Wednesday Overview

Please check the errata in your registration bag to verify course times. Some times might change slightly.

L3 = Level 3
L4 = Level 4
L5 = Level 5  Beverage Breaks are scheduled at 10 am and 3 pm daily.

Wednesday, May 8, 2013

Registration (7 am – 6 pm)
Renaissance Foyer – L3

Speakers Breakfast (7 – 8 am)
Ontario – L3

Commercial Exhibits and Student Posters (9:30 am – Noon)
Renaissance Ballroom – L4

Education Courses (8 am – 5 pm)
Advanced Lubrication 301 – Ambassador 1
Automotive Lubrication 201: Gasoline – Marquette B – L5
Basic Lubrication 102: Basic Applications – Marquette A – L5
Hydraulics 101: Basic Fluids & Applications – Ambassador 2
Metalworking Fluids 250: Understanding & Controlling Metal Removal Fluid Failure – Ambassador 3

Technical Sessions (8 am – Noon)
5A Tribotesting I – Joliet A/B – L5
5B Materials Tribology III – Cadillac – L5
5Ca Nanotribology II – LaSalle – L5
5Cb Nanotribology III – LaSalle – L5
5D Surface Engineering III – Richard A
5E Fluid Film Bearings V – Richard B – L5
5F Commercial Marketing Forum V – Mackinac West – L5
5H Lubrication Fundamentals III – Nicolet – L5
5K Environmentally Friendly Fluids I – Mackinac West – L5

Technical Sessions (1:30 – 6 pm)
6A Tribotesting II – Joliet A/B – L5
6C Nanotribology III Continued – LaSalle – L5
6D Surface Engineering IV – Richard A
6E Rolling Element Bearings V: Panel Discussion – Richard B – L5
6H Lubrication Fundamentals IV – Nicolet – L5
6I Practical Lubrication Practices I – Brule – L5
6K Environmentally Friendly Fluids II – Mackinac West – L5
<table>
<thead>
<tr>
<th>TIME</th>
<th>SESSION 5A Tribotesting I</th>
<th>SESSION 5B Materials Tribology III</th>
<th>SESSION 5Ca Nanotribology II</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 – 8:30 am</td>
<td>Recirculation of Heat within Frictional Contacts, A. Bennett, p. 98</td>
<td>Rheology for Tribology: Additional Informations and Synergies, E. Wolf, p. 99</td>
<td>Implementing Nanoadditive Technologies: The Journey From Laboratory Research to Commercial Viability, B. Branson, p. 100</td>
</tr>
<tr>
<td>9 – 9:30 am</td>
<td>The Brugger Test as a Screening Tool for Hydraulic Fluids, G. Fish, p. 98</td>
<td>Study Into Surface Chemistry and Morphology of Tribofilms Generated by Tribotesting, B. Zhmud, p. 99</td>
<td>Nanotribology and Nanomaterials, H. Spikes, p. 100</td>
</tr>
<tr>
<td>10 – 10:30 am</td>
<td>Break</td>
<td>Break</td>
<td>Break</td>
</tr>
<tr>
<td>11 – 11:30 am</td>
<td>Bench Test for Wear and Friction Measurement, S. Bassu, p. 98</td>
<td>Friction and Wear of Binderless Niobium Carbide, W. Mathias, p. 100</td>
<td></td>
</tr>
<tr>
<td>11:30 am – Noon</td>
<td>Automated High Throughput Tribometer, V. Kalihari, p. 99</td>
<td>Grain Size Evolution of High-Purity Copper Under Reciprocating Tribological Loading, C. Greiner, p. 100</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TIME</th>
<th>SESSION 6A Tribotesting II</th>
</tr>
</thead>
<tbody>
<tr>
<td>1:30 – 2 pm</td>
<td>Wear and Reparability Evaluations of a New Class of Super Self-Lubricating HBN-Ni Coatings, A. Segall, p. 108</td>
</tr>
<tr>
<td>2 – 2:30 pm</td>
<td>Use of Solid-particle Erosion Testing for Screening Engineering Materials, K. Budinski, p. 108</td>
</tr>
<tr>
<td>2:30 – 3 pm</td>
<td>Air Bearing Effects in Polishing of Thin Film Magnetic Recording Disks, T. Karis, p. 108</td>
</tr>
<tr>
<td>3 – 3:30 pm</td>
<td>Break</td>
</tr>
<tr>
<td>3:30 – 4 pm</td>
<td>Industrial Gear Lubricants for Extreme Environments: Coal Dust Contamination and Severe Vibration, E. Muechewich, p. 109</td>
</tr>
<tr>
<td>4 – 4:30 pm</td>
<td>The Traction Behavior of Desert Gold Grease Under Heavy Loads, Low Speeds and Various Temperatures, Yang, p. 109</td>
</tr>
<tr>
<td>4:30 – 5 pm</td>
<td>Tribotesting Business Meeting</td>
</tr>
<tr>
<td>5 – 5:30 pm</td>
<td>Break</td>
</tr>
</tbody>
</table>

Society of Tribologists and Lubrication Engineers
<table>
<thead>
<tr>
<th>SESSION 5C</th>
<th>SESSION 5D</th>
<th>SESSION 5E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nanotribology III</td>
<td>Surface Engineering III</td>
<td>Fluid Film Bearings V</td>
</tr>
<tr>
<td>LaSalle – L5</td>
<td>Richard A – L5</td>
<td>Richard B – L5</td>
</tr>
<tr>
<td>An Investigation of the Tribological Performance of Textured Solid Lubricant Reservoir Tribosystems R. Pudjoprawoto, p. 102</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Break**

<table>
<thead>
<tr>
<th>SESSION 6C</th>
<th>SESSION 6D</th>
<th>SESSION 6E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nanotribology III</td>
<td>Surface Engineering IV</td>
<td>Rolling Element Bearings V</td>
</tr>
<tr>
<td>LaSalle – L5</td>
<td>Richard A – L5</td>
<td>Richard B – L5</td>
</tr>
<tr>
<td>Lubrication in Textiles, Fabrics and Fibers: Metrology Challenges, J. Hinestrosa, p. 109</td>
<td>A Nanostructured Photocatalytic Coating for Wear and Corrosion Protection, X. He, p. 110</td>
<td></td>
</tr>
<tr>
<td>Tribology of Diamond-Like Carbon (DLC) Coatings Against Magnesium Alloy (AM60) and Composite AM60-9% (Al2O3)f, A. Banerji, p. 110</td>
<td>Wire Spraying of Aluminium on Ni-P Coated GFRP Panels, R. Suryanarayana, p. 102</td>
<td>The Account of an Angular Flexibility of Supports of a Cranked Shaft in Designing of the Bearings of Modern Internal Combustion Engines, A. Mylnikov, p. 104</td>
</tr>
</tbody>
</table>

**Break**

<table>
<thead>
<tr>
<th>SESSION 6F</th>
<th>SESSION 6G</th>
<th>SESSION 6H</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nanotribology Committee Business Meeting</td>
<td>Nano Tribological Properties of Tribofilms Obtained From Microcrystalline Lamellar Particles of Graphite, G. Minatchy, p. 109</td>
<td>Nanotribology Committee Business Meeting</td>
</tr>
<tr>
<td>Properties Of Air Plasma-Sprayed WC-12%Co Coatings were Enhanced Through Optimizing Spray Standoff Distance, M. Ajmal, p. 112</td>
<td>Two Dimensional Nanoscale Reciprocating Sliding Contacts of Textured Surfaces, R. Tong, p. 110</td>
<td></td>
</tr>
</tbody>
</table>

**SESSIONS TIME GRID**

<table>
<thead>
<tr>
<th>Time</th>
<th>SESSION 5C</th>
<th>SESSION 5D</th>
<th>SESSION 5E</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 – 8:30 am</td>
<td>Wear Prediction of Inconel 718 Coatings on Mild Steel by ANFIS, R. Suryanarayana, p. 101</td>
<td>Surface Modification of Carbon Fibre Rods, R. Suryanarayana, p. 101</td>
<td>Experimental Force Coefficients for an Open Ends Squeeze Film Damper Performing Large Amplitude Circular Orbital Motions, Centered and Off-centered, S. Jeung, p. 104</td>
</tr>
<tr>
<td>9 – 9:30 am</td>
<td>An Investigation of the Tribological Performance of Textured Solid Lubricant Reservoir Tribosystems R. Pudjoprawoto, p. 102</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9:30 – 10 am</td>
<td>10 – 10:30 am</td>
<td>10:30 – 11 am</td>
<td></td>
</tr>
<tr>
<td>11 – 11:30 am</td>
<td>The Account of an Angular Flexibility of Supports of a Cranked Shaft in Designing of the Bearings of Modern Internal Combustion Engines, A. Mylnikov, p. 104</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11:30 am – Noon</td>
<td>1:30 – 2 pm</td>
<td>2 – 2:30 pm</td>
<td></td>
</tr>
<tr>
<td>1:30 – 2 pm</td>
<td>Tribological Behavior of Ni-P Deposits on Dry Condition, Y. Cheng, p. 110</td>
<td>A Nanostructured Photocatalytic Coating for Wear and Corrosion Protection, X. He, p. 110</td>
<td></td>
</tr>
<tr>
<td>2 – 2:30 pm</td>
<td>Property of Diamond-Like Carbon (DLC) Coatings Against Magnesium Alloy (AM60) and Composite AM60-9% (Al2O3)f, A. Banerji, p. 110</td>
<td>Wire Spraying of Aluminium on Ni-P Coated GFRP Panels, R. Suryanarayana, p. 102</td>
<td></td>
</tr>
<tr>
<td>3 – 3:30 pm</td>
<td>Rolling Element Bearings V: Panel Discussion – Current Perspectives on ISO 281, L. Houpert, p. 112</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3:30 – 4 pm</td>
<td>Surfaces Engineering Business Meeting</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 – 4:30 pm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4:30 – 5 pm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 – 5:30 pm</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**WEDNESDAY >>**
<table>
<thead>
<tr>
<th>TIME</th>
<th>SESSION 5F Commercial Marketing Forum V</th>
<th>SESSION 5H Lubrication Fundamentals III</th>
<th>SESSION 5K Enviro Friendly Fluids I</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 – 8:30 am</td>
<td>Mackinac West – L5</td>
<td>Nicolet – L5</td>
<td>Mackinac West – L5</td>
</tr>
<tr>
<td>8:30 – 9 am</td>
<td>Break</td>
<td>Break</td>
<td>Break</td>
</tr>
<tr>
<td>9:30 – 10 am</td>
<td>Break</td>
<td>Break</td>
<td>Biodegradable Hydraulic Oils and Cleaners, T. Tarrant, p. 106</td>
</tr>
<tr>
<td>10:30 – 11 am</td>
<td>Break</td>
<td>Break</td>
<td>Conveting Used Biobased Lubricants to Bioenergy Via Anaerobic Digestion, C. Halene, p. 108</td>
</tr>
<tr>
<td>11 – 11:30 am</td>
<td>Characterization of GTDI Soot and Comparison to Diesel Soot, D. D. p. 112</td>
<td>Understanding the Deformation of Soot Particle/Agglomerates in a Dynamic Contact: TEM In Situ Compression and Shear Experiments, F. Dassenoy, p. 112</td>
<td></td>
</tr>
<tr>
<td>11:30 am – Noon</td>
<td>Break, Break</td>
<td>Break</td>
<td></td>
</tr>
<tr>
<td>11:30 am – Noon</td>
<td>Break, Break</td>
<td>Break</td>
<td></td>
</tr>
<tr>
<td>1:30 – 2 pm</td>
<td>Nicolet – L5</td>
<td>Burle – L5</td>
<td>Mackinac West – L5</td>
</tr>
<tr>
<td>2 – 2:30 pm</td>
<td>Break</td>
<td>Bypassing Around Filters During Cold Starts: Comparing Different Hydraulic Fluids, W. Needelman, p. 113</td>
<td>Friction and Wear of Jamboha Curcas Oil Using a Four Balls Tester, E. Gallardo, p. 114</td>
</tr>
<tr>
<td>3 – 3:30 pm</td>
<td>Break</td>
<td>Break</td>
<td></td>
</tr>
<tr>
<td>3:30 – 4 pm</td>
<td>Break</td>
<td>Break</td>
<td></td>
</tr>
<tr>
<td>4 – 4:30 pm</td>
<td>Thermoelectric Measurements of Fe-Constantan Sliding Asperity Contact Flash Temperatures, R. Erick, p. 113</td>
<td>Measuring Tapping Performance, M. Miller, p. 114</td>
<td>Evaluation of Karanja Oil (Pongamia Pinnata) as Bio-Degradable Base Oil for Lubricants, J. Haridas, p. 116</td>
</tr>
<tr>
<td>4:30 – 5 pm</td>
<td>Optimization of Siloxane Molecular Structure for Diverse Tribological Applications, T. Zolper, p. 113</td>
<td>Hitting the moving Target, C. Paxton, p. 114</td>
<td>An Investigation Into the Tribological Performance of Diesel and Diesel-GTBE Blends, G. Thaire, p. 116</td>
</tr>
<tr>
<td>5 – 5:30 pm</td>
<td>A Wafer-Scale Particle Augmented Mixed Lubrication Modeling Approach for Chemical Mechanical Polishing, G. Srivastava, p. 113</td>
<td></td>
<td>Environmentally Friendly Fluids Technical Committee Meeting</td>
</tr>
<tr>
<td>5:30 – 6 pm</td>
<td>Investigation of Negative Effects of Polymer Films on Cooling, A. Sasaki, p. 113</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Wednesday May 8, 2013**
miniAV Series

