Engine Friction Reduction Through Surface Finish and Coatings

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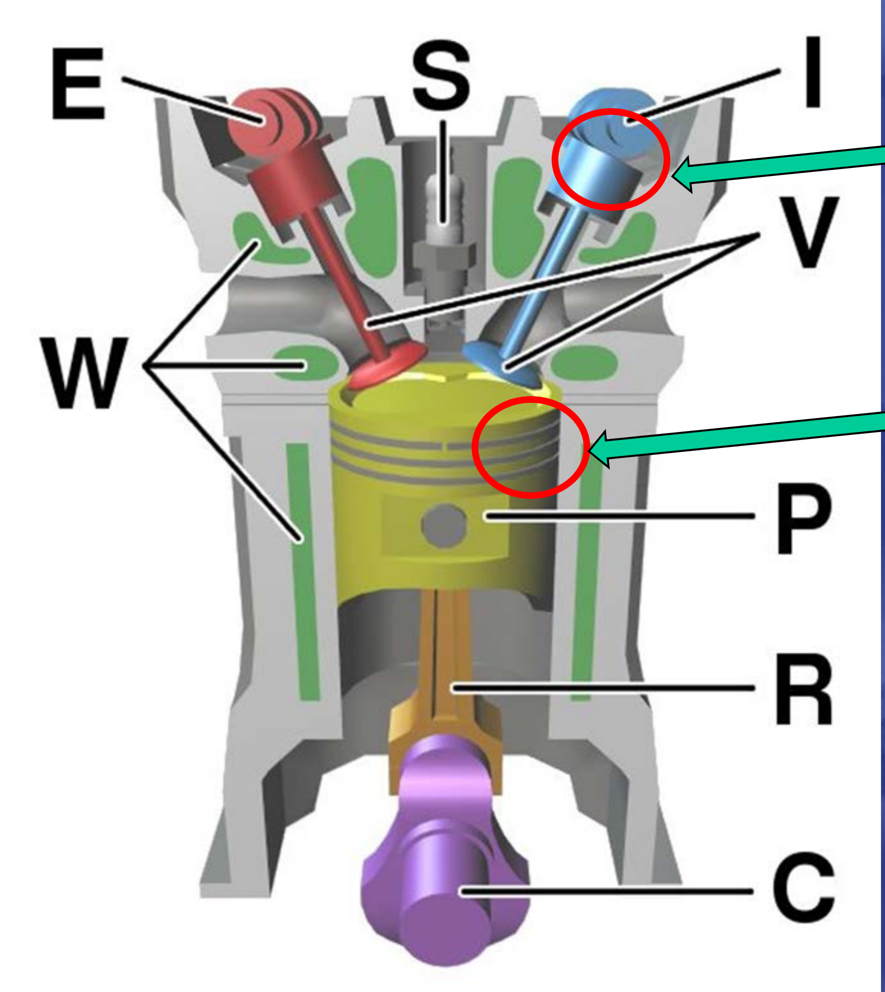
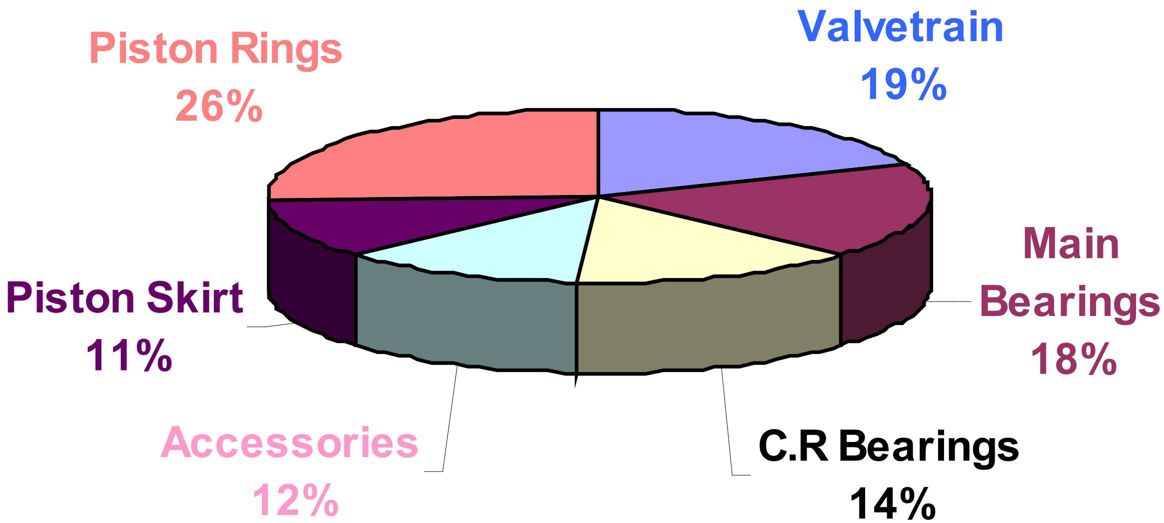
System and Subsystem Description



