Laser Surface Texturing

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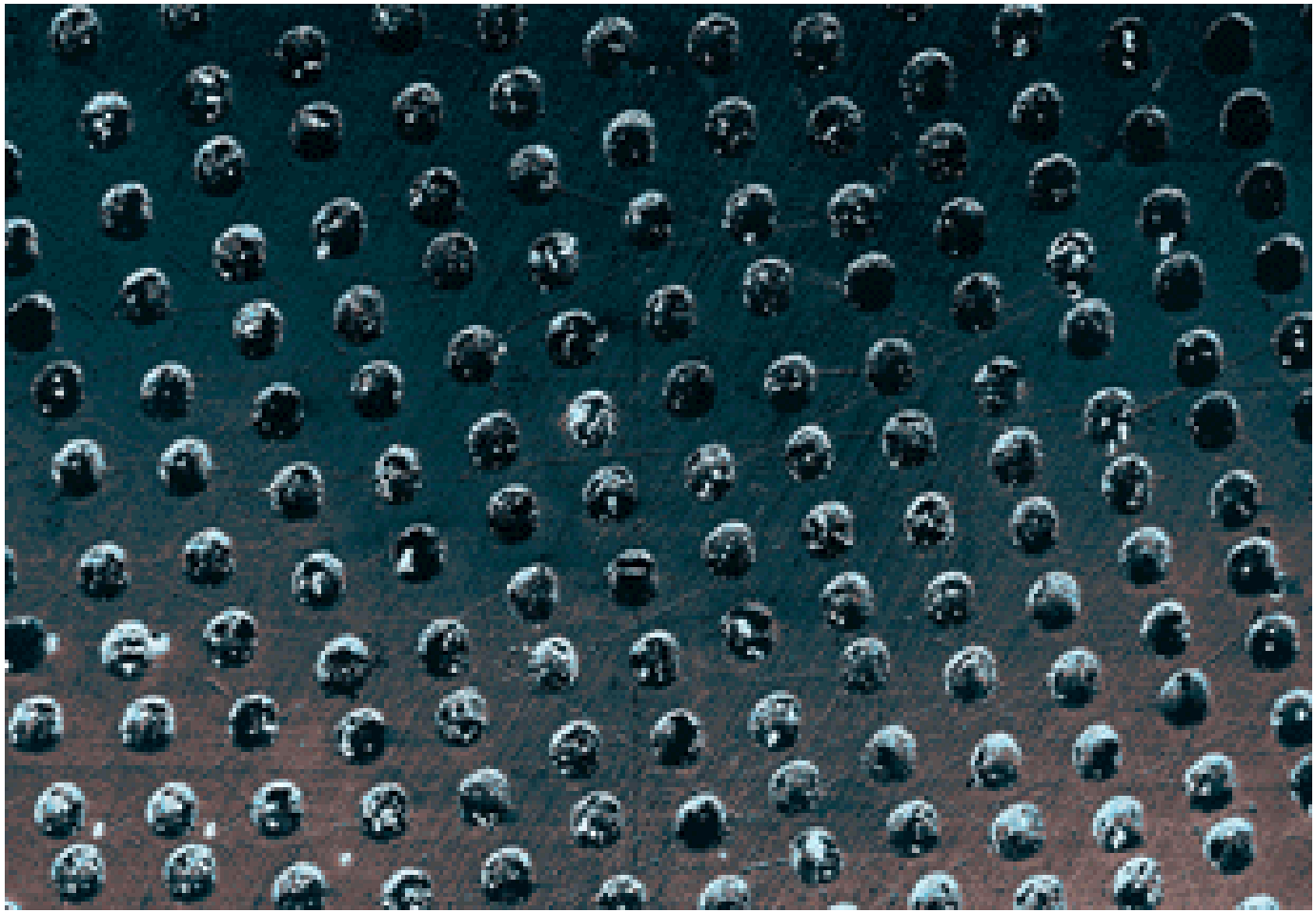
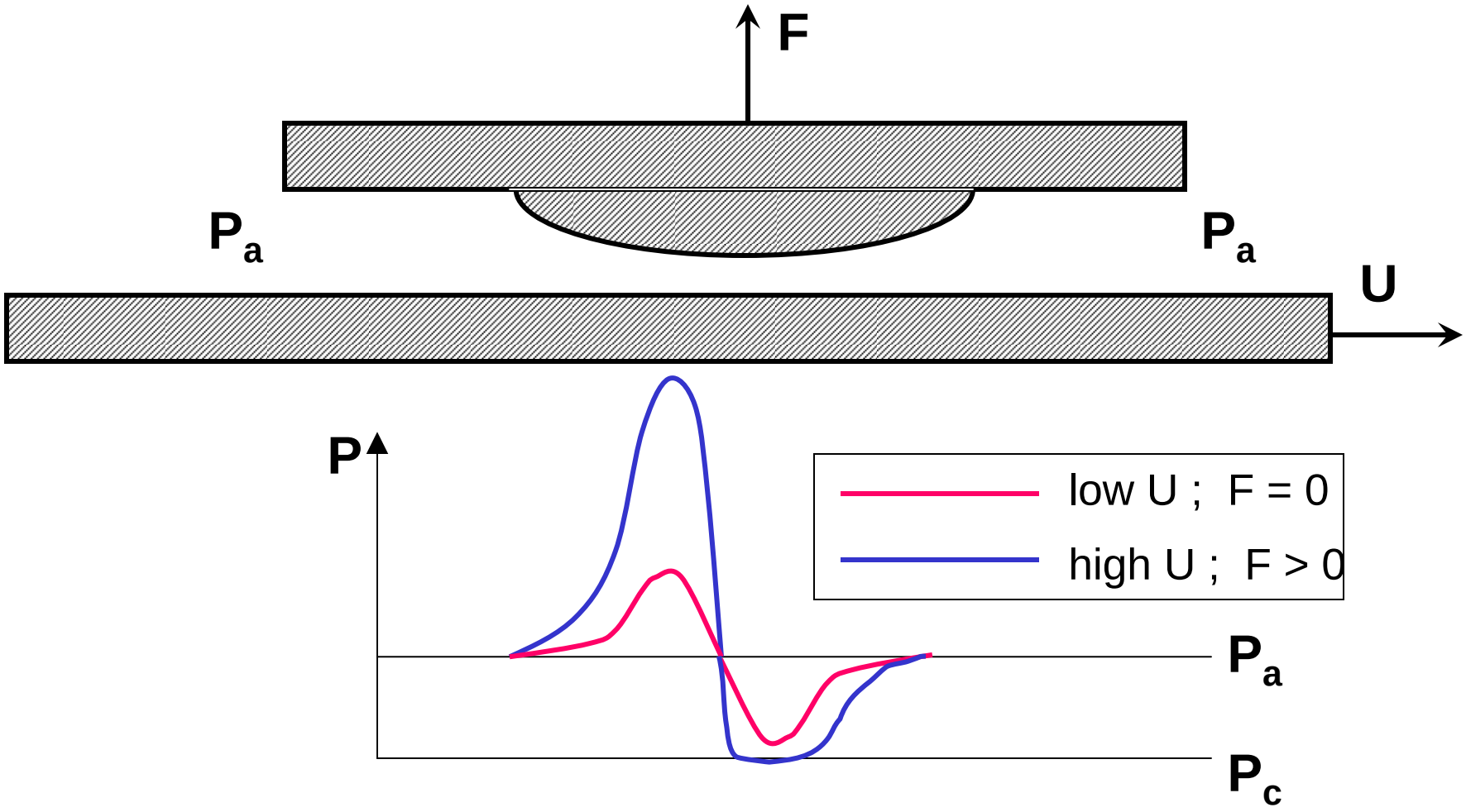
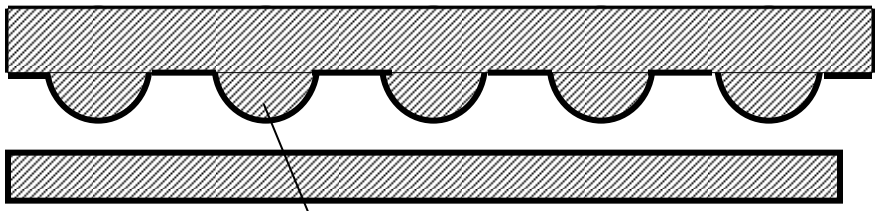
LST Regular Micro-Surface Structure in the Form of Micro-dimples



Hydrodynamic pressure distribution over a single “protrusion”

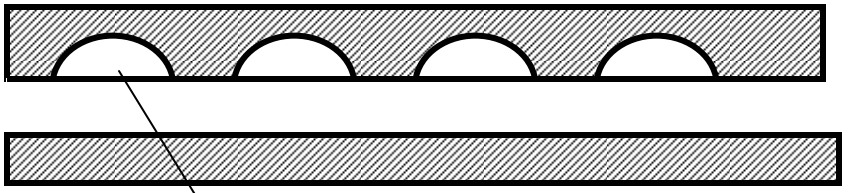


Why dimples ?



“protrusions”

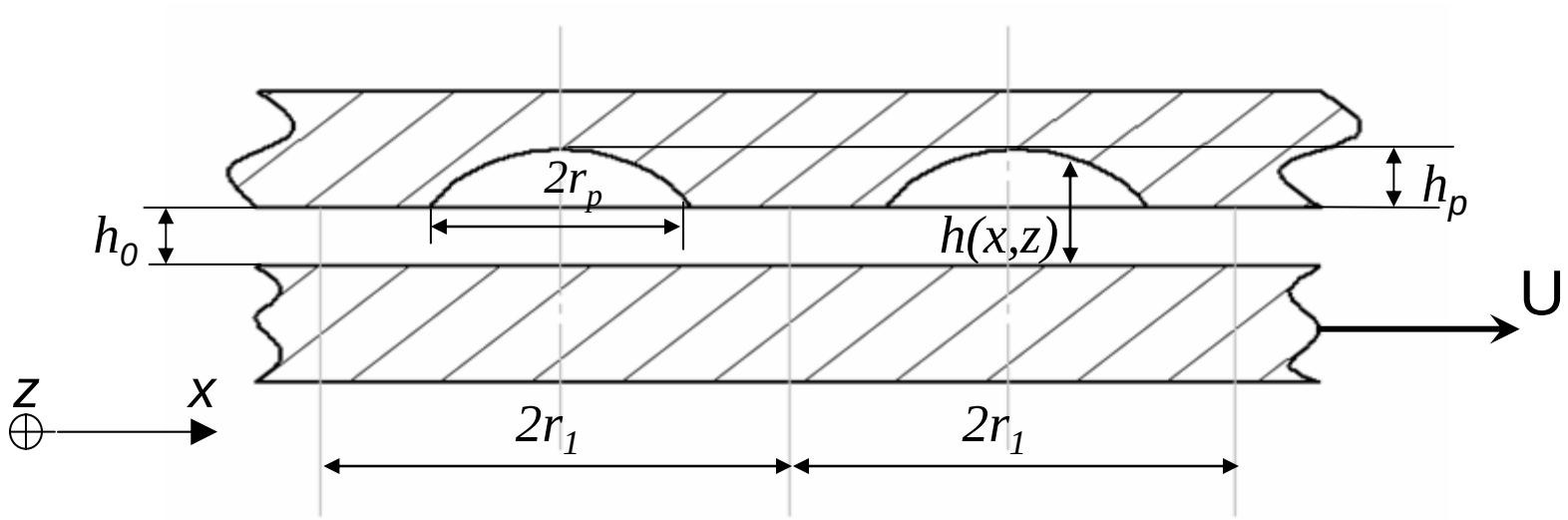
- complicated etching technology
- high wear
- high leakage (seals)



