WEAR NEWS

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ASTM G2 Erosion and Wear Activities (from WebEx meetings on June 17 and 18 2020)

This was the first ASTM G2 meeting in the 40 or so year history of the committee that the committee did not meet in person. The meeting was attended by as many as 20 people from time to time and the input from members and guests from outside the USA was an unanticipated and appreciated benefit. This is apparently one advantage of a virtual meeting over in-attendance meeting. Everybody is on the phone or computer so everybody hears and sees everything the same.

The following are recollections of the actions that resulted from this spring 2020 meeting.

G02.10 Erosion Activities

Chair John Hadjioannou (EPI) reported that the high temperature solid particle erosion test, ASTM G211, is in need of a review and that Jeff Smith (consultant) recommended reballot without change. Some subcommittee members expressed the need for the standard to have procedures for temperatures other than room temperature and 600C. Jeff Smith (Materials Process Tech LLC) reported that it was very difficult to get the ten labs that participated in the interlab tests to do just these two temperatures. Other temperatures could be added to the standard, but somebody would need to step forward to lead the effort and do the inter-lab testing. John said that he would reballot the G211 standard without change.

Chairman Hadjioannou also reported that the ASTM G32 vibratory horn cavitation test is up for review and reballot. Mark Gee (NPL/UK) said that a coworker at NPL uses this standard and he will contact him to see if he will do the needed review.

G02.20 Tribotest Development Activities

This subcommittee was disbanded in 2019.

G02.30 Abrasion Activities

Chair Brian Merkel (Lincoln Electric) conducted the meeting. He reported that three standards: ASTM G75 slurry abrasion test, ASTM G65 Dry-sand rubber wheel abrasion test and ASTM G105 rubber wheel/slurry test need review for reapproval. As always, there was spirited discussion of the rubber wheel and other problems related to the ASTM G65 test. John Hadjioannou reported that his lab is still getting “bow-tie” shaped scars from the G65 tests and a meeting attendee from the UK showed slides of ASTM G65 test specimens that had facets in the wear scars that appeared to correspond to Shalamach waves in the rubber. Also the rubber vendor problem (limited availability) still persists.

In any case, it was resolved that Jim Miller (Whiterock Engineering) will review and update the ASTM G75 slurry abrasion test; four different labs will review the ASTM G65 test and the G105 slurry test will go to ballot without revision. Nick Randall will review and send the ASTM G171 scratch test to ballot.

ASTM G02.04 Non-abrasive Wear activities

Chair Nick Randall (Alemnis AG) reported that the ballot on the twist compression test received a number of negatives and comments and project manager, Ted McClure (SLC Testing Services), stated that he will withdraw the ballot, address all negatives and comments and reballot the test at the subcommittee level.

A number of other standards are needing review and the following reviews were agreed-to: Rich Baker (Tribo Tonic UK) will review the G119 standard on wear/corrosion synergy; Nick Randall will review the ASTM G133 reciprocating ball-on-plane test, and Ken Budinski (Bud Labs) will review the ASTM G204 fretting standard and reballot it.

ASTM G02.5 Friction Activities

Chair Ken Budinski presented PowerPoints on the friction test activities resulting from the December 2019 workshop in New Orleans. It was decided to add a number of lubricated friction tests to the G115 friction standard that lists most ASTM friction tests. Mike Anderson (Falex) stated that the D5183 4-ball friction test for oils is OK as written, but that many users report the friction results at the 40kg load as the friction for the tribosystem.

A proposed attritious friction test was discussed but not even the name was well received at the June meeting. The test and its description will be included to Wear News for comment.

ASTM G2.91 Terminology Activities

ASTM G2 Chair, John Hadjioannou, chaired the terminology subcommittee meeting in the absence of Chair Scott Hummel (Lafayette College). He reported that ASTM G190 on wear test selection is up for review. Peter Blau (Blau Tribology Consulting) agreed to review the document.

Five terms were submitted to the subcommittee for definitions:
Attritious friction
Open tribosystem
Closed tribosystem
Dry tribosystem
Unlubricated tribosystem

Definitions for ballot were crafted at the meeting for the first three terms and John will ballot them before the next meeting.

