples. Using sample size of 4 are taken. These data is shown in the Table 1A (Appendix A). The procedure of implementing of $\overline{X}$ and R charts is discussed in the following section.

4.1 Procedure of implementation of $\overline{X}$ & R charts

The procedure of implementing $\overline{X}$ and R charts as follows

Step 1 Determine the quality characteristics to be considered.

Step 2 Determine the sample size and lot size.

Step 3 Samples are taken at random basis.

Step 4 Calculate the average and range for each sample and record them in a tabular form.

Step 5 Calculate the process average ($\overline{X}$) and Upper control limit (UCL) and lower control limit (LCL) by using the following relation.

$$\bar{\bar{X}} = \frac{\sum \bar{x}}{N}$$

Where, $\bar{\bar{X}}$ = Average of the averages of all samples

$\bar{X}$ = Average of each sample

N = Number of samples taken

Next, find the average of range values by using the formulas given below

$$\overline{R} = \frac{\sum Ri}{N}$$

Ri = Range of individual samples = Max Value – Min Value

$\bar{R}$ = The average of ranges of all the samples range.

Control limits for $\bar{X}$ chart are:

$UCL_{\bar{x}} = \bar{\bar{x}} + A2\ \bar{R}$

$LCL_{\bar{x}} = \bar{\bar{x}} - A2\bar{R}$

Control limits for R chart are:

$UCL_R = D4 \times \bar{R}$

$LCL_R = D3 \times \bar{R}$

Where,

$UCL_{\bar{x}}$, $LCL_{\bar{x}}$ = Upper and lower control limits for $\bar{X}$ chart respectively.

UCLR, LCLR = Upper and lower control limits for R chart respectively.

D3, D4, A2 = Constants, depend upon sample size.

Step 6 Draw $\overline{X}$ and R charts by using above values.

Step 7 Observe and interpret the pattern of the points on $\overline{X}$ and R charts. If there are any points, falling beyond the control limits, delete/ignore them and find the new mean and control limits for $\overline{X}$ and R charts. This procedure may be continued till all the points are falling within control limits of $\overline{X}$ and R charts and the process may be called in statistical control.

Step 8 Calculate the process capability of the process that is in statistical control, as shown in section 4.3.

4.2 Plotting of data points on $\overline{X}$ and R charts

The 100 observations are taken with the help of digital sound level meter of compressor's sound and computations of various parameters are presented in this section as follows:

Mean ($\overline{X}$) Chart:

$\overline{X} = \frac{X1+X2+X3+X4}{4}$

Similarly, Mean or Average of 100 samples can be calculated as:

Samples mean ($\overline{\overline{X}}$) $= \frac{\Sigma\{X1 \ldots\ldots XN\}}{N} =$

($\overline{\overline{X}}$) $= \frac{7206.36}{100}$ =72.063DB

Where, N is the number of subgroups = 100

$\overline{\overline{X}}$ = 72.063DB and Average range can be calculated as:

$\overline{R} = \frac{\Sigma(R1 \ldots RN)}{N}$

$\overline{R} = \frac{41.4}{100}$

$\overline{R} = 0.414$

Upper control limit (UCL_X) $= \overline{\overline{X}} + A_2 \times \overline{R}$

= 72.063+ 0.729 × 0.414 = 72.365DB

Lower control limit =$LCL_X = \overline{\overline{X}} - A_2 \times \overline{R}$

LCL_X =72.063- 0.729 × 0.414 = 71.761DB

Range (R) Chart

Range (R) = $X_{max} - X_{min}$

$\overline{R} = \frac{\Sigma(R1 \ldots RN)}{N} = \frac{41.4}{100} = 0.414$,

Standard deviation

Standard deviation is calculated as follow:

$$s = \frac{\bar{R}}{d2}$$

d2 =2.059 for sample size n =4.

$$s = \frac{0.414}{2.059}$$

S=0.201

Where, N is the number of subgroups = 100 (for this case)

Upper control limit on R chart,

UCLR = D4 × $\bar{R}$ = 2.282 × 0.414 = 0.946

Lower control limit on R chart,

LCLR = D_3 × $\bar{R}$ = 0 × 0.414 = 0, where A_2 = 0.729, D_4 = 2.282, D_3= 0 (values of these factor, corresponding to sample size, are available in all the books of Quality control). The plot for $\bar{X}$ and R charts for compressor's sound (in DB) for initial data are shown in Figure 2.