D445 Viscosity Automation

Small and Affordable
Low Solvent/Sample Volume
Faster Through-Put

- 10 or 100-fold tube ranges KinVis up to 6000 cSt
- Selectable temperature 15 ° to 100°C
- Smart table technology - save space, save time, save money

Customized for used oil analysis!

Visit us at Booth 316 at STLE 2013
Session 5A • Joliet – Level 5

TRIBOTESTING

Session Chair: A. Segall, The Pennsylvania State University, University Park, PA
Session Vice Chair: G. Krauss, The University of Michigan, Ann Arbor, MI

8 – 8:30 am
Recirculation of Heat within Frictional Contacts
A. Bennett, K. Rowe, W. Sawyer, University of Florida, Gainesville, FL

This study expands the previous work of Rowe et al. wherein the phenomena of frictional heating was examined. For relevant material properties, frictional heating of elastomers follows the analytical models on the subject and due to the constrained geometries of the experimental setup, regeneration of heat within the contact causes divergence from such models. As a function of Peclent number, the regeneration of heat and the “thermal wake” due to such geometries can cause the experimental measurement to deviate from 17 – 100 % of predicted temperature rises for elastomer contacts. Experiments have been designed and conducted to not only reduce the regeneration of heat within the contact through applied convective cooling but also to quantify such a source of heat. The resulting data shows that the regeneration of heat within the contact significantly modifies the predicted behavior of frictional heating in tribological contacts and must be accounted for in all systems moving forward.

8:30 – 9 am
Developing Infrared Microscopy to Measure Asperity Temperatures
T. Reddyhoff, J. Le Rouzic, Imperial College, South Kensington, United Kingdom

Surface temperature measurements of sliding interfaces are important since interfacial heat dissipation is closely linked to tribological behaviour. One of the most powerful techniques for such measurements is in-contact temperature mapping whereby a sliding contact is located beneath an infrared microscope. Despite its effectiveness, a number of constraints prevent this technique from being applied to rough surfaces – an area where temperature maps could provide much needed data to inform numerical models. This presentation describes research aimed at improving the validity, robustness, and spatial resolution of the temperature mapping technique, so that measurements of rough surfaces contacts are possible. This involves new methods of calibration validation using Planck’s Law. In addition, super resolution algorithms are successfully applied to measurements in order extend spatial resolution beyond the current, diffraction limited, value of 6 μm.

9 – 9:30 am
The Brugger Test as a Screening Tool for Hydraulic Fluids
G. Fish, The Lubrizol Corporation, Wickliffe, OH

The Brugger test was introduced in 1983 as a method for determining load carrying capacity of lubricants under a mixed friction regime. It consists of an 18mm diameter through hardened cylindrical bearing roller loaded against a rotating 25mm diameter hardened tool steel ring under a load of 400N. The test is run at room temperature. Unloaded it runs at 960rpm with a sliding velocity of 1.14m/s and a duration of 30s. From the measured wear scar dimensions, the contact pressure is calculated and reported as the load carrying capacity of the lubricant in N/mm. It was standardized in 2000 as DIN S1347, but does not have a precision statement. The test features in a number of hydraulic fluid (HF) specifications, despite the contact geometry and materials having no relation to those used in vane or piston-type hydraulic pumps. This presentation discusses issues with including the test in HF specifications and its potential negative effects on long life hydraulic fluid formulations.

9:30 – 10 am
P. Sui, Halliburton, Houston, TX, D. Duckworth, Halliburton, Conroe, TX

Advancement in grease additives has significantly improved journal bearing performance in downhole oil and gas drilling equipment. This improvement created a need for a more sensitive method of differentiating grease performance. Henceforth, a testing and analysis method was developed to meet the challenge. The method’s testing principle is based on the theory of bearing seizure limit. Journal bearing testing was performed with a prototype grease until bearing seizure failure was detected and the total energy input to the test grease was calculated. Testing was repeated numerous times and then the collected energy input data was analyzed with a reliability analysis tool. A characteristics curve representing the prototype grease reliability was established. This method was applied to two different prototype greases and to several different batches of each grease. We concluded that this method is very consistent and useful in comparing bearing grease tribological performance.

10 – 10:30 am • Break

10:30 – 11 am
Stick-Slip Leads to Considerable Error in Measuring Friction Coefficient
K. Nakano, C. Tadokoro, N. Kado, Yokohama National University, Yokohama, Japan

A novel principle of a self-control mechanism was proposed for suppressing stick-slip using a lateral slip given to a single-degree-of-freedom system with sliding friction. This principle was applied to measuring friction coefficient and an anti-vibration tribometer (AVT) was developed. It was confirmed that the AVT suppressed stick-slip caused by negative dependency of friction coefficient on relative velocity. Therefore, it enabled one to measure friction coefficient accurately in the force balance between friction force and spring force. However, when one used the time average of oscillating spring force to calculate friction coefficient under stick-slip, considerable errors (e.g., approximately 30 % underestimation for a steel-steel sliding contact lubricated by glycerin) were made.

11 – 11:30 am
Bench Test for Wear and Friction Measurement
S. Basu, The Lubrizol Corporation, Wickliffe, OH

Industrial gear oils use a combination of antiwear and friction modifier molecules to get the right performance needed in a gear box. In an attempt to evaluate new lubricant candidates, we have developed a new bench test that helps to understand the performances of new antiwear and friction modifier chemistries. This short and inexpensive test uses a high frequency reciprocating rig (HFRR) and gives end-of-test wear scar diameter and coefficient of friction. This test shows extremely high repeatability under conditions similar to those found in an industrial gear box. Extensive surface analyses correlated antiwear film chemistry with the end-of-test wear scar diameter.
11:30 – Noon
Automated High Throughput Tribometer
V. Kailhari, Corporate R&D, Dow Chemical, Midland, M, S. Timpe, Mechanical Engineering, Bradley University, Peoria, IL
Understanding the origin and correlation of different surface properties under a multitude of operating conditions is critical in tribology. Diverse tribological properties and a lack of a single instrument to measure all make it difficult to compare and correlate properties, particularly in light of the wide range of interfaces commonly investigated. In the current work, a novel automated tribometer has been designed and validated, providing a unique experimental platform capable of high throughput adhesion, wear, kinetic friction, and static friction measurements. A case study is presented with multiple surface measurements performed on a set of characteristic substrates. Adhesion, wear, kinetic friction, and static friction are analyzed and compared across surfaces, highlighting the comprehensive nature of the surface data that can be generated using the automated high throughput tribometer (Kailhari et al. Review of Scientific Instruments 84 (2013)).

Session 5B • Cadillac – Level 5

MATERIALS TRIBOLOGY III

Session Chair: T. Scharf, University of North Texas, Denton, TX
Session Vice Chair: H. Khare, University of Delaware, Newark, DE

8 – 8:30 am
Rheology for Tribology: Additional Informations and Synergies
F. Wolf, Anton Paar Germany GmbH, Ostfildern, Germany
The properties of lubricated tribological systems depend among other things on the rheological properties of employed lubricants and solids. The rheological properties – elasticity and viscosity – depend strongly on the internal structure of fluids, which can change due to e.g. stresses or temperature. These properties in turn affect the tribological properties. The contribution will show results of investigations on rheological effects, especially visco-elastic properties, and their impact on the tribological properties. The properties of shear-sensitive, visco-elastic fluids will be highlighted. Associated measurement techniques will be discussed regarding their applicability and transfer of measurement techniques between rheometry and tribometry, as well as the synergy between the two measurement techniques.

8:30 – 9 am
Nano-Mechanical and Chemical Characterization of Tribofilms Formed Under Conformal Contact Conditions
K. Pondicherry, Materials Center Leoben, Leoben, Austria, T. Schöberl, Austrian Academy of Sciences, Leoben, Austria, F. Grün, I. Gödro, Montanuniversität Leoben, Leoben, Austria, E. Lainé, Infineum UK Limited, Milton Hill, United Kingdom, M. Offenbecher, Miba Bearing Group, Laaenkirchen, Austria
Nano-mechanical characterization of tribofilms formed on steel surface was carried out with the help of AFM-nanoindentation technique. Whereas, focussed ion beam technique combined with SEM/EDX, and XPS were used for their chemical characterization. Tribofilms investigated here were generated by sliding pure aluminium against steel under a nominal contact pressure of less than 5 MPa in the presence of a ZDDP containing lubricant. Results reveal that the phosphate tribofilms, 300 to 800 nm in thickness, grew upon metal sulphides of 50 to 100 nm thickness. The hardness and reduced moduli of both these features were found to be around 6 GPa and 105 GPa respectively. These values lie close to those presented in literature, albeit for Hertzian contacts with contact pressures of about two orders of magnitude higher. Additionally, Ca-based films with hardness and elastic modulus slightly higher than the phosphate tribofilms were also detected on the steel surface.

9 – 9:30 am
Study Into Surface Chemistry and Morphology of Tribofilms Generated by Tribocoatinging
B. Zhmud, Applied Nano Surfaces Sweden AB, Uppsala, Sweden
Tribocoatinging is a novel mechnochemical surface finishing process developed for improving the tribological properties of mechanical components made of steel or cast iron. The process combines elements of extreme-pressure mechanical burnishing of the component surface with a tribochemical deposition of a low-friction antwear film of tungsten disulphide WS2. Earlier component rig tests of valve train components and cylinder bores demonstrated significant improvement in the tribological properties of tribocoated parts. The present study extends that research by an analysis of the surface chemistry and morphology of tribofilms generated by the tribocoatinging process. Elemental composition of the tribofilms has been studied by using FIB-TEM technique. Residual stress measurements for tribocoated parts have been carried out using XRD.

