Improving Sealing Performance by Laser Surface Texturing

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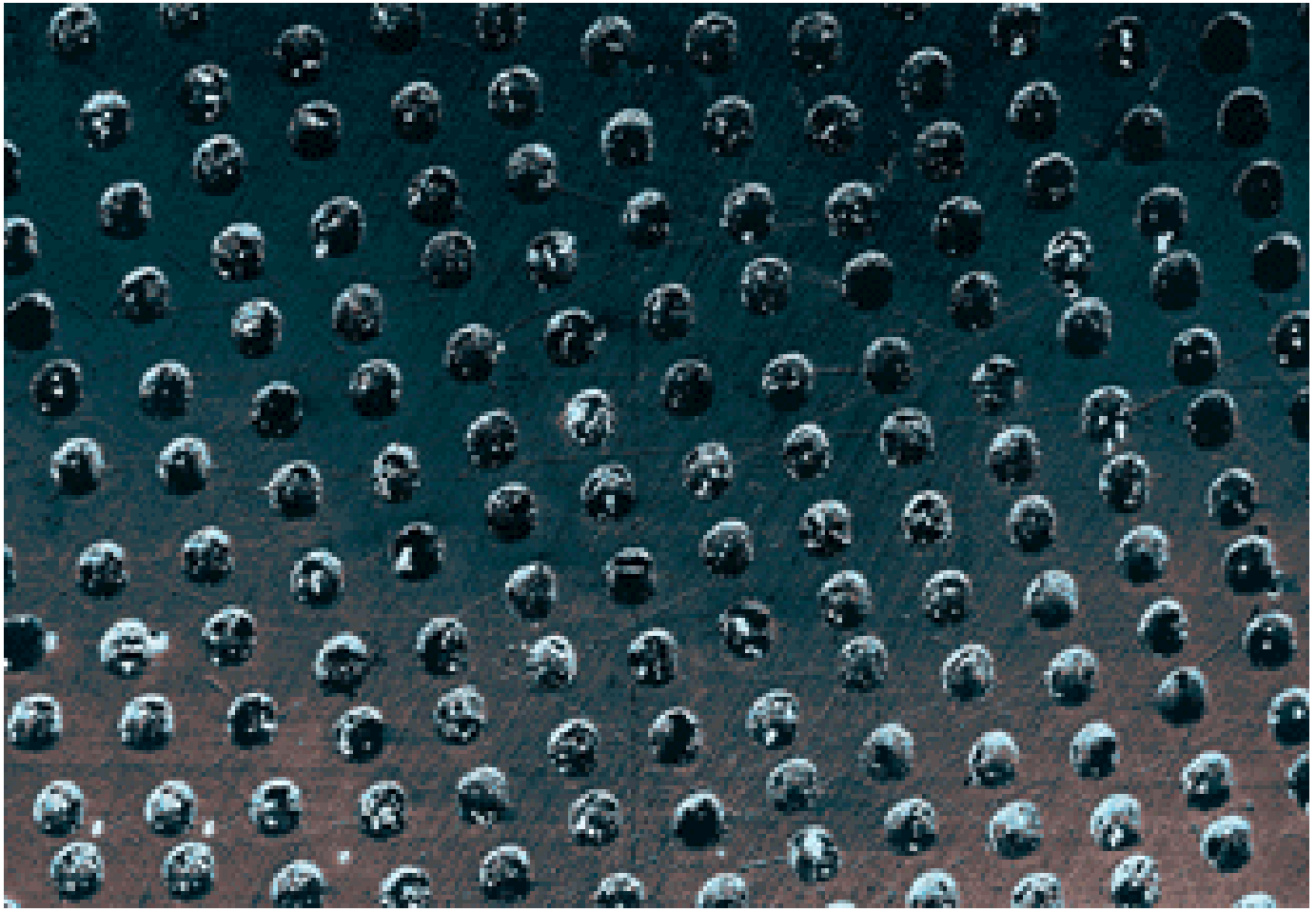
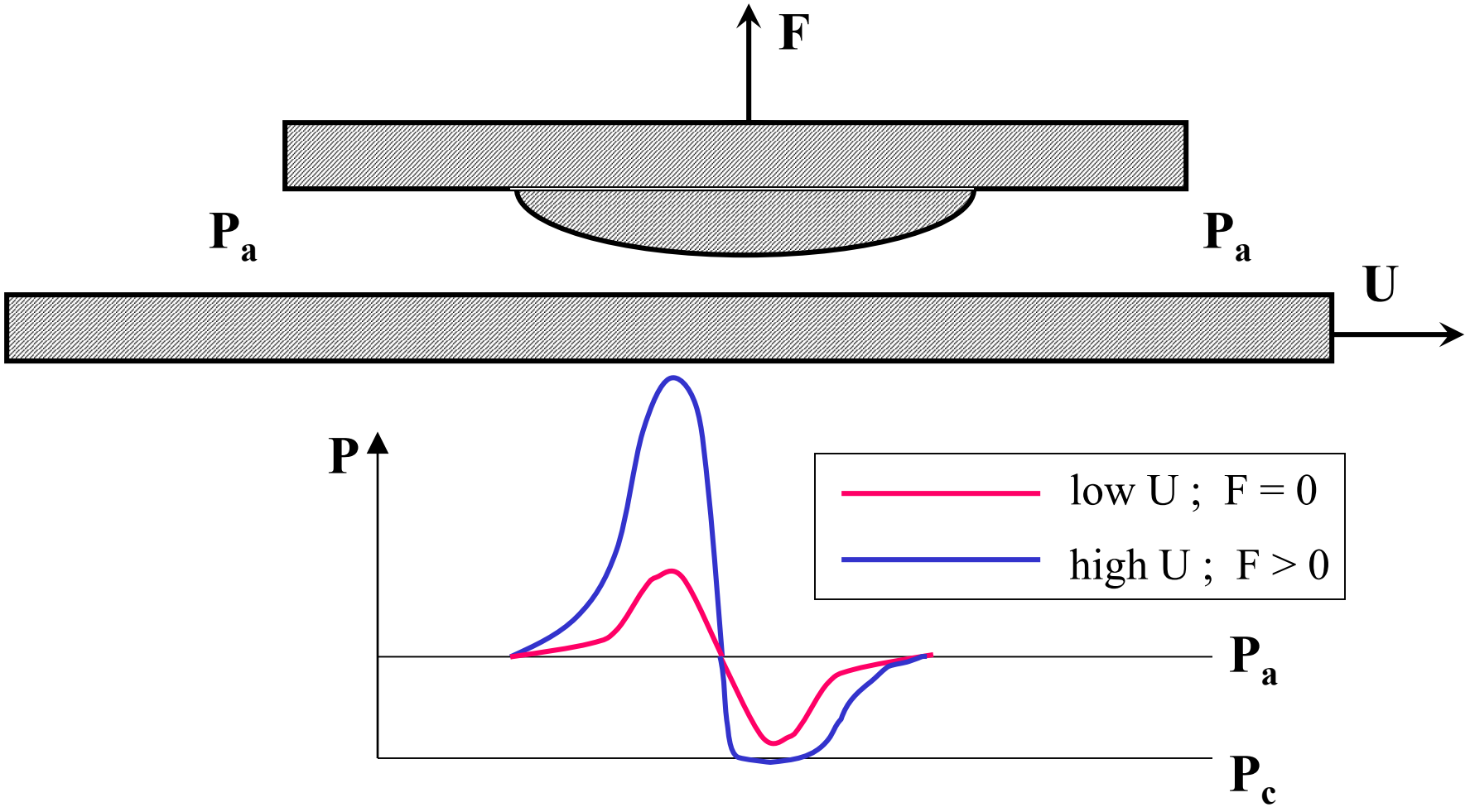
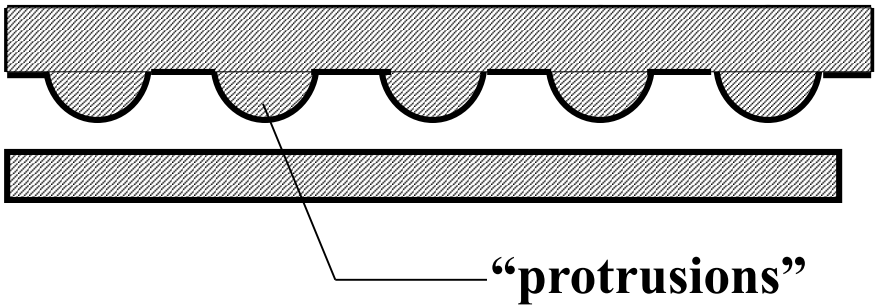
LST Regular Micro-Surface Structure in the Form of Micro-dimples



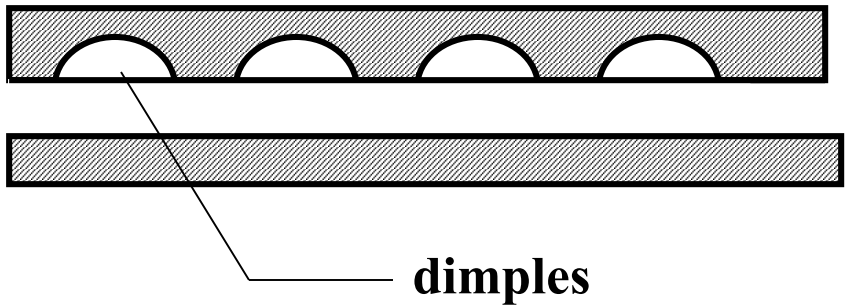
Hydrodynamic pressure distribution over a single “protrusion”



Why dimples ?