dimples

- simple & cheap laser technology
- lower wear
- low leakage/spacing

Film Thickness and Geometry of Micro-Dimples

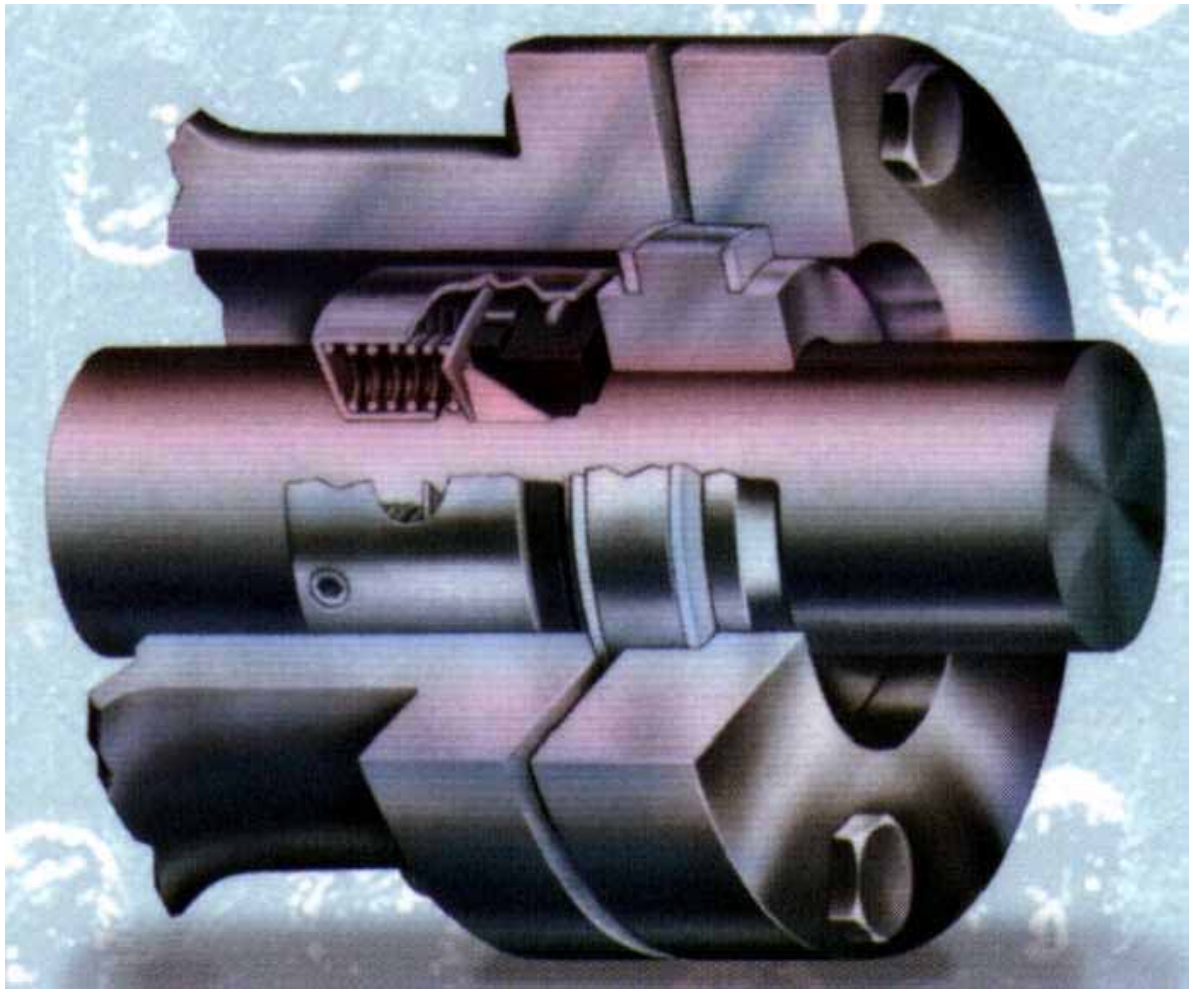


dimensionless minimum clearance : $\delta = h_0 / (2r_p)$

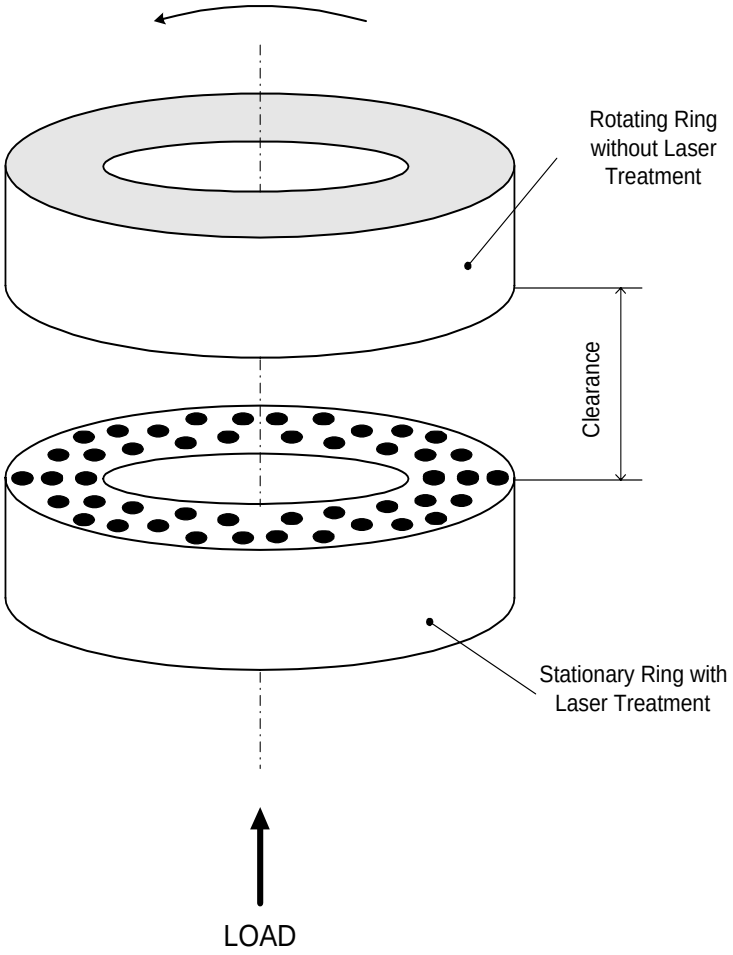
dimensionless local film thickness : $H = h/h_0 = H(\varepsilon, \delta)$

