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Quality Improvement Using GR&R : A Case Study

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Abstract - *Gauge R&R, which means gauge repeatability and reproducibility, is a statistical tool which calculates the variation in the measurement system to how much extent that comes from the measurement tool and the operators calculating the measurement.One of the method of gauge R&R has been explained i.e. crossed study to find Gauge R&R in detail and shows how important role is played by GR&R in finding acceptability of a measuring system of the firm.. We have generated an industry expert interviews and survey based study of Ludhiana- phagwara industrial region also a case study is also done on implementation of GR&R technique in a industry manufacturing engine spare parts.. A four months long industry analysis for initiating GR&R practices and then devising a plan for reducing rejection of manufacturing parts in the Industry and reducing the cost of poor quality of the manufactured parts of the industry*

KeyWord - MSA,bias, accuracy ,precision, linearity, stability, total variation, gauge, part, trial, repeatability error, reproducibility error

1. INTRODUCTION

The motive of implementing Gauge R&R study is determine if a measurement system is sufficient for your requirements which is shown after finding the R&R%. A gauge R&R study will explain operators if the measurement system is fair for its intended use. The gauge study also proves which part of the measurement system is giving contribution the most to the unstability of the measurements and assists operators execute stability to the system. Measurement systems have variation from three major sources: the components, the operators taking the measurements and the device used to take the measurement.The contribution in each of these areas can be analyzed from the GR&R results from minitab . In a good measurement system, one must expect to calculate almost complete variation in the products only. If the operators or the devices creates most of the variation, then the system may not be valid. The goal of using Gauge R&R study is fullfilled if a measurement system is worth for your requirements which can be told after finding the R&R%. However, the disadvantage of applicationof GR&R is that it does not give the idea of accuracy. Though we are having GR&R values which are not significant further results of the test are not accurate and no idea of material or the final product is not obtained.

2. GR&R Study Types

Following are the types

1 .Crossed gage R&R study

A study in which each part is measured by each operator. The study is known as *crossed* because the each operator measure the same parts number of times . To perform a crossed gage R&R study in Minitab,go to stat then quality tools then gage study. Oftenly, we are using a crossed gage R&R study to find out amount of our process variation is caused by measurement system variation.

2. Nested gage R&R study

A study in which each part is measured by single operator because the part is destroyed by the test. This study is known as nested because another factor nest one or more factors and concluding not being crossed with the other factors. To perform a nested gage R&R study in Minitab then follow the same steps as above and click on GR&R (nested)

