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Role Of Antimony And SiC-I-Cu On Mechanical And Dry Sliding Wear Behavior Of Phenol Formaldehyde Composites

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Abstract: The majority of the brake linings utilized depend on metal fiber reinforced phenolic resin, which is a composite of 15-20 constituents and is generally called semi metallic brakes. In practice, asbestos, antimony, and their modified version of organic composite brake materials are used which possess good strength, resistance to temperature, chemicals and wear. In the present work, mechanical and dry sliding wear conduct of non-asbestos natural (NAO) friction composites in particular; antimony and SiC-I-Cu filled phenol formaldehyde (PF) were contemplated adhering to the ASTM guidelines. The tribological behavior was studied under dry sliding conditions using a pin-on-disc apparatus.

Experimental results showed that there is a marginal improvement in the compression strength and hardness SiC-I-Cu filled phenol formaldehyde (SiC-I-Cu-PF) than that of antimony ones. Further, the coefficient of friction increased in SiC-I-Cu-PF composite. Scanning electron micrographs are utilized to examine the fracture and worn surface morphologies.

Keywords: Filler filled phenol formaldehyde, Mechanical properties, Coefficient of friction, Specific wear rate, Scanning electron microscopy.

Introduction: Non-asbestos normal (NAO) based grinding materials are fundamentally multi fixing structures (containing more than 10 fixings, when all is said in done as such) as to achieve the perfect amalgam of execution properties. [1]. Regardless of the way that the once-over of fixings used for enumerating of such composites outperforms the number 700 [2], these are described into four critical arrangements viz., fastener, filaments, grinding modifiers and fillers subject to the noteworthy limit they perform isolated from controlling erosion and wear execution. Fastener is the center of a system which ties the fixings firmly with the objective that they can play out the perfect limit in the grinding materials. Filaments in mix are incorporated

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generally for quality, while grating modifiers are used to control the perfect extent of grinding. Fillers are of two sorts viz., valuable fillers (to improve explicit trademark feature of composites, for instance, insurance from obscure, etc.) and space/idle fillers (generally to cut the cost).

Phenolic saps (balanced and unmodified) are always used as fastener in contact materials as a result of insignificant expense nearby a not too bad blend of mechanical properties, for instance, high hardness, compressive quality, moderate warm block, creep restriction and marvelous wetting limit with most of the fixings. In any case, these phenolics experience the evil impacts of veritable hindrances and repressions, for instance, advancement of hurtful volatiles [3] Wear execution of contact materials depends on the trademark material properties, for instance, compound and physical nature of the fixings and on the working conditions [4]. Various masters have surveyed the scouring and wear of composite brake materials [5]. Plus, straight wear hypothesis was addressed offer a close to estimation of the wear execution of crushing materials and thusly in the aching for cushion life [6]. Despite how it is especially seen that working parameters and compositional changes in materials all the while impact the presentation, no effort has been made to on a fundamental level analyze the regular effects of the individual parameters on the wear system for deterioration materials [7].

Materials and Method:

Manufacturing of the composite

The assembling of composites containing fifteen fixings depended on keeping guardian arrangement of 12 fixings (85%, w/w) steady and fluctuating three fixings, viz. silicon carbide, iron powder and copper powder (15%) in corresponding way. The parent composition contained binders- Linseed oil, Cashew nut oil, PF, Friction dust (30%), functional fillers- Fire clay, Plaster of pairs, Ferro silicon, (30%), frictional material - Rubber, Antimony, carbon(21%), lubricant – graphite (5%) and reinforcing material and catalyst (fiber glass, hexamine) (1%) each.

The required quantity of composites was obtained from the two main suppliers, Mysore pure chemicals and Maxin enterprise. These raw materials are prepared by subjecting it to pulverization process, material are feed in to hammer crusher machine, this machine brake up raw material through the collision of the fast rotating ram and materials.