micro-dimple aspect ratio : $\varepsilon = h_p / (2r_p)$

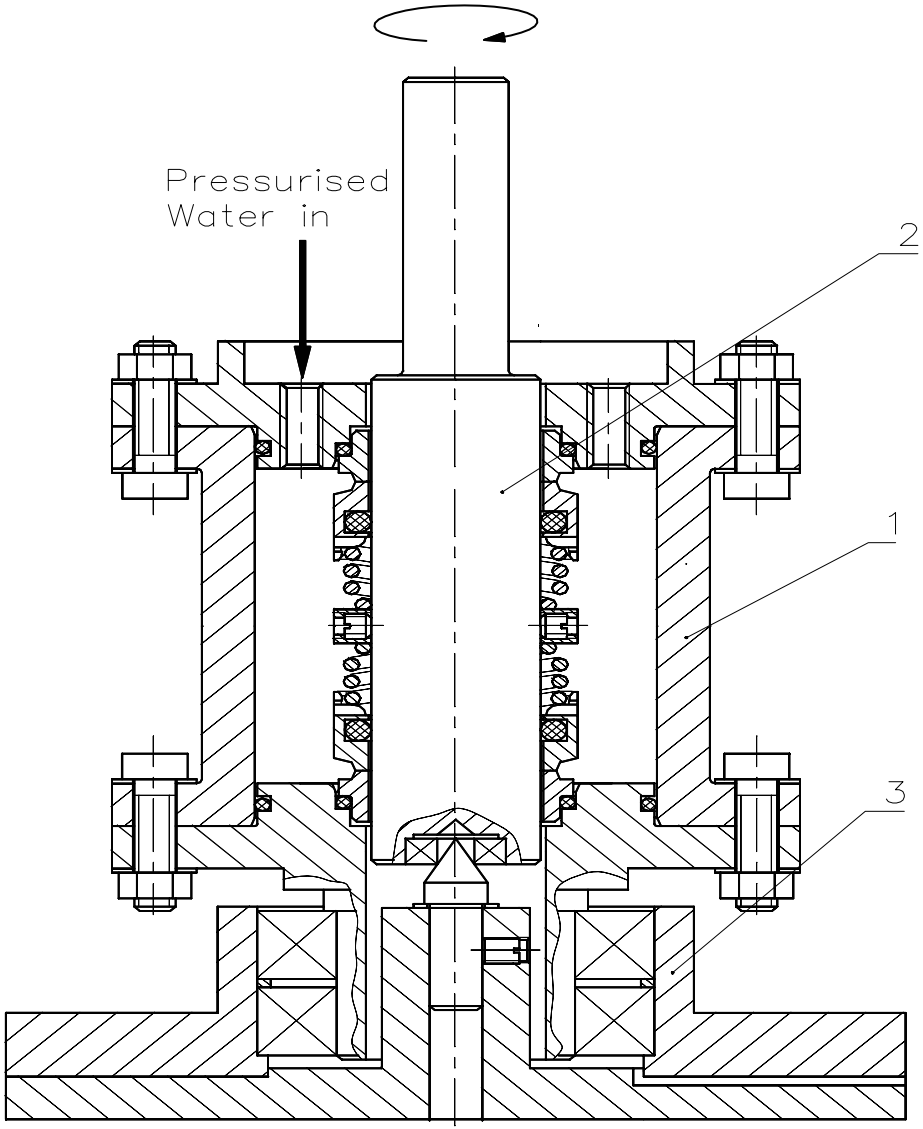
A Mechanical Face Seal



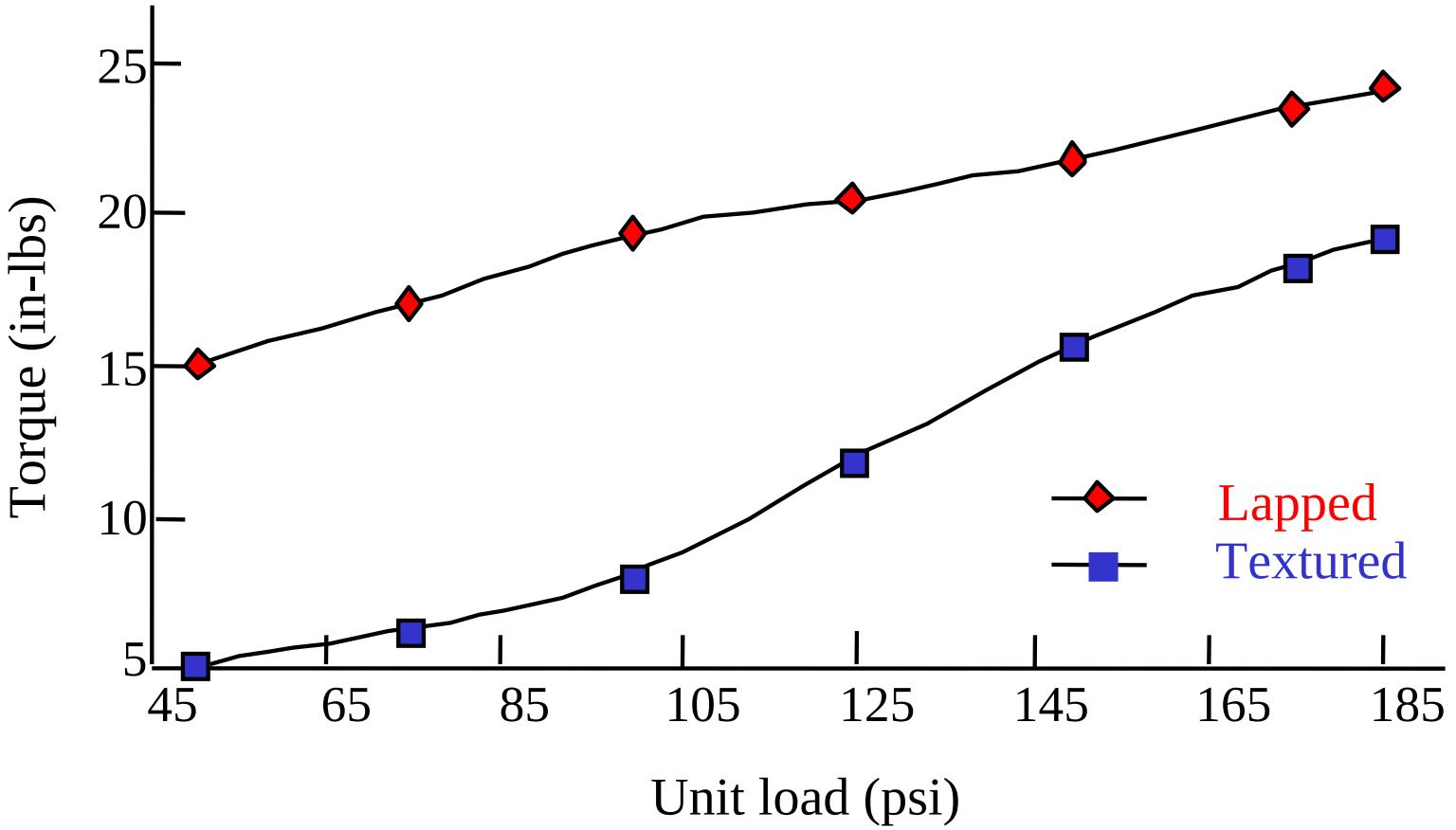
Ring on Ring Scheme



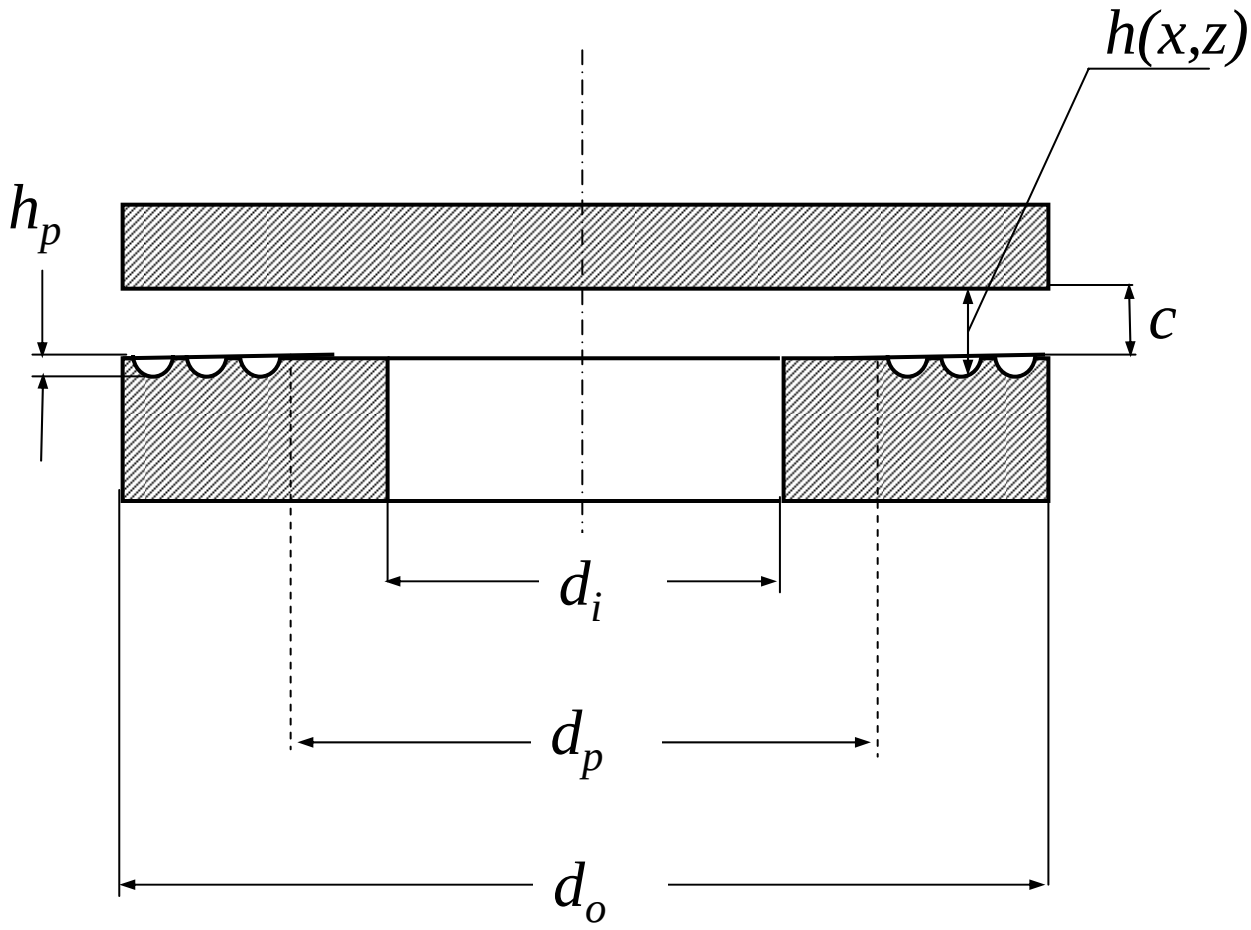
Test rig arrangement



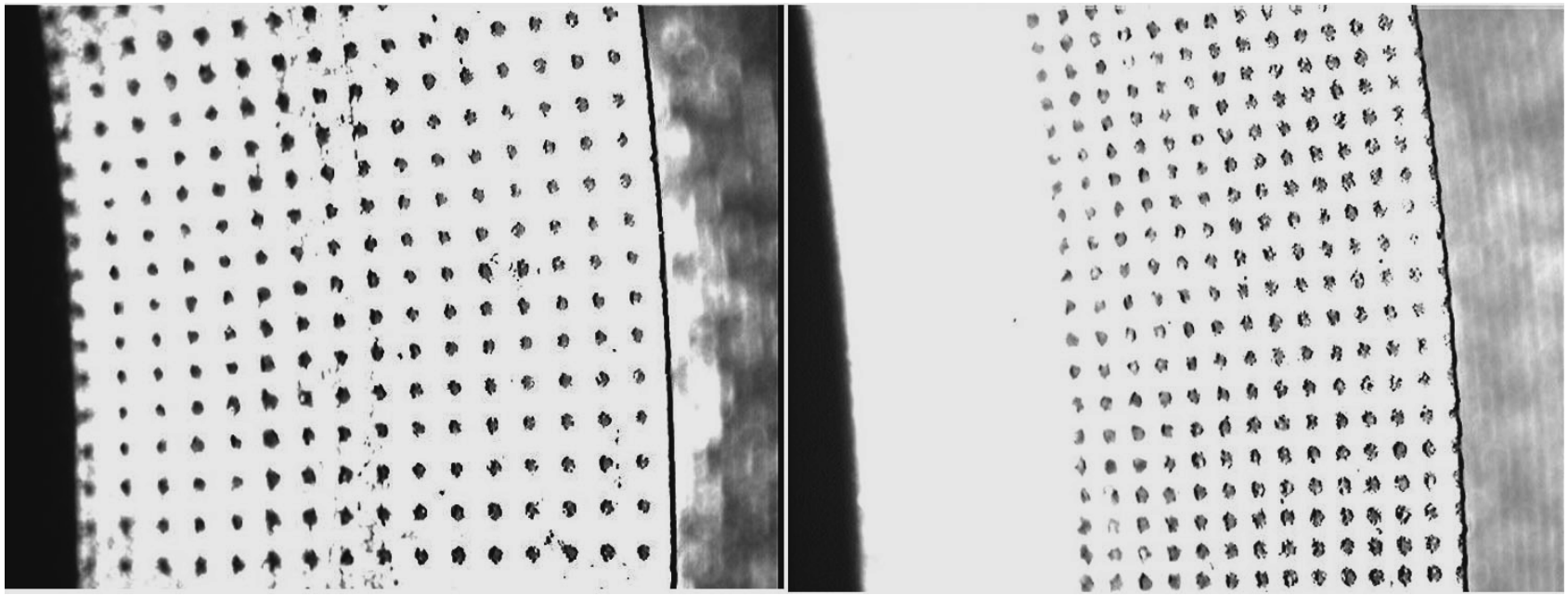
Friction Torque vs. Face Loading for Textured and Non-textured Seals in Water



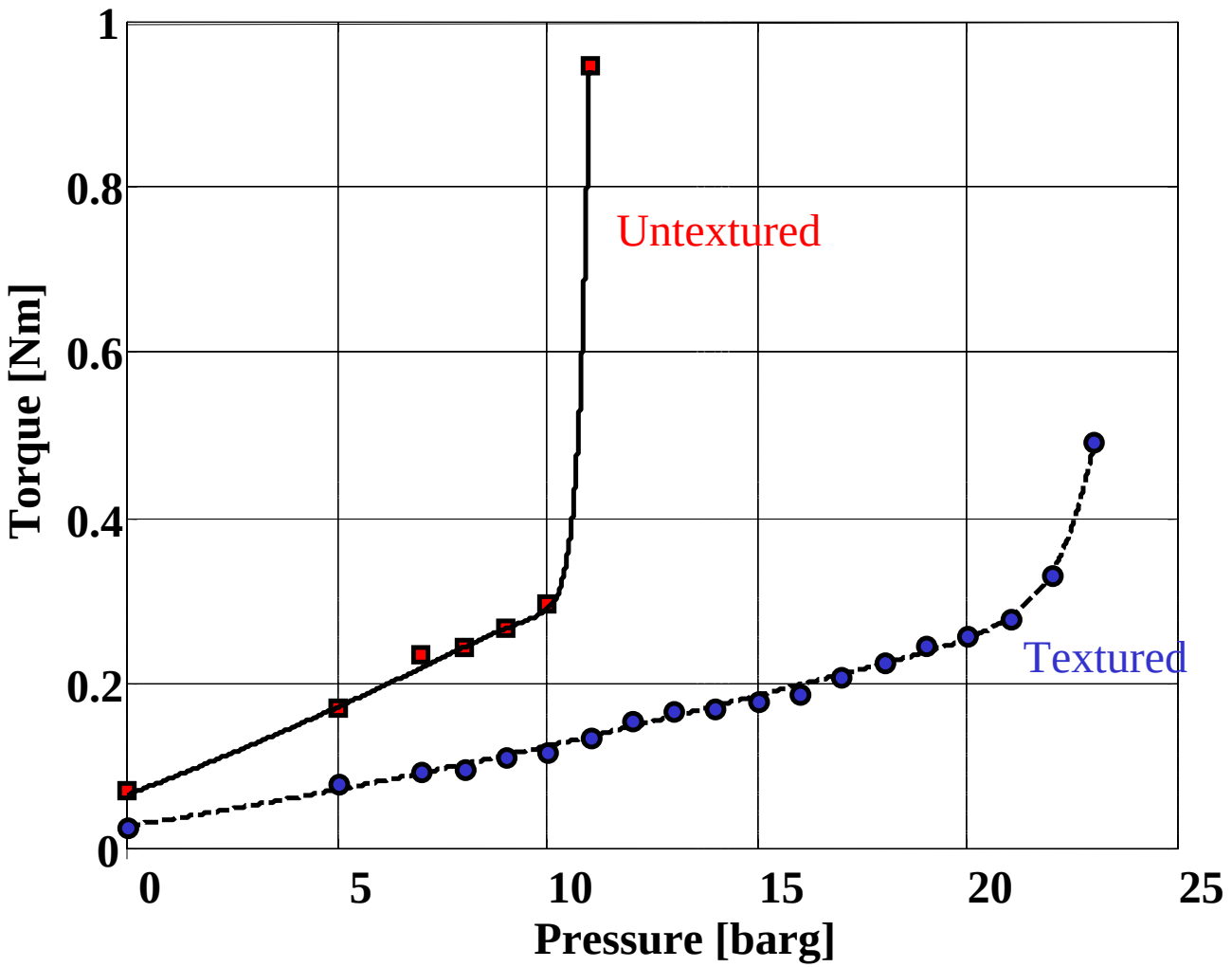
Schematic of a partial laser surface textured mechanical seal



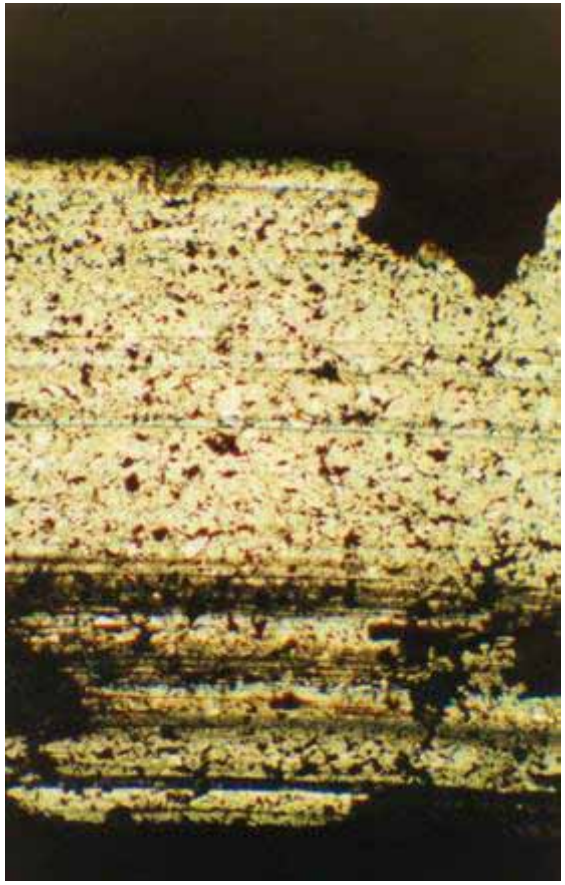
Partial (on the Right) and Full (on the Left) Face Laser Texturing



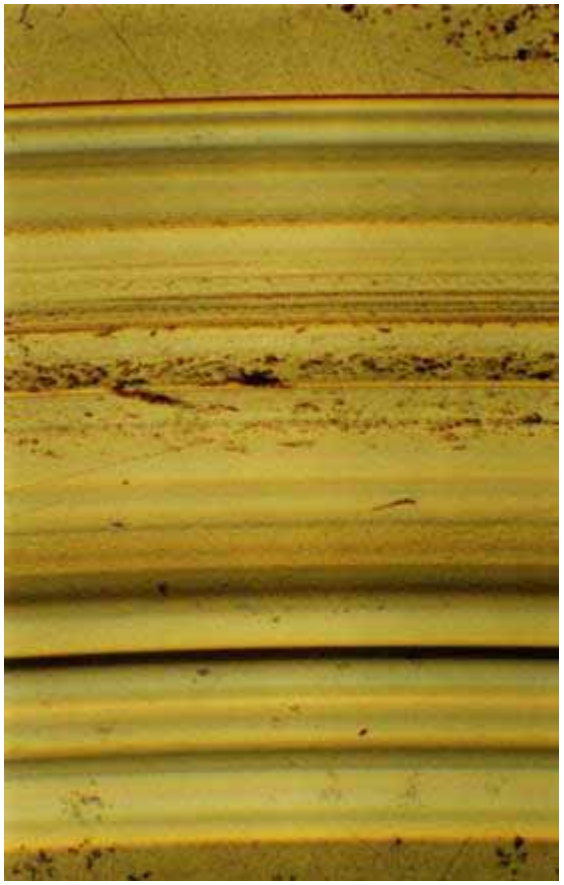
Friction Torque vs. Sealed Pressure for Non-textured and Partial Textured Seals



