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# MEASUREMENT SYSTEM ANALYSIS WITH ATTRIBUTE DATA

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***Abstract:*** *This paper highlights improvement in quality of data produced by measuring instruments. If measuring instruments itself is not producing the accurate data, analysis of manufacturing process will no longer be meaningful. All measurement systems and equipments have some degree of measurement error or uncertainty. Under such circumstances it has become important to understand the magnitude of the variability the instrument causes and how to bring uncertainty within reasonable limits. In order to determine the amount of variation, the thorough study of capability of measuring systems is of prime importance. The present case study highlights the application of Measurement System Analysis (MSA) with attribute data in a leading automotive industry assembly line.*
***Keywords****: Repeatability , Reproducibility .Truth table*

## 1. INTRODUCTION

MSA is a tool used to evaluate the statistical properties of process measurement system (Srinivasan J. 2000). The purpose of MSA is to statistically verify that current measurement system provides real time feedback, unbiased result and minimal variability

The proper application of MSA tools can cut down unnecessary cost by reducing losses due to rework, rejection, guarantee in warranty claims and hidden cost of poor quality.(Raouf et al, 1995) This technique ensure the quality of measurement data there by automatically ensuring the quality of product. If the quality of data is not acceptable, then it must be improved. Improving the measurement system, rather than improving the data itself usually achieves this. (MSA 1998)

## 2. BACKGROUND OF MSA

Ford Motor Company,(Q 101 – Quality System Standard) Chrysler Corporation (SQA - Supplier Quality Assurance) and General Motors Corporation,(Targets for Excellence) three of the world's largest automotive manufacturers developed QS 9000 in an effort to standardize supplier quality system(Narola, 2000). The goal of QS 9000 is the development of quality systems leading to continuous improvement of quality by reduction of variation, defect prevention and waste reduction in supply chain. In accordance with QS 9000 standards compliant automotive suppliers shall utilize the following along with ISO 9001

1. Advanced Product Quality Planning (APQP)
2. Potential Failure Mode and Effect Analysis(FMEA)
3. Statistical Process Control(SPC)
4. Measurement System Analysis(MSA)
5. Quality System Assessment(QSA)
6. Production Part Approval Process(PPAP)

The Automotive Industry Action Group (AIAG) and the American Society for Quality Control (ASQC) copyrighted industry wise MSA standards. The standards are presented in MSA Manual approved and supported by all the three automakers. It provides general guidelines for preparing a MSA.

## 3. KEY CHARACTERISTICS OF MSA

Measurement system variation is characterized by repeatability, reproducibility, bias, linearity, and stability. MSA involves the understanding and quantification of measurement variance as described in the following equation, in relation to process variability and tolerance spread

$$\sigma_T^2 = \sigma_P^2 + \sigma_m^2$$

Where $\sigma_T^2$ : total variance , $\sigma_P^2$ : process variance, $\sigma_m^2$:measurement variance

**4.TYPES OF MSA**

The different types of MSA are attribute measurement system, MSA for complex or non replicable measurement system and MSA for variable measurement system

**5.BENEFITS OF MSA**

MSA provides a method to accept new measuring instruments, a comparison of one measuring device against other. It provides a basis for evaluating a gage suspected of being deficient. Also it helps in comparison of measuring equipment before and after repair. It is required component for calculating process variation and the acceptability level for a production process. MSA provides the information necessary to develop a gage performance curve which indicates the probability of accepting a part of some true value.

**6. PROBLEM AND NEED**

During the study, it was observed that some of the good quality products were rejected and bad products were accepted because of faulty measuring instruments, improper use of measuring instruments and unskilled appraiser. To set right these things in place MSA was carried out on attribute measurement system i.e. Ring snap gauge

**7. ATTRIBUTE MEASUREMENT SYSTEM STUDY**

An attribute gage is one that compares each part to a specific set of limits and accepts the part if the limits are satisfied, otherwise it rejects the part. Unlike a variable gage, an attribute gage cannot indicate how good or how bad a part is, but only that the part is accepted or rejected (MSA (1998)) Techniques for evaluating attribute measurement systems are not as statistically based as techniques for evaluating variable measurement systems.

Attribute measurement systems must have operational definitions to describe the items being controlled. Mandatory criteria for establishment and use of operational definitions include.