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Brake block composite was manufactured by 'Hot compression molding technique'. The way toward assembling a composite brake square comprises of arrangement of tasks including blending, pressure driven squeezing, cooling, post curing and wrapping up. The constituent ingredients, Fire clay, plaster of pairs, ferrosilicon, friction dust, rubber, antimony, carbon, graphite, hexamine and fiberglass were blend for 20 min in a mixer, to ensure the macroscopic homogeneity. The blending succession and time of blending of each part of fixings lead to legitimate consistency in the blend. On the off chance that blending time is low, appropriate homogeneity can't be accomplished. About 20 kg of the blend was discharged onto each performance, the composite are then separated to 1.5 kg of packets manually. The back plates were secured with paste to check holding between the erosion composite and plate, the perform pressure changed between 5-10 ton for 5 seconds. The assembly was then exposed to hot squeezing, which incorporates relieving, at a pressure of 40 ton and temperature at 120^0 C for 40 min. After the prescribe time the composite brake. The pads were then evacuated and were then post-cured in oven at 120◦C for 17 h. Post relieving activity is done to fix the residual resin.

Hardness and Compression test

The hardness test is conducted on Shore D hardness testing machine as per ASTM D-2240 standards, the hardness test is done on antimony and ceramic fillers filled PF composite railway brake block material using diamond pyramid indenter at different points for ten trials each on the same surface and the hardness value is determined. A hydraulic operated crushing test was conducted to investigate the compressive force during the braking application, the test is conducted on hydraulic press testing machine as per RDSO standards on antimony and ceramic fillers filled PF composite railway brake block material for ten trials each on two specimens, the application of load was manual at constant rate till the fracture of block and the bonding strength of the composites are determined.

Dry sliding wear test

A pin-on-disc test device was utilized to research the dry sliding wear qualities of the composites according to ASTM G99-95 gauges. The plate utilized is En-32 steel set to 62 HRC, 120mm track detachment transversely finished and 8mm thick, with surface obnoxiousness of 10μm Ra.

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The tests were driven by picking test length, load and speed and performed in a track of 75 mm width. The test model are cut into required standard and set parallel to the contact surface and to the sliding course. The surface (8 mm X 8 mm) of the composites model reaches to the counter surface. Preceding testing, the models are scoured over a 600 assessment SiC paper to guarantee reasonable contact with the counter surface. The outside of both the models and plate are cleaned with a delicate paper expended CH3)2CO before the test. Underlying load of example was estimated in a solitary container electronic gauging machine with least count of 0.0001g. Particular wear rate Ks was determined from the accompanying condition.

$$K_s = \frac{\Delta m}{\rho \, x L \, x D} \; m^3 / N m \tag{1}$$

Symbols used are:

ρ :density(g/cm^3); Δm: weight loss (g); D: sliding distance (m) and L: load (N).

Result and discussion

Hardness (Shore-D)

Hardness test were conducted on the Antimony and SiC-I-Cu filled PF composite brake blocks using Shore-D hardness tester. Fig. 1 shows the measured surface hardness of the composite brake blocks. It is evident from the figure that hard ceramic fillers filled namely SiC-I-Cu reinforced PF composite had the highest hardness. It is attributed to the ceramic fillers having higher hardness which are compounded with the PF matrix.

