BUCKLING LIFE ESTIMATION OF CIRCULAR TUBES OF DIFFERENT MATERIALS UNDER CYCLIC BENDING

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ABSTRACT

In this paper, the buckling life estimation of circular tubes of different materials subjected to cyclic bending is investigated. A tube-bending machine and a curvature-ovalization measurement apparatus were used to conduct the curvature-controlled cyclic bending test. Materials of the tested circular tubes include 304 stainless steel, 316L stainless steel, 70:30 brass, 7005-T53 aluminum alloy and Ti-2Al-Cb-Ta titanium alloy. The mechanical behavior (moment - curvature and ovalization - curvature relationships) and buckling life (relationship between the controlled curvature and number of cycles necessary to produce buckling) were constructed according to the experimental measured data. The endochronic theory combined with the principle of virtual work was used to simulate the mechanical behavior of circular tubes of different materials. In addition, a theoretical formulation was proposed for estimating the buckling life of circular tubes of different materials. It has been shown that the simulation results are in good agreement with the experimental data.

Key Words: circular tubes of different materials, cyclic bending, moment, curvature, ovalization, buckling life estimation.

I. INTRODUCTION

In 1985, Kyriakides and his co-workers designed a machine that can be used in experiments on tubes subjected to cyclic bending. Since then, a series of investigations has been conducted on tubes of different materials such as 6061-T6 aluminum tube (Shaw and Kyriakides, 1985; Kyriakides and Shaw, 1987; Corona and Kyriakides, 1991), 1018 steel tubes (Shaw and Kyriakides, 1985; Kyriakides and Shaw, 1987), 304 stainless steel tube (Corona and Kyriakides, 1988), and 1020 carbon steel tubes (Corona and Kyriakides, 1991).

After that, Pan and his co-workers also constructed a similar bending machine with their newly invented measurement apparatus to study tubes under cyclic bending (Pan et al., 1998). In their studies, tubes of several materials including Ti-2Al-Cb-Ta titanium alloy (Hsu et al., 2000; Lee and Pan, 2001), 304 stainless steel (Pan and Fan, 1998; Pan and Her, 1998; Lee et al., 2001; Lee et al., 2004; Chang et al., 2008) and 316L stainless steel (Lee et al., 2005) were investigated. In addition, Zhao and his co-workers also investigated different materials such as C350 steel tubes (Elchalakani et al., 2002), very-high-strength (VHS) round steel tubes (Jiao and Zhao, 2004) and concrete-filled tubular (CFT) beams (Elchalakani et al., 2004).

So far, theoretical investigations on the mechanical behavior have been successfully performed. The mechanical behavior includes moment-curvature and ovalization-curvature relationships. Note that ovalization is defined to be the change of the outside diameter divided by the original outside diameter. The method for simulating mechanical behavior involves using the plasticity theory as a basic stress-strain elastoplastic relationship. By using the principle of virtual work to formulate the problem, the relationship between the bending moment, curvature and ovalization can be obtained from the necessary equilibrium equations.