An Experimental Study on Metal Matrix Composites

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Research Article

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ABSTRACT

Aluminium alloy LM6 were reinforced with 3%, 6% and 9% of boron carbide and 3%, 6% and 9% of fly ash is mixed together by liquid metallurgy technique called stir casting. In this reinforcement is preheated to the temperature of about 5000C by using muffle furnace. The wear experiment was carried out by using a pin on disc apparatus for the different load variation of 1.5kg, 3kg and 4.5kg and sliding speed of 1m/s and sliding distance of 1000m. Tribology data acquisition system is used to study the wear rate and coefficient of friction for hybrid metal matrix composites.

So it is mostly preferred in manufacturing of automotive engine parts and it is also influence high hardness and strength. For example Al/SiC/Gr is one of the hybrid metal matrix composites. Recently modern industry rapidly introducing different composites due to their high unique properties.

INTRODUCTION

Composite material is a material composed of two or more distinct phases (matrix phase and reinforcing phase) and having bulk properties significantly different from those of any of the constituents. Many of common materials (metals, alloys, doped ceramics and polymers mixed with additives) also have a small amount of dispersed phases in their structures, however they are not considered as composite materials since their properties are similar to those of their base constituents (physical property of steel are similar to those of pure iron) . Favourable properties of composites materials are high stiffness and high strength, low density, high temperature stability, high electrical and thermal conductivity, adjustable coefficient of thermal expansion, corrosion resistance, improved wear resistance etc.

Metal matrix composites has been identified as attractive materials for the wide range of applications in the field of structural design, electronics system and electronic packaging .Aluminium alloys reinforced with various ceramics such as silicon carbide and aluminium oxide are a unique class of advanced composite material developed for use in aerospace and commercial applications [1-3]. Compared with unreinforced metals, MMC exhibits significant improvements in strength and elastic modulus, wear resistance, fatigue resistance and damping capacity, in addition to high temperature mechanical properties and low thermal expansion. Since the coefficient of thermal expansion of metal matrix composites can be tailored by varying the nature, volume fraction and morphology of the reinforcment in the composite, many applications of aluminium metal matrix composites require controlled thermal expansion characteristics in order to match those of other components [4,5].

A low CTE and high thermal conductivity are desirable for applications such as electronic heat sinks and space structures. Furthermore low density is desirable for aerospace applications, particularly electrical structural applications [6-8]. Conventional metals for electronic packaging application include copper, aluminium, Ni-Fe alloys. However these materials do not meet the requirements in advanced electronic packaging applications for low CTE, high thermal conductivity, low density and low cost. One of the most widely used composites is the aluminium based composites. Aluminium matrix composites refer to the class of light weight high performance aluminium centric materials. The reinforcement in AMCs could be in the form of continuous or discontinuous fibres, whiskers or particulates with volume fractions ranging from a few percent to 70%. Reinforcements commonly used in aluminium matrix composites have been extended to include organic wastes such as rice husk ash, coconut shell ash, palm oil fuel ash, and fly ash and sugar cane bagasse. Ceramic materials being used as reinforcement include carbides, borides, nitrides and alumina. These have been reported to produce desired physical and mechanical properties in aluminium based composites [9-13].

The use of aluminium matrix composites has attracted interest in aerospace, defence and automotive applications owing to high strength to weight ratio, improved stiffness and controlled thermal expansion coefficient. The liquid state processing technique especially stir casting is a promising method for production of aluminum metal matrix composites because of their simplicity and ease of manufacture.

When three materials are present it is called as hybrid metal matrix composites. Hybrid metal matrix composites provides excessive strength and hardness when compared to the normal material. So it is mostly preferred in manufacturing of automotive engine parts and it is also influence high hardness and strength. For example Al/SiC/Gr is one of the hybrid metal matrix composites. Recently modern industry rapidly introducing different composites due to their high unique properties.

LITERATURE REVIEW

A,Baradeswaran , S.C.Vetrivel , A.Elaya Perumal , N.Selvakumar and R. Franklin Issac investigated on mechanical behaviour, modelling and optimization of wear parameters of B4C and graphite reinforced aluminium hybrid composites and concludes that the wear resistance of the composites was increased with the addition of 10 wt % B4C and 5 wt % graphite particles [14,15].

