Proceedings of the ASME/STLE International Joint Tribology Conference
IJTC2009
October 19-21, 2009, Memphis, Tennessee, USA

IJTC2009-15035

TRIBOLOGICAL PERFORMANCE OF PISTON RING IN MARINE DIESEL ENGINE

Tajammal Imran
tajim@mek.dtu.dk
Denmark Technical University,
Kgs. Lyngby, Denmark

Peder Klit
klit@mek.dtu.dk
Denmark Technical University,
Kgs. Lyngby, Denmark

Christian L. Felter
christianl.felter@man.eu
Research Engineer,
R&D, MAN Diesel SE, Denmark

Anders Vølund
anders.voelund@man.eu
Senior Research Engineer,
R&D, MAN Diesel SE, Denmark

ABSTRACT
From a tribology point of view, it is the two dead centers that are the main area of interest for experimental study of piston rings in large marine diesel engines. Therefore, in this work the performance of piston rings is studied to mark the importance of the two dead centers. A test rig based on a reciprocating principle was developed. Tribological parameters such as friction force, thickness of oil film and temperature variation of the piston ring bulk were studied as a function of crankshaft rotational speed, loading of the piston ring and two different types of lubricating oils. Dead loading was applied for each experiment. Selected results are presented for friction force, oil film thickness and temperature variation of the piston ring bulk as a function of crankshaft instantaneous position. Results are also compared for two different oils used in this study. Obtained results showed that the two dead centers have significant influence on the performance of piston rings under lubricated conditions. It can be concluded that at the dead centers the piston rings will experience a transition from dry friction to hydrodynamic friction with corresponding variation in rotational speed.

INTRODUCTION
Friction in the piston ring package (piston, piston rings and liner) is a major source of power consumption in the primary driveline of two stroke marine diesel engines. Likewise, designing an engine for its optimal efficiency and more friendliness toward the environment demands the reduction in frictional loss. This can be well addressed by acquiring a sound knowledge of piston ring tribology and thus changing the design of the piston rings without making key changes in the existing design of primary driveline.
Understanding the tribology of the piston ring package is an active area of research [1-11]. The frictional loss in the piston ring package (piston, piston rings, liner) can be divided on the basis of different lubrication regimes [1]. It is also instructive to classify various modes of friction based on the position of the piston at two dead centers (TDC and BDC) and at the middle of the stroke [11]. It is known through simulation studies that the friction in the piston rings has its maximum contribution around the two dead centers [4-5, 7-8]. Earlier work by the co-authors showed that piston ring will experience a boundary and mixed lubrication at the dead centers and are one of the main area of interest for experimental studies [5, 12]. The present work is an experimental effort to study the piston ring tribology around two dead centers and the transition from partial to full separation. The performance of the piston rings is studied by measuring friction force, oil film thickness and temperature variation of the piston rings as a function of crank shaft position, rotational speed and loading.

EXPERIMENTAL PROCEDURE
Setup and schematic diagram of the test rig is shown in figure 1. The test rig is based on the principle of reciprocating motion of the piston rings. Segments of the piston ring and the cylinder liner material were taken from the new piston rings and cylinder liner parts of the engine and were machined for the dimensions of the test rig (figure 1). The average surface roughness (Ra) of the cylinder liner segment was measured by using a surface profile meter and the average value was found to be 0.14 μm whereas, this value (Ra) for the piston ring segments was 1.6 μm. Radius of the curvature for piston ring segments was selected according to that of an actual piston ring and was 160 mm. Other dimensions of the piston ring segments can be seen in figure 2. Lubrication of the surfaces was done manually at the start of each test in order to ensure lubrication of the mating surfaces. No loss of the lubricant was seen as each test was done for 50 cycles. Loading was employed by means of dead load and can be seen in exploded view of figure 1. Friction force was measured by means of a force transducer. Instantaneous position of the crankshaft was measured by means of an angular encoder. The temperature variation of the piston ring segment during each test was measured by inserting a thermocouple at the top of the piston ring segment. Oil film