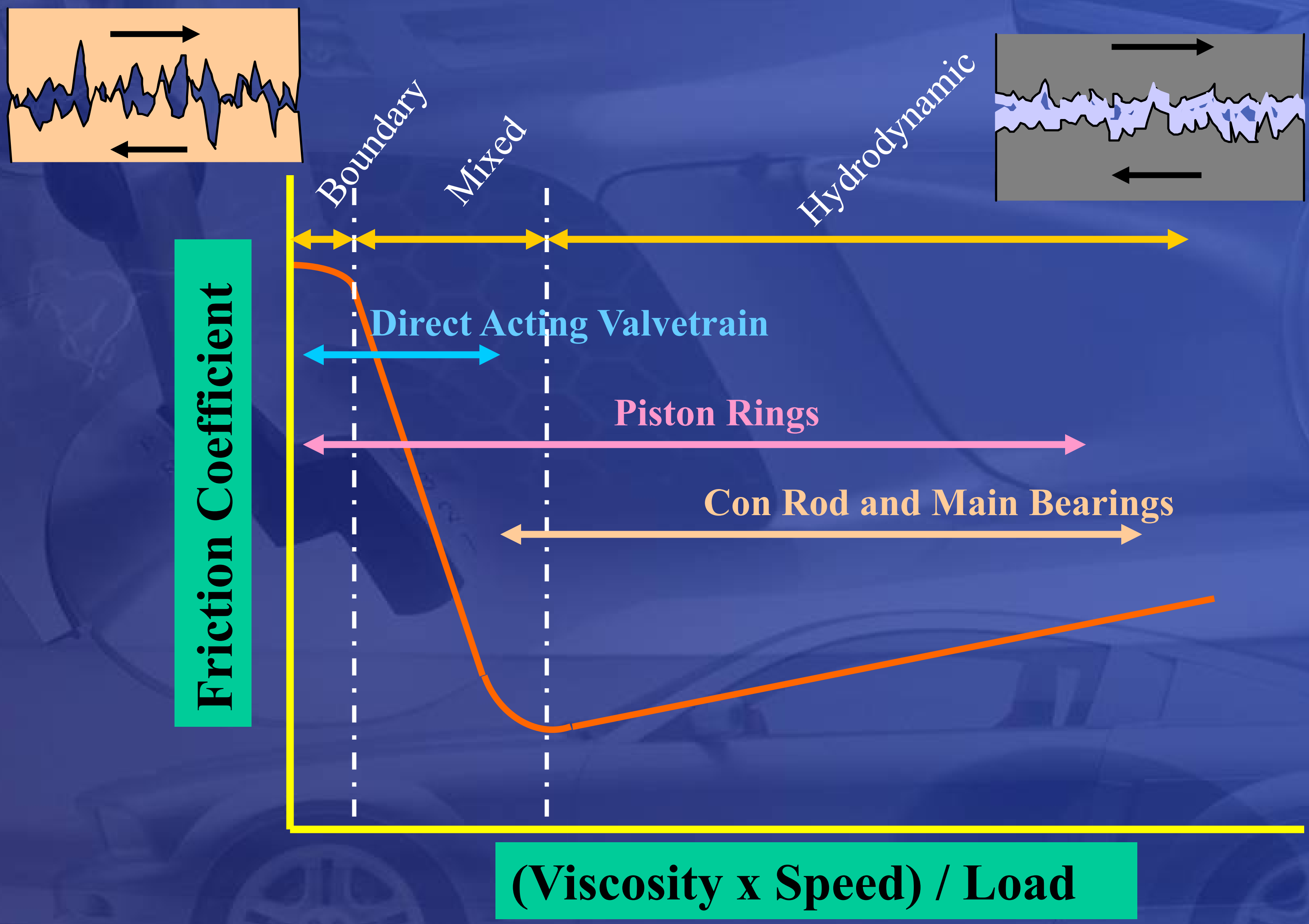
Valvetrain

Ring / Bore contact

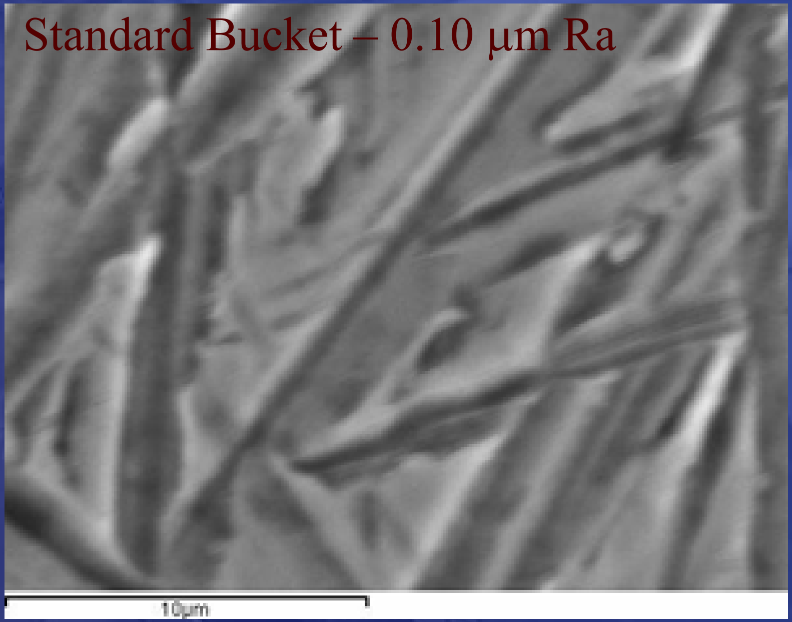
Frictional Losses in Engine



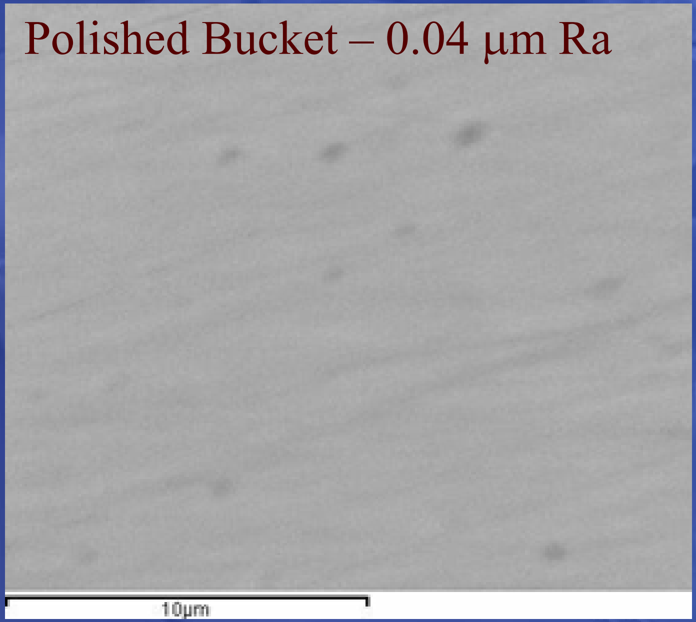
Stribeck Curve



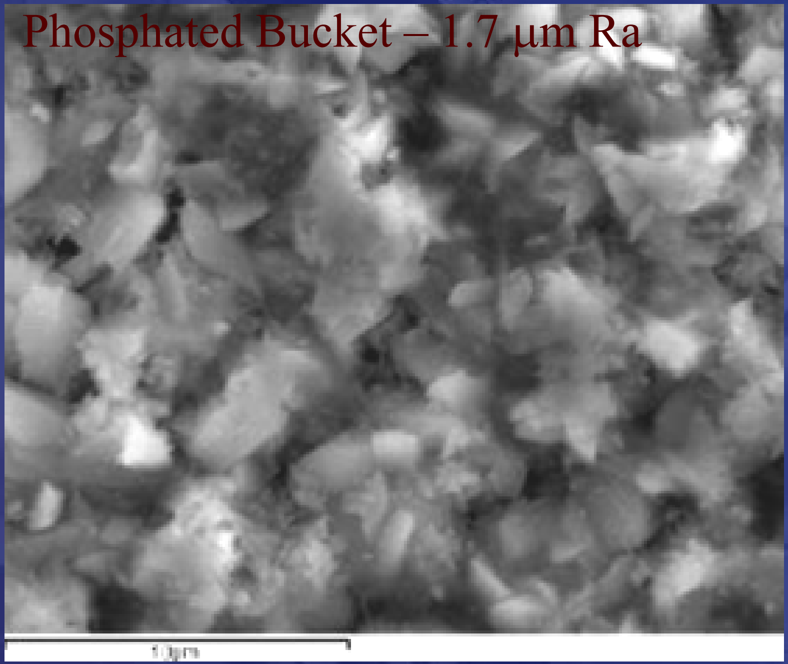
Different Bucket Tappet Surfaces in Valvetrain