The strawman definition for attritious friction is: n. the retarding force on a body as it moves through a fluid

Miscellany

New Cochair

Steve Shaffer (Consultant) will become co-chair with Bill Ruff (NIST retired) of the editorial subcommittee.

Long range planning

Steve Shaffer will work to incorporate plant visits and the like with each future meeting.

Future meetings

December 8 and 9, 2020 virtual WebEx meeting

June 23 and 24. 2021 Kansas City MO with D2

Attritious friction test

In response to no requests, an attritious friction test was developed at Bud Labs to address the issue of the “internal friction characteristics of oil”. Does one oil produce different friction results in a given tribosystem compared to other oils? Every material has a different internal friction relating to how atoms and molecules slide on each other. Damping capacity is the engineering parameter used to measure the damping capacity of different metals. Sonic velocity is also used to measure the damping capacity of materials, but the torsional pendulum is the tradition way to measure the damping capacity of metals. One sets a torsional pendulum of the metal under study in motion and the logarithmic decrement of successive vibrations is the test metric. In pure iron, the damping is caused by carbon atoms jumping between interstitial sites. So why not try this approach on oils and see if oil molecules being pushed out of the way by an oscillating pendulum will measure the internal friction of an oil.

This was the rationale for development of the Bud Labs attritious friction tester which is illustrated in Figure 1.

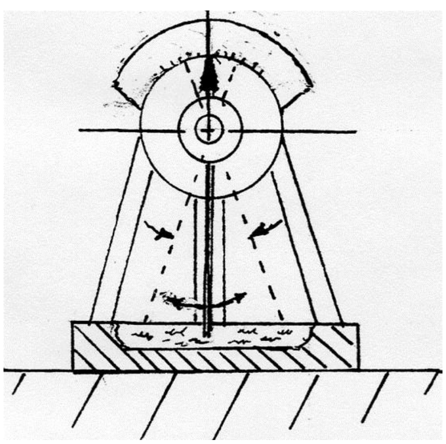

Figure 1 Schematic of test rig. Oil is in shallow cavity in the base of the test rig

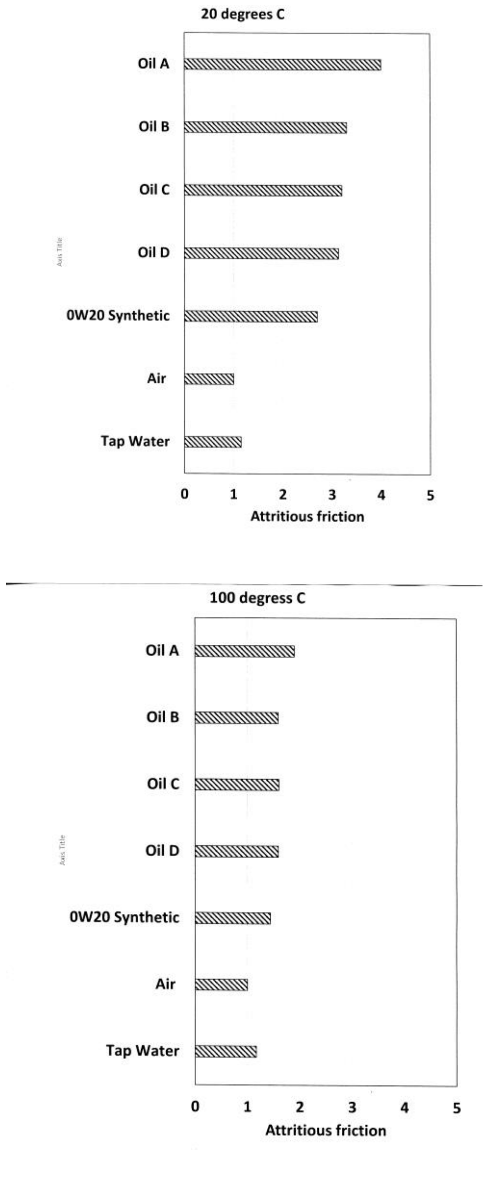

Figure 2 The upper graph is for tests at 20C; the lower graph is for tests at 100C

The attritious friction of four commercial oils with the same API viscosity rating (all four oils were labeled 10W-30), were compared with a low-viscosity oil: 0W-20. These are limited test data, but they suggest that there are attritious friction differences between oils of the same viscosity and those differences change at a typical use temperature of 100C. These data show that there can be significant differences in attritious friction between oils from different manufacturers. This test also produces information on the effect of temperature on oil friction.

