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Literature Overview On Fabrication of Composite Spur Gear

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***Abstract*: Metal Matrix Composites (MMC) are used widely in many areas for engineering. Because of their strength to weight ratio and resistance to wear and high temperature so they were considered as one of the great materials for producing mechanical components for aerospace and automotive industries. We are taking aluminium 6061 metal as matrix and silicon carbide as reinforcement. In this metal matrix composites we are adding magnesium metal powder to the aluminum-silicon carbide molten state. Here magnesium mixed to increase the bonding strength of aluminium and silicon carbide it also increases strength and stiffness of the material. This matrix is produced by stir casting process. To produce the circular blank for gear the treated molten metal is poured into the cavity in the circular die. From the circular blank the teeth were cut by milling process. The strength and durability of both AlSiC MMC and AlSiC-Mg MMC are compared on the test result. Comparing the results, the most effective material is chosen.**

***Keywords*: Wear and high temperature resistance, AlSiC MMC, AlSic-Mg MMC.**

1. Introduction

In present days' composite materials are mostly used for structural constructions for aerospace and automobile industries to decrease weight and increase strength. But we can also use the composite materials for moving components.

By using Metal Matrix Composite (MMC) we can produce material for moving components. We are using aluminium as metal and silicon carbide to produce composite gear. This metal matrix is produced by stir casting process. Here we are adding magnesium to increase the bonding between aluminium and silicon carbide. For this experiments have been conducted by varying weight ratio of silicon carbide from 5% to 25% the best result is being obtained at 15% of SiC with Al. By testing AlSiC and AlSiC-Mg to decide the most durable and stiff material for gear.

2. Objective

- To increase the strength and stiffness of gear.
- To reduce the wear rate.
- To increase the strength of weight ratio.
- To reduce cost of gear.
- To increase the life of gear.

3. Literature Survey

R. Sri Murugan et al., proposed a paper on Study on Mechanical and Metallurgical properties of Glass fibre reinforced PMC Gear Materials. From their point of view in this work, Nylon 6 and E-glass fibre are pooled together to get a polymer matrix composite for the purpose of wear reduction in spur gear material. Nylon 6 and the E-glass fibre were combined by this process in this ratio of (80:20) & (70:30). This paper aimed to investigate the mechanical properties such as tensile, compression and impact test as per ASTM standard. Finite Element model were then developed to simulate the impact and tensile characteristics of PMC. The result shows that there is increase in the property of the composite by adding nylon. Advances in engineering technology in modern years have brought demands for gear teeth. This can function at always-increasing load capacities and speeds the gears generally fail when tooth stress exceeds the safe limit. Therefore, it inessential to explore alternate Gear material the project has focused the alternate gear material. The material has taken from Nylon 6 with E-Glass fibres. The Tensile test properties, as well as the Flexural strength, increased considerably. The Compression properties also increased. The SEM Result has concluded that the morphology properties are evenly distributed in fibre and matrix. The fibre in some places is delaminated due to loading pressure.

R. Gnanamoorthy et al., proposed a paper on Materials and Design in Transmission efficiency of polyamide nanocomposite spur gears from their review Gears made of polymer and its composites find increasing application due to their superior properties. This paper reports the transmission efficiency of pristine polyamide 6 (PA6) and clay incorporated polyamide nanocomposite (PNC) spur gears. Numerical studies were conducted to predict the frictional and hysteresis power loss. A power absorption type gear test rig, developed in-house, was used to determine the power loss during transmission. The effect of applied torque on the transmission efficiency of PA6 and PNC spur gears are reported. Addition of Nano clay particles improves the stiffness and suppresses the viscoelastic nature of polyamide 6. The increase in gear tooth temperature due to hysteresis and friction, significantly affects the tooth shape, and thereby, the gear performance. The enhancement in mechanical properties of polyamide nanocomposite gears

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results in higher power transmission efficiency compared to pristine polyamide gear. The performance of injection moulded polyamide 6 and polymer nanocomposite gears were investigated at various torque levels using a power absorption type gear test rig. The enhanced mechanical and thermal properties of nanocomposite gears due to the addition of Nano-clay reduce frictional losses and hysteresis losses in gear during meshing. Applied torque has detrimental effect on the efficiency of the polyamide 6 and polyamide nanocomposite gears. The Nano-clay reinforcement reduces the dependency of gear efficiency on applied torque. The increase in weight percentage of Nano-clay is beneficial for the efficiency of the gear.

