MATERION

TECH BRIEFS

Enhancing ToughMet® 3 Alloy Bearing Performance with Metalife Hard Coated Steel

ToughMet® alloy is a spinodally hardened copper-nickel-tin alloy that combines high strength, lubricity and wear resistance under severe loading conditions. ToughMet® 3 CX105 alloy offers a similar friction coefficient to leaded bronze with a five-fold increase in load bearing capacity and far greater wear resistance. In comparative sleeve bearing tests against a hardened steel shaft, ToughMet alloy showed unprecedented performance for a metallic bearing material. ToughMet alloy's bearing properties can be further enhanced when coupled to steel that has been hard coated and polymer impregnated for improved performance.

This study compares the performance of ToughMet 3 CX105 alloy when coupled to steel (AISI 8620, case hardened to 60-64 HRC) with and without a hard coating surface treatment. Thrust washer wear tests and journal bearing PV limit tests were conducted. In addition to wear rates, bearing temperature and coefficients of friction were measured during testing. The steel was treated with Metalife's proprietary MLP coating, which consists of a petrochemical wax thermally introduced into the microcrystalline structure of molecular-bonded thin-dense chrome (72 HRC). The overall coating thickness was about 0.0001 inch (25.4µm).

A high-leaded tin bronze alloy, C93200, was tested under the same conditions. Both the ToughMet alloy and the Metalife coating technology increased the PV limit and reduced the wear rate in lubricated and dry running conditions. The mechanical properties of the alloys evaluated in these tests are provided.

Thrust Washer Wear Test

In the Falex #6 test, a copper alloy washer, rotating at constant speed (100 surface feet per minute 30.5 meters per minute) and load (20 pounds 88 Newtons), contacts a stationary steel plate. Both test pieces are nominally 1 inch in (25.4 mm) diameter and the contact area is 0.2 in^2 (129 mm^2), with a pressure = 100 psi (0.7 MPa). Wear rate is determined by weight loss measurements of the copper alloy; wear of the steel was negligible. Lubrication, either Mobilith SHC 460, a synthetic base grease containing lithium, or Krytox GPL 227 grease, was applied at the start of the test. The test concluded at a designated time or when the sample temperature increased significantly.

The only combination to produce zero measurable wear on both mating parts was ToughMet alloy on MLP-coated steel with grease lubrication. The differences in wear rate and coefficient of friction between the other lubricated samples can be considered negligible

Bearing	Steel	Lubri-cant	Test Time (hr)	PV (psi x sfpm)	Co-efficient of Friction	Wear Rate (mg/hr)
T3 CX105	8620 MLP	Mobilith	20	10,000	.08	0
C93200	8620	Krytox	20	10,000	.09	0.2
C93200	8620 MLP	Mobilith	20	10,000	.05	.6
T3 CX105	8620	Krytox	20	10,000	.07	0.8
T3 CX105	8620 MLP	Dry	20	10,000	.13	3.2
T3 CX105	8620	Dry	10	10,000	.34	3.4
C93200	8620 MLP	Dry	11	10,000	.25	12.3
C93200	8620	Dry	10	10,000	.60	431

Against the uncoated steel sample, in the lubricated tests, both the ToughMet 3 CX105 alloy and C93200 performed almost identically with both alloys exhibiting <0.1 coefficient of friction and <1 mg/hr wear rate. When the tests were conducted without lubrication, the wear rate for C93200 was more than one hundred times that of ToughMet alloy; the C93200 coefficient of friction was 76% greater than that of ToughMet alloy.

The addition of the Metalife coating to the steel surface is most notable in the unlubricated tests. Compared with the uncoated steel tests, both the ToughMet alloy and the C93200 experienced large reductions in wear rate and coefficient of friction. The ToughMet alloy-on-Metalife system had the best performance with a nearly-hydrodynamic 0.13 coefficient of friction. This was the only dry combination capable of running the entire 20 hours

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without erratic behavior indicative of the onset of seizing. The other dry tests were stopped before they seized and damaged the testing equipment.

Journal Bearing PV Limit Test

In the Falex #5 apparatus, the copper alloy sleeve bearings (1 inch OD x 1 inch long [25.4 mm x 25.4 mm]) were tested on a rotating steel shaft at 100 sfpm (30.5 surface meters per minute) with the bearing load increased in 50-psi (345 kPa) increments. All journal bearing tests used an AISI 8620 case hardened steel shaft that was either MLP coated or uncoated. The shaft roughness was about 10 micro-inches (0.25 μm)and the bearing alloy roughness was about 40 micro-inches (100 μm) Ra. When the test fixture's load capacity was reached, velocity was increased in about 100 sfpm increments until the coefficient of friction or test temperature increased significantly. Each test condition was run for 30 minutes before temperature and coefficient of friction measurements were taken. Lubrication was applied at the onset of testing and added as required during the test. The test was terminated at indications of excessive wear. The PV limit of each test is based on reasonable combinations of load and speed that did not result in excessive increases in friction and temperature.

Bearing	*Steel*	*Lubricant*	*Temp (°F)*	*Coefficient of Friction*	*PV (psi x sfpm)*
T3 CX105	8620 MLP	SAE 10W-HD	213	.02	360,000
T3 CX105	8620	SAE 10W-HD	-	-	275,000
C93200	8620 MLP	SAE 10W-HD	240	.02	160,000
C93200	8620	SAE 10W-HD	-	-	75,000
T3 CX105	8620 MLP	Dry	420	.24	31,000
C93200	8620 MLP	Dry	460	.44	22,000

Lubrication reduced the test temperature by about half and reduced the coefficient of friction by an order of magnitude. With lubrication, both copper alloys showed an approximate ten-fold increase in PV limit. As evidence of its higher strength and wear resistance, ToughMet alloy's lubricated PV limit is more than double C93200's against MLP coated steel, and the ToughMet alloy PV limit is about four times that for C93200 against the uncoated steel. Substituting MLP coated steel for uncoated steel increased the PV limit of both copper alloys in lubricated tests.

Conclusion

Comparing uncoated steel to a polymer impregnated, thin-dense chrome coated steel in thrust washer wear rate testing: the coefficient of friction and the wear rate of ToughMet 3 CX105 alloy were about the same in lubricated wear tests; while in unlubricated testing, the coefficient of friction decreased by about 60% and the wear rate was unchanged. C93200 showed similar results with the exception of much higher wear rates.

In journal bearing testing, the PV limit of ToughMet 3 CX105 alloy increased by 25% when comparing uncoated steel to a polymer impregnated, thin-dense chrome coated steel. The PV limit of C93200 increased by 100%, but was still well below ToughMet alloy's PV limit.

Metalife Industries is a company specializing in highly advanced industrial chrome processing. For additional information on Metalife or Metalife coatings visit their web site at www.metalifeind.com.

ToughMet® alloy is a registered trademark of Materion Corp.

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