Review on Tribological Behaviour of Bronze-Metal matrix Composite

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***Abstract**:Metal matrix composites are engineered materials with a combination of two or more dissimilar materials, (at least one of which is a metal) to obtain enhanced properties. The use of different kind of composite materials is in constant growing over the years, because they have better physical, mechanical and tribological properties comparing to matrix materials. Bronze, an industrially relevant material, is always at a constant need for improvement in its properties. It should possess superior hardness, wear resistance and high tensile properties. The microstructure of the composite was characterized by using an optical microscope. The mechanical and tribological tests were carried out on the developed composite samples as per standards. It was observed that the hardness of the developed bronze composite increases with an increase in the reinforcement addition. The tensile properties were found to improve with addition of reinforcement particles into bronze matrix but.*

***Keywords:** Metal matrix Composite, Friction and wear, Tribology Setup.*

1. INTRODUCTION

bronzes are commonly used for a variety of tribological applications are used in journal and sleeve bearings, bushings and other heavy load supports in airframes, off-road construction equipment, mining equipment, and heavy manufacturing equipment. The alloys are known to be less susceptible to scuffing and galling under severe contact conditions in the boundary lubrication regime. In general, these alloys have a combination of properties such as adequate strength, excellent corrosion resistance, and high thermal conductivity that make them suitable for various challenging tribological applications. Bronze and brass alloys with a variety of compositions and microstructures are commercially available and are used for tribological applications. Bronze is not a good candidate for hard coatings, in part because it is relatively soft and in part because of inherently poor adhesion of coatings onto copper-based materials.

Another approach that could be applicable for bronze material is near-surface region is microstructural modification. This can take the form of machining, mechanical peening, etc. Such operations can be used to cold work or refine the grain size and microstructure of the near-surface layer through recrystallization. The near-surface layer properties of relatively soft materials can also be enhanced by the incorporation of a hard second phase. This can be done by a variety of techniques such as near-surface melting and particle incorporation, for instance by laser. of course, melting and re-solidification of the near-surface material can sometimes be accompanied by some undesirable defects such as microstructural and compositional heterogeneities, both of which can have detrimental effects on the properties and performance of the surface layer. A relatively new surface modification technique that can be used to enhance the near-surface material properties of bronze is friction stir processing (FSP).

1.1 Composite materials

It consists of just two materials in which on is matrix or binder surrounds the other material called reinforcement in the form of fibres or particulate. Generally, a composite material is composed of reinforcement (fibers, particles, flakes, and/or fillers) embedded in a matrix (polymers, metals, or ceramics). The matrix holds the reinforcement to form the desired shape while the reinforcement improves the overall mechanical properties of the matrix. When designed properly, the new combined material exhibits better strength than each individual material.

Volume fraction of component materials should be above 5 % of total volume and their properties must differ from one another. Usually, volume fraction of one material is significantly higher than the volume fractions of the others and that material is called – matrix. Matrix can be ceramic, metal and polymer.

"The composites are compound materials which differ from alloys by the fact that the individual components retain their characteristics but are so incorporated into the composite as to take advantage only of their attributes and not of their shortcomings", in order to obtain an improved material. Composites are multifunctional material systems that provide characteristics not obtainable from any discrete material. They are cohesive structures made by physically combining two or more compatible materials, different in composition and characteristics and sometimes in form. Composite materials are heterogeneous materials consisting of two or more solid phases, which are in intimate contact with each other on a microscopic scale. They can be also considered as homogeneous materials on a microscopic scale in the sense that any portion of it will have the same physical property

1.2 Need of Composite Material

The biggest advantage of composite material is to enhancing mechanical and physical properties such as light weight as well as strong and system efficiency. The use of different kind of composite materials is in constant growing over the years, because they have better physical, mechanical and tribological properties compared to matrix materials. Composites based upon light metals like aluminium, magnesium and zinc, grace to their low density, are being applied in many industries, including the automotive. Among all these, Brass based composites might be the most frequently used ones and extensive research has been performed on possibilities of their use for manufacturing of the tribomechanical components, so they will be analyzed in the following text as representatives of the light metals based composites. While composites have already proven their worth as weight-saving materials, the current challenge is to make them cost effective. The efforts to produce economically attractive composite components have resulted in several innovative manufacturing techniques currently being used in the composites industry. It is obvious, especially for composites, that the improvement in manufacturing technology alone is not enough to overcome the cost hurdle. It is essential that there be an integrated effort in design, material, process, tooling, quality assurance, manufacturing, and even program management for composites to become competitive with metals.

