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The Refinement of the contact compression ring chamfer

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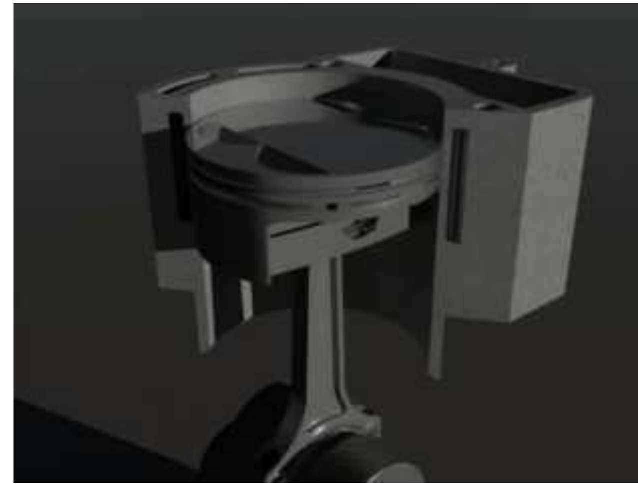
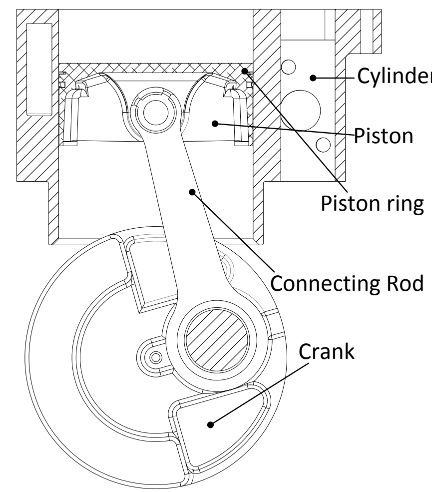
Introduction

1) Ramsbottom's pioneering work
2) The piston ring rectangular common design
3) Design modifcations of the ring have been, chamfer and fillets that have been applied to reduce stress, through A.E.Loves work.
4) Modern methods of piston ring manufacturing





[1] J.Ramsbottom, ARCHIVE: Proceedings of the Institution of Mechanical Engineers 1847-1982 (vols 1-196) 5 (1854) 70-74.
[2] 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.

Mathematically Calculating Position & Forces

Connecting rod to crank ratio: $n = \frac{L}{R} = \frac{\sin\theta}{\sin\phi}$ [3]

Position: $x = R\cos\theta + L\sqrt{\left(1 - \frac{\sin^2\theta}{n^2}\right)}$ [3]

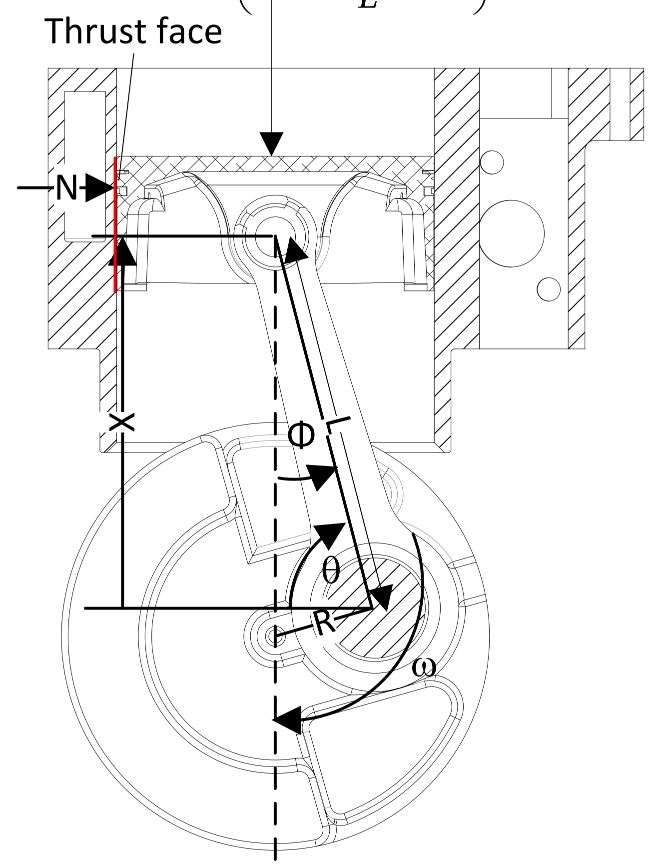
Substituting $w = \frac{d\theta}{dt}$ using $R = \frac{L}{n}$ [3]