The goal of the auto industry's trend to use ever-lower engine oil viscosity to reduce the energy losses involved with moving oil around and mechanisms sloshing through the oil. The test data in Figure 2 suggests that at 100C, the lightest commercially-available oil, 0W20, produces a slight reduction in attritious friction at 100C compared to the best 10W30 oil. One must question what the trade-off is in engine component wear life. That is another study.

In any case, readers are asked to comment on the the applicability of this test to ASTM standardization.
Email: kenbudinski@hotmail.com with comments

Development of a 2-body ASTM G65 abrasion test

The OECD International Research Group had to cancel their May 2020 meeting in Lausanne because of the Corona-19 virus travel bans. The following is an abstract of the paper that was to be presented by Ken Budinski of Bud Labs USA:

Redesign of the ASTM G65 3-body abrasion test to be a 2-body abrasion test

The ASTM G65 test is likely the most widely used wear test on the planet. It has been a testing standard for about 35 years and many manufacturers of wear-resistant materials have relied on its results to improve their materials. Many hardfacing suppliers have decades of test data on the materials that they make. However, over the last decade or so, many wear-resistant materials were improved to the point where the sand abradant used in ASTM G65 is not aggressive enough to produce a measurable scar in some wear-resistant materials; many cemented carbides are not damaged by the standard ASTM G65 test.

However, in addition to this problem, the chlorobutyl rubber that is used in the test to force the sand against the test specimen has become expensive and very difficult to obtain. In 2018 or thereabouts, a procedure was added to the G65 test to allow the use of neoprene rubber for wheels, but data from neoprene wheels may not give the same result as from chlorobutyl rubber wheels.

A logistic problem has always been associated with this test. The test sand must come from a single mine in Ottawa Illinois in the USA. This, of course, creates a significant problem for users in other countries; it is expensive to ship hundreds of kilograms of sand around the world and each test uses about 20 kg of sand.

Finally, there are health issues with using silica sand as an abradant. In the USA, the OSHA regulatory body that oversees heath issues in the workplace has recently issued a 62-page long guide on what must be done to use sand in a workplace.

The ASTM G174 test is a 2-body abrasion test with none of these problems. However it has been an active ASTM standard for more than twenty years, but it is still not as widely used as the ASTM G65 test. The purpose of this paper is to present a redesign of the ASTM G65 test rig to convert it to a modification of the ASTM G174 test. The objective of the redesign is to allow the use of ASTM G65 test specimens in a two-body abrasion test using aluminum oxide as the abradant.

Redesign details:

The ASTM G174 loop abrasion test was designed originally to measure the abrasion resistance of tool steel and similar tool materials for punch and die type of applications. It was convenient to use relatively small (3mm thick, 8mm wide and 32 mm long) test specimens. These small test specimens were also convenient for tests of coatings and surface treatments. However, these small test specimens are not very suitable for application of hardfacing fusion weld overlays. The ASTM G65 test specimens with a specimen thickness of 21.7 mm are more suitable for fusion weld applications. The solution to the small specimen problem of the ASTM G174 test as well as the sand and rubber wheel problem of the ASTM G65 test was to merge the two as shown in Figure 1.

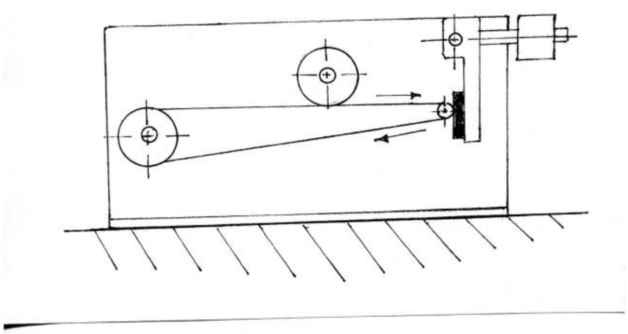

Figure 1 Schematic of the ASTM G174 modification to allow use of ASTM G65 test specimens.

