Available online at www.sciencedirect.com
ScienceDirect
Procedia Engineering 12 (2011) 236–241
Engineering Procedia

2011 SREE Conference on Engineering Modeling and Simulation

Simulation Technology in Failure Analysis of Drill Pipe

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Abstract

Drill pipe failure accidents often occur in oil exploration and development process, especially in transition zone position. With the help of ANSYS software, established the analysis model based on the structure of drill pipe, and analyzed the stress state of the transition zone position. Analysis results show that the transition zone is the weakest position of the whole drill pipe. Length of transition zone Miu and transition zone chamfer radius R has significant influence on stress concentration factor Kt, which is in good agreement with the actual situation. At the same time, optimization of the Miu and R values based on the minimum Kt value of transition zone was finished. Simulation analysis not only helps analyze failure cause, prompts drill pipe structural optimization, improves research methods and saves a lot of financial resources.

Selection and/or peer-review under responsibility of Society for Resources, Environment and Engineering

Keywords: modeling, simulation, drill pipe, failure analysis, optimization;

1. Introduction

Drill pipe is an important tool in oil and gas exploration and development process, which locates in the upper part of the drill string. During working process, complex loads including tension, torque, bending torque, centrifugal force and vibration load was acted on drill pipe. Drill pipe failure accidents often occur [1-6], and lead to a lot of human, material and financial losses. Therefore, analyze failure cause and improve design is very important for safe and efficient conduct of drill pipe in petroleum exploration and development process. Several drill pipe leakage failure accidents occurred in one oilfield, shown in

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doi:10.1016/j.proeng.2011.05.037

Figure 1. Drill pipe's failure location focused on drill pipe within the transition zone region. Drill pipe's chemical composition, mechanical properties, microstructure, crack propagation and cross section morphology were analyzed. Results show that the mechanical properties of drill pipes meet relevant standard requirement, and their failure is fatigue failure. In order to analyze the cause of early fatigue, we established the analysis model based on the structure of drill pipe, and analyzed the stress state of the transition zone position.

2. Modeling

Schematic diagram of the drill pipe is shown in Figure 2, which consists of tool joints and seamless tube by friction welding. As a result of the changes in structure size, transition zone becomes the weakest position of the drill pipe, the structure size of transition zone shown in Figure 3. Minimum length of transition zone Miu and the fillet radius of curvature R are two important parameters. The fillet radius of curvature R is not clearly defined in the present standards on drill pipe. In order to analyze the effect of both Miu and R on the stress distribution of drill pipe. We define Miu and R as variable parameters, and analyze their influence on stress concentration factor Kt. Analysis model is established with ANSYS software, and stress distribution state is researched. Considering the drill pipe's axial symmetry characteristics, establish axial symmetry plane model shown in Figure 4. Grid model is shown in Figure 5. In order to facilitate analysis, local grid in the transition zone surface is refined.

