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Fatigue analysis of low alloy steel forgings used in the subsea industry

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Abstract

Design $S-N$ curves are presented for low alloy machined steel forgings. Separate $S-N$ curves are given for air and for seawater with cathodic protection. The selection of the $S-N$ curve is made based on the tensile strength and the surface roughness. $S-N$ curves for four tensile strength classes and two surface roughness classes are given. The tensile strength classes cover steels with a tensile strength in the range of 517 MPa to 793 MPa. The two surface roughness classes cover surface roughnesses up to $R_a = 6.3$ μm. Separate $S-N$ curves are given for a stress ratio of $R = 0$ and for a high mean stress. Secondly, a method for adjusting the peak stress in the notch root with respect to the stress gradient is presented. The stress gradient corrected peak stress is used with the presented $S-N$ curves for estimating the fatigue life of fatigue tested notched specimens with typical subsea design features. All estimated fatigue lives are demonstrably conservative compared to the test results for the wide variety of notched specimens types considered.

Keywords: Design $S-N$ curves, mean stress factor, notch support factor, notched specimens, fatigue life estimation

1. Introduction

This paper is the culmination of a large study and gives fatigue design guidance drawn from the four earlier papers [1–4] presenting experimental fatigue data for machined low alloy steels frequently used in the subsea industry. Fatigue data for smooth specimens tested in air and in artifical seawater with cathodic protection (CP) are given in [1, 2]. Fatigue test results for notched specimens tested in the same two environments are given in [3, 4]. The fatigue testing in artifical seawater with CP was performed using a potential of -1050 mV Ag/AgCl. The fatigue tested specimens were all machined from hollow, thick-walled steel forgings having tensile strengths ranged from 600 to 800 MPa.

In [1], the effect of the surface roughness, mean stress and material strength on the high cycle fatigue crack initiation life on low alloy steels were evaluated based on experimental data. Further, a method for estimating the $S-N$ curve for a smooth low alloy steel specimen from the tensile strength or the Vickers hardness was presented.

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