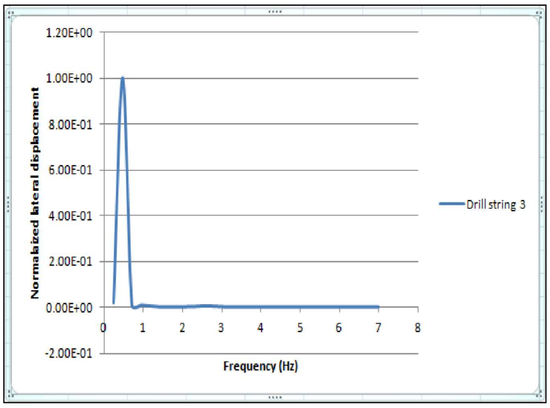

Fig. 14 Harmonic analysis of drill string 3.

The peaks indicate the onset of resonance in the harmonic response plot. This plot can be used to interpret which parts of the drill string is subject to large lateral displacements. In case of drill string 1, the drill collar is subject to large displacements at 4.8 Hz. This indicates that, the drill string is subject to maximum deflection at 4.8 Hz, while the peaks 2.2 and 4.2 Hz account for 90% and 38 % of maximum deflection. Thus, the operator has an idea of which frequency to avoid and which frequency to operate the drill string. Even though drill string experiences resonance at 4.2 Hz, the deflection of the drill string is not as severe as that encountered at 2.2 and 4.9 Hz. Similarly, for drill string 2, the displacement is high at .8 and 1.9 Hz but only 40% of maximum displacement is experienced at 4.5 Hz. However, for drill string 3, maximum displacement occurs at .5 Hz, and very small displacement occurs at 1 Hz. Therefore the drill string is safe to operate at its usual operating conditions.

This study also shows that finite element analysis is very suitable for the use of vibration studies by drilling engineers, in particular when the simulation results are compared with experimental data. In previous studies, finite element analyses are also shown suitable for design and thermal studies of well casings [11]–[13].

IV. Conclusions

Lateral vibrations can cause a significant amount of failures in MWD tools, drilling tools, and drill collars. This vibration effect is further amplified by the mass imbalance created by the MWD tools or the initial drill collar sag. The shocks produced by lateral vibrations can be higher than those which result from torsional or axial vibrations. This is because, under lateral vibrations, the drill string collides with the wellbore wall, creating huge shocks. As a rule of thumb, it can be understood that the more the mass and longer the drill string, the lower is the lateral resonant frequency.

A FEM model has been developed to investigate the problem of vibrations. When compared to field experiment data, the model has produced very close results. Therefore, it is very suitable for use in vibration studies by drilling engineers. The benefits of this study are that identifying the safe operating ranges of rotary speed for the drilling string as well as the lateral displacement of a critical component for a range of frequencies, thus avoiding damage to the string.

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