Velocity: $v = -wR\left(\sin\theta + \frac{\sin 2\theta}{2n}\right)$ [3]

Acceleration: $a = -w^2R\left(\cos\theta + \frac{\cos 2\theta}{n}\right)$ [3]

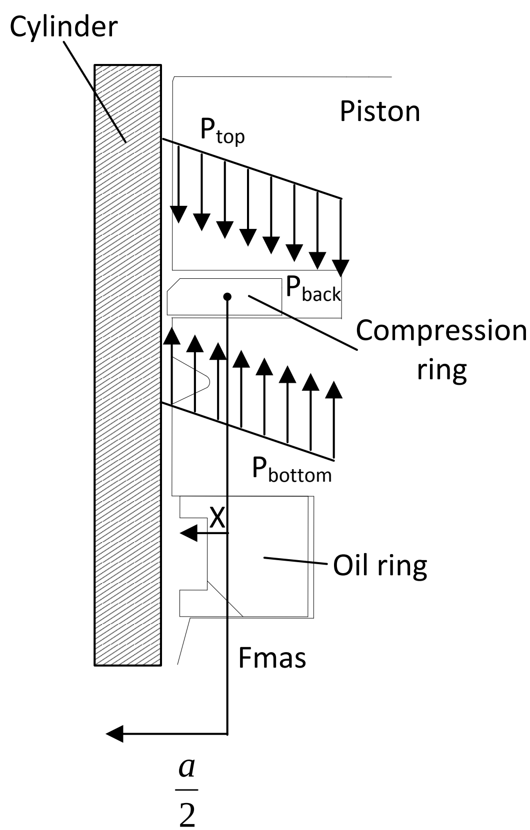
Piston Inertia Force: $F = -m\omega^2R\left(\cos\theta + \frac{1}{n}\cos 2\theta\right)$ [3]

$$F \approx mR\omega^2\left(\cos\theta + \frac{R}{L}\cos 2\theta\right)$$



[3] R.Stone and J.K.Ball, Automotive engineering fundamentals (SAE International, 2004).

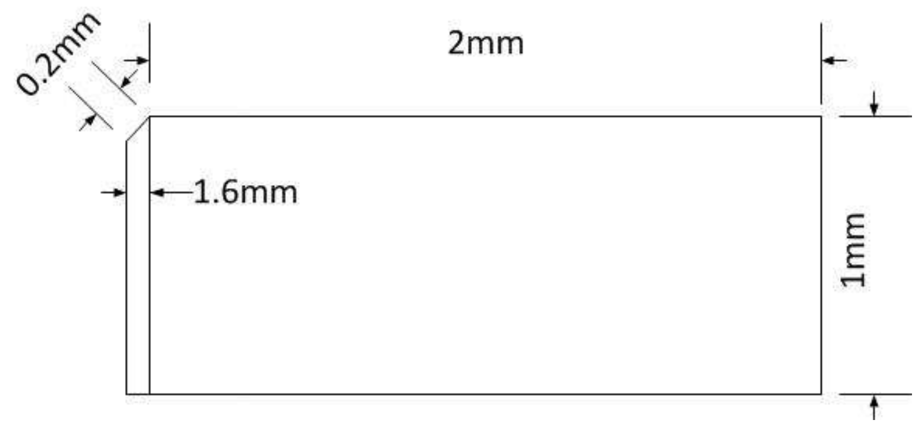
Mathematically Calculating piston ring pressures



$$p(x) = \frac{1}{2}(P_{bottom} + P_{back})\frac{x}{a} + (P_{bottom} - P_{back}) \quad [4]$$

$$p(x) = -\frac{1}{2}(P_{top} - P_{bottom})\frac{x}{a} - (P_{top} - P_{bottom}) \quad [4]$$