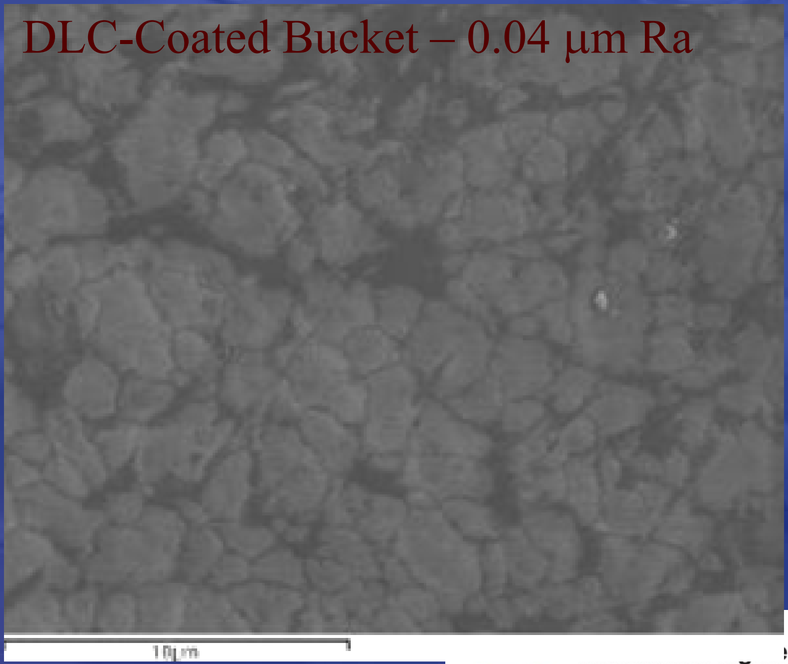
Standard Bucket – 0.10 µm Ra



Polished Bucket – 0.04 µm Ra

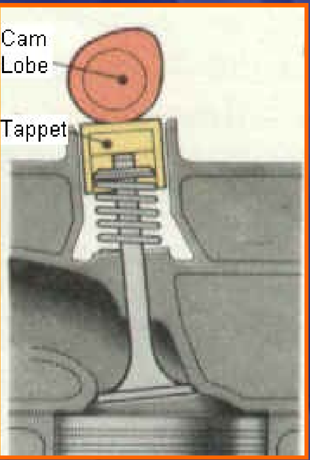


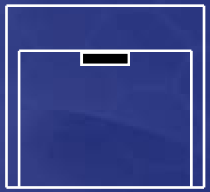
Phosphated Bucket – 1.7 µm Ra



DLC-Coated Bucket – 0.04 µm Ra

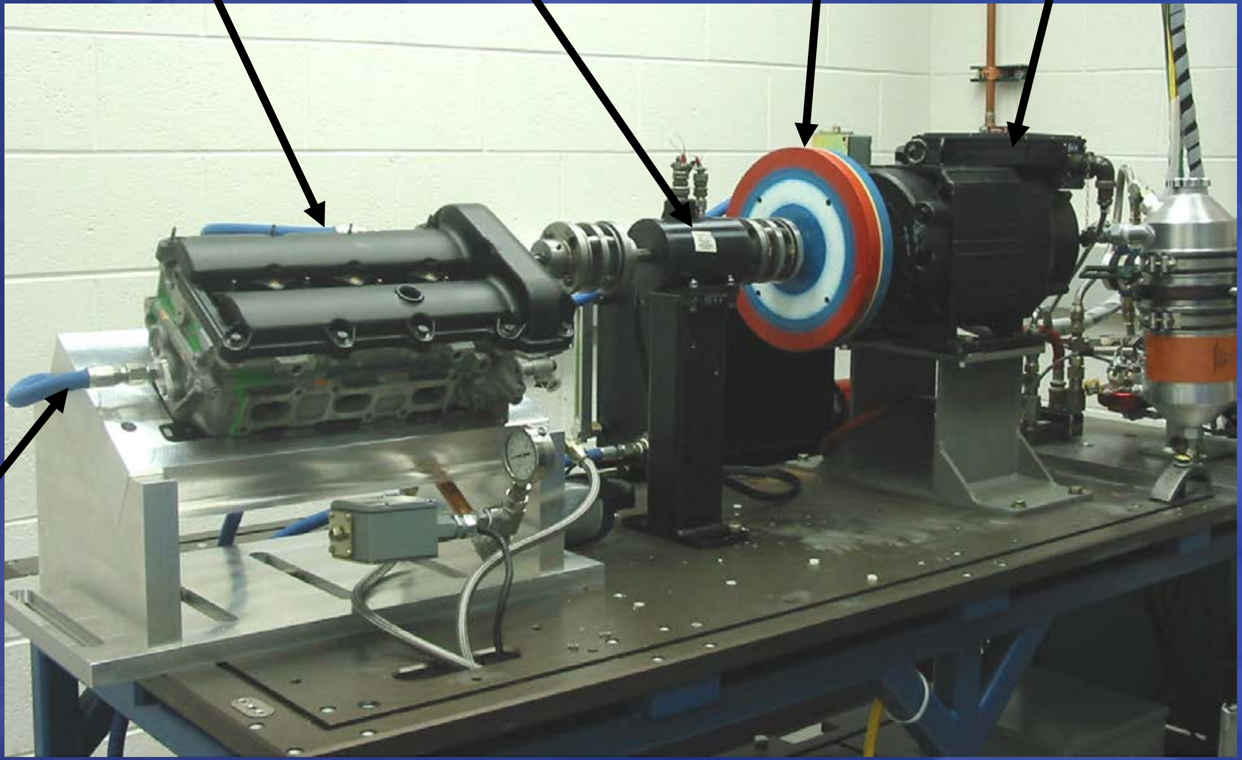
Motored Friction Measurements





1 piece bucket

Cylinder head Torque Meter Flywheel Motor

