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Welding and inspection Industry Measurement System Analysis

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Abstract

Data-driven studies extensively depend on the quality of measurement data. The quality of the measurement data depends on the statistical characteristics, which is obtained from a number of measurements under stable conditions, from a measurement system.Ensuring accurate measurement data and continuous and timely control of equipment is a great step in improving the quality of components and structures in the welding and inspection industry. During the construction and servicing of parts, it is possible to have a variety of discontinuities with different sizes, that the future function of the piece influences their exact nature and size. Economic and environmental damage caused by the incorrect size of the welding connection will have adverse consequences. Welding industry expansion has made the protection of this industry essential. The purpose of this study is to measure the error rate in the measurement system and to analyze the factors affecting the error in welding inspection. This descriptive and cross-sectional study was carried out on the quantitative inspection results of a refinery distillation tower sample with quantitative MSA and the results of the radiographic examination of the perimeter weld line used in the pipelines by qualitative MSA. Based on the findings, analysis of the quantitative measurement system was approved within the acceptable limits. Qualitative Measurement System Analysis was indicative of noncompliance, as well as re-decision on indicators such as inspection sensitivity, replacement or repair costs, acceptance or non-acceptance of the tool.The measurement system analysis assures customers that the results of the measurement data are in accordance with customer specific requirements and legal requirements.

Keywords: analysis,measurement system, welding industry,inspection.

1. Introduction

A measurement system is a process that includes standards, personnel, and methods for measuring some of the characteristics. The measurement system analysis (MSA) is one of the most important quality tools to ensure the measurement system quality and related products. The purpose of MSA is to determine the accuracy and stability of a measurement system. In addition, the MSA is used to evaluate the measurement errors of a variety of resources, including measuring instruments, evaluators, and pieces[7].

MSA is also used to identify the source of fluctuations and evaluating the ability of equipment[3]. MSA plays an important role in the Six Sigma and the ISO / TS 16949 standards to assess the reliability of input and output data in the production process, assess changes from assessors, machinery, methods, materials and the environment [8].

When measuring the results, there is an oscillation process that originates from different sources of a process [2,6] , so, with a few measurements of a piece, the same results will not be created.

Saikaew presents a method for evaluating the equipment and machinery measurement system with gage repeatability and reproducibility and the analysis of variance method [9]. Zanobini et al. presented a study titled “gage repeatability and reproducibility system" [11].

Al-Refaieand and Bata evaluated the GR & R function with four steps including the ratio of accuracy to noise, signal to noise ratio, the ratio of differentiation, and the capability of the process [1]. Senol examined the measurement system analysis using experiments designed to minimize the risks of α-β and n [10].

The internal research has so far been more focused on the analysis of the measurement system in the form of instructions, but it seems that foreign studies have not been carried out in the welding and inspection industry. Assessing the quality of inspection data to meet customer expectations will lead the organization to better prioritize its future technical inspection services.

1-1- Measurement System Analysis

The measurement system error is classified into two categories, accuracy and precision.The accuracyshows the difference between the size obtained and the actual size of the piece. The precision is observed oscillations during repeated measurements of a piece with another device.Each measurement system can include one or both of the above problems.The accuracy of the measurement system is usually divided into three parts: Bias, Linearity relationship, and stability. The precision of the measurement system consists of two parts: repeatability and reproducibility. The Bias is the amount of deviation in the measurement system. The Linearity relationship is the amount of piece size effect on the precision of the measurement system. Stability will be the measurement of the precision of the measurement system in the long-term.Repeatability is the volatility of the measuring instrument.The reproducibility of the oscillations is related to the measurement system [4,5].

There are two types of measurements based on the type of measurement specifications: quantitative specification measurements and qualitative specification measurements. In measuring quantitative specifications, the characteristics are measured with continuous values such as length, diameter, and weight. In measuring qualitative characteristics, the acceptance or non-acceptance of the characters takes place and the result of the measurement will be two positive and negative states. Also, depending on which metric system measures what kind of features there is also a different way to analyze the errors of that system. The analysis of measuring systems for quantitative characteristics is based on the study of the repeatability and reproducibility of the measurement system (GageR & R). This technique evaluates how the measurement system is affected by repeatability and multiplication errors. The analysis of measurement systems describes descriptive characteristics uses performance indicators, the probability of non-recognition of non-conforming parts, the probability of wrong risk declaration and bias [4,5].

