



May 19, 2005

Dr. David Krus
Brush Wellman Inc.
1776 Clair Ave.
Cleveland, Ohio 44110

Re: Evaluation of Toughmet CX105 Sliding Against Metalife Coated AISI 8620 Steel.

Dear Dave:

We have completed the tests on the Metalife coated samples and find the results to be encouraging. Four tests were run on the coating against Toughmet alloy. Two were journal bearing tests and two were thrust washer tests. One of each test was run lubricated and one was run unlubricated

Test Conditions

The test conditions were as follows:

Journal Bearing Test, PV Limit Test

Materials - Toughmet CX105 vs
- Case 60 shafting coated with metalife

Surface Roughness

Bearing - 32.2 to 39.6 u" Ra
Shaft - 12.6 to 15.5 u" Ra

Bearing Size - 1" OD X 1" long

Contact Area - 1.0 sq. inch (Projected Area)

Load - 50 psi increments to failure

Velocity - 100 to 600 ft/min

Lubricant

Test 1 - Dry

Test 2 - Quaker State SAE 10W - HD

Temperature - 72°F at the start

Thrust Washing Wear Test

Material

- Rotating Sample - Toughmet CX105
- Stationary - AISI 8620 Case
Carburized to 60 to 64 RC, surface coated with Metalife system

Surface Roughness

- Toughmet - 31.6 to 37.4 u" Ra
- Steel - 10.7 to 12.6 u' Ra

Contact Area - .2 sq. inches

Velocity - 100 ft/min

Load - 20 lbs, 100 psi

PV Level - 10,000

Lubricant

- Test1 - Dry
- Test 2 - Mobilith SHC 460 grease

Temperature - 72°F at the start

Test Duration - 20 hrs.

Test Procedure

Journal Bearing PV Limit Test

The test procedure was as follows:

- Wipe excess liquid from the Metalife coated steel samples
- Measure surface roughness, in u" Ra, on the Form Talysurf
- Install the bearing and shaft in the LFW 5 (Falex #5) Journal bearing test apparatus
- Apply load and start the shaft rotating at 100 ft/min
- Run for 30 minutes and measure friction force and bearing temperatures

- Increase load and run for an additional 30 minutes
- Continue the previous 2 steps until failure. During this process when the load capacity of the test apparatus was reached, the velocity was increased to 200, 300 etc. ft/min in order to increase the PV value
- At failure the test rig was allowed to cool and disassembled
- The surface roughness of the contact area was re-measured
- Take macrophotographs of the bearing and shaft

Failure was determined by the bearing smoking and increased friction

Test Procedure

Thrust Washer Wear Test.

The test procedure was as follows:

- Clean rotating sample in reagent grade methanol and wipe excess fluid off the metalife coated sample
- Weight samples on an analytical capable of 4 decimal places in grams
- Measure surface roughness of the sample in u" Ra on a Form Talysurf
- Assemble test samples in the LFW6 (Falex #6) thrust washer test apparatus apply grease where necessary
- Apply load and start test rig
- Allow test rig to run for 20 hours and measure friction force and temperature
- At the end of 20 hours, store test rig
- Reclean and reweigh samples
- Remeasure surface roughness
- Take macrophotographs of the test samples

Test Results

Table I & II show the results of this evaluation.

The PV limit for the combination was 31,000 in the unlubricated condition and 360,000 PV for the lubricated condition. The dry friction coefficient was .29 and the lubricated value was .02. The maximum temperature was 420°F for the unlubricated condition and 213°F for the lubricated condition.

There was slight damage to the bearing and shaft in the unlubricated condition and little to no damage in the lubricated condition.

Table II shows the results of the thrust washer wear tests. The friction coefficient in the unlubricated condition was .13 and in the lubricated condition was .08. The maximum temperature was 475°F for the unlubricated condition and 313°F for the lubrication test.

The wear rate for the unlubricated condition was 3.2 mg/hr and less than < 0.1 mg/hr for the lubricated test. Slight damage was noted on the unlubricated sample surface and very little damage was obvious on the lubricated sample.

Figures 1 & II show the overall appearance of the test samples after test.

Conclusions

The overall results for the Metalife coated samples show a considerable increase in PV limit when compared to previous tests run on uncoated samples. Similar comparisons to uncoated wear tests indicate that the wear rate was reduced significantly when coated with the metallife system.

If you have any questions, please do not hesitate to call me.

Sincerely,



Salvadore J. Calabrese
Research Specialist

Table 1 - Metalife Coating

	Journal Bearing	Wear Test
	Unlubricated	Lubricated*
PV Limit	31,000	360,000
Friction Coef.	.24	.02
Max Temp	420°F	213°F
Bearing/Shaft Clearance	.005"	.006"
<u>Roughness</u> <u>in u" Ra</u> **Shaft	32.4	12.2
Bearing Before Test	42.1	40.1
After Test	66.9	31.6
Max P	210	600
Max V	300	790

*Quaker State SAE 10W-HD

** BeforeTest - 13.6 u" Ra

Table II - Metal Life Coating

Thrust Washer Wear Test

	Unlubricated	Lubricated*
Test Duration	20 hrs.	20hrs.
Friction Coef.	.13	.08
Max Temp °F	475°	313°
Wear Rate in mg/hr	3.2	<.1
Surface Roughness in u" Ra	16.6	11.7
Comments	Ran Well	Ran Very Well

* Mobilith SHC 460 grease