Observation and Analysis of the Divergent Zone in an EHL contact

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In order to reduce oil consumption due to oil spread followed by oil burning in vehicles, a detailed analysis of the oil flow in the outlet of the rings/piston/liner interface was required. To do so, an *in-situ* methodology of the 3D observation and characterization of the contact outlet was implemented for a wide range of conditions, $\eta.u_e$ between 10^{-2} and 10 $Pa.m$, for fully-flooded to starved contacts, on an EHL tribometer. This allowed us to identify oil droplets and air bubbles, their formation conditions as well as to build their flow cartography.

Keywords: divergent zone, EHL contact, *in-situ* observation

1. Introduction

In internal combustion engines, for the purposes of saving energy and increasing efficiency, moving parts are lubricated. The lubricated rings/piston/liner of a cylinder is usually experimentally simulated using an EHL contact. However, the interests in EHL theory often concerns contacts and effects of parameters on lubrication conditions[1][2]. The main point in this abstract was to investigate and understand how the fluid flows in the outlet of the contact (divergent) according to the working conditions.

2. Methods

In order to understand the oil behavior at the outlet of an EHL contact, a 3D *in-situ* observation of the contact area was developed combining an EHL rig, the film thickness distribution in the high pressure zone using white light interferometry and a lateral observation of the outlet zone using laser. In the local base of the contact, $\vec{x}$ is the direction of flow, $\vec{y}$ is the transversal one and $\vec{z}$ is the direction of the film thickness.

2.1. Tribometer
With our EHL tribometer we produce conditions of pure rolling contact between a transparent disk coated with a semi-reflective chromium layer and a steel ball. This relative movement creates a fluid flow between $0.1\ m/s$ and $1\ m/s$. Pression in the contact is about $3.10^8 Pa$. The bulk oil viscosity in our experiments ranged between $0.8\ Pa.s$ and $4\ Pa.s$.

2.2. Visualization device
To 3D-characterize the flow, the EHL rig was associated with two visualization techniques. White light interferometry was used to display information about the EHL contact and the film thickness distribution while a second system, composed of a double-pulse Nd:YAG laser synchronized with a camera, allowed to observe the outlet, perpendicularly to the flow, and to identify the shape of the meniscus and oil droplets and/or air bubbles present in this divergent zone. The Laser beam was changed into a thin laser sheet in the (x,y) plane thanks to a cylindrical lens.

2.3. Observations
Figure 1 presents an illustration of lateral observations of the divergent zone at 1mm of an EHL contact for $\eta.u_e = 1.24\ Pa.m$

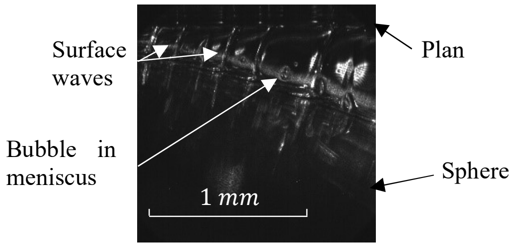

Figure 1: Lateral view of the rear of an EHL contact with the highlighting of bubbles in the liquid lubricant for $\eta.u_e = 1.24\ Pa.m$

A post-processing software was developed in order to follow flow trajectories and speeds, dimensions of particles like droplets or bubbles.

3. Discussion

Bubbles trapped in the liquid meniscus and surface waves were observed. The meniscus dimensions varied with speed and contact feeding conditions. Surface waves and bubbles, as well as their distribution changed according to the experimental conditions. The cartography of trajectories of these structures was built and allowed us to discuss the mechanisms occurring in the outlet zone, using various dimensionless numbers, such as the Weber or Capillary numbers.

4. References

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