FATIGUE CRACK GROWTH RESISTANCE AND FRACTURE TOUGHNESS OF PIPE WELDS EXPOSED TO A BLEND OF HYDROGEN AND NATURAL GAS UNDER HIGH PRESSURE

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With respect to the carbon neutrality objectives, Natural Gas (NG) grids will be crucial by accommodating, in the medium term, new sustainable gases, from biomethane to pure hydrogen. As more specifically concerns H_2, a NG + H_2 blend will be initially transported in the existing grid, then, in a second stage, when the hydrogen economy will be more mature, pipelines dedicated to the transport of pure H_2 will be developed.

The option of using the existing natural gas network, however, raises the issue of the quantity of hydrogen gas that can be mixed with NG while guaranteeing safe operating conditions of the pipe, in particular in the presence of crack-type defects. In this regard, the present study was undertaken to assess the impact of hydrogen gas content in a blend with natural gas on the crack propagation resistance of pipeline girth welds representative of the actual grid. For this purpose, tensile, fracture toughness and fatigue crack propagation tests were carried out at room temperature on a servo-hydraulic machine equipped with an autoclave under NG, H_2 and blends under a total pressure of 8.5 MPa. CT specimens were prepared from various girth welds (respectively pipes with a diameter of 350 and 900 mm and 7 and 13 mm thick), so that the crack plane is located within the joint. Three couple of steel grades associated with a welding process were studied, namely two carbon steel pipes, a vintage pipe (X60) and a modern pipe in L415 (X60), welded using a manual cellulosic electrode welding process (SMAW), and finally a modern pipe in L485 steel (X70) welded by mechanized welding process (GMAW). It is shown that fracture toughness is only slightly affected by hydrogen in terms of K values, while plastic opening and CTOD values are affected to different degrees according to the weld under study. Furthermore, fatigue crack growth rates are enhanced by more than an order of magnitude in the 25% H_2-NG blend in the high ΔK region compared to NG. Additional analyses, in particular based on microfractographic observations, are presented to interpret these results.