The Refinement of the contact compression ring chamfer for race engine conditions

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Introduction

For many years the combustion engine has been renowned for the levels of extensive research that has been dedicated to it. One of the areas of interest in the engine is the piston ring, its common rectangular cross-sectional shape has not changed in appetence since the work completed by Ramsbottom **[1]**. During operation of bottom dead centre to top dead centre, the piston will tilt, to incorporate for the stress acting on the ring, designers have incorporated a chamfer. However during operation this chamfer can large levels of stress acting upon it.

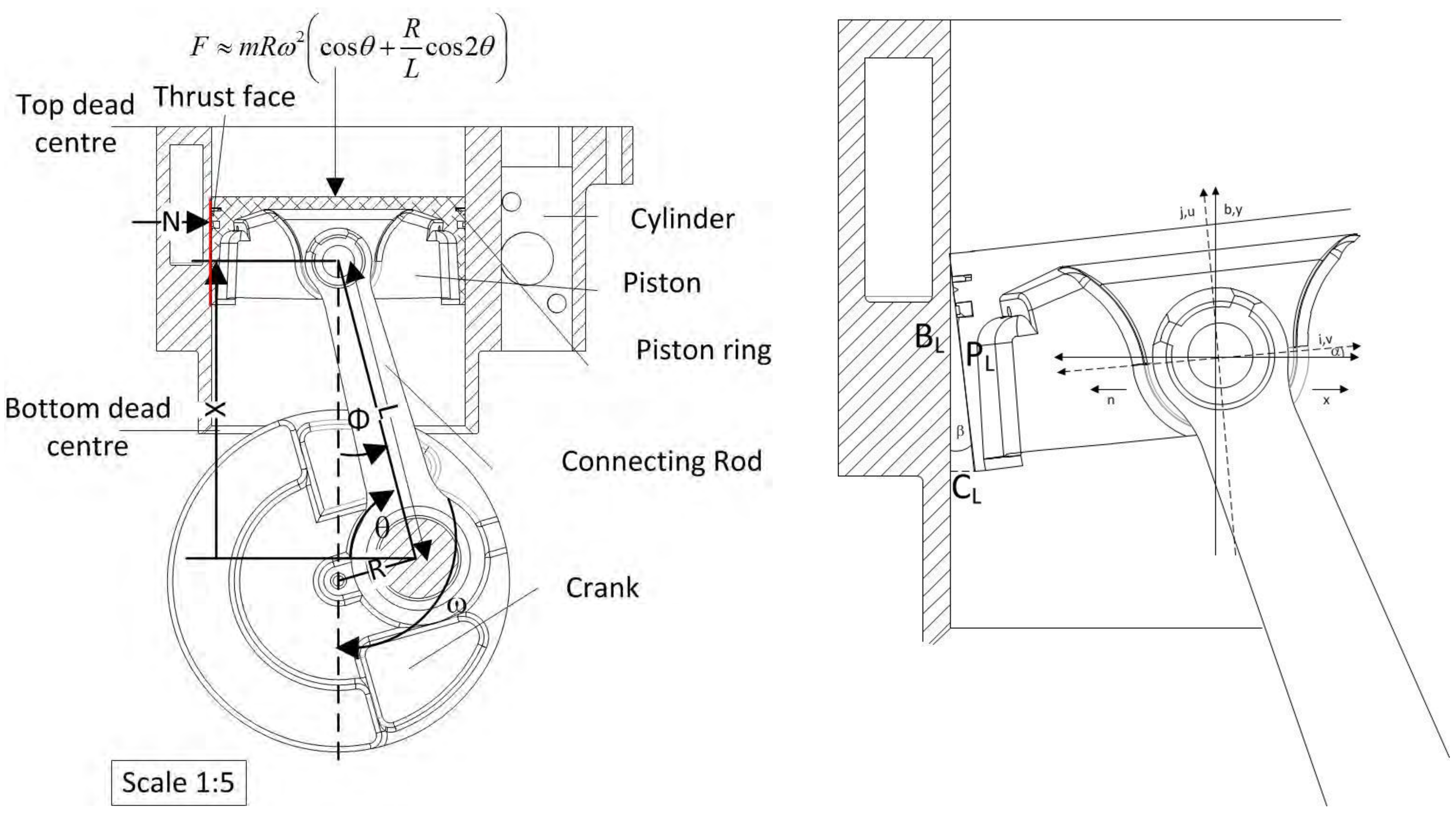

Figure 1 A. Showing engine configuration, position and forces. **B.** Showing the piston