Field Test with Water Pump

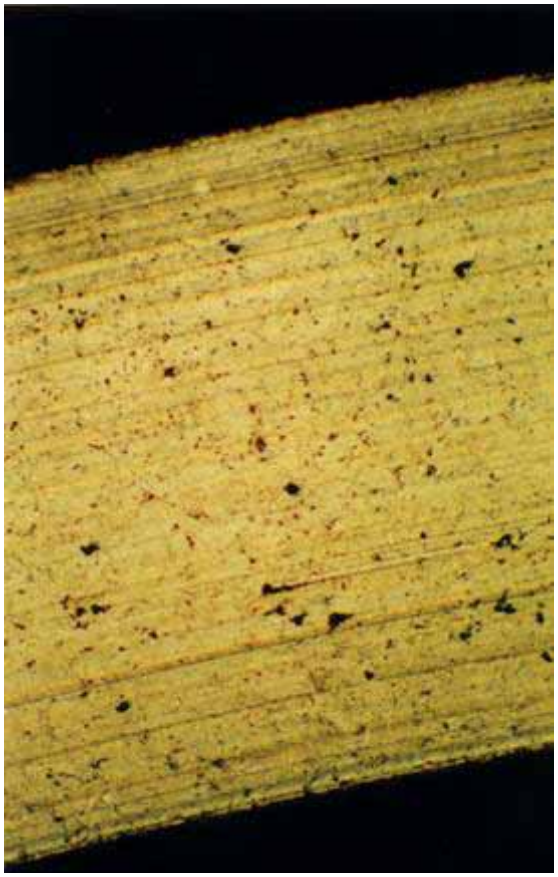


Carbon Ring - Standard Seal
After 400 Hours

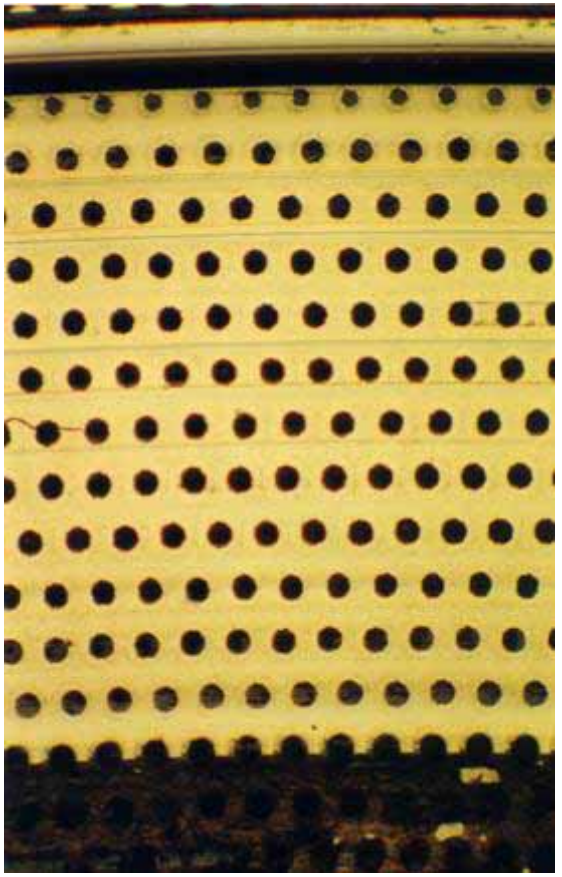


WC Ring - Standard Seal
After 400 Hours

Field Test with Water Pump

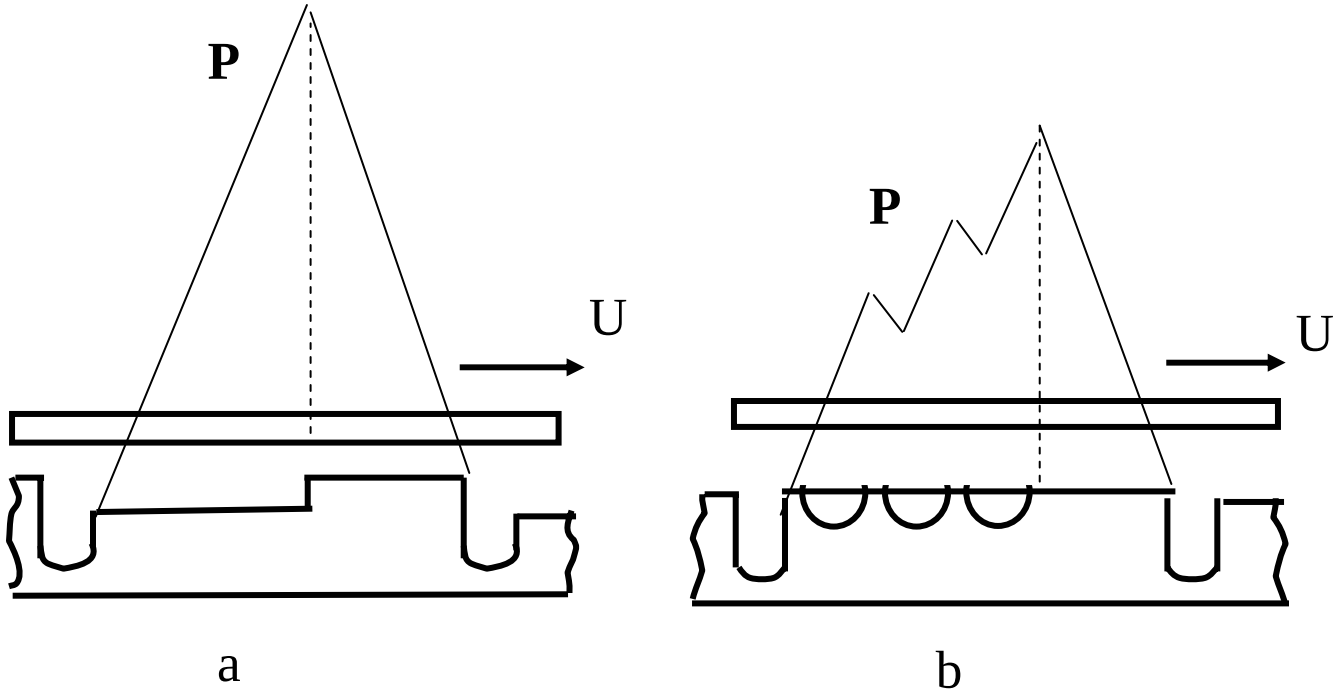


Carbon Ring - LST Seal
After 550 Hours

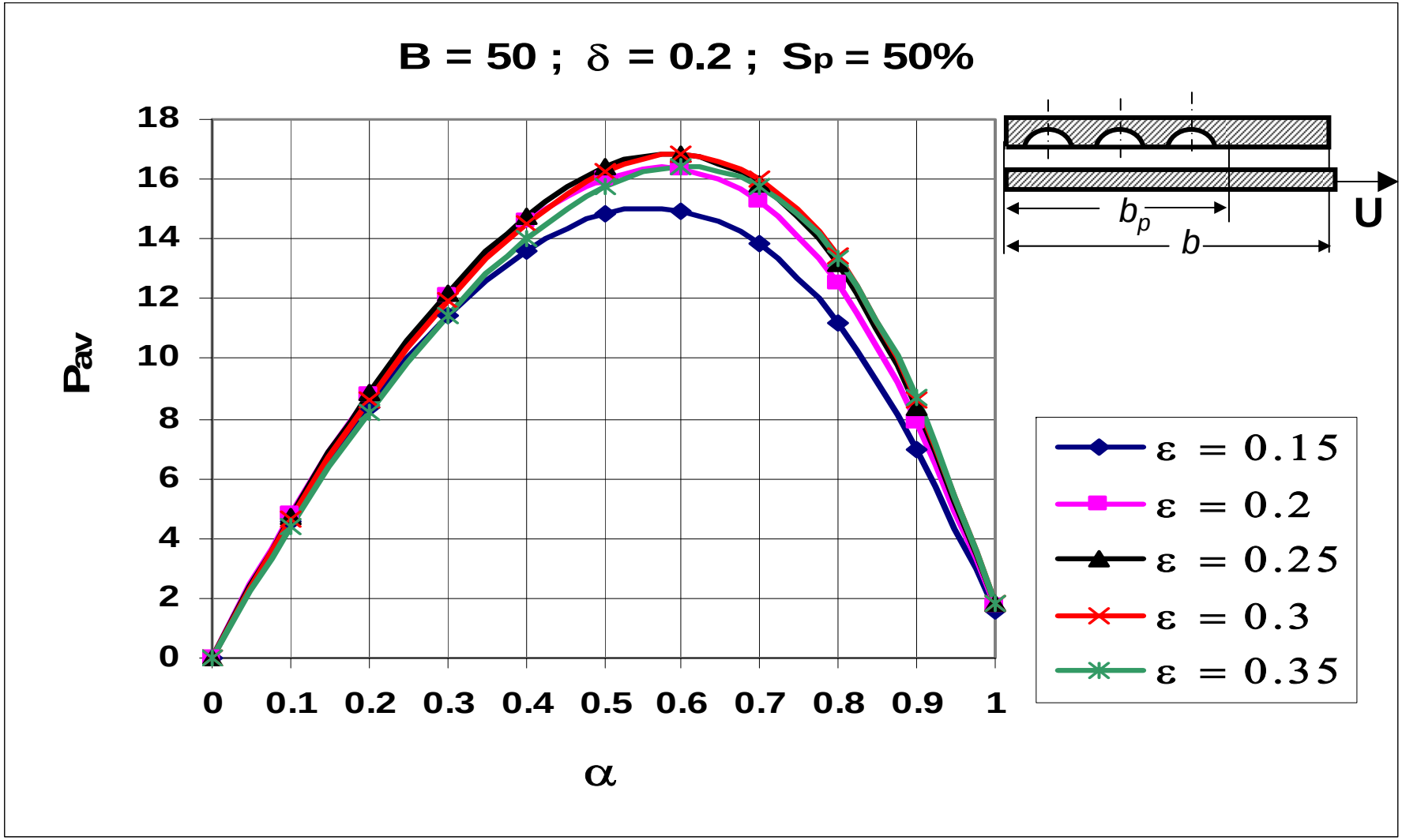


WC Ring - LST Seal
After 550 Hours

Pressure Distribution in a Stepped Slider (a), and in a Surface Textured Parallel Slider (b)



Results for Infinitely Long Slider.



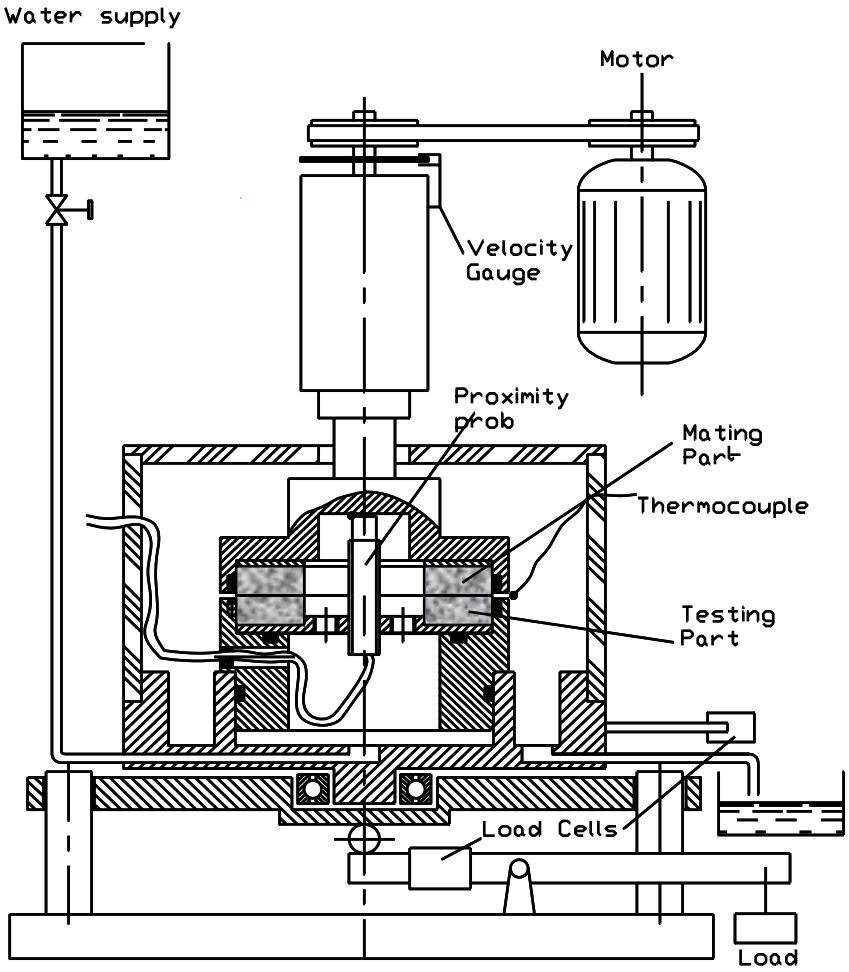
Bearing Mating Surfaces Showing a Textured Flat Stator and a Flat Rotor

Unidirectional (a) and a bi-directional (b) versions of the partial LST thrust bearing

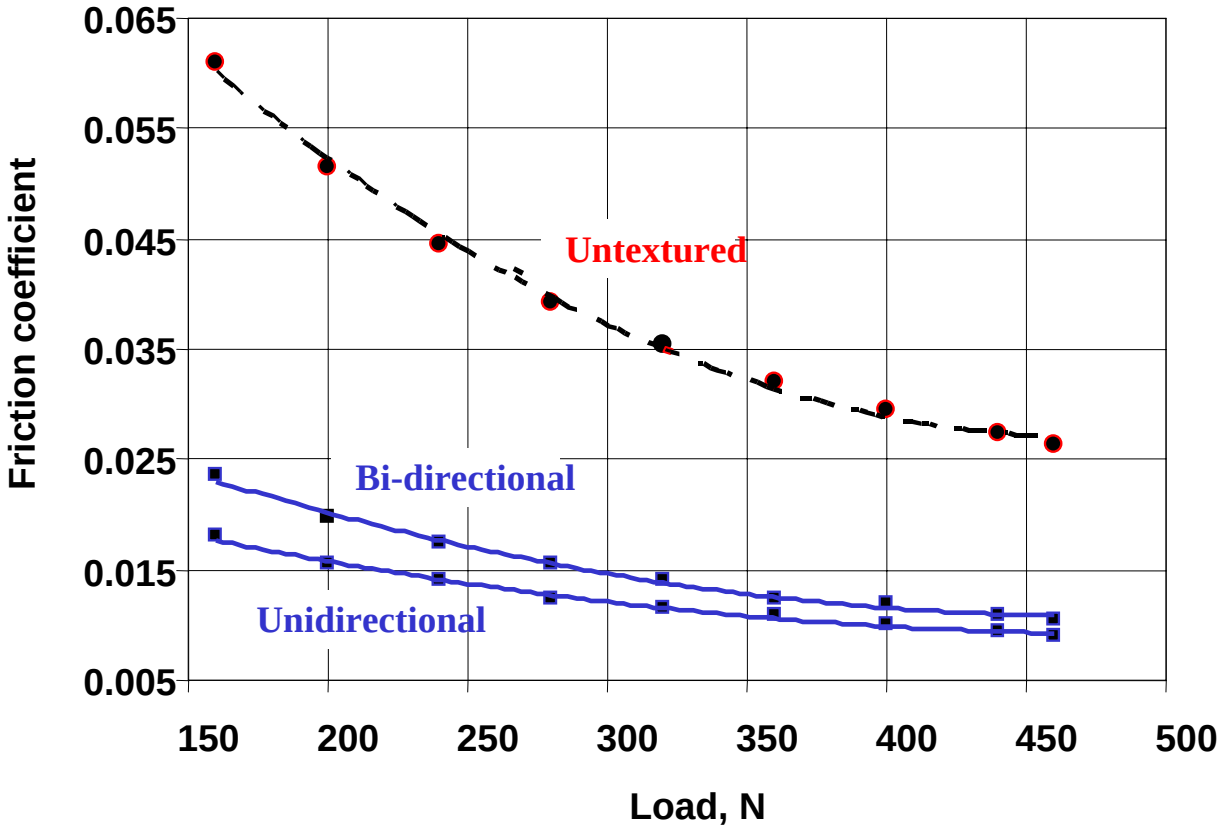
a

b

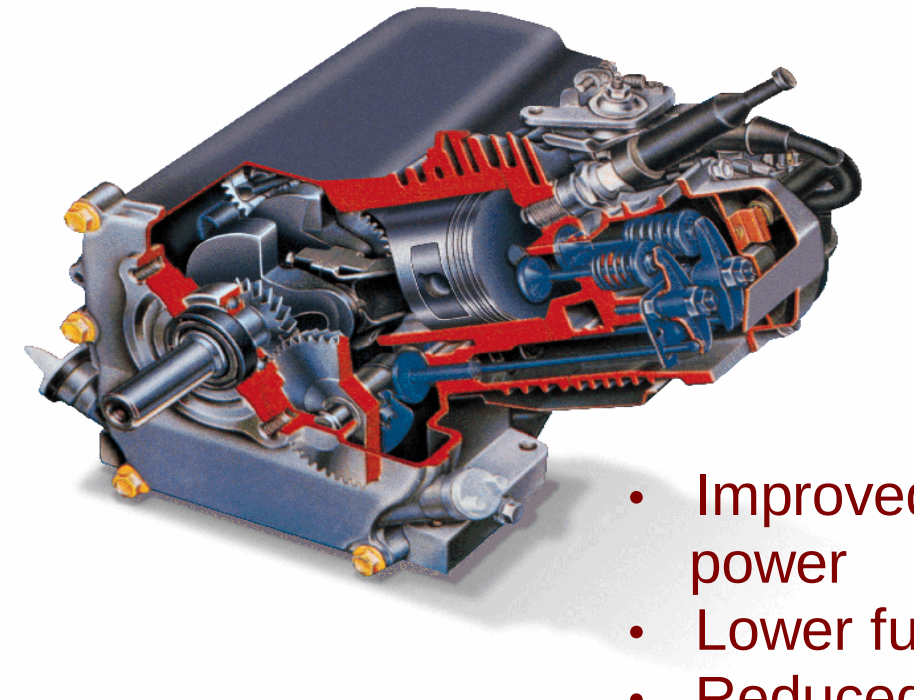
Schematic of the Test Rig



Comparison of Partial LST Bearings and a Non-textured Bearing Friction at 1500 rpm