9:30 – 10 am
Rolling Contact Fatigue Processes of Coated Materials Applying Granular Finite Element Techniques
R. Petrich III, J. Schall, Q. Zou, G. Barber, Oakland University, Rochester, MI
Bearings with hard, smooth surfaces display improved fatigue, wear, and frictional performance. A common approach to achieving these improved properties is to apply a surface coating. Bearing coatings are generally between 20 m and 450 m thick and contain a variety of materials. The most common methods for applying these coatings are thermal spraying, physical vapor deposition, and chemical vapor deposition. With so many different combinations possible, the mechanisms leading rolling contact fatigue failure have been studied for only a small selection of coated materials. The interest of finite element models to study rolling contact fatigue processes along material microstructures has grown greatly in recent years. In this work a microstructural finite element model has been developed to investigate the behavior of coated bearing materials. The affect of residual film stress on stress distribution, film delamination, and crack formation beneath contacting surfaces will be presented.

10 – 10:30 am • Break

10:30 – 11 am
Investigation of Thin Iron Oxide Layers on 22MnB5 for Press Hardening
M. Schrenk, C. Peuker, A. Trausmuth, AC2T research GmbH, Wiener Neustadt, Austria
The reduction of fleet-emissions is driven by the announcement of fines in the EU. Together with the improving instrumentation of modern vehicles the need for lightweight design gains importance. Hot Stamping allows due to improved material characteristics to use thinner sheets in construction and hence saving weight. Understanding and controlling the process parameters allows to adjust the properties of the product and to optimize the process. In addition to cold forming operations oxide layers form on the surface of the blank, which cause
higher abrasion than the blank material. An oven was developed with controlled atmosphere, so the specimen can be heated and cooled in inert atmosphere. The specimen can be exposed to synthetic air at temperatures up to 1000°C for a defined time between 0 and 40 seconds. This setup and investigation tools allow to test the influence of different parameters (holding time, material, oven temperature, atmosphere) on the formation of the oxide scale.

11 – 11:30 am
Friction and Wear of Binderless Niobium Carbide
W. Mathias, BAM Fedl Inst f. Matls and Testing, Berlin, Germany, S. Marcos, NIOBELCON Bvba, Schilde, Belgium, M. Hardy, CBMM Companhia Brasileira de Metallurgia e Mineração, São Paulo, Brazil
The unlubricated (dry) friction and wear behavior of alumina (99.7%) mated against binderless niobium carbide (NbC) rotating disks under the type of motions of unidirectional sliding (0.03 m/s to 7 m/s; 22°C and 400°C) and oscillation (f= 20 Hz, x= 200 mm, 2/50/98% rel. humidity, n= 105/106 cycles) will be shown. The microstructure and mechanical properties are also presented. Thanks to the tribological database TRIBOCOLLECT of BAM; the obtained tribological data will be benchmarked with different ceramics, cermet and thermally sprayed coatings. The established tribological profile revealed a strong position of NbC under tribological considerations and for closed tribo systems against traditional references, like WC, Cr3C2, (Ti,Mo)(C,N), etc.

11:30 am – Noon
Grain Size Evolution of High-Purity Copper Under Reciprocating Tribological Loading
C. Greiner, KIT, Karlsruhe, Germany
Correlating a material’s microstructure with its friction and wear properties is a central question in tribology. Still, there is a significant lack of knowledge about the mechanics of the materials involved and how exactly the microstructures evolve under tribological loading. We investigated a reciprocating motion and high-purity copper in contact with a sapphire ball. Starting with an annealed microstructure, we varied the energy intake into the sliding material by increasing the sliding distance up to several meters. With scanning electron and focused ion beam microscopy we followed the evolution of the microstructure in the wear track thoroughly. A goal of this study is the formulation of a model description of the microstructural changes focused on energetic and mechanistic considerations in order to understand these changes and their influence on tribological properties. This might allow for tailored microstructures combining low friction forces and very small wear rates.

Session 5Ca • LaSalle – Level 5
NANOTRIBOLOGY II
Session Chair: J. Choo, Petronas Group Research, Kajang, Malaysia
Session Vice Chair: D. Demydov, NanoMech Inc., Springdale, AR

8 – 8:30 am
Implementing Nanoadditive Technologies: The Journey From Laboratory Research to Commercial Viability
B. Branson, sp3 nanotech, LLC, Carrolton, TX
Before wide-scale adoption of nanomaterials can occur, R&D efforts must solve the challenges of integrating nanoadditives into existing lubricant infrastructures and demonstrate benefits in “real-world” applications. This presentation will review how one nanoscale additive technology was ushered out of basic research, through the technology validation process, and into a commercially-viable technology. The discussion will address common barriers to adoption (safety, compatibility, cost), illustrate how bench-scale testing is useful during the development process, and finally correlate such low-fidelity testing to “real world” performance benefits utilizing in situ fuel efficiency testing (GF-5/ASTM D7589) of a nanodiamond additive for motor oil.

8:30 – 9 am
Advanced Multi-Component Nanolubricant Additives for Lubricating Greases, Pastes, and Oils
W. Zhang, D. Demydov, A. Malshe, NanoMech Inc., Springdale, AR
To address industrial demands for more efficient and durable lubricants under extreme conditions, wide applications, and different mechanical components, systematic investigation of nanomaterial-based multi-component lubricant systems which contain functional groups is performed. Different types of these surface-modified, nano-engineered lubricant additives are specially designed for addition to greases, pastes, and oils for extreme conditions in different applications. The tribological benefits of these additives are realized by the wear and extreme pressure properties through Pin-on-disk, Block-on-ring, and Four-ball Wear/EP Test Machine and their fundamental properties are studied by different lubricant analysis testers. Moreover, their performance in extreme conditions and different applications are evaluated through specific testing instruments or rigs. Their performance shows synergistic effect when combined with others additives in formulated/non-formulated base lubricants.

9 – 10 am
Nanotribology and Nanomaterials
H. Spikes, Imperial College, London, United Kingdom
Nanotechnology concerns the preparation and properties of organised ensembles of atoms and molecules of nanometer scale dimensions. The growth of nanotechnology is having a profound impact on the development of tribology, to the extent that a new branch of the field, termed “nanotribology” has emerged. This lecture will outline some of the main contributions of nanotechnology to tribology to date, including the application of nanoscale experimental techniques, modelling of tribological systems at the nanoscale and the study and properties of nanoscale structures and processes in rubbing contacts. One of the most interesting recent advances in nanotribology is the development and use of dispersed nanoscale colloidal particles as lubricant and fuel additives. The properties, behaviour and limitations of these nanoadditives and their likely future applications will be discussed.

10 – 10:30 am • Break
Graphene (individual layers of hexagonally-oriented carbon atoms) is the strongest material measured. It has also been shown to be gas-impermeable and chemically and thermally stable, which makes it an excellent candidate as a nanoscale tribological coating for N/MEMS, electrical contacts, and data storage. However, the wear and failure mechanisms of graphene under sliding load are not fully understood.

This study seeks to elucidate graphene's protective capability by examining its tribological characteristics under nanoscale sliding. A nanoscale hemisphere is slid at parametrically-varied velocities over a graphene monolayer that has been transferred to a silicon dioxide substrate. Wear is quantified ex-situ using Raman spectroscopy techniques. In this work, sliding velocity is shown to have an impact on friction and wear of a graphene monolayer, with low velocity causing high wear and friction (due to adhesion) and high velocity causing negligible wear and low friction.

11 – 11:30 am
Development of a Low Friction and Wear Resistant PTFE Thin Film Modified with a Polydopamine Adhesive Layer
S. Beckford, M. Zou, University of Arkansas, Fayetteville, AR

The influence of a polydopamine adhesive layer on the friction and wear resistance of PTFE thin films coated on stainless steel has been investigated using a linear reciprocating tribometer and stylus surface profiler. The friction and wear tests were carried out using a ball-on-flat configuration under a load of 50 g, sliding speed of 2.5 mm/s and stroke length of 15 mm. These tests show a similar coefficient of friction of approximately 0.6 for the dual layer polydopamine/PTFE film as well as for a single layer of PTFE coated on stainless steel. However, the polydopamine/PTFE film was able to withstand approximately 100 times more rubbing cycles than the single layer of PTFE.

11:30 am – Noon
Tribological Properties and Wettability of Patterned Surfaces with Different Diameter, Pitch and Aspect Ratio and Coated Surfaces with DLC and Z-dol
E. Yoon, S. Piao, N. Machavallavan, D. Pham, Korea Institute of Science and Technology, Seoul, Republic of Korea; K. Jhang, Hanyang University, Seoul, Republic of Korea

A combination of topographically and chemically modified surfaces promises to be an effective method to improve tribological properties. We fabricated Si nanoscale patterns of varying diameter, pitch and aspect ratio, and subsequently coated with DLC and Z-dol films. Wetting behavior and nano-adhesion/friction of the modified surfaces were investigated. Results showed that the patterning enhanced wettability of Si flat surfaces, along with two distinct wetting states: the Wenzel and the hemi-wicking, depended on the value of the pitch-over-diameter ratio. In DLC and Z-DOL coated patterns, three wetting states were observed: the Cassie-Baxter, the Wenzel, and their transition. Examination of the nanotribological properties indicated that the combination of the nanopatterns and the films greatly reduced the adhesive and frictional forces. Furthermore, the pitch and diameter of the nanopatterns were found to significantly influence their adhesion/friction behaviors.

8:30 – 9pm
Surface Modification of Carbon Fibre Rods
R. Suryanarayana, PESIT Bangalore India, Bangalore, India; A. Hiriyanaiah, RVCE,Bangalore India, Bangalore, India; A. Gupta, L. Swami, PESIT Bangalore India, Bangalore, India

Carbon fibre rods are currently the most promising reinforcement material for developing high strength and modulus metal matrix composites for structural applications. But the major challenge they pose is the poor wettability with the molten metal/alloys. This is addressed in the present work by focusing on surface engineering of carbon fibre rods with the main objective being to improve its wettability with molten aluminium alloy. Carbon fibre rods are first coated with electrolysis nickel coating after thorough cleaning and proper sensitization. Nickel-phosphorous coated carbon rods are then subjected to copper electrophating. In-depth microstructural studies have been carried out to investigate the interfaces between copper & nickel and also between copper & aluminium alloy.

8:30 – 9am
Wear Prediction of Inconel 718 Coatings on Mild Steel By ANFIS
R. Suryanarayana, PESIT Bangalore India, Bangalore, India; A. Gupta, L. Swami, PESIT Bangalore India, Bangalore, India

ANFIS which saves time and money when properly trained with the knowledge domain data is used in the present work to predict the wear of Inconel 718 coatings on mild steel. In the present work, atmospheric plasma spraying technology has been used to deposit Inconel 718 which is a super alloy of nickel on mild steel with the sole objective of improving its wear and corrosion resistance. Wear experiments are being conducted on coated pins using pin on disc apparatus. Hybrid training process is being used to map the inputs to the outputs at the time of learning. The ANFIS system is input with the training set at the time of learning and testing data after learning for prediction of wear. Good agreement do exist between the predicted and experimental wear results.