Jian-Fei Shi et al., proposed a paper on Mechanism and Machine Theory in Calculation of time-varying backlash for an involute spur gear pair from their view Backlash plays a significant role in gear design and geared dynamics analysis. This study aims to establish a model of the time-varying backlash for a standard involute spur gear pair. The elastic deformations, thermal deformations and film thickness deformation at the meshing point are considered in this model. Asperity and fluid loads are included in film thickness. A time-varying backlash model with contact ratio is developed according to the force analysis at the meshing point. The contributions and effects of the various deformations on the backlash are analysed. The effects of rotation speed, torque load and tooth surface temperature on the time-varying backlash are studied. Results show that the influence of various parameters on the backlash cannot be ignored. The time-varying backlash is less affected by elastic deformation and oil film thickness deformation, and is greatly affected by the thermal deformation. The time-varying backlash increases with the increase of torque load and the decreases of rotation speed and tooth surface temperature. Tooth surface temperature is validated experimentally due to its importance in the established model. The calculation model of the time-varying backlash is established with the considerations of the elastic deformations, thermal deformations and film thickness deformation for the standard involute spur gear system. Under certain parameters of the studied gears, the time-varying backlash is calculated and analysed. Also, the effects of rotation speed, torque load and tooth surface temperature on the time-varying backlash are studied. Some novel results have been obtained. Firstly, the time-varying backlash jumps and changes greatly at the shift of the single-tooth and double-tooth meshing areas. The values of the backlash in the single-tooth zone are greater than the values in the double-tooth zone. Secondly, under the parameters of the studied gear, the total thermal deformation amount has a great contribution to the change of the time varying backlash, while the elastic deformations and oil film thickness deformation have little contribution to the backlash. Thirdly, increasing the rotation speed increases the backlash variation and decreases the time-varying backlash.

P. B. Pawara et al., proposed a paper on Analysis of Composite Material Spur Gear under Static Loading Condition from their journal Spur gears are the simplest and widely used in power transmission. In recent years it is required to operate machines at varying load and speed. Gear teeth normally fail when load is increased above certain limit. Therefore, it is required to explore alternate materials for gear manufacturing. Composite materials provide adequate strength with weight reduction and they have emerged as a better alternative for replacing metallic gears. In this work metallic gears of steel alloy and Aluminium Silicon carbide composite have been manufactured. Composites provide much improved mechanical properties such as better strength to weight ratio, more hardness, and hence less chances of failure. So this work is concerned with replacing metallic gear with composite material so as to improve performance of machine and to have longer working life. Efforts have also been carried out for modelling and finite element analysis of gears using ANSYS 14.0. Composite gears have been manufactured by stir casting, which is economical method. Composite gears offer improved properties over steel alloys and these can be used as better alternative for replacing metallic gears. In the present work Al-SiC composite have been prepared by stir casting and various mechanical tests are conducted for evaluating properties of composite. Following conclusions are drawn from the experimental work and numerical analysis done on gears, ¾ Al-SiC composite prepared by stir casting provides improved hardness, Tensile strength over base metal. Better results have been obtained at 18% SiC is added.70% Gears manufactured from composite provides almost 60% less weight compared to steel gear, while power rating of both gears remains almost same. 70% FE Analysis also shows less chances of failure in Al-SiC gear. Almost 3-4% difference has been observed between theoretical and FEA values of bending stress.70% of these gears can be used for transmitting almost 24kW power.

B. K. Sridhara et al., proposed a paper on Effect of addition of graphite particulates on the wear behaviour in aluminium–silicon carbide–graphite composites from their review Aluminium matrix composites with multiple reinforcements (hybrid AMCs) are finding increased applications because of improved mechanical and tribological properties and hence are better substitutes for single reinforced composites. Few investigations have been reported on the tribological behaviour of these composites with % reinforcement above 10%. The present study focuses on the influence of addition of graphite (Gr) particulates as a second reinforcement on the tribological behaviour of aluminium matrix composites reinforced with silicon carbide (SiC) particulates. Dry sliding wear tests have been performed to study the influence of Gr particulates, load, sliding speed and sliding distance on the wear of hybrid composite specimens with combined reinforcement of 2.5%, 5%, 7.5% and 10% with equal weight % of SiC and Gr particulates. Experiments are also conducted on composites with % reinforcement of SiC similar to hybrid composites for the sake of comparison. Parametric studies based on design of experiments (DOE) techniques indicate that the wear of hybrid composites decreases from 0.0234 g to 0.0221 g as the % reinforcement increases from 3% to 7.5%. But the wear has a tendency to increase beyond % reinforcement of 7.5% as its value is 0.0225 g at reinforcement of 10%. Experiments are conducted on Al–SiC composites with reinforcement up to 10%

and Al–SiC–Gr hybrid composites with combined reinforcement up to 10% using pin-on-disc equipment. Following are the conclusions of the investigation. Percentage reinforcement, sliding speed, load and sliding distance affect the wear. Interactions exist among sliding speed, load and sliding distance in Al–SiC–Gr hybrid composites and such interactions do not exist in Al–SiC composites.

