COMSOL CONFERENCE 2014 CAMBRIDGE

A study into the coated compression rings

M. Dickinson, N. Renevier, J. Calderbank

University of Central Lancashire Preston UK
Racing to research

MDickinson1@uclan.ac.uk
(01772) 893261

uclan

COMSOL

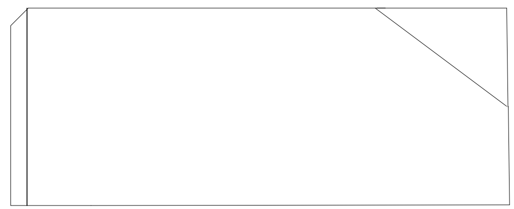
Contents

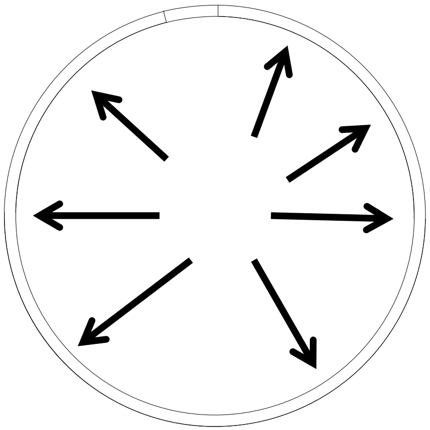
- Background
- KTM 520 System
- Methods used for the simulation
- Effect of the material on the simulated KTM 520 performance
- Conclusions

uclan

Introduction

- 1854 Rambottoms [1]
- 1862 Miller [2]
- 1882 A.E.H. Love [3]
- 1940's The introduction of hard coatings [4]
- 1986, 2003 ISO 6622 [5]
- 1993, 1999 Piston compression ring position [6]





[1] J.Ramsbottom, ARCHIVE: Proceedings of the Institution of Mechanical Engineers 1847-1982 (vols 1-196) 5 (1854) 70-74.
[2] G.M.Miller, ARCHIVE: Proceedings of the Institution of Mechanical Engineers 1847-1982 (vols 1-196) 13 (1862) 315-327.
[3] A.E.H.Love, Philosophical Transactions of the Royal Society of London. Series A, Containing Papers of a Mathematical or Physical Character 228 (1929) 377-420.
[4] Patent US2380654 - Method of Piston Ring Manufacture (1945)
[5] ISO 6622-1 Internal combustion engines - Piston rings - Part 1: Rectangular rings
[6] Patent US5203294 - Horizontal cylinder arrangement for an internal combustion engine (1993)

uclan

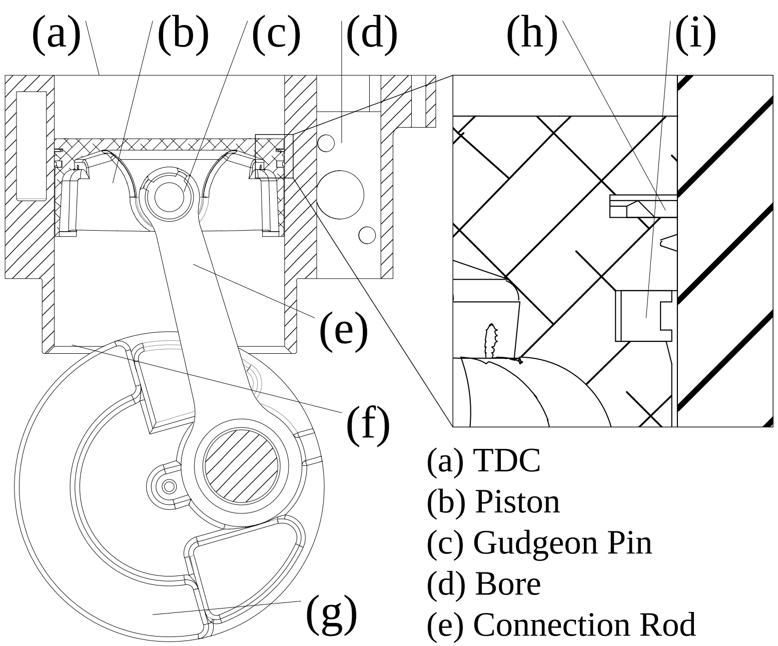
KTM 520 System

Piston
F94.95 mm (AMS 4032-T6 alloy)