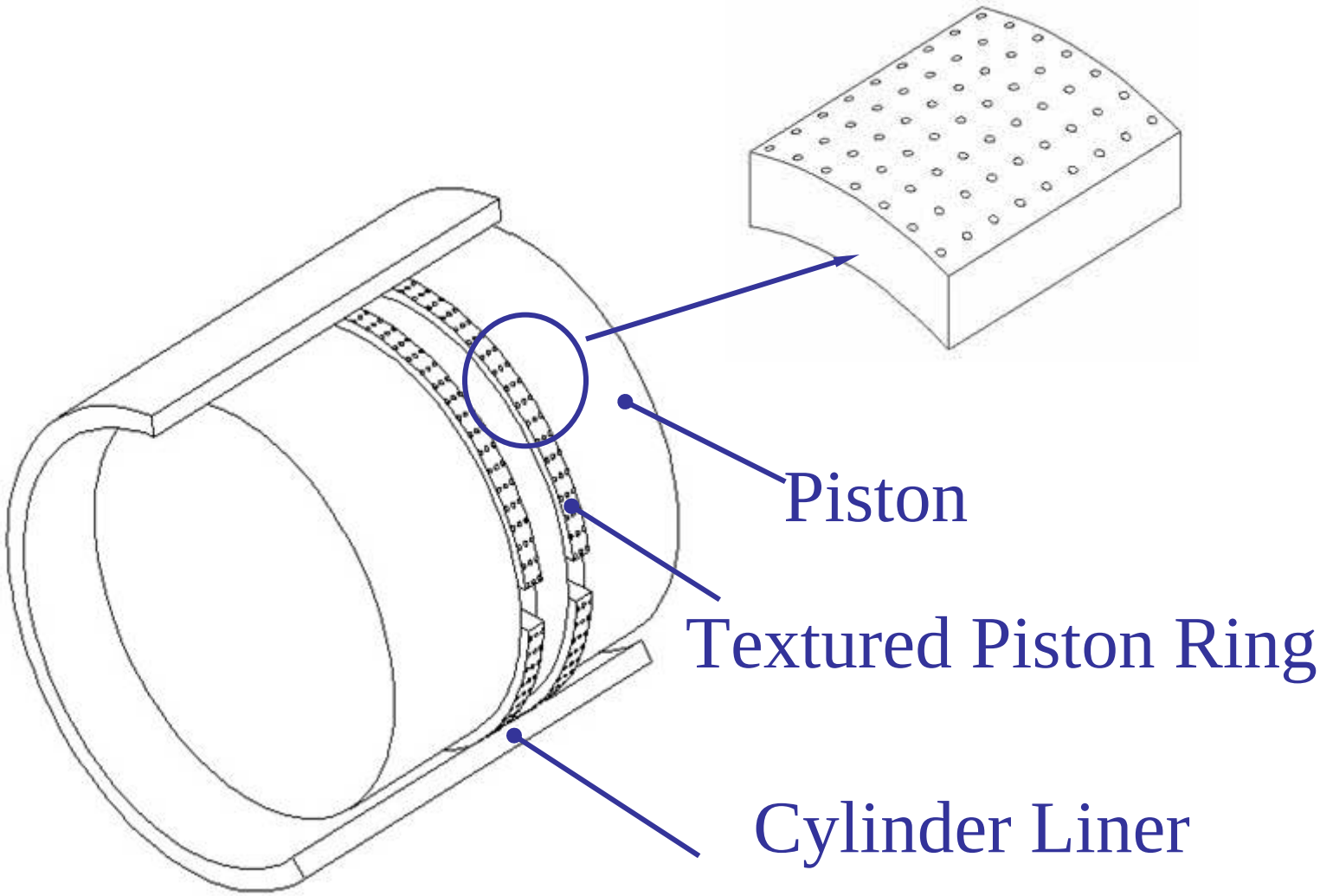
Internal Combustion Engines



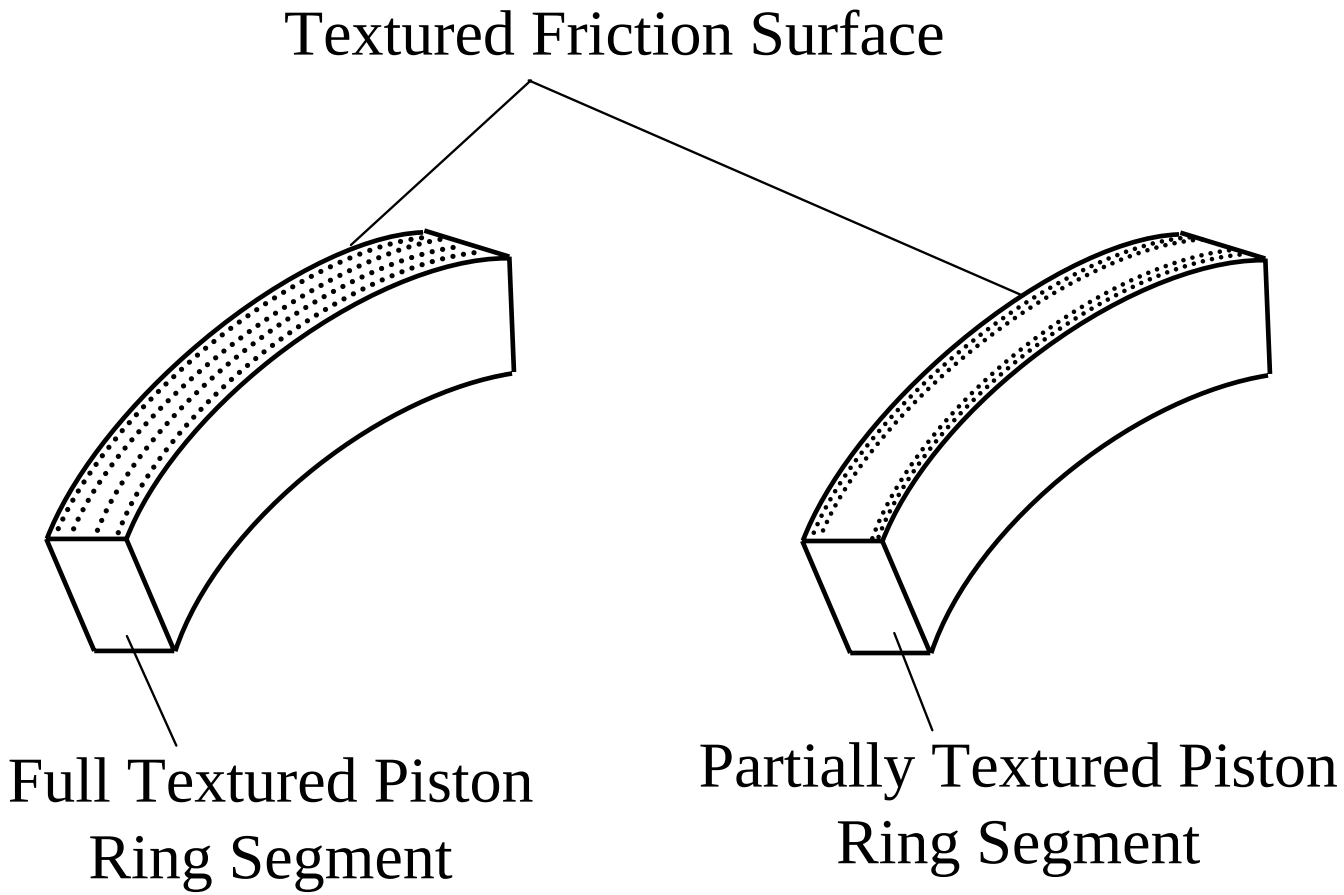
- Improved lubrication, speed and power
- Lower fuel consumption
- Reduced exhaust levels and operating temperatures
- Minimized cylinder wear and mechanical losses

