

Statistical Measurement System Analysis of Ruston TA1750 Gas Turbine 1st Stage Nozzle

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Abstract: - Measurement of the rotation in TA1750 first stage nozzle is carried out by putting the nozzle in a special tool (controlling fixture), and using a height gauge as the measurement tool. The rotation is the height difference between the two ends of the root when the nozzle is placed in the controlling fixture, which should not be more than 0.2 mm. MSA comprises several stages which should be carried out in a certain order. The first stage is the calculation of the capability of the measurement tool, referred to as Capability of Gauge (Cg). Calculation of Cg is done in the actual environment by a skilled operator. In the next stage the stability of the system is assessed. In the third stage the capability of the measurement system, referred to as Gauge Repeatability and Reproducibility (GR&R) is calculated by gathering data and analyzing it using Minitab 15. In the end, considering the Cg, GR&R, and the diagrams obtained from Minitab 15, the capability of the measurement system can be assessed. The significance of this work is that by determining the capability and stability of the measurement tool, and detecting the problems with the measurement system, unintended errors in the measurement system can be minimized. It is also made possible to detect the operator*part interaction by the Analysis of Variance (ANOVA) method, so we can take the necessary measures in order to eliminate it.

Key-Words: - Measurement System Analysis, Statistical analysis, Gas Turbine 1st Stage Nozzle, Analysis of Variance.

1 Introduction

During the recent years in Iran, reducing the incidents of error and increasing the capability of measurement systems have received considerable attention in the Iranian automotive industry. However, unfortunately in other industries such as power plants there is no trace of capability analysis of measurement systems that are being employed in different sections of the power plant for measurement. This is despite the fact that in most of the cases the output of these measurements are of considerable importance and even has a large influence on the efficiency of the overall power plant. With the high rate of errors and problems in measurement systems and consequently low efficiency of these measurements, measures must be taken in order to minimize these errors so the costs due to these unwanted errors in measurement systems are minimized. An increase in measurement errors would lead to undesirable outcomes which come with costs. Therefore it is necessary to make use of statistical analysis of measurement methods to implement the best possible measurement system so the highest profit is gained from the operation.

In industrialized countries such as Japan, statistical process control and statistical analysis of measurement systems have received considerable attention and a lot of

effort has been put into it, and with the development of various statistical software and their use fine results have been accomplished. In Iran the industries have a long route ahead of them in minimizing measurement errors down to a desirable level.

The best solution is the use of statistical analysis of measurement systems in order to minimize the cost of these unwanted errors in measurement systems. This method has been used for Statistical Measurement System Analysis of Ruston TA1750 Gas Turbine 1st Stage Nozzle.

The aim of this study is to analyze the measurement system of rotation parameter in a Ruston TA1750 Gas Turbine 1st Stage Nozzle, and to assess the accuracy and precision of its measurement gauge, and assuming the capability of the gauge, minimizing or elimination of the errors.

Figures 1.1 and 1.2 show the controlling gauge of the cast part of Ruston TA1750 Gas Turbine 1st Stage Nozzle and the nozzle itself respectively, and in figure 1.3 measurement of the rotation parameter using a height gauge by the operator is shown.



Fig. 1.1. controlling gauge.

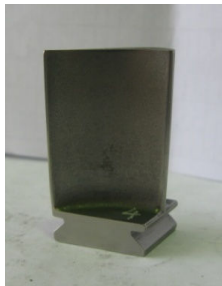


Fig. 1.2. Ruston TA1750 Gas Turbine 1st Stage Nozzle



Fig 1.3. measurement of the rotation parameter using a height gauge by the operator

2 Assessing capability of measurement tool using C_g and C_{gk} , and calculation of bias

With the calculation of measurement tool capability indices we can assess the intrinsic errors of any measurement tool. With the C_g and C_{gk} indices we can simultaneously assess the repeatability and bias of a

measurement tool. These indices are usually used for new tools or newly repaired tools as well as assessing the reliability of a measurement method. Figure 4 shows the mathematical explanation of these indices. The top of the figure shows the tolerance range (T) for the property which is being measured (rotation in this case) and the bottom of the figure shows the range of variation of the measurement data. When a target range around the tolerance range is determined (X_m) that its size is 20% of the tolerance range, if the variation of the measurement data is within this target range, it means that the measurement tool is capable.