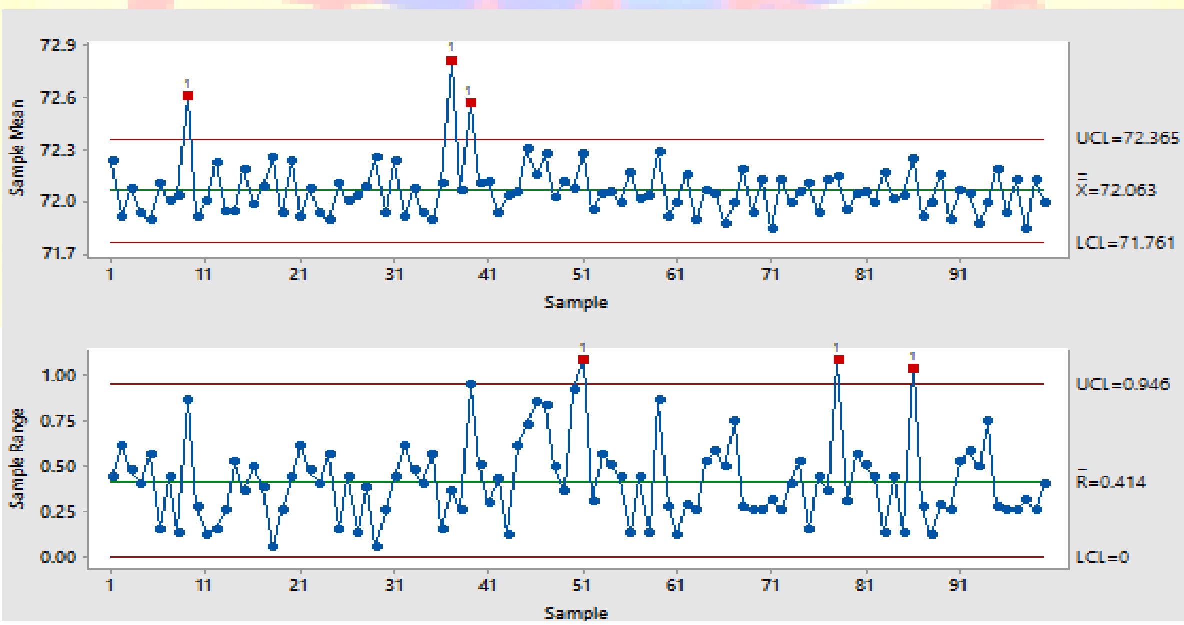

Figure 2 $\bar{X}$ and R charts for initial observed data

It has been observed from the observation that observation numbers 9, 37and 39 are falling beyond upper control limit (UCL) on $\bar{X}$ chart in the first stage. Similarly; observation numbers 50, 51, 59, 78 and 86 are falling beyond upper control limit (UCL) on $\bar{X}$ chart in the second stage. So the above observations need to be deleted and new values for range are calculated to check the statistical control of the process. The same procedure has been continued till all the points are within control limits on $\bar{X}$ and R charts. The final computed parameters of the statistical control of the process are as follows:

$\bar{\bar{X}} = \frac{6627.68}{92}$

$\bar{\bar{X}}$ = 72.04 DB

$\bar{R} = \frac{34.914}{92}$

$\bar{R}$ = 0.3795

$\bar{X}$- Chart

$UCL_{\bar{X}}$= 72.3164 and $LCL_{\bar{X}}$ = 71.7636

R-chart

$UCL_R = D4 \times \bar{R} = 2.282 \times 0.3795 = 0.8659$

$LCL_R = D3 \times \bar{R} = 0 \times 0.3795 = 0$

UCLR =0 .8659 and LCLR = 0

Figure 3 shows $\bar{X}$ and R charts of statistically controlled process of compressors sound.

