A Comment on MSA with Destructive Testing

By Keith M. Bower

Six Sigma practitioners may encounter measurement system analyses where the inspected part is markedly affected. Since such parts cannot validly be expected to provide similar readings across other operators, practitioners are frequently encouraged to use nested ANOVA designs.

For many practical applications, however, "standard" Gage Repeatability and Reproducibility (SGR&R) studies may be utilized, provided an important assumption regarding the parts is approximately met.[1] This article provides recommendations to practitioners for the implementation and interpretation of results from "destructive" Gage Repeatability and Reproducibility (DGR&R) studies.

"Destructive" Testing

SGR&R studies assume the parts being assessed by operators are undamaged during the act of measurement. For many systems, however, that may be an unrealistic assumption. For example, the measurement may require the complete destruction of a part to record the bursting strength. Since the part could not be assessed by anyone other than the operator who tested it, practitioners are typically advised to employ a nested ANOVA model.[2]

However, the use of a nested design may be moot if the assessed quality characteristic is homogenous throughout a "part" and enough specimens from it may be provided to the operators in the study. Such a situation is not uncommon in practice and would allow for interpretation of results using SGR&R methodologies. For an illustration consider the following scenario.

Example of a "Destructive" GR&R Study

A manufacturer of kitchen paper towels is required to assess the measurement system used to record breaking strengths.

An assumption is made that the breaking strength within one sheet of paper is relatively homogenous. There is obviously variation between different sheets and between different rolls of paper owing to the various sources of variation for paper making. For the purpose of the GR&R study, however, it is assumed that within one sheet of paper enough specimens may be distributed to operators for evaluation. Provided each operator may

receive two or more test specimens from a sheet, an estimate of repeatability can be obtained.

The "standard" ANOVA model as shown in (1) may then be used to assess the individual sources of variation.

(1) $Y_{ijk} = \mu + Operator_i + Part_j + (Operator*Part)_{ij} + \varepsilon_{k(ij)}$, i = 1,2,…,*a*; j = 1,2,…,*b*; k = 1,2,…,*n*

There are several characteristics worth noting for this study:

a. Despite a destructive test being performed, it is possible to estimate the Operator by Part interaction effect.
b. Estimates for the Operator and Part main effects may also be obtained, using the ANOVA procedure, without concerns for a nesting structure.
c. The repeatability estimate in a DGR&R study confounds the homogeneity assumption ("identical" values within a sheet) with the variation due to the measuring device (the "gage").

An important conclusion that may be drawn from (c) is that if repeatability - identified as $\varepsilon_{k(ij)}$ in (1) - is an important source of variation, there is no way of discerning directly from the study whether it is the homogeneity assumption that may be questionable, or if there is a high level of variation due to the gage, or both.

Summary

When a crucial assumption regarding the homogeneity of tested items may be approximately met, destructive tests may be assessed using SGR&R techniques. Though the use of nested models is typically encouraged as the default method for DGR&R studies, practitioners would be advised to consider the applicability of "standard" procedures to obtain estimates of repeatability and may be able to legitimately investigate operator by part interaction effects.

About the Author

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References

1. For a description of “standard” Gage R&R studies, see the section “MSA with Continuous Data: The Standard (Manufacturing) Approach” by Keith M. Bower in “Non-Traditional MSA with Continuous Data”, ASQ Six Sigma Forum (2003).
2. For more information on nested designs with MSA studies, see Douglas Gorman and Keith M. Bower, “Measurement System Analysis and Destructive Testing”, ASQ Six Sigma Forum Magazine 1 no. 4 (2002): 16-19.

Bibliography

1. Automotive Industry Action Group, *Measurement System Analysis*, (2002).
2. Douglas C. Montgomery and George C. Runger, “Gauge Capability and Designed Experiments: Part I: Basic Methods,” *Quality Engineering* 6, no.1 (1993): 115-135.
3. Richard K. Burdick, Connie M. Borror, and Douglas C. Montgomery, “A Review of Methods for Measurement Systems Capability Analysis,” *Journal of Quality Technology* 35, no.4 (2003): 342-353.