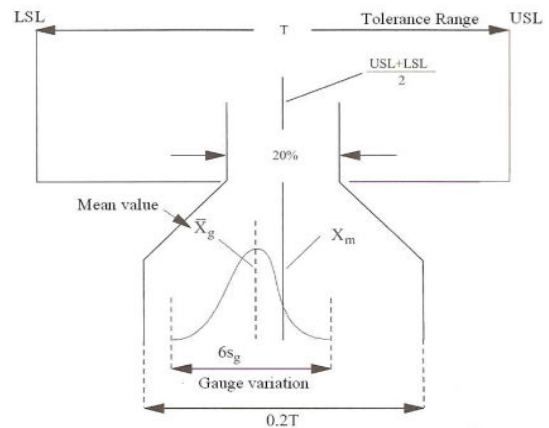


Fig. 1.4. mathematical basis of calculation of measurement tool capability indices

In order to assess the capability of the measurement tool, a master part with a fixed size is measured at least 25 times using the height gauge and the results are written down in the “measurement tool capability calculations” and then the run chart in order to confirm that the process is randomized and controlled. the acceptance criteria C_g and C_{gk} is 1.33

3 Determining the stages of measurement system analysis of Ruston TA1750 Gas Turbine 1st Stage Nozzle

The stages of the statistical process of measurement system analysis are as follows:

Table 1.1. measured properties for the analysis of measurement gauge

Property type	Property title	Specified tolerance	Measurement tool	Tool code	Operators
Quantitative	Rotation	0 ± 0.2	Height gauge and the specific fixture	E14, J1A6212	1, and 2

- **First stage**

Selection of measured properties for the analysis of measurement gauge is shown on table 1.2.

- **Second stage**

The second stage of the analysis is measurement of rotation. Analysis of the measured property (rotation) in the nozzle has the following stages:

3.1 Initial assessment of the capability of the measurement tool using the Cg and Cgk indices and calculation of bias

At first using a height gauge and controlling tool used as the fixture of the nozzle, a master part (selected from the reference nozzle) is measured 30 times by the person in charge of quality control and the results are written down in the form shown in figure 5.

Since, as seen in diagram X, the variation decreases with the passage of time. The reason is that the operator is getting used to a certain size. Therefore two other master parts are given to the operator for measurement and only the size of one of the three parts was used without

revealing it to him. The bias of the measurement tool is calculated using this formula [5-9]:

$$\text{Bias} = \bar{X}g - X_m = 0.003 - 0 = 0.003 \quad (1)$$

The abovementioned method only gives us the bias. We cannot judge the acceptability of this quantity and in the next stage using the Cgk index and the determined limit for it we can recognize the appropriateness level of bias. Cg (capability of gauge) shows the precision of a tool and is calculated using this formula:

$$C_g = (0.2 \times T) / (6 \times \sigma) \quad (2)$$

The Cgk index shows the accuracy of the tool and is calculated using this formula:

$$C_{gk} = ((0.2 \times T) - |\bar{X} - X_m|) / (6 \times \sigma) \quad (3)$$

In this formula T is the tolerance range, σ is the standard deviation of the measured property, \bar{X} is the mean of the measured data, and X_m is the base quantity. Considering the figure 5 and the obtained results for Cg and Cgk indices and the bias, the tool is approved.

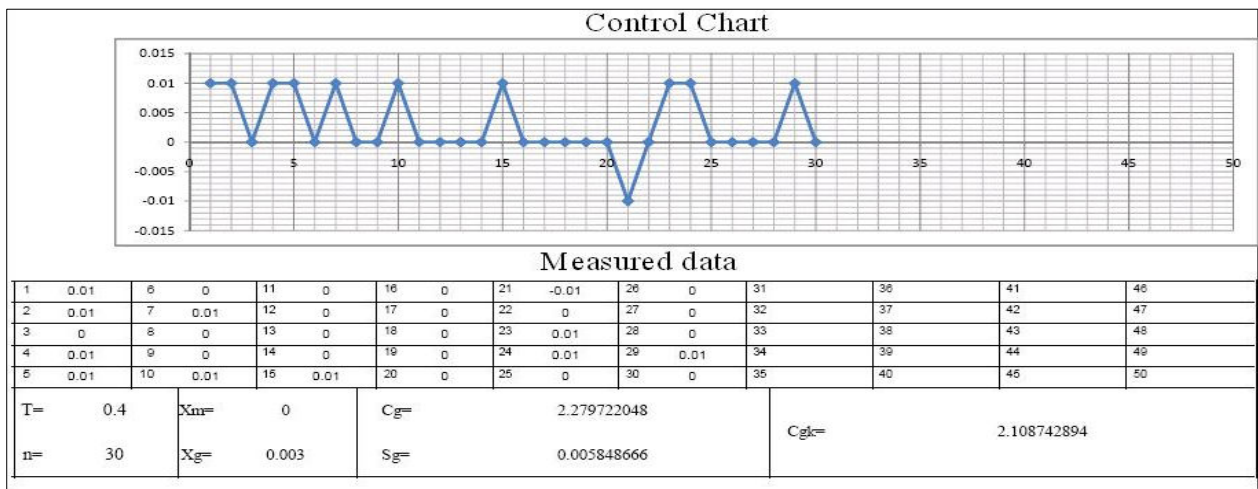


Fig 1.5 the results of quality control of the controlling tool used as the fixture of the nozzle of a master part

3.2 Assessment of Stability

Since in the measurement process the accuracy and the precision changes over time, therefore its stability should constantly be assessed and controlled. Assessment of stability of the measurement process which is done based on its two important indices (accuracy and precision) is discussed under the name of "stability". If either of these two indices changes, the process is not stable. The important point here is that not having stability in the process will put the reliability of

the rest of the calculations such as bias, R&R, etc. under question [9-5].

at first a master part from among the reference nozzles with a fixed size over time that resembles the production parts is selected and is measured in certain intervals using the measurement tool. At every measurement, the master part is measured 5 times and the results are written down. This was done repeatedly for 25 times in different intervals (according to the measurement process and system). \bar{X} and R diagrams for the obtained data are plotted using MINITAB 15.