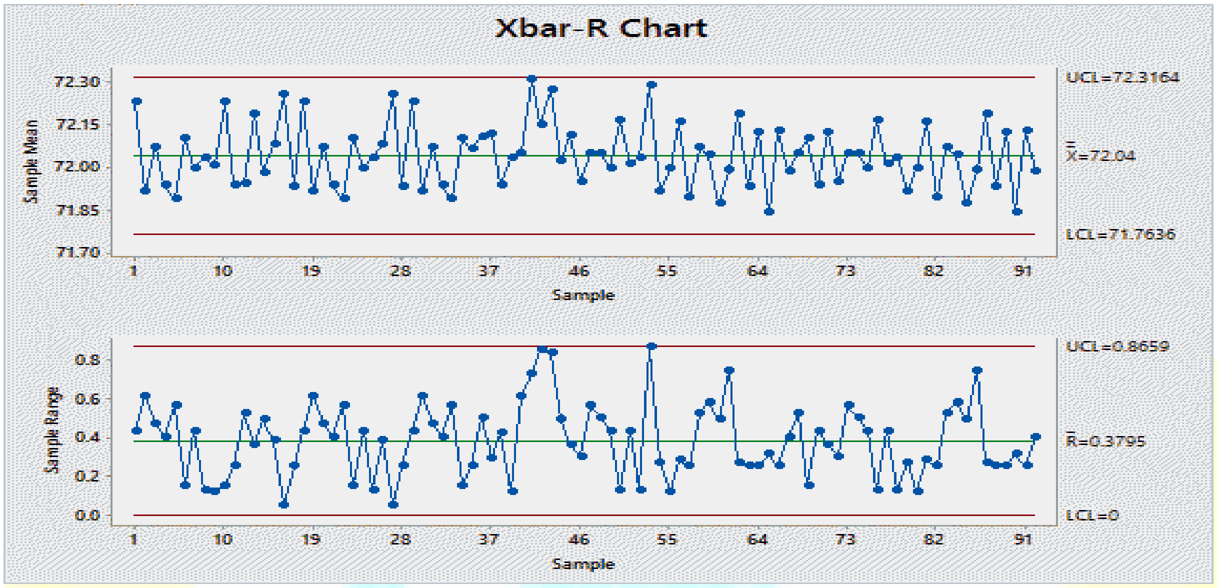

Figure 3 $\bar{X}$ and R charts of statistically controlled process

4.3 Process capability analysis

It can be defined as the minimum spread of the process under controlled conditions. It is the measure that is frequently used in the normal distribution deviations. The R chart is a distribution of range (R) values and has a standard deviations SR. The upper control limit is 3 times standard deviations above the mean. The $\bar{X}$ chart is a distribution of $\bar{X}$ values and has a standard deviation S$\bar{x}$. Normally, the control limits are set at 3 times the standard deviations from the mean.

$$\bar{\bar{X}} = \frac{\sum\{\overline{X1}..........\overline{XN}\}}{N}$$

$$\bar{\bar{X}} = \frac{6627.68}{92}$$

$\bar{\bar{X}}$ = 72.04 DB

LSL = Lower specification limit = 71.75 DB

USL = Upper specification limit =72.25 DB

From Figure 4,

$\bar{\bar{X}}$= 72.04 DB

For this case, N is the number of subgroups = 92 (for statistically controlled process for $\bar{X}$ chart)

$$\bar{R} = \frac{\sum(R1....RN)}{N}$$

$$\bar{R} = \frac{34.914}{92}$$

$\bar{R}$= 0.3795

For this case, N is the number of subgroups = 92 (for statistically controlled process for R chart)

Standard deviation is calculated as follow:

$$s = \frac{\bar{R}}{d2}$$

d2 =2.059 for sample size n =4.

$$s = \frac{0.3795}{2.059}$$

s = 0.1843

Upper control limit and lower control limit are calculated as follows:

Upper control limit = UCL $_x$ = $\bar{\bar{X}}$ + A2 × $\bar{R}$

= 72.04 + 0.729 × 0.3795 = 72.3164 DB

Lower control limit = LCL $_x$ = $\bar{\bar{X}}$ - A2 × $\bar{R}$

= 72.04 - 0.729 × 0.3795 = 71.7636 DB

UCL_R = D4 × $\bar{R}$ = 2.282 × 0.3795 =0.8659

LCL_R = D3 × $\bar{R}$ = 0 × 0.3795 = 0

The area beyond upper specification limit can be calculated as follow by putting x as USL

$$Z_U = \frac{x - \bar{\bar{x}}}{s}$$

$$Z_U = \frac{72.25 - 72.04}{0.184}$$

$Z_U = 1.141$

The area under upper specification limit process corresponds to z = 1.141 to the upper side of the curve is 0.873 (from normal distribution curve table).

