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Tensile Test: Comparison Experimental, Analytical and Numerical Methods

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Abstract**—*The objective of this work is to study and analyze the stress-strain curves obtainedthrough the experimental tensile test and the comparison of thedata obtainedwith the analytical and numerical methods. For the development of the analytical method, we proposed equations for the stress-strain curve of the material, using MS-EXCEL 2016. For the numerical method, a modeling of the test specimen was elaborated using the ANSYS Workbench® version 16 software. The steel selected for the studies was ABNT 1020.*
Keywords—Hooke's Law, Plastic-strain, Tensile test.

I. INTRODUCTION

Tensile test was used for evaluating the mechanical properties of material and the plastic strain modify this properites.
Use tensile test for determinate the final of plastic phase. ([2])
The state of tension in which plastic deformation occurs dependent on the degree of current plastic deformation and this phenomenon is called hardening. ([1])

II. METHODOLOGY

2.1 Experimental Methodology
The methodology based on experimental analysis using ABNT 1020 material specimen.
After the test will be collected the data obtained and generated the stress-strain curves of the engineering and actual deformation of the test.
The data obtained of the test will shown in Table 1.

Table1:TensileTest Data

Data	Value
Maximum Stress [MPa]	546.60
Area [mm^2]	63.62
Initial length [mm]	55.50
Final length [mm]	73.00
Initial diameter [mm]	9.00
Final diameter [mm]	5.10

With the achievement tensile stress, the stress-strain curve constructed, as shown in Figures 1 below.

Fig. 1: Experimental curve

2.2 Analytical Methodology
In the analytical method, it proposed the determination of a curve that approached the stress strain curve obtained from the tensile test.
To determination the curves describing the behavior of the material, divided the curve experimental curve through pre-established intervals.
Four different equations has developed to divide into the following phases of the behavior of the material: elastic phase, beginning of the flow stage, ending of elastoplastic transition and plastic phase.
The selected interval of the curves has approximated by log, exponential or polynomial tendency curves.Thus, equations has developed that approached the maximum of the real curve of the tensile test.

2.3 Elastic Phase
The proposed curve for the elastic phase of the material uses Hooke's law, (1) and shown inFig. 2.

$$\sigma = E.\varepsilon\sigma < \sigma_{esc} \quad (1)$$

σ = tensile stress [MPa]
ε = strain [MPa]
E = elastic modulus

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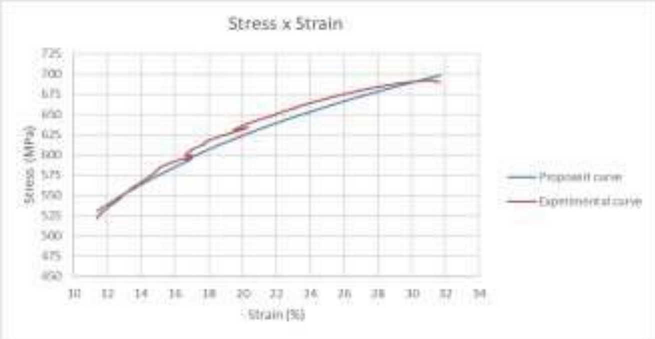

Fig. 2: Elastic phase curve

2.4 Beginning of the flow stage

The curve proposed for the beginning of the flow stageuses, (2) with the constants values of A and b shown below. The curves shown in Fig. 3.

$$\sigma = A.\, e^{b.\varepsilon} \qquad \varepsilon > \varepsilon_{esc} \qquad (2)$$

σ = tensile stress [MPa] ε = strain [MPa]

A = 432.248 b = 0.001

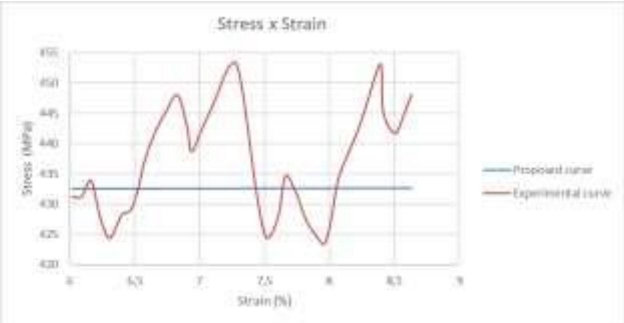

Fig. 3: Beginning of the flow stage

2.5 Ending of elastoplastic transition

The curve proposed for the ending of elastoplastic transition considers, (3) with the constants values of C and d shown below. The curves shown in Fig. 4.

$$\sigma = C.\, \varepsilon^{d} + F.\varepsilon + G \qquad \varepsilon < \varepsilon_{ep} \qquad (3)$$

