Minitab Gage R&R Notes
Crossed Gage R&R

Kevin Maher
Vettejeep365@gmail.com

October 2, 2017

Introduction

- Simulated Gage R&R to take a look at the Minitab Output

    - Uses "GageData.MTW" from Minitab Website

    - 10 parts, no specification limits given

        - 3 operators, 3 replicates per part per operator

    - Part mean ranges from -1.5711 to 1.94

    - Somewhat arbitrarily, I chose a range of +/- 1.5 for the specification

   - This gives a good spread of parts to the spec

Components of Variation

- Part-to-Part variation dominates the graph and the variation seen in the simulation – but:

- Total Gage R&R is percent to tolerance is 60.47% which is very poor
  - This is much higher than the 10% considered optimum or the 30% that is sometimes considered as acceptable

- Both Repeatibility (part) and Reproducability (operator) are poor as a percent of tolerance
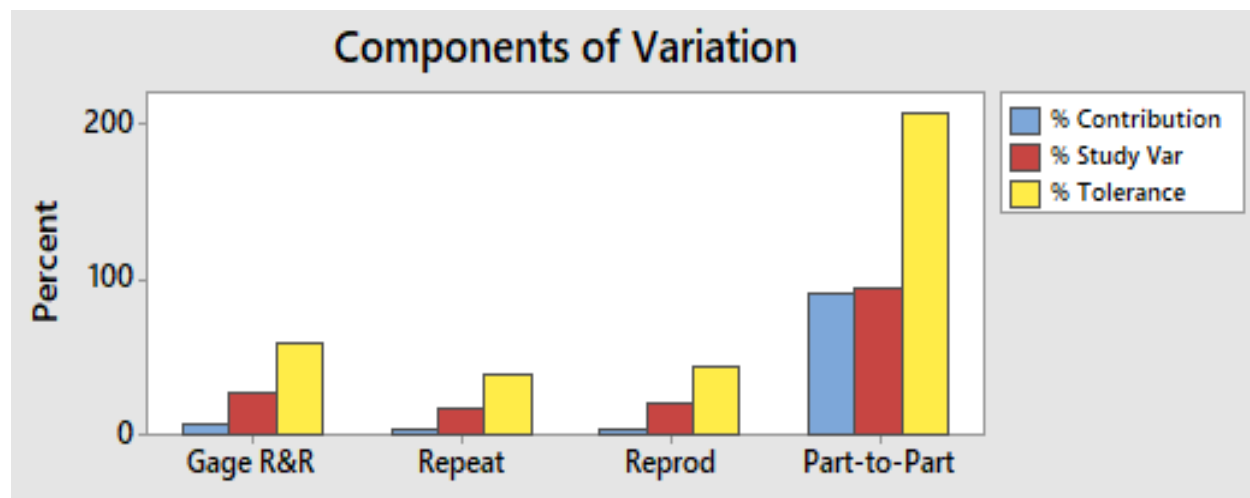
Measurement by Part

- Measurement by Part chart shows that there are significant differences in the measurements for each part

- The part means vary but that is to be expected as we want to exercise our gage with parts that span the tolerance zone and even a bit beyond it – but we want each individual part to have a narrow range of measurement which is not the case here

