Surface systems and lubricants mitigating in-cylinder friction

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Abstract - Many aspects of performance, efficiency and reliability of the internal combustion engine filter down from the developments found in the world of Motorsport. A significant number of the features that are found in modern mass-produced engines originate from high performance engines. One of these advancements has been the reduction of friction that is created at the interface of the moving components within the engine. The most significant area where the highest single point of friction occurs is between the cylinder liner and the piston ring. This is highest in the areas of “bottom dead center” (BDC) and “top dead center” (TDC) where the piston and rings momentarily stop and then change direction. By developing an advanced piston liner material, mated to a suitable lubricant, this area of friction could be significantly reduced.

I. INTRODUCTION

As this project is directed at high performance spark ignition engines the primary objective is to obtain the maximum levels of performance as possible. A secondary consideration is wear of any components. To achieve this the development of high performance piston liner materials with suitable substrate support is required. To compliment these developments in piston liner advancements suitable lubricants that assist in the reduction of friction will need to be paired with these cylinder liners. This project has the two elements mentioned earlier that need to be addressed so that a performance gain can be achieved due to the reduction in friction. So that we can understand the importance for the need to reduce friction, consider that a typical spark ignition engine has efficiency losses that are as high as 60-70% [1]. Of this these losses a large proportion are thermal losses, but as much as 33% can be attributed to frictional losses within the engine. Almost half of this 33% can be attributed to the frictional losses relating to the piston assembly, of this around 7-8% occurs at the piston ring and cylinder liner interface [2].

II. RELATED WORK

There have been many studies and experiments carried out to quantify the levels of friction present relating to the moving components within internal combustion engines [3,4]. Much of this work has centred around either the lubricant film or the liner materials themselves. A few studies have combined both lubrication film and liner material specification, but this has been generally limited to a single oil type and liner coating. The study of the tribological conditions along with the development of surface microstructure and manufacturing techniques has led to significant reductions in friction levels in internal combustion engines [5,6]. This project aims to expand existing research to include other variables encountered in the end user product.

III. PROPOSED RESEARCH

Initially six sample coatings will be assessed for their friction coefficients in their “dry” state, then with three different sample oils per coating. Surface roughness and topography measurements are analysed using Optical Spectroscopy, these results are then compared with post testing measurements. Both “dry” and “wet” friction testing will take the form of Atomic Force Microscopy (AFM) and Lateral Friction Sliding Rig Analysis. Initial AFM testing showed encouraging results with a NiScC2 (nickel silicon carbide) liner coating, results can be seen in Figure 1. The “novelty” factor of the research is to test the friction characteristics with both the coatings and oils at elevated temperatures, as high as 180 degrees Celsius. In conjunction with the elevated temperatures, testing experiments will be carried out at varying piston ring velocities to simulate the varying conditions within the engine.

Figure 1: SiNiC2 Friction Data

References