The current ASTM G174 test rig shows the test specimen to be horizontal and the abrasive loop to be vertical. A machine was built at Bud Labs like the schematic shown in Figure 1 and tests were conducted to obtain a test procedure that could be added to G174 test method. The specimen loading mechanism remains the same as that in G65 only a fixed aluminum oxide loop and steel drive spindle replace the rubber wheel and sand. The redesign has other benefits like allowing lower specimen tolerances and the ability to easily change the abradant size. A recent study on cemented carbides was conducted with larger than 30µm alumina as the abradant. The smaller abrasion scar also allows replicate tests on the same test specimen (Figure 2).

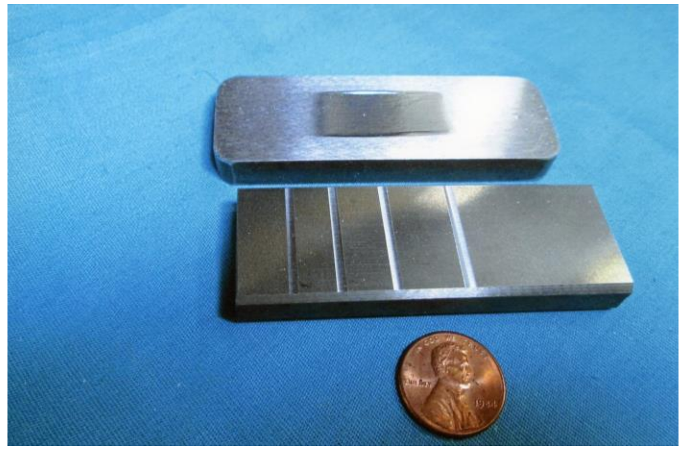

Figure 2 Four ASTM G174 abrasion tests on one ASTM G65 test specimen.

Studies have been conducted on the correlation of G174 with G65 (Figure 3) so old data could be used with the redesigned test rig.

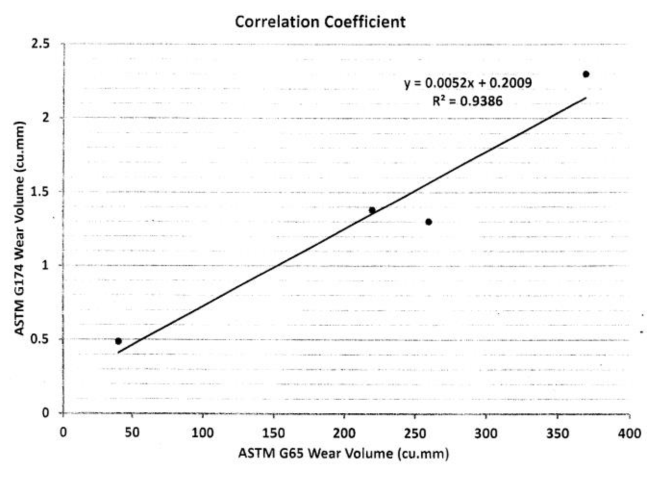

Figure 3 Correlation of ASTM G65 test data with ASTM G174 test data.

Overall, there are very serious reasons for replacing ASTM G65 as the worldwide abrasion test. Two-body abrasion is known to be more aggressive than 3-body abrasion. It is also well known that fixed alumina abrasive is more aggressive than 3-body sand. Thus the proposed test is more aggressive to deal with the test materials that are too hard for sand and the use of fixed alumina as the abrasive removes the silica health issues.

Standardization of the proposed horizontal procedure for ASTM G174 simply needs collaborators for inter-lab testing.

On the mechanism of abrasion

It is likely at this time (August 1, 2020) that the International Wear of Materials Conference scheduled for April 2011 in Banff Canada, will likely be cancelled. The following is a synopsis of the paper offered to WOM by Ken and Steven Budinski of Bud Labs USA.