  - There are also outliers, measurements separated from, and higher or lower than, the main group for that part
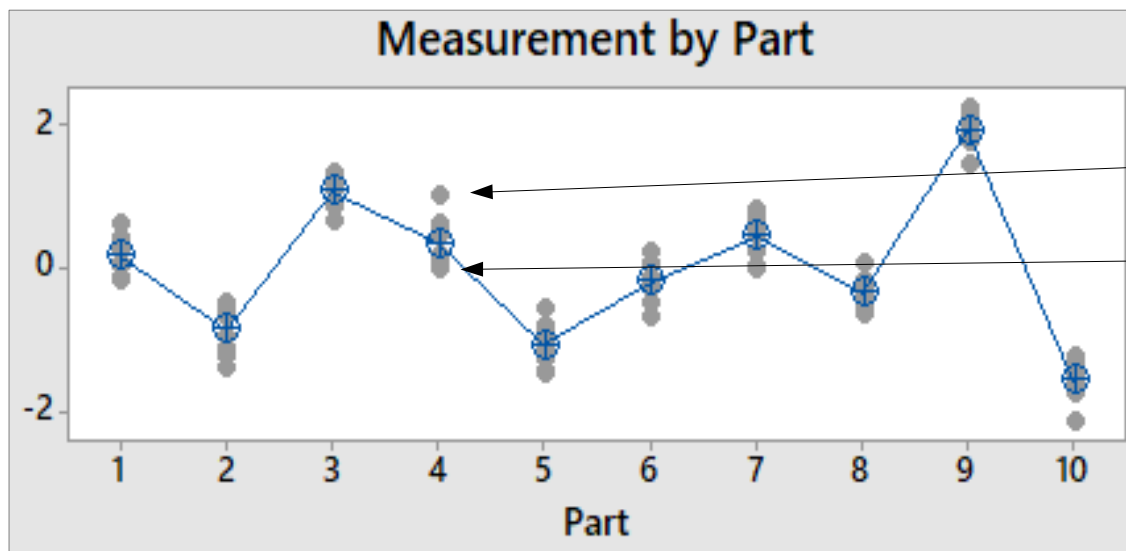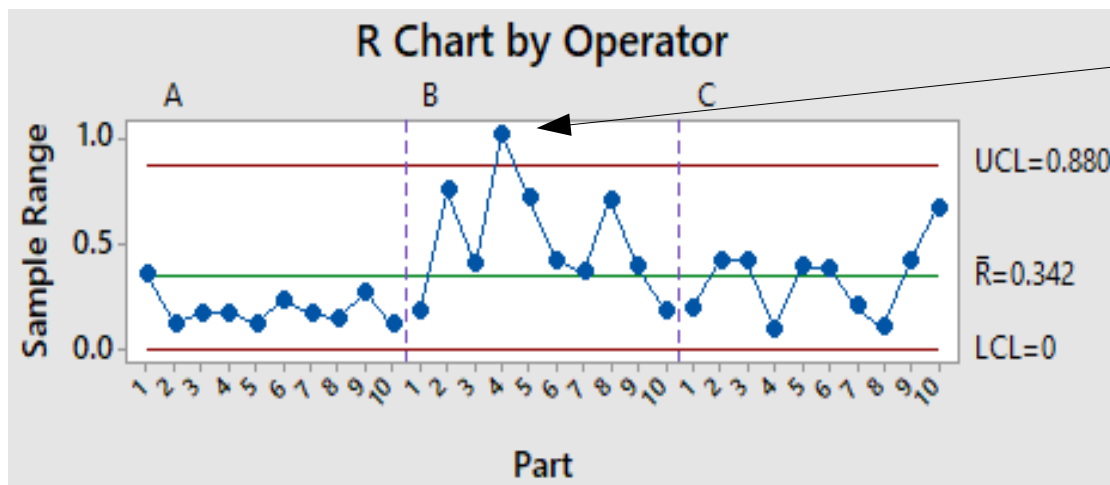

Example - Part #4:

Max Measure = 1.030

Min Measure = 0.010

Way too much variation!
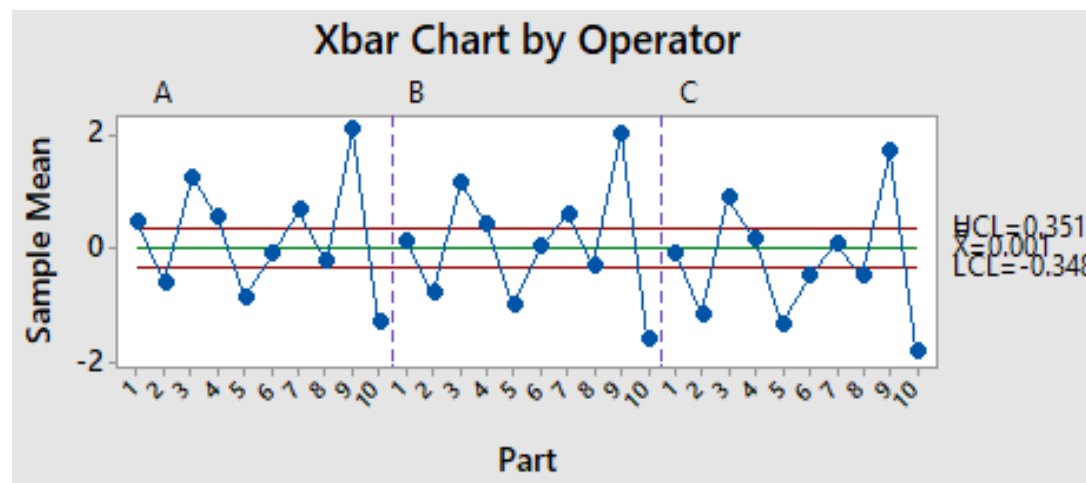
R Chart by Operator

