Modelling of drill-string dynamics for stick-slip suppression

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A drill-string presents a highly complex dynamical behaviour due to strong geometrical and material nonlinearities occurring during a downhole drilling process. These complexities can be analysed by classifying drill-string dynamic responses into axial, lateral and torsional vibrations. We focus our attention on the stick-slip phenomenon, which is a self excited vibration mode, happening due to nonlinear characteristics of drill-bit rock interactions, that is of particular interest to the drilling community, due to its negative effect on drilling efficiency. During the stick phase, the dynamical helical configuration is observed for a rod inside a cylinder which represents the drill-string inside the casing. This can have a significant effect on the dynamics of the system and cause its instability. This was studied extensively at Aberdeen University's drill-string dynamics labs by using a flexible shaft. During the sticking interval the flexible shaft undergoes a helical buckling, hanging its shape dramatically which results in multiple contact points with the wall and thereby affect response of the system.

In this talk, I will focus on the complexity of the nonlinear behaviour of twisted rod, which represents the drill-string under excessive torsional load. The analytical calculation of a rod under buckling load and the corresponding FE model model will be presented in detail along with the experimental studies carried out on the Aberdeen drill-string rig. The methods of controlling the torsional vibration will be discussed including the TOMAX anti-stall-tool (AST).