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On the Deformation Modes of Continuous Bending under Tension Test

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Abstract

In this paper the continuous bending under tension (CBT) test is analyzed by numerical simulation. In CBT test, the material is deformed to high level of strain that is beyond the achieved strain by the standard tensile test. The main stability criterion describes the importance of compressive stress produced by bending in stabilizing the deformation. At the symmetry line of the strip, the material can be assumed simply to deform by bending and stretching in plane strain condition. The focus of this paper is to study the deformation modes through thickness at the symmetry line. It is found that the material experiences three deformations modes. The cyclic parts through thickness experiences two deformation modes: the first is limited between uniaxial tension and plane strain and the second deformation mode is limited between pure shear and uniaxial compression. The third deformation mode is observed at the middle part through thickness and it is based on tension and the contribution of through thickness stress.

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1. Introduction

The continuous bending under tension (CBT) test can be seen as a tensile test on strip material with additional bending by a set of rolls that is traveling over the length of the strip. The main effect of additional bending is that the required tensile force for the same elongation is reduced [1]. The CBT test was proposed as a method for increasing elongation to investigate material properties at high levels of straining [2]. The deformation around rolls in the CBT test bears resemblance with the deformation around the spherical tool in incremental sheet forming (ISF). This resemblance motivated Hadoush et al to present a 2-dimensional finite element model for the CBT test as a simplified test of ISF process [3]. The main focus was to study the contribution of bending in stabilizing the deformation of a strip to high strain. Experimentally, Emmens and Boogaard showed that high levels of strain are obtained for various materials using CBT test [4]. Also, the CBT test is identified as incremental forming process because the strip, that is used in CBT test, is deformed incrementally rather than continuously as in a standard tensile test, the proposed CBT setup by Emmens and Boogaard is shown in figure 1.

Figure 1: CBT setup [4].

CBT test is a simple test to perform but many aspects of the test have not been investigated yet e.g. deformation modes during the test. Hadoush et al. present a numerical investigation, focusing on the process description, to analyze the obtained cyclic force-displacement curve of CBT test [5]. It is concluded that the cyclic force-displacement curve consists of two parts: a steady part and a transient part (peak). A simple mechanical model incorporating non-constant bending radius and cyclic material behaviour is presented in [6] in addition to an extensive overview on stability and formability of CBT test.

The focus of this work is to study the deformation modes during continuous bending under tension. Numerically, part of the CBT test is simulated which mimics qualitatively half cycle of the process. The stress

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