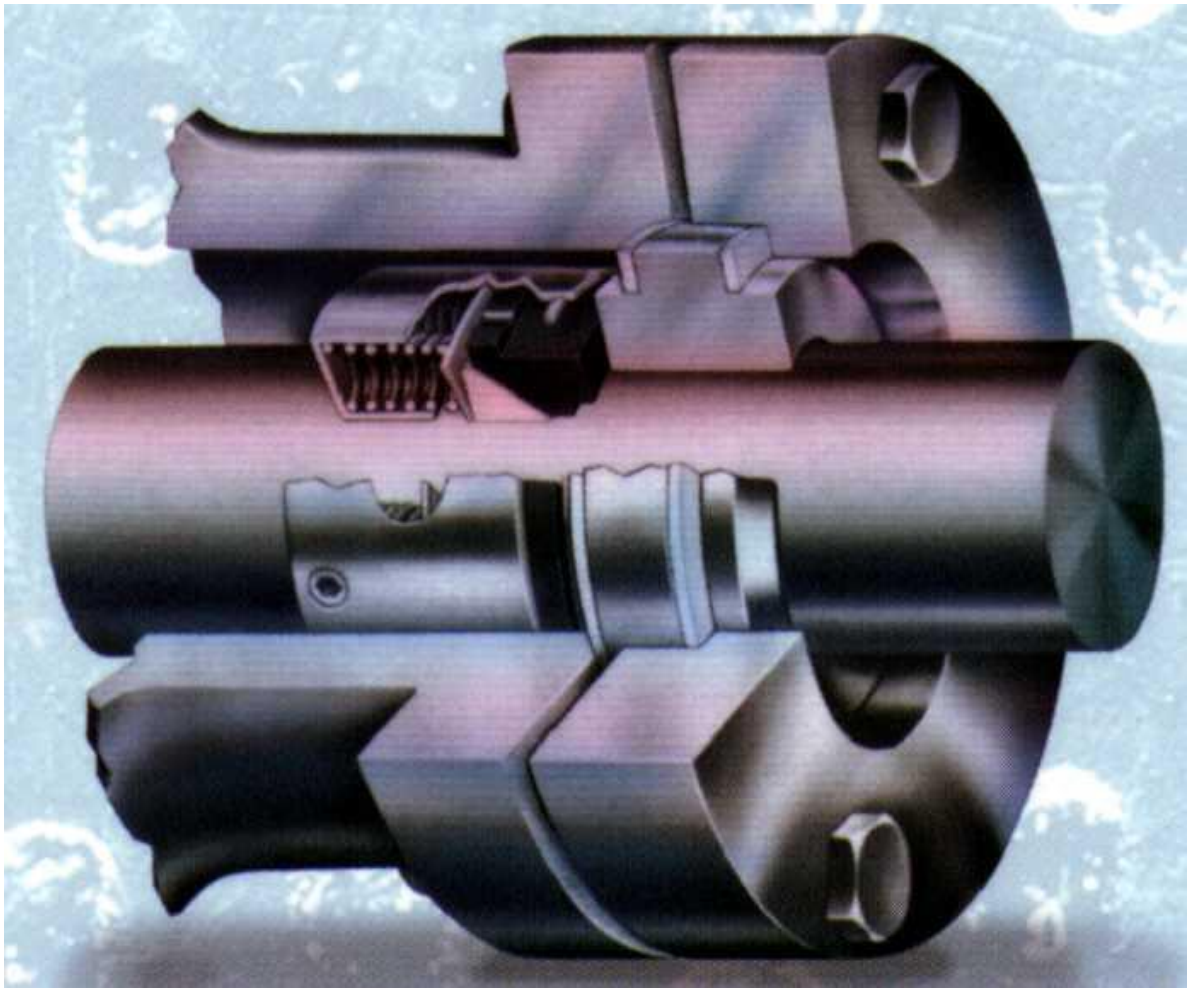


- complicated etching technology
- high wear
- high leakage

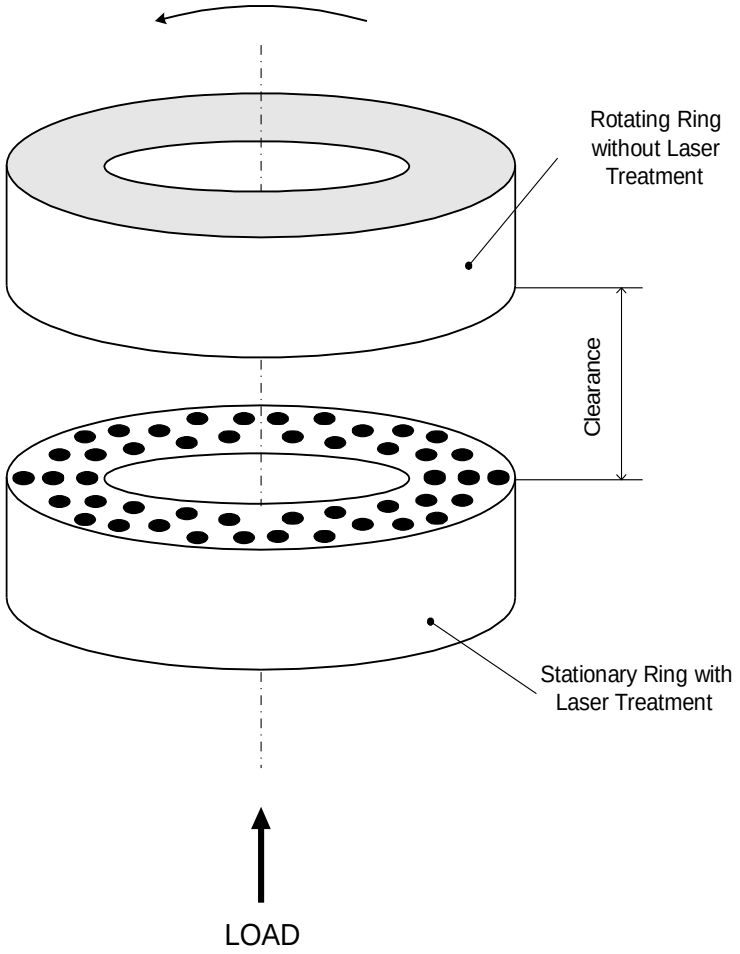


- simple & cheap laser technology
- lower wear
- low leakage

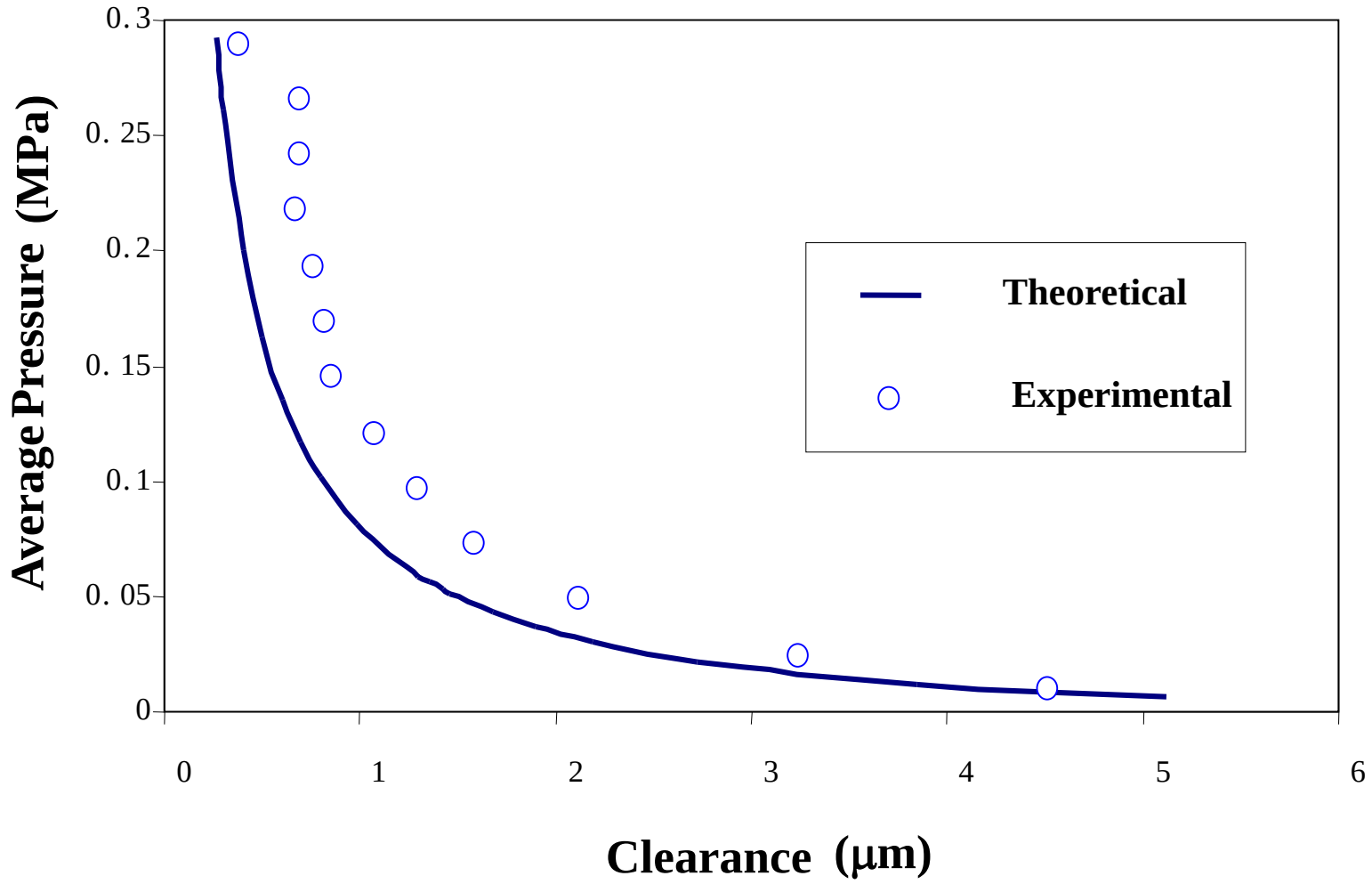
A Mechanical Face Seal