Ashok Kr. Mishra, Vinod Kumar, Rajesh Kr. Srivastava has investigated on Optimization of Tribological Performance of Al-6061T6-15% SiCp-15% Al2O3 HybridMetal Matrix Composites Using Taguchi Method & Grey Relational Analysis and concludes that the Incorporation of SiC and Al2O3 particulate increases the wear resistance of hybrid composites by performing a protective layer between pin and counterface. It has a significant effect on the friction and wear depth.

N. Radhika, R. Subramanian,S. Venkat Prasad has investiged on Tribological Behaviour of Aluminium/Alumina/Graphite Hybrid Metal Matrix Composite Using Taguchi’s Techniques and concludes Incorporation of graphite as primary reinforcement increases the wear resistance of composites by forming a protective layer between pin and counter face and the inclusion of alumina as a secondary reinforcement also has a significant effect on the wear behaviour.

Muharr em Pul ,, Recep Çalin , Ferhat Gül has investigated abrasion in Al–MgO metal matrix composites and concludes that hardness values of the composite specimens increasewith the MgO reinforcement rate, the amount of resistance decreases and the amount of wear multiplies and the amount of wear increases as the amounts of load applied and particles multiply.

K.Umanatha, S.T.Selvamanib, K.Palanikumarc and R.Sabarikreeshwarana has investigated Dry Sliding Wear Behaviour of AA6061-T6 Reinforced SiC and $Al2O_3$ Particulate Hybrid Composites and concludes that the The wear decreases with increase in vol. content of reinforcements.

S.A.Alidokht A.Abdollah-zadeh H.Assadi has investigate on the effect of applied load on the dry shielding wear behaviour and subsurface deformation on hybrid metal matrix composites and concludes that the the wear resistance of hybrid metal matrix composistes increases with increase in percentage of MoS2.

M. Uthayakumar ,S. Aravindan b, K. Rajkumar has investigate on Wear performance of Al–SiC–B4C hybrid composites under dry sliding conditions and concludes that this hybrid composites show that, could not perform better at higher load and higher sliding speed.and the wear rate and coefficient of friction decreases with increase in the sliding speed upto 4m/s.

K.R. Padmavatha, Dr. R.Ramakrishnan has investigated on the Tribological behaviour of Aluminium Hybrid Metal Matrix Composite and concludes that Aluminium reinforced with SiC and MWCNT exhibits better dry abrasive wear resistance and Hardness of the composites increase as the hybrid ratio increases.

K.Umanatha, S.T.Selvamanib, K.PalanikumarKc and D.Niranjanavarmaa has investigated on the Metal to Metal Worn Surface of AA6061 Hybrid Composites Casted by Stir Casting Method and concludes that the The porosity of the test material increases with increase in vol. fraction of reinforced particles.

EXPERIMENT

For the pin-on-disk wear test, two specimens are required. One, a pin with a radiuses tip, is positioned perpendicular to the other, usually a flat circular disk. A ball, rigidly held, is often used as the pin specimen. The test machine causes either the disk specimen or the pin specimen to revolve about the disk centre. In either case, the sliding path is a circle on the disk surface. The plane of the disk may be oriented either horizontally or vertically. Wear results may differ for different orientations. The pin specimen is pressed against the disk at specified load usually by means of an arm or the lever and attached weights. Other loading methods have been used, such as, hydraulic or pneumatic.

Wear results may differ for different loading methods. Wear results are reported as volume loss in cubic millimetres for the pin and the disk separately. When two different materials are tested, it is recommended that each material be tested in both the pin and disk positions. The amount of wear is determined by measuring appropriate linear dimensions of both specimens before and after the test, or by weighing both specimens before and after the test.

If linear measures of wear are used, the length change or shape change of the pin, and the depth or shape change of the disk wear track (in millimetres) are determined by any suitable metrological technique, such as electronic distance gaging or stylus profiling. Linear measures of wear are converted to wear volume (in cubic millimetres) by using appropriate geometric relations. Linear measures of wear are used frequently in practice since mass loss is often too small to measure precisely. If loss of mass is measured, the mass loss value is converted to volume loss (in cubic millimetres) using an appropriate value for the specimen density.