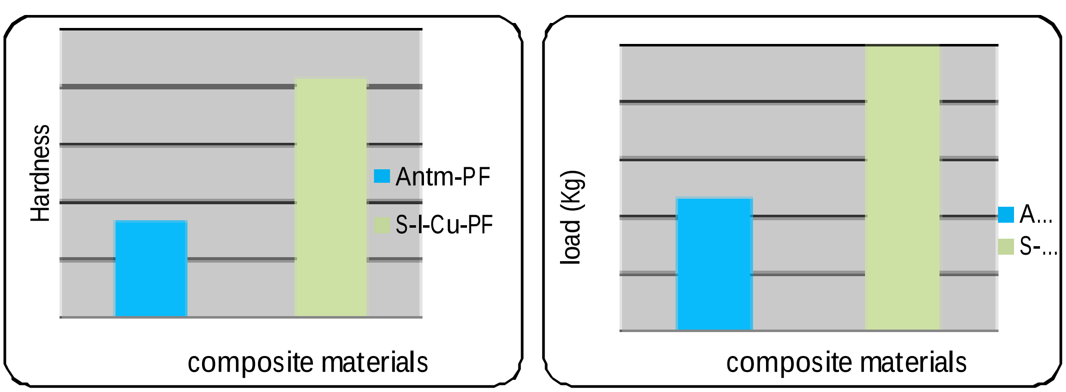

Fig. 1 Hardness of Composite brake blocks.
Fig. 2 Crushing strength of the composite brake blocks

Crushing strength

This test is conducted to determine the compressive force during the application of brakes, it is evident from the Fig. 2 crushing load of the S-I-Cu-PF composite exhibits better withstand to compressive force compared to Antm-PF composite.

Coefficient of friction

The coefficient of grinding was found to differ for two loads to be specific 40 and 80 N while doing the wear test; the model used for try was of 8 mm separation crosswise over and is slid against a turning steel plate. From the outset 40N weight is applied on test against a speed of 236 rpm of the turning plate. Underlying time equal to 15 s took into account achieving steadiness. Past this, it is obvious from the plot that the coefficient of friction is practically steady. A comparative pattern is watched for the examples at 80 N applied load. This plainly shows the SiC-I-Cu-PF composite has commendable protection from wear under various stacking conditions, and the coefficient of friction is large for SiC-I-Cu-PF composite contrasted with antimony filled PF composite.

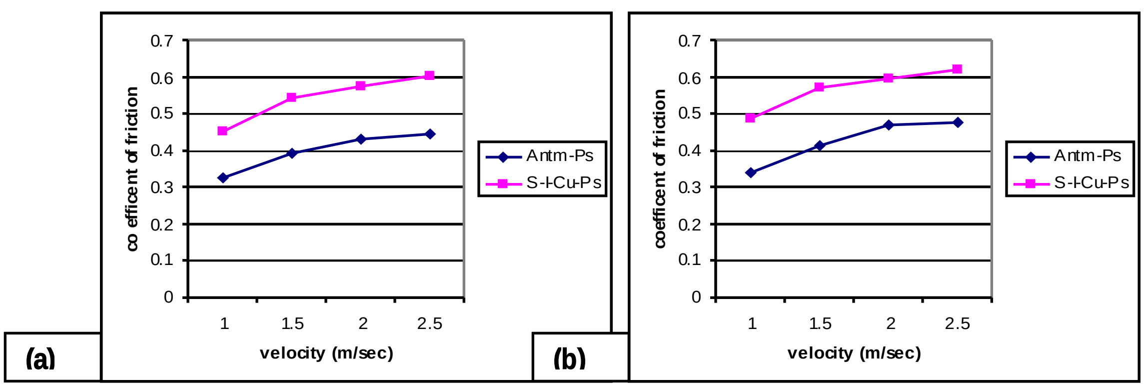

Fig. 3 Plot of sliding velocity vs coefficient of friction of composite brake blocks at: (a) 40N and (b) 80N.

Wear volume loss

Plot of wear volume misfortune as an element of sliding speed for antimony and SiC-I-Cu filled phenol formaldehyde (SiC-I-Cu-PF) composites for applied ordinary of 40 and 80 N are