After analyzing each diagram the stability of the measurement system is approved.

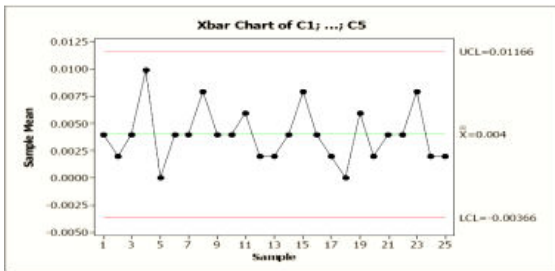


Fig 1.6 \bar{X} diagram for controlling the mean of process data

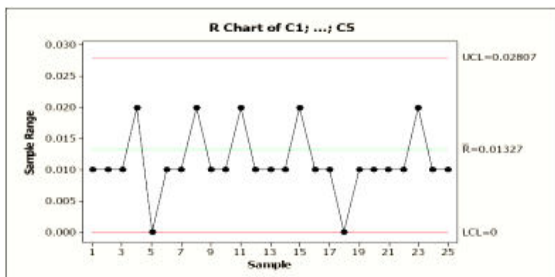


Fig 1.7 Range diagram for controlling the standard deviation of the process

3.3 GR&R studies

In order to determine the precision of the measurement system its standard deviation must be calculated so that the variations are determined by it. In order to do this GR&R index is used, which is the resultant of repeatability and reproducibility. for calculating the capability of measurement system using quantitative data while selecting parts and collecting data, these points must be considered [2-3]:

1. discrimination of measurement tool must be 10 times the tolerance of the measured property
2. The parts must be selected in a way that they cover the total range of production from the smallest to the largest production size
3. The parts must be selected randomly

In order to do GR&R studies, 13 parts are handed over to the first operator and each part is measured 5 times by them. Then the same parts were handed over to the second operator who repeated the procedure. Then the results of the measurements were analyzed using Minitab software and the following results were obtained:

- a. According to the variance analysis table (table 3) and P it is concluded that the operators and the parts have mutual influences on each other

(figure 8), therefore ANOVA is the best choice to solve this problem.

- b. Considering the %contribution column in the GR&R table (table 4) which shows the percentage share of every component of the variance from the total variation, since the total gauge R&R is 19.10, and the acceptable range is $\%0 < \%GR\&R < \%20$, therefore the studied measurement system is acceptable and most of the variation is because of the part to part variation.
- c. The diagrams on the “graph” window approve the abovementioned points as well as the following:
 1. variation of the measurement for each operator is under control and
 2. The \bar{X} diagram for each operator shows that the means of measurement data of operators do not have a considerable difference and also since most of the points are out of the controlled range, most of the process variation is because of the part to part variation.

4 Conclusion

Considering the high rate of errors and problems in the measurement systems and subsequently low efficiency of these measurements, the best solution is the use of statistical analysis of measurement systems so that the costs of these unwanted problems in measurement systems are minimized.

Using the Cgk index and the specified limit for it we can determine the appropriateness of bias.

Variation of measurements for each operator in using the measurement gauge is under control.

Since most of the points were outside the control range, most of the process variation is due to part to part variations.

Operators and parts have mutual influence on each other, which shows that ANOVA method is the best choice for statistical analysis of the measurement tools.

Table 1.2 Analysis of variance

Source	DF	SS	MS	F	P
Part	12	0.25	0.025	23.78	0.00
Operator	1	0.00	0.00	0.014	0.09
Part * Operator	12	0.01	0.008	2.35	0.01
Repeatability	104	0.038	0.00		
Total	129	0.3			

Table 1.3 percentage share of each component of variance in total variation

Source	%Contribution
Total Gage R&R	19.10
Repeatability	15.04
Reproducibility	4.06
Operator	0.00
Operator x Part	4.06
Part – to - Part	80.90
Totalvariation	100

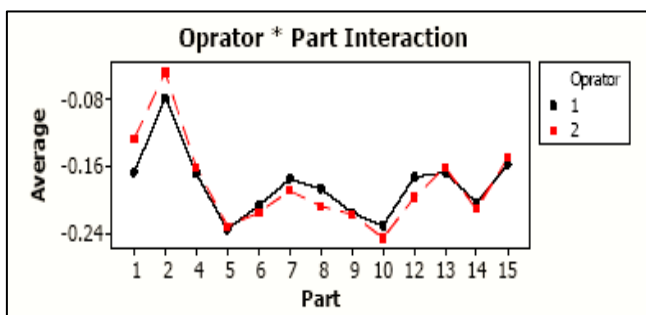


Fig 1.8 mutual influence of operators and parts

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