Surface Texturing for Friction Control

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Project ID # PM025

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Overview

Timeline

- Start date - Jan 2010
- End date - Dec 2015
- Percent complete – 10%

Budget

- Total project funding
  - DOE share – 200K
  - Contractor share
- Funding
- FY10 – 200K

Barriers

- Barriers addressed
  - Safety, durability, and reliability
  - Computational models, design and simulation methodologies
  - Higher vehicular operational demands

Partners

- Interactions/ collaborations
  - Northwestern University

Project Description

- Surface texturing in terms of topographical modification and design have been shown to a means of controlling friction at oil lubricated interface.

- Specifically, surface texturing (LST) in the form of micro dimples have been shown to sometimes reduce friction, but unbeneficial at other times, especially in non-conformal contacts.
  - If the mechanisms by which surface dimples can be adequately understood, it can be a very cost effective method to reduce friction in appropriate components in vehicle.
  - Friction reduction will improve efficiency and translate to fuel savings and emission reduction

- Besides dimples, other forms of surface texturing can be used to reduce friction and wear in transportation vehicle components.

Project Objectives

- In order to effectively utilize surface texturing technology for friction control in vehicle system components the overall objectives of this project are:
  - Develop mechanistic understanding of the effect of surface texturing on friction behavior in various lubrication regimes
  - Develop application specific performance evaluation methodology for textured surfaces
  - Develop methods for the optimization of surface texturing for different applications
  - Determine the impact of surface texturing on lubricant additives

Technical Approach

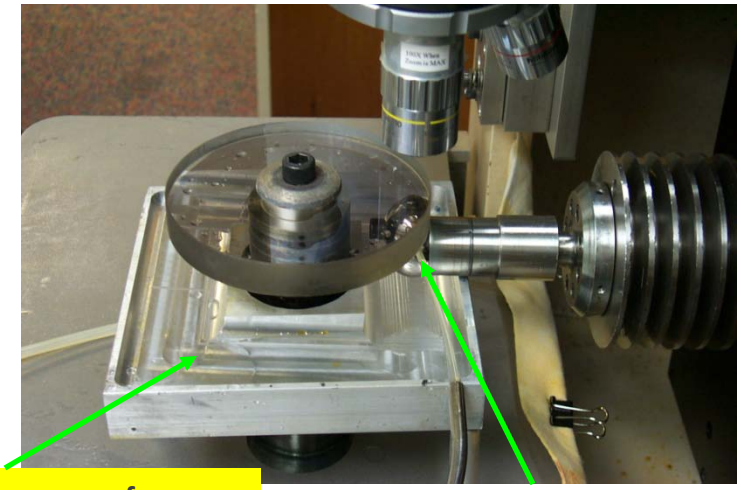
- In lubricated contacts, the effect of surface topography and texture will be more pronounced on the lubricant fluid film. Consequently, mechanistic study of the impact of surface texture (dimples for a start) will be studied by measuring lubricant fluid film thickness and friction under different lubrication regimes.

- Application specific evaluation will be evaluated initially with appropriate bench top test rig. Eventually, component testing will be conducted on optimized textured surfaces.

- The impact of surface texturing on basic tribological failure mechanisms will be evaluated using appropriate testing, surface and subsurface analysis and characterization.

