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Redefining the OCTG Fatigue—A Theoretical Approach

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Abstract

New drilling technologies and new well applications (e.g. gas storage wells, deep water wells, CO_2 sequestration wells) are producing a different load on Oil Country Tubular Goods (OCTG) than those considered and accepted by the API. Casing drilling is one of the examples in which excessive torque and wear must be added to the casing design stage in order to obtain good well integrity. Fatigue is not an unknown failure mode for mechanical components, but it was considered as being un-important for well tubulars such as casing or tubing.

Based on the increased demand on OCTG to serve the new technologies, many of the OCTG manufacturers are developing new systems in which the fatigue aspects are considered. The increase in non-typical uses of OCTG makes the selection criteria for these new applications more difficult than conventional well usage. During the life of a well the fatigue load of a casing string may change from simple fatigue (high cycle) to low cycle fatigue. Based on these changes, a damage accumulation method must be applied in order to estimate the total life of the casing.

This paper presents a theoretical approach to the fatigue of OCTG focusing on how and when fatigue becomes a critical load for the OCTG, especially casing. It will be shown that fatigue has a direct influence on long-term wellbore integrity. Also the causes of fatigue will be investigated for different well applications such as HPHT or underground storage wells.

Introduction

Although the casing string is generally statically or quasi-statically loaded, in the special cases of steam injection or geothermal wells the casing string is subjected to variable loads due to temperature changes or variable internal pressure. Due to the restriction of axial movement (i.e. cement ring around the casing) temperature variation induces thermal stresses in the casing string. The value of the induced thermal stresses may exceed the material yield strength and the failure mode of the casing material can be considered as low-cycle fatigue. The presence of changes in the cross section of the casing body (i.e. thread) acts as stress concentration zone (notch) and reduces its low-cycle fatigue resistance or fatigue life.

Connections are the most critical element of a casing and tubing. They should provide sealing and mechanical resistance for a successful drilling operation and long life production or injection of the well.

In today's progressing drilling technology, connections are manufactured in order to withstand a more complex technical and economical demand. More exacting connections must be able to withstand the demands of increased production, as well as greater depths where they are exposed to higher temperatures and higher pressures. New technologies such as casing drilling also need reliable connections to provide successful results. To meet these challenges many modern and innovative designs have been developed by traditional and pioneering manufacturers and are now available for application on the field.

This growing number of connections may have advantages and disadvantages, depending on the case characteristics and costs. These pros and cons are not visibly to the naked eye could be similar types on the market that could be favorable and also economical for a certain case.

OCTG

Based on the actual OCTG design one tubular can be divided in three components: body, transition zone and threaded zone or connection, see F**ig. 1**. Each one of these zones is subjected to specific loads and may fail differently. For example the threaded connection may fail due to internal pressure by losing its tightness while the body may fail due to burst. **Figure 2** shows a classification of possible loads for OCTG, after [6]. The loads are classified as mechanical and thermal induced loads. In the category of mechanical loads, static and dynamic loads will form sub-categories.

Typically, OCTG are classified by their outer diameter (OD), weight or wall thickness (WT) and grade. These dimensions allow the well designer to choose the proper well geometry. Additionally, the connection type is the element that has the greatest affect on the casing string integrity. Since all tubulars are jointed to each other by connections, the individual connection integrity affects the entire system integrity. The following factors may influence the connection integrity: stress strain-state after make-up, load level given by coupling location inside of the casing string, material imperfections and manufacturing tolerances.