The composites industry has begun to recognize that the commercial applications of composites promise to offer much larger business opportunities than the aerospace sector due to the sheer size of transportation industry. Thus the shift of composite applications from aircraft to other commercial uses has become prominent in recent years. MMCs have also begun to substitute for conventional materials in household appliances, computers, audio and video equipment, as well as in sport appliances. Compressive and tensile strength, as well as the hardness at room and elevated temperatures, are also increased significantly, resulting in an improvement in the wear resistance of the composite material.

Whilst the use of composites will be a clear choice in many instances, material selection in others will depend on factors such as working lifetime requirements, number of items to be produced (run length), complexity of product shape, possible savings in assembly costs and on the experience & skills the designer in tapping the optimum potential of composites. In some instances, best results may be achieved through the use of composites in conjunction with traditional materials.

1.3 **Characteristics of the composite**

Composites consist of one or more discontinuous phases embedded in a continuous phase. The discontinuous phase is usually harder and stronger than the continuous phase and is called the 'reinforcement' or 'reinforcing material', whereas the continuous phase is termed as the ' matrix'. Properties of composites are strongly dependent on the properties of their constituent materials, their distribution and the interaction among them.

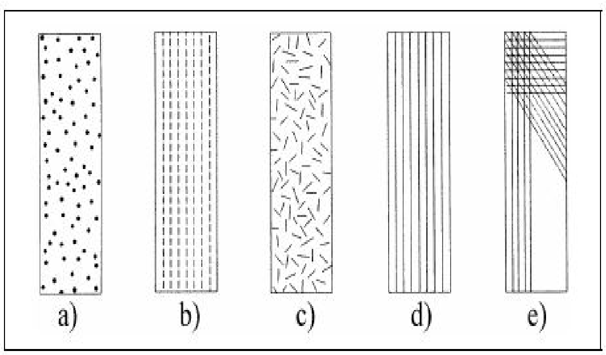

Figure 1: Orientation and Shape of reinforcement in composite material

The shape of the discontinuous phase (which may by spherical, cylindrical, or rectangular cross-sanctioned prisms or fibers), the size and distribution (which controls the texture of the material) and volume fraction determine the interfacial area, which plays an important role in determining the extent of the interaction between the reinforcement and the matrix. The orientation of the reinforcement affects the isotropy of the system. A fibrous reinforcements are characterized by its length and diameter so we distinguish, long (continuous) fibers (Figs. 1d and 1e) and short (discontinuous) fibers - whiskers (Figs. 1b and 1c). Arrangement can be, as well, preferred (Fig. 1b) and random (Fig. 1c), and often the direction of fibers is changed from one layer to another (Fig. 1e).

2. LITERATURE SURVEY

Title, Name & Year	Input Parameter	Response Parameter	Optimization Technique	Work material	Remark
Optimization Study on Surface Roughness and Tribological Behavior of Recycled Cast Iron Reinforced Bronze MMCs Produced by Hot Pressing Aydın Güne MDPI-2021	Reinforcement, Temperature and pressure	Wear rate, surface roughness and coeff of friction	Taguchi Method	Bronze with graphite	The obtained findings reveal that a 10% reinforcement ratio gives better surface quality and coefficient of friction Taguchi design of experiment technique can be very efficiently used in the optimization of process parameters
Development of Bronze Metal Matrix Composite for Automobile and Marine Applications Rohit U. Krishnan Materials Science Forum-2019	Reinforcement, load and temperature	Wear rate, hardness and tensile strength	Taguchi Method	Bronze and SiC	It was observed that the hardness of the developed bronze composite increases with an increase in the Reinforcement addition. The tensile properties were found to improve with addition of reinforcement particles into bronze matrix The tensile properties of the developed composite increased significantly and reduced the Percentage elongation rate compared to that of unreinforcement bronze.
Tribological Investigation and Development of bronze composite Bearing Material	Reinforcement and load	Wear rate	Taguchi Method	bronze with SiC	It has been observed that at same operating conditions pure brass has higher wear value as compare to brass composites.

