# Thermo-hydrodynamic analysis of nano-lubricant flow with carbon nano-particles in tribological contacts

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# Thermo-hydrodynamic Analysis of Nano-lubricant Flow with Carbon Nano-particles in Tribological Contacts

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## 1. INTRODUCTION

The use of nano-particles in lubricants is currently an emerging area of research. The challenges both in manufacturing and application of nano-lubricants include finding cost effective method of manufacturing nano-particles, suspending these in the desired base oil and finally producing an intrinsically stable colloidal solution. Nevertheless, majority of these challenges have been resolved and nano-lubricants of various compositions have been described in the literature [1]. Not so much unexplored are the implications in the application of nano-lubricants in real tribological conjunctions and their effect on the performance metrics, such as friction, load carrying capacity and heat removal. One of the well-known properties of the nano-fluids is their effectiveness in heat transfer. Such properties can also have a direct influence on the frictional performance of the contact, by affecting the rheology of the lubricant. This paper presents a combined experimental and numerical study of friction behaviour of a nano-lubricant (PAO6) sliding contacts

## 2. METHDOLOGY

The method of analysis is based on the solution of Navier-Stokes equations along with inclusion of vapour/gas transport equation and use of Lagrangian for representation of discrete phases, such as the nano-particles and cavitation-induced bubbles. The trajectory of a discrete phase particle is predicted by integrating the force balance on it in Lagrangian frame of reference. This force balance equates the particle inertia with the other forces acting upon it. The dispersed phase can exchange momenta, mass, and energy with the fluid continuum. The cavitation model proposed by Singhal et al [2] is also used to account for the growth of cavities in low pressure regions of the contact. Therefore, cavitation bubbles are confined to a finite size conjunction. This is of particular importance in the small scale gaps encountered in tribological contacts. Experimental are also carried out with an in-house pin-on-disc tribometer. A symmetric parabolic profile for the pin contact face is used for this study.

## 3. RESULTS

Figure 1 shows the experimental results for the coefficient of friction variation with slip speed under two different normal loads. Based on the results for shown in Figure 1, the combination of sliding and loading conditions replicates all the three main regimes of lubrication: hydrodynamic at higher speeds and mixed and boundary regime of the lubrication at medium to low sliding speeds.

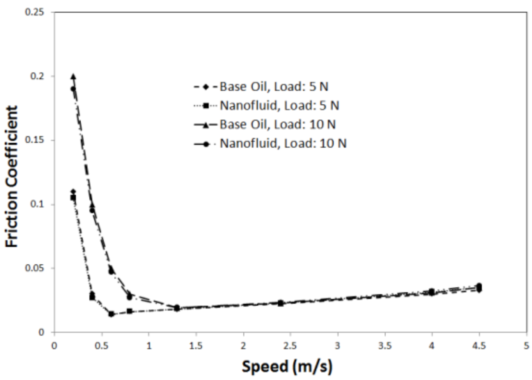


Figure 1: Friction coefficient vs. speed at two different loads

In addition, Figure 2 illustrates the result from the multi-physics, multi-phase numerical analysis in which the contours of particle speeds as well as void fraction in cavitation region are shown.

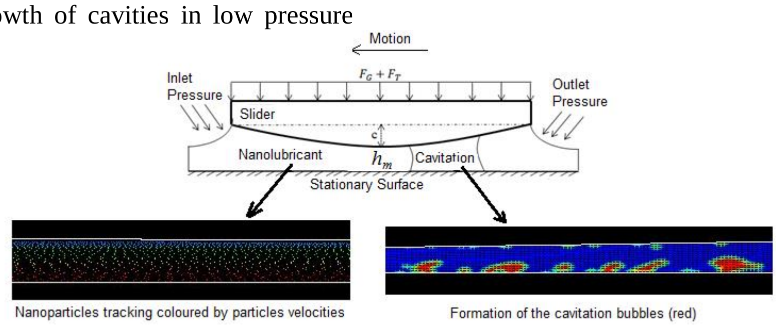


Figure 2: Contours of particle speeds and void fraction in the cavitation region

**REFERENCES**

[1] J.M. Martin, et al., Nanolubricants, Wiley (2008) p. 234

[2] A.K. Singhal, et al, "Mathematical Basis and Validation of the Full Cavitation Model", ASME FEDSM'01 Conference, New Orleans, 2001