Background

Pin-on-flat wear and friction tests are ubiquitous. The pin is almost always a sphere or hemisphere to reduce test variability due to alignment issues. What role does the prevailing surface texture of the test specimens play? The purpose of this study was initially to address the role of surface texture in unlubricated metal-to-metal reciprocating sliding tests. A specific goal was to determine if it makes a difference if a polished ball rider rubs transverse- to or with the lay on ground counterfaces.

However, exploratory reciprocating wear testing showed that very often in metal-to-metal wear tests, the ball rider develops a polished wear flat (Figures 1 and 2). What causes this polishing? Thus the study was redefined to investigate the abrasivity of wear debris from metal-to-metal tribosystems. The objective of the work was to determine the source of polishing abrasion in unlubricated steel versus steel reciprocating wear tests.

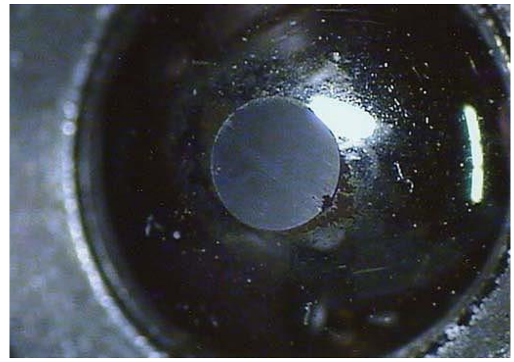

Figure 1 Polished flat on 6.3 mm diameter ball after 10,000-cycle reciprocating wear test.

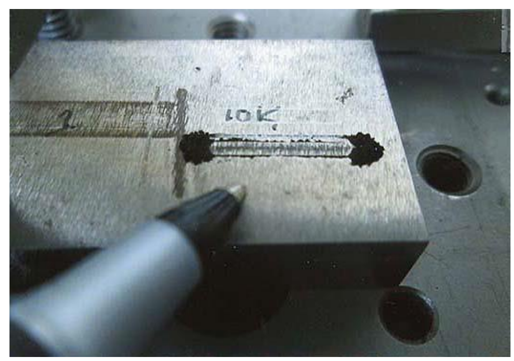

Figure 2 Type H13 tool steel counterface (43 HRC) wear scar after 10,000-cycle reciprocating wear test versus the 52100 steel rider (60 HRC) shown in Figure 1.

Laboratory tests

Reciprocating wear tests (17N, 12.6 mm stroke, 3.3 Hz, 20C, 10,000 reciprocating cycles) were conducted on the following test couples:

Rider	Counterface
52100 steel (60HRC)	vs. 1020 steel (85 HRB)
52100 steel (60 HRC)	vs. H13 tool steel (43HRC)
52100 steel (60 HRC)	vs. O1 tool steel (60 HRC)
52100 steel (60 HRC)	vs. carbide WC/6%Co

Replicate tests were run parallel and perpendicular to the lay of the ground test surfaces. In addition, tests were conducted on O1 tool steel (60 HRC) polished versus a polished 52100 ball rider (60 HRC).

All of the hard vs. hard tests showed polishing of the 52100 riders. It appeared that the wear detritus was the polishing agent. Tests were then conducted to assess the abrasivity of hard vs. hard wear detritus. The detritus was collected and embedded in different plastics and rubbers to see if it would become a polishing abradant for 52100 ball riders at 60 HRC.

Test Results

Figure 3 presents the results of the reciprocating tests.

