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TECH BRIEFS

ToughMet® Alloy Plain Bearings – Performance with High PV

ToughMet alloy, made by the EquaCast® product process, is a spinodally hardened CuNiSn alloy system that has shown exceptional bearing performance in a wide range of demanding applications. This lead-free alloy is pre-heat treated to high yield strengths, in excess of 100 ksi (700Mpa)…while having high corrosion resistance, good thermal conductivity, machinability and low coefficient of friction. ToughMet alloy also provides excellent high temperature stability including 600°F (315°C) durability and very good creep and stress relaxation resistance.

A series of standardized journal bearing tests showed ToughMet alloy far exceeds conventional bronzes in PV Limit performance. ToughMet alloy was evaluated in both cast (CX) and wrought (AT) conditions.

Temper	0.2% Offset Yield Strength	Ultimate Tensile Strength	Elongation	Hardness
CX 105	105 ksi 724 MPa	110 ksi 758 MPa	4%	HRC 28
AT 110	110 ksi 758 MPa	125 ksi 862 MPa	10%	HRC 30

Table 1. ToughMet 3 Alloy Properties

Comparative Behavior

Placed in the context of other materials for plain bearings, the following table illustrates the position of ToughMet alloy.

This extracted table is the result of essentially identical testing over many years at the same testing and evaluation source and provides a baseline by which one might rank materials.

In the non-lubricated condition ToughMet alloy exhibited PV Limit similar to lubricated materials including graphite impregnated copper, low lead tin babbit and carbon bearings, approximately 16-18,000 psi-sfpm (0.56-0.63 MPa-m/s).

In the lubricated condition, ToughMet alloy with a typical bearing finish of 10 µ-in (0.3 µm) showed PV Limit values significantly higher than any other bearing alloy, including the popular cast manganese and aluminum bronzes.

As a plain bearing, ToughMet alloy achieved a PV-limit of 260-290,000 psi-sfpm (9-10 MPa-m/s), comparable to very high performance hybrid polymeric bearing materials.

PV Limit Comparisons

Material (Lubricated, except where noted)	Maximum PV	
	(psi-sfpm)	(Mpa m/s)
ToughMet ® 3	275,000	9.63
Manganese Bronze	150,000	5.25
Aluminum Bronze Cast	125,000	4.38
C93200	75,000	2.63
SAE 841 Bronze PM	50,000	1.75
SAE 863 Fe PM	35,000	1.23
60 Cu 40 Fe	35,000	1.23
PM SAE 850 Fe	30,000	1.05
High Tin Babbitt (89%)	30,000	1.05
Low Tin Babbitt (10%)	18,000	0.63
ToughMet ® 3 Unlubricated	17,000	0.60
Graphite/Metallized Brgs	15,000	0.53
Carbon	15,000	0.53
Low Tin Low Pb (6%) Babbitt	12,000	0.42

Table 2. PV Limit Comparion Data from Bunting Bearing Corp.

Plain Bearing Tests

The basic testing apparatus for determining the PV Limit is a 1 inch diameter shaft of hardened steel (HRC 60) fitted with a plain bearing of nominal 1 inch (25.4 mm) ID x 1 inch (25.4 mm) long. The test was run at constant rotational speed with incremental loading to the bearing.

This test has been used for over a decade to establish basic plain bearing alloy performance comparisons by a prominent bearing manufacturer and data are publicly available.

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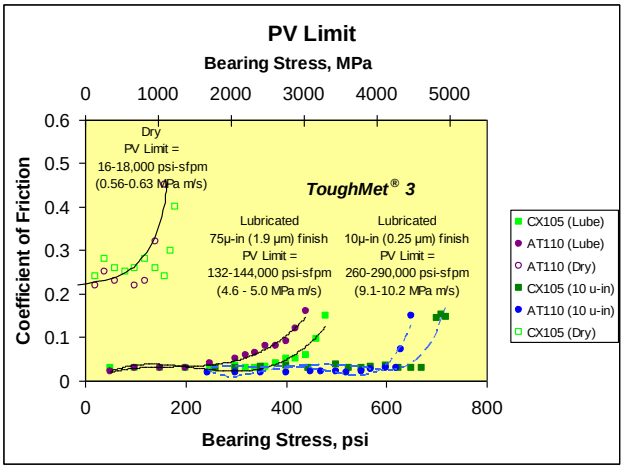
Bearing Materials	ToughMet 3 CX105 Alloy ToughMet 3 AT110 Alloy
Shaft Material	Case 60
Velocity	300 – 400 sfpm 1.52 – 2.03 m/s
Temperature	Room Temperature at Start
Normal Pressure	20 psi (138 kPa) increments
Lubricant	SAE 10 W HD
Surface Roughness µ-in R_a (µm R_a)	Shaft 10 – 20 (0.25 – 0.51)
	Bearing 75 and 10 (1.9 and 0.25)