- Range chart by operator – shows that operator "B" had higher variance in their measurements than the others

  - Also that operator "A" had the least variation (best)

- This indicates that some improvement might be made by better operator training

- Control limits on this chart do NOT mean much because adhering to them would not be enough to obtain a good Gage R&R result and they are based on our bad measures anyway

High variation by operator "B", especially for part #4

Xbar Chart by Operator

- Xbar chart by operator – careful examination reveals some of the differences in how the mean measure of each part varies by operator

    - Note for example how part #7 is measured with a high value by operator "A" but a lower value near the mean by operator "B"

- Control limits do not have meaning here since we would purposely chose a wide part variation in order to examine gage performance over the full range of measurements that it would be expected to cover in the real process


Xbar Chart by Operator

Measurement Box Plot by Operator

- In my view this chart is of little value here – it is dominated by the range of the individual part values and does not really emphasize the differences in operator

  - The chart is part of the standard Minitab output

- Still, we can see that operator "C" had a bias to reporting lower values than the other operators
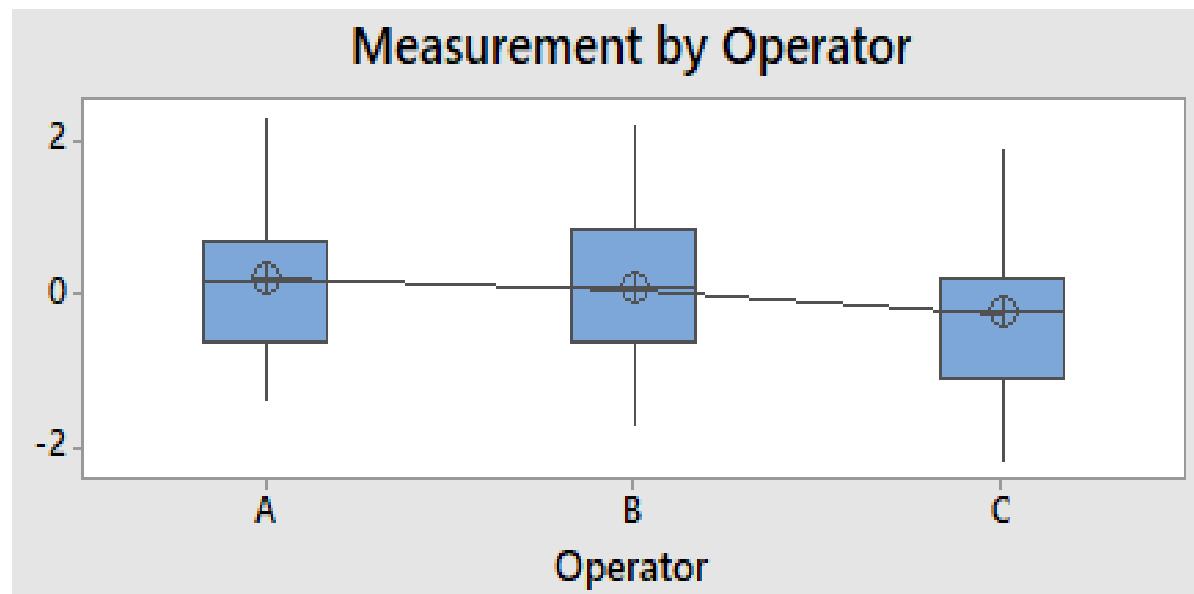
Part by Operator Interaction Plot

- Appears to show little interaction between parts and operators

- This is confirmed by the p-value reported by Minitab for part*operator interaction as 0.974