Fig.1 Washout morphology of drill pipe in transition zone

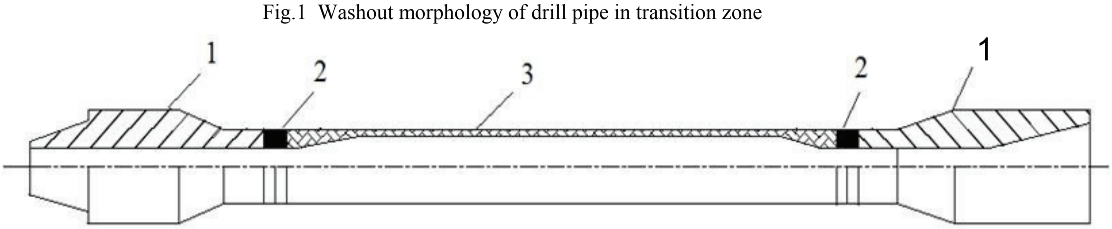

Fig.2 Schematic diagram of the drill pipe

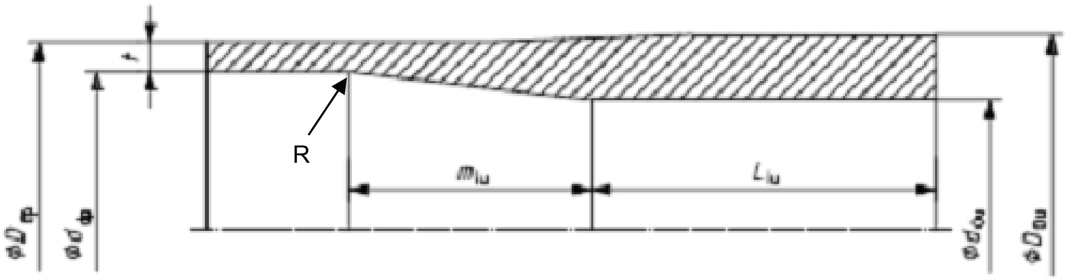

Fig.3 Schematic diagram of the transition zone

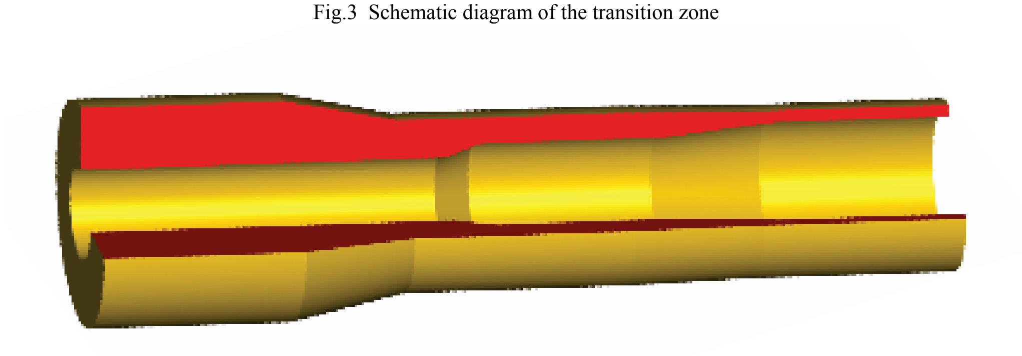

Fig.4 Simulation model of drill pipe

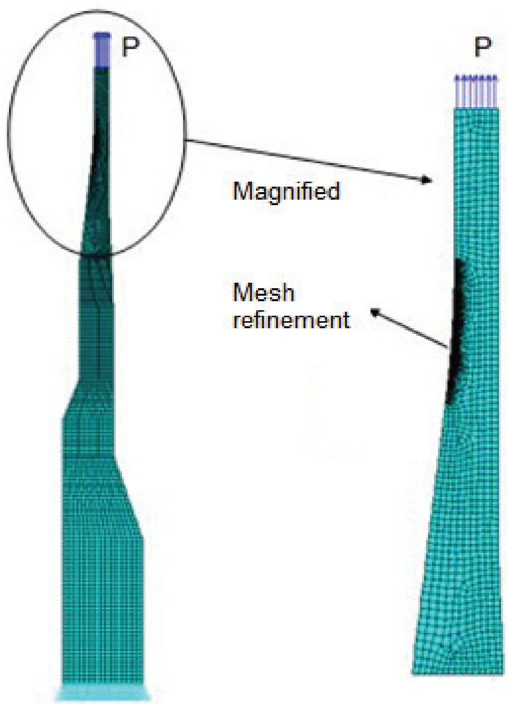

Fig.5 Mesh of simulation model

3. Simulation analysis

In order to simplify loads, we consider the axial tensile stress as the main factor in simulation process. Simulation analysis shows that the stress concentration in transition zone regions is significantly serious than that other parts of drill pipe and tool joint, and the most serious location is the fillet radius of curvature between transitional zone and tube pipe. Stress distribution indicates that transition zone is the weak position of the drill pipe. In fact, transition zone is the main location, where washout or fracture occurs. Statistics show that 85% of the drill pipe failure occurred in the site. Figure 6 shows the stress distribution of simulation model.