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appeared in Fig. 4 individually. From the plot it was seen that, the wear volume mishap increments with increment in speed for the two composites. The wear volume loss of SiC-I-Cu-PF composites is lower than that appeared by the antimony-PF composites under the condition of 3000 m sliding division. The proportions of SiC, Fe and Cu in PF composite are 12, 1.5 and 1.5 wt % independently. In this way, the fillers stacked PF wear volume misfortune were pretty much nothing and wear volume misfortune was caused generally by network wear. In like manner, it should be seen that SiC-I-Cu-PF composite showed the most raised wear hindrance under various sliding pace/loads. This lead can be credited to the vicinity of SiC, Cu and graphite particles, which go about as powerful squares to divert enormous scale brokenness of phenol formaldehyde (PF). This is furthermore clear from the little size of the wear debris particles as constrained by SEM assessment (Figs. 6 and 7).A few creators have talked about the job of SiC and as a successful filler material. The glass fiber and SiC fortifies the composite, while the graphite lubricants oil together giving upgraded wear opposition.

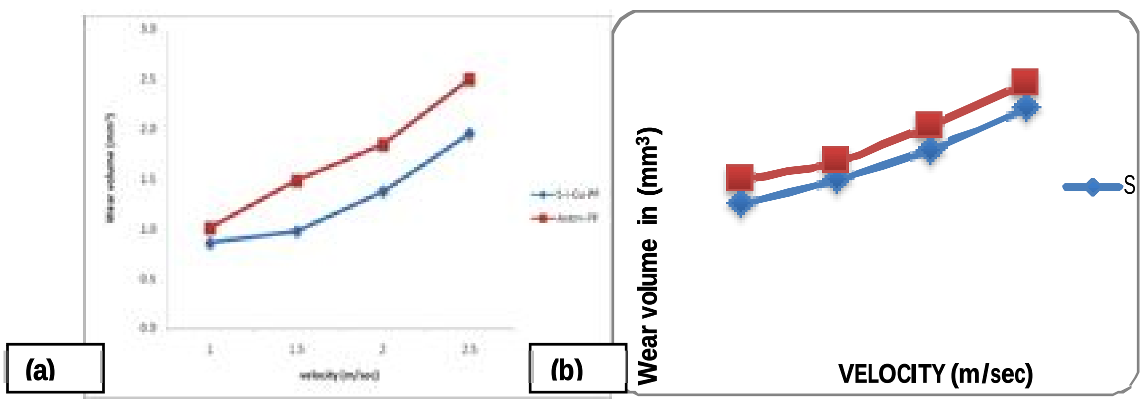

Fig. 4 Wear volume of Antimony and SiC-I-Cu filled PF composites at: (a) 40 N, 3000 m, and (b) 80 N, 3000 m.

Thusly, the reasonable creation as exhibited have been gotten after different emphasess and primers and mix-ups related with them, along these lines streamlining the method essentials.

Scanning electron microscopy

The checking electron minute appraisal of worn surfaces of antimony and SiC-I-Cu recorded PF composite models against steel countersurface under 40 and 80 N loads and at 1 and 2.5 m/s

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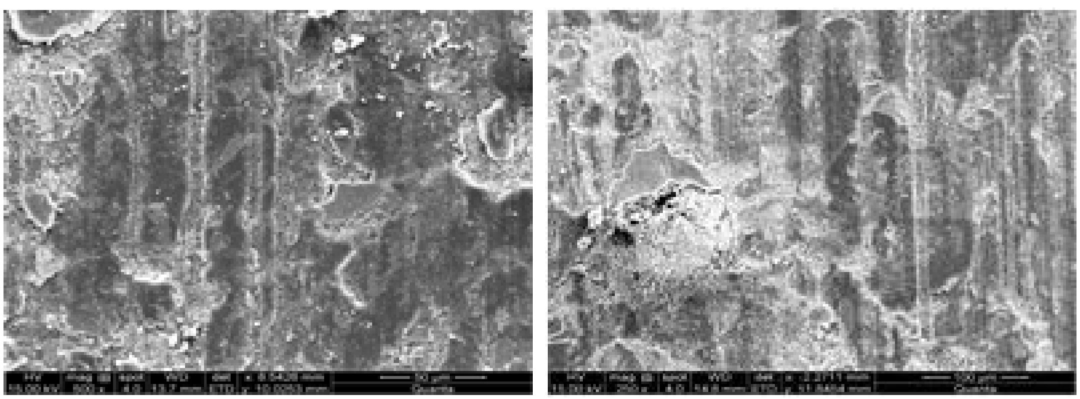
sliding rate are given in Figs. 6 a-d and 7 a-d. Void age is confined and is irrelevant on account of the splendid wear resistance appeared by the composite (Fig. 6)