Now substitute the LSL for the value of x.

$$Z_L = \frac{71.75 - 72.04}{0.184} = -1.576$$

The area beyond lower specification limit corresponds to z = - 1.576 to the lower side is 0.05821 (from normal distribution curve table).

Percentage of observation falling out of specification limits =1-(0.8731-0.0582)

= 0.1851 or 18.51%.

4.3.1 Calculation of capability Ratio

Population standard deviation

s =0.184

So, Process capability (Cp) = 6s = 6×0.184=1.104

To be process under control,

(USL – LSL) ≥ 6s

(72.25 – 71.75) ≥ 6×0.184

0.5 ≤ 1.104

So, process is considered to be out of control.

The Capability ratio can also be calculated as:

$$PCR = \frac{6s}{USL - LSL}$$

$$PCR = \frac{6 \times 0.184}{72.25 - 71.75}$$

PCR= 2.208

This value of PCR shows that the process is not adequate to conform the specifications.

4.3.2 Calculation of process capability index (C_{pk})

There are two working version of capability index C_p and C_{pk}. The C_p is just the reciprocal of PCR.

$$C_p = \frac{Tolerance}{6s} = \frac{USL - LSL}{6s}$$

$$C_p = \frac{72.25 - 71.75}{6 \times 0.184}$$

C_p= 0.45or 45%

$$C_{pk} = \text{Minimum of } \left[\frac{USL - \bar{\bar{x}}}{3s} \text{ or } \frac{\bar{\bar{x}} - LSL}{3s}\right]$$

The minimum occurs with the specification limit that is closest to $\bar{\bar{X}}$. The $\bar{\bar{X}}$ is closest to LSL.

$\bar{\bar{X}}$- LSL = 72.04 – 71.75 = 0.29 OR USL -$\bar{\bar{X}}$ = 72.25-72.04=0.21

s = 0.184

$$C_{pk} = \text{of } \left[\frac{USL - \bar{\bar{x}}}{3s} \text{ or } \frac{\bar{\bar{x}} - LSL}{3s}\right]$$

$$C_{pk} = \left[\frac{72.25 - 72.04}{3 \times 0.184} \text{ or } \frac{72.04 - 71.75}{3 \times 0.184}\right]$$

C_{pk} = [0 .38 or 0.53]

$$\frac{1}{Cpk} = \frac{1}{0.38} = 2.631$$

According to above calculations, the values of C_p = 0.45 and C_{pk} = 0.38 and 1/C_{pk} = 2.631; that shows the process is not capable to meet the specifications.

5. CONCLUSIONS

The statistical concepts that are applied in SPC are very basic and can be learned by everyone in the organisation. All workers must know how SPC applies to their specific jobs and how it can be used to improve their output. Supervisors must be aware of the ways SPC can be used in their sections; they must create and maintain a management style that emphasizes communication and cooperation between levels and between departments.

Statistical process analysis is very helpful tool in manufacturing industry for improvement of efficiency. By using statistical process control the no. of defects are decrease thus the rework cost also decrease and expensive time in future. The $\overline{X}$ and R control charts are plotted for the noise (in DB) and used to find whether the processes are with-in statistical control or not of statistical control. IT is found that the process is going out of control, which will lead to reject the product. Hence the process capability of this process is required to be improved by the management to reduce the major loss. In this case study, it is found that the process is not able to meet its specification limits set by the manufacturer.

REFERENCES

- Chaudhary, S.S. and Higbie J.R. (1989), "Practical Implementation of Statistical Process Control in a Chemicals Industry", International Journal of Quality & Reliability Management, Vol. 6 Issue: 5.
- Cheikh A. & McGoldrick P.F., 1988, The Influence of Cost, Function and Process Capability on Tolerance, International Journal of Quality & Reliability Management, Vol. 5 Issue 3, pp.15 – 28.
- Chen, J.P. and Ding C.G. (2001), "A new process capability index for non-normal distributions", International journal of Quality & Reliability Management, Vol. 18 Issue 7, pp. 762 – 770.
- Das, N. (2012), "Performance of control chart using generalised lambda distribution, International journal of Productivity and Quality Management, 2012 Vol.10, No.4, pp.411 – 427.
- Derman, C. and Ross, M. S. (1997), "Statistical Aspects of Quality Control", Academic Press, San Diego, CA.