Table 3. Test conditions

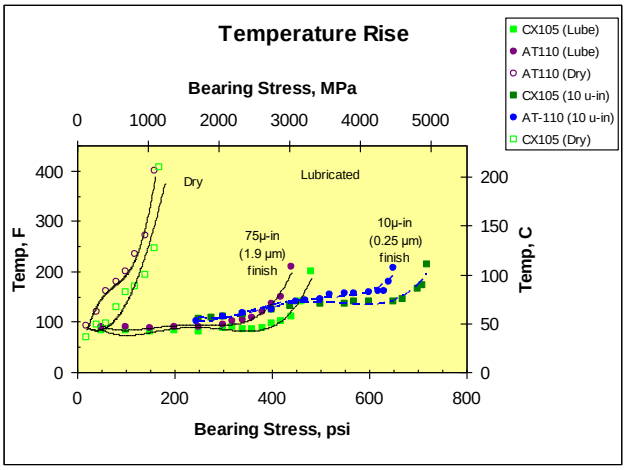
Three sample conditions were assessed including two surface finishes, one of which was tested in the unlubricated condition. Lubricant was wiped on before the test and additional drops of lubricant were applied as necessary to keep the friction coefficient below 0.1 as the load was increased. Failure is defined to have occurred at the projected bearing stress when the coefficient of friction exceeds 0.15 or the measured temperature increases above about 210F (100C).

RESULTS

As with other materials, the PV Limit for ToughMet alloy in the dry condition was considerably lower than that for the lubricated condition as shown in the following figures.



With lubrication and a nominal 10 µ-in (0.3 µm finish typical of plain bearings, PV Limit values were 260-290,000 psi-sfpm (9-10 MPa-m/s) while the nominal 75 µ-in (1.9 µm) finish showed 132-144,000 psi-sfpm (4.6-5.0 MPa-m/s) value.



The PV and Temperature Rise diagrams for the lubricated cases also show the tendency within one category of surface finish, for the cast (CX) microstructures to have slightly better PV Limit than the wrought (AT) material at the same strength level.

CONCLUSIONS

Plain Bearing tests were conducted to establish the PV Limit of ToughMet 3 alloy with a yield strength in excess of 100 ksi (690 MPa):

1. ToughMet alloy exhibited a PV Limit of about 275,000 psi-sfpm (9.6 MPa-m/s) against a high hardness bearing steel, in excess of 75% higher than popular manganese bronze and approaching high performance hybrid polymers.
2. ToughMet CX alloy cast product performed slightly better than the AT wrought product.
3. Non-lubricated testing showed ToughMet alloy to behave similarly to lubricated graphite impregnated copper, low lead tin babbit and carbon bearings.
4. Improving the surface finish from 75 µ-in (1.9 µm) to 10 µ-in (0.3 µm) doubled the PV Limit.

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REFERENCES

1. W.A. Glaeser, "Wear Properties of Heavy Loaded Copper-Based Bearing Alloys", J. Metals, October 1983, pp. 50-55.
2. ToughMet3 AT alloy and CX Datasheets, Materion Performance Alloys
3. "Spinodal Decomposition In ToughMet® Alloys", Materion Performance Alloys TechBrief AT0025.
4. Machining of ToughMet® alloy, Materion Performance Alloys Tech Brief AT0029.
5. ToughMet alloy & EquaCast® product are registered trademarks of Materion Corp.

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