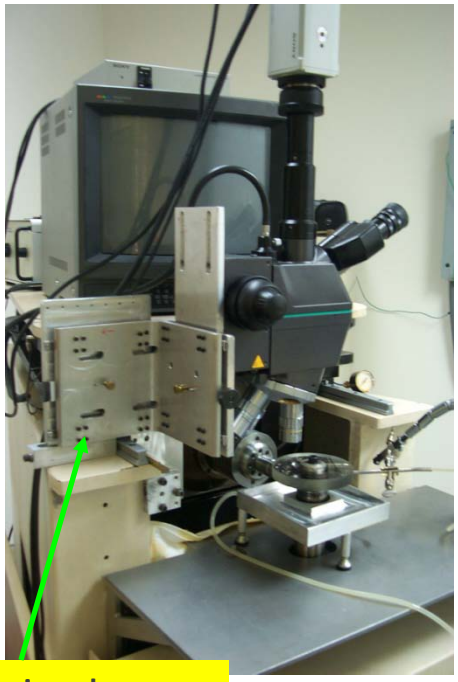
FY10 Technical Accomplishment

- Lubricant fluid film thickness measurement with optical Interferrometry



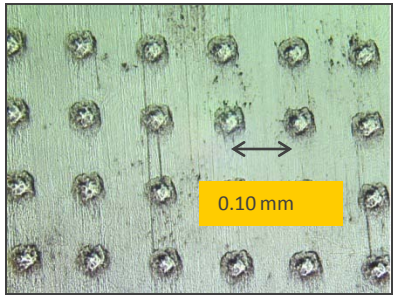
New sump for re-circulating oil supply

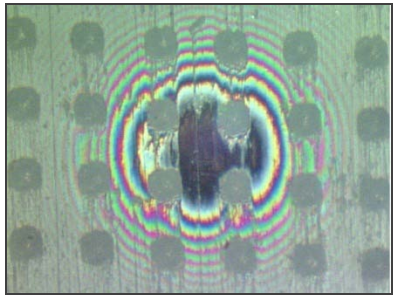
Driven, 1.125 inch diameter ball



Redesigned microscope mount

Laser Dimpled Surface, (100X)



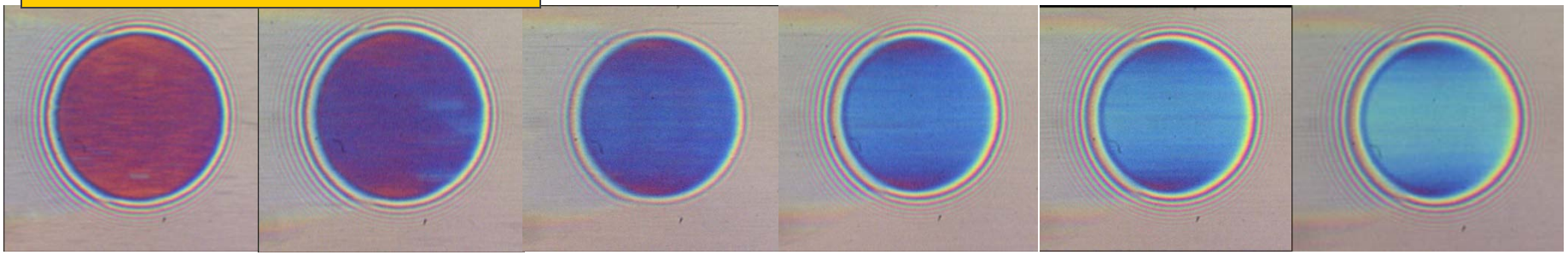


Experimental set-up uses ball-on-flat contact configuration

FY10 Technical Accomplishment

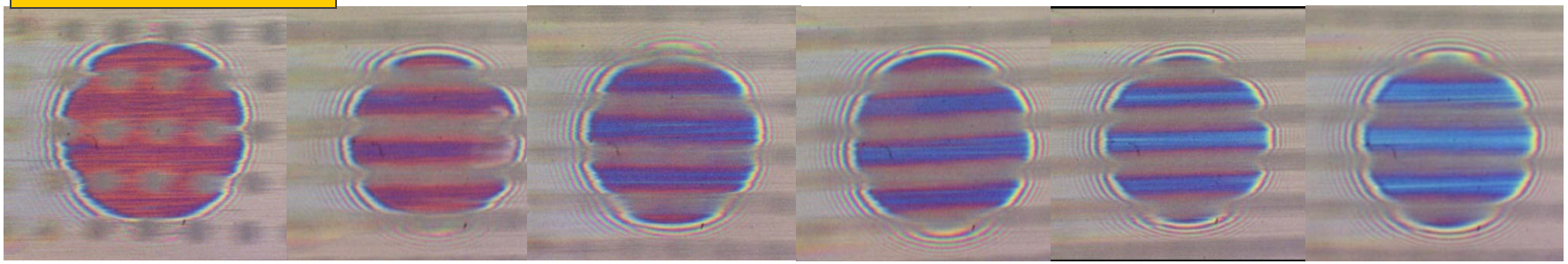
- Comparison of fluid film thickness for dimpled and undimpled surfaces

