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# HYDRODYNAMIC LUBRICATION OF PARALLEL SURFACES WITH RANDOM ROUGHNESS AND GROOVES

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## KEYWORDS

***Oil control ring; cylinder liner; load carrying capacity***

## INTRODUCTION

For lubricated contacts, the component macro-geometry (radius of curvature) determines the pressure generation and the micro-geometry (i.e. roughness, texturing) alters it somewhat. However, for parallel surfaces, i.e. the oil control ring (OCR), the micro-geometry completely determines the hydrodynamic lubrication (HL).

For a smooth OCR-cylinder liner contact, the cross-hatched grooves provide a certain load carrying capacity (LCC). Furthermore, the surface (plateau) roughness can be an additional source of LCC. So, is the influence of grooves on the LCC of rough liner surfaces positive or negative?

The current paper studies the hydrodynamic pressure and LCC of parallel surfaces with random roughness and/or grooves. This paper extends the work by Biboulet et al. [1]. They developed an efficient global grid refinement solver of the Reynolds equation, which originates from [2], using a mass-conserving cavitation algorithm. The solver provides a fast and stable convergence for parallel surfaces with sinusoidal roughness or dimple texturing.

## RESULTS

The dimensionless Reynolds equation with cavitation and Fischer-Burmeister equation are solved simultaneously:

$$\frac{\partial}{\partial X}\left(H^3\frac{\partial P}{\partial X}\right)+\frac{\partial}{\partial Y}\left(H^3\frac{\partial P}{\partial Y}\right)=\frac{\partial((1-\theta)H)}{\partial X} \qquad (1)$$

$$P+\theta-\sqrt{P^2+\theta^2}=0 \qquad (2)$$

where $H$ is the gap; $P$ is the pressure; $\theta$ is the cavitation fraction.

Two types of artificially generated surfaces were studied, illustrated in Fig.1. 'R' refers to a surface with only roughness; 'R+G' indicates that the rough surface contains grooves.

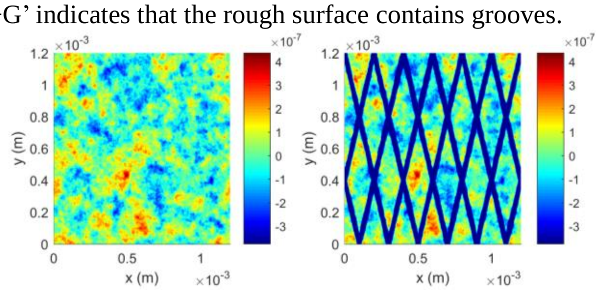


Fig.1 Cylinder liner surfaces: 'R' (left) and 'R+G' (right).

The surface roughness is randomly generated, with a Gaussian height distribution and an exponential autocorrelation function. The groove cross-section is sinusoidal. The pressure distributions for Fig.1 are shown in Fig.2. One can see that the grooves change the pressure distribution substantially.

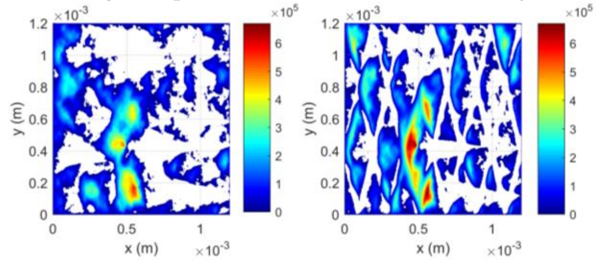


Fig.2 Pressure distribution for 'R' (left) and 'R+G' (right).

To find out if grooves are beneficial, we conducted many calculations. Fig.3 shows the variation of the LCC with the RMS for an 'R' and three 'R+G' surfaces.

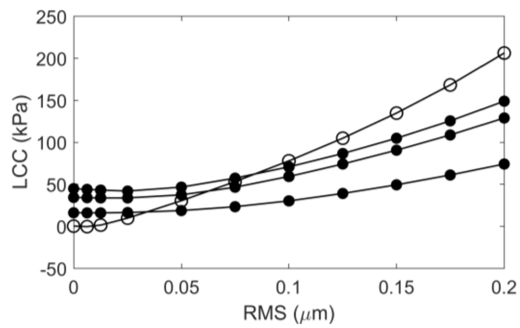


Fig.3 LCC as a function of the surface RMS roughness for 'R' (open dots) and for 'R+G' with a groove spacing of 0.1,0.2,0.3 mm bottom to top (closed dots).

We found that for increasing RMS (the surface roughness remains the same), the LCC increases for both the 'R' and 'R+G' cases. For 'R+G' cases, the larger the groove spacing, the higher the LCC-RMS curve. The curve for an 'R' surface intersects with those for 'R+G', showing that for small roughness, the introduction of grooves increases the LCC while for large RMS, grooves decrease the LCC. The grooves serve as channels for oil flowing from high pressure to low pressure zones. This results in a decrease in LCC, as was shown in [3].

## REFERENCES

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