Fig. 5a–d presents the features of worn surfaces of antimony recorded PF composites under different sliding conditions, for instance 40 N, 1 and 2.5 m/s, 80 N, 1 and 2.5 m/s, independently. At low load surface was tolerably smooth and associated with small scale splits in the framework (Fig. 5a). At higher sliding pace, damage to the fiber and other hard fillers is higher achieving more fiber removal from the surface (Fig. 5b). Exactly when the heap extended up to 80 N, the wear misfortune and in this manner the contact temperature were phenomenally extended. Like manner, the surface harm shockingly extended with etches left by the isolating strands (Fig. 5c and d). Similarly, for all intents and purposes entire fiber/filler garbage was seen on the countersurface. For this circumstance, the strands were cleared with greater fixes and experienced little wear. Likewise, the huge fiber flotsam and jetsam could moreover decrease the wear resistance of composite inferable from a three-body grating wear sway. Thusly, the wear pace of the antimony recorded PF composites was consistently overhauled at expanded burden and sliding velocity.



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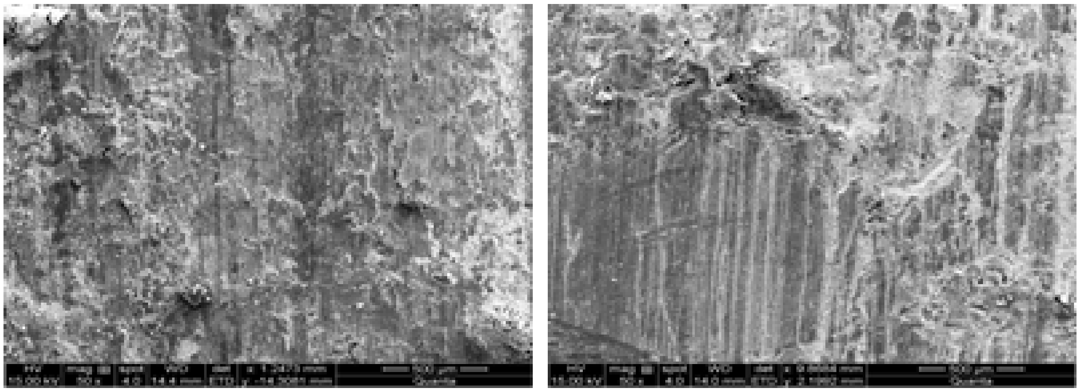

Fig. 5 SEM pictures of Antimony filled PF samples at (a) 1m/s, 40 N, (b) 2.5 m/s, 40 N,(c) 1m/s, 80 N, and (d) 2.5 m/s, 80 N