  - Since 0.974 is far above the usual p-value significance threshold of 0.05 we accept the null hypothesis that there is no interaction
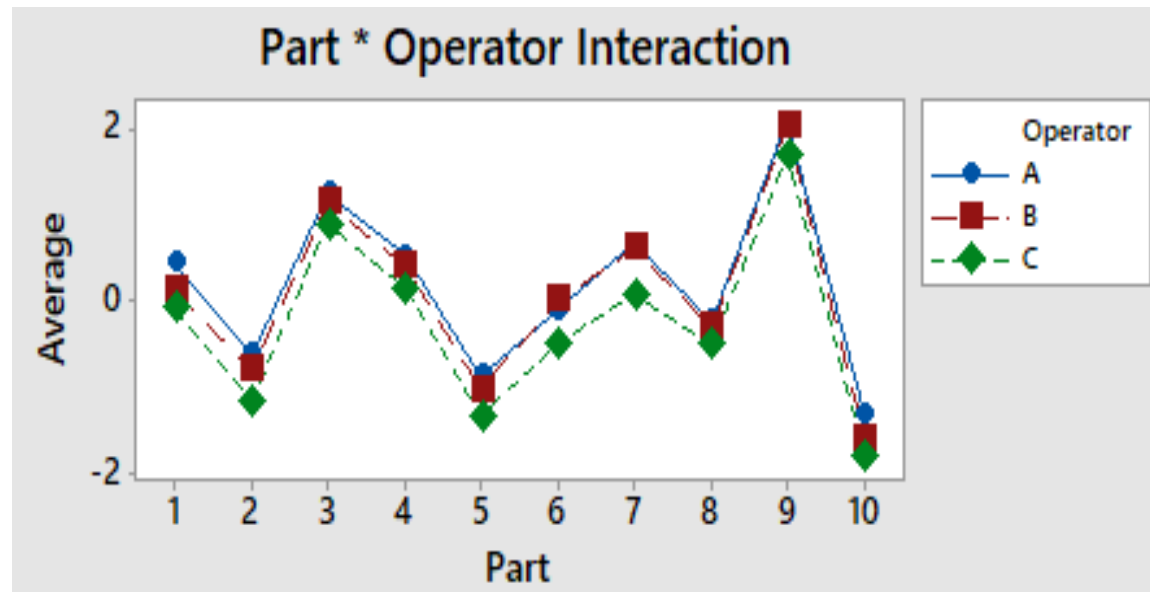
Gage R&R ANOVA

- Part and operator are significant sources of the variability seen in the Gage R&R ANOVA

    - Evidenced by the p-values Minitab reported as zero

    - We want part to be significant – but we don't want operator to be

- The part*operator interaction is not significant as noted earlier because the p-value is well above 0.05 at 0.974

Two-Way ANOVA Table With Interaction

Source	DF	SS	MS	F	P
Part	9	88.3619	9.81799	492.291	0.000
Operator	2	3.1673	1.58363	79.406	0.000
Part * Operator	18	0.3590	0.01994	0.434	0.974
Repeatability	60	2.7589	0.04598		
Total	89	94.6471			

α to remove interaction term = 0.05

Two-Way ANOVA Table Without Interaction

Source	DF	SS	MS	F	P
Part	9	88.3619	9.81799	245.614	0.000
Operator	2	3.1673	1.58363	39.617	0.000
Repeatability	78	3.1179	0.03997		
Total	89	94.6471			

Gage R&R Variance

- Part-to-part variance dominates which is good

- However, the Total Gage R&R, Repeatability (part) and Reproducability (operator) have very high precision to tolerance values and are not acceptable

Gage R&R

Variance Components

Source	VarComp	%Contribution (of VarComp)
Total Gage R&R	0.09143	7.76
Repeatability	0.03997	3.39
Reproducibility	0.05146	4.37
Operator	0.05146	4.37
Part-To-Part	1.08645	92.24
Total Variation	1.17788	100.00

Process tolerance = 3

Gage Evaluation

Source	StdDev (SD)	Study Var (6 × SD)	%Study Var (%SV)	%Tolerance (SV/Toler)
Total Gage R&R	0.30237	1.81423	27.86	60.47
Repeatability	0.19993	1.19960	18.42	39.99
Reproducibility	0.22684	1.36103	20.90	45.37
Operator	0.22684	1.36103	20.90	45.37
Part-To-Part	1.04233	6.25396	96.04	208.47
Total Variation	1.08530	6.51180	100.00	217.06

Number of Distinct Categories = 4

Total Gage R&R % Tolerance is 60.47% - far above the 10% desired

Both Repeatability (39.99%) and Reproducability (45.37%) are bad

Data Source

https://support.minitab.com/en-us/minitab/18/help-and-how-to/quality-and-process-improvement/measurement-system-analysis/how-to/gage-study/crossed-gage-r-r-study/before-you-start/example/.