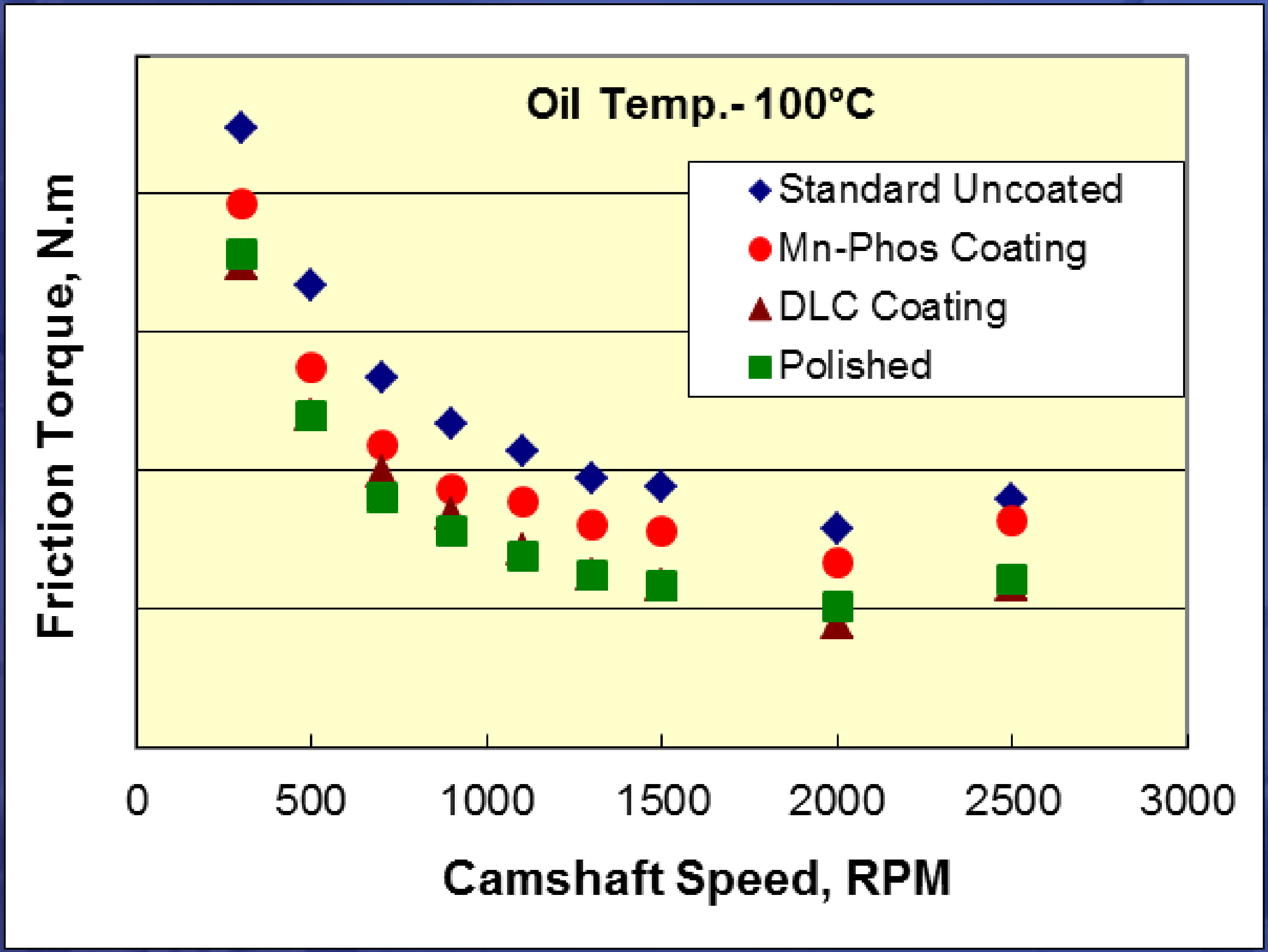


Coolant line

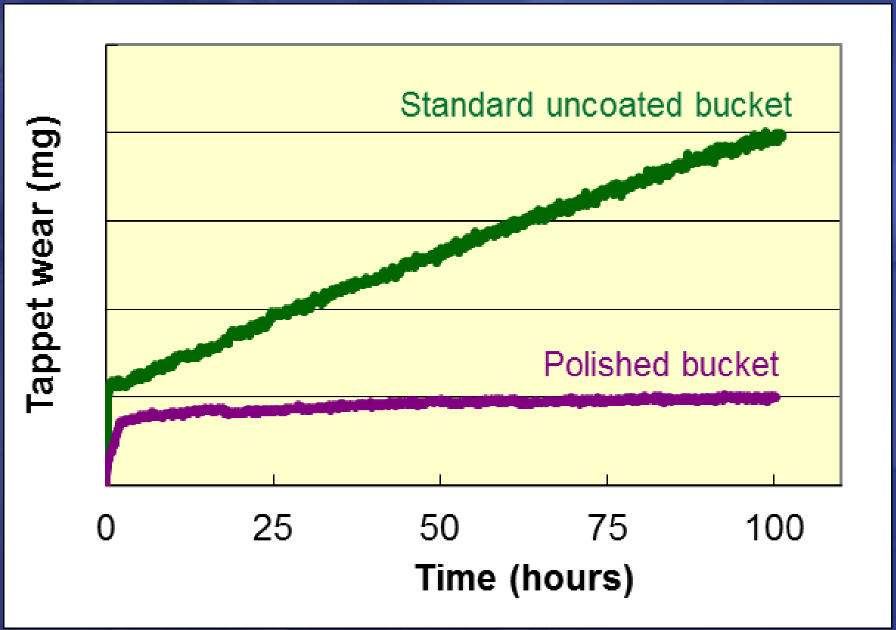
Friction Results

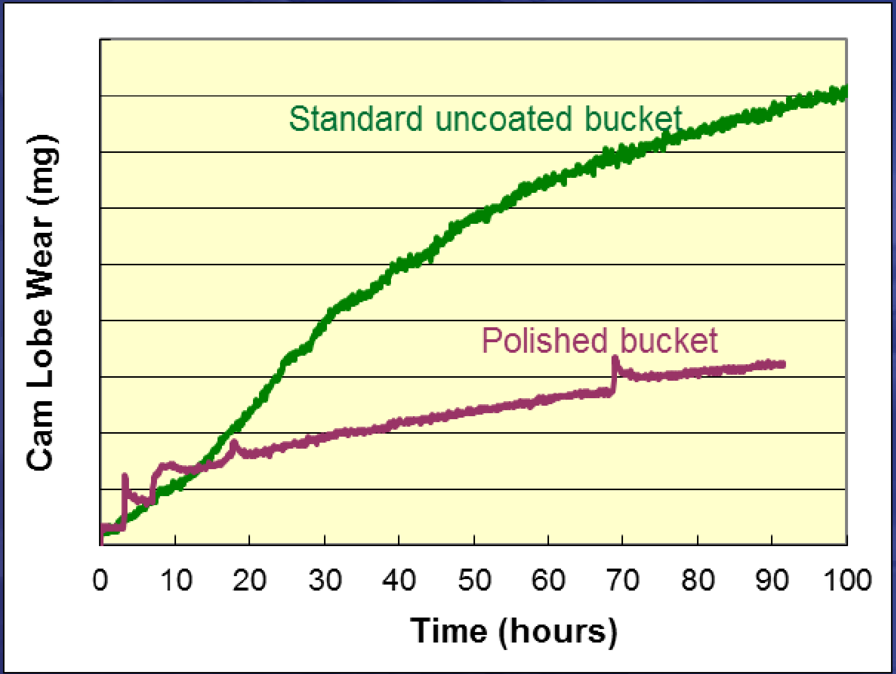
Mn Phos 5 - 14% improvement

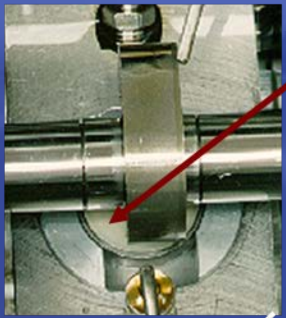
Polished & DLC 17- 25% improvement



Wear Data







Tappet insert/camlobe

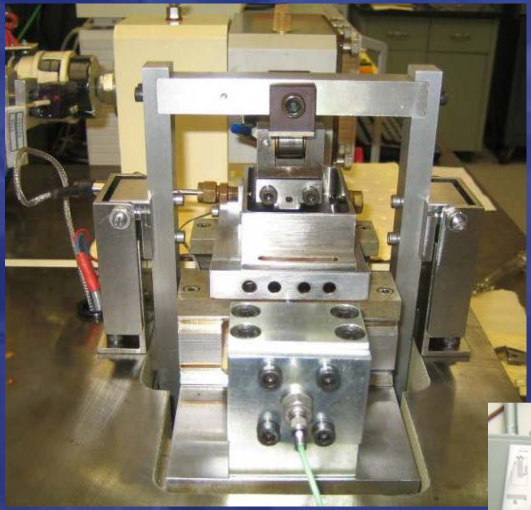
Converted to ^{56}Co by proton beam

