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Variation in Process Measurement of Variation in Terms of Cp & Cpk with Methodology of Implementation

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Abstract: *As the variation is inevitable either due to natural cause or some assignable cause so the variation in output quality is also inevitable. But if the output quality is going out of specified range then a lot of quantity or / and efforts are fruitless. Hence the process must be so much robust to handle these variations to that extent that the output quality does not go out of specified range (USL-LSL). Statistics defines the process is capable or not with the term called Process capability Cp and Process Capability Index Cpk. A measurement of Cp and Cpk gives us an idea to predict the stability and capability of the process. Cp shows about the spread where as Cpk describes whether the process mean is at target or not. The purpose of this article is to highlight that individually Cp or Cpkcan not define a good control on the process. We need to control both.*

Keywords: Pulp and Paper Industry, Output Quality, Variation in Process Measurement

Concept of Cp and Cpk and how to implement in process industry:

Statistical model of a process is defined as that output is a function of input.

Output (Y) = f (input X)

The variation in the output is the summation of the variation in the process and variation in the inputs.

If we want to control the variation in the output quality level, then we have to control the individual variation in the inputs as well as in the process.

A process whose quality is predictable and falls within the specified range most of the time is called stable process or a capable process. The output of such a process is well defined and the quality of such output does not change with time, with different operators etc.

Let us understand little more about Cp…

As variation is bound to happen therefore there is always an agreement between both to accept within a range along with specified target. This is called tolerance.

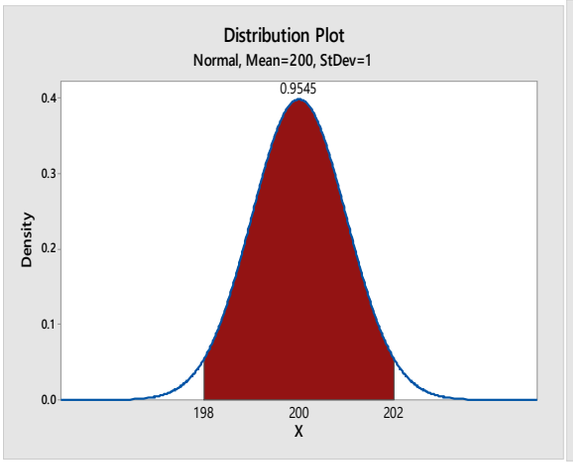
Say for example a customer is asking for 200 gsm with a specified range of =/-2 gsm, so the LSL is 198 and USL is 202. The customer will accept every quantity what is been supplied within the range of 198-202.

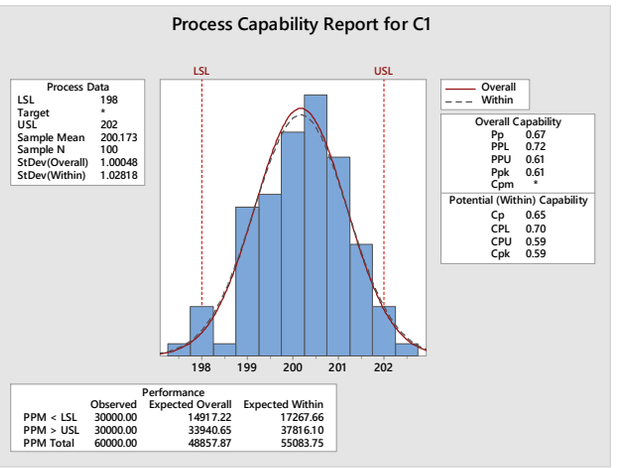
Now what about the process end? Does every time the producer is making between 198-202 ? What is the variability in the manufacturing process?

Let us collect some data on gsm actual being manufactured…

Gsmavg 200.17 SD 1.0 LSL 198 USL 202									
201.0	200.5	197.3	201.0	200.2	200.1	199.4	200.3	200.9	201.0
199.6	199.9	200.6	199.4	201.8	201.4	200.3	199.8	199.8	200.4
199.9	201.3	199.7	199.9	201.5	200.4	199.7	201.0	200.2	201.2
200.4	199.1	200.1	200.8	201.5	198.8	201.1	198.2	199.8	199.3
198.9	199.6	201.3	199.2	199.9	198.3	202.1	201.0	200.0	197.8
200.6	199.8	199.7	202.2	198.1	202.3	200.0	200.5	199.0	200.8
199.8	199.7	201.4	200.2	199.5	200.6	198.8	200.4	200.5	200.9
201.4	199.3	201.1	199.8	199.6	201.3	199.2	201.2	201.0	200.8
198.8	200.3	200.3	200.6	198.8	200.6	200.3	200.6	199.2	199.1
201.5	200.4	201.9	200.0	201.2	200.7	200.4	199.2	197.8	199.7