9 – 9:30 am
Synthesis; Mechanical, Chemical, and Structural Characterization; and Tribological Testing of Iron-Doped Hydrogenated Amorphous Carbon Coatings
P. Gupta, M. Graham, Northwestern University, Evanston, IL; R. Erck, Argonne National Laboratory, Argonne, IL

The field of doped carbon coatings has evolved considerably due to increased interest in using diamond-like carbon coatings for lubricated applications. Many studies have been done on various dopants, but few studies of iron as a dopant have been performed. Additives in many commercial synthetic lubricants are designed to interact with ferrous surfaces, and iron-doped carbon coatings may enhance the friction and wear performance during boundary lubricated sliding. Such improved
performance could consequently enable wider use of iron-doped carbon coatings in numerous industrial applications. In this study, iron-doped hydrogenated amorphous carbon coatings were deposited using a reactive physical vapor deposition method. The coatings were mechanically, chemically, and structurally characterized, and they were also tribologically tested using various loads and speeds. The effect of iron dopant concentration on friction and wear during boundary lubricated sliding was studied.

9:30 – 10 am
An Investigation of the Tribological Performance of Textured Solid Lubricant Reservoir Tribosystems
R. Pudjoprawoto, R. Onler, P. Dougherty, B. Ozdoganlar, C. Higgs, Carnegie Mellon University, Pittsburgh, PA
In this study, the effect of size of circular powder lubricant reservoirs was investigated. Solid lubricant reservoirs (SLR) with specific geometry were fabricated on different acrylic slider pads by employing the mechanical micromachining process. The reservoir depths of 0.3 mm and 0.6 mm and diameters of 100 µm, 250 µm, 500 µm, and 1000 µm were considered. Molybdenum disulfide (MoS2) powder lubricants were used as the solid lubricant reservoir material, and the SLR performance of two different MoS2 particle sizes were evaluated. Each slider pad was slid against a stainless steel disk. It was observed that the time scale at which a test configuration reached the dry friction coefficient from its lubricated friction coefficient was depended on the size of the reservoirs as well as the particle size of the MoS2 powder lubricant. A volumetric fractional coverage model was also employed to help gain insight into the tribological behavior of the test configurations.

10 – 10:30 am • Break

10:30 – 11 am
The Effect Of TBC On Diesel/biodiesel Fuelled C I Engine Performance
R. Suryanarayana, PESIT Bangalore India, Bangalore, India, T. Prasad, SSIT, Tumkur, India, Z. Khan, Bournemouth Univesity, Dorset, Bournemouth, United Kingdom
Development of thermal barrier coatings (TBCs) is currently the most sought after surface engineering technique in improving the thermal efficiency of IC engines. Significant data as regards the assessment of TBC’s performance in conventional fuelled engines is available. However, no information is available as regards the performance of TBCs on use of hybrid fuel of diesel and biodiesel. Currently, most of the mass transportation vehicles in particular public buses in India run on the hybrid fuel which satisfies both environmental byelaws as well as conservation of natural resources. In the light of the above, this work focuses on development of TBCs on inside surfaces of CI engines by a thermal spray process and assessing its performance using the standard engine test facility. The developed coating has proved effective in terms of improved efficiency of the engine under standard test conditions.

11 – 11:30 am
Effect of Test Atmosphere on the Tribological Behaviour of the Non-Hydrogenated Diamond-like Carbon (NH-DLC) Coatings Against Titanium
M. Rahman, S. Bhowmick, A. Alpas, University of Windsor, Windsor, ON, Canada
This study reports the results of experiments pertaining to the effects of test atmosphere on the tribological behaviour of NH-DLC coated M2 steel disks sliding against Ti-6Al-4V. These coatings are of interest as potential tool coatings for Ti alloys. Pin-on-disk tests were performed in argon, dry air and air with humidity levels varying from 25 to 75% RH. The NH-DLC coatings exhibited high COF of 0.52 in argon and 0.45 in dry air due to adhesion and material transfer that occurred from the Ti pins to the DLC coating surfaces. Tests conducted in an ambient air resulted in low COF values of 0.11-0.15 which is attributed to the formation of carbonaceous transfer layers on the Ti as well as the passivation of the coatings’ surface. The changes in wear and frictional mechanisms at different environments are explained by microscopic and spectroscopic techniques and will be presented at the conference.

11:30 am – Noon
Wire Spraying of Aluminium on Ni-P Coated GFRP Panels
R. Suryanarayana, PESIT Bangalore India, Bangalore, India, Z. Khan, Bournemouth Univesity, Dorset, Bournemouth, United Kingdom, P. DSilva, S. Kumar, L. Trinadh, PESIT Bangalore India, Bangalore, India
Currently, the shortcomings of FRPs, namely, its moisture absorption and poor resistance to aggressive environment are being addressed by using metallic coatings through electroless deposition route. Electroless coatings have a major limitation as regards the maximum thickness one can obtain and also the inherent high levels of porosity. In the light of the above, this work focuses on use of hybrid technique of electroless coating and wire spray technique to develop high quality aluminium coatings on GFRP panels. Corrosion studies in 3.5% NaCl is being carried out on both uncoated and coated GFRP using Scanning potentiostat. Indepth microstructural studies have been carried out to enunciate the mechanism of corrosion in the developed coatings.
High Purity + Premium Performance

Synthetic Ester Basestocks for:

- Metalworking Fluids
- Chain Lubricants
- Greases
- Compressor Fluids
- H1 Food Machinery Lubricants

For inquiries call:
1-800-521-9891
or 215-271-0800
email: lubeinfo@inolex.com

Download our paper on Synthetic Esters:
www.inolex.com/pdfs/whitepaper.pdf
FLUID FILM BEARINGS V

Session Chair: M. Braun, The University of Akron, Akron, OH
Session Vice Chair: D. Kim, University of Texas at Arlington, Arlington, TX

(withdrawn)

Measured Displacement Coefficients of an Adjustable Hydrodynamic Rotor Journal Bearing
J. Martin, D. Parkins, Open University, Milton Keynes, United Kingdom

An adjustable bearing concept is described having the means to effect continuous pro-active adjustments to the hydrodynamic characteristics during operation, irrespective of load, speed and other running conditions. In simulating a proposed machine tool application the bearing system comprised a stationary spindle or shaft supporting a belt driven rotor. The design is outlined as is a specially designed and constructed test rig. Observations are given on the bearing’s performance characteristics. The effects of the adjustments on rotor eccentricity are shown, along with the ability to maintain a given rotor eccentricity, including zero, irrespective of load and changes in load. Results of measured rotor displacements and displacement coefficients are given showing that the bearing exhibited high stiffness at zero load and eccentricity and that stiffness could be changed by adjustment if required. An approach to uncertainty estimation of measured data is included.

8:30 – 9 am
Experimental Force Coefficients for an Open Ends Squeeze Film Damper Performing Large Amplitude Circular Orbital Motions, Centered and Off-centered
S. Jeung, G. Bradley, Texas A&M University, College Station, TX

Rotating machinery often incorporates Squeeze Film Dampers (SFDs) to reduce rotor vibrations and to improve system stability while operating at high rotational speeds. Damping is most needed while a rotor traverses a critical speed with large amplitudes of motion. This paper presents dynamic force coefficients obtained in a test open ends SFD lubricated with an ISO VG 2 oil and operating with large orbital motions at various increasing static journal eccentricities. The test SFD comprises of two parallel film lands (L=25.4 mm, D=127 mm) separated by a deep feed groove and a support elastic structure. The frequency domain analysis of the applied forces and ensuing damper motions yields damping force coefficients that increase as the orbit amplitude and the static eccentricity increase. On the other hand, the damper stiffness and the added mass force coefficients decrease dramatically for whirl amplitudes exceeding 60% of the film clearance.

9 – 9:30 am
Determination of Angular Stiffness in a Large Thrust Bearing
S. Duriseti, Auroras’ Engineering College, Hyderabad, India

An FDM solution for the Reynolds’ and energy equations of the film in a hydro generator bearing is described. Viscosity variation and hot oil carroyor are considered. The pressure and thermal gradient induce the pad to thermo-elastically deform. A coupled method using ANSYS determines its deformation with 8 elements each in the radial, circumferential and thickness directions to a total of 512 hexahedral Solid 226 elements. The nodal temperatures of the elements of the bottom surface match the corresponding values of the lubrication problem. Torques for pad positions 1 and 2 are calculated. The angular stiffness considering pad deformation is calculated for the 2-1 pair with 0.5-20 % variation of ho. The values of Kt* converge asymptotically. The unique interpolation of a single pad’s angular film stiffness results to determine the characteristics of all the pads is highlighted. Unlike in previous studies this study is helpful in understanding the pad dynamics and flutter.

10 – 10:30 am • Break

10:30 – 11 am
Influence of Wear on the Performance of Four-Pocket/Six-Pocket Conical Journal Bearing System compensated with Constant Flow Valve Restrictor
V. Phalle, S. Sharma, Veermata Jijabai Technological Institute (VJTI), Matunga, Mumbai, India

The four-recessed/six-recessed conical hybrid journal bearing offers excellent performance characteristics for axial and radial external load applications. In the present work, an analytical study concerning the influence of wear on the performance of a four-pocket/six-pocket hybrid conical journal bearing system compensated with a constant flow valve (CFV) compensated restrictor has been studied. The Reynolds equation governing the lubricant flow in the clearance space of the bearing has been solved using finite element method. The static and dynamic performance characteristics have been presented for the various values of external radial load, wear depth parameter and for the various values of semi-cone angles vis-à-vis four-pocket/six-pocket conical journal bearing. The numerically simulated results of four-pocket/six-pocket suggest that, the performance of the conical bearing is greatly affected by the wear defect.

11 – 11:30 am
Key Measurements and Processing Requirements for an Accurate Determination of Journal Bearings Dynamic Coefficients
A. Dadouche, National Research Council, Ottawa, ON, Canada

Stability and safe operation of rotating machinery is highly influenced by the dynamic properties of rotor-support systems. The values of bearings dynamic coefficients play a significant role in determining machinery critical frequencies, hence allowing machinery designers to properly set operating threshold speeds for dynamic instabilities. A variety of experimental methods for bearing dynamic characteristics evaluation are available in the literature. They are all based on exciting the bearing system (input force), measure its response and then calculate the transfer function from which the dynamic coefficients are obtained. This investigation deals with the key measurements of the bearing response, such as bearing displacement and acceleration, to multi-frequency excitations and the effect of processing steps in time and frequency domains on the overall values of bearing stiffness and damping coefficients.

11:30 am – Noon
The Account of an Angular Flexibility of Supports of a Cranked Shaft in Designing of the Bearings of Modern Internal Combustion Engines
A. Mlynikov, J. Rjodjvestnys, N. Khoenjenjuk, I. Levanov, South Ural State University, Chelyabinsk, Russian Federation

Eventually power plants requirements on unit capacity made by them is grown. It leads to increase of loads operating on friction units of internal combustion engines (ICE). There are irregular wear, scuffing of bearings, the operational life is decreased. The technique taking into account influence of a flexibility differing on supports of a cranked shaft on working conditions of main bearing is offered. The technique is based on the system «an elastic crankshaft – nonlinear lubricant layers – the elastic crankcase». Both the axial and angular flexibility were
Boundary Films and Explain the Lubrication Mechanisms Under Severe Boundary Conditions

We synthesized a series of catalytically active nanocomposite coatings and confirmed their ability to derive diamondlike carbon (DLC) boundary films from synthetic, mineral, and vegetable-base lubricating oils. Nanocomposite coatings were produced on steel samples by a PVD technique and by adjusting the ratios of softer catalytic phases (such as Pd, Cu, etc.) and harder nitrides of Mo, W, V, and Re, etc. which are also catalytically active. When such films are tested on sliding surfaces under severe boundary conditions, UV Raman and a variety of other surface and structure analytical techniques confirmed formation of a DLC-like boundary film which is typically produced by CVD and PVD methods. These DLC boundary films provided very low friction and high resistance to wear and scuffing to sliding surfaces. We will provide further insight into the structural and chemical nature of these DLC boundary films and explain the lubrication mechanisms under severe operating conditions.

