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Process Capability – A Case Study

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Abstract:

The primary objective of this investigation is to conduct an analysis of process capability within filling operations. A process capability index serves as a tool for evaluating the conformity of a process with engineering specifications, commonly referred to as capability or performance indices. These indices are extensively utilized across various industries. The aim of this study is to perform a process capability analysis specifically tailored to filling operations. An industrial case study is provided to exemplify the monitoring of filling processes using process capability analysis. The findings underscore the efficacy of process capability analysis in overseeing the quality of filling processes.

1 Introduction:

Assessing process capability involves determining how effectively the process can adhere to specifications and maintain the required level of control. It also reflects the extent to which machinery, materials, personnel, and methods can be integrated to consistently produce products meeting engineering standards. Methods such as histograms, probability plots, and control charts are employed for process capability analysis, which serves as an effective means of monitoring. Ensuring the process is under statistical quality control is essential before evaluating capability. Once process stability is confirmed, normality tests are conducted on the data using histograms and probability plots. Capability indices, including CP, Cpk, Cpm, and Cpmk, are commonly used in manufacturing industries to assess the process's ability to meet engineering specifications and evaluate performance.

2 MATERIALS AND METHODS

1. Theoretical Analysis:

Statistical methods optimize manufacturing output quality by selecting the best procedures. Computational formulas for control charts and process capability indices are detailed.

2. Control Chart:

A graphical display of quality characteristics measured against sample number. It includes a center line (CL) for average value and upper (UCL) and lower (LCL) control limits. When the process is in control, all sample points fall within these limits.

3.The mean ($\bar{x}$) chart:

To create a mean chart, which is based on the average of samples from the processbeing analyzed, we begin by establishing the center line (CL) of the chart. This line is calculated as the mean of all the means within the samples.

$$\bar{\bar{X}}=\frac{x_1+x_2+\ldots+x_m}{m} \quad (1)$$

Where m represents the number of samples. To estimate the upper and lower control limits of the (x̄) - chart, the following formulas are used;

Upper control limit (UCL) =

$$\bar{\bar{X}}+ A_2\bar{R} \ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Lower control limit =

$$=\bar{\bar{X}}- A_2\bar{R} \ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Where:

$\bar{\bar{X}}$= The Grande average of the sample means.

$\bar{R}$= The sample rang of all m samples.

$$\bar{R}=\frac{R_1+R_2+\ldots+R_m}{m} \ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

4. The Range (R) chart:

The R-chart is constructed in a manner is similar to x̄ bar chart. The centre line of the control chart is the average range of R bar and the upper and lower control limits are computed as following:

$$CL_R = \bar{\bar{R}}$$

$$UCL_R = D_4\bar{\bar{R}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

$$LCL_R = D_3\bar{\bar{R}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

5:Process Capability Indices:

These indices gauge a process's ability to meet engineering limits and are significant only when the process is under control. Widely utilized in industries, common indices include Cp, Cpk, Cpm, and Cpmk. Analysis techniques involve probability plots and control charts to ascertain process performance and statistical control.

6: Work at industry:

Process capability in a industry involves assessing the ability of a process to consistently produce products or services that meet customer requirements. Here's how it generally works

1. *Define Specifications:* The first step is to define the specifications or requirements that the product or service must meet. These specifications are typically based on customer expectations and industry standards.

2. *Collect Data:* Data on the process output or performance is collected over time. This data may include measurements of key characteristics or parameters related to the product or service.

3. *Calculate Process Capability Indices:* Various process capability indices, such as Cp, Cpk, Cpm, and Cpmk, are calculated based on the collected data. These indices provide quantitative measures of how well the process is capable of meeting the specifications.

4. *Interpret Results:* The calculated indices are then interpreted to assess the capability of the process. A process may be deemed capable if the indices indicate that the process output is well within the specifications and variation is minimal. Conversely, if the indices suggest that the process output is not consistently meeting specifications or there is excessive variation, further analysis and improvement efforts may be needed.

5. *Continuous Monitoring and Improvement:* Process capability analysis is an ongoing process. Companies continuously monitor the performance of their processes and make improvements as needed to ensure that products or services consistently meet customer requirements and standards.

By implementing process capability analysis, companies can identify areas for improvement, reduce defects and waste, enhance product quality, and ultimately improve customer satisfaction.

3 RESULTS

SR.NO	OD	IN TIME	OUT TIME	LABOUR TIME
1)	49.986	11:32	11:34	
2)	49.985	11:34	11:36	
3)	49.987	11:37	11:39	
4)	49.987	11:39	11:40	
5)	49.989	11:40	11:42	
6)	49.988	11:42	11:43	
7)	49.987	11:43	11:45	
8)	49.986	11:45	11:47	
9)	49.985	11:47	11:50	
10)	49.987	11:50	11:51	
11)	49.988	11:51	11:53	Lunch Time
12)	49.985	12:30	12:33	
13)	49.987	12:33	12:35	
14)	49.988	12:35	12:37	
15)	49.988	12:37	12:39	
16)	49.987	12:39	12:42	
17)	49.985	12:42	12:44	
18)	49.987	12:44	12:45	
19)	49.988	12:45	12:47	
20)	49.987	12:47	12:49	
21)	49.988	12:49	12:51	
22)	49.988	12:51	12:53	
23)	49.987	12:53	12:55	
24)	49.988	12:55	12:57	
25)	49.987	12:57	12:59	
26)	49.988	12:59	01:00	
27)	49.987	01:01	01:03	
28)	49.985	01:03	01:04	
29)	49.986	01:04	01:06	
30)	49.987	01:06	01:07	
31)	49.987	01:07	01:09	
32)	49.988	01:09	01:11	
33)	49.987	01:11	01:13	
34)	49.988	01:13	01:15	
35)	49.985	01:15	01:17	
36)	49.986	01:17	01:19	
37)	49.985	01:19	01:21	
38)	49.988	01:21	01:23	
39)	49.987	01:23	01:25	
40)	49.988	01:25	01:26	
41)	49.988	01:26	01:27	
42)	49.987	01:28	01:29	
43)	49.985	01:30	01:32	
44)	49.986	01:32	01:34	
45)	49.988	01:34	01:36	