Compression ring
F95 mm (Ring 1: BS-Grade 400 grey cast iron coated with 0.116mm MoS_2)
(Ring 1: SAE 9254 steel coated with 0.116mm MoS_2)

Cyclinder
F95 mm (NikaSil™)

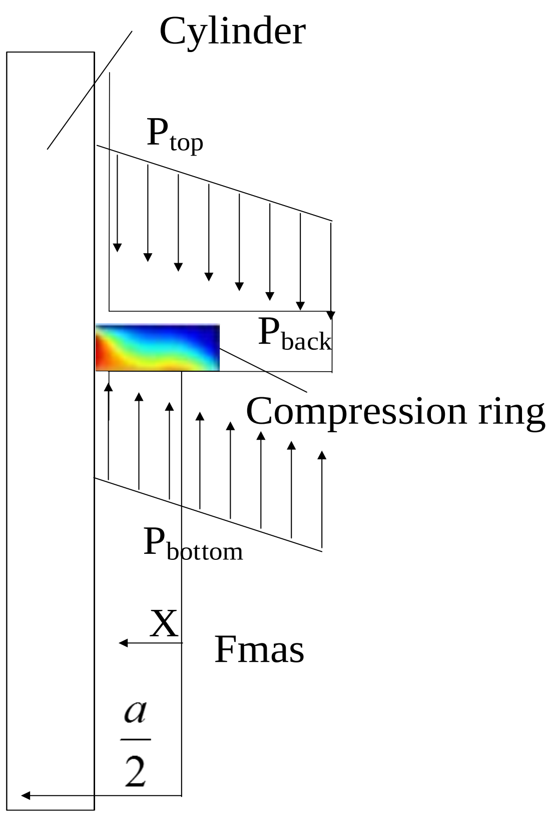
Testing conditions
Speed = 8,000 rpm
Lubrication = 10W-50 Putoline™ oil



(a) TDC
(b) Piston
(c) Gudgeon Pin
(d) Bore
(e) Connection Rod
(f) BDC
(g) Crank
(h) Compression Ring
(i) Oil Control Ring

Method used for the simulation

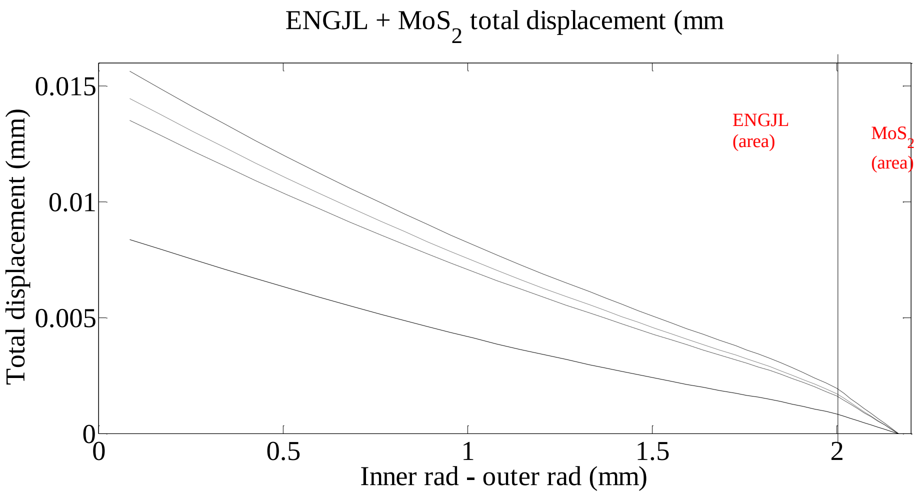
- Comsol Multi-physics
- Key Theories
  - Top, back and bottom pressure [7,8]
  - Primary, first and second inertia forces [8]
  - Piston tilt [9]
  - Otto Cycle and engine kinematics [8]
  - Rotation principles [11]
  - Thermal expansion [12]

