Desenvolvimento de ensaio de tração para micro corpos de prova

Development of a tensile test for microspecimens

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Resumo: Um modelo de análise de microtração foi desenvolvido com o objetivo de implementar o método para análise de corpos de prova de dimensões reduzidas de uma amostra de aço DP600. Esta técnica permite uma análise profunda das propriedades de tração para materiais em situações particulares. Dispositivos e corpos de prova foram projetados de forma a permitir o posicionamento da amostra na máquina de ensaios e interferometria a laser foi utilizada para a obtenção das curvas tensão-deformação. Comparado com resultados de ensaios de tração convencionais, os ensaios obtidos através de microtração apresentaram comportamento similar, apesar de um pouco inferior aos encontrados através de ensaios convencionais.

Palavras-chave: Ensaio de tração; micro corpos de prova; aço DP600.

Abstract: A model of microtensile analysis was developed aiming an implementation of the method for test specimens with small dimensions of a sample of DP600 steel. This technique permits a deeper analysis of tensile properties for materials in singular conditions. Dispositive and specimens were projected to permit the positioning of the sample on the test machine and laser interferometry was used to obtain the stress-strain curves. Compared with results of conventional tensile tests; the microtensile’s results had a similar behavior but a little inferior from the conventional.

Keywords: Tensile test; microspecimens; DP600 steel.

1. INTRODUCTION

Analyzing materials in scarce conditions, in a very specific position or with high costs of manufacturing, generates a demand of using the least quantity of material to achieve the most information possible. A solution to solve the problem of getting tensile properties of materials in these conditions is the use of specimens in reduced dimensions. In practice, the tensile properties can be obtained by tabulations for comparison using measured values of hardness, as an alternative for cases in which the tensile properties cannot be obtained. But this conversion is just an estimative, because comparing two testing methods where physically different damage processes occur implies in the appearance of associated errors [1].
DP-type steels are low-carbon steels and have a microstructure containing ferrite and martensite, where the first provides a good ductility and the second has its amount controlled on the steel to acquire the strength wanted. This microstructure provides a high strength associated with an excellent formability, what improve the vehicle crashworthiness without increasing the car body weight [2, 3].

2. EXPERIMENTAL PROCEDURE

The specimen’s shape chosen was the flat, which is more indicated for tests in sheets. Using a plane shape is more convenient due to its facility of accommodating and maintaining the position of the retro-reflective target, used on the measure of the strain, and also has the ability to permit the extraction of a greater number of specimens per volume, if compared with the cylindrical shape. The dimensions of the specimens are shown in Figure 1, as the dispositive used on the tests [4].

The dispositive is made of 4340 steel and has a cavity to permit the entrance of the headpiece up to 2.3mm thick. The tension is applied on the shoulders of the specimens and a tape was applied to avoid buckling or fluting, and to guarantee that the tension axis was on the middle of the specimen, avoiding deflecting. The specimens, analyzed by the microtensile test method, had their respective width and thickness obtained with a digital caliper, as the measured initial length, which was marked on the specimens. After the initial measures, the specimens had retro-reflective target fixed on both marks to accompany the elongation. The strain was measured on the specimens with laser interferometry. This technique is easily applicable because the laser focuses on the two retro-reflective markers, is reflected from the both and the reflected laser is read by the instrument, using the created light and dark interference bands, similar to Young’s two-slit experiment, which gives a signal of displacement. The extensometer must be in an angle (θ) $0^\circ < \theta < 90^\circ$ of the specimens’ surface, mainly if the surface has been polished, to avoid the reflection of the surface directly on the extensometer’s reader, which could induce measurement errors. Figure 2 shows the analysis apparatus [4, 5].

![Figure 1](image1.png)

**Figure 1.** (a) Microtensile specimen; (b) Dispositive containing a specimen.
By testing the equipment and the procedure, three specimens of a sample of DP600 steel, obtained on the longitudinal direction of rolling, were machined into the dimensions of the specimens and were submitted to testing. The tests were taken on a MTS’ model 810 servo-hydraulic machine (100kN of capacity) with load cell of 10kN, a stroke velocity of 0.5mm/min and the strain was obtained by a MTS’ model LX500 laser extensometer (0.001mm of resolution) with a focus’ distance of 381mm. The machined specimens are shown on Figure 3.

3. RESULTS AND DISCUSSION

Figure 4 illustrates the stress-strain curves obtained from the tests’ data. It is observed that some noise has appeared on the curves, which could have been caused by the dimensions of the test machine, which are over dimensioned compared with the dimensions of the specimens.

![A representative stress-strain curve.](image)

The tensile properties obtained by the microtensile test are shown in Table 1. The results taken from the tests were the tensile strength (UTS), the yield strength by the offset method (0,2%) and the elongation after the fracture [4]. Mechanical properties are compared to those presented in the literature [2, 3].

<table>
<thead>
<tr>
<th></th>
<th>Yield Strength [MPa]</th>
<th>UTS [MPa]</th>
<th>Elongation [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wu-rong [2]</td>
<td>412</td>
<td>676</td>
<td>27,0</td>
</tr>
<tr>
<td>Huh [3]</td>
<td>422</td>
<td>632</td>
<td>26,9</td>
</tr>
<tr>
<td>Microtensile Specimens (average)</td>
<td>356 ± 19</td>
<td>581 ± 6</td>
<td>18,2 ± 4,0</td>
</tr>
</tbody>
</table>
The results obtained on different studies using the conventional tensile test are found higher than the microtensile. The difference could be a result of the small transversal area of the specimens, in which small imperfections on the surface or microstructure effects have larger and direct impacts on the final results, so the use of this method turns uniformity on the microstructure an important factor when smaller specimens are used. It can be applied to the elongation of the material, which was expected to be much higher, because of the predominance of the plane stress state in smaller thickness specimens [6, 7].

4. CONCLUSIONS

The microtensile test can be used in special cases, in which more specific information is necessary. A method of tensile analysis for specimens with small dimensions was implemented. The specimens were tested and the tensile properties were obtained. A test machine with smaller dimensions should be used in the future, with the same procedure described in this work. Besides the use of small dimensioned specimens has direct effects on the final results, the dispositive and procedure developed provide an easy replication, permitting a large application for innumerous cases and provide an alternative more exact than using comparative tabulations with values obtained on hardness tests.

5. REFERENCES


