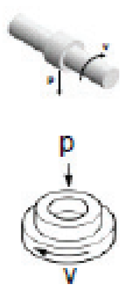
MATERION

TECH BRIEFS

ToughMet® Alloy with Solid Lubricant Inserts: A Maintenance-Free Option at Higher Speeds and Pressures

Self-lubricating bearings are used when operating conditions make it desirable or necessary for a plain bearing to run without external lubrication. Examples range from small engine and compressor bushings that are unlubricated at start-up to platen bushings in industrial presses that operate nearly continuously. Inserting solid lubricant plugs into a metal bushing or wear plate is a common method for making self-lubricating components. As a mating surface slides or rotates against these components, thin layers of lubricant are wiped into the interface. If the component is properly fitted to the application, the interface will be maintenance free over a long lifetime.



Generally, bearings with solid lubricant inserts are made with a base material of either steel or copper alloys, commonly manganese bronze or aluminum bronze. As with other bearing types, steel is used to provide high strength while the bronze alloys provide lower friction at moderate strength. Solid lubricant plugs provide lubrication and maintenance advantages, but the drilling of holes to accommodate the solid lubricant reduces the load-bearing capacity of the metal bushings. Bearings with solid lubricant inserts also must be kept below a maximum operating temperature, usually around 120°C (250°F), to avoid breakdown of the solid lubricant matrix. Because high speeds and/or loads generate excess heat from friction, solid lubricant insert bearings have a limited range of PV (pressure x linear speed) in which they can operate.

Recent tests have shown that solid lubricant insert bearings made with Materion Brush Performance Alloys' ToughMet alloy as the base material can be used without additional lubrication at higher pressures and speeds than can be achieved with other base materials. ToughMet 3 CX105 is a copper - 15% nickel - 8% tin alloy that combines the best attributes of steel with that of other bronze alloys. ToughMet 3 CX105 is used as a bearing material because it has a coefficient of friction lower than that of aluminum bronze or manganese bronze with a yield strength up to four times higher. In addition, ToughMet has twice the thermal conductivity of aluminum or manganese bronze so the bearings run cooler.

SLEEVE BEARNG TEST – PV LIMIT

A testing apparatus for determining the PV limit of a material is a 1" diameter shaft of hardened steel (HRC 60) fitted with a plain bearing of nominal 1" inside diameter by 1" long. The test is run at constant rotational speed between 200 and 400 surface feet per minute (sfpm) with incremental loading to the bearing.

Metal bearings without self-lubrication are initially wiped with oil and then relubricated with oil as needed to keep the coefficient of friction below 0.15 as the load is increased. Self-lubricating bearings with ToughMet were tested without external lubrication. Failure is defined to have occurred at the bearing stress where the coefficient of friction exceeds 0.15.

Materion Brush Performance Alloys
6070 Parkland Boulevard
Mayfield Heights, OH 4414 USA
phone: 216.486.4200 fax: 216.383.4005
e: BrushAlloys-Info@Materion.com

TECHNICAL INQUIRIES
ph: 800.375.4205

MATERION CORPORATION
www.materion.com

AT0053/0311

Table 1: Sleeve Bearing Test Conditions

Bearing Material	ToughMet 3 CX105 with solid lubricant plugs
Shaft Material	Case 60
Pressure	20 psi increments
Test Duration	30 minutes/load
Velocity	200 sfpm
Temperature	Room temp. at start

Table 1 shows the specific conditions for the test on ToughMet. In the unlubricated condition, ToughMet 3 CX105 with solid lubricant inserts was found to have a PV limit of 80,000 psi-sfpm (400 psi x 200 sfpm) with an average coefficient of friction of 0.07. In Table 2 are listed PV limits for other bearing materials in the lubricated condition. It is notable that ToughMet with solid lubricant inserts has a higher PV limit than C93200 leaded tin bronze with oil lubrication, a common choice for moderately loaded, intermediate speed systems.

Table 2: PV Limit Comparisons
(Oil lubricated unless otherwise noted)

Material	Maximum PV (psi-sfpm)
ToughMet 3	275,000
Manganese Bronze	150,000
Aluminum Bronze	125,000
ToughMet 3 with solid lubricant plugs, no oil	80,000
C93200 (Cu-7Sn-7Pb-3Zn)	75,000
60Cu-40Fe PM	35,000

Comparison Data from Bunting Bearing Corporation

Wear rate testing was performed on the same sleeve bearing test apparatus at a PV of 15,000 psi-sfpm (50 psi x 300 sfpm) for 100 hours. The wear rate of ToughMet with solid lubricant plugs in the dry condition was 8.3 x 10^{-8} in/in/hr.