Piston Group

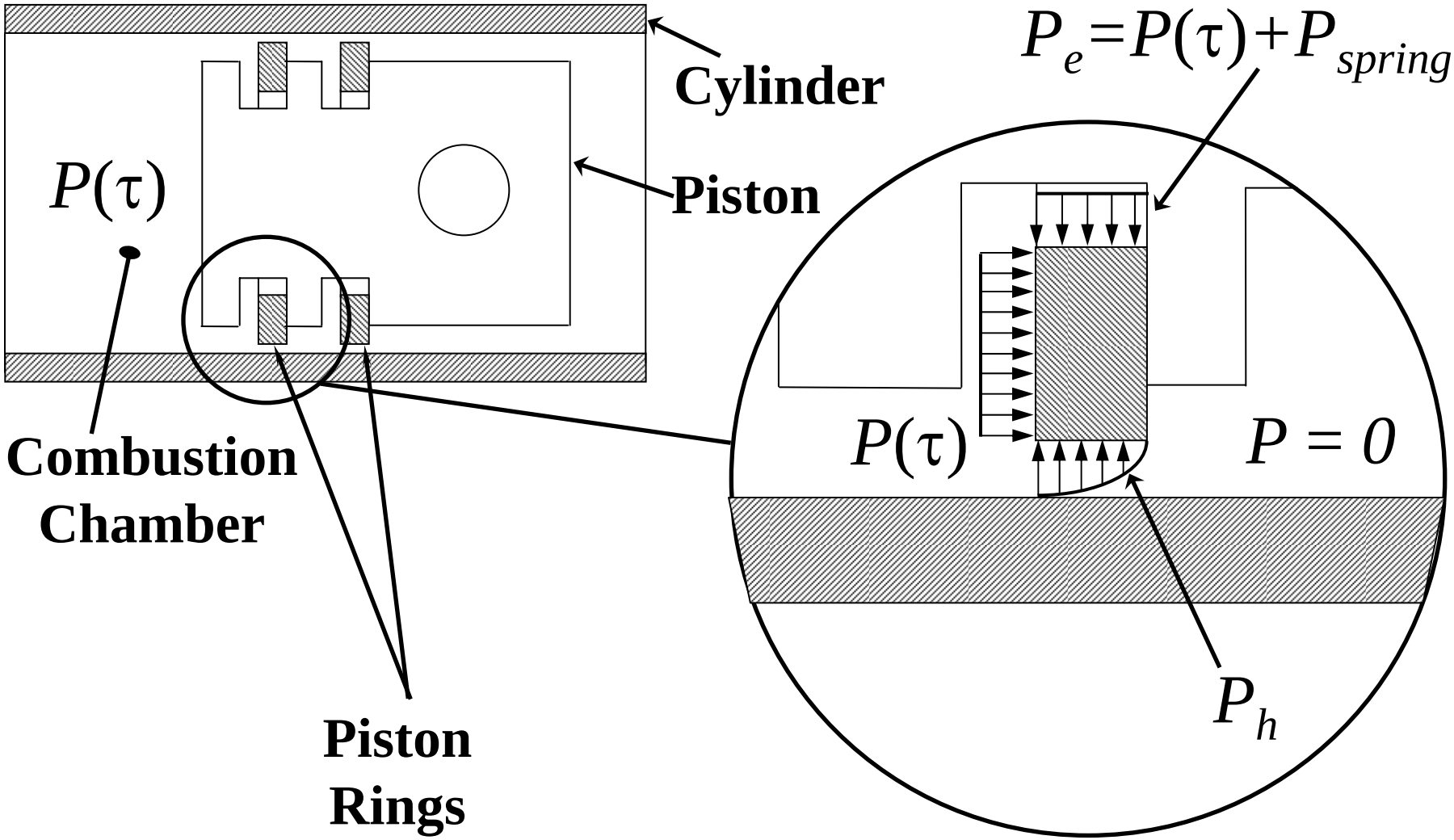
Laser Textured Piston Ring



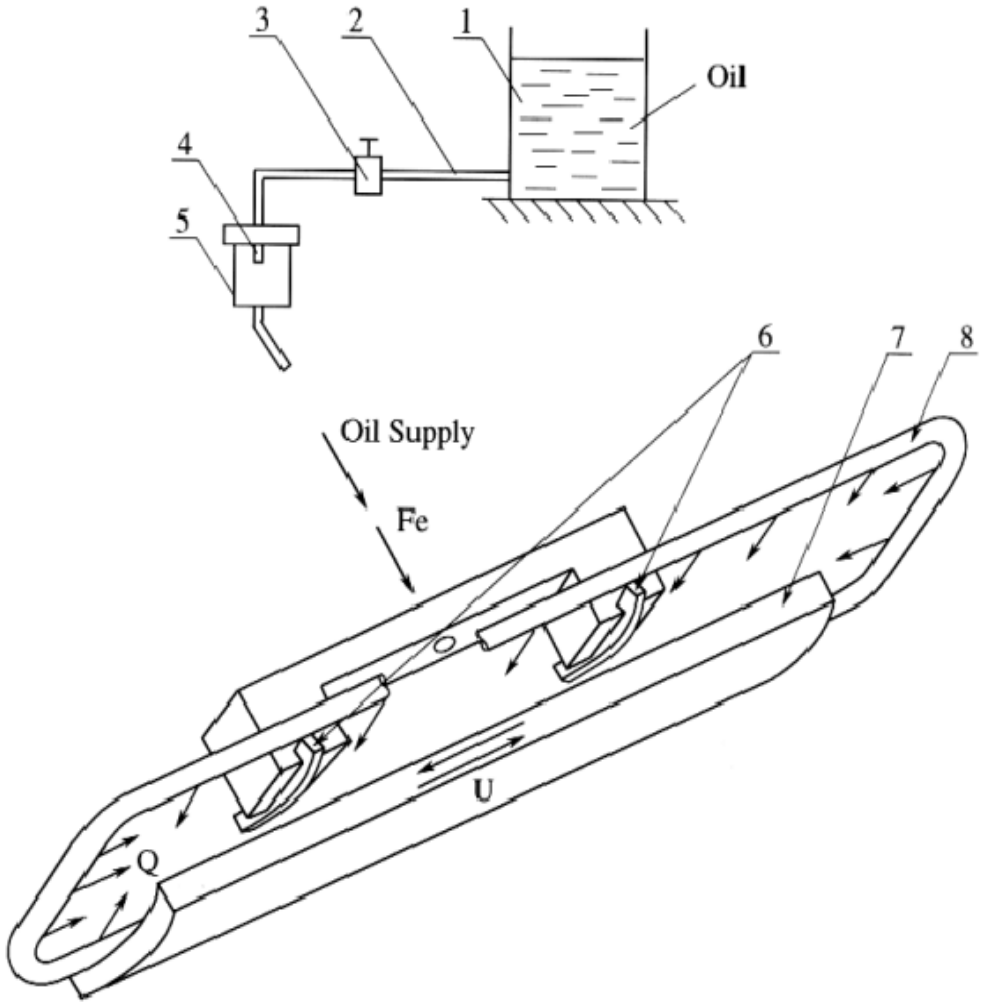
Laser Textured Piston Ring



Force Balance – Engine



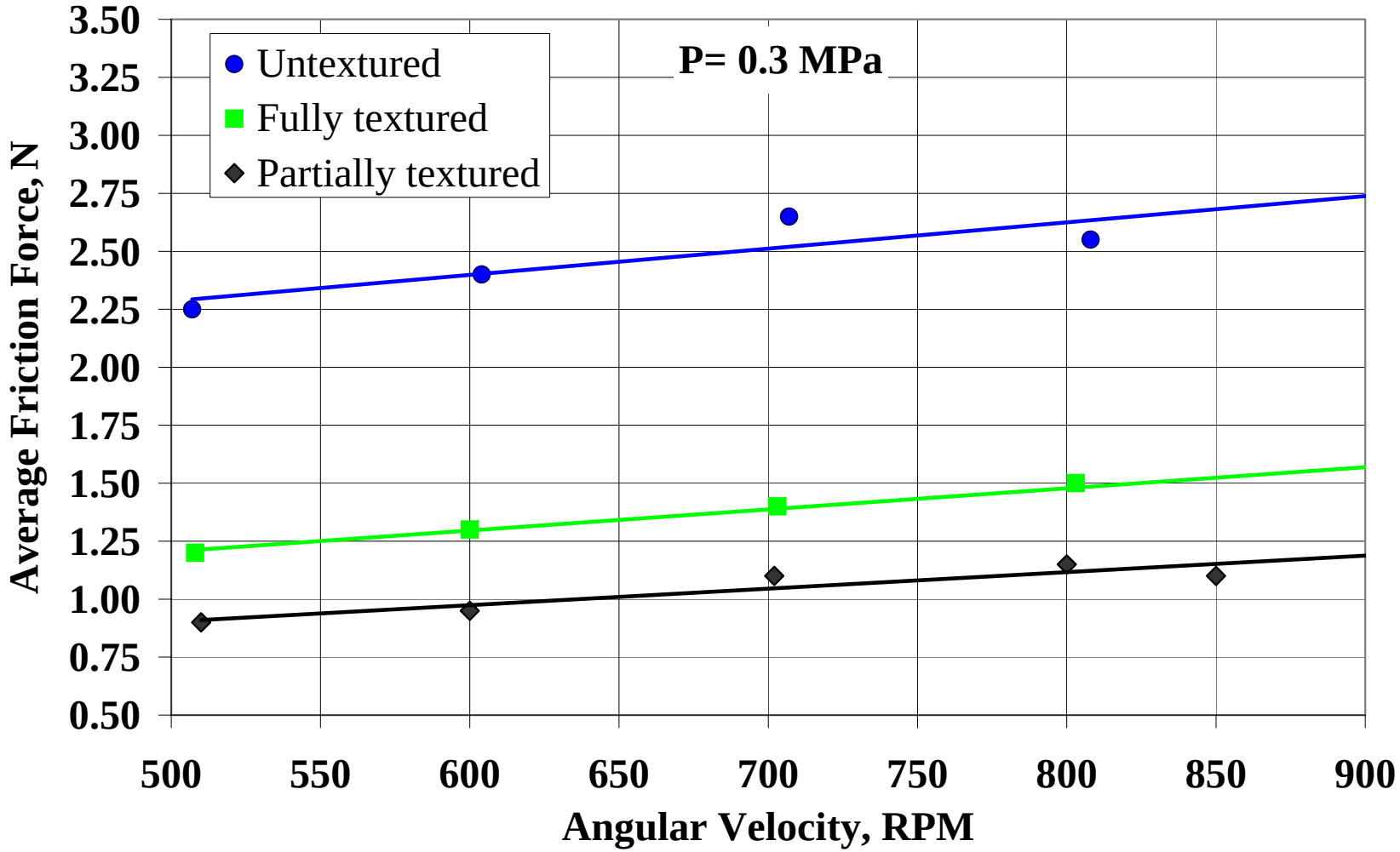
Reciprocating Test Rig



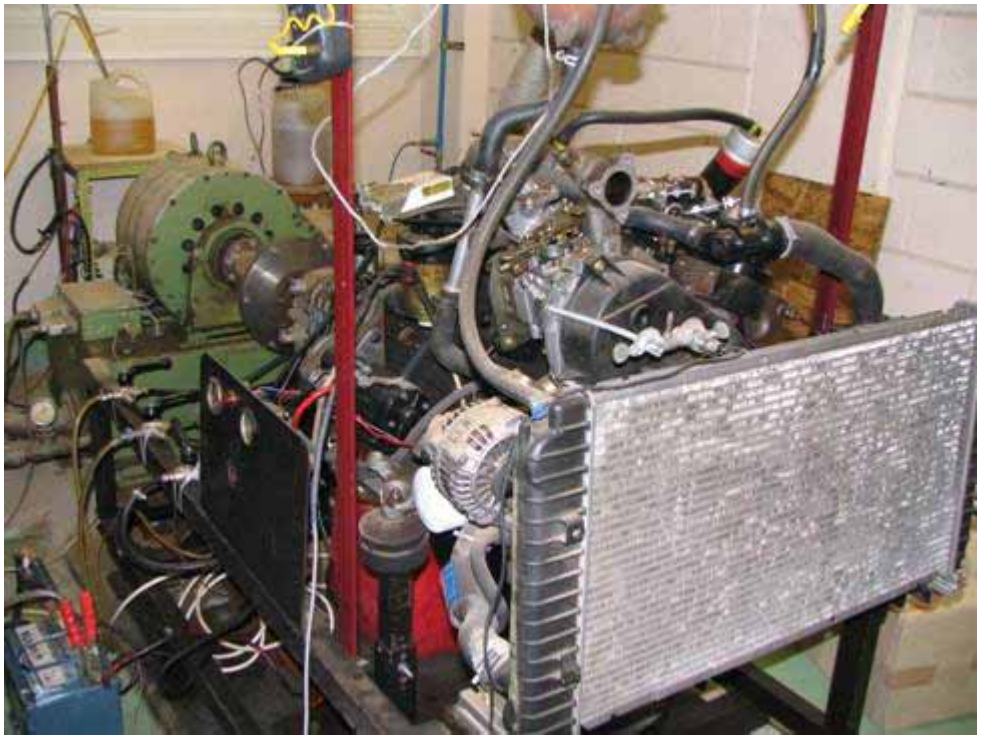
Piston Rings Holder

Piston Rings and Cylinder Liner

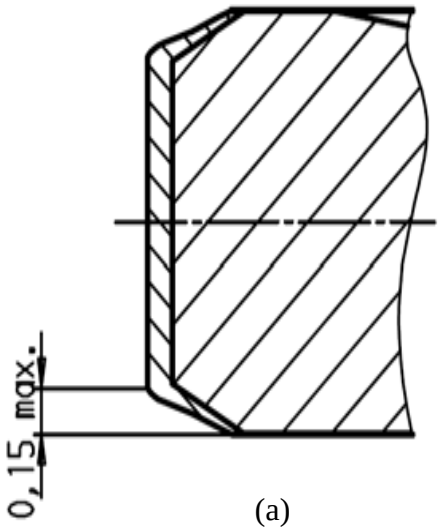
Test Results



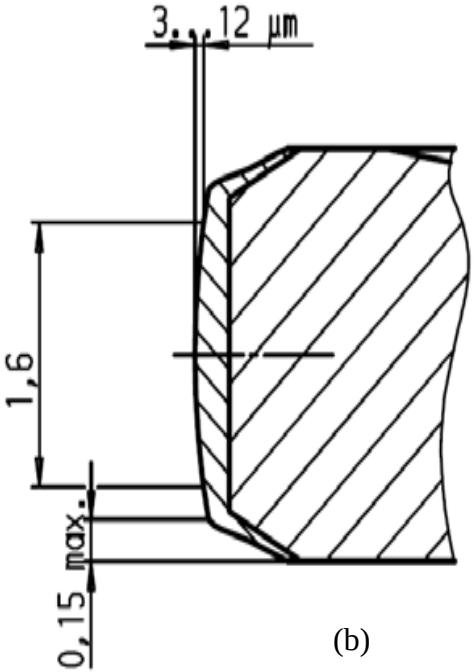
Ford transit engine on the test bench



Cross sections of cylindrical (a) and barrel shape (b) Cr coated piston rings

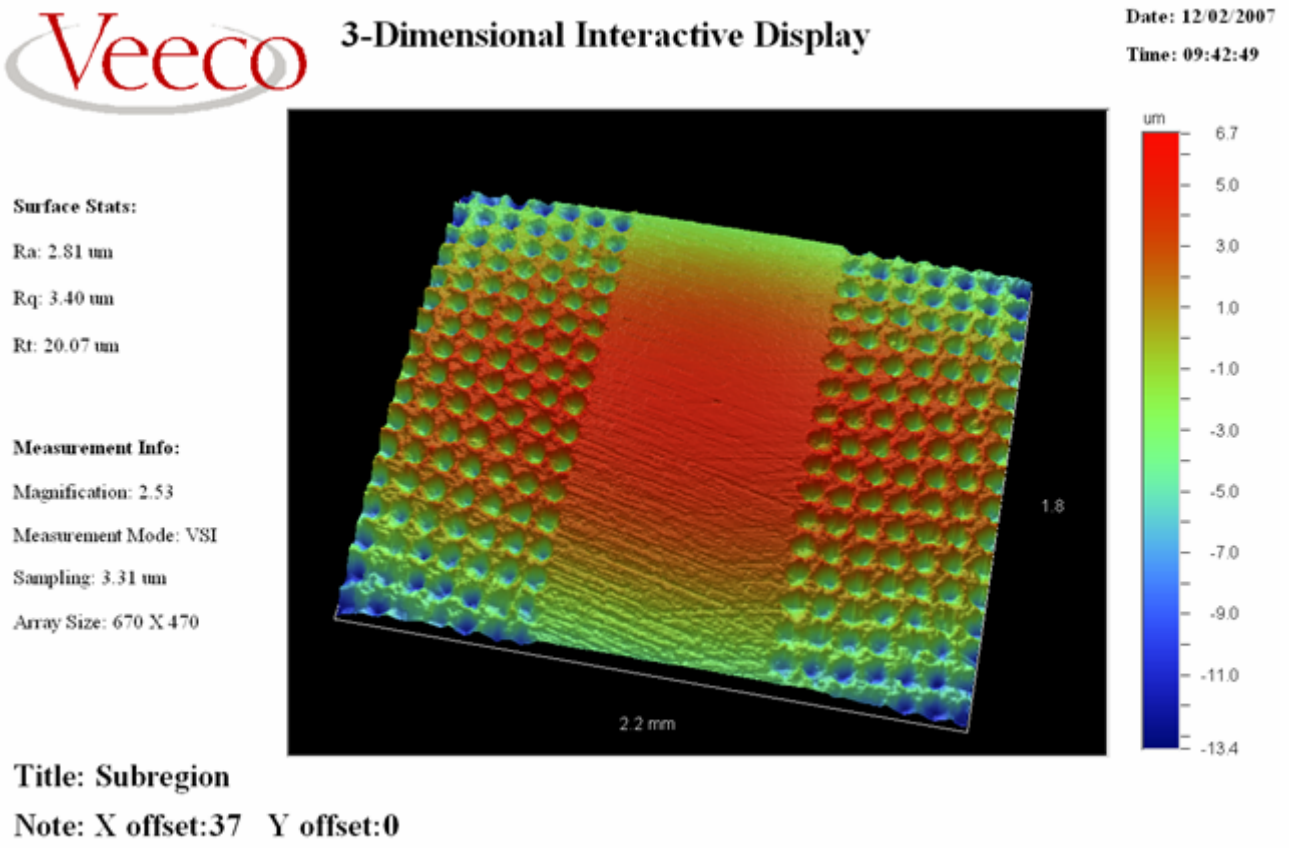


(a)



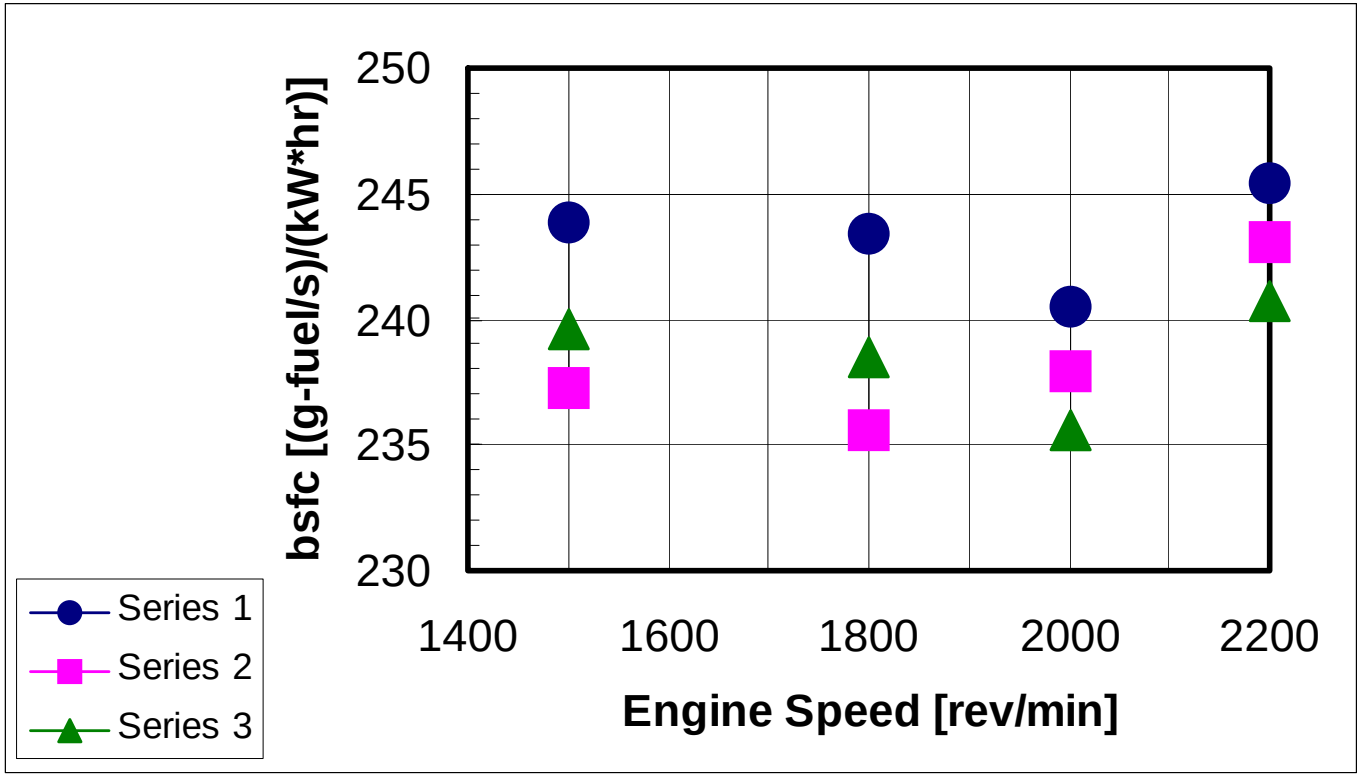
(b)

Partial LST cylindrical face piston ring



Engine specific fuel consumption vs. engine speed.