Piston Ring / Cylinder Bore Friction

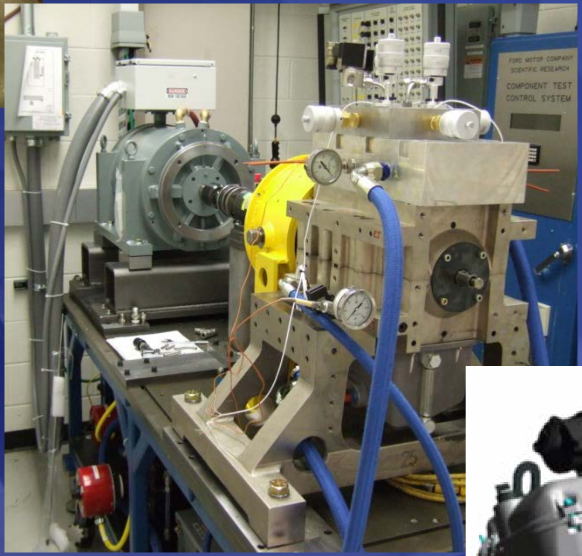
- Factors affecting friction
  - Piston Ring
    - **Ring coating (Mo-NiCr, PVD, DLC, nitrided)**
    - Ring tension
    - Ring design (barrel faced, 2pc vs. 3 pc oil control ring)

  - Cylinder bore
    - Bore finish
    - **Bore coating to replace liners**
    - Bore cylindricity
    - Honing patterns

