Polytetrafluoroethylene lubrication in highly loaded rolling contacts

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Introduction: Highly loaded tribological contacts (p>1000 MPa) occur in many machine elements, such as rolling bearings or gear wheels. To ensure low friction and wear rates, lubricants are used to separate the interacting surfaces in tribological contacts. Solid lubricants are used as alternative lubrication media as soon as the use of oil or grease is no longer possible (e.g. in vacuum) or undesirable (e.g. food industry). For PTFE, a lubricant supply through coatings or sintered materials is not suitable for highly loaded rolling contacts due to the high contact pressures. Therefore, the solid lubricant is transferred in form of transfer films in the vicinity of the rolling contact and transferred to the contact zone. The mechanisms of provision and lubrication in rolling contacts have so far not been sufficiently investigated. This work describes the lubricant film formation in a highly loaded rolling contact which is supplied by PTFE relubrication.

Methods: A ball-on-disc tribometer is extended by a PTFE pin pressed on the rotating disc. Due to the sliding contact between pin and disc, a PTFE transfer film is formed on the disc, which lubricates the rolling contact between disc and ball. The lubricating film formation is analyzed by in situ microscopy and film thickness measurements using optical interferometry. Simultaneously the lubrication effect is evaluated by means of friction measurements in the PTFE lubricated rolling contact. This allows to determine the effect of relubrication on the film formation and its influence on the coefficient of friction considering the operational conditions.

Results: The results show the necessity of relubrication for an effective PTFE lubrication in rolling contacts. Without relubrication the initial film is removed within short time by shear and compressive stresses in the rolling contact inducing high friction, which is in good accordance to the results of other authors. In contrast, a stable friction regime is established by continuously supplying small amounts of PTFE into the rolling contact. In this way, the coefficient of friction can be reduced up to 65 % compared to the unlubricated conditions. This friction reduction is correlated to the PTFE film thickness and film homogeneity in the rolling contact. These results establish an advanced understanding of the physical mechanisms of PTFE lubrication in rolling contacts and demonstrate that permanent lubrication of highly loaded rolling contacts using PTFE is possible.

Keywords: solid lubrication, polytetrafluoroethylene (PTFE), film formation, highly loaded rolling contacts

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