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Research Article

Longitudinal Harmonic Response Analysis of Drill String in Deep Well by Using ANSYS

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Abstract: With energy consumption and the development of exploitation technology of oil and gas underground, the drilling engineering has developed toward the direction of deep well, even ultra-deep well. The problem of fatigue of drill string has a great effect to drilling engineering. Strong vibration is one of the main reasons that induce drill string fatigue. In this study drill string of deep well is object being studied. The models about longitudinal vibration is set up. First, modal vibrations of drill string are studied. Then, harmonic response analysis of drill string vibration is studied. Rules of all kinds of free frequency are obtained by drilling instance. This study can offer basic method for optimizing drilling tool of deep well and drilling parameter for the purpose of reducing drill string failure.

Keywords: ANSYS, deep well, drill string, harmonic response, longitudinal vibration, modal

INTRODUCTION

Drill string is the important tool during drilling of deep well. In fact, drill string is a very complex system, drilling tool's fatigue has often taken place in the oil field, drilling operators have been worried about these fatigue problems for a long time. The expenses because of drill string fatigue were so high each year that some of drilling well had to stop drilling continually. The treatment of these accidents had consumed great manpower and material resources, at the same time it affected drilling speed badly. The stronger vibration of drill string was the main reason of drill tool's fatigue (Zhao and Long, 1988; Yan and Han, 2009). There are many kinds of vibration, but longitudinal vibration is stronger than other vibration, questing for the dynamical behavior has been an important problem during the drilling engineer. But the problem of drill string vibration is complex. This study will arm at the problem of drill string vibration of deep well in Daqing oil field, various vibrations of drill string are studied by using ANSYS and the basic rule of drill string longitudinal vibration are obtained. The result is important to drilling operation.

SIMULATION OF DRILL STRING

Modeling of free vibrations of deep well drill string: For the model set up in this study, the main factor should be paid attention and the effect of subordinate factor is ignored. At the same time the equipment in the mouth of well is simplified. The big rope is considered as spring; the hole track of well is thought of straight line; the effect of sub of drill string is ignored; the stabilizer is ignored; the drill string is simplified as the system that is made of drill collar and drill pipe; the density of drill liquid is 7.85×10^3 kg/m^3 (Zhao and Long, 1988). Based on the suppose, the model of drill string is set up by using ANSYS. The job name is Songshen2 Daqing, the title is harmonic analysis of drill string of Songshen2. For the drilling system of deep well, choose combination>spring damper 14 is the type of steel wire of the mouth of well. Then choose pipe>immersed 59 is the type of drill pipe and drill collar, pipe59 can endure pull, press, wrest and bend and that pipe59 can simulate the mechanics effect of the liquid outside pipe. Pipe59 cell embodies the equal distributing mass by density manner, in the cell the effect of stress stillness and big distortion can be considered (Jing *et al*., 2003).

During the drilling engineering of deep well, along with the depth increasing, the drill string stiffness will decrease comparatively and drill string presents itself losing steady, as drill string on the situation of resonance, drill string will be destroyed. The behaviors of drill string vibration commonly are: longitudinal vibration, lateral vibration and torsional vibration, sometimes coupled vibration. The longitudinal vibration is along the axes of drill string, the strong longitudinal vibration can cause easily drilling accidents, such as bit bouncing, bit fatigue, buckle blocked and drilling tool rupture. Lateral vibration is also string vibration, this form of vibration is like string vibration, when lateral vibration takes place, the big drilling rope in the mouth of well maybe shake. Torsional vibrationl is also commonly form of motion of drill string, when torsional

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vibration happened, drilling tool loses control, Bottom Hole Assembly strikes the well wall, then causes the fatigue of drill string and well wall caved in. When the moving frequency of drill string is near to the free frequency, drill string is in the condition of resonance, the condition is very dangerous (Han and Yan, 2006; Li and Gao, 2007). For vertical deep well, the longitudinal vibration is more easily taken place. So this paper studies the longitudinal vibrations, in order to optimize parameter, reduce the fatigue of drill string and enhance the drill efficiency. The study of drill string vibration is important to the drilling works.

For Songshen2 well of Daqing, the drill string structure is: Φ215.9 mm three teeth bit ×0.25 m + Φ215×1.6 m LF1 + Φ159×71.4 drill collar ×1.52 m + Φ215×1.6 m LF2 + Φ159×71.4 drill collar ×9.0 m + Φ214×1.6 m LF3 + Φ159×5.44 m Damper + Φ159×71.4×18.0 m + LF4 Φ214×1.6 m + Φ159×71.4×27.0 m + LF5 Φ214×1.6 m + Φ159×71.4 drill collar ×207.0 m + Φ127×76.2 HW drill pipe ×27.0 m + Φ127×108 drill pipe.

