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Finite element analysis of tooth load distribution on P-110S conic threaded connections

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ABSTRACT

Based on elastic mechanics and by use of thick cylinder theory, this paper presents a finite element analysis model with interference fit and axial load on P-110S conic threaded connections and the tooth load distributions on contact threaded surfaces were investigated. A 2D finite element model with elastic-plastic axisymmetric contact threaded surfaces was established and the tooth load distributions on its thread teeth were analyzed under different interference fit and axial load. Results for the loads on every engaged tooth are obtained. These indicate that the load distribution on the engaged teeth is not uniform, with the maximum tooth load concentrated on the first three pairs or the farthest two pairs of engaged teeth from the pin end and the middle teeth only bear a very small load. Such results are identical to the practical situation and indicate that the finite element model proposed in this paper is reasonable.

1. Introduction

Conic threaded connections are widely used in the oil industry and this kind of connection has advantages of well assembly, high joint strength and good seal ability. However, failure on threaded connections is the main factor in oil tubing and casing accidents. According to a survey, thread failure mostly happens on the joints of threaded connections in oil industry. Thus, improving the quality of threaded connections has a positive effect on deep oil drilling project.

Researches in the past indicate that every thread tooth was under a different load, which leads to the damage or destruction of threaded connections. Stromeyer [1], Den Hartog [2], Goodier [3] and Sopwith [4] analyzed threaded connections subjected to axial load to find out the load distribution on the teeth and they observed that the maximum load occurs at the first tooth pair from the tool joint shoulder or the farthest loading tooth pair from the pin end. Heywood [5] concluded that the variation of stress concentration factor along the teeth is due to two different mechanisms. The first is tooth bending like a cantilever beam, and the second is notch stress effects.

More recent investigations into the distribution of load in threaded connections have involved the use of finite element methods. Yuan and Yao [6] made a non-linear finite element analysis in API round threaded connections under make-up torque and axial tensile load. Tafreshi and Dover [7] analyzed threaded connections using FEM to obtain the location of maximum stress concentration at the drill string tool joint under axial load, pure torsion and bending. Bahai [8] used 2D finite element modeling to calculate the SCFs for API thread connectors used in drill string applications. The threaded joint was subjected to preloading, axial loading and bending loads. Baryshnikov and Baragetti [9] determined the percent of load bearing of each tooth to calculate allowable loads for API drill string threaded connections under bending, axial and combined loading. They concluded that in different conditions of loading, the first engaged tooth has the greatest contribution in load bearing and bears 20% of the total load. Chen and Shih [10] performed a finite element stress analysis under the conditions of make-up torque and axial tension load and proposed a theoretical guide to enhance the API tubing performance. Brennan and Dover [11] made analysis in stress strength on both pipe threaded and conic threaded connections. Placido [12] conducted some experiments on full and reduced scale samples of aluminum drill pipes under cyclic bending and constant tensile loads to investigate their fatigue mechanism. Tanaka [13,14] introduced a modified two-dimensional finite element method to analyze such cases as threaded connections subjected to a transverse displacement and flange coupling under an arbitrary type of loading for typical examples of the threaded connections subjected to an external load. Fukuoka [15] used an axisymmetric finite element method with four types of model that included the effects of friction on two contact surfaces between threads of the bolt and nut, and between fastened plate and nut.

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