- Erameh, A.A., Nurudeen, A., Raji, R.O., Durojaye, and Yussouff, A.A. (2016), "Process Capability Analysis of a Centre Lathe Turning Process", Scientific Research Publishing, Vol. 8, No.3, pp. 79-85.
- Goh, T.N. (2000), "Operating frameworks for statistical quality engineering", International journal of quality and reliability management, Vol. 17, issue 2, pp.180-188.
- Juran, J. M. (1999), "Quality Handbook", 5th Edition, McGraw-Hill.
- Jose, A., Steve, E., Barber, K.D. and Meier, H.S. (2010), "Overall equipment effectiveness (OEE) and process capability (PC) measures: A relationship analysis", International Journal of Quality & Reliability Management, Vol. 27 Issue 1, pp.48 – 62.
- Klein, M. (2000), "Two alternatives to the $\overline{X}$ Control Chart", Journal of Quality Technology, Volume 32, Number 4, pp. 427 - 431.
- Prajapati, D.R. and Mahapatra, P.B. (2007), "An Effective Joint $\overline{x}$ and R Chart to Monitor the Process Mean and Variance. International Journal of Productivity and Quality Management, 2007; 2 (4): 459- 474.
- Prajapati, D.R. and Singh, S. (2014), "Effect of Warning Limits on the Performance of the Chart under Autocorrelation', International Journal of Productivity and Quality Management, Vol. 13, No. 2, pp. 235-250.
- Shewhart, W. A. (1931), "Economic control of quality of manufacturing product", Van Nostrand, New York.
- Sun, J., Tsubaki, M. & Matsui, M. (2007), "The PDCA and CAPD economic models of the P control chart", International journal of Productivity and Quality Management, Vol.2, No.3, pp.365 – 386.
- Wanare, S.P. and Gudadhe, M.V. (2013) Performance Analysis of Vertical Machining Center through Process Capability, International Journal of Innivations in Engineering and Technology, **2**, 198-207.
- Wu, Z. (1996), "Asymmetric control limits of the -bar chart for skewed process distributions", International Journal of Quality & Reliability Management, Vol. 13 Issue 9, pp.49 – 60.

Appendix A

Table 1A Observations of sound of compressor of refrigerator (DB units)