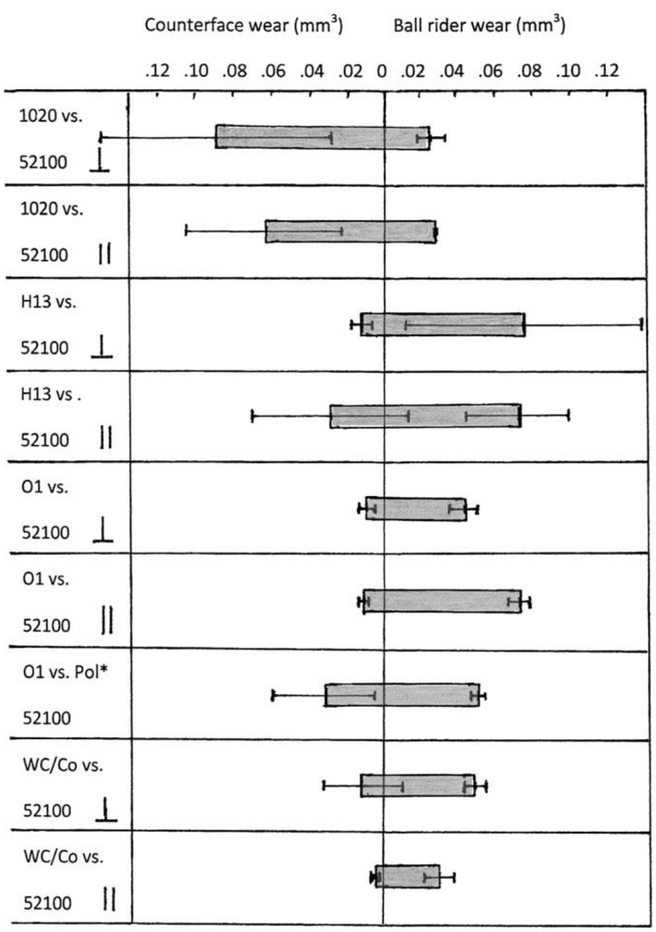

Figure 3 System wear volumes from perpendicular and parallel to grinding lay unlubricated reciprocating metal-on-metal wear tests

The highest system wear volume was obtained with the 1020 steel versus hard 52100 steel. The lowest system wear volume was obtained with the WC/Co versus hard 52100 steel test couple.

The hard vs. hard couples produced polishing wear on the 52100 ball riders; the hard versus soft steel couples produced scratching abrasion on the 52100 ball riders.

The effect of surface texture orientation was not consistent, but these tests showed that without surface texture to hold polishing wear debris (Figure 4), severe wear occurs. The polished couples displayed high friction and severe counterface wear. There were no surface features to accumulate wear detritus and form a tribofilm.

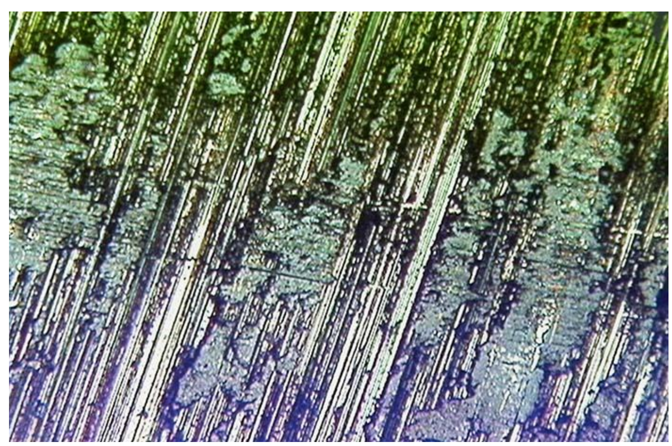

Figure 4 Fine wear detritus trapped in grinding lay after 1000 cycles of 52100 steel (60 HRC) versus H13 tool steel (43 HRC)

The abrasivity studies showed that the hard vs. hard wear detritus is abrasive, but when embedded in soft conforming surfaces like plastic and rubber it tends to produce scratching rather than polishing abrasion (Figures 5 and 6). The scratches are caused by clumps of the abradant as opposed to a uniform film of abradant.

Most importantly, these studies showed that wear debris from steel versus steel tests produces wear detritus that can become a submicron powder that becomes an abradant (probably iron oxide) to produce abrasive wear on both members of a tribocouple.