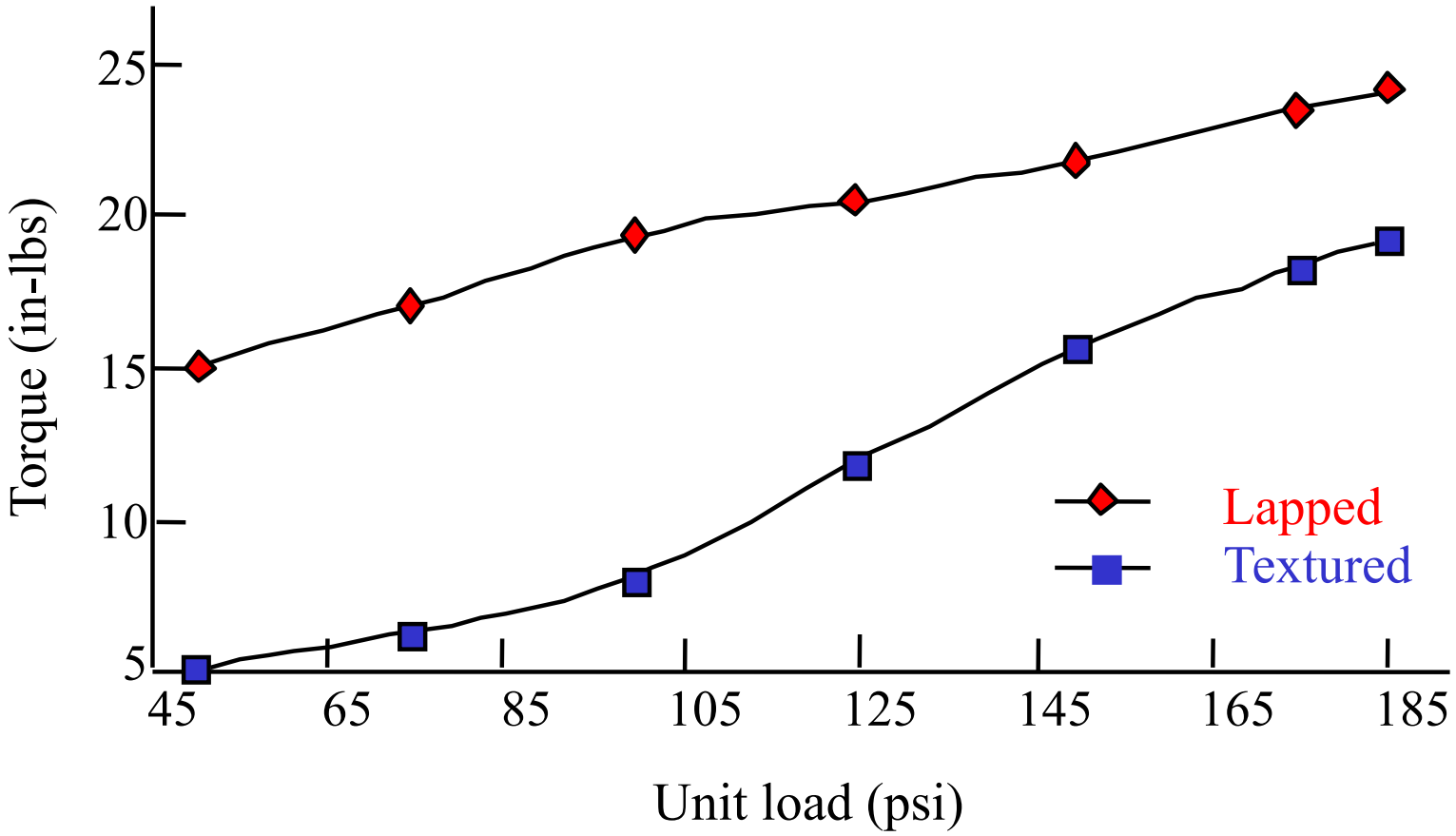
Ring on Ring Scheme



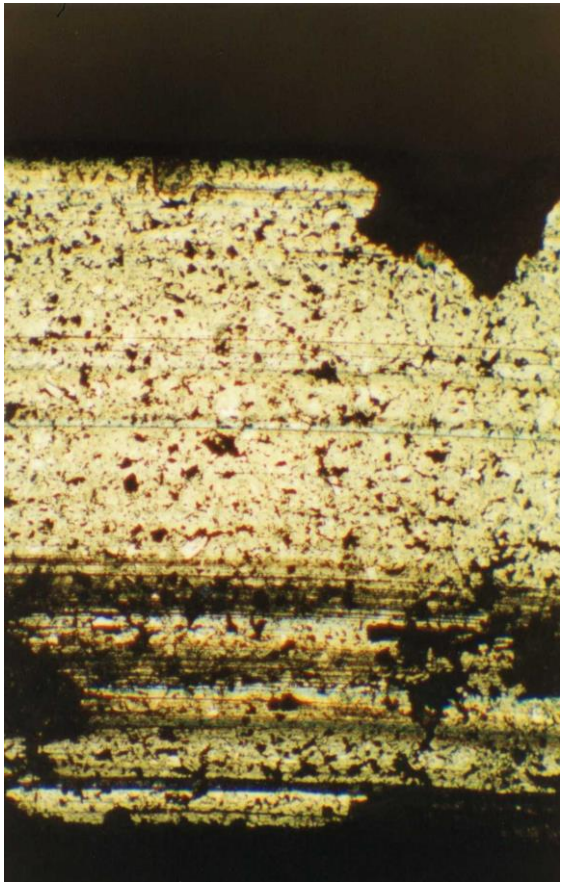
Comparison of Theoretical and Experimental Results of LST Mechanical Seal



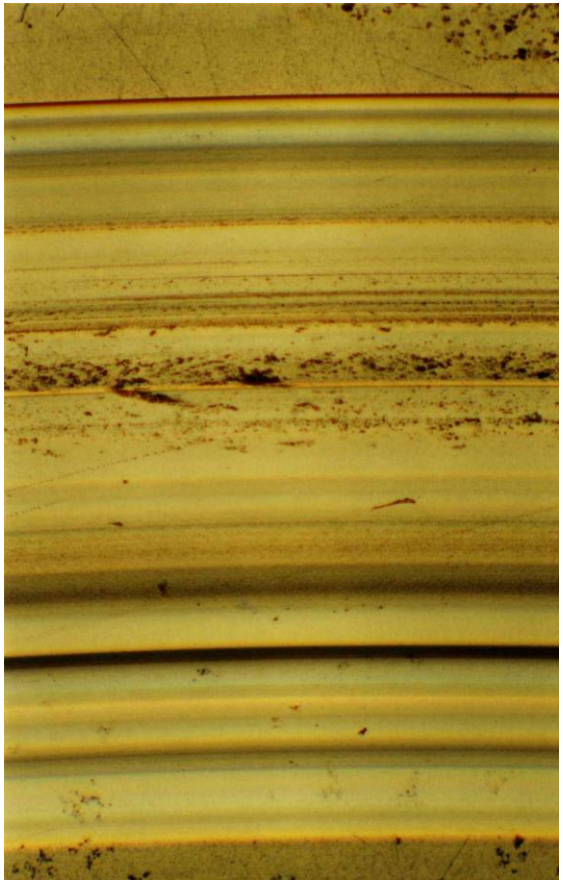
Friction Torque vs. Face Loading for Textured and Non-textured Seals in Water



