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Complementary approach in stick-slip analysis of a lubricated contact: from the local contact behavior to the dynamical response of the system

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Stick-slip in greased contacts involves a complex series of phenomena that influence each other's, from the local frictional response of the greased contact to the system dynamic response. The present work proposes a methodological approach, for investigating contact instabilities in a greased contact, with both experimental and numerical investigations. Focus of the study is the grease contribution to the stick-slip occurrence and the role played by each grease components, within the low-sliding velocity conditions. The results allowed for asserting that the local response of the greased contact, the grease thickener and additives, play a key role in the stick-slip instability.

Keywords: Friction-Induced Vibration, Stick-Slip, Grease, Tribology

1. Introduction

The stick-slip phenomena engage multiple scientific challenges [1]. Each change in the contact parameters influences directly the dynamic and frictional response of the system, due to the mutual influence of the local scale (contact) and the system scale (macroscopic frictional and vibrational response) [2]. The grease presence at the contact interface increases the complexity of the phenomenon, from both a tribological and dynamic point of view. Lubricated systems are supposed to reduce the frictional losses and wear, but they can also collaborate in the appearance of dynamic contact instabilities, due to the friction-velocity characteristics when passing from boundary to mixed contact regimes [3]. The complex rheology of a grease, function of both the matrix, additive and oil responses, becomes then a key point for the occurrence and evolution of stick-slip. Despite the great importance of this phenomenon, from both scientific and industrial points of view, a lack emerges into the literature about stick-slip of lubricated interfaces. The different role of the grease components, during the sliding, is nowadays still not clear. A general approach is then needed to account for the coupling between the local phenomena and the system dynamic response.

2. Methods

The present work proposes a novel methodological approach to the stick-slip problem of a lubricated contact, referring to a real industrial case, in order to deploy the obtained results in a more realistic and detailed manner. The subject of the investigation is a mechanical brake used in tubular electric actuators [4, 5], which can present frictional instabilities originated at the lubricated contact between the two main brake components. The methodology used is twofold: i) on one hand, experimental tests are carried out to understand the local frictional response of the lubricated contact; ii) on the other hand, a lumped model is created in order to simulate and analyze the system dynamic response. The information about the local lubricated contact behavior (friction law), achieved experimentally, is introduced into the numerical model. Particular attention has been placed on the analysis of the lubricant rheology, dealing with different types of lubricants and regimes of lubrication, with both oil and grease [5].

3. Discussion

The frictional response has been related to the different contributions of the grease components (i.e. thickener, base oil and additives), and to the rheology at the interface within the low sliding velocity range (from 0 to 20mm/s). The obtained local information has been then integrated in the lumped model to evaluate the unstable dynamic response of the entire system (i.e. the stick-slip phenomena) and identify the lubrication parameters that most influence its appearance. The obtained results allowed to identify the lubrication components, and the respective friction-velocity curves, more favorable for the stick-slip occurrence. Combining grease rheology with stick-slip dynamics represents now a further challenge in both domains of research.

4. References

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