S. No	X_1	X_2	X_3	X_4	$\bar{X}$	Range (R)
1	72.25	72.00	72.24	72.43	72.23	0.43
2	71.75	71.69	71.92	72.30	71.92	0.61
3	72.00	72.25	72.25	71.78	72.07	0.47
4	72.15	72.05	71.75	71.79	71.94	0.40
5	72.18	71.75	72.00	71.62	71.89	0.56
6	72.13	72.12	72.15	72.00	72.10	0.15
7	72.06	71.75	72.18	72.00	71.99	0.43
8	72.00	72.00	72.13	72.00	72.03	0.13
9	72.86	72.03	71.83	72.00	72.18	1.03
10	71.93	71.73	72.00	72.00	71.92	0.27
11	72.07	72.00	71.95	72.00	72.01	0.12
12	72.25	72.27	72.12	72.27	72.2275	0.15
13	72	72	71.75	72	71.9375	0.25
14	72.27	71.75	72	71.75	71.9425	0.52
15	72	72.36	72.03	72.36	72.1875	0.36
16	71.75	72.22	71.73	72.22	71.98	0.49
17	72.36	71.98	72	71.98	72.08	0.38
18	72.22	72.25	72.27	72.27	72.2525	0.05
19	71.98	71.75	72	72	71.9325	0.25
20	72.25	72	72.24	72.43	72.23	0.43
21	71.75	71.69	71.92	72.3	71.915	0.61
22	72	72.25	72.25	71.78	72.07	0.47
23	72.15	72.05	71.75	71.79	71.935	0.4
24	72.18	71.75	72	71.62	71.8875	0.56
25	72.13	72.12	72.15	72	72.1	0.15
26	72.06	71.75	72.18	72	71.9975	0.43
27	72	72	72.13	72	72.0325	0.13
28	72.36	71.98	72	71.98	72.08	0.38
29	72.22	72.25	72.27	72.27	72.2525	0.05
30	71.98	71.75	72	72	71.9325	0.25
31	72.25	72	72.24	72.43	72.23	0.43
32	71.75	71.69	71.92	72.3	71.915	0.61
33	72	72.25	72.25	71.78	72.07	0.47
34	72.15	72.05	71.75	71.79	71.935	0.4
35	72.18	71.75	72	71.62	71.8875	0.56
36	72.13	72.19	72.65	72	72.2425	0.65
37	73.05	72.75	72.95	72.83	72.895	0.3
38	72	72	72.25	72	72.0625	0.25
39	72.94	71.69	72	72.15	72.195	1.25
40	72.5	72.35	72.75	73.03	72.6575	0.68
41	72	72.05	72.29	72.13	72.1175	0.29
42	71.76	71.75	72.17	72.06	71.935	0.42
43	72	72.12	72	72	72.03	0.12
44	72.09	71.75	72	72.36	72.05	0.61
45	72.28	72	72.72	72.22	72.305	0.72
46	72.6	71.98	71.75	72.27	72.15	0.85
47	72.83	72.25	72	72	72.27	0.83
48	72	71.75	72.09	72.24	72.02	0.49
49	72.25	72	72.28	71.92	72.1125	0.36
50	71.76	71.69	72.6	72.25	72.075	0.91
51	71.75	72.25	72.83	71.75	72.145	1.08
52	71.75	72.05	72	72	71.95	0.3
53	72	72.25	72.25	71.69	72.0475	0.56
54	72.15	72.05	71.75	72.25	72.05	0.5
55	72.18	71.75	72	72.05	71.995	0.43
56	72.13	72.12	72.15	72.25	72.1625	0.13
57	72.06	71.75	72.18	72.05	72.01	0.43
58	72	72	72.13	72	72.0325	0.13
59	72.86	72.03	71.83	72.25	72.2425	1.03
60	71.93	71.73	72	72	71.915	0.27
61	72.07	72	71.95	71.96	71.995	0.12
62	72.25	72.27	72.12	71.99	72.1575	0.28
63	72	72	71.75	71.82	71.8925	0.25
64	72.27	71.75	72	72.25	72.0675	0.52
65	72	72.36	72.03	71.78	72.0425	0.58
66	71.75	72.22	71.73	71.79	71.8725	0.49
67	72.36	71.98	72	71.62	71.99	0.74
68	72.22	72.25	72.27	72	72.185	0.27
69	71.98	71.75	72	72	71.9325	0.25

70	72.25	72	72.24	72	72.1225	0.25
71	71.75	71.69	71.92	72	71.84	0.31
72	72	72.25	72.25	72	72.125	0.25
73	72.15	72.05	71.75	72	71.9875	0.4
74	72.18	71.75	72	72.27	72.05	0.52
75	72.13	72.12	72.15	72	72.1	0.15
76	72.06	71.75	72.18	71.75	71.935	0.43
77	72	72	72.13	72.36	72.1225	0.36
78	71.75	72.25	72.83	71.75	72.145	1.08
79	71.75	72.05	72	72	71.95	0.3
80	72	72.25	72.25	71.69	72.0475	0.56
81	72.15	72.05	71.75	72.25	72.05	0.5
82	72.18	71.75	72	72.05	71.995	0.43
83	72.13	72.12	72.15	72.25	72.1625	0.13
84	72.06	71.75	72.18	72.05	72.01	0.43
85	72	72	72.13	72	72.0325	0.13
86	72.86	72.03	71.83	72.25	72.2425	1.03
87	71.93	71.73	72	72	71.915	0.27
88	72.07	72	71.95	71.96	71.995	0.12
89	72.25	72.27	72.12	71.99	72.1575	0.28
90	72	72	71.75	71.82	71.8925	0.25
91	72.27	71.75	72	72.25	72.0675	0.52
92	72	72.36	72.03	71.78	72.0425	0.58
93	71.75	72.22	71.73	71.79	71.8725	0.49
94	72.36	71.98	72	71.62	71.99	0.74
95	72.22	72.25	72.27	72	72.185	0.27
96	71.98	71.75	72	72	71.9325	0.25
97	72.25	72	72.24	72	72.1225	0.25
98	71.75	71.69	71.92	72	71.84	0.31
99	72	72.25	72.25	72	72.125	0.25
100	72.15	72.05	71.75	72	71.9875	0.4