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Conclusions

In this thesis, it was shown that it is possible to mitigate the stick-slip phenomenon in the presented test setup and in the model, by applying a small torque on the bit, orders of magnitude lower than the one applied by the main motor, i.e. top drive. It also becomes clear that in a real system, even a reduced scale one like the apparatus presented, where the torque on bit cannot be modeled as a simple equation, the stick-slip form is highly dependent of the top drive speed, although to eliminate the stick slip by simply increasing the speed of the top drive may require a substantial increase in that speed. It was also shown that a simple PID controller tuned using a linearized plant, if turned on with the plant remaining still, is able to control the stick-slip with a reasonable control effort (torque) and without increasing the angular speed.

The proposed L_1 adaptive controller showed a good result on stabilizing the modeled system, although the time until stabilization was not satisfactory in the cases studied. The proposed structure of an L_1 adaptive controller used together with the conventional PID controller showed that the advantages of both systems (adaptiveness form L_1 and fast response from PID) can be used together without compromising the simplicity of the approach or the computational effort. Applying the L_1 controller to the experimental setup requires the use of a capable hardware as the control laws with a reference model are complex, therefore it was not the objective of this thesis. Future works should address this problem.

The experimental analysis of a drilling rig with an embedded torque source (DC motor) poses a big challenge to the construction since there is a need for a wireless data link with a good speed and the miniaturization of the system, including the power source, a Lithium polymer battery. Despite the construction challenges, the results presented in this thesis shows that the presence of a torque source on the bit of the drilling column (a kind of bottom hole motor, or mud motor) has a very important role on the torsional vibrations of the column. The presence of the bottom motor is almost not studied by the dynamics and vibrations community.

Experimental tests made to obtain the mechanical properties of the experimental setup shows that it is very difficult to precisely quantify values as the torsional stiffness and specially the parameters of the friction law on the contact points. For this reason, a study of a dynamical system with friction should consider a stochastic point of view of these parameters, or, as presented in this thesis, a control structure capable of adapting itself to overcome the influence of the not known, or not modeled dynamics of the system.

Finally, it was shown in section 4.2 that there is an important difference when using an incremental rotary optical encoder to obtain angular speed through a differentiation over time process. It was shown that when this process is done on a PC there is a significant increase on the noise measured when compared with the results from an analog tachometer. Therefore, to measure angular speeds it should be preferred the use of a tachometer.