σ = tensile stress [MPa] ε = strain [MPa]

c = -6.5945 d = 2

F =163.39 G = -485.62

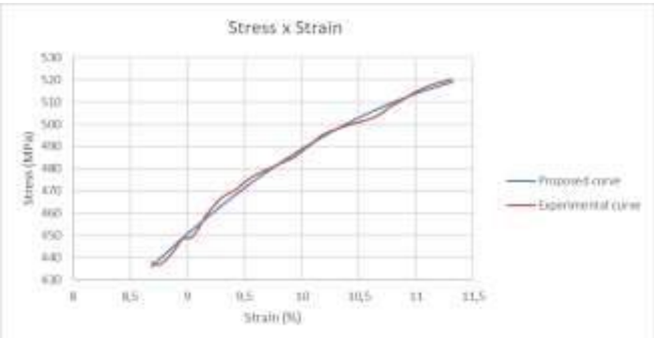

Fig. 4: Ending of elastoplastic transition

2.6 Plastic Phase

The curve proposed for the plastic phase uses, (4) with the constants values of H and K shown below. The curves shown in Fig. 5.

$$\sigma = H.\ln\varepsilon + K \qquad \varepsilon > \varepsilon_{ep} \qquad (4)$$

σ = tensile stress [MPa] ε = strain [MPa]

H = 160.674 K = 140.04

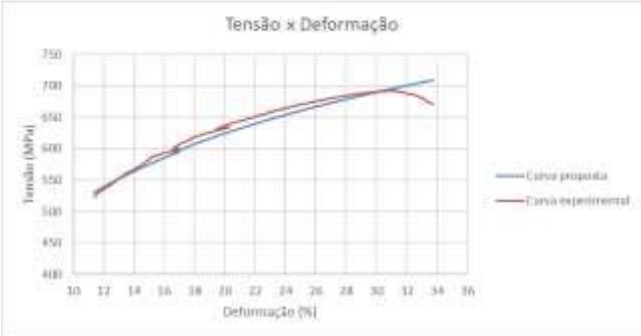

Fig. 5: Plastic phase

2.7 Developed curve using the proposed equations

For development of proposed curve has been used the equations 3 to 6. The Fig. 6 shown the proposed curve of performed tensile test.

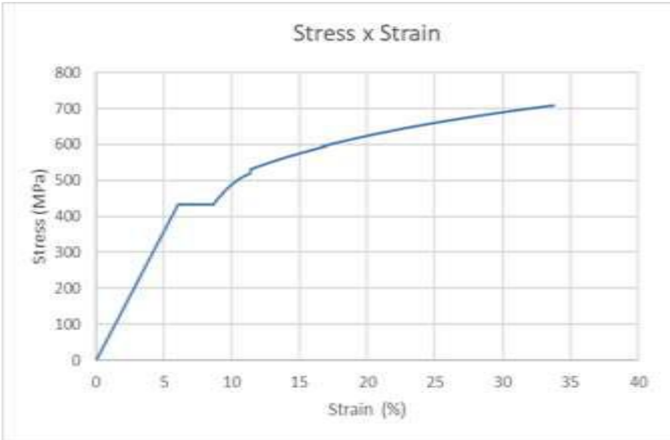

Fig. 6: Proposed curve

III. COMPARISON OF EXPERIMENTAL AND ANALYTICAL METHODS CURVES

The Fig. 7 shown the comparison of experimental and analytical methods curves of the ABNT 1020 material.

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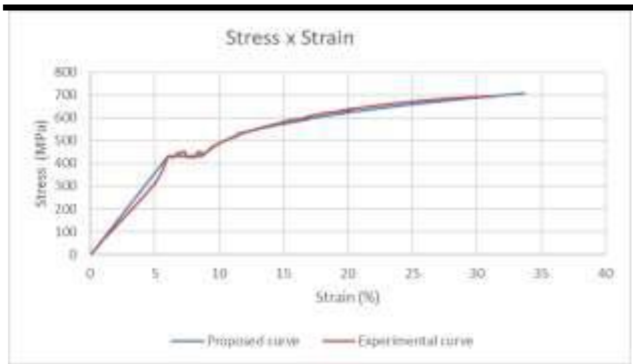

Fig. 7: Comparison curves

IV. NUMERICAL METHODOLOGY

The test specimen of ABNT 1020 material modeled in the AutoCad 16 and imported to ANSYS 16, in the Mechanical module a mesh has defined for it and its restrictions and loads were created. A fixed support has created at the base of the specimen and load has applied to the top of the specimen, as seen in Figs. 8 and 9.