Sagar Shinde IJCET-2018					
On some mechanical properties and wear behavior of Sintered bronze based composites reinforced with some Aluminides micro additives E. Feldshtein IJMET-2017	Reinforcement, Speed, load	Wear rate	Taguchi Method	Bronze and Al_2O_3	Taguchi design of experiment technique can be very efficiently used in the optimization of process parameters Adding reinforcement in sintered bronze leads to increasing its hardness, but the flexural strength may increase or decrease depending on the chemical composition of aluminides.
Tribotechnical Properties Of Sintered Bronze-Based Composites Reinforced With Al-Based Hard Particulates Larisa Dyachkova Composite theory and practice-2017	Reinforcement, load and sliding speed	coeff of friction and wear rate	Taguchi Method	bronze with Ni	as a rule it is lower in comparison with sintered bronze under stable Loading and concentrated contact conditions. When the loading is increased, differences in the friction coefficients are observed. In the MMC wear process, micro-craters are formed on the contact surface and it is the principal reason for the decrease in the wear rate
Enhancement of bronze alloy surface properties by FSP second-phase particle incorporation O.O. Ajay Elsevier -2017	Reinforcement, speed and time	Wear rate and heat affected zone	Taguchi Method	Bronze with Mg	The FSP process produced some increase in the hardness of the processed surface layer via a combination of grain refinement and dispersion hardening. In the as-processed condition, FSP treatment resulted only in marginal improvement in wear. Surface polishing to remove the roughening effect and the loose

					burrs associated with the FSP process resulted in significant improvement in the sliding wear resistance of the bronze material under lubricated sliding contact against hardened steel. Given the observed load shielding by hard second-phase particles in the baseline bronze
Dry sliding friction and wear behavior of bronze matrix composites reinforced with Ni3Al particles: Comparison with conventional brake lining brahim Çelikyüre Int. J. Mater. Res-2016.	Percentage of Reinforcement, Sliding distance	Wear rate, Tensile strength and hardness	Taguchi Method	Bronze With Ni3A	the reinforcing particles may reduce the wear resistance instead of increasing it through moving from the matrix At the lower sliding speed the coefficients of friction of composites increased with increasing friction load whereas it reduced for conventional brake lining. In addi- tion, the coefficient of friction of composite also increased with increase in reinforcing particle size at the lower sliding speed
Microstructure And Tribological Properties Of Tin Bronze-Graphite Composites Made By Stir Casting	Reinforcement, load and sliding speed	Wear rate	Taguchi Method	Bronze with Graphite	The results indicate possibility of manufacturing of good quality, especially in terms of tribological properties, composite materials with particles of lubricating phase (graphite) in the process of melting and casting with simultaneous mechanical stirring in a liquid state and confirm the possibility of application of the examined composite materials of lead-free copper-graphite type for sliding elements operating in conditions of increased friction and wear.

1.3 CONCLUSIONS

1. The available literatures about metal matrix composites reveal that there are different types of reinforcement such as graphite, boron carbide, tungsten disulphide and molybdenum disulphide which reduces the wear rate and improves the mechanical properties of the brass based metal matrix composite materials.
2. The experiments were carried out and on the basis of comparison with the results & the analysis, it was concluded that the predicted values match the experimental values reasonably well for Wear rate, Hardness, Tensile Strength etc.
3. The optimization techniques used by various researchers with different techniques are Taguchi method, RSM (Response Surface Methodology), Algorithm, Grey rotational analysis were mentioned in the review
4. From the literature survey it clear that very few works has been carried out by varying wt% of SiC as a parameter for dry sliding wear rate of bronze as a base material and SiC as reinforcement in composite using Tribology Setup.
5. From the literature it is also clear that many researchers have studied the effect of different parameters like load, sliding velocity, sliding distance, frequency, temperature, counter face hardness and weight percentage of reinforcement and found out that these parameter have significant influence on wear rate. But less work has done with combination of load, reinforcement, and Frequency was not studies.
6. A lot of research on the dry sliding wear behavior of MMCs has been reported. It is clear from the above literature that the wear properties are improved remarkable by introducing a hard inter metallic compound into the aluminium matrix. Work published in the literature is mainly concerned with SiC. A few attempts have been made to fabricate MMC to increase the wear resistance characteristics using low cost reinforcement like bauxite, corundum, granites, and sillimanite. The ever-increasing demand for low cost reinforcement stimulated the interest towards the utilization low cost reinforcement like SiC.
7. From the literature survey it clear that very few work has been carried out by varying wt% of silicon carbide powder as a parameter for dry sliding wear rate of bronze as a base material and silicon powder powder as a reinforcement in composite using pin tribology Setup machine.
8. Mechanical properties of the silicon powder powder is better than the earlier material used by the researchers, so, I have used this material to increase the strength, hardness and less wear rate than the other material.

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