A) Criteria that can be applied to an object (or a group of objects) which precisely describes what is acceptable and unacceptable.

B) A written description of the process for collecting data, including the method in which accept/reject decisions will be made.

C) Review of the accept/reject criteria with people who will do the inspections to ensure that the requirements are understood.

**8. TYPES OF ERRORS IN ATTRIBUTE MEASUREMENT SYSTEMS**

**Type 1 errors**: A type 1 error occurs when a good part is rejected Type 1 errors are also called as “Producer’s risk” or alpha errors.

**Type 2 errors**: A type 2 error occurs when a bad part is accepted. Type 2 errors put the customer at risk of receiving defective parts hence they are called as "Consumer's risk". or beta errors.

**9. GUIDELINE FOR MAXIMUM ACCEPTABLE ERROR**

If Type 1 error probabilities are too high, our manufacturing costs will increase and become uncompetitive. If Type 2 error probabilities are too high, our warranty costs will increase and our customers will lose confidence in quality. It is desirable to minimize both types of error probabilities. As a general guideline, both Type 1 and Type 2 probabilities should be below 0.05. If the characteristic to be measured has a significant impact on customer satisfaction or some other important indicator, it may be advisable to set a tougher standard for Type 2 probability, such as 0.01.

Table 1 Truth table

| | **PART IS GOOD** | **PART IS BAD** |
|---|---|---|
| **ACCEPT PART** | **#1** | **#2** |
| | **CORRECT DECISION** | **TYPE 2 ERROR** |
| **REJECT PART** | **#3** | **#4** |
| | **TYPE 1 ERROR** | **CORRECT DECISION** |

Given above is the truth table with the help of which all the calculations for the type 1 and type 2 errors are made. The probability of making an error can be estimated using the following formulas: -

Probability of TYPE 1 error = ( QTY in Box # 3) / ( QTY in Box # 1 + Box # 3).

Probability of TYPE 2 error = ( QTY in Box # 2) / ( QTY in Box # 2 + Box # 4).

If the error probabilities are large, the measurement system has failed and must be modified or replaced. In addition, subsequent studies should use larger sample sizes

## 10. METHODOLOGY FOR ATTRIBUTE MEASUREMENT SYSTEM STUDY

1. Select at least 20 parts to be evaluated during the study. At least 5 of the parts should be defective in some way. If larger sample sizes are used 25% defective parts should be included
2. Three inspectors evaluate each part twice. A fourth person should record the data. The order of inspections should be randomized after each group of inspections to minimize the risk that the inspector will remember previous accept/reject decisions.
3. The inspectors must work independently and cannot discuss their accept/reject decisions with each other
4. Data is fed in data sheet of Minitab version 13

## 11. CASE STUDY

- **Part**: Ring gear. (Bore width). **Specifications:** 0.5050"/0.4945"
- Type of gauge: Snap gauge. Gauge no: 22

### 11.1 Trial 1

Table 2
Assessment agreement analysis table for the bore width

| Operator 1 (1) | Operator 1 (2) | Operator 2 (1) | Operator 2 (2) | Operator 3 (1) | Operator 3 (2) | Master reading |
|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 1 | 0 | 1 | 1 |
| 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| 0 | 0 | 1 | 0 | 0 | 1 | 1 |
| 0 | 0 | 0 | 1 | 1 | 0 | 1 |
| 0 | 0 | 1 | 1 | 0 | 0 | 1 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | 1 | 0 | 1 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |

( 1- NOT OK JOB) ( 0-OK JOB)

From Fig.1

Within appraisers:

Operator 1:100%

Operator 2: 80%

Operator 3: 80%

Appraiser v/s standard:

Operator 1: 75%

Operator 2: 80%

Operator 3: 75%

The assessment agreement analysis was found to be unsatisfactory hence a re-trial needs to be conducted.

