

SURVIVAL ASSESSMENT AND FATIGUE ANALYSIS OF DIE-MARKED DRILL PIPES, USING FINITE ELEMENT METHOD AND COX REGRESSION MODEL

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Summary. Drill pipe fatigue damage occurs under cyclic loading conditions due to, for instance, rotation in a dogleg region [1, 2]. This paper presents two approaches to evaluate damage in drillpipes. First, Finite Element Method is used to evaluate cumulative effects of fatigue damage with respect to the actual drilling conditions and the fatigue damage curves for smooth and die-marked drillpipes are obtained. Second, as a case study, the Cox Regression Model, a broadly applicable method of survival analysis is used to analyze the failure data of the southern oilfields of Iran. The resultant cumulative survival and hazard functions can reliably predict the time of failure.

1 INTRODUCTION

Failure due to fatigue is a very costly problem in oil and gas industry [3]. The purpose of this study is to present two approaches to evaluate fatigue damage in G-105 drillpipe [4] when it passes through a hole that has a change in direction. (a dogleg)

2 FINITE ELEMENT METHOD

In this approach, first a portion of the drillpipe in transition area of tool joint is modeled and all the boundary conditions with respect to the actual drilling conditions were applied. The results show how the geometry of drillpipe in transition area and die-marks, raise the stress. As it is shown in figure 1, stress concentration factors are ranging between 1 and 2.8 for a die mark depth ranging between 0.1 and 1.8mm (see Fig. 1).

The concentrated stresses are then determined and used in a fatigue damage calculation. Fatigue damage curves are presented, considering dogleg severity (DLS) between 1 to 5 degrees per 100 feet. These graphs can be easily used to determine the allowable length of a G-105 drillpipe below dogleg that consumes 100% the fatigue life of the pipe section (see Fig. 2, 3).

As it is obvious from the graphs, by increasing DLS from 1 to 5, the allowable length below dogleg will decrease. Also, we see that the current approach of fatigue analysis using smooth pipe surface is not reliable and doesn't predict fatigue failures with sufficient accuracy.

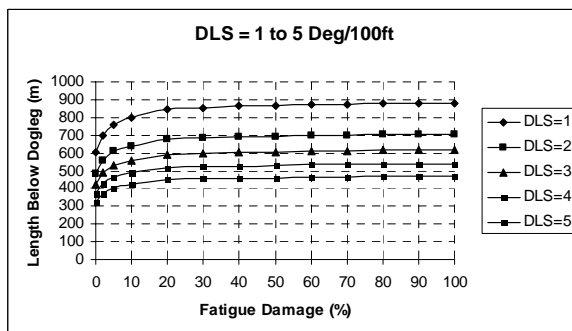


Figure 2: Fatigue curves for DLS ranging 1 to 5 deg/100ft for smooth drillpipe

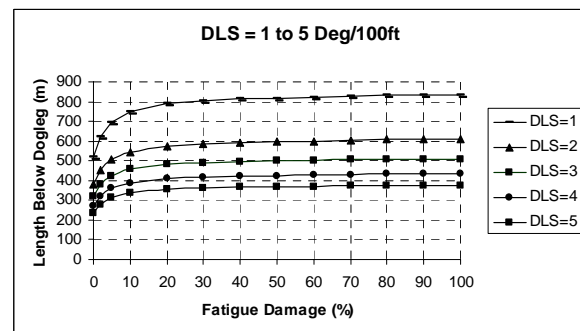


Figure 3: Fatigue curves for DLS ranging 1 to 5 deg/100ft for 0.3 mm die-marked drillpipe

3. COX REGRESSION MODEL

The Cox regression model is a standard tool in survival analysis for studying the dependence of a hazard rate on covariates (parametrically) and time (nonparametrically) [5]. The model showed that only three parameter including weight on bit, rotating speed of the drillstring and neutral point in drillstring from the six considered parameters are affecting the time of failure and based on predicts the survival and hazard functions (see Fig. 4).

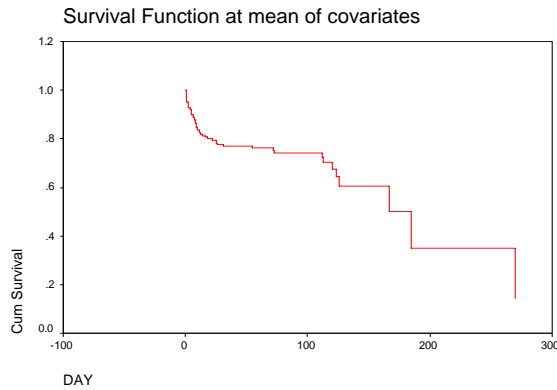


Figure 4: Survival Function Curve

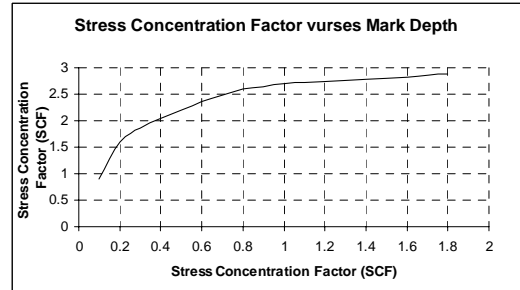


Figure 1: SCFs for Die-Mark Depth ranging from 0.1 to 1.8 mm

4. CONCLUSION

- The analysis showed that end of the internal upset taper, is the most likely area for a washout to occur.
- The stress concentration factors, versus die-mark depth were analytically determined. The SCFs was ranging 1 to 2.8 for die-mark depth between 0 and 1.8mm (0.07 inch).
- The fatigue life of die-marked drillpipe that passing through a dogleg region was calculated, by using S-N curve with equivalent alternating stress to take into account the effects of stress concentration factors and axial tension load.
- the results are presented graphically for G-105 drillpipes to easy calculate the allowable length of a G-105 drillpipe below dogleg that spend 100% the fatigue life of the pipe section.
- As a case study, survival analysis, using Cox regression model, was done on failure data obtained from the southern oilfield of Iran to predict the failure time with respect to actual drilling parameters.

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