The Incorporation of Geometric Profile to Encourage Greater Performance of the Combustion Ring

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Abstract

Introduction: For over 100 years, piston rings have been used in the internal combustion engine to create, during operation, a seal between the cylinder wall and the piston (Figure 1). In operation, the heat generated on the top ring, will cause the piston to deform and tilt. To accommodate with this effect, designers have improved the performance ring by applying a chamfer to the contact face of the ring to reduce the concentration of stress on the ring when the piston tilts (Figure 1). It can be found that the piston ring coatings (MoS2 based) can lose structural integrity and state of the art rings incorporate a chamfer as shown in Figure 2a, is to chamfer the coating on the ring contact face up to the substrate material. In the current design the coatings covers the full length of the chamfer which can lead to excessive stress concentration in A (Figure 2). This paper examines the effect of the contact chamfer and proposes a new solution to relieve active stress from the performance ring. Use of COMSOL Multiphysics: In operation, the piston ring is surrounded by gas acting on it, using effect of chamfer design has been considered using Love's equation in conjunction with Stone's equation for force ad Miler's equation for gas pressure modeling. Dimensional changes on the piston due to changes in thermodynamic and tilt created during BDC to TDC cycle generates stress concentration on A. Structural mechanic bloc from COMSOL has been used for the simulation where variables defined from (Love 1929; Mittler and Mierbach 2009; Neuber and Federhofer 1951; Stone and Ball 2004) equations. The chamfer geometry was controlled through variable inputs such as coating thickness, ring thickness, distance from the ring angle ring to cylinder to incorporate the tilt. The simulation has considered variables such as position, time to impact during contact between the cylinder liner and the piston ring coating. To better represents the two surfaces contacting a multiple meshing procedures. These procedures allows for the shearing process to simulate at 10,000 rpm. COMSOL has enabled to generate a single simulation considering aspects mentioned above. Results: The results of this simulation confirmed ISO 6622-1 on dimensions for ring contact chamfer (Figure 4). When engine operate at 6,000 to 12,000 rpm localized high stresses are found on the contact chamfer face of the ring. With a new proposed designed (Figure 2b) the concentrated stress at this point is reduced. Conclusion: The piston ring will go through several thermal dynamic changes inducing structural damage to the component. The present methodology

has been to use to reduce highly localized stresses on chamfer placed on the contact face by reducing its dimension. This design alteration may runs in conjunction with Love's theory of elasticity.

Reference

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Figures used in the abstract

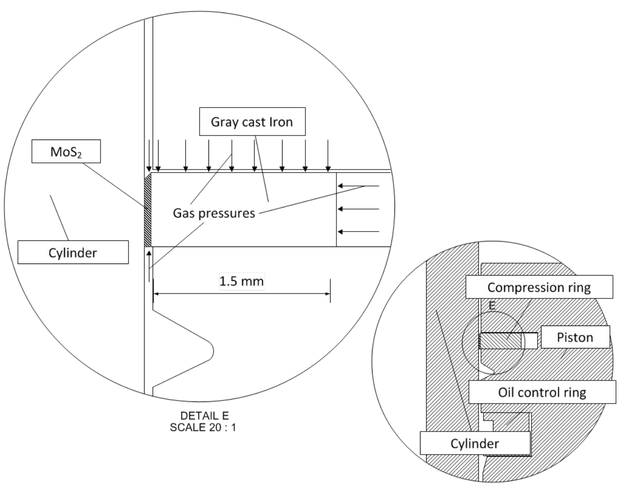

Figure 1: Cross section of the piston and cylinder liner from a high performance motorbike engine.

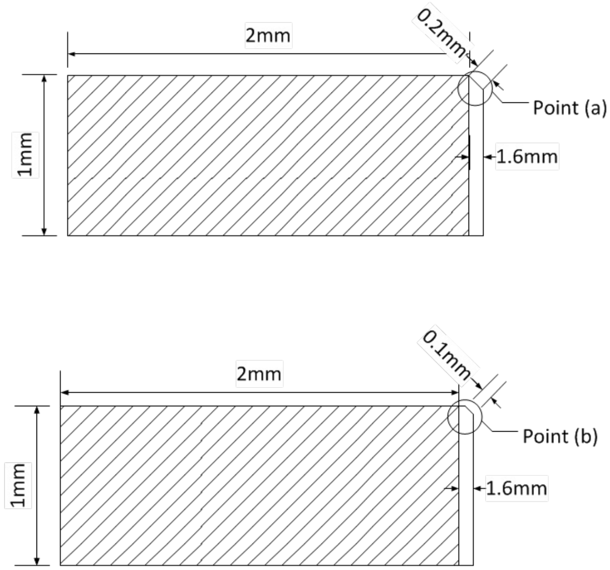

Figure 2: (a) Chamfer deign from ISO 6622-1; (b) New design.