L. M. Tham et at., proposed a paper on effect of limited matrix–reinforcement interfacial reaction on enhancing the mechanical properties of aluminium–silicon carbide composites. From their survey an unconventional approach to strengthening Al/SiC composites through controlled matrix–reinforcement interfacial reactions were studied. Composites with two distinct interfacial microstructures were prepared by varying the contact time between the SiC particles and molten aluminium during processing. The formation of a thin Al4C3 reaction layer along the particle–matrix interface was found to increase the composite yield strength, ultimate tensile strength, work-hardening rate and work-to-fracture, and change the fracture pattern from one involving interfacial de-cohesion to one where particle breakage was dominant. These changes were attributed to a stronger interface bond, which is thought to result from the tendency for the Al4C3 reaction layer to form semi coherent interfaces and orientation relationships with the aluminium matrix and SiC particles and for it to be mechanically "keyed-in" to both these phases. The stronger interface bond also enhanced the levels of plastic constraint which, when coupled with the greater work hardening, promoted local matrix failure, thereby reducing the composite ductility. The morphology of the matrix–reinforcement interface was altered by the Al–SiC chemical reaction that took place because of extended exposure of the SiC particles to the aluminium melt during composite processing. The average yield strength, ultimate tensile strength, work hardening and work-to-fracture of the composite were increased as a result of the stronger interface bond associated with the formation of the thin Al4C3 reaction layer about 2.5μm thick. The observed change in fracture behaviour from particle–matrix de-cohesion to particle breakage that accompanied the improvement in mechanical properties was similarly ascribed to the increase in the interfacial bond strength. The improved bonding is thought to result from the tendency for the Al4C3 reaction layer to form semi coherent interfaces and orientation relationships with the aluminium matrix and SiC particles and for it to be mechanically "keyed-in" to both these phases.

Rabindra Behera et al., proposed a paper on Study on Machinability of Aluminium Silicon Carbide Metal Matrix Composites from their point of view. This paper presents the influence of machining parameters such as cutting forces and surface roughness on the machinability of LM6/ SiCp metal matrix composites at different weight fraction of SiCp. Machining tests were carried out at different cutting speed (i.e.30, 68 &103 m/min) and different depth of cuts (i.e.0.5, 1.0 & 1.5mm) at constant feed rate i.e. 0.05 mm/rev to study the machinability of as cast composites. It is observed that the depth of cut and the cutting speed at constant feed rate affects the surface roughness and the cutting forces during dry turning operation of cast MMCs. It is also observed that higher weight percentage of SiCp reinforcement imparts a higher surface roughness and needs high cutting forces. This experimental analysis and test results on the machinability of Al/SiC-MMC will provide essential guidelines to the manufacturers. The experimental study on the machining parameters such as cutting forces and surface roughness of the as cast composites at different weight fraction of reinforcements, during dry machining of MMCs by using tungsten carbide cutting tools concludes the following points:

1. The cutting forces (Ft, Ff &Fr) increased on increasing the depth of cut at constant feed rate and different cutting speed.
2. The cutting force components Ft, Ff and Fr were decreases on increasing the cutting speed of the composites at constant feed rate and different depth of cut.
3. The surface roughness of MMCs increased on increasing the weight percentage of SiCp in the matrix metal and it increases on increasing the depth of cut at constant feed rate and different cutting speed.
4. On increasing the cutting speed at constant feed rate and different depth of cut, the surface roughness decreases.
5. The sizes of chips are decreases on increasing the weight fraction of SiCp in the matrix metal.

C. H. Andersson et al., proposed a paper on Silicon carbide fibres and their potential for use in composite materials. From their review the chemical properties of SiC relevant to the use of SiC fibres as reinforcement in metal matrix composite materials are reviewed. Particular attention is paid to the oxidation of SiC, and to the interaction of SiC with metals and alloys with respect to chemical interactions and fibre/matrix bonding. The chemical reactivity of SiC with many candidate matrices is a serious hindrance to the full exploitation of its high-temperature stability in SiC-fibre and whisker-reinforced composites. Nevertheless, a number of chemically stable matrices exist, including glasses, silicon, aluminium and copper. Of these, glasses and aluminium have received some attention in studies on fibre-reinforced composites while silicon and copper appear hitherto to have attracted surprisingly little attention. The effect of alloying on the wetting of SiC by these and other candidate matrices is also a subject that demands attention and should prove rewarding.

4. Conclusion

Thus we are managed to produce a composite spur gear. By testing and comparing it with each other we conclude that composite produced with aluminium, silicon carbide and magnesium have more efficient results.

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