Drilling parameter: Well depth is approximately 5000 m, the averaged weight on bit is 180.00 kN, the rotary speed at 80.0 rpm. The material property is liner, elastic and isotropic, EX = 2.06×10^{11}, PRXY = 0.3, density is 7.85×10^{3} m/s.

Setting up the model, meshing, solving: The drilling system is set up along the y-axes negative direction under the global Cartesian, the coordinate origin is in the mouth of well. Different segment of drill string is belonging to its different element type and real constant. Then according to practice the drill string is meshed, the No. of element division of steel wire of the mouth of well is 1; the drill pipe and drill collar are meshed according to the real size (Han and Yan, 2005; Hong and Liu, 2002). Click the solution, choose modal, the displacement of top point is zero, hold the longitudinal or lateral or torsional master degree, then solve. If the solution is done, look over the results summary and look into the animate mode shape of various vibration and contour plot>DOF solution>displacement of vector sum.

Table 1: Frequency of longitudinal vibration

n	1	2	3	4	5
f (Hz)	0.21	0.67	1.23	1.66	2.18
n	6	7	8	9	10
f (Hz)	2.70	3.23	3.76	4.28	4.81

LONGITUDINAL MODAL OF VIBRATION OF DRILL STRING

Different vibration style of different frequency can be obtained, the weaken part can be seen by studying the displacement of vibration of drill string. For Songshen2, when well depth is 5000 m, the results analyzed by ANSYS are followed, Table 1.