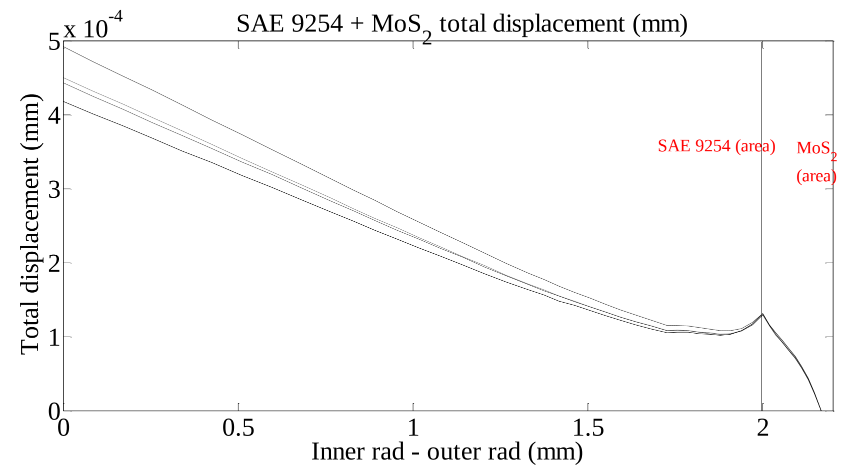


[7] S.N.Kurbet and R.K.Kumar, Proceedings of the Institution of Mechanical Engineers, Part K: Journal of Multi-body Dynamics 218 (2004) 107-117.
[8] M.Dickinson, N.Renevier, and W.Ahmed. Optimising Piston Ring Contact Face Chamfer for High Performance Engines. SAE 2013 World Congress & Exhibition. 2013-01-0965. 8-4-2013. SAE. 16-4-2013.
[9] R.Mittler. Optimization of Piston Ring Dynamics by direct 3D analysis of dynamic effects. 7-10-2009.
[10] R.E.Bradley and E.Sandifer, Leonhard Euler: Life, Work and Legacy (Elsevier Science, 2007).
[11] D.E.Neuenschwander, Emmy Noether's Wonderful Theorem (Johns Hopkins University Press, 2010).
[12] C.Y.Ho and R.E.Taylor, Thermal Expansion of Solids (ASM International, 1998).

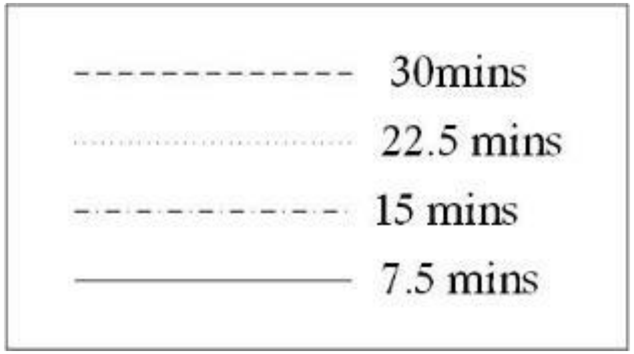
uclan

Effect of the Material change on the simulated KTM 520 performance





- ENGJL 250 will deform to a maximum of 0.018 mm over the 30 minutes of running
- SAE 9254 will have minor deformation up to 50μm during the same operation period
- However in both sets of results the substrate material is restricted in fully deforming by the MoS2 coating.



uclan

Conclusions

- As the heat increases the substrate will act against the coating attempting to deform however the coating will restrict the ring, as seen in results for both substrates.

- The MoS2 could be subjected to possible shear from the use of Fe material

- The coating will resist the ring leaving and incomplete deformation process, leave a drop in performance.

- Further work should examine the idea of a running-in process coating less and then coating the ring.

Thank you

Any questions ?

Matthew Dickinson
University of Central Lancashire Preston UK
Racing to research
MDickinson1@uclan.ac.uk
(01772) 893261