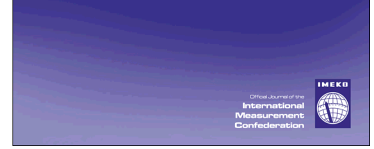

DOI: http://dx.doi.org/10.1016/j.measurement.2016.07.027
Reference: MEASUR 4214

To appear in: *Measurement*

Received Date: 9 May 2014
Revised Date: 10 August 2015
Accepted Date: 5 July 2016

Estimation of the measurement uncertainty in the anisotropy test

Abstract

The evaluation of the sheet metal drawability in mechanical shaping processes depends on a large number of analysis, among which the anisotropy evaluation. Nowadays, there is no Brazilian test laboratory accredited by the Metrology, Quality and Technology National Institute (INMETRO) to perform this analysis. So, the object of the present work is to establish a procedure for the estimation of the measurement uncertainty in the plastic anisotropy ratio of sheet metals, in accordance to the Guide to the Expression of Uncertainty in Measurement (GUM), aiming at the accreditation of this test in the Physical Metallurgy Laboratory. As results, we present the calculations performed and the uncertainty form proposed, and an analysis of which sources contributed the most for the uncertainty in the execution of a test. Finally, we propose improvement actions aiming at the reduction of the calculated uncertainty and the adequacy of the Measurement System for the desired application.

Keywords: Measurement uncertainty; GUM; Anisotropy; Plastic strain ratio.

Highlights

A procedure to estimate measurement uncertainty in the anisotropy test was proposed.
At first, the measurement system was considered unacceptable.
Pareto charts were used to rank the uncertainty sources.
Reproducibility had a large influence in the plastic strain ratio uncertainty.
The plastic strain ratio calculus is sensitive to small changes in the variables.

1. Introduction

Test laboratories are committed to offering to the society the means and the knowledge to obtain solutions for the existing problems, through the results provided [[1]]. For this, it is fundamental to confirm the quality of the results, which generates the need for implementation in the Quality Management Systems (QMS) and, in many cases, the accreditation by the ISO/IEC 17025 standard [[2]].

The implementation of a Quality System in university laboratories is a difficult task [[1], [3]-[4]] that demands a large amount of planning [[5]]. Still, university laboratories can be accredited by ISO/IEC 17025, as long as their particularities are respected and flexible solutions to each institution's reality are adopted [[3]], as the implantation of a Management System in laboratories bring various benefits [[1], [3], [6]-[7]].

ISO/IEC 17025 recommends the use of the Guide to the Expression of Uncertainty in Measurement (GUM) [[8]] to elaborate the procedures and the spreadsheets for testing/calibration measurement uncertainty [[2]]. The correct expression of the measurement uncertainty by the test laboratories can be considered a key factor, as it impacts directly in the results interpretation [[9]].

In processes of metallurgy products fabrication, it is important to study the properties of the materials in order to reduce losses and defects, for the use of the most adequate material to each process. The mechanical properties of a processed material can vary according to the direction. This phenomenon, called anisotropy, results from the preferential orientation of the planes and crystalline directions of the metal after a large deformation by mechanical processing or due to the alignment of inclusions, voids, and segregation, or alignment of a second precipitated phase [[10]]. A useful measurement unit to evaluate the plastic anisotropy of materials is the plastic strain ratio *r* (coefficient of anisotropy), which can be calculated according to the ASTM E517 Standard [[11]].

The Physical Metallurgy Laboratory (LAMEF) of the Federal University of Rio Grande do Sul is accredited by INMETRO for the execution of mechanical-metallurgical tests, and has decided to increase its accreditation scope to include the determination of the coefficient of anisotropy. By consulting the Brazilian Network of Testing Laboratories catalog [[12]], we observe that, by January 2014, no Brazilian test laboratory included anisotropy test in its accreditation scope. Besides, there is little literature about the GUM application for the measurement uncertainty calculation in this test.

Thus, the main objective of this work is using GUM for the calculation of the measurement uncertainty of the anisotropy coefficient. With this, we expect to: *(i)* develop an uncertainty spreadsheet that can be used in the routine of the laboratories that perform this test, *(ii)* evaluate the variability sources that most influence the uncertainty of this test, and *(iii)* obtain the test accreditation for LAMEF.