8:30 – 9am
Nanodiamond-Based Nanolubricants: Investigation of Friction Surfaces
O. Shenderova, International Technology Center, Raleigh, NC,
M. Ivanov, Ural Federal University, Yekaterinburg, Russian Federation, Z. Mahbooba, International Technology Center, Raleigh, NC, D. Ivanov, Ural Federal University, Yekaterinburg, Russian Federation, S. Turner, University of Antwerp, Antwerp, Belgium

Recently, certain nanomaterials have emerged as potential anti-friction and anti-wear additives to a variety of base lubricants. Among them, detonation nanodiamonds (DND) are very promising nano-colloidal additives. Field test experiments demonstrated fuel efficiency improvement due to DND-based additives by 5% and higher. In order to optimize additive composition and expand a range of applications of DND nanolubricants, mechanisms of DND action need to be elucidated. In this paper, synergistic compositions of DND particles with other AF additives were used in ring-on-ring, four-ball and block-on-ring tests as an additive to PAO and engine oils. Modest to significant improvements in reduction of friction coefficients, or wear, or both were observed. The friction surfaces were characterized with SEM, EDX and profilometry. Significant polishing effects of the friction surfaces in lubricants containing DND were revealed elucidating DND role in nanolubricant applications.

9 – 9:30 am
The Tribology of Viscosity Index Improvers in GTL Base Fluids
S. de Rooy, A. Mayernick, Shell Global Solutions (US) Inc., Houston, TX

Viscosity index improvers are hydrocarbon-soluble polymers which increase lubricant viscosity preferentially at high temperatures and thereby reduce the overall dependence of lubricant viscosity on temperature. Viscosity index improving polymers may also be functionalized with various chemistries, to provide dispersant, anti-wear, and friction reduction functions. We use optical interferometry to examine the formation of thin boundary films for a range of viscosity index improvers of differing molecular structure in a Group III base oil. Anti-wear and friction reduction performance were quantified using reciprocating wear tests and rolling-sliding friction measurements, respectively. The results are discussed in the context of establishing structure-function relationships for viscosity index improver performance in synthetic lubricants, and guiding the design of formulations with increased fuel economy and anti-wear performance.

9:30 – 10 am
Polymer Process Engineering for the Lubricant Additives Industry
M. Covitch, G. Meldrum, Lubrizol Corp, Wickliffe, OH, D. Price, Lubrizol Corp, Hazelwood, United Kingdom, B. Schober, Lubrizol Corp, Wickliffe, OH

Polymers are frequently used as performance additives in today’s lubricating oils. Besides serving their traditional roles as viscosity modifiers and pour point depressants, polymers are often functionalized to provide dispersancy, improve compatibility, and/or reduce wear. Once a single polymer composition or mixture of polymers has been developed for a given application, the challenge becomes how to manufacture it at high quality and minimal cost. That’s where polymer process engineering comes in. This paper will present a number of engineering solutions that have been shown to improve quality, lower costs and simplify the supply chain. Certain unit operations, not normally found in conventional lubricant additive manufacturing plants, have been successfully introduced. Examples that will be discussed in the paper include reactive extrusion, extrusion mixing and/or shearing, high intensity dispersive mixing and living free radical polymerization.
10 – 10:30 am  • Break

10:30 – 11 am
Effect of Operational Parameters of Diesel Engine Dynamometer Tests on Diesel Soot Chemistry and Tribofilm Formation
P. Aswath, University of Texas at Arlington, Arlington, TX, M. Patel, R.T. Vanderbilt, Norwalk, CT, V. Sharma, University of Texas at Arlington, Arlington, TX, C. Karunanakan, Canadian Light Source, Saskatoon, SK, Canada
The different operating conditions of dynamometer tests might influence the interaction between diesel soot and lubricants additives chemistries. In the present study, attempts have been made to establish the effect of engine parameters on the soot chemistries & structure. It is not possible to distinguish the effect of each parameter separately on the structure and composition of soot for each standard engine tests. However, characterization of extracted soot from these standard dynamometer tests might provide better comprehension of the effect of engine parameters, if any. To study the correlation between tests conditions and soot chemistries, XANES spectroscopy, STXM spectroscopy, Raman spectroscopy and HRTEM have been employed. In addition, piston ring and header from Cummins ISM engine test, roller follower pin from GM RFWT engine test have been characterized to understand the tribofilm formation and generation of wear track.

11 – 11:30 am
Characterization of GTDI Soot and Comparison to Diesel Soot
In the quest to improve fuel economy in gasoline engines, automotive manufacturers are producing more gasoline turbocharged direct injection engines (GTDI). One unintended byproduct of this operation is the increased generation of soot in the engines, which can lead to increased wear in engine components similar to that observed in diesel engines. In this work, we compare physical and chemical characteristics of GTDI soot with diesel soot. Drains from several vehicles equipped with GTDI and diesel engines and dyno tests are collected in order to characterize soot in oil. Exhaust soot is also collected. X-ray fluorescence, X-ray photoelectron spectroscopy, high resolution transmission electron spectroscopy, quasi-elastic light scattering, and infrared and Raman spectroscopy are among the techniques used for characterization. We also discuss a possible model for GTDI soot using commercially-available elemental nanocarbon compounds.

11:30 am – Noon
Understanding the Deformation of Soot Particle/Agglomerates in a Dynamic Contact: TEM In Situ Compression and Shear Experiments
F. Dassenoy, I. Lahouij, B. Vacher, Ecole Centrale of Lyon, Ecully, France, K. Sinha, D. Brass, M. Devine, INFINUEM USA, Linden NJ
Soot particles are known to impact both the lubricant and engine performance causing increased viscosity and promoting wear. The hard soot particles have been proposed as the origin of the abrasive wear that has been seen on engine parts. Consequently, understanding the nature of soot particles and their role in engine wear is a major area of research in the lubricant industry and more fundamental understanding is needed in this area. In this work, a High Resolution Transmission Electron Microscope (HRTEM) equipped with a nanoindentation holder has been used to observe in real time the deformation and degradation behaviour of agglomerates of soot particles in a dynamic contact. Analysis of the soot showing whether the graphitic planes shear under external load or resist deformation will be addressed. Fundamental understanding of how the soot particles/aggregates behave in a tribological contact will be used to establish a link between the soot properties and wear.

Session 5K  • Mackinac West – Level 5

ENVIRONMENTALLY FRIENDLY FLUIDS I

Session Chair: P. Vettel, Amyris Inc., Emeryville, CA
Session Vice Chair: B. Sharma, UIUC, Champaign, IL

8:30 – 9 am
Definition and Characterization of Environmentally Acceptable Lubricants – The Eco-Label
W. Bartz, Technische Akademie Esslingen, Ostfildern, Germany
Often the environmentally acceptability is equated with the fast biodegradability. But for the degradation process oxygen is necessary. If large amounts of lubricants will be introduced in to the environment, for instance as an accident, too much oxygen has to be taken from the surrounding that other organisms will suffer. Nevertheless the regulations to define environmentally acceptable lubricants, which are listed in the framework to receive the European Eco-label do not consider these aspects. The criteria for the Eco-Label include environmentally and human health hazards, aquatic toxicity requirements, biodegradability, exclusion of specific substances, the imperative use of renewable materials and of course the technical performance. Details of these criteria will be explained in the presentation.

9 – 9:30 am
Test Methods for Testing Biodegradability of Lubricants
B. Mueller-Zermini, G. Gaule, Hermann Bantleon GmbH, Ulm, Germany
Although it is widely used, there is no precise definition for the term bio oil. Discussions on this subject are often politically influenced and not scientifically sound. The main criterion for these products is biodegradation, which must reach a certain minimum speed. There are many different methods to measure biodegradability. For testing biodegradation rates of chemicals the OECD 301 test methods are commonly used. Nowadays they are used for lubricants, too. But the OECD 301 tests are defined only for testing pure chemicals. Lubricants however, are mixtures of base oils and additives. In addition most lubricants are water insoluble which complicates the measurement according to OECD 301. In July 2012 the European CEC organization published a new test method for testing biodegradation rates which was developed especially for lubricants. It is called CEC-L-103-12: Biological Degradaability of Lubricants in Natural Environment.

9:30 – 10 am
Biodegradable Hydraulic Oils and Cleaners
T. Tarrant, Hydro Safe, Inc., DeWitt, MI
This session will help end users, engineers, architects and others to understand the definitions, appropriate uses, advantages and disadvantages of biodegradable products. This session will include a PowerPoint presentation followed by an open discussion and question and answer session.

10 – 10:30 am  • Break
NEW METHODS
NEW SOLUTION

Did you know that ASTM has new methods to address In Service Oil testing that will ultimately replace E2412? A complete series of methods will be developed, seven of which have already been approved (D7214, D7412, D7414, D7415, D7418, D7624, D7844). They will provide clear, definitive ways to measure In Service Oil by FTIR.

Powered by our industry-leading IR spectrometer, the intelligent, integrated design of PerkinElmer’s OilExpress™ 4 helps to meet these new methods. Our complete analytical solutions help you to achieve dependable throughput for testing a wide range of analytes.

Visit us at Booths 212 & 214 at STLE 2013
10:30 – 11 am
**Estolides – The Dawn of Biosynthetics**
J. Bredsguard, T. Thompson, Biosynthetic Technologies, Irvine, CA

Industry tribologists have recognized that naturally occurring vegetable oils provide excellent lubricity and have high viscosity indexes, while being both biodegradable and nontoxic. While economically and environmentally attractive, vegetable oils have not been successful at displacing petroleum-based products in industry due to their oxidative/hydrolytic instability and poor cold temperature properties. Biosynthetic Technologies’ LubriGreen products are a novel line of biobased esters referred to as estolides. As compared to traditional biolubricants, LubriGreen’s biosynthetic estolides offer oxidative stability on par with many petroleum-derived synthetics, excellent hydrolytic stability, and low pour points. Furthermore, they preserve the favorable properties of triglycerides by providing superior lubricity, protection from wear, low volatility, while being biodegradable, renewable, and nontoxic.

**(withdrawn)**

**Performance Trends in Environmentally Friendly Industrial Fluids**
D. Rettemeyer, BASF SE, Ludwigshafen, Germany, J. Sherman, V. Bala, BASF Corporation, Florham Park, NJ

Environmentally Friendly Fluids (EFFs) have seen resurgence due to recent global legislature especially driven out of Europe (EU Ecolabel). The EU Ecolabel has developed stringent performance categories for EFFs. The categories for EFFs initially included hydraulic fluids and have been expanded to other industrial fluids such as gear oils as well. Several key performance requirements have been revised for biodegradation, bio-accumulation, thermal and oxidative stability, renewable or bio-content, hydrolytic stability and seal compatibility. These key performance requirements described in EU Ecolabel, are targeted for implementation in 2015. In the US, similar labeling programs such as Bio-Preferred have been initiated by the US Department of Agriculture supporting the 2002 and 2008 US Farm Bills. This paper highlights several of the key performance requirements of biodegradation, seal compatibility thermal, oxidative and hydrolytic stability, renewable or biobased fluids.