Smooth Finish Ball, Ra < 1 μ-inch:



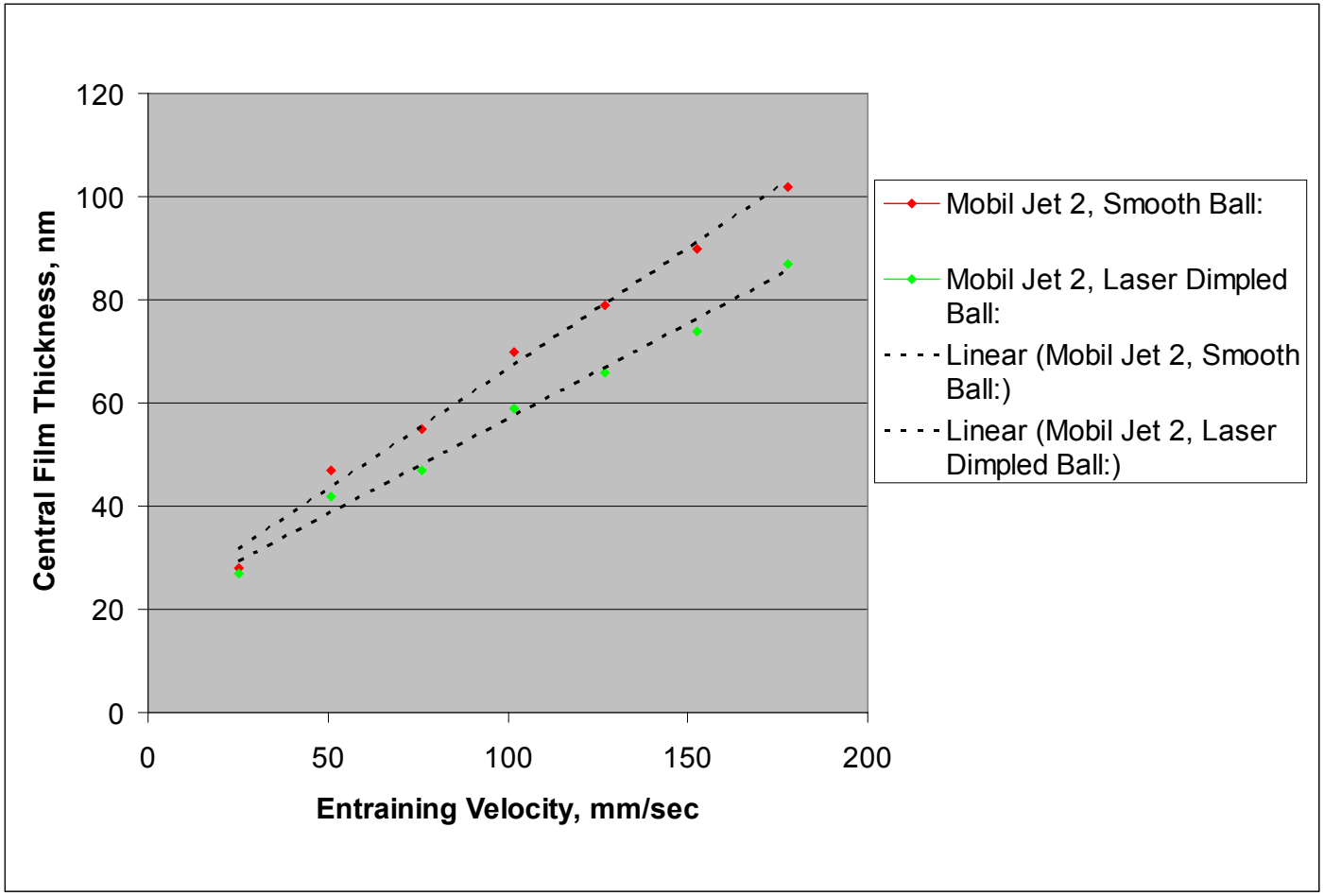
Ue = 1 in/sec Ue = 2 in/sec Ue = 3 in/sec Ue = 4 in/sec Ue = 5 insec Ue = 6 in/sec