Testing Sequence



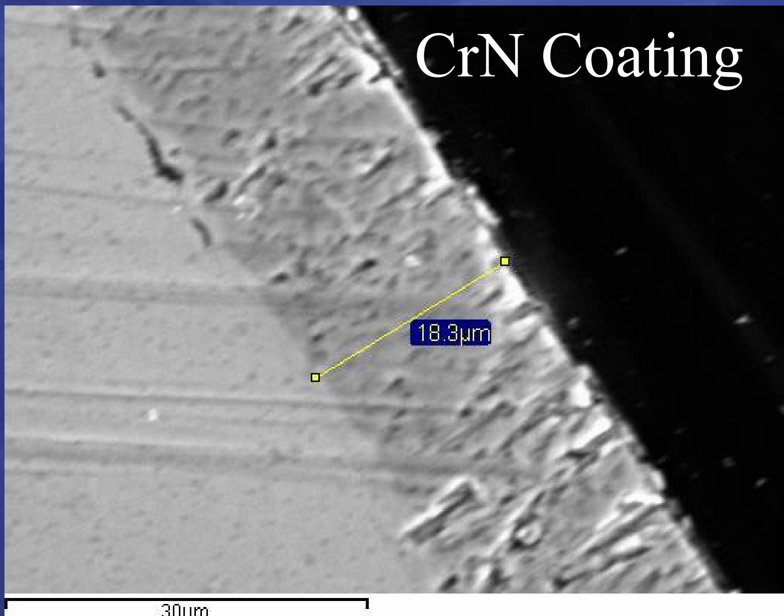
Lab bench tests

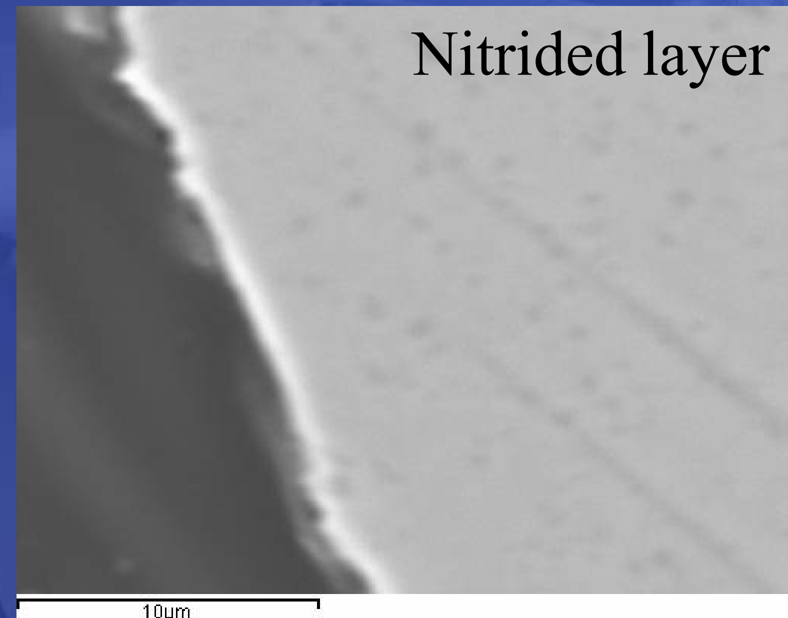


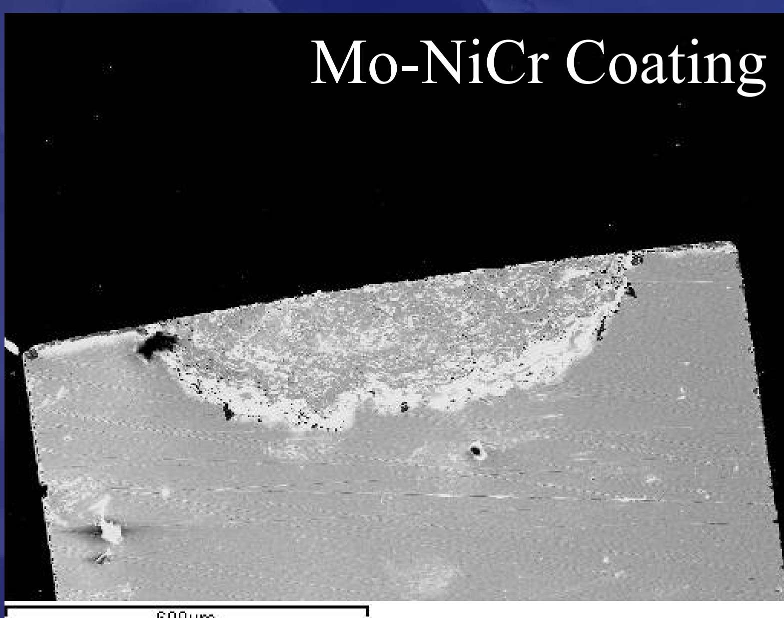
Single cylinder tests

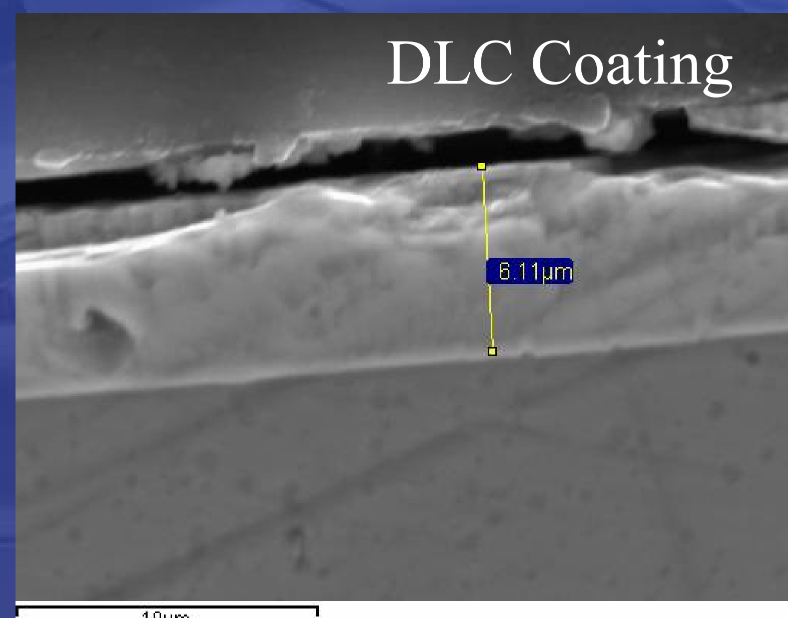
Engine tests

Different Piston Ring Coatings Evaluated

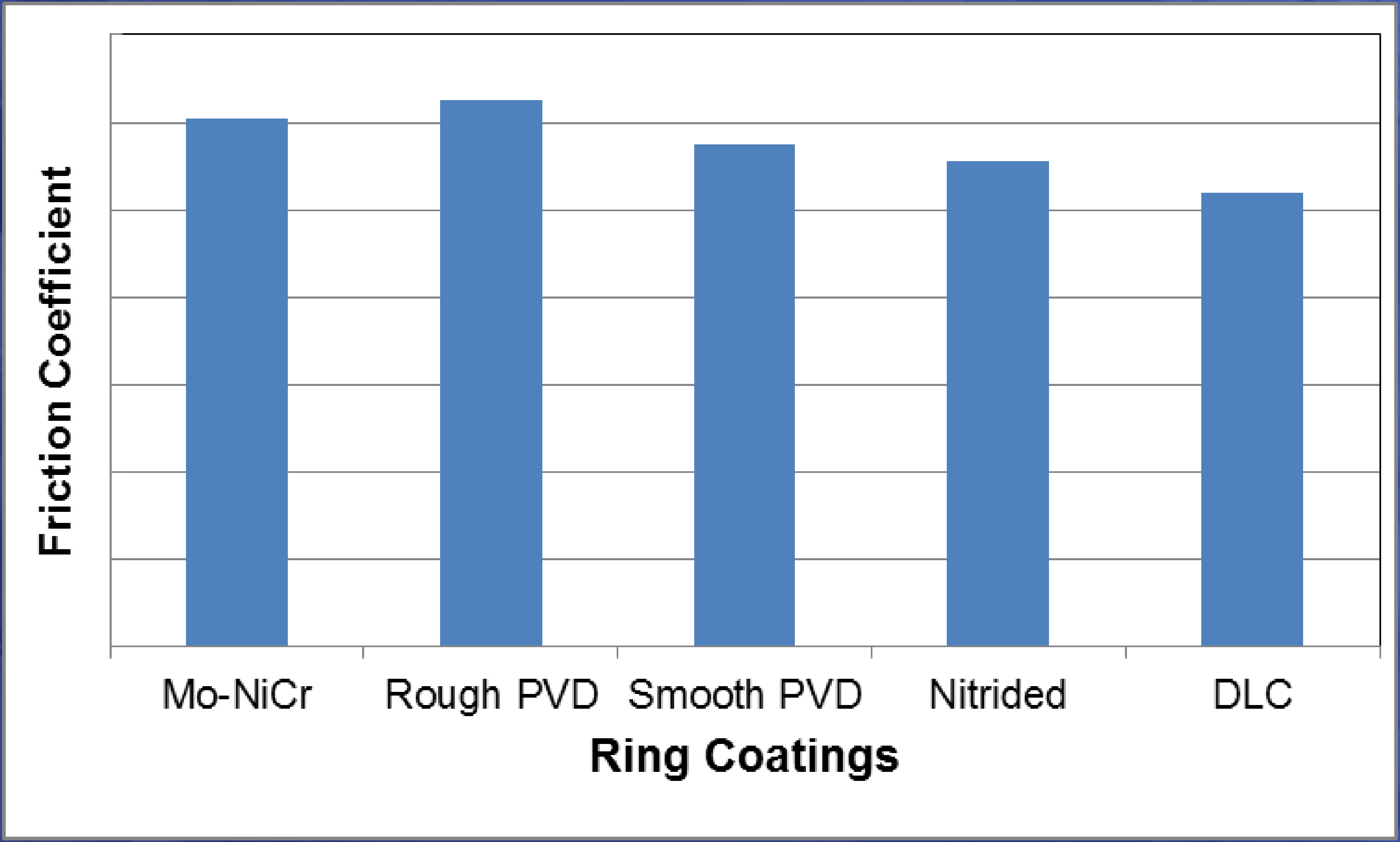




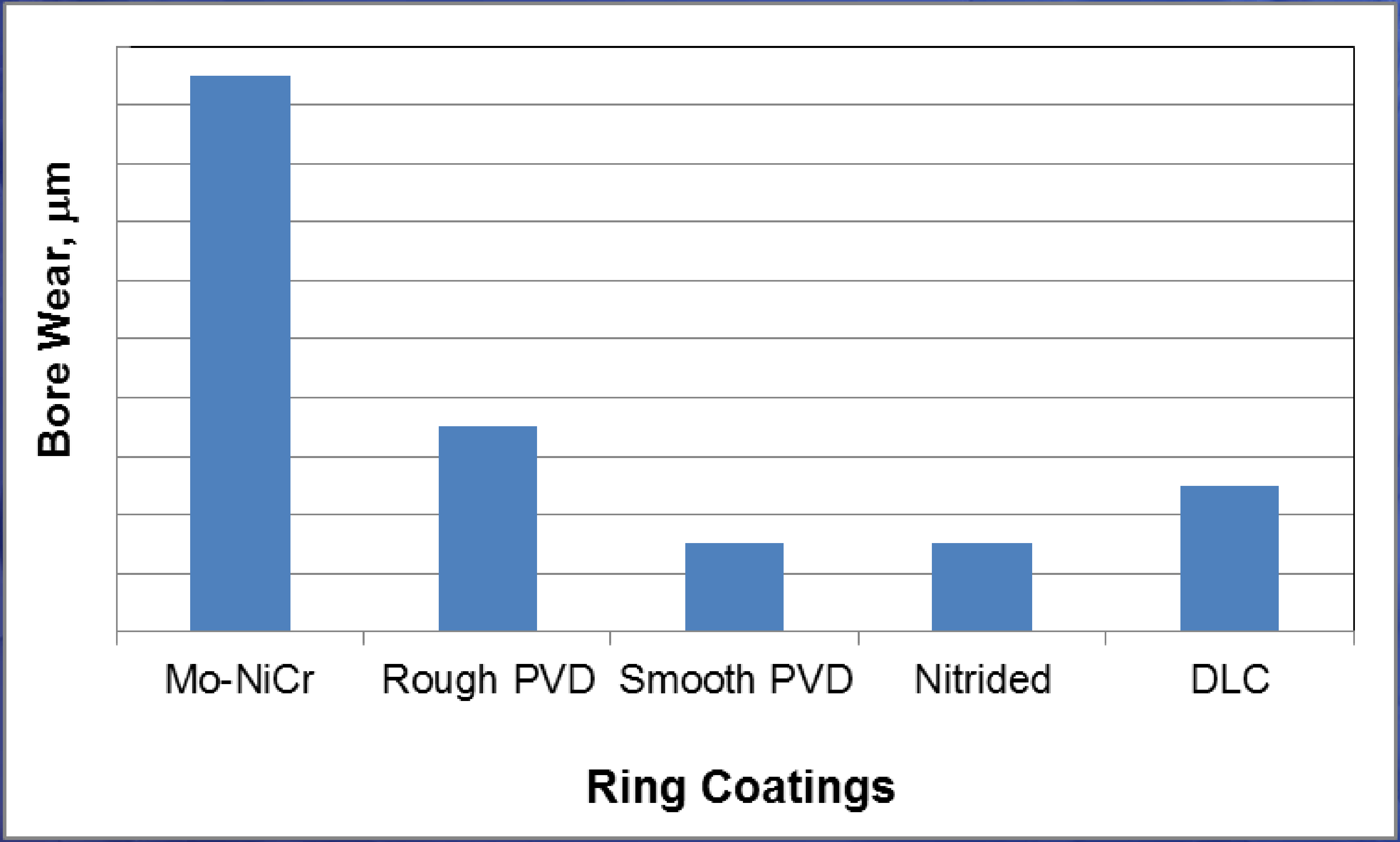




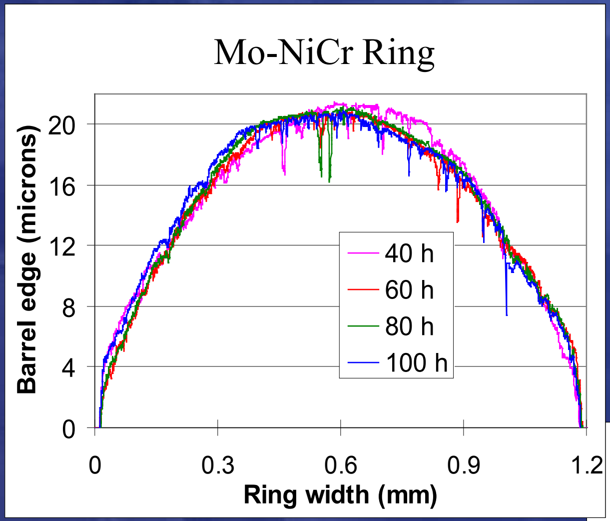