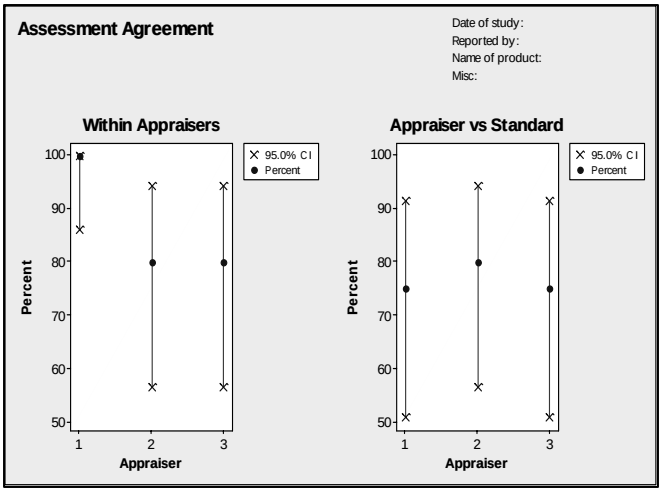


Fig 1: Assessment agreement graph

Table no.3 Truth Table for bore width

| | PART IS GOOD | PART IS BAD |
|---|---|---|
| ACCEPT PART | 60 | 20 |
| | CORRECT DECISION | TYPE 2 ERROR |
| REJECT PART | 0 | 40 |
| | TYPE 1 ERROR | CORRECT DECISION |

Type 1 error=0 Type 2 error= 0.333

### 11.2 Trial 2

Table 4 Assessment agreement analysis table for the bore width

| Operator 1 (1) | Operator 1 (2) | Operator 2(1) | Operator 2(2) | Operator 3(1) | Operator 3(2) | Master Reading |
|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |

( 1- NOT OK JOB) ( 0-OK JOB)
From Fig 2.

Within appraisers:

Operator 1:100%

Operator 2: 100%

Operator 3: 100%

Appraiser v/s standard:

Operator 1: 100%

Operator 2: 100%

Operator 3: 100%

Table 5
Truth Table for bore width (re-trial).

| | PART IS GOOD | PART IS BAD |
|---|---|---|
| ACCEPT PART | 60 | 0 |
| | CORRECT DECISION | TYPE 2 ERROR |
| REJECT PART | 0 | 60 |
| | TYPE 1 ERROR | CORRECT DECISION |

Type 1 error=0 Type 2 error =0

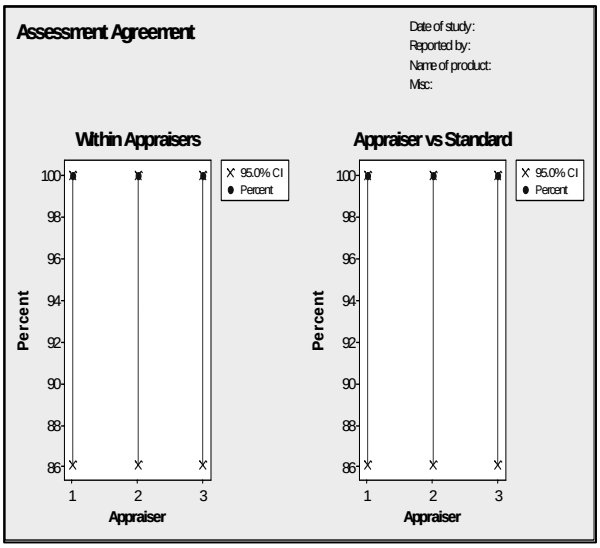


Fig 2: Assessment agreement graph

### 12. DISCUSSION

In trial 1 TYPE 1 error is 0, which is an ideal condition. The TYPE 2 error value is above 0.05 hence a re-trial needs to be conducted with the following corrections

1)While checking the bore width, the ring gear needs to be placed in a vertical position so that the width can be checked.

2) Sometimes incorrect handling of the job may cause an error in judgment.

3)The operators need to be trained as to how to hold the job while checking for the bore width.

As per the 2nd trial taken all of the values were found to be above 85% hence the results are satisfactory. Type 1 error is 0 %, and Type 2 error is 0% which means ideally the operators will make no mistake while checking the jobs. This indicates the gage is fit for its intended purpose

### 13. CONCLUSION

MSA will help in the better understanding of the magnitude of measurement error and its contribution to process variation to keep such uncertainties within reasonable limits, consistent with specific requirement of that measurement application. Companies should realize that the tools like MSA should be used to survive in this competitive global environment to minimize variation, reduce waste and rework and thereby increase the productivity.

## 14. REFERENCES


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