Field Test with Water Pump

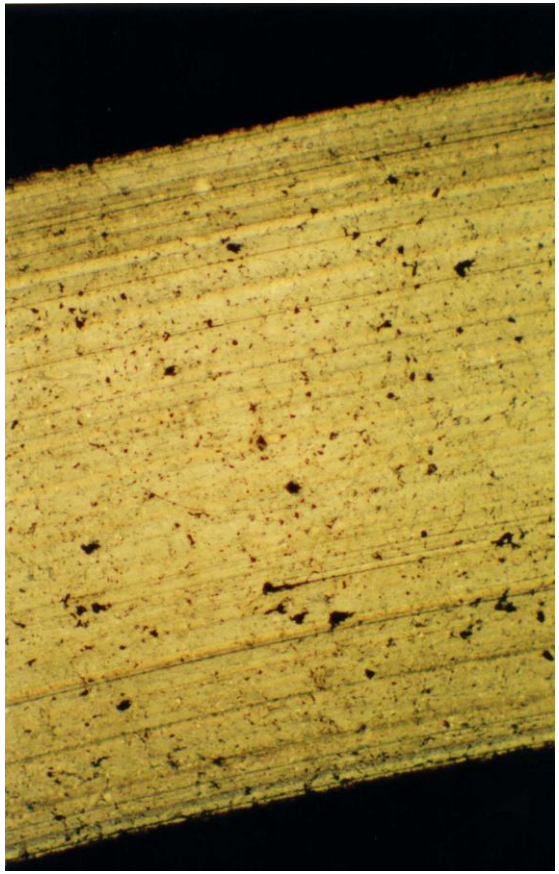


Carbon Ring - Standard Seal
After 400 Hours

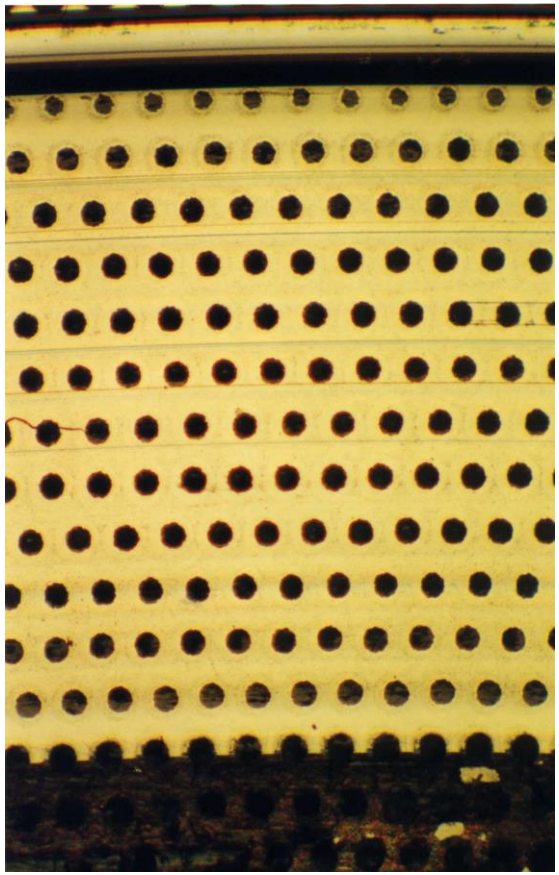


WC Ring - Standard Seal
After 400 Hours

Field Test with Water Pump

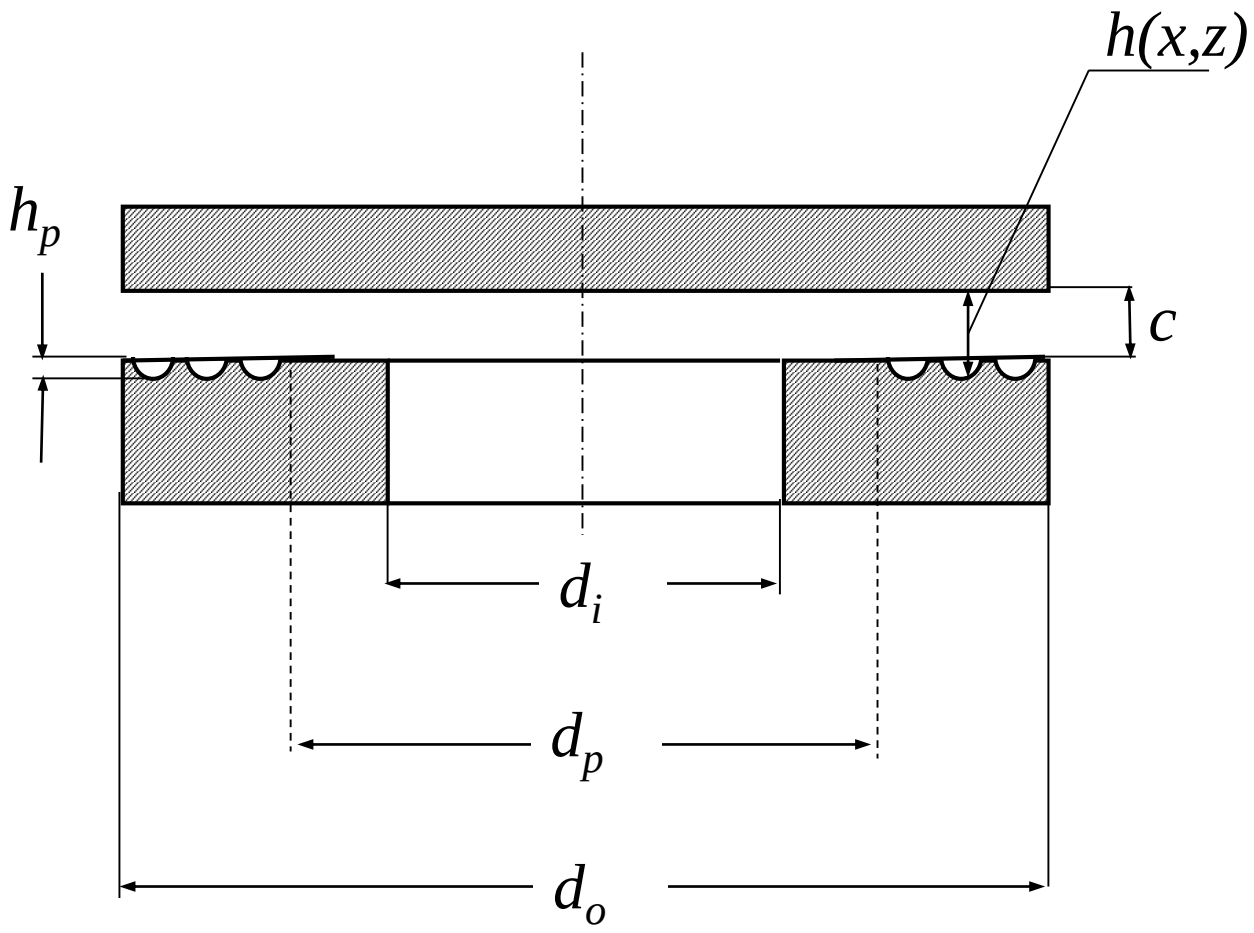


Carbon Ring - LST Seal
After 550 Hours

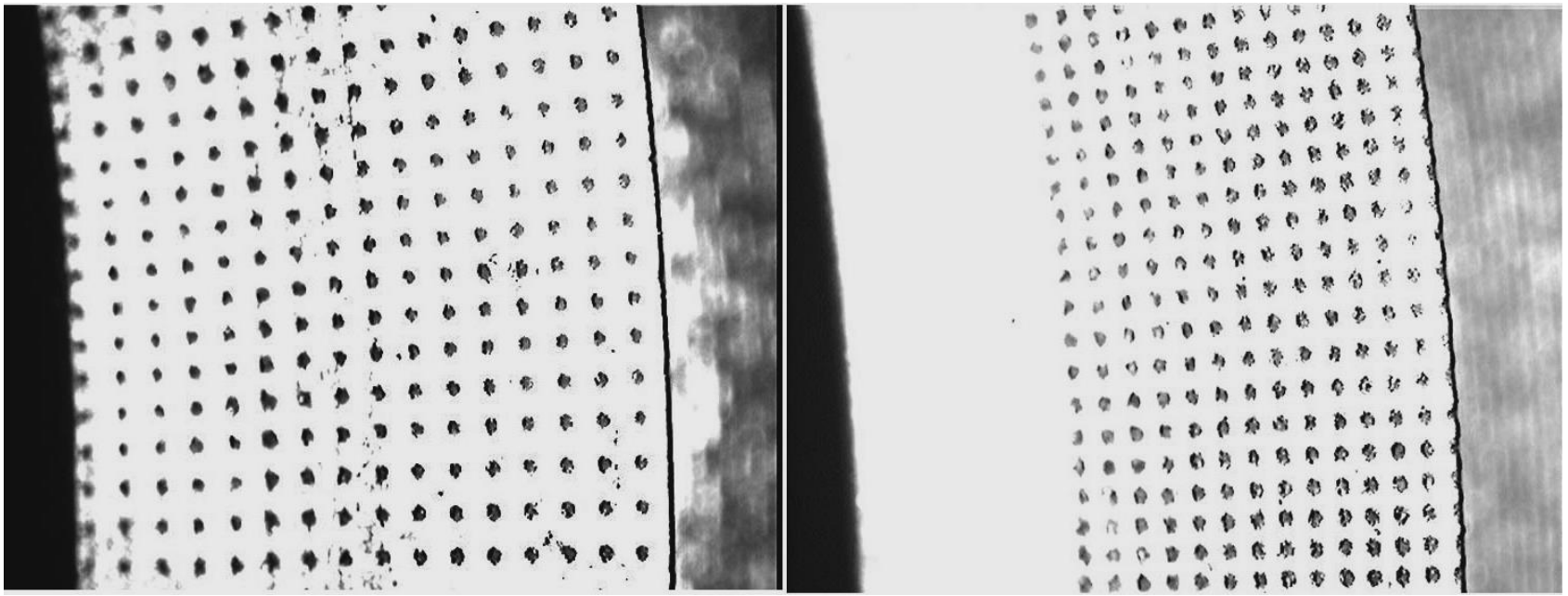


WC Ring - LST Seal
After 550 Hours

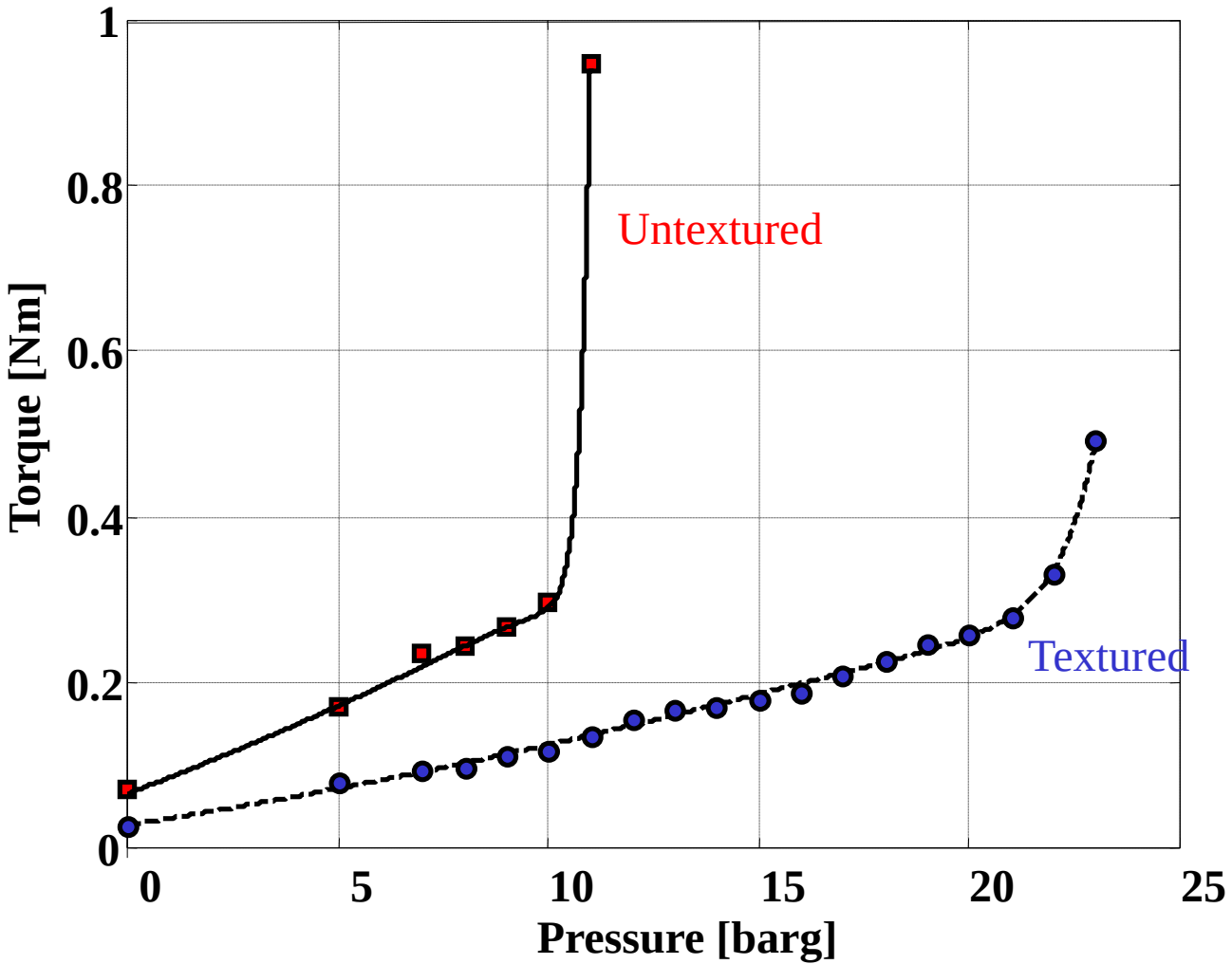
Schematic of a partial laser surface textured mechanical seal



