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Further Investigation of Engine Piston-Ring Lubrication Phenomena: Flow and Cavitation

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Cavitation effect in lubricating contacts has been recognized as the source of performance degradation. Oil properties should be specifically blended to minimize cavitation adverse effects, such as low load carrying capacity and oil film pressure profile alteration. It was shown that different chemical additives in the lubricant affect cavitation initiation and oil film thickness in parallel to changing operating conditions (speed, load, temperature). The focus of this study is towards visualization through experimental study with a high-speed camera set-up so that a clear picture of the engine piston-ring lubrication phenomena can be established and investigated.

Keywords: cavitation, piston-ring lubrication, ICE experiments

1. Introduction

The basic concept that drives piston-ring lubrication research is the reduction of fuel consumption and harmful exhaust emissions. At the same time, engine performance and durability should reach higher levels. Some significant resources and funding has been invested towards optimizing the combustion process, powertrain and tribology inside the internal combustion engine through research and development. The piston-liner interface and their interaction during the reciprocating motion is the major source of frictional losses in engines. Any miscalculation regarding the effective lubrication control of the rings-liner interface is translated to lubricant transport from the crankcase onto the cylinder walls and towards the combustion chamber, participating in total emissions.

2. Methods

Flow and cavitation visualization has been carried out in a single-ring test rig and cavitation visualization in an engine so that direct results comparison is achieved. Previous research carried out at the test rig showed different oil properties had an effect in film thickness measurements that were either measured with a capacitance or a Laser Induced Fluorescence sensor [1]. This study has taken into account cavitation, through visualization and assessment of different oil sets. A direct link between the oil formulation and different operating conditions could be established.

2.1. Custom - built Algorithm

In engine experiments, to assess the appearance of cavitation a custom-build algorithm based on identification of variably colouring areas on the piston-surface was built [2]. The software identifies the area between the cavitating regions, where cavitation never takes place and sets that as the centre line of the non-cavitating area. Then, it compares all images to find shift and tilt between images (vibrations, etc) and filters are applied. Desired data are processed and plotted in graphs, while videos are recorded [2].

2.2. Results

Cavity length and width, area of cavitation and number of cavities present in the area between the piston-ring and liner were extracted according to the software.

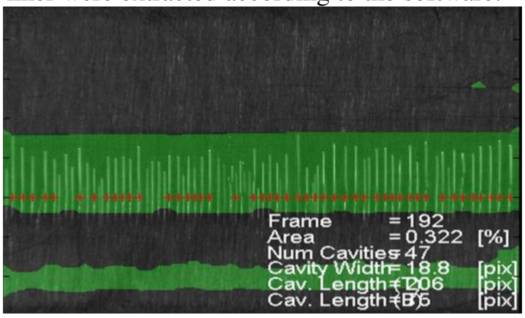

Figure 1: Two marked cavitated areas (green) as identified by the software on the piston-ring surface [2].

3. Discussion

As it was shown in the past [3], in engine applications direct observation through visualization is the most appropriate method to study cavitation. Valuable results were extracted showing the performance of each lubricant in terms of cavitation. Furthermore, a direct link between oil formulation and the operating conditions can be established. Oil transport is assisted by the high-pressure gases that are moving from the cylinder to the crank case due to the increased in-cylinder pressure. Blow-by phenomena have been successfully captured in imaging process.

4. References

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