Computational Methods

By using the methods noted by A.E.Love **[2]** and methods shown by R.Mittler, the geometry and force calculation where done.

$$p(x) = \frac{1}{2}(p_{bottom} + p_{back})\frac{x}{a} + (p_{bottom} - p_{back})$$

$$p(x) = -\frac{1}{2}(p_{bottom} - p_{back})\frac{x}{a} - (p_{bottom} - p_{back})$$

Equation 1a noting the first principle pressure acting in the negative direction (above). **1b** noting the first principle pressure acting in the positive direction (below)

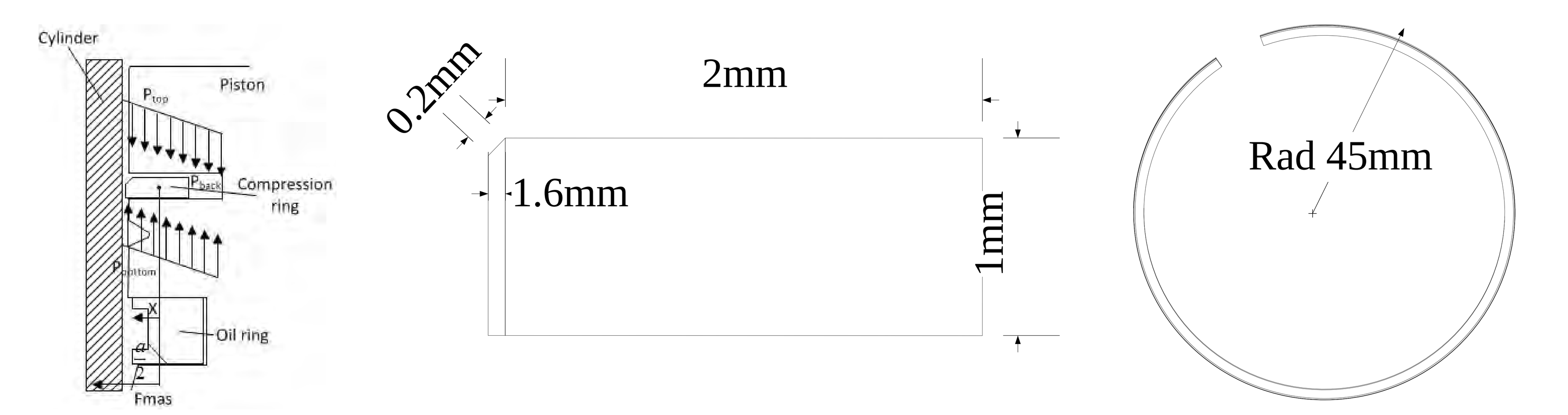

Figure 2a Showing mathematical model (left). **b** Showing ISO 6622-1 Internal combustion engines cast iron standard (centre). **c** showing ring OD (right).

The boundary condition of the piston ring pressures where calculated using equation **1a-b**. The negative first principle pressures where calculated for the negative direction using equation 1a and for the positive equation **1b**.

Results

The results show the variation of engine speeds used on the piston ring, the range of 9000-12000rpm was used each response resulting in a similarity to **figure 3b**. To offer solution to the concentrated levels of stress at this point the chamfer was modified to 0.1mm showing in **figure 3a**.

