Materials and Design 32 (2011) 3756–3764

Contents lists available at ScienceDirect

Materials and Design

journal homepage: www.elsevier.com/locate/matdes

Surface durability and design criteria for graphite–bronze sintered composites in dry sliding applications

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ARTICLE INFO

Article history:
Received 20 January 2011
Accepted 20 March 2011
Available online 8 April 2011

Keywords:
Wear
Non-ferrous metals and alloys
Selection for material properties

ABSTRACT

Sintered bronze with the addition of graphite as self lubricant is widely used in sliding bearings and bushes applications, especially where grease and oil lubricant cannot be considered. Aim of this work is to study the dry sliding wear behavior of a porous sintered bronze–graphite composite, which is characterized by a transition from solid lubrication to adhesive wear. In this last condition graphite loses its efficiency as solid lubricant due to the frictional heat. The efficiency of the solid lubrication was examined at different loads and sliding velocities; it decreases on increasing both load and velocity. The behavior in the different dry sliding conditions was investigated and the corresponding flash temperature was calculated. Results indicate that transition occurs when the flash temperature reaches at least 360 K. Some design guidelines were then proposed, based on a P_0 vs. v map, which defines the parameters ensuring both that no plastic deformation occurs and that solid lubrication is efficient during dry sliding. The relative design scheme gives a tool to verify if the dimensional and geometrical characteristics of the part are guaranteed during its expected life.

1. Introduction

Sintered bronze/graphite composites are widely used in sliding bearings and bushes applications due to their heat conductivity, wear resistance and low friction [1,2]. Solid self-lubricants are chosen for production of bearing materials and generally considered for use where grease and oil lubricants cannot be used [3,4]. Graphite is one of the most common self-lubricants. Its structure is a hexagonal lamellar one, with weak Van der Waals forces between interlayers of C atoms, that makes it easy shearing along the basal plane of the crystalline structure. The effect of graphite depends on environment and temperature. Bryant et al. showed that in vacuum the interlayer bond strength is from 6 to 10 times as high as values reported in air [5]. When substances such as water vapor or oxygen are present, they prevent the II-electron bonding so that the interlayer forces are reduced effectively to Van der Waals forces. According to Lansdown [6] graphite becomes a good lubricant when contaminants as water vapor are intercalated between the carbon layers. Water vapor and other volatile compounds cease to be effective above about 423 K. Above 620 K graphite gives low fraction coefficients in contact with some metal surfaces due to the interaction with surface oxides. Finally, it begins to oxidize above 810 K, and friction coefficient starts increasing again. So, the solid lubricant effect of graphite is limited to temperatures either below 423 K or between 620 K and 810 K.

The effect of environment was investigated by Jun-hong Jia et al. [7], who made a comparative study between dry and water lubricated conditions for a bronze–graphite composite against stainless steel. They established that water lubrication improves the wear resistance since it hinders the transfer of the composite onto the counterface steel, reduces the surface temperature and provides boundary lubrication.

The dry sliding wear resistance and frictional properties of composites with different amounts of graphite (from 8% up) were investigated by Moustafa et al. [8]. On increasing the load, a low-mild-severe wear transition occurs, due to the change in the wear mechanism from oxidative to delamination (surface plastic deformation) to extreme plastic deformation, fragmentation and growing (seizure). Transition is accomplished by an increase in the friction coefficient. The presence of graphite improves the wear and frictional properties, thanks to the smeared graphite layer at the sliding surface generated by the extrusion of graphite to the surface. On increasing the amount of graphite, the transition is shifted towards higher loads, because of the thicker smeared graphite layer formed on the surface.

The effect was confirmed by Chen et al. [9] and by Jun-hong Jia et al. [7], even if in the former study friction coefficient also

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doi:10.1016/j.matdes.2011.03.048