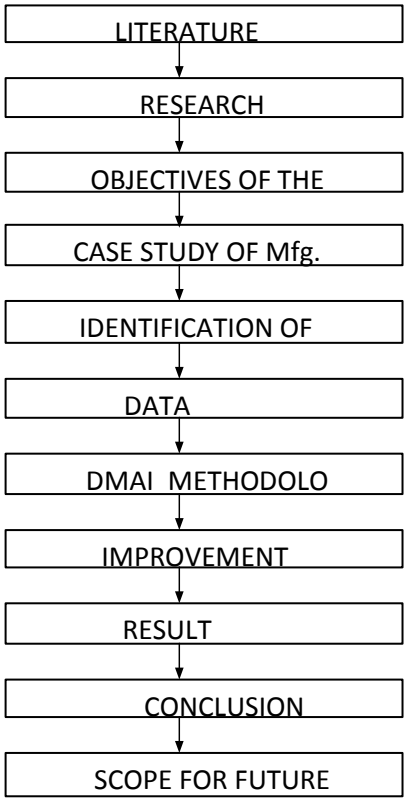
3. Expanded gage R&R study

A study in which one or more of the following conditions are valids

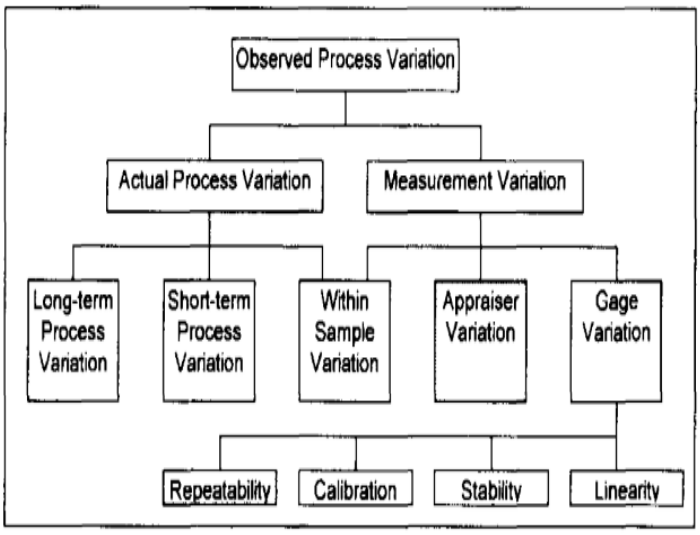
- More than two factors, mainly appraisels, measuring instruments, and product.
- Random or fixed factors
- Both crossed and nested conditions
- Design is not balanced.

This study is known as *expanded* because it is applicable in many types of conditions. To perform an expanded gage R&R study in Minitab, follow the same initial steps then GR&R(expanded)

3. Research Methodology



4. Sources of variation



Actual process variation and measurement variation is in each observation of process variation. Actual process variation made of extended, short, and within sample variation. Gage variation made up of of variations due to calibration, stability, repeatability, and linearity

1. Repeatability & Reproducibility Error (R&R)
The R&R error is the combined result of repeatability reproducibility error.

2.Appraiser Variation(Av) Or Reproducibility Error : Reproducibility error is caused when the reading of a part is not reproduced across operators or under different environmental conditions. It is also termed as Operator appraiser error

3. Part Variation Error (Pv)
Part Variation error is the error coming from product choosen for measurement.

4. Total Variation (Tv)
Total variation is the resultant of Repeatability and Reproducibility error (R&R) and Part variation error (PV).

5. Equipment Variation (Ev) Or Repeatability Error
When instrument is not repeating reading of the product when same operators measure no. of times in the same conditions of environment . It is also called Instrument error.

5. Measure phase of DMAIC METHODOLOGY

To ensure system (measurement) is statistically sound Gauge R&R study is performed. Gauge reproducibility & repeatability studies shows that how much of the observed process variation is due to measurement system variation. It has been conducted with 3 operators,3 repeats and 14 parts using dial gauge and micrometer. Forming a gauge run chart and then conducting analysis of gauge R&R study and then answering questions

TABLE4.1: MINITAB DATA SHEET OF DIAMETER OF LINER CYLINDER FOR GAUGE R&R STUDY (IN MILIMETER)

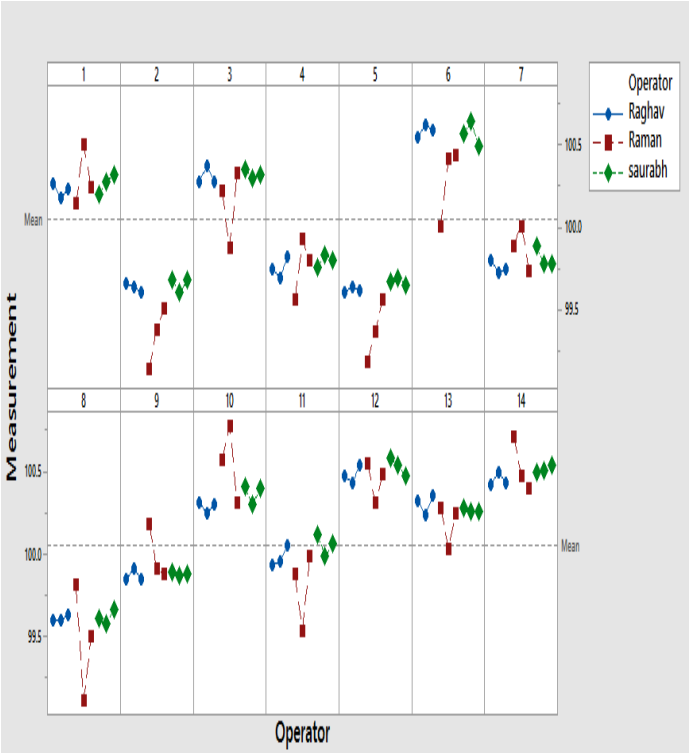
SERIAL NO.	TRIALS	OPERATORS	MEASUREMENT
1	1	Raman	100.139
2	2	Raman	99.123
3	3	Raman	100.216
4	4	Raman	99.552
5	5	Raman	99.171
6	6	Raman	99.997
7	7	Raman	99.884
8	8	Raman	99.809
9	9	Raman	100.174
10	10	Raman	100.567
11	11	Raman	99.871