EXPERIMENTAL PROCEDURE

“The aluminium hybrid metal metal matrix composites are fabricated by stir casting method. Before stir casting the reinforcements are preheated to the temperature of about 5000C by using muffle furnace and reinforcement after preheating is added to the aluminium alloy which is in liquid state and it is get stirred by using stir casting apparatus at the speed of 500 rpm and the hybrid metal matrix composites in the liquid state is taken and it is get poured into the cylindrical shape die. After pouring into the die it is then allowed to cool for some time and the composite called hybrid metal matrix composite is obtained as shown in the figure below (Figure 1).

Figure 1. Aluminium hybrid metal metal matrix.

After Casting the material is machined to the required dimensions for the pin on disc test and the test is carried out for different parameters such as load, sliding distance, speed and time and the various results are discussed (Figure 2).

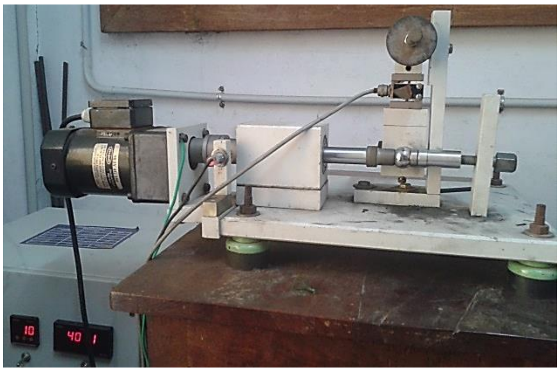

Figure 2. Experimental Setup.

The dimensions of the pin are pin length of 50mm and the diameter of the pin is 6mm.After machining the test piece specimen made to insert to the pin holder and it is tightened. The disc called EN31 is placed below the surface of the pin and surface.

The Variation of coefficient of friction of the composite of three different percentages for the applied load as shown in figure 1.1. The coefficient of friction for 3% is increases with the increase for the applied load of 15 N and the coefficient of friction for 6% is increases with decrease for the applied load of 30N and coefficient of friction for 9% is increases with increase for the applied load (N) .The coefficient of friction is high for the composite for 9% when compared to 3% and 6%. The reduction of coefficient of friction is due to the major role played by the formation of boron oxide layer at the contact zone. The boron carbide reacts readily with environment and leads to the formation of boron oxide layer. The formation of boron oxide layer is influenced by the generation of heat. It is observed coefficient of friction decreases up to the load of 30N for 3% and 6% and drastically increases.

DISCUSSION

The Variation of Wear loss of composite reinforced with boron carbide and fly ash with aluminium alloy lm 6 with the normal load is shown in the above graph. The wear loss for the composite increases with increase for the applied load (N). The aluminium with boron carbide and fly ash pin of 3% showing the continuous increase of weight loss and then it is drastically increase for the increase in percentage of boron carbide and fly ash.

The Variation of wear rate for the composite reinforced with the boron carbide and fly ash with aluminium alloy LM6 with the normal load is shown in the above graph. The wear rate for composite specimen decreases with increasing the value of the load. Therefore as the load increases for the composite specimen there will be the reduction in wear rate as well as the percentage of reinforcement increases there will be the decrease in the wear rate for the applied.

The variation of wear loss for the composite specimen reinforced with boron carbide and fly ash with aluminium alloy LM6 for the applied load is shown in the above graph. The weight loss increases with increase in the value of the load and the percentage of reinforcement. The variation of thermal expansion coefficient for the composite specimen reinforced with boron carbide and fly ash with aluminium alloy LM6 is shown in the above graph. The thermal expansion obtained is of the type of linear type thermal expansion which results in the value of change in thermal expansion coefficient for the change in temperature. The value of thermal expansion coefficient decreases with increase in the percentage of reinforcement as well as the change in length of the specimen decreases with increase in the percentage of reinforcement.

It can be expected that agrochemicals will be used more commonly by farmers who experience production problems from weed, insect, fungus and bacterial infestations. It is commendable if, indeed, farmers use safer methods to manage production issues. The results may also indicate that socio-economic issues have a greater impact on production in Grenada than agronomical issues that usually require chemical remedies. In any case, further studies should be conducted to understand how farmers deal with different production issues and, specifically, which issues warrant or hinder the use of public health-significant agrochemicals. Farmers should also be supported to use good agricultural practices, including the use of protective equipment when applying agrochemicals. A system should also be developed to monitor the use of agrochemicals and to enable an evidenced-based approach to the management of agrochemicals in Grenada.