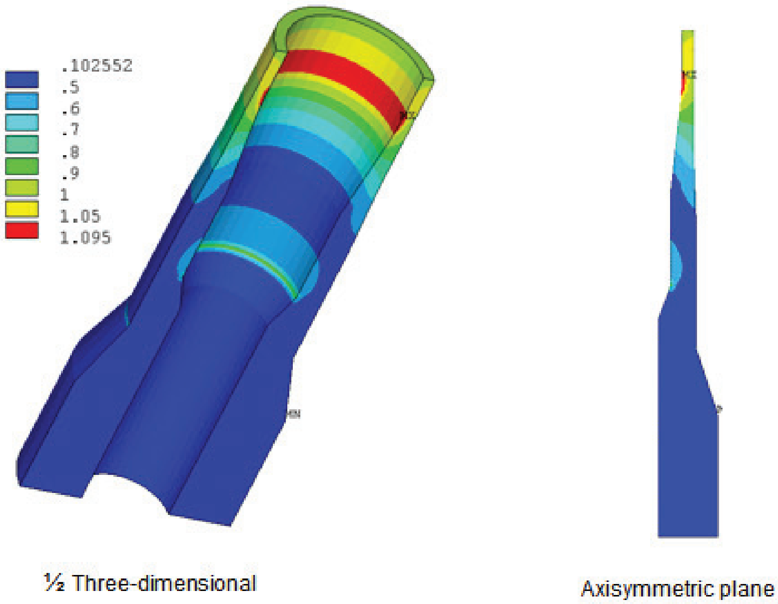

Fig.6 Stress distribution of simulation

During research process, transition length Miu is variable during 40mm to160mm range and the transition radius R is variable during 0 to 300mm range. Curves of stress concentration factor Kt with Miu for certain fillet radius of curvature R as shown in Figure 7. Curves of stress concentration factor Kt with R for certain length of the transition zone Miu shown in Figure 8. It can be seen from Figure 7 that the stress curve whose R is 0 is on the top of all the curves, on the other mean, its stress concentration factor Kt is maximum. With Miu increasing, the curve decreased rapidly, which means that increasing the length of Miu is one effective method of reducing the stress concentration factor Kt. For the curves whose R is 20 mm or R is 40 mm, when Miu is in 90mm to 160 mm range, there are some mutations. That means change of stress concentration factor Kt is more complex, and 20mm to 40mm range is not appropriate to Miu. When R changes from 80mm to 300mm, the stress concentration factor is basically a regular decrease with the Miu increasing. R is larger and Miu is longer, Kt is smaller. When R is greater than or equal to 240mm, the curve tends to a horizontal line Kt with the Miu increasing and Kt does not obviously change. Available from the Figure 8, in the Miu certain, when R changes from 0 to 100mm, Kt curves whose Miu is 100mm, 120mm and 160mm have several mutations. Therefore, R should be larger than 100mm.When Miu is160mm and R is 200mm, stress concentration factor Kt is the lowest.When Miu is greater than 40mm, stress concentration factor Kt decreases with R increasing. When R is up to 300mm, Kt of different Mius tend to a minimum value. Figure 9 shows the maximum stress concentration factor with different R as Miu is 80mm. Above all, when R is 300mm, the stress concentration factor Kt is relatively stable and small.