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



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

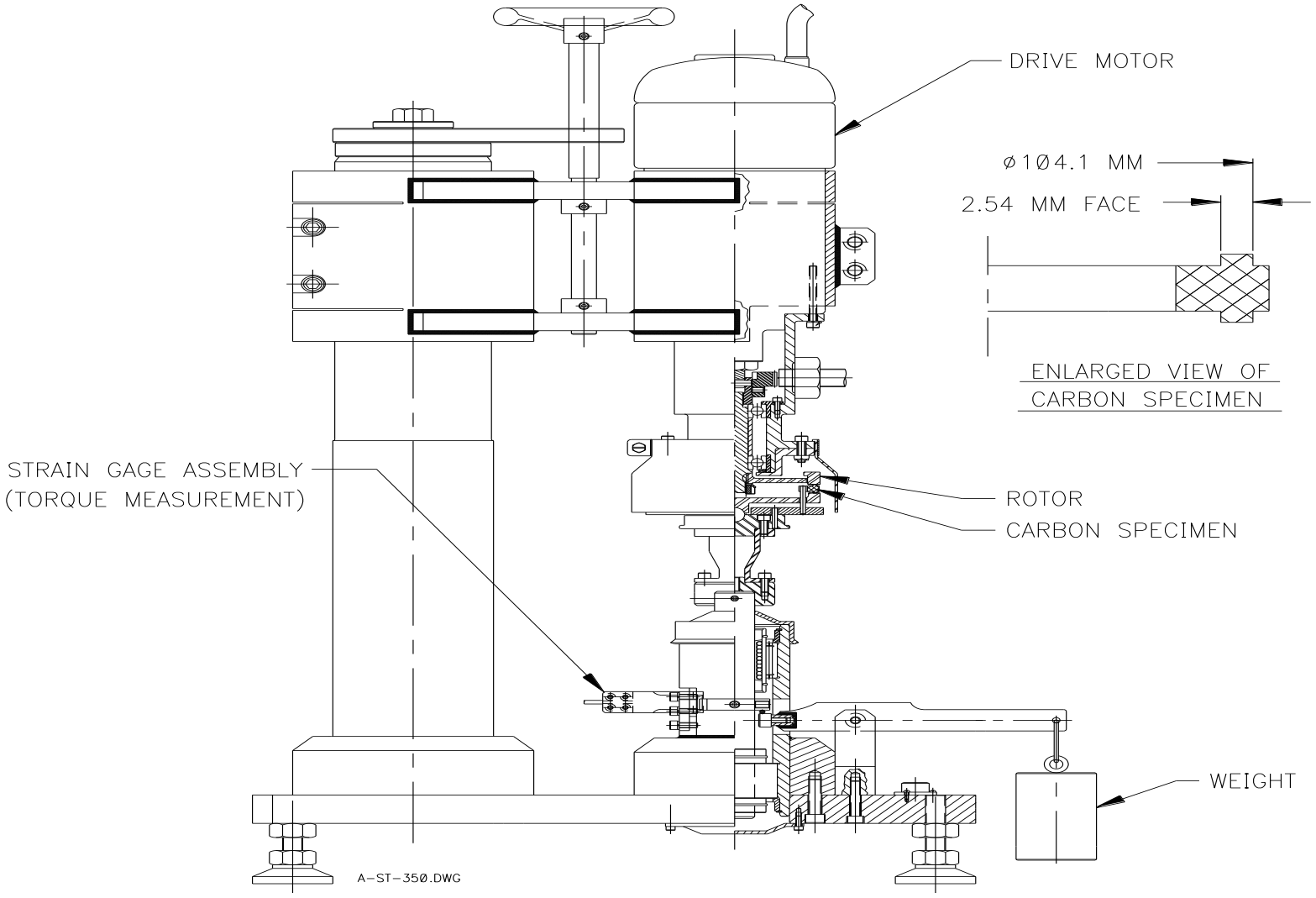


Improved Main Shaft Seal Life in Gas Turbines using Laser Surface Texturing

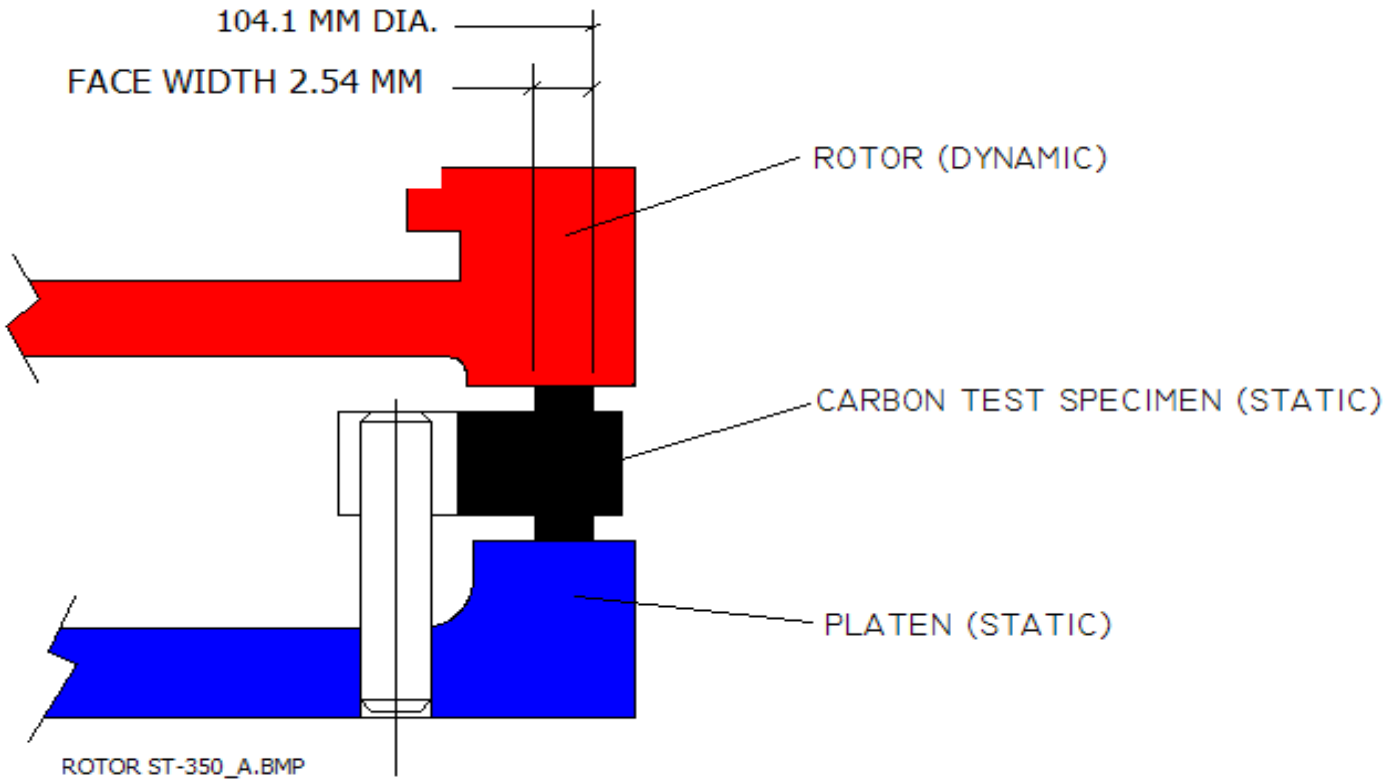
- **GOALS:**
  - Develop computer code for hydrodynamic force evaluation
  - Develop Laser Surface Texturing (LST) for mechanical seals
  - Increase Seal Life & Performance