12	12	Raman	100.545
13	13	Raman	100.282
14	14	Raman	100.714
15	1	Raghav	100.263
16	2	Raghav	99.650
17	3	Raghav	100.270
18	4	Raghav	99.741
19	5	Raghav	99.595
20	6	Raghav	100.543
21	7	Raghav	99.791
22	8	Raghav	99.591
23	9	Raghav	99.844
24	10	Raghav	100.304
25	11	Raghav	99.934
26	12	Raghav	100.472
27	13	Raghav	100.319
28	14	Raghav	100.421
29	1	saurabh	100.196
30	2	saurabh	99.673
31	3	saurabh	100.348
32	4	saurabh	99.744
33	5	saurabh	99.667
34	6	saurabh	100.563
35	7	saurabh	99.881
36	8	saurabh	99.599
37	9	saurabh	99.885
38	10	saurabh	100.403
39	11	saurabh	100.116
40	12	saurabh	100.578
41	13	saurabh	100.274
42	14	saurabh	100.492
43	1	Raman	100.499
44	2	Raman	99.364
45	3	Raman	99.865
46	4	Raman	99.920
47	5	Raman	99.356
48	6	Raman	100.411
49	7	Raman	100.004
50	8	Raman	99.102
51	9	Raman	99.908
52	10	Raman	100.776
53	11	Raman	99.533
54	12	Raman	100.310
55	13	Raman	100.023
56	14	Raman	100.474
57	1	Raghav	100.180
58	2	Raghav	99.633
59	3	Raghav	100.375
60	4	Raghav	99.685
61	5	Raghav	99.627
62	6	Raghav	100.618
63	7	Raghav	99.713
64	8	Raghav	99.595
65	9	Raghav	99.903
66	10	Raghav	100.249
67	11	Raghav	99.951
68	12	Raghav	100.433
69	13	Raghav	100.232
70	14	Raghav	100.499
71	1	saurabh	100.272
72	2	saurabh	99.596
73	3	saurabh	100.295
74	4	saurabh	99.827
75	5	saurabh	99.681
76	6	saurabh	100.639
77	7	saurabh	99.773
78	8	saurabh	99.567
79	9	saurabh	99.863
80	10	saurabh	100.302
81	11	saurabh	99.981
82	12	saurabh	100.535
83	13	saurabh	100.256
84	14	saurabh	100.502
85	1	Raman	100.239
86	2	Raman	99.502
87	3	Raman	100.329
88	4	Raman	99.789
89	5	Raman	99.549
90	6	Raman	100.438
91	7	Raman	99.727
92	8	Raman	99.497
93	9	Raman	99.872
94	10	Raman	100.310
95	11	Raman	99.986
96	12	Raman	100.481
97	13	Raman	100.242
98	14	Raman	100.394
99	1	Raghav	100.228
100	2	Raghav	99.595
101	3	Raghav	100.269
102	4	Raghav	99.810
103	5	Raghav	99.606
104	6	Raghav	100.586
105	7	Raghav	99.741
106	8	Raghav	99.624
107	9	Raghav	99.844
108	10	Raghav	100.300
109	11	Raghav	100.044
110	12	Raghav	100.538
111	13	Raghav	100.352