11 – 11:30 am
**Conveting Used Biobased Lubricants to Bioenergy Via Anaerobic Digestion**
C. Halene, Y. Li, Quasar Energy Group, Cleveland, OH

Technical advancements have displaced some traditionally petroleum based lubricants with environmentally friendly vegetable and animal based alternatives. As the use of biobased lubricants becomes more common in manufacturing, an opportunity arises to sustainably manage used (waste) lubricants via anaerobic digestion to generate renewable energy in the form of methane rich biogas. Anaerobic digestion advances allow for beneficial use of used nonpetroleum oils by converting these wastes into renewable energy in an environmentally friendly manner. The used biolubricants have high biogas potential and can be co-digested with traditional feedstocks of anaerobic digestion such as dewatered sewage sludge and animal manure. The performance of anaerobic co-digestion of used biobased lubricants with other organic waste streams will be reported in this presentation. Potentially hazardous chemicals and their impact on the anaerobic digestion process will also be reported.

**Session 6A • Joliet – Level 5**

**TRIBOTESTING II**

Session Chair: N. Gilis, Bruker Nano, Campbell, CA
Session Vice Chair: G. Krauss, The University of Michigan, Ann Arbor, MI

1:30 – 2 pm
**Wear and Reparability Evaluations of a New Class of Super Self-Lubricating hBN-Ni Coatings**
A. Segall, I. Smid, T. Eden, M. Neshastehriz, J. Potter, Penn State University, University Park, PA

High Velocity Particle Consolidation (HVPC) commonly known as Cold-Spray has successfully avoided many of the problems associated with traditional thermal spray methods such as HVOF and Plasma. Indeed, HVPC is a very promising lower-temperature spray method that rapidly and efficiently creates a coating through a process related to friction welding by exposing a substrate to a high-velocity jet of solid-phase particles; this allows both the building and repair of unique surfaces that can include solid lubricants. As such, high performance hBN-Ni systems have been developed and optimized with very promising results in terms of significant improvements of bond-strength, reductions of wear and friction, and unprecedented reparability. As with all materials and coatings, evaluating HVPC surfaces does present a number of interesting tribotesting challenges given their unique properties and abilities.

2 – 2:30 pm
**Use of Solid-particle Erosion Testing for Screening Engineering Materials**
K. Budinski, Bud Labs, Rochester, NY

There are many industrial, aircraft, and military applications where erosion of materials by solid-particle impact is a limiting factor. It must be dealt with and a variety of tests have been employed to screen candidate materials for improved solid-particle erosion resistance. This paper describes the more popular tests, but the ASTM G 76 test is described in detail. Attempts to make this test less aggressive are described and several less-severe erosion procedures are proposed that could simply be added to the ASTM G 76 test method to make it more discriminating in assessing erosion-resistant materials.

2:30 – 3 pm
**Air Bearing Effects in Polishing of Thin Film Magnetic Recording Disks**
T. Karis, T. Suthar, F. Hendriks, HGST, A Western Digital Company, San Jose, CA

Polishing of the carbon overcoat on thin film magnetic recording disks is particularly challenging due to the grain roughness of perpendicular magnetic recording media. Excessive overcoat removal opens up pinholes for corrosion. The polishing tape for this study comprises a nominally flat, randomly rough, alumina abrasive composite on a Mylar support film. The tape rms roughness is 80 nm, while the disk rms roughness is initially 0.5 nm. We explore the dependence of the polishing friction on contact pressure (40 to 120 kPa), linear velocity (1 to 6 m/s), and radial traverse rate (1 to 6 mm/s) on 65 mm diameter disks using a laboratory bench top friction tester. The most interesting result is that the friction decreased linearly with velocity at a given load. At higher velocities, a plot of friction vs. load exhibits a negative intercept, which measures the air bearing lift force on the tape.

3 – 3:30 pm • Break
3:30 – 4 pm
Industrial Gear Lubricants for Extreme Environments: Coal Dust Contamination and Severe Vibration
E. Akucewich, J. Vinci, Lubrizol Corporation, Wickliffe, OH
Coal dust contamination and externally-induced vibration are two malefactors which are especially threatening to the life of industrial gears; both circumstances manifest as abrasive wear which degrades gear tooth surfaces. Coal-fired power plants present the harshest of contaminating environments, while vibration-induced stress can occur in any plant or mill where surrounding equipment operates at full capacity. In order to understand how to counter these effects through lubrication, we devised a controlled laboratory test method employing a helical gear set under fixed speed and loading. Lubricants were evaluated in this test under two separate duress regimes: with added coal dust and with externally-applied vibration. A special profilometry technique was used to quantify the resulting surface distress on the gears, and this enabled the tailoring of additive approaches for the extreme conditions of coal dust contamination and vibration, respectively.

4 – 4:30 pm
The Traction Behavior of Desert Gold Grease Under Heavy Loads, Low Speeds and Various Temperatures
Yang, B. Su, X. Yan, Henan University of Science and Technology, Luoyang, China, Hua, D., Independent Consultant, Shorewood, IL, USA, Su, B., and Yan, X., Henan University of Science and Technology, Luoyang, China
It is necessary to understand the traction behavior of grease before analyzing the reliability and durability and performance of a lubricated shaft-sleeve joint running under heavy loads and low speeds. In order to meet the demand, the special lubricant Desert Gold Grease is tested by a new test rig. The structure of the rig is presented. Testing results of the grease under various conditions for measuring the traction data are as follows: relative speed in the range of 0.006 – 0.035 m/s, radial Hertzian stress up to 290 MPa, and temperature in the range of room temperature and up to 235 centigrade. The testing results are presented as the traction coefficient, µ, close to 0.007 and vibration, respectively.

4:30 – 5 pm
Tribotesting Business Meeting

Session 6C • LaSalle – Level 5

NANOTRIBOLOGY III

Session Chair: C. Korach, Stony Book University, Stony Brook, NY
Session Vice Chair: D. Demydov, NanoMech Inc., Springdale, AR

1:30 – 2 pm
Nanoscale Tribologic Behaviour of Partially Fluorinated Graphitized Carbon Nanofibers

Recent studies of the tribologic behaviour of fluorinated carbon nano fibres (FCNFs)[1] show that fluorination of carbon fibres improves their friction efficiency at macroscale. In order to understand the macroscopic results, the nano friction behaviour of FCNFs is investigated by Atomic Force Microscopy (AFM), using oxidized silicon tip, and correlated to the morphology of the fibers studied by Transmission Electron Microscopy (TEM). FCNFs are first embedded into epoxy resin. For TEM investigations, thin sections (60 nm thickness) of the epoxy/fibres block are prepared by ultramicrotomy. The remaining block surface is nano machined by Focussed ion Beam (FIB), to cut emerging fibers, and then plasma cleaned. The TEM investigations revealed that the studied FCNFs are constituted of a graphitized carbon core surrounded by a perfluorinated shell. The AFM measurements, carried out on individual fibers, point out a higher friction on the fluorinated shell than on the graphitized core.

2 – 3 pm
Lubrication in Textiles, Fabrics and Fibers: Metrology Challenges
J. Hiesteroza, Y. Li, Cornell University, Ithaca, NY
Fricction and lubrication phenomena are ubiquitous in the production of fabrics and fibrous products. While several empirical solutions have been developed through centuries to facilitate ancient processes such as fiber spinning, textile weaving and yarn knitting there is still a significant gap in understanding friction and lubrication during fiber processing. This gap is due primarily to limitations in the capabilities of metrology equipment currently used by the textile industry as well as the poor correlation of these measurements to molecular phenomena. In this talk we will discuss the shortcomings of methods currently employed to assess friction and lubrication in fibrous materials and we will present some of our studies on the use of lateral force microscopy and molecular dynamics that has allowed us to get a unique glimpse of lubrication phenomena at the nanoscale.

3 – 3:30 pm • Break

3:30 – 4 pm
Nano Tribological Properties of Tribofilms Obtained From Microcrystalline Lamellar Particles of Graphite

Trilobic studies, performed at macro scale, of graphite micro-particles pointed out a drastic decrease of the friction coefficient when the experiments were done in the presence of pentane [1-3]. In order to better understand the contribution of the liquid in the nanostructuring of the films, macrotribologic films have been characterized at the nanoscale by means of AFM/FFM apparatus. The surface of the tribofilm built up in the presence of liquid is heterogeneous and constituted of graphite platelets oriented parallel to the sliding plane with friction coefficient, µ, close to 0.007 surrounded by less organized area (µ=0.15). In dry conditions the film surface appears homogeneously smooth (µ=0.2) resulting from the carbon tribo-amorphization confirmed by Raman spectrometry. Analyses of the platelet/granular area ratio show that the surface density covered by the platelets is not sufficient to explain the friction reduction observed at the macro scale.
4 – 4:30 pm  
**Two Dimensional Nanoscale Reciprocating Sliding Contacts of Textured Surfaces**  
R. Tong, G. Liu, T. Liu, Northwestern Polytechnical University, Xi’an, China  
Textured surface in sliding contacts plays an important role in many mechanical components as it can improve tribological characteristics. The influences of textures will be more significant in micro/ nanoelectromechanical systems due to higher surface-to-volume ratio. The wear particles are trapped by texture or act as lubricant, which will further influence sequent sliding process. Understanding detailed behaviors of textured surfaces during the reciprocating sliding contacts will help to achieve desired friction characteristics. Employing multiscale method, nanoscale reciprocating sliding contacts of textured surfaces are investigated in this paper. Four textured surfaces with different asperity shapes are designed, and a rigid cylindrical tip is used to slide on these textured surfaces. For different textures and indentation depths, average potential energies and average friction forces of each sliding process are analyzed, and steady friction processes are discovered.

4:30 – 5 pm  
**Measurement of Mechanical and Tribological Properties of Nanowires Inside Scanning Electron Microscope**  
S. Vlassov, Institute of Physics, University of Tartu, Tartu, Estonia, B. Polyakov, Institute of Solid State Physics, University of Latvia, Riga, Latvia, L. Dorogin, M. Antsov, I. Kink, R. Lohmus, Institute of Physics, University of Tartu, Tartu, Estonia  
Nanowires (NWs) are now among most important objects in modern science, as they have demonstrated remarkable properties and have number of promising applications in nanotechnology. Considering that fabrication of NW-based devices requires precise control over positioning and subsequent behavior of the NWs, it is evident, that deeper understanding of their mechanical properties and NW-surface bilateral tribology mechanisms is crucial from applicative point of view. In present work mechanical and tribological properties of nanowires are experimentally investigated and theoretically interpreted. Measurements are based on manipulation of nanowires with atomic force microscope (AFM): tip inside scanning electron microscope (SEM). AFM tip is glued to quartz tuning fork (QTF) with simultaneous force measurements during manipulation. Elastic beam theory is applied for interpretation of experimental data and calculation of force distribution inside the NW.

5 – 5:30 pm  
**Nanotribology Committee Business Meeting**

---

2 – 2:30 pm  
**A Nanostructured Photocatalytic Coating for Wear and Corrosion Protection**  
X. He, H. Liang, Texas A&M University, College Station, TX  
We report a novel nanostructured coating incorporated with metallosupramolecular polymers, inhibitors, and polyelectrolyte into titanium dioxide (TiO2) nanoparticles (NPs). The potentiodynamic polarization measurements and real-time electrochemical impedance spectroscopy (EIS) monitoring showed that the surface film protected aluminum (Al) from corrosion. Photocatalytic TiO2 was able to release incorporated 8-HQ under UV resulting in a self-healing effect. Real-time EIS results showed that a new passivated layer was formed after 8-HQ molecules were released. In the presence of excess free ligands, the photocatalysis led to temporary disentanglement in non-covalent supramolecular motif and healing the wear crack. In this presentation, details in properties and performance of the coating are discussed.