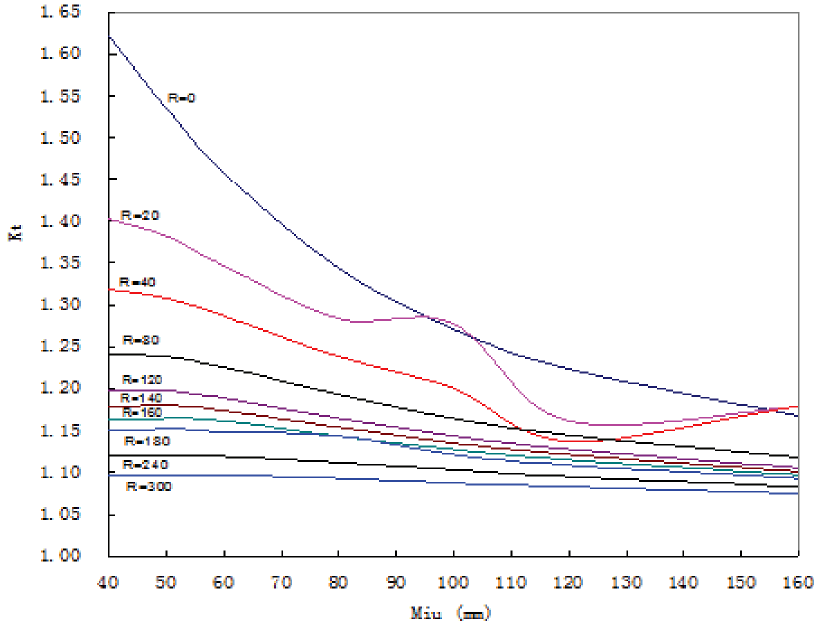

Fig.7 Relationship between Kt and Miu

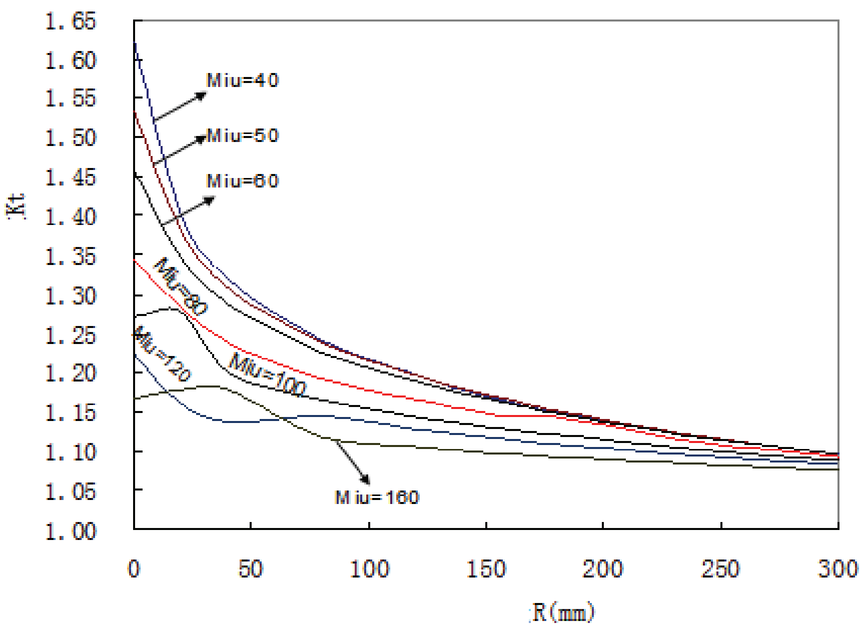

Fig.8 Relationship between Kt and R

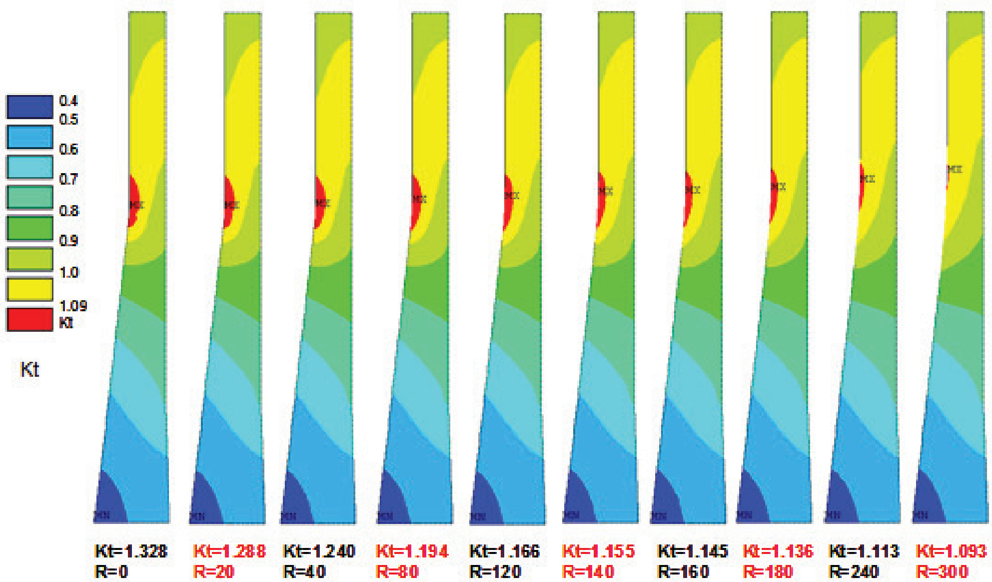

Fig.9 Changing of Kt with R as Miu is 80mm

4. Simulation Conclusion

(1) Under the effect of axial tensile load, stress transition zone in is significantly serious than that of other parts of drill pipe and tool joint. The stress concentration in the position of transitional zone round corner is the most serious of all.

(2)R value shoulder be no less than 100 mm, or it is easy to cause fluctuations on stress concentration factor Kt curves.

(3)When Miu is 160mm and R is 300mm, stress concentration factor Kt is decrease to the minimum, and it is the best structure size.

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