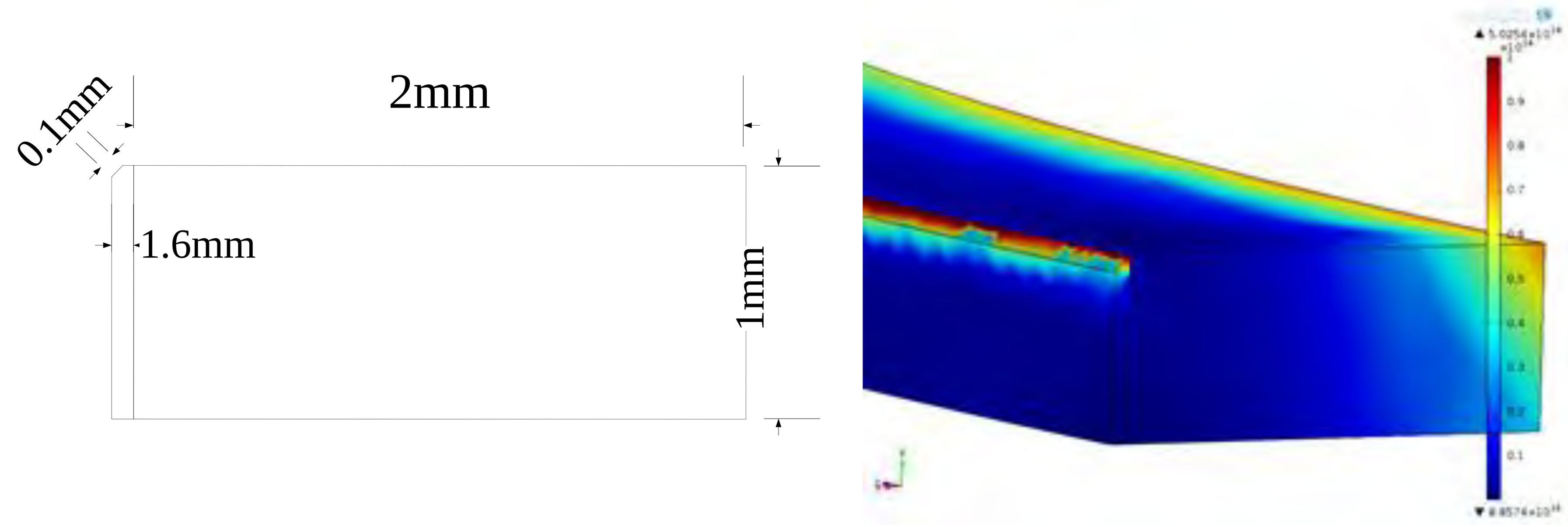

Figure 3 a. showing new Dickinson chamfer (left). **b.** showing Comsol plot (right).