2:30 – 3 pm  
**Tribology of Diamond-Like Carbon (DLC) Coatings Against Magnesium Alloy (AM60) and Composite AM60-9% (Al2O3)**  
A. Banerji, S. Bhowmick, A. Alpas, University of Windsor, Windsor, ON, Canada  
Sliding wear of non-hydrogenated (NH-DLC), hydrogenated (H-DLC) and fluorinated DLC (F-DLC) coatings were performed against a magnesium (AM60) alloy and magnesium (AM60) composite reinforced with 9vol% Al2O3 fibres under ambient conditions. Sliding tests using F-DLC coating generated a low coefficient of friction (COF) of 0.11 which was 50% lower than that observed against NH-DLC (0.22) and 58% lower than that observed against H-DLC (0.26). Formation of carbonaceous transfer layers along with MgF2 formation were detected by X-ray photoelectron spectroscopy on the AM60 surfaces due to sliding against F-DLC. Sliding of F-DLC coating resulted in 33% reduction of wear rate as compared to the NH-DLC and a 40% reduction of wear rate as compared to the H-DLC. The wear mechanisms, comprising of graphitization of DLC surfaces were studied using Raman spectroscopy along with electron microscopy (SEM, TEM) and will be discussed during the presentation.
Croda Lubricants
Leading the way naturally

Creative Innovation

Croda Lubricants has launched a range of new, industry leading products including:

- Perfad 5000 - Bio-based seal conditioning agent. Combats shrinkage of seals as well or better than phthalate esters at comparable treat rates.
- Priolube 1962, Priolube 1963 and Priolube 1965 - chain oil base fluids capable of operating at high temperatures for extended periods of time.
- Perfad 8100 and Perfad 8400 for neat metalworking fluids - a breakthrough technology in high performance lubrication for cutting, stamping and drawing fluids. Replaces chlorinated paraffins in mineral oil and ester-based forming fluids.
- Perfad 3000 series - unique polymeric friction modifiers for engines oils which can give a significant reduction in friction, increased fuel efficiency and reduction in exhaust emission.

If you would like more information on any of our new products, please contact us on 732-417-0800 or email marketing-usa@croda.com.

Visit us at Booth 309 at STLE 2013
3 – 3:30 pm • Break

3:30 – 4 pm
Properties Of Air Plasma-Sprayed WC-12%Co Coatings were Enhanced Through Optimizing Spray Standoff Distance
M. Ajmal, M. Afzal, Metallurgical and Materials Engineering, University of Engineering and Technology, Lahore, Pakistan

Properties of Air Plasma-sprayed WC-12%Co coatings were enhanced through optimizing spray standoff distance. Grit blasted SS-321 disks were coated using a 3MB APS gun. The spraying parameters were kept constant except for the spraying distance that was varied from 80 mm to 130 mm at 10 mm intervals. Coated samples were analyzed with optical and scanning electron microscopes. These samples were studied for the overall porosity of the coatings and the percentage defects at the interface. In addition, XRD analysis and hardness testing of all the coated samples were also carried out. The micro-structural study revealed that coatings sprayed at 100 mm distance had least porosity as compared to coatings sprayed at other distances. Similarly, the interface of the coatings and substrate deposited at 100 mm distance was better than the coatings produced at other standoff distances. These samples also exhibited optimal hardness.

4 – 4:30 pm
Surface Engineering Business Meeting

Session 6E • Richard B – Level 5

ROLLING ELEMENT BEARINGS V: PANEL DISCUSSION
1:30 – 3 pm & 3:30 – 5 pm
Current Perspectives on ISO 281

3 – 3:30 pm • Break

Session 6H • Nicolet – Level 5

LUBRICATION FUNDAMENTALS IV

Session Chair: J. Guevremont, Afton Chemical Co., Richmond, VA
Session Vice Chair: T. Zopler, Northwestern University, Evanston, IL
Session Chair: J. Qu, Oakridge National Laboratory, Oak Ridge, TN

1:30 – 2 pm
On the Stribeck Curves for Lubricated Counterformal Contacts of Rough Surfaces
D. Zhu, J. Wang, Sichuan University, Chengdu, China, Q. Wang, Northwestern University, Evanston, IL

The “Stribeck curve” is well-known, demonstrating the frictional properties of a lubricated interface during the transition from boundary and mixed lubrication all the way up to full-film hydrodynamic/elastohydrodynamic lubrication. Its description can be found in nearly every tribology textbook/handbook and many technical papers. However, the majority of published Stribeck curves are only conceptual without real data from either experiments or numerical solutions. This is because obtaining friction data, either experimentally or numerically, over the entire transition has been a challenging task. In the present study a set of numerical solutions in lubricated counterformal contacts of rough surfaces is obtained by using the deterministic mixed EHL model recently developed. The Stribeck curves are plotted and discussed based on the simulation results from different types of rough surfaces. Comparison of sample results with experiments is also made, and a good agreement is found.

2 – 2:30 pm
A Numerical Simulation of Liquid-Mediated Adhesion in Contacting Solids
J. Streator, Georgia Institute of Technology, Atlanta, GA

Many engineering contacts involve a liquid at the interface of two elastic solids. In cases where the liquid quantity is insufficient to flood the interface, there is the potential for capillary effects, whereby the pressures in the film become sub-ambient. Such capillary films can cause unwanted tensile stresses or “stiction” in the interface, especially with microscale structures, often compromising device function. In the present work, a model is developed to simulate the flow of liquid at the interface between contacting elastic solids of specified roughness. The Reynolds equation of lubrication is used in conjunction with models of capillarity and elastic deformation to investigate the process by which the interface achieves equilibrium. Of particular interest is the development of adhesive stresses.

2:30 – 3 pm
Three Dimensional Interfacial Fluid Mechanics and Pressure Prediction
J. Sierra Suarez, G. Srivastava, C. Higgs III, CMU, Pittsburgh, PA

Previous work on chemical mechanical polishing (CMP) has shown both sub-ambient and super-ambient fluid pressures between the pad and wafer during polishing but only along constant velocity lines. In other words, the fluid pressure in the three-dimensional (3D) interface for the mixed lubrication regime was not shown to have captured both pressure levels. In this study a 3D mixed-lubrication model is developed for the resulting slurry fluid pressure during CMP, where the 2D sliding flat punch solution has been replaced by solutions to the Cerruti and Boussinesq elastic potential functions. Preliminary modeling results match well with the experiment.

3 – 3:30 pm • Break

3:30 – 4 pm
Lubrication Options for Ammonia Refrigeration Compressors

Ammonia has been used as a refrigerant since the nineteenth century. Its use in commercial refrigeration compressors has increased in recent years due to its favourable Ozone Depletion Potential (ODP) and Global Warming Potential (GWP) compared to other available refrigerants. This is especially the case in the food industry. Several lubricant technology options, both mineral and synthetic, exist for ammonia refrigeration compressors. Due to the nature of the application, these oils must be: resistant to thermal stress, have an appropriate viscosity profile at both low and high temperatures, and be compatible with seals. A 2011 study, conducted with laboratory tests intended to assess performance in refrigeration compressors, showed that oils based on polyalphaolefin (PAO) offer significant benefits over mineral naphthenic or mineral paraffinic oils. Oils based on PAO and alkylated benzene (AB) also offered benefits, especially when switching from mineral naphthenics.
4 – 4:30 pm
Thermoelectric Measurements of Fe-Constantan Sliding Asperity Contact Flash Temperatures
R. Erck, O. Ajayi, G. Fenske, Argonne National Laboratory, Argonne, IL

When two metals are brought together to form a sliding contact, friction and/or deformation at load-bearing asperities cause a local increase in temperature. If the counterfaces are dissimilar materials that generate a thermoelectric voltage, the “dynamic” thermocouple method can be used to measure instantaneous or “flash” temperatures during sliding. Sliding flash temperatures were measured using unidirectional (block on ring) conditions with iron-constantan (55Cu45Ni) counterface materials. For oil-lubricated sliding up to 4.8 m/s, maximum and average temperatures were on the order of 200°C and 150°C. For higher-load scuffing conditions, large increases in coefficient of friction were accompanied by large jumps in temperature. For light loads, average asperity temperature increase was almost proportional to sliding speed.

4:30 – 5 pm
Optimization of Siloxane Molecular Structure for Diverse Tribological Applications
T. Zolper, Northwestern University, Evanston, IL, M. Jungk, Dow Corning GmbH, Wiesbaden, Germany, T. Marks, Y. Chung, J. Wang, Northwestern University, Evanston, IL

A molecular-rheological-tribological model has been developed to predict the film forming ability and friction performance of several siloxane-based lubricants from their molecular structure. The molecular-rheological model calculates rheological properties including viscosity and pressure-viscosity indices from siloxane molecular structure such as branch type, content, and molecular chain length. The rheological-tribological model uses the rheological properties to predict film formation and friction coefficients of these siloxane-based lubricants. Elastohydrodynamic film formation and friction are modeled at temperatures of 303 to 398K and several slide-to-roll ratios resulting in conditions representative of boundary, mixed and full film lubrication regimes. Structural-functional relationships derived from experiments and the literature are used to optimize siloxane molecular structures for divergent applications of their Newtonian and non-Newtonian characteristics.

5 – 5:30 pm
A Wafer-Scale Particle Augmented Mixed Lubrication Modeling Approach for Chemical Mechanical Polishing
G. Srivastava, C. Higgs, Carnegie Mellon University, Pittsburgh, PA

Most chemical mechanical polishing (CMP) researchers assume that the polishing occurs in the mixed-lubrication regime, where the applied load on the wafer is supported by the hydrodynamic slurry pressure and the contact stress generated during the pad-wafer contact. The particle augmented mixed lubrication (PAML) approach has been employed as an extremely high-fidelity micro-scale mixed-lubrication CMP model. The current work introduces a more efficient wafer-scale PAML model, called PAML-lite, which employs a two-dimensional average flow Reynolds’ Equation incorporating spatial dependence of entrainment velocities to model the hydrodynamic pressure. Parametric studies were conducted to understand the effect of some unexplored CMP parameters.

5:30 – 6 pm
Investigation of Negative Effects of Polymer Films on Cooling
A. Sasaki, Maintek Consultant, Yokohama, Japan, K. Matsumoto, Honda R & D Co., Ltd., Tochigi, Japan

One of the important functions of lubrication is to remove heat which is generated during operation of machinery. The energy which is used for cooling machinery is not productive but unavoidable for machine operation. When oil is used in machinery for many months, oil will oxidize and polymerized oil oxidation products will be formed in oil. Such oil oxidation products will be adsorbed on metal surfaces and form varnish. It can be considered that the varnish that formed on metal surfaces will reduce cooling effects. Sometimes oil tanks are coated with paints for protecting the oil tank from rusting. Such painting will also have negative effects on cooling. The authors have investigated the negative effects of varnish films and painting on cooling. This is the report of measurement of the influence of films on the cooling effects by lapping a uniform thin polymer film on the surfaces of metal cans.

Session Chair:
D. McCoy, The Elco Corporation, Cleveland, OH

1:30 – 2 pm
Deposition on Bearing Pads by Insoluble Particulates in Turbine Oils
F. Yokoyama, Y. Shinka, Y. Iwama, IHI Corporation, Yokohama, Japan

One of the primary failure modes for lubricants serving in thermo-oxidative environments is commonly considered to be the production of deposit. Much production of the deposit on bearing pad might cause the temperature rise and remarkable vibration. The composition of deposit is mainly organic compounds which is so-called “sludge”. The sludge caused by oil degradation is not soluble in lubricating oil, and can be deposit precursor. In this study, the deposit precursor in lubricating oil was investigated and the demonstration of the mechanism of deposit production was conducted.