- **APPLICATIONS:**
  - Gas Turbines (aviation & land based)
  - Turbo machinery

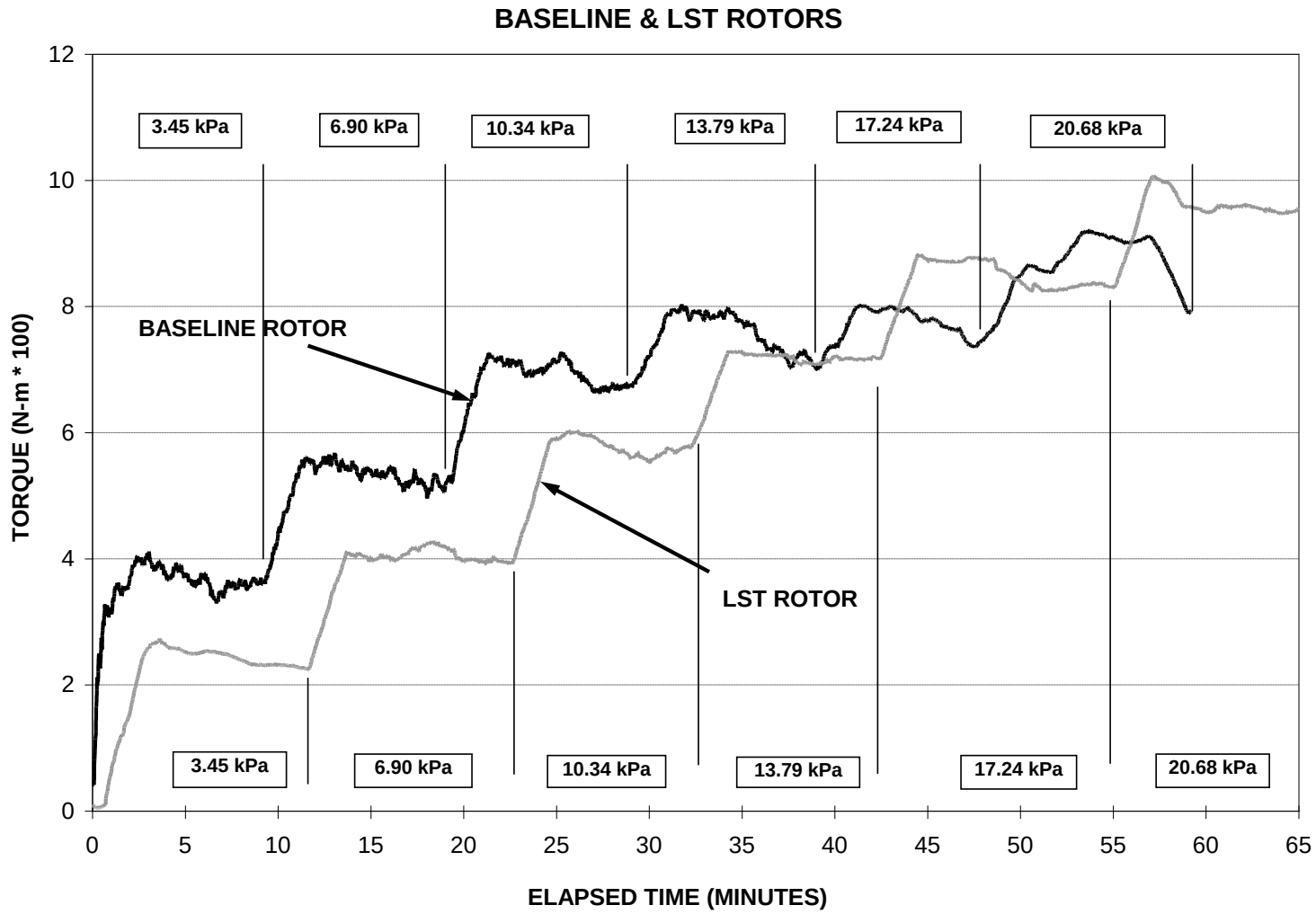
Wear Test Rig



Enlarged View of Rotor - Carbon Specimen Interface



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



Case Study: LST Technology Tested at a Petrochemical Refinery

- Gadiv Petrochemical Industries Ltd, one of Israel's largest petrochemical companies, started a field test in 1998 in order to improve the reliability of the mechanical seals at its petrochemical refinery plant.
- Gadiv evaluated the benefits of LST by comparing the performance of identical pumps that pumped liquid hydrocarbons – one was fitted with an LST-treated seal, and the other with a standard non-textured seal.

Case Study Results

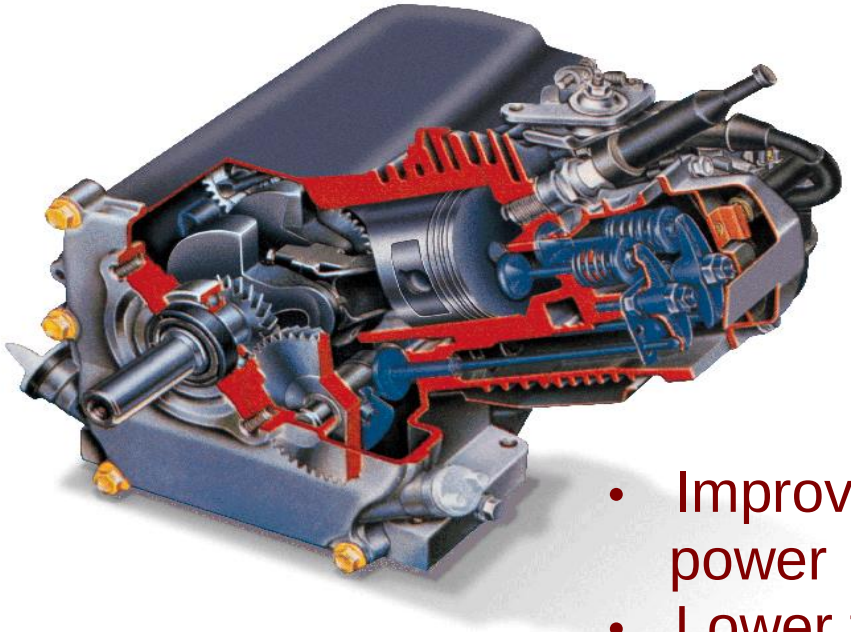
- The LST-treated seal operated for more than 10,000 hours over a 38-month period before it was replaced because of an O-ring failure.

- Over the same time, the untreated seal had to be replaced four times.

Conclusions

- LST is applied to mechanical seals with a great success.
- Both laboratory and field tests show substantial friction reduction and up to threefold increase in seal life.
- This success is attributed to the theoretical modeling of LST, which permits optimization of the LST parameters.

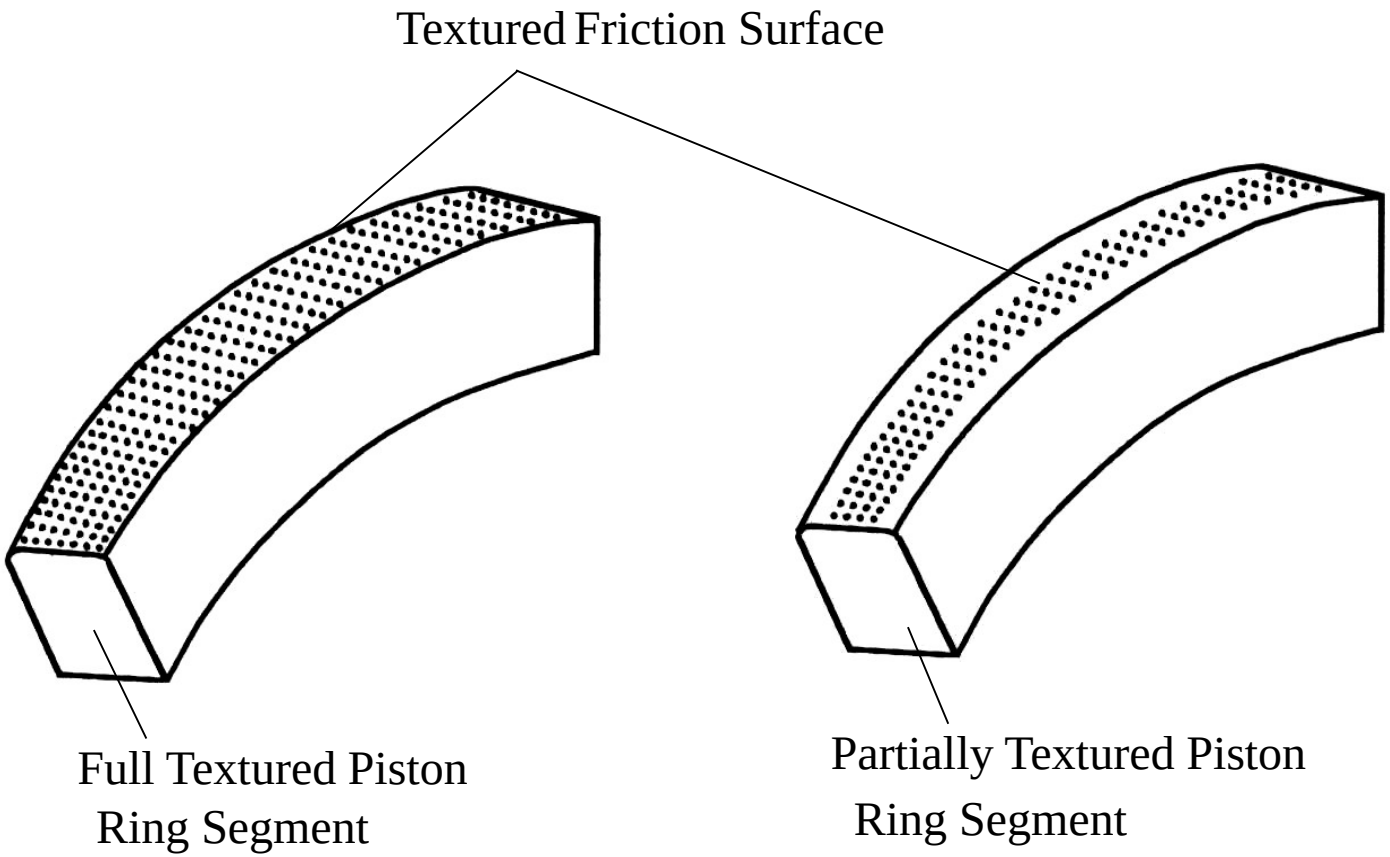
Internal Combustion Engines



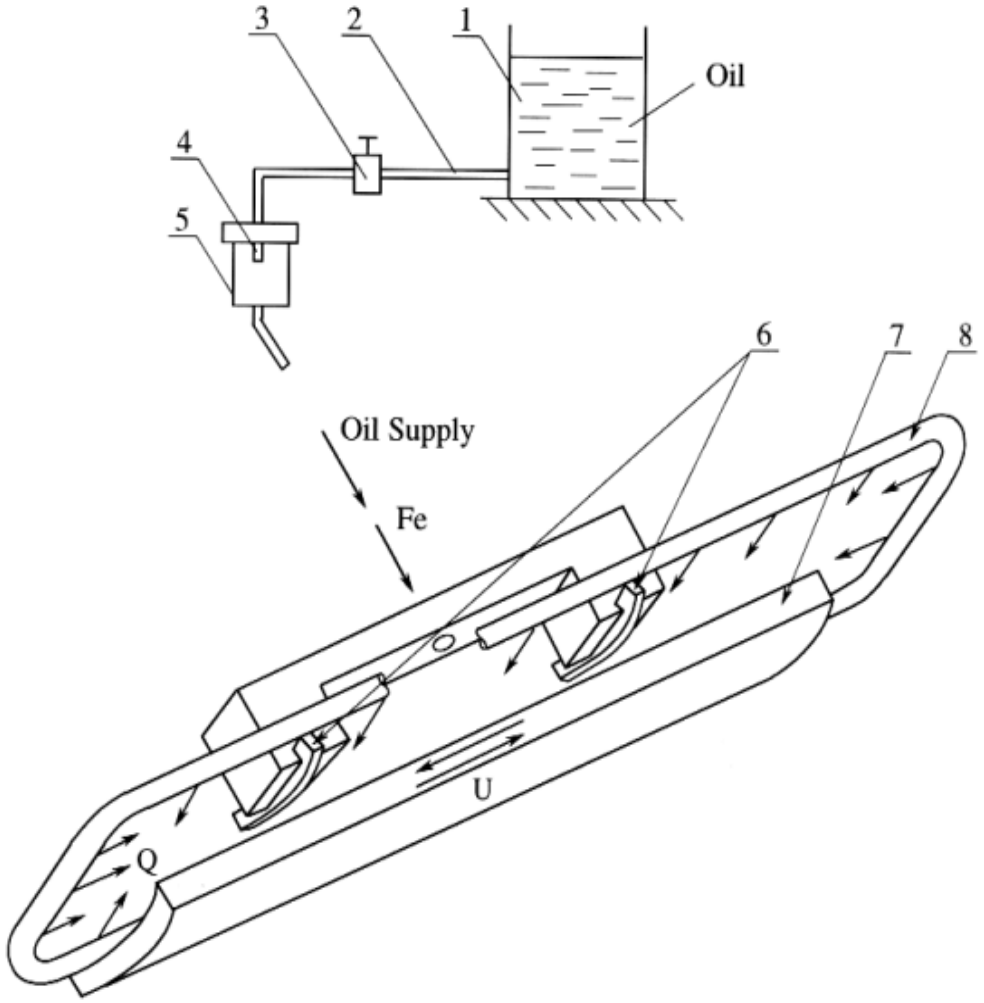
- Improved lubrication, speed and power
- Lower fuel consumption
- Reduced exhaust levels and operating temperatures
- Minimized cylinder wear and mechanical losses

