Shape memory alloys as pipe joints: applicability as vibration attenuators to drill-strings torsional dynamics

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ABSTRACT

In the last decade, Schlumberger's Cameron SMA Technology have proposed the use of shape memory alloys (SMAs) for the coupling of drill-pipes by taking advantage of shape memory effect in assembly. This application can avoid problems such as loosening on traditional threaded tool joints, but the added benefit on the drill-string dynamics was not investigated. This paper investigates the use of shape memory alloys as pipe joints on drill-string dynamics [1]. The idea is to evaluate the influence of the hysteretic behaviour of superelastic effect and its help to attenuate severe torsional vibration, especially stick-slip oscillations. A simplified lumped parameter model is used to model the torsional dynamics of the drill-string, with imposed angular speed at the top and a nonlinear bit-rock interaction at the bottom. This simplified model is validated through finite element analysis. Thermomechanical behaviour of SMA is described using a constitutive model due to Lagoudas et al. [2]. The numerical results show strong dependence of the system torsional oscillations on temperature and austenitic elastic modulus of the selected material in some drilling conditions as weight on bit and top angular speed. In order to evaluate the impact of SMA parameter uncertainties [3] on the system dynamic response, the material parameters are modelled as random variables, and perform Monte Carlo simulations to estimate the statistics of the random response. The random stability map is obtained for different values of weight on bit and top angular speed. The stick-slip severity factor, which is a measure of the amplitude of the torsional vibration, is computed for this purpose. Overall, this work stands that the main variables in drilling operation can be improved by the introduction of an admissible length of SMA connection, and it brings new perspectives to smart material adoption in a very significant mechanical system.

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