Laser Dimpled Ball:



Ue = 1 in/sec Ue = 2 in/sec Ue = 3 in/sec Ue = 4 in/sec Ue = 5 insec Ue = 6 in/sec

Comparison of measured lubricant fluid film thickness for dimpled and smooth surface



'Take-home' message: Dimples do not appear to enhance the central lubricant fluid film thickness

FY10 Technical Accomplishment

- Application specific journal bearing benchtop testing – to assess application for engine main bearing.
- Used a conformal block-on-ring contact configuration

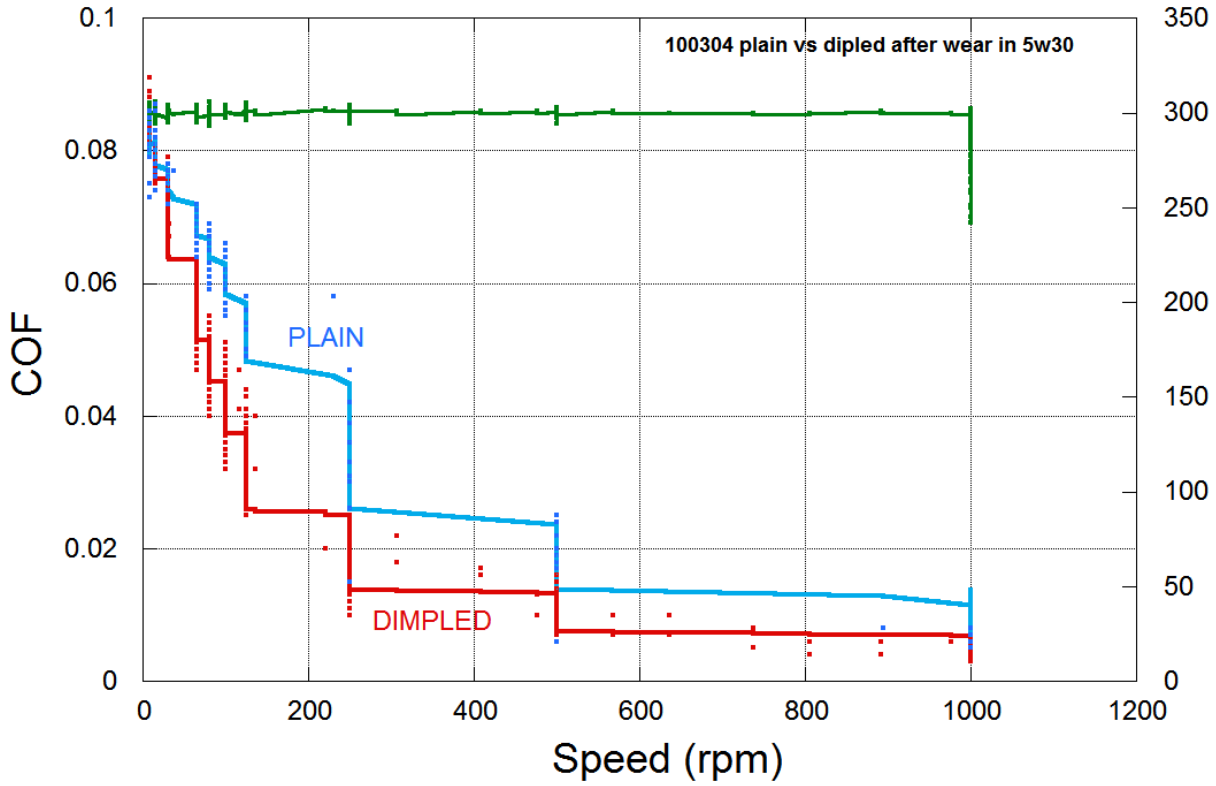
Block-on-Ring Test Stand

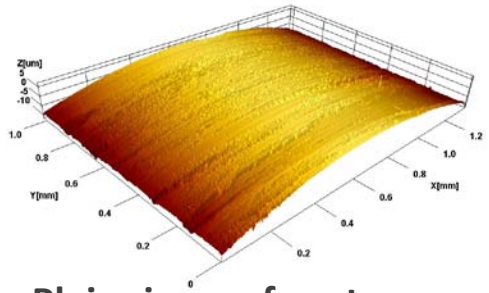
Block

Ring

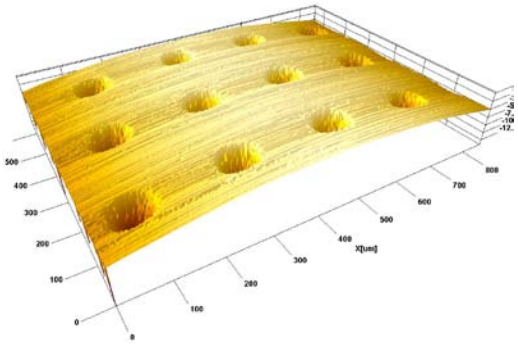
Friction was measured for dimpled and undimpled steel ring sliding against conformal steel block.

FY10 Technical Accomplishment: Friction Performance Comparison





Plain ring surface topography



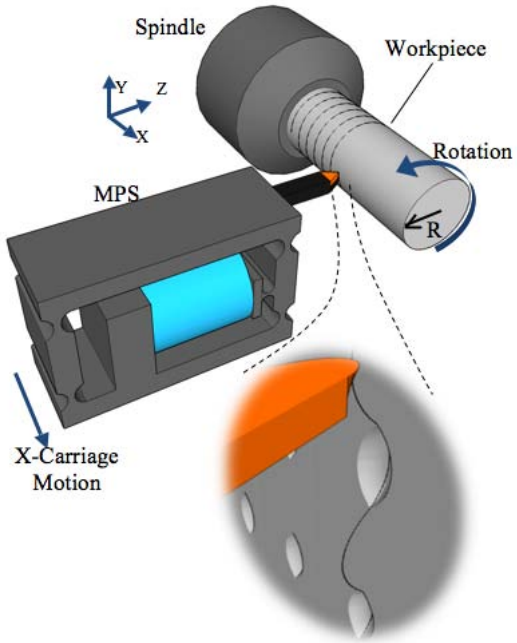
Dimpled ring surface topography

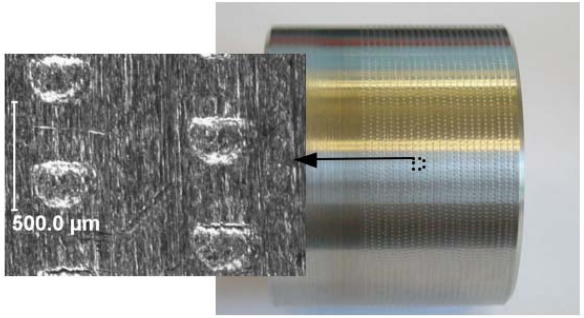
'Take-home' message: Surface texture (dimples) reduced friction in conformal journal bearing contact configuration test.

Collaboration

Partner:

- Northwestern University (Academic): Collaboration on vibro-mechanical method of surface texturing with dimple





Aaron Greco et al., "Surface Texturing of Tribological Interfaces Using the Vibromechanical Texturing Method," *Journal of Manufacturing Science and Engineering* 131, no. 6 (2009): 061005.

Proposed Future Work

- Continue application specific tribological performance testing of textured surfaces
  - Input and pathway for technology optimization for appropriate application
  - Identify the limits of the technology
- Evaluate the impact of surface texturing on the various tribological failure mechanisms – Scuffing, wear, contact fatigue, etc
- Evaluate the impact of surface texturing on the actions of lubricant additives in formation of tribochemical boundary films
  - Possible pathway to a topo-chemical surface engineering for optimized tribological performance.
- Explore various methods and forms of surface texturing for tribological performance enhancement

Summary

- The impact of surface texturing on friction and wear performance of surfaces still require further understanding
  - Initial test results show that surface texturing by dimples do not necessarily increase the lubricant fluid film thickness in non-conformal contact
  - On the other hand, texturing by dimple reduce friction in the journal bearing contact configuration.

- Surface texturing in general has a potential to be a cost effective and easy to implement approach to friction and wear reduction if adequate understanding can be developed.
  - Potential to combine surface texturing with other technologies to further improve performance.