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# Fatigue behaviour of T welded joints rehabilitated by tungsten inert gas and plasma dressing

Armando L. Ramalho [a,*], José A.M. Ferreira [b], Carlos A.G.M. Branco [c]

[a] Escola Superior de Tecnologia, Instituto Politécnico de Castelo Branco, 6000-767 Castelo Branco, Portugal
[b] CEMUC, Universidade de Coimbra, Rua Luís Reis Santos, 3030-788 Coimbra, Portugal
[c] ICEMS, DEM, Instituto Superior Técnico da UTL, Avenida Rovisco Pais, 1096 Lisboa Codex, Portugal

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ABSTRACT

This paper concerns a fatigue study on the effect of tungsten inert gas (TIG) and plasma dressing in non-load-carrying fillet welds of structural steel with medium strength. The fatigue tests were performed in three point bending at the main plate under constant amplitude loading, with a stress ratio of $R = 0.05$ and a frequency of 7 Hz.

Fatigue results are presented in the form of nominal stress range versus fatigue life ($S$–$N$) curves obtained from the as welded joints and the TIG dressing joints at the welded toe. These results were compared with the ones obtained in repaired joints, where TIG and plasma dressing were applied at the welded toes, containing fatigue cracks with a depth of 3–5 mm in the main plate and through the plate thickness. A deficient repair was obtained by TIG dressing, caused by the excessive depth of the crack. A reasonable fatigue life benefits were obtained with plasma dressing. Good results were obtained with the TIG dressing technique for specimens with shallower initial defects (depth lesser than 2.5 mm).

The fatigue life benefits were presented in terms of a gain parameter assessed using both experimental data and life predictions based on the fatigue crack propagation law.



## 1. Introduction

Fatigue life of welded joints is mainly influenced by pre-existing cracks in the weld toe [1] inherent with welding techniques used in steel structures. The presence of such defects, together with the stress concentration induced in the weld toe section, explains the relatively poor fatigue strengths of fillet welds. The fatigue crack initiation from the weld toe is despicable, and therefore the fatigue life is largely spent in crack propagation.

In this case, for welded joints, fatigue life predictions can be done by using mechanical fracture parameters [2]. For this purpose, solutions for stress intensity factors ($K$) can be found in the literature. Bowness and Lee [3,4] have developed a very extensive research to obtain database-estimated equations for the weld toe magnification factor ($Mk$) to T-butt joints. The proposed $Mk$ factors equations have been included in the British Standard BS 7910 [5], the replacement for PD6493 [6].

Post-weld improvement techniques remove the weld defects and/or reduce the stress concentration at the weld toe, increase the fatigue crack initiation period and afterwards improve fatigue strength. Techniques such as: TIG and plasma dressing, burr grinding, needle, shot and hammer peening have been studied in last decades and reported in numerous papers [7–11]. More recently, some attention has been placed on the investigation of high frequency peening treatment, referred to as ultrasonic impact treatment or as ultrasonic peening, that has proved to be an efficient way for fatigue life improvement [12,13]. The published results indicate, in general, large increases of fatigue strength by using these techniques [1,7,11]. TIG and plasma dressing are important industrial techniques, which produce more effective benefits than grinding [11]. However, the efficiency of these processes seems to be lower than hammer and ultrasonic penning [7,11]. The fatigue strength improvement achieved through these techniques, increases with nominal yield stress and therefore the greatest benefits are obtained for high strength steels [7,9,12,14,15]. Recently, some work has been focused on the application of these steels and post-weld treatments in the medium cycle regime, i.e. 10,000–500,000 cycles [15]. Since the best benefits obtained in the high strength steels appear to be related to the introduction of residual stresses, some studies have been conducted in order to analyse the effect of relaxation of these stresses under constant and variable amplitude loading and the effect of variable amplitude loading on the benefits of the improved joints [16–18].

Despite the large number of studies in this area, the use of these techniques in the design codes is still very limited. One reason for this reluctance is the wide spread of results reported by these studies [19]. The new approach of fatigue by hot spot stress,

* Corresponding author. Tel.: +351 272339300; fax: +351 272339399.
*E-mail addresses:* ramalhoarmando6@gmail.com, aramalho@ipcb.pt (A.L. Ramalho).

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