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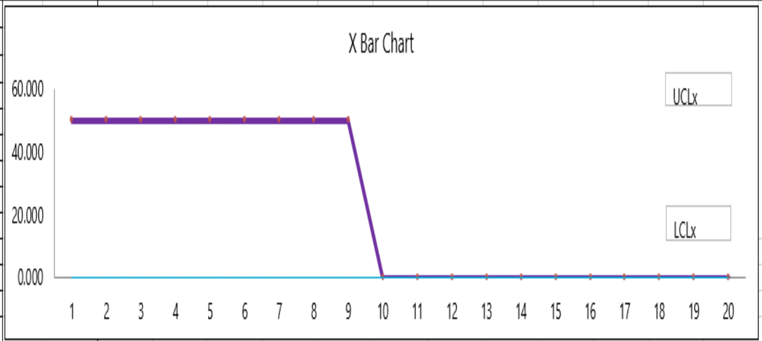
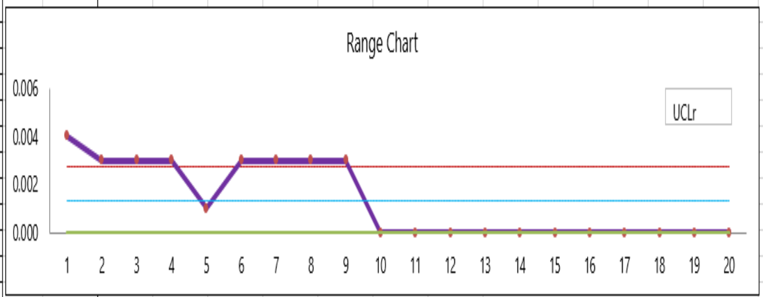
KINETIC GEARS	Worksheet For Statistical Process Control Chart
	Date:- Shift:- 1st Plant Name:- Kinetic Gears (KG)

	NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Part Name :- Fuel pump shaft																					
Operation :- Grinding	1	49.986	49.988	49.988	49.987	49.988	49.988	49.987	49.986	49.988											
Machine No. :- GYN/CNC/01	2	49.985	49.987	49.985	49.985	49.988	49.987	49.988	49.985	49.987											
Parameter :- OD	3	49.987	49.986	49.987	49.987	49.987	49.985	49.987	49.988	49.985											
Operator :- Nilesh Dhurve	4	49.987	49.985	49.988	49.988	49.988	49.986	49.988	49.987	49.986											
Inspector :- Saqib khan	5	49.989	49.987	49.988	49.987	49.987	49.987	49.985	49.988	49.988											
	Sum	249.934	249.933	249.936	249.934	249.938	249.933	249.935	249.934	249.934	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Instrument ID:- KG/QC/BDG/09	Avg X	49.987	49.987	49.987	49.987	49.988	49.987	49.987	49.987	49.987	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Sepcification:-45.009/45.048	Range	0.004	0.003	0.003	0.003	0.001	0.003	0.003	0.003	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Total Tolerance =	0.039
USL =	45.048
LSL =	45.009
Instrument Used:- Bore Dial Gauge	
Unit of Measure:-	mm
Calculation	
$\bar{\bar{X}}$ = sum(avg X)/20	#DIV/0!
$\bar{R}$=sum(Range)/20	0.001
σ = $\bar{R}$ / D2	0.001
$\bar{\bar{X}}$+3σ	#DIV/0!
3σ	0.002
6σ	0.003
Cp=Total Tol./6σ	**11.630**
UCLx = $\bar{\bar{X}}$ + A2 x $\bar{R}$	#DIV/0!
LCLx = $\bar{\bar{X}}$ - A2 x $\bar{R}$	#DIV/0!
UCLr = D4 x $\bar{R}$	0.003
Cp L =($\bar{\bar{X}}$ - LSL) / (3 x σ)	#DIV/0!
Cp U =(USL - $\bar{\bar{X}}$) / (3 x σ)	#DIV/0!
Cp K=min (Cp L , Cp U)	**#DIV/0!**
Where A2 =	0.580
Where D4 =	2.110
Where D2 =	2.326
No. of Parts above UTL	0
No. Of Parts Below LTL	0
Comment:-	
#DIV/0!	





CP= 11.630

CPk= #DIV/0!

Prepared By:- Approved By:-

4 CONCLUSION

1. The investigation was carried out within the filling industry, utilizing CP, Cpk, Cpm, and Cpmk indices to showcase the significance of process capability analysis in overseeing and guaranteeing product quality to meet customer demands.

2. Before assessing the process capability, it's essential to validate the control state of the process and confirm the normal distribution of the quality attribute.

3. The process capability index Cpmk offers greater assurance regarding process yield and loss to customers compared to the other two indices, Cpk and Cpm.

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