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A study of the braided corrugated hoses: Behavior and life estimation

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ABSTRACT

This work presents the virtual simulation of the hoses hydroforming; the main objective is to predict when and where cracks can appear during a cyclic loading.

A methodology has been proposed to investigate the effects of plastic strain and residual stress after hydroforming on cyclic life fatigue.

First, an axisymmetric simulation of the hydroforming of flexible metal hoses was accomplished using the finite element method, then a cyclic loading is applied, finally the life cycle is estimated using a model based on Chaboche's model.

The results are compared with experimental data, a good agreement is found if we take in account the residual stress and the hardening due to hydroforming.

A mechanical behavior model has been developed to study the braid which is the second element of the braided corrugated hoses; they are added to corrugated hoses in order to improve its radial and axial stiffness.

1. Introduction

Flexible corrugated hoses of stainless steel (Fig. 1) are mechanical components which are used in many applications, for example they are used to minimize the effect of vibrations on piping and car engines, doing well for this purpose, these components can suffer dynamic loads from gas and liquid pulsation and fail.

It is well-known that the metallic material is subjected to large irreversible deformation in hoses hydroforming, this leads to high strain and high stress localization areas, these two parameters have great impact on cyclic life fatigue of the hydroformed hoses [1–12].

Significant advances have been made in recent years for obtaining more accurate and reliable determinations of residual stress distributions. These include both experimental and numerical methods [13–16].

The failures of the corrugated hoses frequently happen in the form of small holes or cracks, therefore the conditions of leak before break is generally most frequent in prediction of damage; this enables the reduction of the failure consequences in a working environment [17]. Wang et al. [18] studied the effect of stamping on fatigue life FEM prediction using plastic strain and thickness variation Zapatero et al. [19] studied the influence of maximum load, the crack length and stress ration on the fatigue crack closure by means of finite element analysis. Matsui et al. [20] explored the influence of strain ratio on bending fatigue life and fatigue crack growth in TiNi shape-memory. Li et al. [21] used the finite element method to simulate the cyclic stress/strain evolutions for multi-axial fatigue life prediction. Marakami et al. [22] studied the effect of hydrogen on cracks propagation of SUS316L flexible hoses of hydrogen station, Marron et al. [23] dealt with the effect of forming in the design of deep drawn structural.

The objective of this study is to improve the fatigue analysis using finite element method considering effects of hydroforming (residual stresses and plastic hardening) on cyclic life fatigue of corrugated hoses.

In addition to the accurate parameters of fatigue damage models, the investigations of this work showed that the accurate estimations of the cyclic stresses, residual stresses and plastic strains after hydroforming are very important to have an accurate estimation of fatigue life, thus a performant element and a refined mesh are required to do the analysis.

2. Hydroforming effects of the corrugated hose

The case selected in this study is a corrugated hose used in automobile engines; the corrugated hose is manufactured from a straight tube. The original blank is a stainless steel tube (**AISI 316L**), the mechanical properties are shown in Table 1 and the hardening curve is shown in Fig. 2, The initial thickness of the tubes **0.25 mm**. A non-linear FEM code is used to simulate the hydroforming process.

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