112	14	Raghav	100.424
113	1	saurabh	100.319
114	2	saurabh	99.670
115	3	saurabh	100.320
116	4	saurabh	99.788
117	5	saurabh	99.643
118	6	saurabh	100.494
119	7	saurabh	99.774
120	8	saurabh	99.658
121	9	saurabh	99.877
122	10	saurabh	100.391
123	11	saurabh	100.063
124	12	saurabh	100.472
125	13	saurabh	100.250
126	14	saurabh	100.536

6. MINITAB RESULTS

Figure 1: gauge run chart



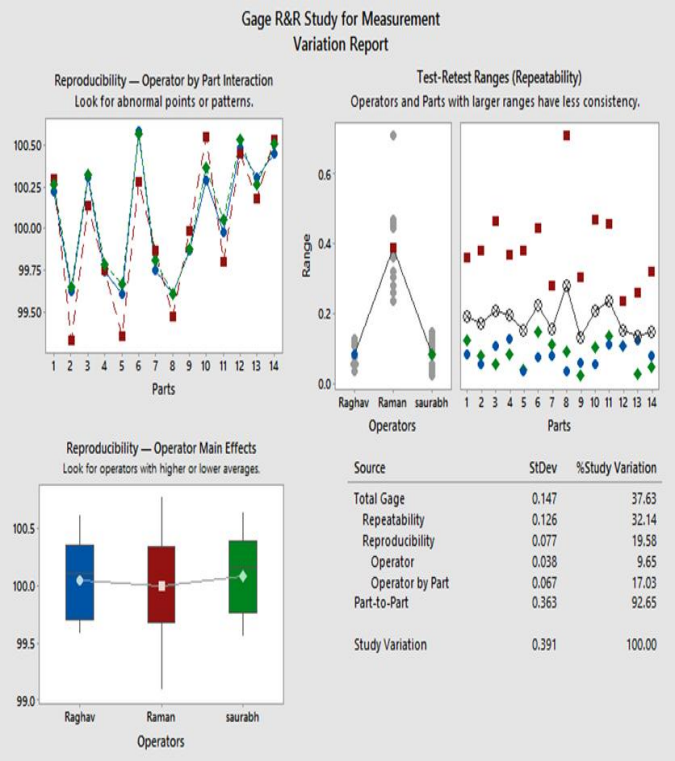


Figure 2: variation report

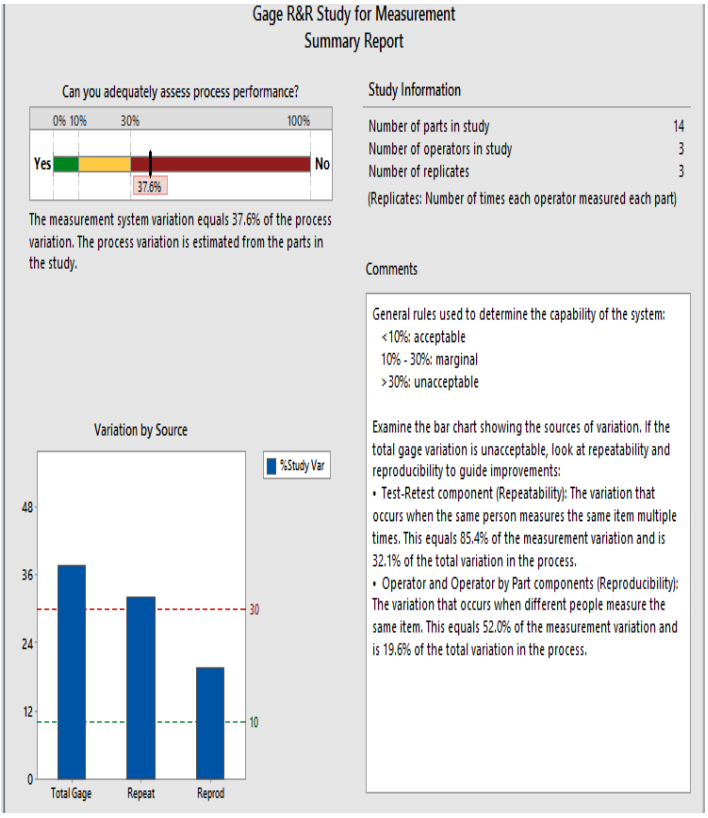


Figure 3 : summary report

7. ANALYSIS PHASE OF DMAIC methodology

From gauge run chart 2 things can be analysed

1. Reproducibility and Repeatability issues

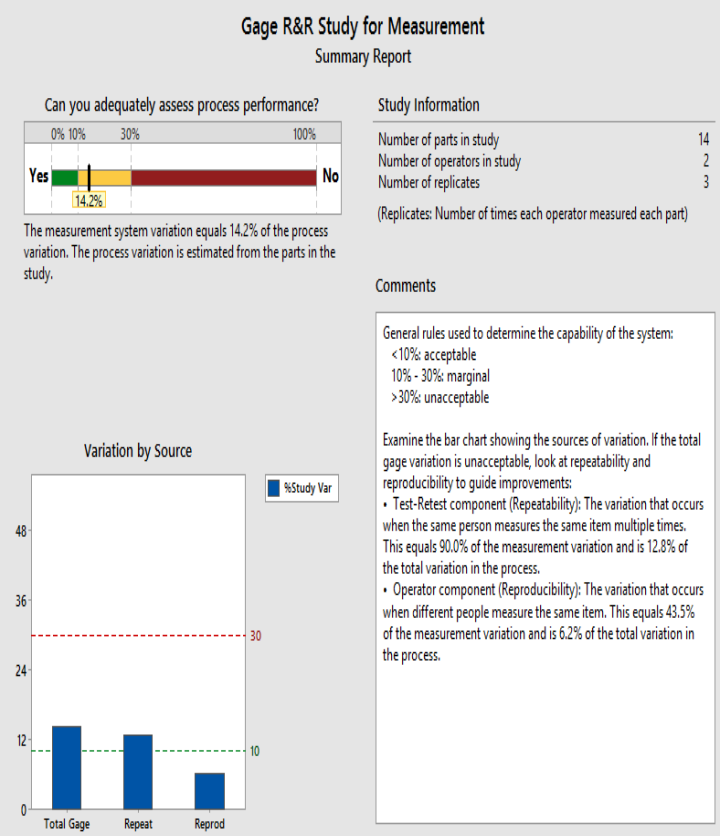
Raman is not agreeing with himself and with others so he is responsible for repeatability and reproducibility issues

2. Range of parts

It tells what is the maximum and minimum size and what is the difference between the two and how does that compare to the errors. Sixth part on an avg has highest measurements and part with lowest measurement is eighth. Biggest range is between sixth and eighth and how does Raman errors compared to that range and errors he is making are quite significant

From fig variation report we can analyze after looking at avg measurement for each part and operator that Raghav and saurabh are overlapping with each other and Raman is not agreeing with avg measurement so he is the problem creating factor. From box charts for each operator , box charts are,nt so bad actually they are quite level, just tails on the poor Raman is longer and for repeatability issues we can have a look at the range charts that this is range of measurements plotted for each part we have difference between max and min for each operator for each part plotted here and again Raghav and saurabh agree with each other . Range for Raman is far greater than other 2 guys and we can see how Raman range of measurement is way bigger than anyone else and for PART 8 we are giving break down at the error. Other thing to note here under reproducibility we have atleast one guy having problem by % study variation and atleast one part's manufacturing i.e. 8th must be checked to lessen down the rejection. In this phase, an action plan is created to close the gap between how things currently work and how the organization would like them to work in order to meet the goals for a particular product or service.

8. IMPROVEMENT PHASE



In this phase we try to improve the cause of problem. In current case operator must be well trained and ovality is found to be the source of problem so the improvement action is taken for same.There is something wrong with part 8 i.e. ovality variation,perpendicularity,etc because raman's measured data is away from other guys so its manufacturing in a production line must be analyzed and controlled.Eliminating raman's measured data measurement system variation become equal to 14.2 % of process variation, so he must undergo training program to measure properly.Moreover since capability of system is marginal we have some repeatability issues to avoid and eliminate it our measuring instrument should be proper caliberated

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