Piston Group

Schematic of Full and Partial LST Piston Ring Segments

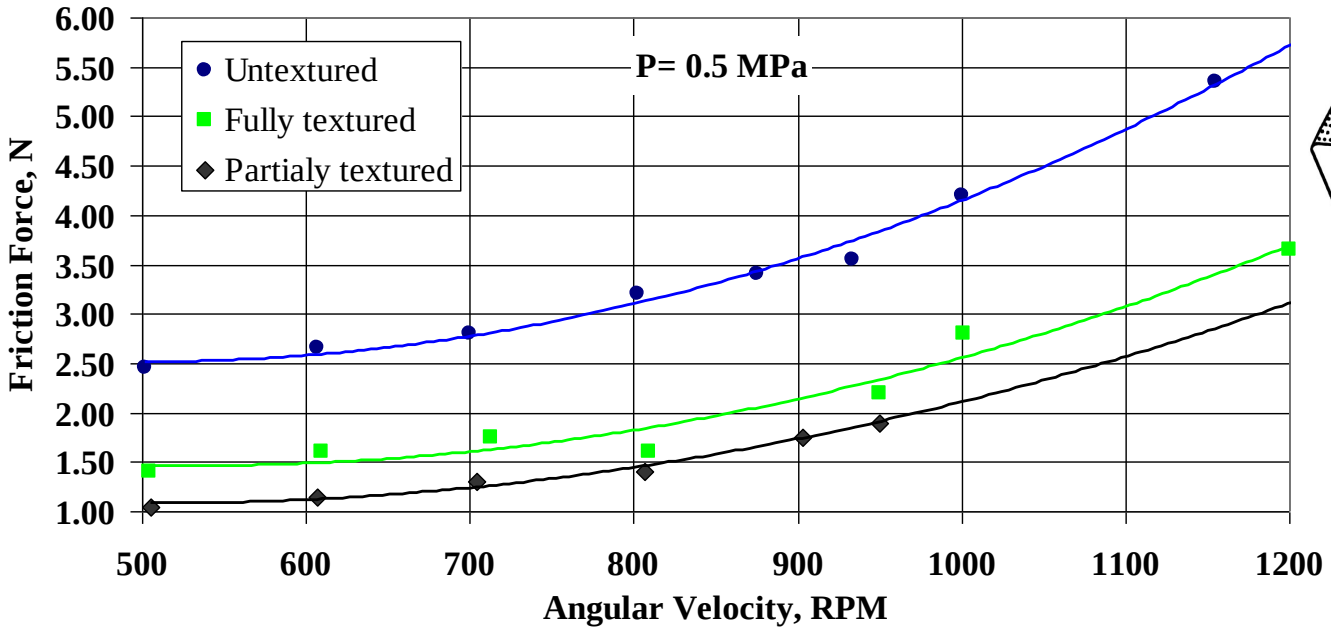


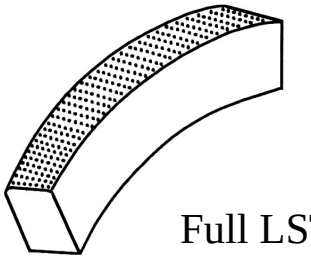
Reciprocating Test Rig



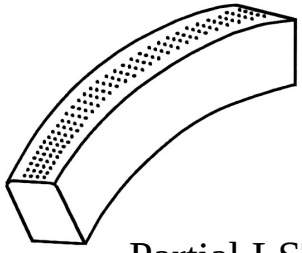
Full and Partial LST Test Results

Full Texuring: $2r_p$=78µm, h_p=9µm, S_p=10%
Partial Texuring: $2r_p$=75µm, h_p=6µm, S_p=51%