The results show farmers who received technical assistance were less likely to use agrochemicals and, therefore, had a lower risk of experiencing health problems related to the use of agrochemicals. In a study in Trinidad, Ganpat et al. found that farmers who were visited by extension officers 1-4 times per month were more consistent with GAP than farmers who were visited 5 or more times per month. The study in Trinidad is interesting, showing that high demand for technical assistance may be related to poor agriculture practice which can also include inappropriate use of agrochemicals. While odds ratio for having ever used agrochemical and number of visits by extension officers was not investigated in Grenada, the findings may indicate a general preference by technical officers to restrict the use of agrochemicals. This may warrant the need to distinguish between how much technical support is for prevention and how much support is to address problems. The need to understand the relationship between technical support, farming practices and, in particular, the use of agrochemicals in Grenada is recognized.

In Grenada's context, access to credit and location of the farm/farmer's residence may also be indicative of the likelihood of purchasing agrochemicals and other commercial resources. With just about 12% of farmers reporting they used agrochemicals in agriculture production, there is indication that the overwhelming majority of producers in Grenada are subsistence farmers. Small and part-time (subsistence farmers) farmers are, however, unlikely to solicit credit for production which may explain why the odds ratio was <1 for having ever used agrochemicals by farmers who did not access credit. The two largest agriculture supply shops were also located in St. George's (town) and, farmers that reside or have farms in the city area may have greater access to chemicals. St. John is the second poorest parish in Grenada and is also known as the "fishing capital of Grenada." Understandably, the farmers in St. John are, therefore, least likely to do commercial farming that may require high use of agrochemicals.

Fresh produce market is another critical point of entry to address indiscriminate use of agrochemicals and health risk. The farmers who sold to markets were at least 3 times more likely to have used agrochemicals that farmers who did not sell to markets. Controlled markets generally require produce that are safe for consumers and may discourage the frequent use of agrochemicals. However, agrochemical use is increasing to protect crops from emerging and traditional problems. As such, the SCT construct of expected outcome may provide a plausible explanation for why farmers with market presence used agrochemicals more frequently than farmers without market presence. However, the safe use of agrochemicals can be promoted through reinforcement, concessions and other incentives from markets.

The results show a slightly higher odd for farmers who had joint ownership of land with household or non-household members to have ever used agrochemicals and, therefore, had a higher risk of experiencing health problems from exposure. Apart from the farmer, other owners of the land may also provide labor and other support or visit the farm. In doing so, household members and other residents can be exposed to the hazardous chemicals. Studies in other countries show household members were at risk for health problems from assisting on farms and poor hygienic practices by farmers. Further research is, therefore, necessary to understand risk from agricultural practice for household and community members in Grenada. Appropriate interventions should be developed and implemented to address exposures beyond the farm environment.

CONCLUSION

In conclusion, the study produced results about the relationship between social-economic characteristics of farmers in Grenada and the frequency of use of agrochemicals at levels that can potentially cause farmers to experience sleep apnea, rheumatoid arthritis, decrease in LINE-I DNA methylation, and allergic and non-allergic wheeze. It is clear from the results that commercial activities have direct bearing on expenditure and income had the most significant influence on farmers' decisions to use agrochemicals. This study, therefore, provided crucial information that both the Ministry of Health and Ministry of Agriculture, primarily, can use to inform campaigns to create awareness, build capacity and address public health challenges in Grenada. A limitation of this study is the absence of reporting the specific agrochemicals that were used by the farmers. While the results provide a general indication of the health problems that Grenadian farmers can experience as a consequence of the use of agrochemicals further studies are encouraged for comprehensive and in-depth information about the agrochemical use and health risk in Grenada. By using the findings from this study, an adhoc approach can be avoided and interventions can be better mainstreamed to improve stewardship in the use of agrochemicals; monitoring and control the use of agrochemicals; and address gaps in knowledge, practice, and systems to improve and maintain the health and well-being of citizens in Grenada. In addition, this study contributes to close the gap in knowledge about the potential impacts on health from the use of agrochemicals in the Caribbean region. Paraquat, glyphosate, and carbaryl were also commonly used in other Caribbean countries. By addressing the excessive of use of these chemicals and the lack of use of personal protective equipment significant benefits to public health can be realized..

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