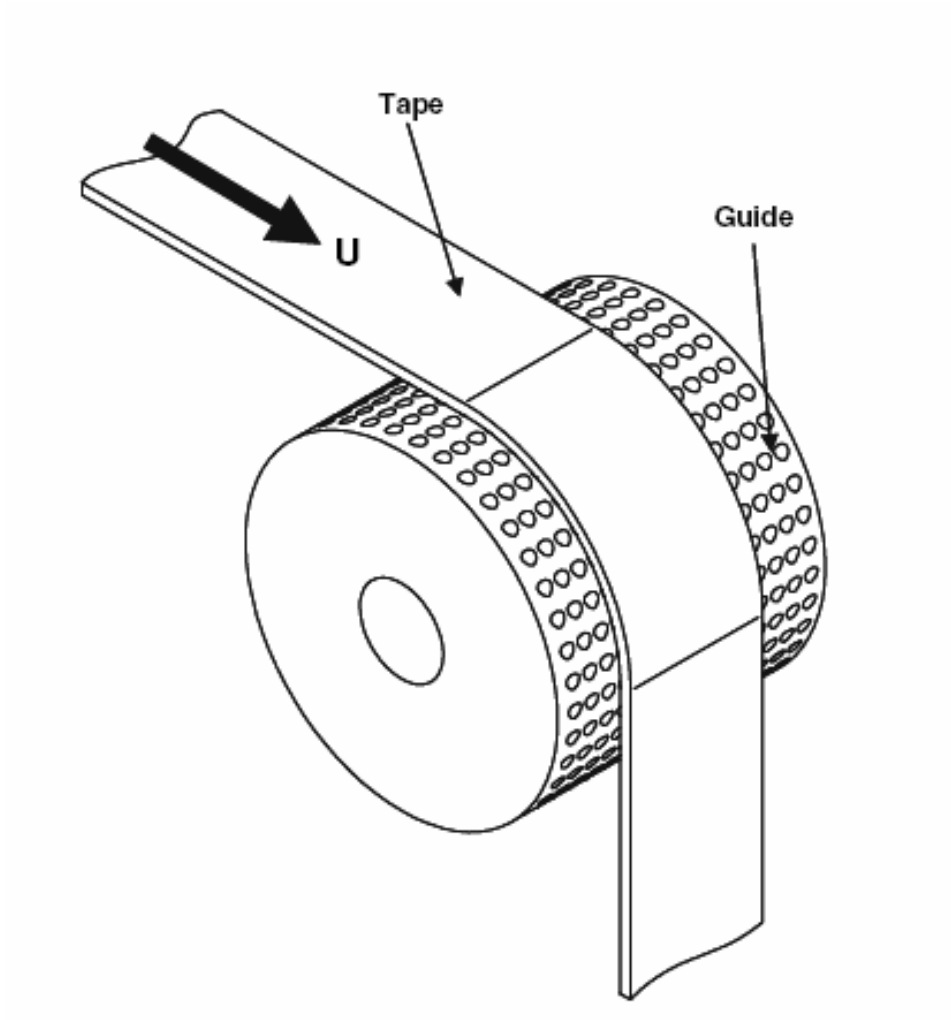
Series 1: Barrel, chrome coated, baseline, Series 2: Flat, chrome coated, laser treated, Series 3: Flat, no chrome, laser treated



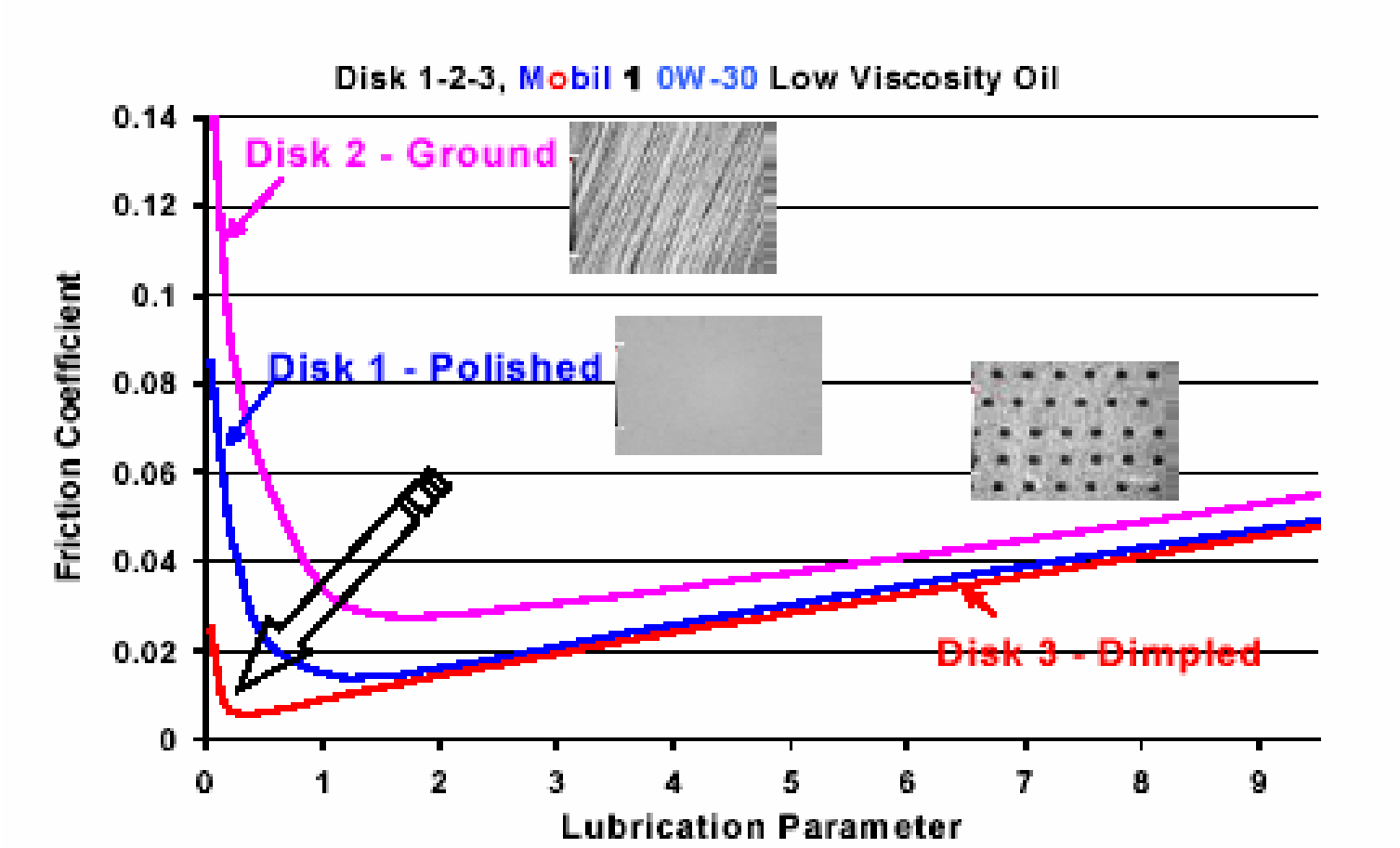
Piston

Piston pin and bearing

Tape moving over a LST guide



Impact of LST on Lubrication Regime Transition



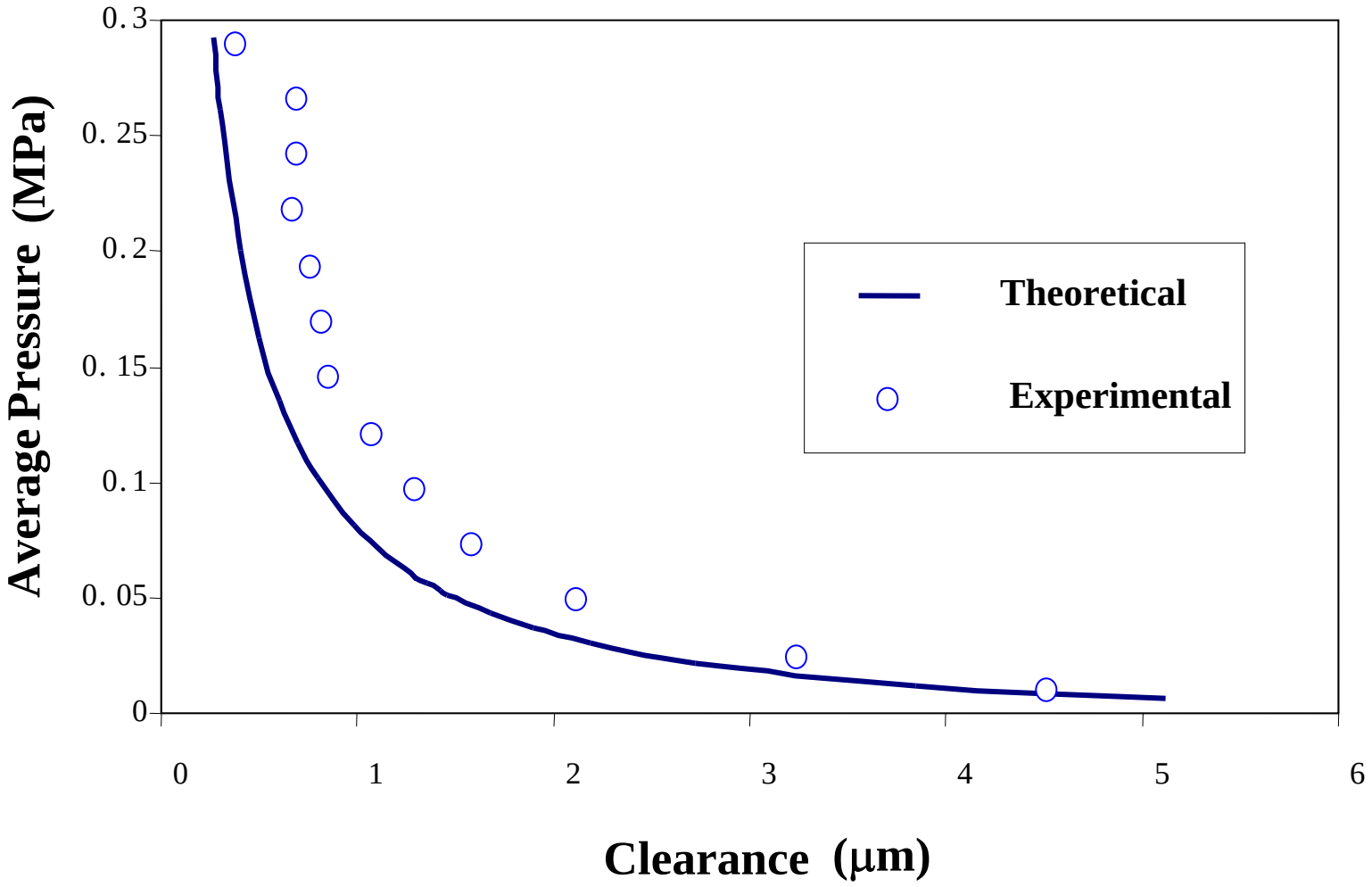
Distribution of researchers by countries of origin

Algeria	Japan
Argentina	Netherlands
Brazil	Poland
Czech Republic	Sweden
Finland	Switzerland
France	Turkey
Germany	UK
Greece	USA
Israel	

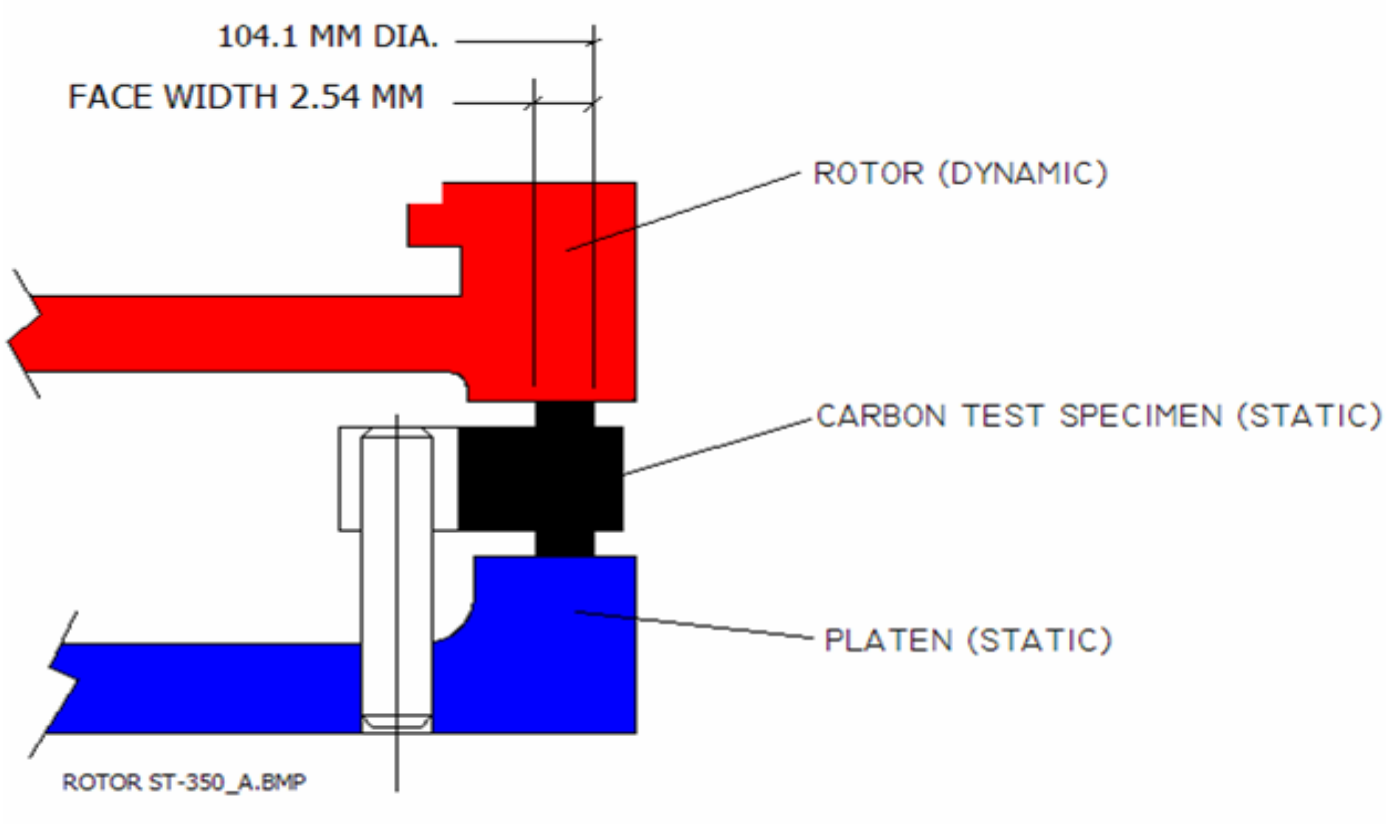
Summary

- Laser surface texturing has emerged in recent years as a viable means of enhancing tribological performance.
- The laser is extremely fast, clean to the environment and provides excellent control of the shape and size of the micro-dimples, which allows realization of optimum designs.
- Several applications were shown to benefit from LST. These include dynamic sealing, thrust bearings, magnetic recording and internal combustion engines.
- Most of this work is still in a stage of theoretical modeling and laboratory testing. LST was successfully applied to mechanical seals resulting in up to 60% friction reduction and threefold increase in seal life in pumps operating in the field
- This success is attributed to the theoretical modeling of LST under full fluid film conditions, which gave good agreement with laboratory tests and permitted optimization of the LST parameters.
- It is envisaged that with the continuing R&D effort more applications may benefit from LST in the coming years.