2. Research Method

The present research is applied research in terms of objectives and in terms of data collection method; it is descriptive and is a survey type. In this study, the experiences of technical inspectors of an engineering company have been used. This descriptive and cross-sectional study was carried out on the quantitative inspection results of 10 refinery distillation tower samples for quantitative MSA and the results of a radiographic test of the environmental weld line used in the pipelines were done for qualitative MSA using quantitative and qualitative MSA questionnaires. Excel software was used to analyze the data. The analysis of measuring systems is one of the most widely used tools that can help in challenging the quality of the welding industry and inspection.

3. Results

Ten samples of refinery distillation tower were surveyed to analyze the welding and inspection industry measurement system. Each piece was tested three times. The results of the experiments are presented in Table (1).

The average bias error (Bias) indicates that the inspectors have seen fewer measurements. The volatility of the device (EV) is 0.005389535 and the inspectors' fluctuation (AV) is 0.00131824. The total system accuracy (R & R) is 0.00755817. In order to check the acceptability of this accuracy, it is necessary to measure that ratio to design tolerance or the process. A maximum of 10% R & R (%) or (GR & R) indicator in the inspection studies indicates the acceptability of the measurement system.

To qualitatively test of MSA, the environmental weld line used in the pipeline project was surveyed. The defects of welding were detected by radiographic examination.In the various sections of this process, two people, as an interpreter of radiographic films, were present. All defects were observed in the form of Root Concavity/Suck Back, Burn Through, Tungsten Inclusion, Undercut, Lack of Fusion, Lack of Penetration, Linear Porosity, Wagon Track, Porosity.The results of the experiments are presented in Table (2). The symbol C represents the accepted welded line and the N symbol representsthe unacceptable discontinuity in accordance with the acceptance criteria of API 1104 standard.

Bias error is not acceptable and indicates that there is a tendency to accept. Efficiency indicates the ability of the inspector to correctly identify the discontinuities. Efficiency (E) is within the margin. P (miss) is the probability of accepting the welding line that does not match the specifications. In fact, there is a kind of error that causes an inconsistent piece to be accepted and reaches the customer. P (miss) is within the margin. P (FA) is the probability of incorrect alert and it is vice versa (P (miss).The occurrence of this error leads to reworkingand re-inspection and it is very important because it will cause imposes waste costs. P (FA) is acceptable.

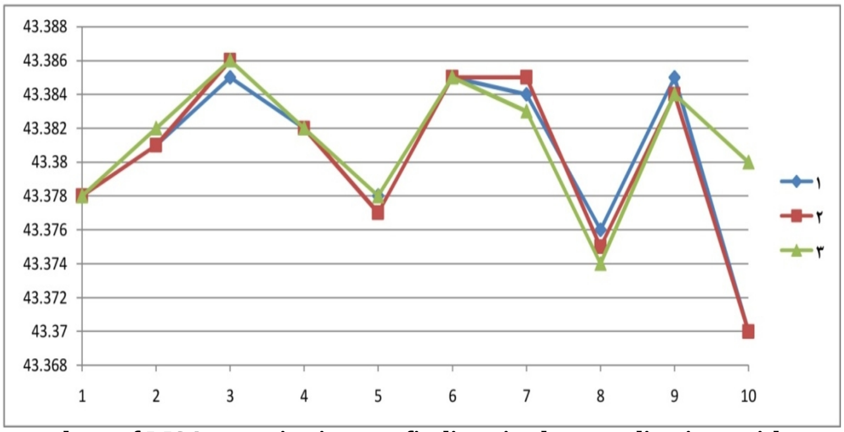

Figure 1. Scatter chart of MSA quantitative test findings in three replications with ten samples of the refinery distillation tower

Table 1. Quantitative MSA test results in three replications with ten samples of the refinery distillation tower