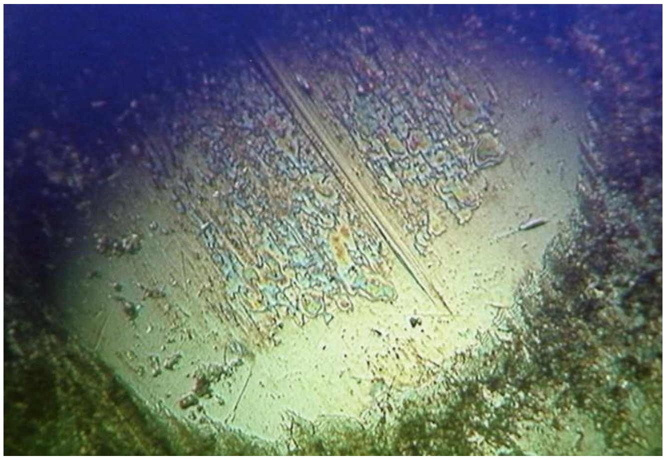

Figure 5 A 52100 rider (60HRC) after 10,000 reciprocating cycles versus acetal plastic 100X.

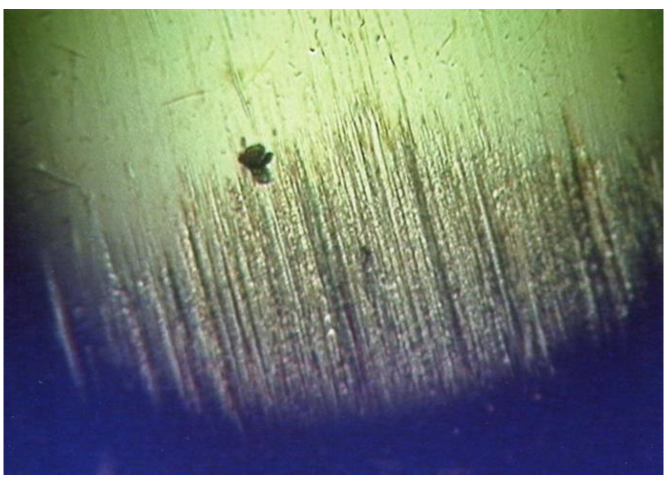

Figure 6 A 52100 rider (60 HRC) after 10,000 reciprocating cycles on acetal plastic with embedded hard versus hard steel wear detritus 100x.

Discussion

The test results on the role of surface texture in dry unlubricated steel versus steel wear were not those anticipated. In early tests we stopped the test at 10, 100, 1000, and 10,000 cycles and these exploratory tests suggested that a perpendicular lay produced a wear advantage. The final test data showed that it is not consistent as to whether perpendicular is better than parallel, but all test clearly showed that surface texture is very important in system wear. Polished steel surfaces do not make a happy tribocouple .

The finding that rubbing hard steel against a steel counterface produced polishing or scratching abrasion on the hard member is thought to be the most significant part of this study. For many years, the ASTM G2 Committee on Wear and Erosion refrained from forming an "adhesive" wear subcommittee to complement the abrasive wear subcommittee, because it was the consensus that abrasion could be conjoint with adhesive wear. These tests confirm that abrasion can occur in "adhesive wear" tribotests.

Another significant learning (to me) of this study is how scratching abrasion occurs in metal-to-metal tribosystems that contain no abrasive particles. Where do the scratches come from? Our microscopy studies on rubber and plastic and soft steel wear scars showed that wear debris clumps and forms hard protuberances that produce scratching. Plastically deformed rubbing surfaces can produce scratching abrasion early on before much wear debris accumulates. Metallic fractured particles can weld to one or both rubbing surfaces and cold work to the point where they become protuberances to produce scratching abrasion. Adhered particles can act like a fixed abrasive.

Conclusions

1. Surface texture on unlubricated steel vs. steel counterfaces tends to reduce system wear by formation of a separating tribofilm.
2. Polished unlubricated hard steel vs. hard steel tribocomponents tend to produce high friction and severe wear
3. Abrasive wear is a significant part of system wear in unlubricated steel vs. steel tribosystems.
4. Adhered particles or clumped wear detritus can form hard protuberances that produce scratching abrasion in unlubricated steel vs. steel tribosystems

Note: Wear news is the informal account of selected tribology events and the activities of the ASTM G2 Committee on Wear and Erosion

Contributed tribology articles are welcome. Send them and inquiries to
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