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R&R STUDY FOR ANALYSIS OF THE MEASUREMENT SYSTEM OF A PUMP LABELING PROCESS

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ABSTRACT

The National Institute of Metrology, Quality and Technology (INMETRO) created the Brazilian Labelling Program (PBE), with the purpose of regulating in Brazil the estimation of energy consumption of products, such as centrifugal pumps. In 2010, the labeling process became mandatory for centrifugal pumps, which led to an increase in demand for tests at the Centrifugal Pump Laboratory (LEB) at the Federal University of Itajubá (UNIFEI), one of the few accredited EBP reference laboratories to carry out these tests. In view of the great demand for analysis and constant search for excellence in the reliability of the results, the present work aimed to evaluate the reliability of the LEB centrifugal pump measurement system by means of a Repeatability and Reproducibility (R&R) study. The results indicated that, although the LEB measurement system has been classified as marginal, it is acceptable for certain applications and is able to efficiently identify the difference between the evaluated parts. The results also suggest that, in order to increase the reliability of the measures carried out by the LEB, it is necessary to invest in training for the operators and a greater standardization of the process.

Keywords: study of repeatability and reproducibility, analysis of measurement system, labelling of pumps.

INTRODUCTION

Pumping systems have wide application, ranging from the industrial segments that use liquids in their processes, to the feeding of reservoirs of the sanitation services. In this last one, the greater financial expenses come from the consumption of electric energy (Bridi, 2013), which ends up driving the search for more energy efficient hydraulic pumps.

Seeking to regulate in Brazil the dissemination of information on the energy efficiency of several products, the National Institute of Metrology, Quality and Technology (INMETRO) created the Brazilian Labeling Program (PBE), which establishes measurement procedures and parameters for consumption evaluation different products, among them centrifugal pumps. In 2010, the labeling process became mandatory for centrifugal pumps (BRASIL, 2010).

The labeling process for centrifugal pumps is based on the annual comparison of all the trade marks in order to inform the consumer of the performance of each brand available in the market, in its numerous flow and pressure ranges, according to their respective energy

consumption (INMETRO, 2006), thus allowing the consumer to decide, with more clarity, which product to purchase.

According to information from the INMETRO website, the Laboratory of Labeling of Centrifugal Pumps (LEB) at the Federal University of Itajubá (UNIFEI) is one of the few laboratories accredited to carry out these tests (INMETRO, 2017).

Due to the constant increase in demand and the pursuit of excellence in reliability of results, the repeatability and reproducibility (GR & R) study is required in the LEB centrifugal pump labeling tests, since such a procedure is essential for verification of the ability of the system to efficiently monitor the process (Burrick and Borror; Montgomery, 2003). According to Burdick, Borror and Montgomery (2003), the study of R&R can be done in almost any industry and its main applications are in the identification and removal of the sources of variability of the data in the measurement system and in the verification of its capacity.

The present work had the objective of evaluating the reliability of the centrifugal pump measurement system of the Laboratory of Labeling of Centrifugal Pumps, through a study of Repeatability and Reproducibility (R&R).

RESULTS AND CONCLUSIONS

The results obtained from the Gage R&R (Nested) analysis performed in *Minitab17*®, are presented in Table 1 and 2.

Table 1 - ANOVA for pump efficiency.

Source	**DF**	**SS**	**MS**	**F**	**P**
Operators	2	0,0214	0,01072	0,0001	0,999
Part	12	91,2469	7,60391	117,283	0,000
Repeatability	30	1,945	0,06483	-	-
Total	44	93,2133	-	-	-

Considering a significance level of 0.05, from the p-value results it can be concluded that the differences between the operators are not significant (p-value> 0.05) in the measurement of the "efficiency" output variable. However, the same cannot be said for the parts, since the p-value for this variable was zero, indicating that the differences between the parts significantly influence the process.

Table shows important data regarding the main responsible for the variability in the process, indicating that the repetitiveness contributed with a small portion of the variation (2.52%), suggesting that there was variation of an evaluator when using equipment to measure several times a same feature in the same part.