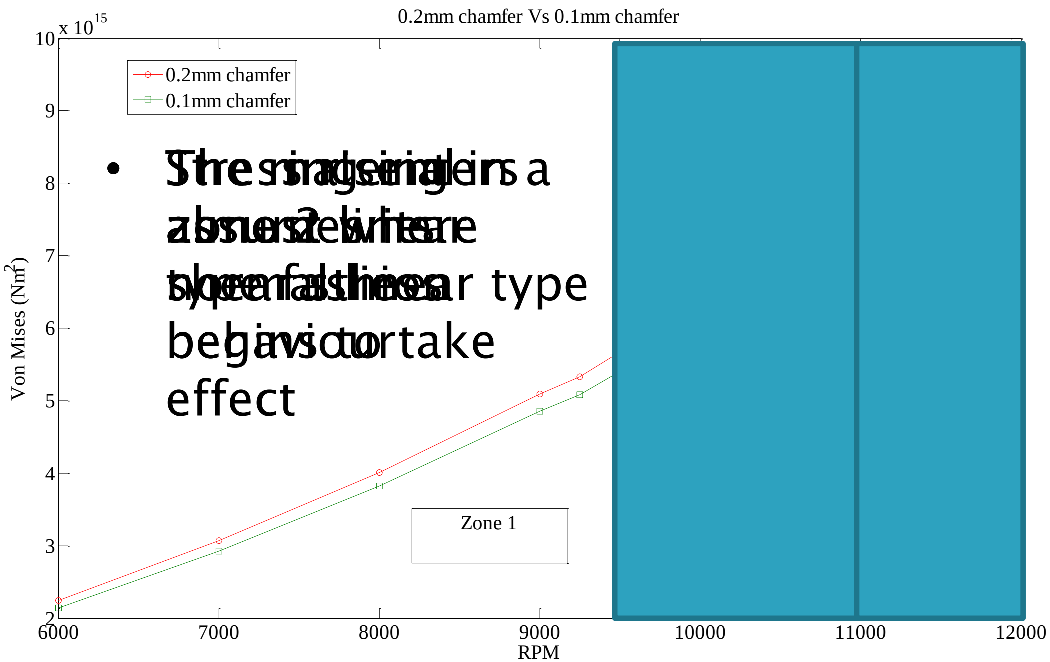
$$Gas_F = -\frac{1}{2}a(P_{top} - P_{bottom}) \quad [4]$$



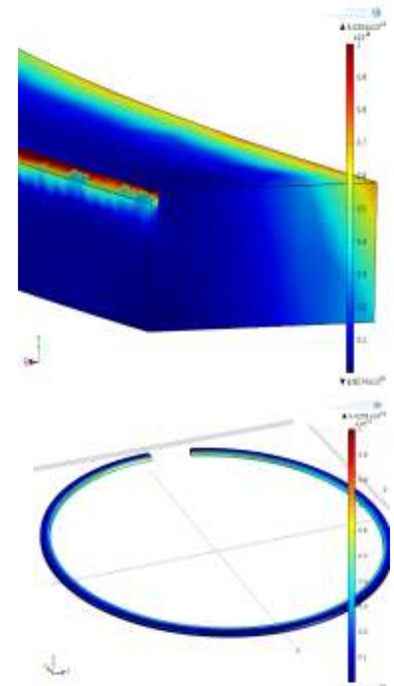
[5]

[4] R.Mittler, A.Mierbach, and D.Richardson, ASME Conference Proceedings 2009 (2009) 721-735.
[5] ISO standards ISO 6622-1 Internal combustion engines - Piston rings

Simulation



- The stress singularity in a zone 2 where non-linear type behaviour begins to take effect



A engine operation range of 6000-12000 rpm was used

The new chamfer modification from 0.2 to 0.1mm

Conclusion

- The paper that has been presented has shown possible design modifications to the present ISO 6622 piston ring, in the aim of reducing the piston ring contact chamfer stress. The engine that was used for the study was the KTM 525, the piston ring was a grey Fe that was produced with a MoS_2 coating attached, with a 200um contact chamfer machined to the upper outside face corner of the piston ring. The modification that has been suggested makes no major alterations to the manufacturing method of the ring. For high performance engines a benefit of making this alteration to the ring is that the ring coating will have a longer life cycle. However the results presented do indicate that material damage should be present on the ring coating when under examination.

Thank you. Any questions ?