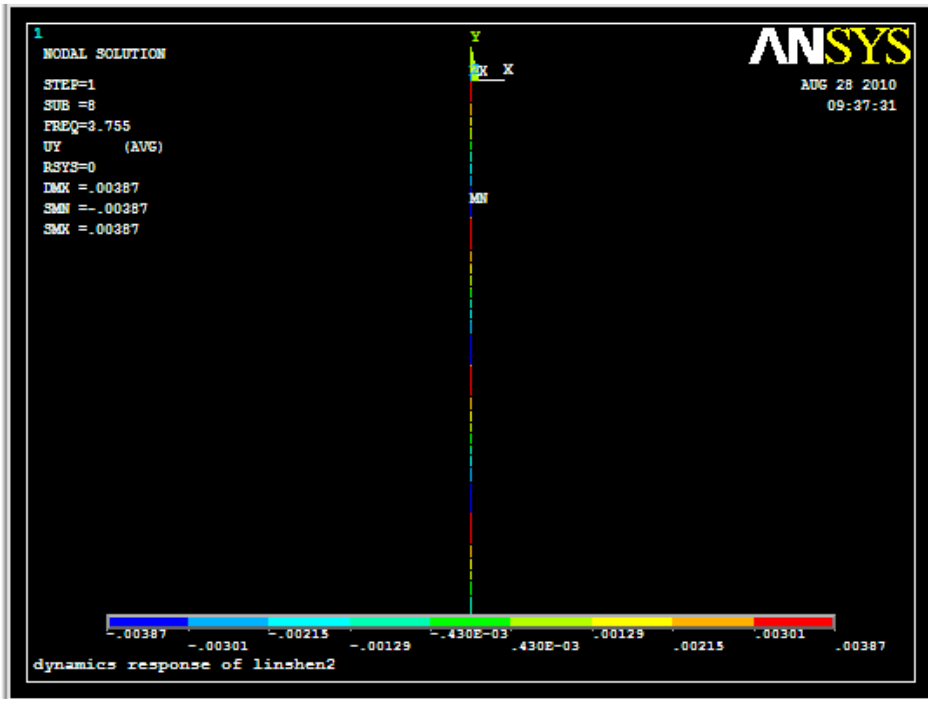

Fig. 1: Modal situation for 3.76 Hz

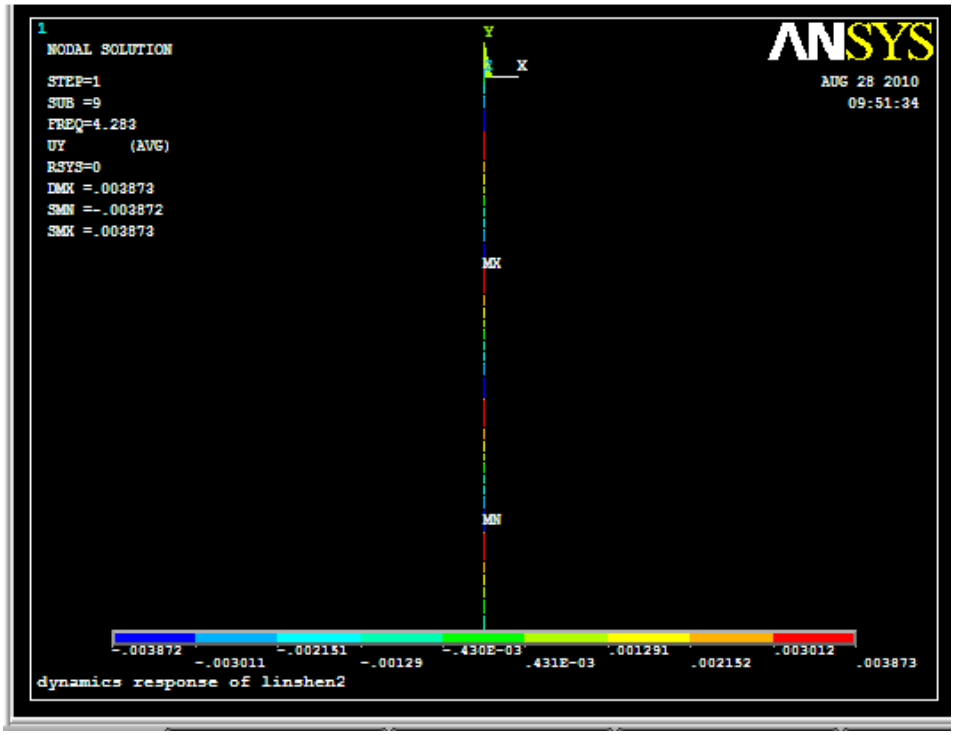

Fig. 2: Modal situation for 4.28 Hz

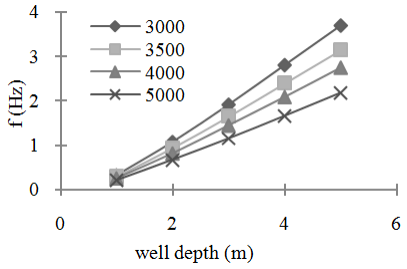

Fig. 3: The longitudinal vibration for different well depth

The Table 1 shows that the longitudinal resonance of drill string takes place easily. Because Songshen2 well used the three teeth bit at this segment, the bit running a circle, the longitudinal vibration of drill string appeared three times, this provided the source of surge vibration for longitudinal vibration. For example, when the rotary speed is 80 rpm (1.33 Hz), the frequency of longitudinal vibration is closed to the nature frequency 3.99 Hz, this value is close to 3.76 and 4.28 Hz and so on. This situation must be avoided during drill engineer. The modal situations for 3.76 and 4.28 Hz of longitudinal vibration can be obtained, Fig. 1 and 2.

When longitudinal vibration frequency is 3.76 Hz of drill string, the part of well mouth has large displacement, the displacement is 3.8699×10^{-3} m, Fig. 1. For the frequency 4.28 Hz, the part that has large displacement is in the upper middle, the displacement is 3.8727×10^{-3} m, Fig. 2.

The frequency of vibration of drill string maybe change with the change of drill string parameter, the effect for the drill string length to frequency can be obtained. The frequency of longitudinal vibration decreasing with well depth increasing, the frequency of longitudinal vibration increasing with step increasing, Fig. 3.

HARMONIC ANALYSIS OF LONGITUDINAL VIBRATION OF DRILL STRING

The range of frequency is 0~5 Hz; the solving step is 50; the force acted on the bit is periodic, magnitude is 5000 kN. The response situation of drill string can be obtained for the well depth 4000 m, Fig. 4 and the response situation of drill string can be obtained for the well depth 5000 m, Fig. 5.

For well depth 4000 m, three nodes are selected. These nodes lie in the part of bottom of well, lower part and above part of drill string. The longitudinal vibration for these nodes performances stronger at frequency 3.4 Hz, this situation is strongest for sixth step and the node in the above part of drill string has stronger vibration.