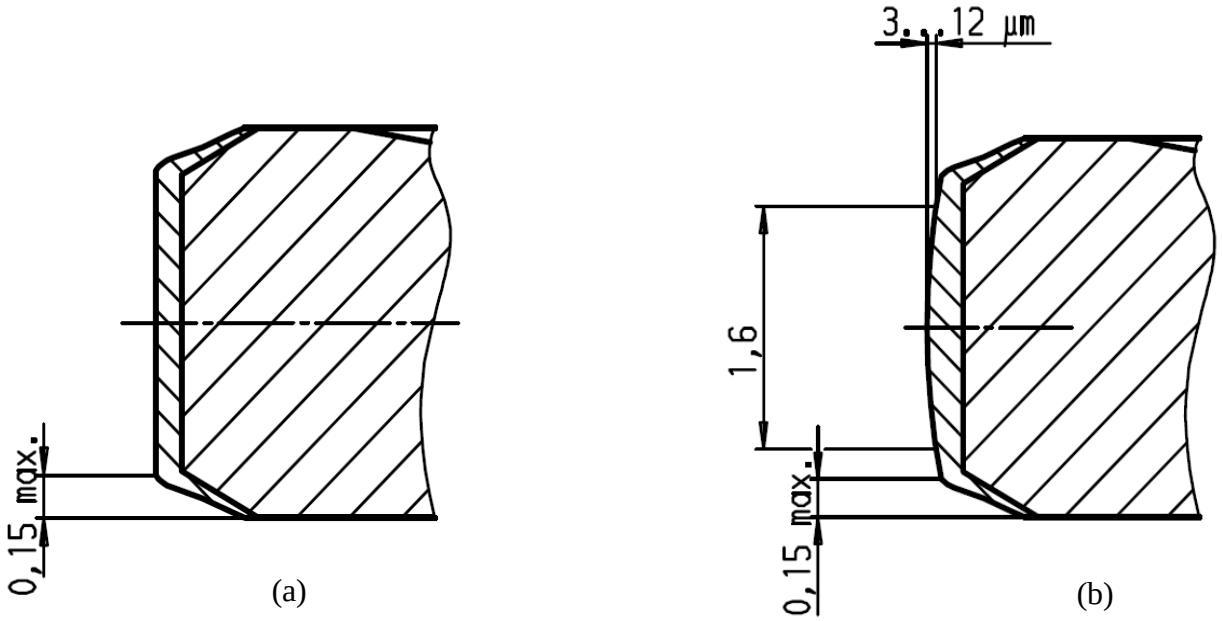


Full LST



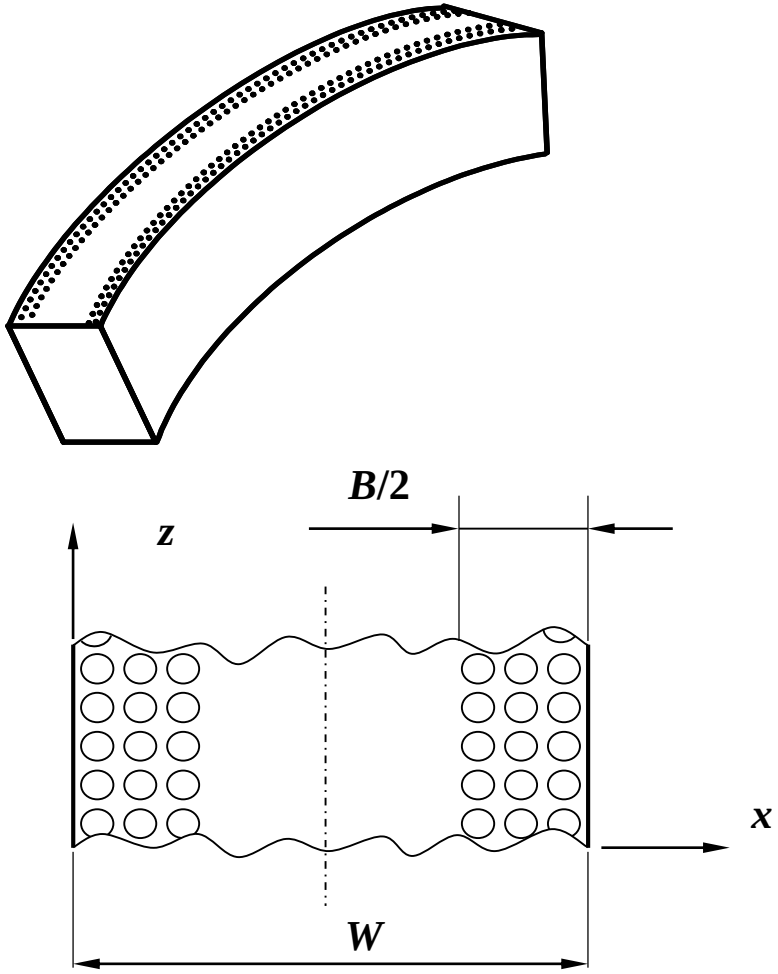
Partial LST

Piston ring specimens

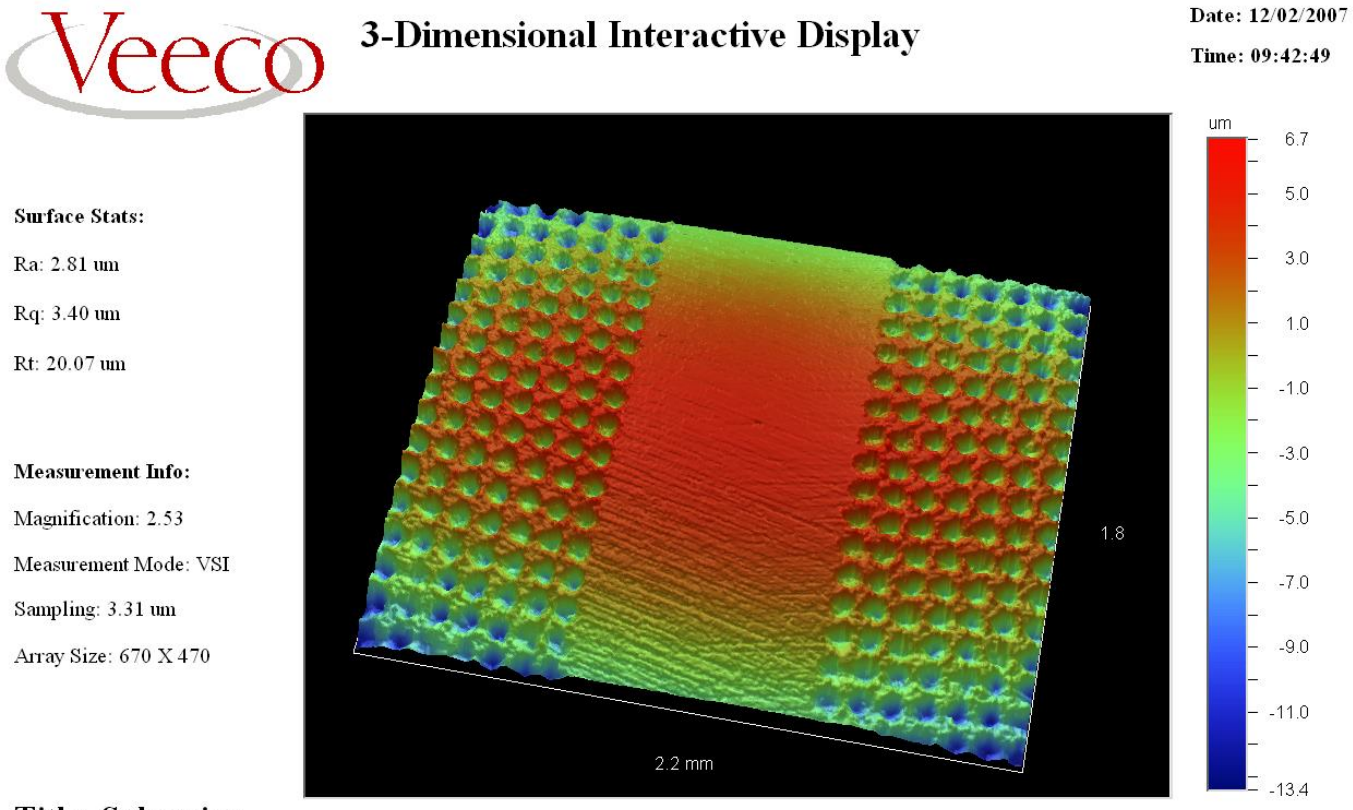


Cross sections of cylindrical (a) and barrel shape (b) Cr coated piston rings

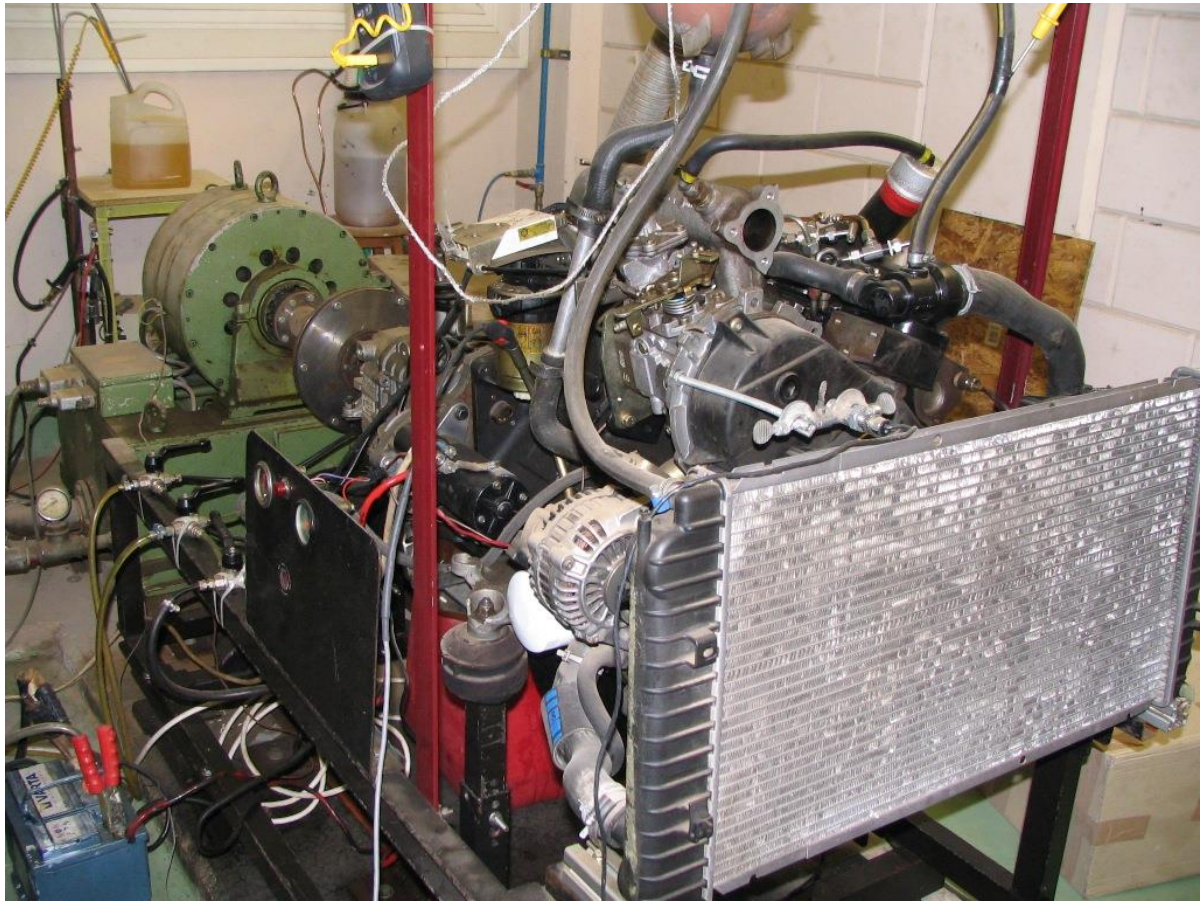
Partial LST cylindrical face piston ring



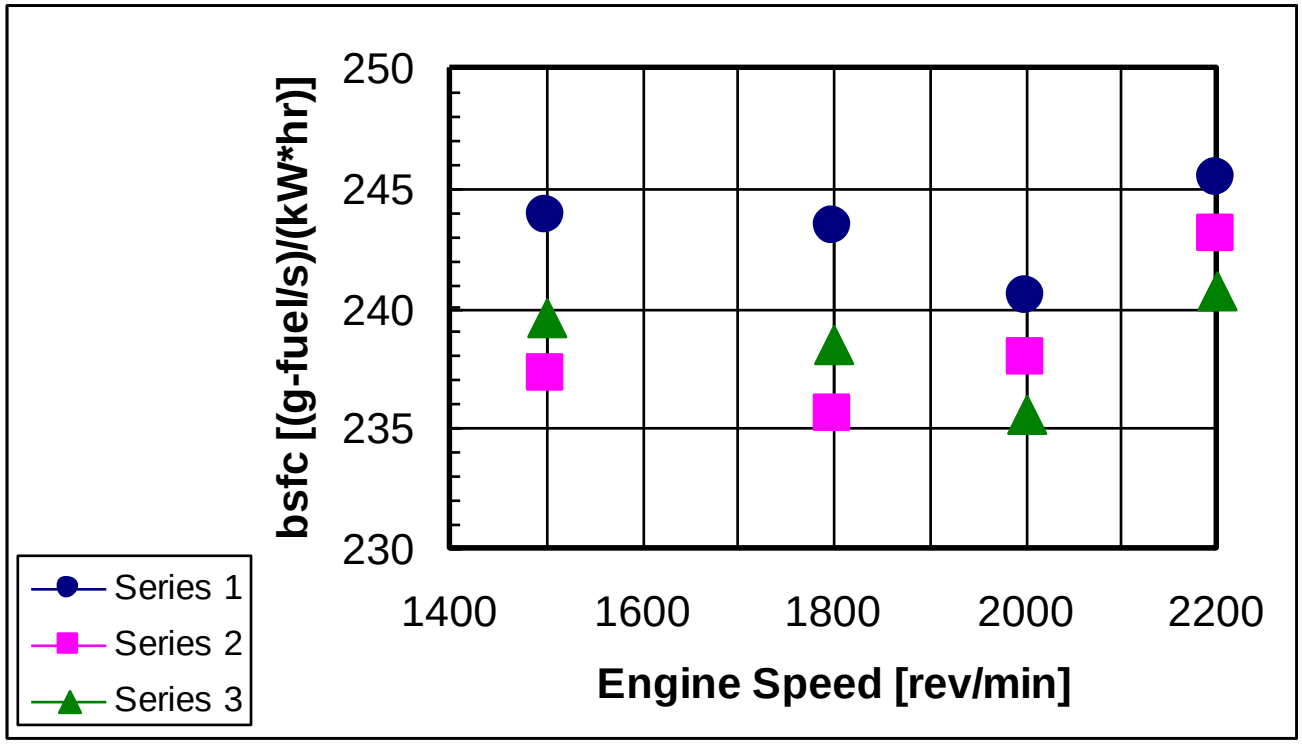
An optical profilometry of a partial LST cylindrical face piston ring



A 4-cylinders Ford Transit naturally aspirated 2,500 cc Diesel engine



Engine specific fuel consumption vs. engine speed



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

Summary

A collaboration existed between Technion, and SurTech aiming to improve tribology of various mechanical components by Laser Surface Texturing (LST).

Extensive theoretical, experimental and field test results show the potential of LST in reducing friction and wear in mechanical seals.

Other components such as in engine and transmission components may also benefit from LST.

Collaboration with local industry and partners abroad in implementing LST was very successful.