THRUST PLATE TESTING – FRICTION AND WEAR

ToughMet 3 CX105 thrust plates, with solid lubricant inserts covering 30% of the surface, were run on a typical thrust bearing test apparatus. In this test, the bearing sample and mating steel disk are 2" in diameter. Pressure is applied normal to the mating surfaces and the steel disk is rotated at continuous speed. Table 3 contains parameters from the tests. In both tests, the plates were lubricated with grease on installation only. At a PV of 28,000 psi-sfm (2800 psi x 10 sfpm) in Test 1, the coefficient of friction, after a brief initial wear-in, was constant at about 0.01 for 8 hours (see Figure 1). There was no measurable wear of the thrust plate or roughening of the hardened-steel mating part during the entire test including wear-in.

Table 3: Thrust Bearing Test Conditions

Bearing Material	ToughMet 3 CX 105 with solid lubricant plugs	
Mating Material	S45C, carburized	
Testing Regime	Test 1	Test 2
Pressure	2800 psi	144 psi
Test Duration	8 hours	4 hours
Velocity	10 sfpm	400 sfpm
Temperature	Room temperature at start	

In Test 2, the speed was increased to achieve a PV of 57,000 psi-sfpm (145 psi x 400 sfpm). After an initial wear-in period of a few minutes, the coefficient of friction stabilized, this time at about 0.025 (Figure 2). Also shown in Figure 2 is the surface temperature that rose as high as 77°C (170° F) initially then decreased to near room temperature for the remainder of the test. The total surface wear on the thrust plate was 0.0001", most of which came during the brief wear-in period.

Materion Brush Performance Alloys
6070 Parkland Boulevard
Mayfield Heights, OH 4414 USA
phone: 216.486.4200 fax: 216.383.4005
e: BrushAlloys-Info@Materion.com

TECHNICAL INQUIRIES
ph: 800.375.4205

MATERION CORPORATION
www.materion.com

Figure 1: Thrust Bearing Test 1 Coefficient of Friction

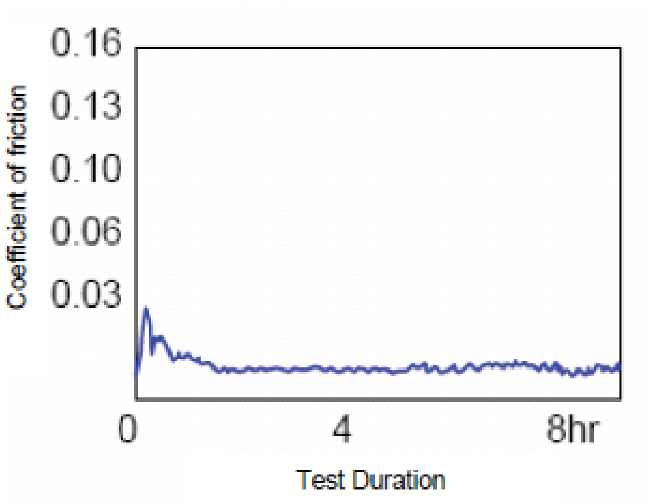
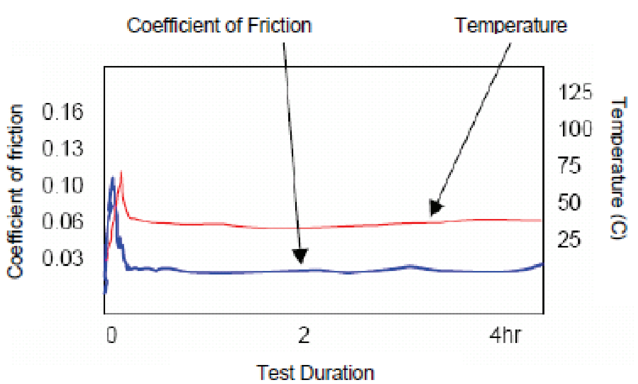


Figure 2: Thrust Bearing Test 2 Coefficient of Friction and Temperature



CONCLUSIONS

1. At moderate speeds and pressures, ToughMet alloy bearings with solid lubricant inserts may be used as maintenance-free replacements for lubricated leaded tin bronze bearings.

2. Depending on operating environment, ToughMet alloy bearings with solid lubricant inserts may show little or no wear at PV values in excess of 57,000 psi-sfpm, especially if lubricated on installation.

3. The property combination of strength, lubricity and thermal conductivity of ToughMet makes it a superior base material for solid lubricant insert bearings.

ACKNOWLEDGEMENT

The bearings with solid lubricant inserts were manufactured by LuBo Industries using ToughMet supplied by Materion Brush Performance Alloys. The thrust plate testing was performed by LuBo.

Materion Brush Performance Alloys
6070 Parkland Boulevard
Mayfield Heights, OH 4414 USA
phone: 216.486.4200 fax: 216.383.4005
e: BrushAlloys-Info@Materion.com

TECHNICAL INQUIRIES
ph: 800.375.4205

MATERION CORPORATION
www.materion.com