Surface Texturing for Friction Control

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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 be 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

- Laser Dimpled Surface, (100X)
  - 0.10 mm

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 in/sec
- 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 in/sec
- 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

Friction was measured for dimpled and undimpled steel ring sliding against conformal steel block.
FY10 Technical Accomplishment: Friction Performance Comparison

‘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

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.