Samples / Replications	1	2	3	4	5	6	7	8	9	10	
1	43.3780	43.3810	43.3850	43.3820	43.3780	43.3850	43.3840	43.3760	43.3850	43.3700	
2	43.3780	43.3810	43.3860	43.3820	43.3780	43.3850	43.3850	43.3750	43.3840	43.3700	
3	43.3780	43.3820	43.3860	43.3820	43.3780	43.3850	43.3830	43.3740	43.3840	43.3800	
Real	43.3780	43.3810	43.3860	43.3820	43.3770	43.3850	43.3850	43.3750	43.3840	43.3800	**43.3813±0.00037**
$\bar{X}$	43.378	43.3813	43.38567	43.382	43.37767	43.385	43.384	43.375	43.3843	43.3733	**$\bar{X}_{DIF}$=0.012333**
R	0	0.001	0.001	0	0.001	0	0.002	0.002	0.001	0.01	**$\bar{R}$ =0.0018**
Bias	0	0.00033	-0.00033	0	0.00067	0	-0.001	0	0.00033	-0.0067	**T_{Bias}=-0.000667**

$$\sigma_{RPT} = \frac{0.0018}{1.72} \quad (1)$$

$$EV = \sigma_{RPT} \times 5.15 = 0.005389535 \quad (2)$$

$$AV = \sqrt{\left(\frac{\bar{R}}{d_2^*} \times 5.15\right)^2 - \frac{(EV)^2}{n'r}} = \sqrt{\left(\frac{\overline{0.0018}}{1.72} \times 5.15\right)^2 - \frac{(0.005389535)^2}{30}} = 0.00131824 \quad (3)$$

$$(R,R) = \sqrt{EV^2 + AV^2} = 0.00755817 \quad (4)$$

$$GR\&R = \frac{(R,R)}{USL-LSL} = \frac{0.0253994}{0.00724} = 1.00240984 \quad (5)$$

Table 2. Qualitative MSA findings on the results of radiographic test results in the peripheral welding line used in pipelines.

Real situation of the Sample	Inspection1	Inspection2
C	C	C
C	C	C
C	C	C
N / PO	N / PO	N / PO
N / BT	miss / RC	N / BT
N / U/C	N / U/C	miss / LOF
C	C	C
C	C	C
C	C	C
N / L-Por	miss / LOF	N / L-Por
N / WT	miss / WT	C / LOP
N / Ti	N / Ti	N / Ti
C	C	C

$$E = \frac{18}{26} = 0.846 \quad (6)$$

$$P(miss) = \frac{4}{12} = 0.333 \quad (7)$$

$$P(Fa) = \frac{0}{10} = 0 \quad (8)$$

$$B = \frac{P(FA)}{P(miss)} = 0 \quad (9)$$

4.DISCUSSION AND CONCLUSION

The measurement error in the welding and inspection industry has a significant impact on post-process decision-making and process control. In the welding inspection, if discontinuity, wrongly diagnosis as a defect, and repairs on that part will be inspected, despite damage to the piece that does not need to be repaired (type 1 error - impact on the product), excessive defect costs, edging rebuilding, non-destructive testing before and during welding, heat treatment after welding and final non-destructive testing to correct the defect will suffer huge economic losses in the project. In this study, a quantitative MSA test was performed on the inspection results of a 10 pieces sample of the refinery distillation tower and qualitative MSA test on the results of the radiographic test of the peripheral welding line used in the pipelines.Based on the findings, the analysis of the quantitative measurement system was within acceptable limits and was accepted.The analysis of the qualitative measurement system showed that with regard to the marginalization of efficiency (E) and P (miss), the decision should be made on indicators such as the sensitivity of the inspection, the cost of replacing or repairing the tool, the acceptance or non-acceptance of the tool.Organizations must establish an Effective Measurement Management System in such a way as to ensure that measurement equipment and systems of measurement are appropriate for use. Measurement equipment and measurement processes can have an adverse effect on the quality of an organization's products by providing incorrect results.The goal of the management system is to measurement and risk management. The ISO 10012 standard is a measurement management system that incorporates the requirements of measurement processes and measurement equipment and assures the organization that measurement equipment and measurement processes are essential to achieving product quality objectives and to manage the risk of incorrect measurement results.The deployment of this system assures customers that the results of measurement data are in accordance with customer specific requirements and legal requirements.This standard, with the help to MSA, sets out the general requirements and guides the principles in managing the measurement and verification processes of the measuring equipment required to support and demonstrate compliance with metrological requirements.

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