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Vickers Hardness Test of Steel Pipes Welded by High Frequency Induction

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The rapid development of design technology and strong market competition have prompted us to look into the field of production of steel pipes with a process that perfectly meets industrial requirements, which is high frequency (HF) induction welding, which is the most common welding process to produce steel pipes. This process is currently better known for the manufacture of pipes of different diameters at the Tube Gaz unit in Tebessa (Algeria). Among the various known destructive tests, the Vickers hardness test is used to control the pipe. This test will allow us to determine the evolution of hardness in the longitudinal and transverse directions of the welded joint. The objective of our study is based on the characterization of the processes controlling the mechanical behavior of steel pipes (type S235) with a thickness of 2.2 mm and an outside diameter of 70.70 mm, welded by HF induction. The analysis shows the existence of very diverse microstructures in the studied welded joint.

Keywords: Steel pipe, Hardness, Vickers, High frequency, Induction welding.

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1. INTRODUCTION

Tubes represent the most important semi-finished product in terms of steel production [1]. High-frequency (HF) induction welding is the most common welding process to produce steel pipes [2]. The HF induction welding process was discovered in the late 1940s, developed into reality in the 1950s, and became the main method to produce pipes in the late 1960s and 1970s [3]. Induction heating is a direct application of two fundamental laws of physics: Lenz's law and the Joule effect. By supplying an inductor with an alternating current at a given frequency (often between 50 Hz and a few hundred kHz), an electromagnetic field is created in the vicinity of this inductor. When a conductive body is immersed in these fields, it is crossed by a magnetic flux whose variations induce, according to Lenz's law, an electromotive force giving rise to eddy currents [4]. Electric resistance welded (ERW) pipes are increasingly being used in natural gas and petroleum services due to remarkable advances in fabrication, forming, welding, and other pipe manufacturing techniques. In addition, as the HF welded pipe meets the required standards, it can be economically used as a substitute for similar submerged arc welded (SAW) products or expensive seamless products under the most aggressive conditions of oil and gas production industries [5]. In the case of induction welding, the voltage is induced by the magnetic flux around the coil (without contact with the pipe) (Fig. 1) [6].

Edges of the coil material are heated up to high temperatures (Fig. 2a) and carbon along the surfaces is oxidized forming CO and CO_2. Afterwards, the heated edges are forged with external rolls and some metal is expelled (Fig. 2b) together with the oxides formed during heating [7].

At the welding point (1450 °C), the edges of an open pipe are pressed against each other by clamping rollers. Hot pressure welding follows, creating a bulk which is

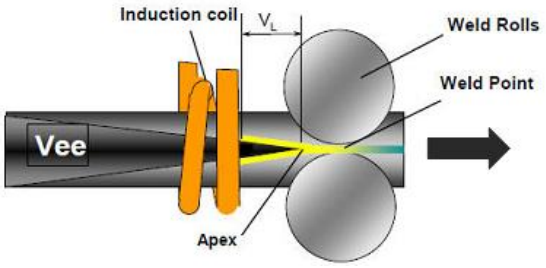

Fig. 1 – Joining of pipes by HF induction welding

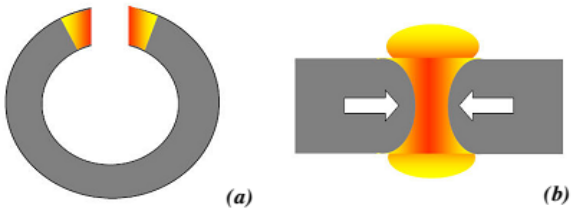

Fig. 2 – Illustration of (a) heating of the coil edges and (b) forging in HF induction welding for pipe production

removed from the outside, and possibly inside, by means of dimensions. All hardness testing methods require a good understanding of the testing process in order to obtain good results.

Hardness, which is a material control tool, is widely used to quickly determine whether the material being tested is suitable for its use. If the material is too soft, it may break due to the forces imposed on it. If it is too hard, it may crack due to brittleness of a scraper while the pipe is still hot. In some cases, welding is followed by cooling. The pipe is then calibrated, cold-formed, and finally shaped exactly.

Tubes and pipes require further examination due to their hollow shape. Obtaining the best results requires the proper choice of special techniques that can be used to improve the test method [8].

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