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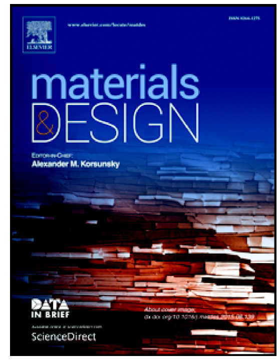

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Development of an improved prediction method for the yield strength of steel alloys in the Small Punch Test

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ABSTRACT

The Small Punch Test (SPT) is a miniaturized test to characterize the mechanical properties of the materials. The load-displacement curve obtained by this test does not directly provide the material parameters, and linear correlations between data obtained from SPT curve and each mechanical property are necessary. The main difficulty of these correlation methods is the high level of scattering showed when analyzing a wide set of materials in the same study.

In this paper, a finite element analysis focused on steel alloys was performed to understand the specimen behavior in the early stages of the SPT. Present methods to correlate the material yield strength with the data obtained from the SPT curve were also analyzed via this FEM study to discover the meaning of the current correlation scattering for this mechanical property. This numerical research also proved the accuracy of the proposed correlation method for the yield strength via the SPT. The maximum slope of zone I ($Slope_{ini}$) of the SPT curve showed an accurate correlation with this mechanical property.

Focusing on steel alloys, experimental tensile tests and SPT's were performed to validate the numerical analysis and to demonstrate the suitability of the proposed $Slope_{ini}$ versus yield strength correlation method.

Keywords: Small Punch Test, SPT, yield strength.

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1 Introduction

In the early 1980s an innovative Miniaturized Disk Bend Test (MDBT) was developed as a cost-effective method to test the post-irradiated state of materials used in thermonuclear reactor applications [1-2]. Many researchers have investigated and improved this test, developing the Small Punch Test (SPT) as a test method for characterization. It consists of a punch which deforms a firmly gripped specimen between two dies until fracture (see Fig. 1). Research and investigation in the SPT were focused on the evaluation of material properties, including the elastic modulus, yield strength and tensile strength [3-5], ductile-brittle transition [6], fracture properties [7-10], etc. The significant interest shown by researchers in this testing procedure motivated the development of a CEN Code of Practice for the application and use of the small punch test method for metallic materials [11].

Results data recorded during SPT are the load/displacement curves (see Fig. 2). Zones distinguished in this curve are [12]:

Zone I: elastic bending.
Zone II: transition between elastic and plastic bending.
Zone III: plastic hardening.
Zone IV: softening due to material damage initiation.
Zone V: crack growth with a circular shape around the center of the specimen until failure.