Friction Results

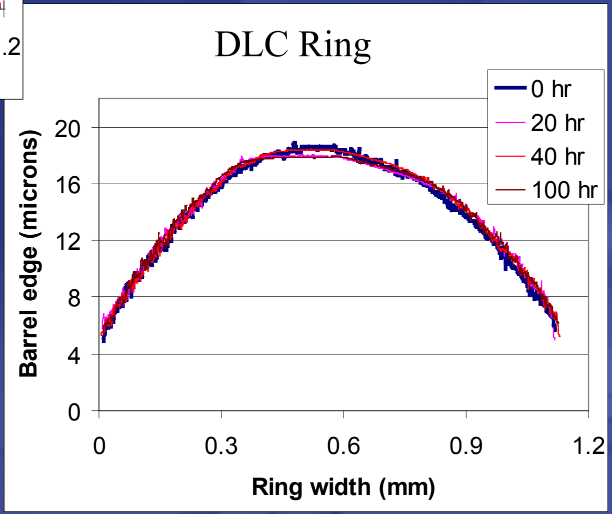


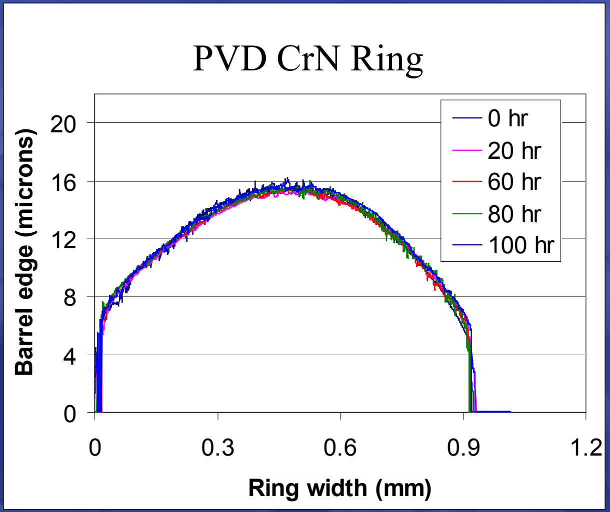
Bore Wear


Bore Wear, µm
Mo-NiCr
Rough PVD
Smooth PVD
Nitrided
DLC
Ring Coatings

Ring Wear







Research and Advanced Engineering

Next Steps

- Further opportunities exist with advanced lubricant technologies
- DOE awarded a grant to Ford to explore polyalkylene glycol base lubricants for engine friction reduction

Summary

- Polished buckets showed significant friction reduction in valvetrain application
- DLC coating on piston ring offered some friction benefit under boundary lubrication condition
- Improved surface finish on piston rings also offered friction reduction
- Thin film coatings showed lower bore wear and coatings appeared to be quite durable
- Opportunities exist for friction reduction with advanced material technologies