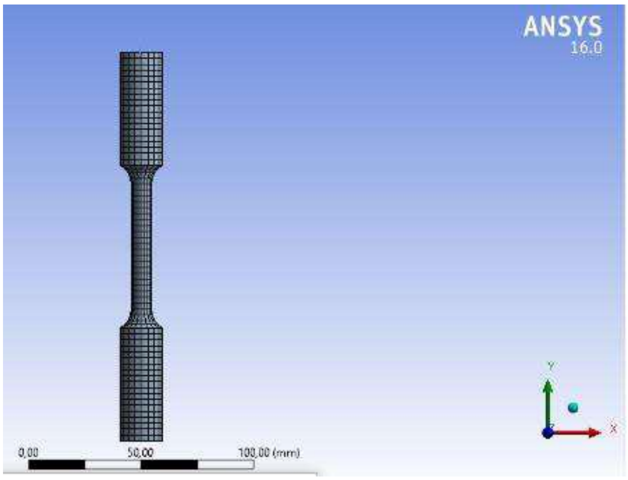

Fig. 8: Test specimen mesh

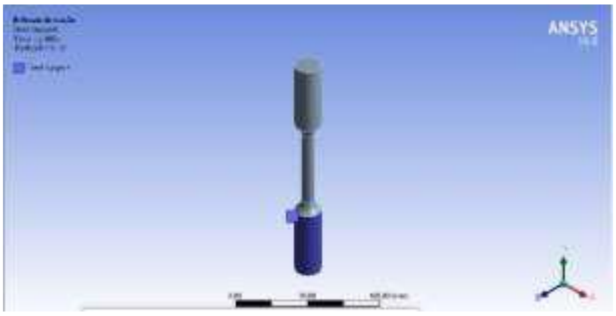

Fig. 9: Test specimen constrain

The displacement are show in Fig. 10 and tensions obtained are shows in Fig.11.

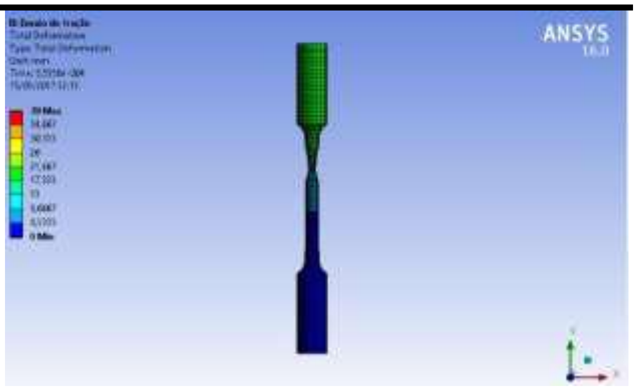

Fig. 10: Test specimen displacement

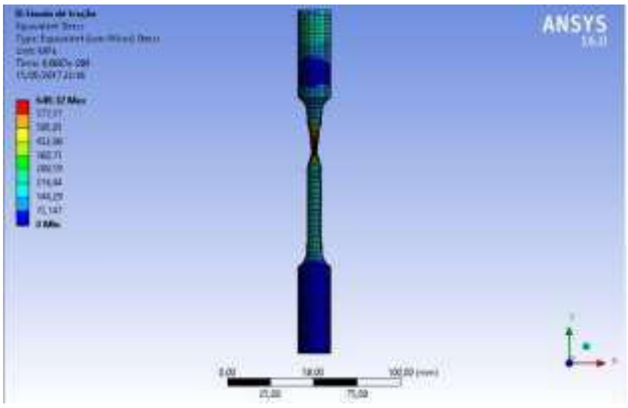

Fig. 11: Test specimen stress

The obtained curve through the numerical simulation shown in Fig. 12.

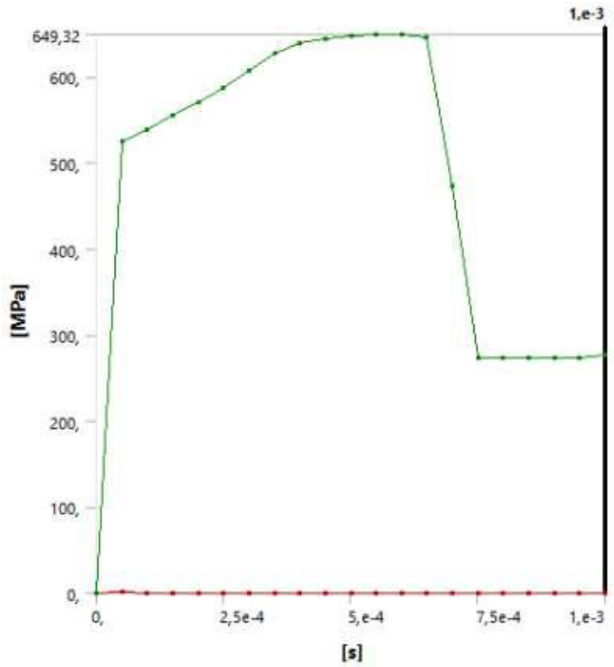

Fig. 12: Numerical curve

A curve of Fig. 13was designed in MS-Excel. The curve were created stress as a function of time, but it can be observed that the behavior of the curve is similar to those found in the experimental and analytical analyzes, because it presents an elastic phase, an elastoplastic transition and the plastic phase.

Fig. 13: Numerical curve – MS-Excel

V. CONCLUSION

The results were as expected. The specimen rupture occurs approximately 35 mm, as shown in Fig. 11.

The tensile test was of great importance to have a practical knowledge of the engineering data used in mechanical designs.

By comparing the experimental, analytical and numerical methods, one can note the importance of each one of them and how important it is to have an idea of the behavior of the material for the use of a numerical method in a safe and reliable way.

The results were as expected. The specimen rupture occurs approximately 35 mm, as shown in Fig. 11.

The advantage of this study is the confidence obtained in the execution of the proposed methodology, since the results obtained are very close to the experimental test.

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