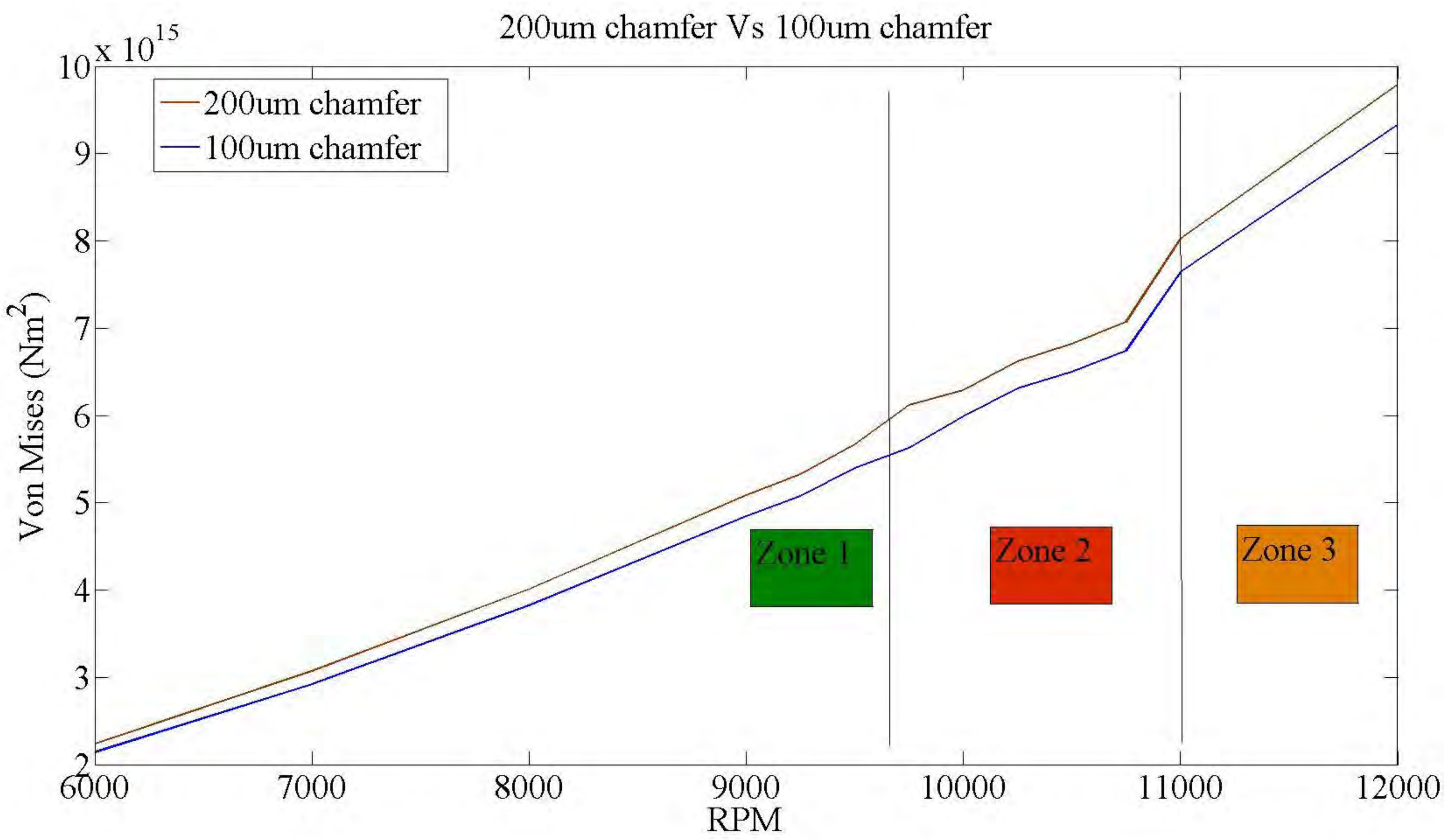

Figure 4. showing the results with ISO standard against the Dickinson modification

Notice that in zone 2 of Figure 4, the material begins to enter a shear stage.

Conclusion

In this work the contact chamfer standard ISO 6622 piston ring with contact chamfer has been presented. The results show that the ring during operation is subjected to a large level of stress which can lead to surface fatigue. To relieve some of the stress at this point a new design modification has also been presented. This modification when compared against the standard chamfer shows relieved stress levels. It should be noted that if the engine is operating at levels beneath the 9000 rpm level, this modification would not be needed as the point of passing from zone 1-3 (**Figure 4**) would not occur.

References:

[1] Ramsbottom J. On an improved piston for steam engines. ARCHIVE: Proceedings of the Institution of Mechanical Engineers 1847-1982 (vols 1-196) 1854 Nov 1;5(1854):70-4.
[2] Love AEH. The Stress Produced in a Semi-Infinite Solid by Pressure on Part of the Boundary. Philosophical Transactions of the Royal Society of London Series A, Containing Papers of a Mathematical or Physical Character 1929 Jan 1;228:377-420.
[3] Mittler R, Mierbach A, Richardson D. Understanding the Fundamentals of Piston Ring Axial Motion and Twist and the Effects on Blow-By. ASME Conference Proceedings 2009 Jan 1;2009(43406):721-35.

Excerpt from the Proceedings of the 2012 COMSOL Conference in Milan