Buckling failure of 310 stainless steel tubes with different diameter-to-thickness ratios under cyclic bending

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Abstract. In this paper, experimental and theoretical investigations on the response and collapse of 310 stainless steel tubes with different diameter-to-thickness ratios subjected to cyclic bending are discussed. The tube-bending device and curvature-ovalization measurement apparatus were used to conduct the experiment. The endochronic theory combined with the principle of virtual work and finite element software, ANSYS, were used to simulate the moment-curvature and ovalization-curvature relationships. It is shown that although the two methods lead to good simulation of the moment-curvature relationship, the endochronic theory combined with the principle of virtual work has the better simulation of the ovalization-curvature response when compared with experimental data and the simulation by ANSYS. In addition, the theoretical formulations proposed by Kyriakides and Shaw (1987) and Lee \textit{et al.} (2001) were used to simulate the controlled curvature–number of cycles to produce buckling relationship. It is shown that the theoretical formulations effectively simulate the experimental data.

Key words: 310 stainless steel tubes; buckling failure, diameter-to-thickness ratio; cyclic bending.

1. Introduction

Stainless steel tubes 310 are frequently used as the transporting tubes for oil, gas, and water. They are also frequently used as mechanical members, such as oil-drill tube, heat exchanger tube, and bike-frame tube. These tubes are constantly subjected to cyclic bending. It is well known that the ovalization of the tube cross-section (change of the outside diameter / original outside diameter, $\Delta D/o/D_o$) is observed when a circular tube is subjected to bending. If the loading history is cyclic bending, the ovalization increases in a ratcheting manner with the number of cycles. Increase in ovalization causes a progressive reduction in the bending rigidity, which can result in buckling of the tube components. Therefore, the experimental and theoretical studies of the response and collapse of 310 stainless steel tubes under cyclic bending are of importance in many industrial applications.

It has been found that a lot of metal tubes have been studied such as: 6061-T6 aluminum alloy tube (Kyriakides and Shaw 1987, Corona \textit{et al.} 2006), 7005-T51 aluminum alloy tube (Lee \textit{et al.} 2010), Ti-