Variable	N	N*	Mean	SE Mean	StDev	Minimum	Q1	Median	Q3	Maximum
C1	100	0	200.17	0.100	1.00	197.31	199.64	200.27	200.94	202.26

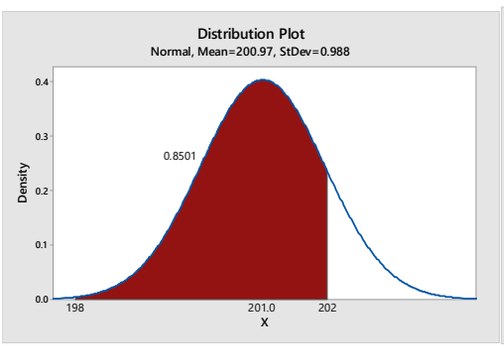


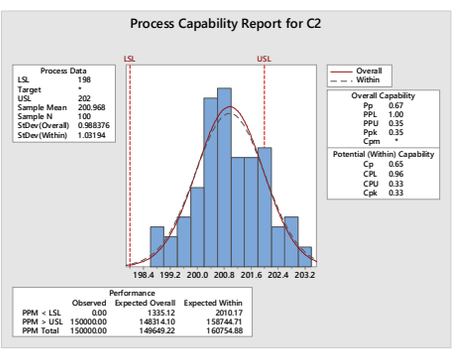


There is 95.45 % acceptance in this process ,i.e. 4.55 % is off quality. The Cp value is 0.65 and Cpk also nearly same 0.59
Now in this process if we deviate the average by 1 Sd ,i.e a gsm then

Gsmavg 200.97 SD 0.988 LSL 198 USL 202									
200.3	200.9	199.1	202.6	199.9	200.7	199.8	199.4	201.8	201.2
201.1	200.8	200.6	202.7	201.0	199.8	201.6	202.0	199.4	202.4
201.3	201.6	201.0	200.5	201.4	201.9	202.4	200.4	201.4	200.6
200.6	199.6	201.9	202.2	200.0	201.0	199.2	198.9	201.9	201.5
201.5	201.0	202.0	202.0	200.6	200.6	199.9	200.4	202.1	200.0
200.7	201.7	200.8	201.5	200.3	200.9	201.2	200.4	203.1	200.7
201.3	201.5	201.5	199.0	200.6	201.0	200.2	202.9	202.6	201.2
200.6	202.8	201.5	201.8	201.0	201.4	200.6	201.1	199.8	200.6
200.2	200.9	200.3	200.9	200.5	198.9	202.1	199.7	202.2	199.8
201.8	200.5	198.9	200.5	202.8	203.0	200.9	200.5	201.2	200.5

Variable	N	N*	Mean	SE Mean	StDev	Minimum	Q1	Median	Q3	Maximum
C2	100	0	200.97	0.0988	0.988	198.87	200.40	200.92	201.63	203.13



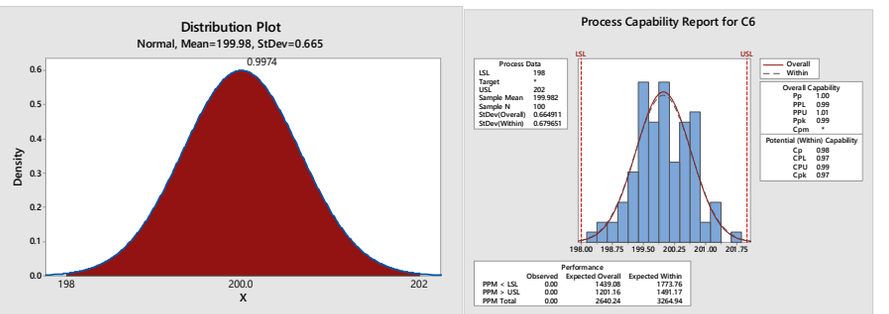


There is only 85.01 % acceptance in this process ,i.e. 14.99 % is off quality. The Cp value is still 0.65 and Cpk value is very low i.e at 0.33. From Graph also it is visible that the data are skewed left side.
In this process, even without change in SD, if there is a shift in the average by 1 SD then the % loss is increased by (14.99-4.55)10.44%.