2 – 2:30 pm
Bypassing Around Filters During Cold Starts: Comparing Different Hydraulic Fluids
W. Needelman, Donaldson Company, Inc., Minneapolis, MN

When hydraulic equipment starts up in cold ambient environments, highly viscous hydraulic fluid automatically shunts around the main system filter. This avoids pressure damage to the filter and starvation of the downstream mechanical components, but allows unfiltered fluid to reach and possibly damage critical components. A previous paper presented the results of a new model quantifying cold start bypassing as a function of type and service time of hydraulic filters. In this paper, a similar model is used to compare the amount of bypassed fluid and bypassed contaminant produced by different hydraulic fluids during typical cold start situations. Results for representative mobile and industrial systems are presented, and the extent of damage caused by bypassed contaminants is discussed. The paper concludes by suggesting steps for reducing the negative consequences of contaminant bypass during cold starting.
2:30 – 3 pm  
**Development of Boron-11 NMR Method to Determine Low Levels of Boric Acid in MWF Borate Derivatives**

S. Anderson, Afton Chemical, Manchester, United Kingdom

Boric acid derivatives have been used in metalworking fluids for over thirty years to provide corrosion protection and reserve alkalinity. Implementation of the GHG and the European CLP regulations now require producers to indicate the level of free boric acid. Boric acid has been identified as a reproductive toxin so products containing >0.1% must indicate its presence. Analysis of free boric acid at very low levels has been problematic and measurements in MWF fluids containing below 5% has not previously been possible to an acceptable accuracy. This presentation describes the method development to analyse boric acid in additifs and formulated fluids containing amine borate produced via high temperature condensation reaction. The use of Boron-11 NMR by this method can identify boric acid at below 0.05% and demonstrates that amine borate condensation products do not contain boric acid and are stable to hydrolysis when formulated and used in traditional MWF aqueous emulsions.

3 – 3:30 pm • Break

3:30 – 4 pm  
**Ferrography Today 2013**

R. Dalley, Ferrography, Akron, OH

Ferrography has been around since the 1970’s invented by Vernon Westcott due to a need to observed wear particles/Ferrography in the 5-350 micron range. Most believe this is the particle size range to detect potential failure prior to any mechanical problems. However, the ferrography analysis was thought to be time consuming, expensive and not repeatable. Several years ago a colleague of mine, Brian Johnson, a reliability engineer of Arizona Public Power form an ASTM committee to establish a standard for Wear Particle Analysis/Ferrography. He contacted experts in the market to form a sub-committee called CS96.6 under the Lube Oil Testing Standard. Ferrography is an excellent diagnostic tool but deem very subjective. The committee goals is to establish a procedure to eliminate majority of the subjectivity and provide a guide using charts and photos to diminished any guesswork and present quantifiable data for better diagnosis. My presentation will discuss the work involved to establish a standard using teamwork, experts in the field updating on the technology and finally writing the standard with everyone’s input for acceptance. In addition, I wanted to provide an overview of the ferrography technology and most to officially thank the colleagues on the ASTM Committee to establishing a Standard in a very short period of time.

4 – 4:30 pm  
**Measuring Tapping Performance**

M. Miller, CLC Lubricants, Downers Grove, IL

“Measuring Tapping Performance” presents the development of the use of a Microtap Tapping Torque Tester as a tool that quickly and with fewer data points can predict field performance of a variety of fluids, determine additive treat levels, troubleshoot machining performance issues, and evaluate EP performance in various metalworking fluids. This program was originally presented at the 2001 STLE Annual Meeting in Nashville and remains valid today. Anyone looking for a tool to determine fluid performance in the field with laboratory test data will find this program helpful.

4:30 – 5 pm  
**Hitting the moving Target**

C. Paxton, C.L.S. OMA, Warren, MI

With today’s around the Clock operating Schedules, Access to Industrial Equipment, Machinery and Conveyors to perform routine Preventive Maintenance is becoming more challenging. This talk will be centered around the success or failure of Your Lubrication Maintenance Program. We will be discussing “Outside the Box” methods for coping with the necessity to continually alter Your Schedules to perform Lubrication Maintenance. A few case studies will be discussed as well.

**Session 6K • Mackinac West – Level 5**

**ENVIRONMENTALLY FRIENDLY FLUIDS II**

Session Chair: D. Vargo, Functional Products Inc., Macedonia, OH  
Session Vice Chair: B. Sharma, UIUC, Champaign, IL

1:30 – 2 pm  
**A New Environmentally Friendly Algal Oil with Enhanced Performance**

C. DiCicco, Solazyme, South San Francisco, CA

Two of the main problems with using vegetable oils as lubricant basestocks are oxidation and inferior fluidity at low temperatures. Commonly used vegetable oils such as soybean display only adequate performance because of these deficiencies. A new base oil with a high oleic content combined with no polyunsaturation (linoleic and linolenic) has now been developed and shows promise as a lubricant basestock that displays enhanced resistance to oxidation combined with better low temperature operating conditions. The benefits of this oil are displayed in standard lubricant industry oxidation such as the Oil Stability Index Test and the RPVOT. The effect of commercially available pour point depressants in improving the performance of this basestock is also examined (ASTM D97). This basestock has the potential to be used not just in biodegradable lubricant applications but as an attractive co-solvent with conventional mineral oil basestocks in a variety of applications.

2 – 2:30 pm  
**Friction and Wear of Jatropha Curcas Oil Using a Four Balls Tester**

E. Gallardo, F. Nieto, M. Vite, M. Figueroa, E. Garcia, Instituto Politecnico Nacional, Mexico City, Mexico

Jatropha curcas oil is a good option as renewable energy for biodiesel and as lubricant feedstock. In México, the Jatropha curcas oil is widely distributed in more than 15 states. This work describes the characterisation of Jatropha curcas oil as additive in engine oil blended mixtures using a four ball test rig at five different loads. Initially, the Engine oil and Jatropha curcas oil were individually tested. The Jatropha curcas oil and the engine oil were mixed at 5%-95%, 10%-90%, 15%-85%, 20%-80%, and 50%-50%. The results have shown a low friction coefficient when only Jatropha curcas oil was tested compare to engine oil at 100%. Nevertheless, the wear scars were bigger when only Jatropha curcas oil was used. The results from the oil mixtures showed good potential of using Jatropha curcas oil as an additive.
Sea-Land Chemical Company represents some of the most trusted brands and companies in the industry to provide you with the quality you demand. We stock hundreds of products, providing you the right chemicals, right away. It’s one-stop shopping to meet your needs quickly and simply.

And, with our expanded North American and International Sales Teams we’re here to meet your requirements for local and global formulations.

More than a supplier, we are a resource for your success. Make Sea-Land Chemical Company your first call.

821 Westpoint Parkway | Westlake, OH 44145 USA
440-871-7887 | www.SeaLandChem.com
2:30 – 3 pm  
Synthesis, Characterization and Evaluation of 2-Ethyl Hexyl Ester of Karanja Oil Fatty Acid Estolide  
A. Govindapillai, M. Damodaran, J. Narakathara Haridas, Cochin University of Science and Technology, Kochi, India  
Karanja oil is a non-edible seed oil from karanja tree (Pongamia Pinnata). Fatty acid profile of karanja oil was determined by GC/MS method. Nearly 50% of karanja oil fatty acids were found to be saturated. Eicosanoic acid (20:0), behenic acid (22:0) and tetracosanoic acid (24:0) constituted about 20% of the fatty acid content. Because of the high saturated fatty acid content karanja oil showed poor cold flow properties. To improve the poor cold flow properties, 2-ethyl hexyl ester of estolides from karanja oil fatty acids was synthesized. FTIR and NMR spectroscopic analyses were used to characterize the estolide ester. The product of synthesis was found to be a mixture of different esters of fatty acids and estolides. The product was evaluated for tribological, viscometric, oxidative and cold flow properties by four ball tester, ASTM 445 method, TGA/DTA and DSC respectively. The results were comparable to SAE20W40 oil.

3 – 3:30 pm  •  Break

3:30 – 4 pm  
Synthesis of a Potential Biodegradable Lubricant from Castor Biodiesel Esters via Enzymatic Catalysis  
J. da Silva, Petrobras, Rio de Janeiro, Brazil, A. Habert, D. Freire, Federal University of Rio de Janeiro, Rio de Janeiro, Brazil  
Millions of tons of lubricants are disposed of in the environment through leakages, exhausted gases, inadequate disposal, etc. Some of them are resistant to biodegradation, representing an environmental threat. One solution to modify this situation is the replacement of the mineral oils by biodegradable synthetic lubricants. Thus, in this work, it was investigated the production, through enzymatic catalysis, of synthetic base oils using castor (methyl ricinoleate) biodiesel as raw material. From the best reaction conditions, it was obtained products with higher than 95% yields, in 24 hours, using a Candida rugosa lipase as biocatalyst. These products showed the following properties: viscosity at 40°C: 291.6 cSt; viscosity at 100°C: 27.59 cSt; viscosity index: 126 and pour point: -42°C. These results indicated the feasibility of the proposed process route, with the biocatalyst (lipase), for the production of synthetic biodegradable lubricants.

4 – 4:30 pm  
Evaluation of Karanja Oil (Pongamia Pinnatta) as Bio-Degradable Base Oil for Lubricants  
J. Haridas, M. Damodaran, Cochin University of Science and Technology, Kochi, India  
Karanja oil is a non-edible oil extracted from the seeds of Karanja (pongamia pinnatta) tree. Karanja oil is widely used in rural India for lighting lamps, as fuel for cooking and as medicine for skin diseases. The oil's non-edible nature and wide availability makes it a suitable candidate as an alternative base oil for lubricants. As a first step in the evaluation, the fatty acid profile of the oil is determined by GC/MS followed by physicochemical, viscometric, tribological, oxidative (TGA/DTA), and cold flow analyses (DSC). The saturated fatty acid content is approximately 50% in karanja oil. The saturated fatty acids include significant percentage of carbon chain lengths above 20. Karanja oil showed excellent viscosity index (170°C), high flash point (254°C) and fire point (266°C) and good antifriction properties (µ=0.05). To improve the antwear, oxidative and cold flow properties different nanoparticles were added and properties were evaluated.

4:30 – 5 pm  
An Investigation Into the Tribological Performance of Diesel and Diesel-GTBE Blends  
G. Thakre, S. Kaul, M. Negi, D. Bangwal, P. Arya, B. Shukla, CSIR-Indian Institute of Petroleum, Dehradun, India  
Glycerol Tertiary Butyl Ether (GTBE) is recognized as an additive for bio- and fossil diesel. When blended with diesel GTBE reduces PM emissions significantly in diesel engines. Addition of GTBE affects lubricity of diesel and therefore caters interest to investigate the tribological performance of diesel-GTBE blends prior to engine testing. The aim of present research is to investigate the trib- performance of diesel and diesel-GTBE blends in laboratory conditions. An in-house synthesized GTBE is blended with three commercial diesel samples and the performance in terms of friction and wear is investigated. Experiments are performed on a four ball tester using varying concentrations of GTBE in commercial diesel samples procured from Indian market. The physico-chemical characteristics and SEM investigations of the used test specimens are carried out. Experimental results indicating the effect of GTBE concentration in diesel on wear and friction has been analyzed and reported.

5 – 5:30 pm  
Environmentally Friendly Fluids Technical Committee Meeting