For well depth 5000 m, three nodes are selected similarly. The longitudinal vibration for these nodes

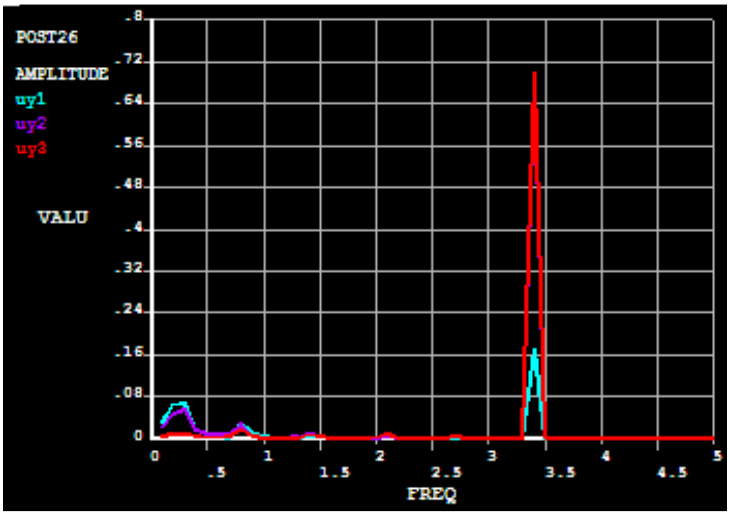

Fig. 4: Harmonic response of drill string 4000 m

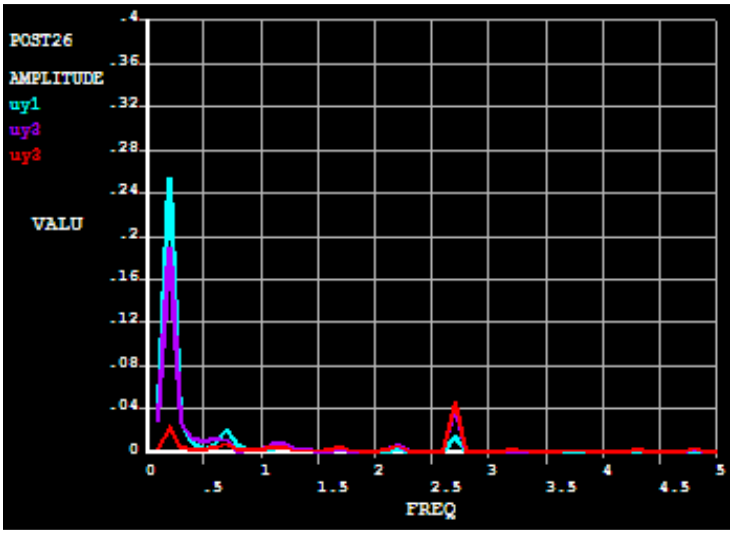

Fig. 5: Harmonic response of drill string 5000 m

performances stronger at frequency 0.2 Hz, this situation is strongest for first step and the node in the part of bottom of well has stronger vibration.

CONCLUSION

The various kinds of vibration of drill string are pervasive problems for deep well. The results must be prejudged before drilling; the harmonic vibration of drill string shows the state of drill string system under different frequency. ANSYS has extensive applied foreground for the drilling engineering. The harmonic response analysis is a kind of very important method to study the vibration of drill string.

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REFERENCES

Han, C.J. and T. Yan, 2005. Analysis on drill string vibration of deep well. Nat. Gas Ind., 25(9): 76-79.

Han, C.J. and T. Yan, 2006. Study on drill string vibrations in extended reach wells and its application. Nat. Gas Ind. China, 26(6): 72-74.

Hong, Q.Z. and Q.J. Liu, 2002. ANSYS Teaching Example. Chinese Railroad Press, Beijing.

Jing, J.G., X.Y. Shu, N.L. Wei and H.B. Lin, 2003. Drilling Pipe Torsional Vibration Analyses with ANSYS. Software Exploration Eng., Supplement: 176-179.

Li, Z.F. and B.Y. Gao, 2007. Analysis of Longitudinal Vibration of Drillstring in Air and Gas Drilling. Proceeding of the Rocky Mountain Oil and Gas Technology Symposium Hold in Denver (SPE 107697), April, 16-18, Denver, Colorado, U.S.A.

Yan, T. and C.J. Han, 2009. Analysis on drill string vibration in deep wells by ANSYS. Proceeding of the International Conference on Pipelines and Trenchless Technology, October 21, pp: 1844-1851.

Zhao, G.Z. and W.A. Long, 1988. Borehole Mechanics Basis. Oil Industry Press, China, pp: 100-110.