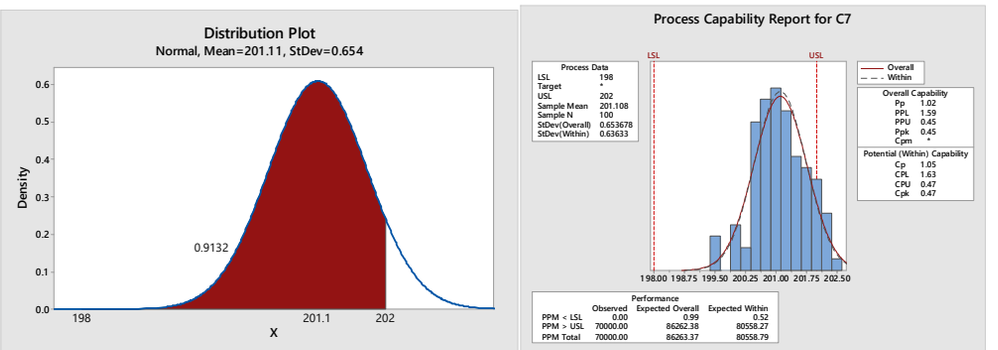
Now let us apply methodology for applying Cp and Cpk:
It is three steps approach followed by data analysis to control Standard deviation
Step 1: Find the given range or tolerance i.e. USL-LSL
Step 2: Equate this range or tolerance to 6*S.D.
6* S.D. = Tolerance, { S.D. = Tolerance/ 6}
Step 3: Found value of sigma from above equation is the MAXIMUM VALUE OF S.D. for making the process just capable.
6* S.D. = (202-198),
Or, Maximum S.D. = 4/6 =0.666 ~ 0.67
Any value of S.D. lesser than 0.67 will be sufficient enough to make the process just capable.
Let us have a set of data with controlled SD of 0.65 and average is 200 gsm

Gsmavg 199.98 SD 0.665 LSL 198 USL 202									
200.0	199.5	199.2	201.0	199.1	200.1	200.7	199.8	200.6	200.5
200.1	199.6	200.6	200.3	200.8	201.4	199.6	199.6	199.5	200.5
200.7	200.7	200.2	199.2	200.7	200.6	200.3	198.8	200.5	199.9
201.3	198.8	200.1	200.7	199.9	199.1	199.7	200.4	200.2	200.4
200.8	199.6	201.3	200.1	199.9	199.9	199.9	200.7	200.1	198.6
200.3	201.7	199.6	199.3	199.1	198.3	199.4	199.7	199.2	199.7
199.5	200.4	199.8	199.6	201.2	199.6	199.9	200.1	201.0	198.5
199.8	200.8	200.1	200.4	200.4	199.0	199.4	200.6	199.0	199.7
200.7	200.4	199.3	200.4	199.4	199.9	200.1	200.0	199.3	199.7
200.0	199.4	199.4	199.6	200.4	199.4	200.2	199.8	199.9	199.6

Variable	N	N*	Mean	SE Mean	StDev	Minimum	Q1	Median	Q3	Maximum
C6	100	0	199.98	0.0665	0.665	198.31	199.50	199.95	200.44	201.67



There is 99.74 % acceptance in this process ,i.e. 0.26 % is off quality only. The Cp value is 1.0 and Cpk also nearly same 0.97
Now in this process if we deviate the average by 1 gsm, i.e a gsm then



There is only 91.32 % acceptance in this process, i.e. 8.68 % is off quality. The Cp value is still 1.02 and Cpk value is very low i.e at 0.47. From Graph also it is visible that the data are skewed left side.
In this process, even without change in SD, if there is a shift in the average by 1 gsm then the % loss is increased by (8.68 – 0.26) 8.62%.

This is the importance of Cpk that whether the process is capable enough but if process average is not kept at target then the % loss is higher.

Conclusion:

The process capability indices are the effective tools for checking the capability of the process as per statistical modelling. The approach is to be followed from tolerance as back calculation to decide the maximum tolerable value of Standard deviation. At this SD the system is just capable.

Thereafter any reduction in SD is increases the capability and also gives a support for the process to absorb any small variation. Speaking of individual indices to control is not advisable. After controlling of Cp(i.e SD) control on process mean (The data are dummy data created with the help of minitab).