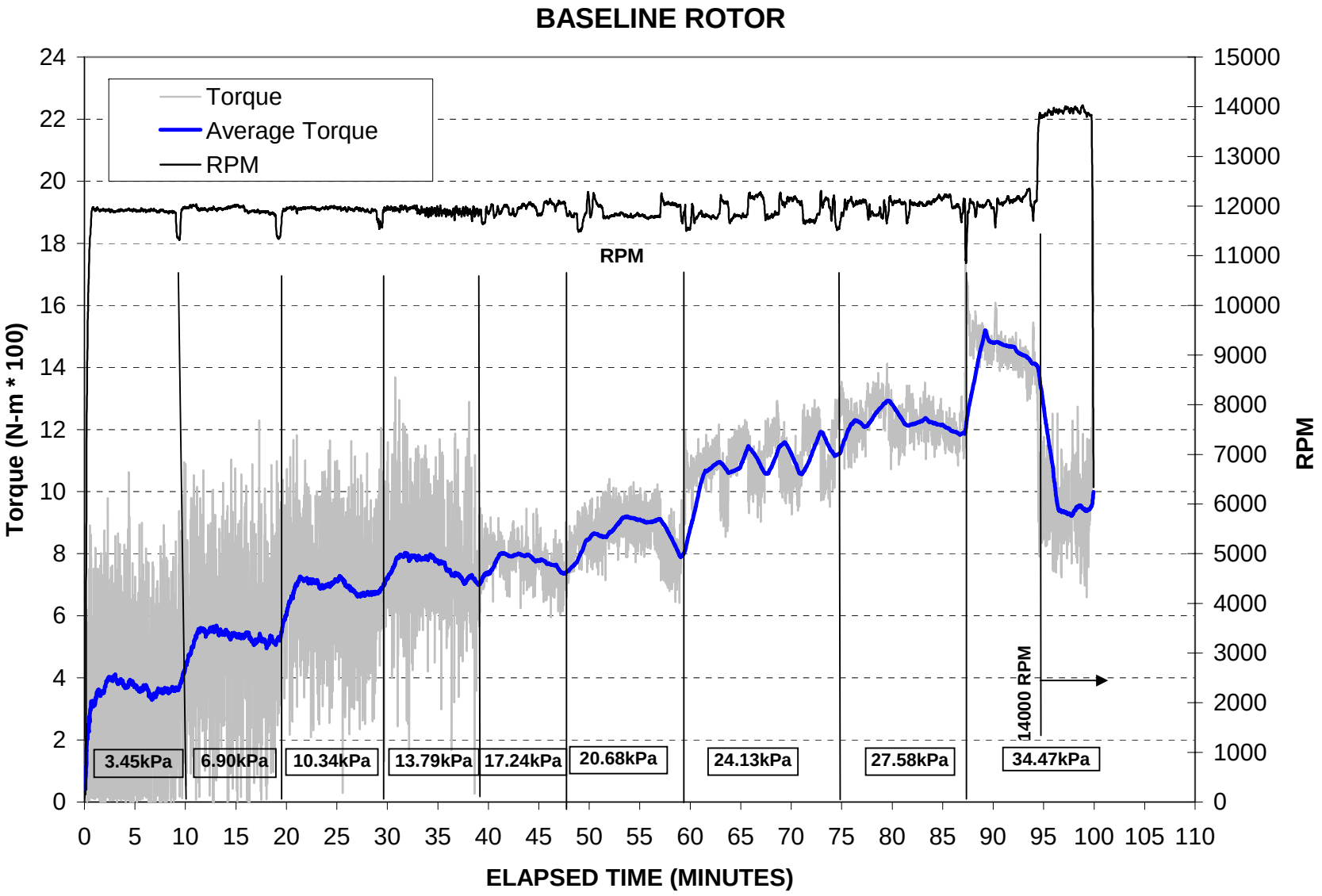
Comparison of Theoretical and Experimental Results of LST Mechanical Seal



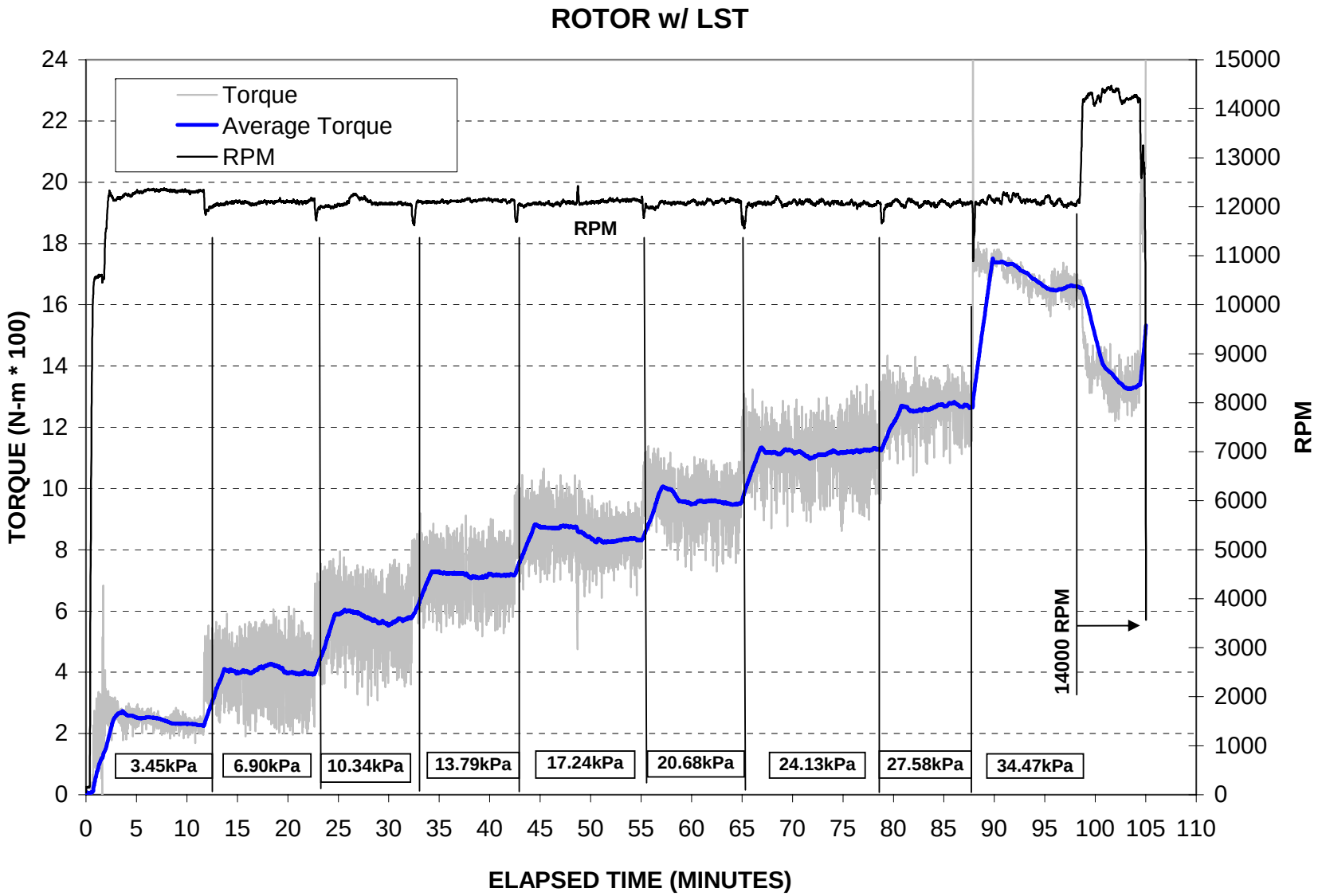
Enlarged View of Rotor - Carbon Specimen Interface



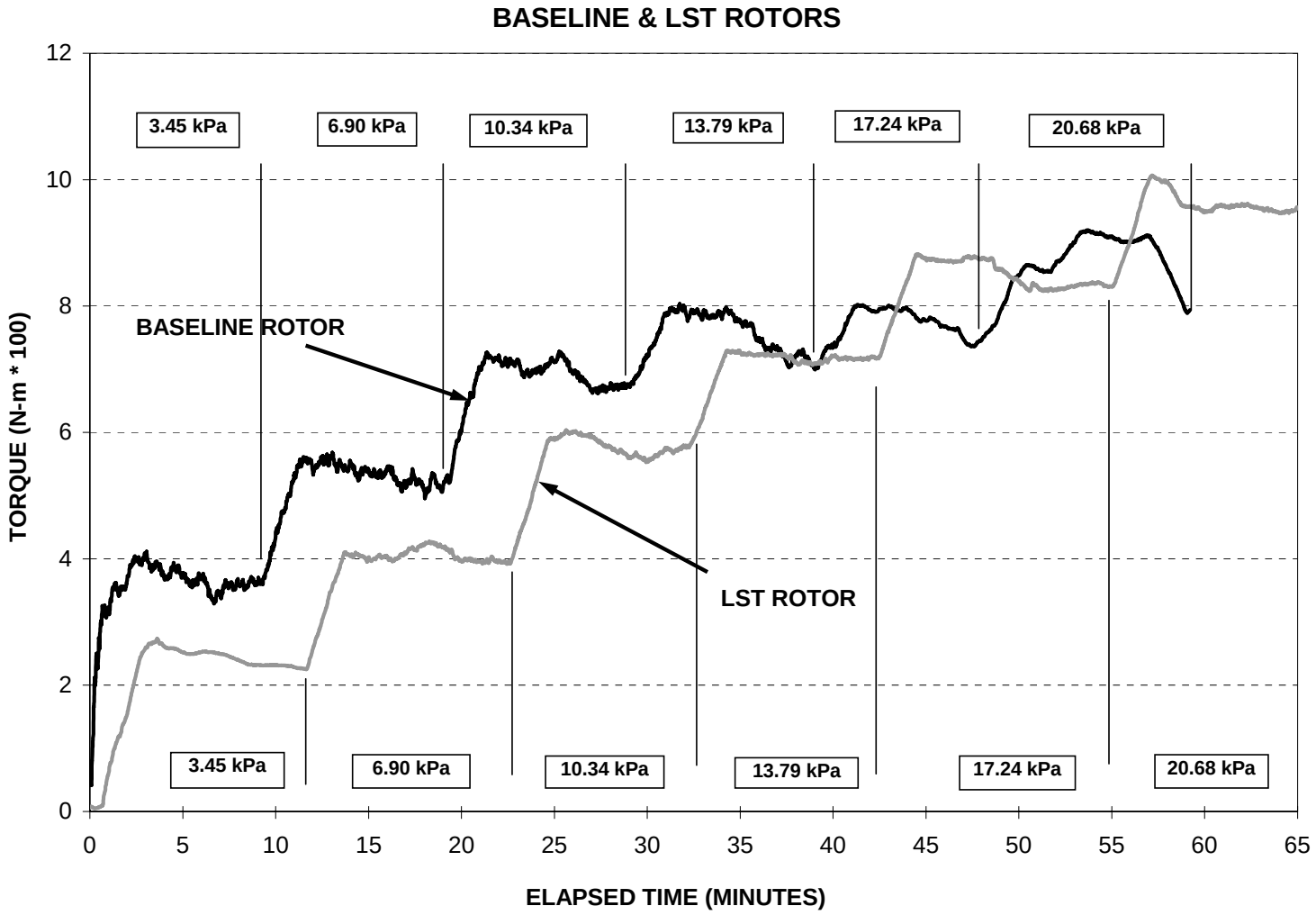
Torque vs. Time (Baseline rotor)



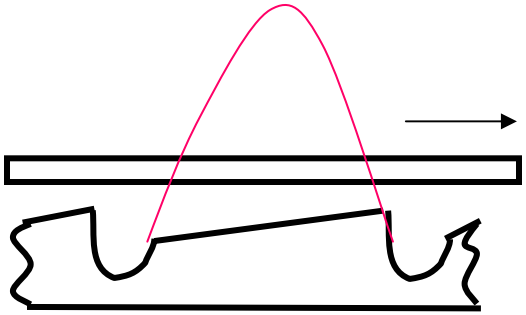
Torque vs. Time (LST rotor)



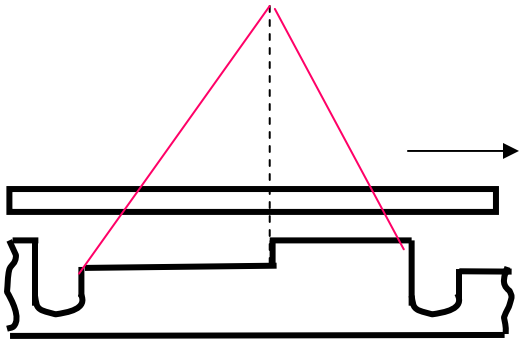
Average Torque vs. Time, Comparison of Baseline & LST Rotors at 12,000 rpm



Typical Pressure Distributions and Maximum Load Capacity

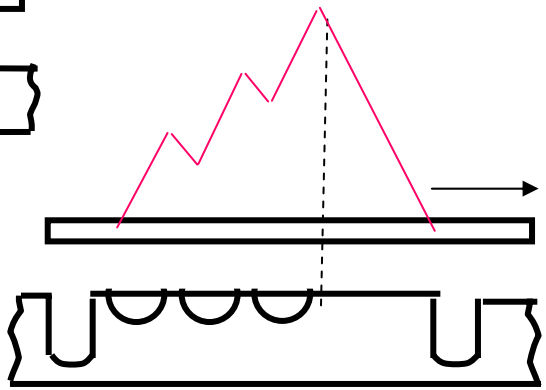


Tapered
***W*=0.16**



Stepped
***W*=0.205**

$0.4 < S_p < 0.65$



Parallel LST
$W=0.16S_p$

A Comparison of Partial LST Bearing and Non-textured Bearing Performance