Table 2 - Result of the GR&R Study

Source	**σ**	**% Contribution**
$\sigma_{GR\&R}$	0,25462	15,86
$\sigma_{repeatability}$	0,25462	15,86
$\sigma_{reproducibility}$	0.0000	0.00
$\sigma_{part\text{-}to\text{-}part}$	1,58525	98,73
σ_T	1,60557	100,00
ndc	8	

The value obtained for the GR&R study was equal to 15.86%, indicating that the measurement process is classified as Marginal, and may or may not be acceptable according to the specifications adopted. The number of distinct categories identified by the system was equivalent to 8, a criterion classified as acceptable according to AIAG (2010). Figure 1 illustrates the results obtained from the Gage R&R (Nested) analysis for efficiency, through 5 graphs, which help in understanding the results already elucidated in Tables 1 and 2.

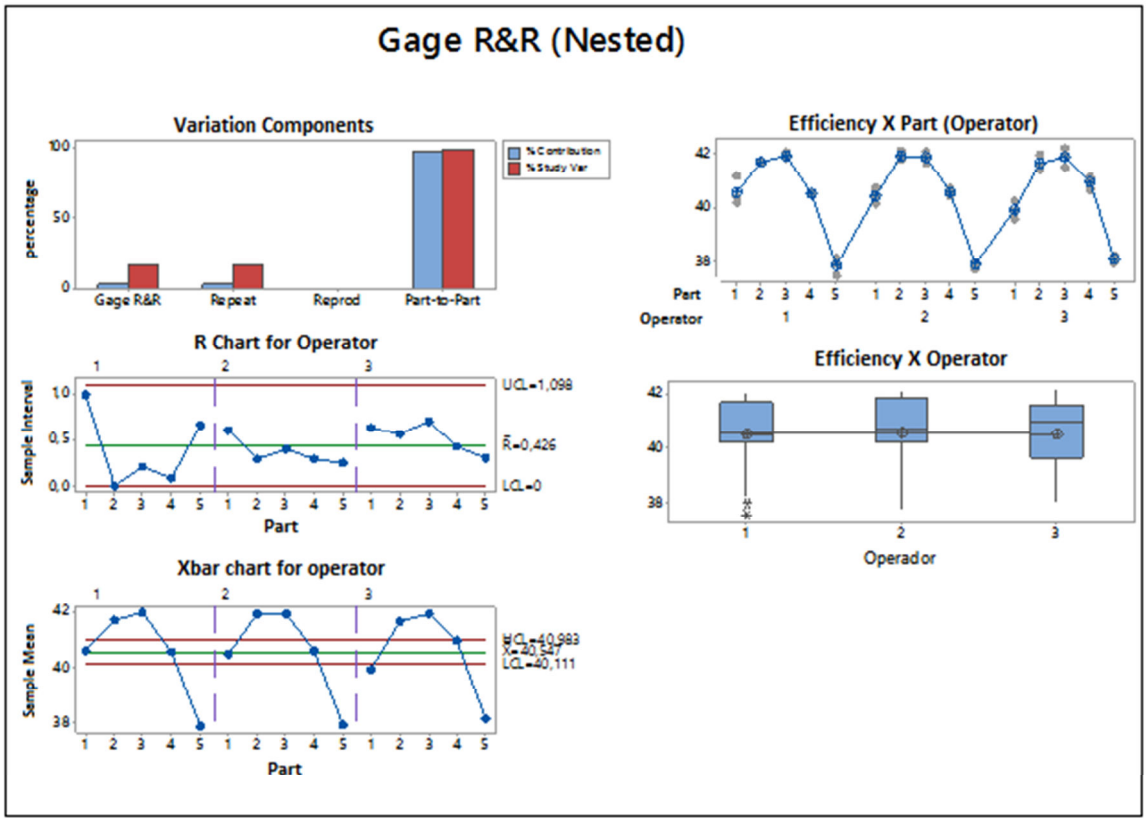

Fig. 1 - Gage R & R (Nested) Analysis Charts. a) Variation components. b) Efficiency X Part (Operator). c) R Chart by Operator. d) Efficiency X Operator. e) Xbar Chart per Operator.

In view of the study, it was possible to notice that the measurement system for the verification of energy efficiency of centrifugal pumps, is able to efficiently identify the difference between the evaluated parts. Although it has been classified as a marginal measurement system, it may be acceptable for certain applications, given the high cost of the process.

For the analysis of the data, the operator who presented the worst performance was Operator 1. In order to increase the reliability of the measurements performed by the laboratory and to reduce the variation of the measurement system due to the repetitiveness (2.5%), it´s necessary an investment in training for operators and standardization of the process.

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