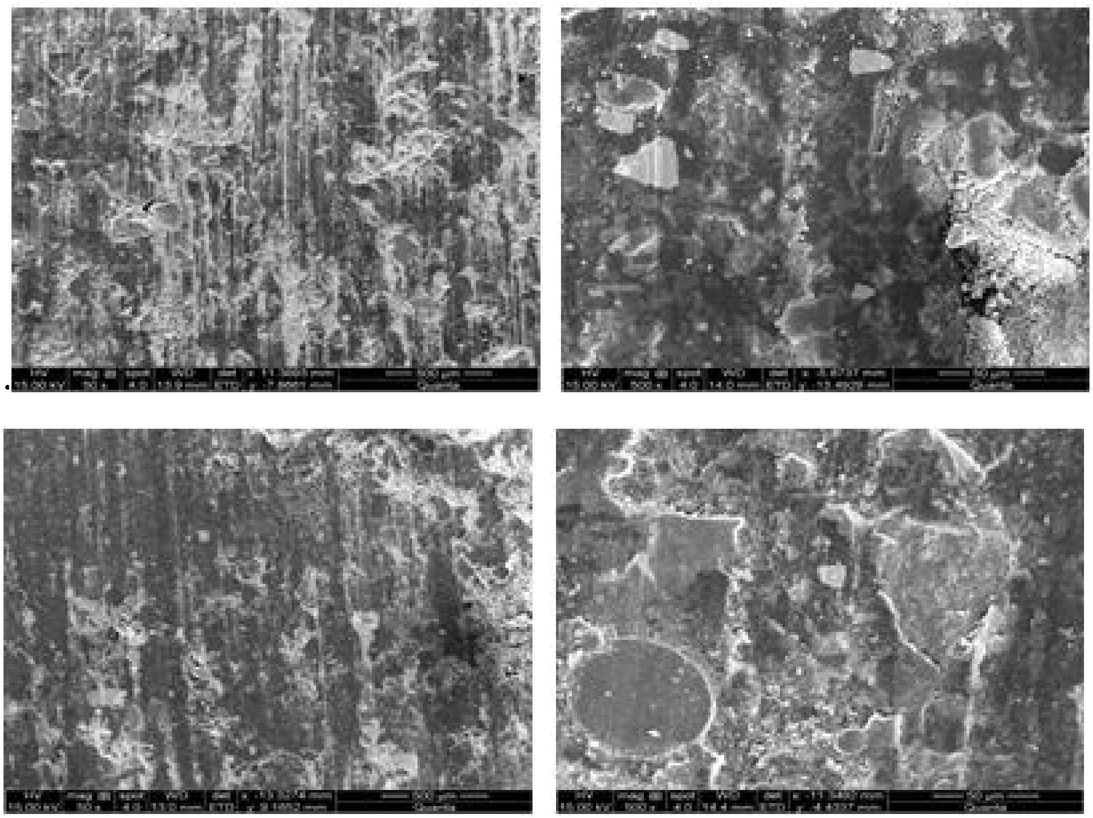

Fig. 6 SEM pictures of SiC-Iron-Cu filled PF samples at (a) 1m/s, 40 N, (b) 2.5 m/s, 40 N,(c) 1m/s, 80 N, and (d) 2.5 m/s, 80 N.

Fig. 6a–d shows the well used surfaces of SiC-I-Cu archived PF composites attempted under 40 N, 1 and 2.5 m/s, 80 N, 1 and 2.5 m/s, exclusively. In connection with Fig. 5a–d, clearly the well used surfaces were a ton of smoother compelled with the development SiC, Fe, Cu and graphite particles. As showed up in Fig.6c and d, impressively under a by and large high burden, the well

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used surface preformed reasonably smooth and depicted by scaled down scale surface mischief are a direct result of weariness wear, which conventionally occurs at high temperatures and clears the surface layer by miniaturized scale breaks. In like way, the fiber garbage came about as a result of composite (Fig. 6c) are much more slim and tinier than that of antimony filled PF under the comparable sliding condition. Along these lines, with the increases of SiC, Fe, Cu and graphite particles, the strands were kept up provoked a redesigned burden conveying limit of the composite. Furthermore, Fig. 6d gives a type of weakening of the model. Further, C-E stacked up with SiC, Fe, Cu and graphite shows progressively stable wear execution under all test conditions. Apparently extra oils add to a consistent headway of the trade film even at unprecedented sliding conditions, suggesting that uniform trade of graphite from the guide to the counterface is watched.

The examples (SiC, Fe, Cu and graphite filled PF) arranged was found to show high wear opposition, vital for vehicle brake linings. It is likewise apparent from the above outcomes that the qualities displayed by the SiC, Fe, Cu and graphite filled PF composite has better attributes when analyzed than the antimony filled PF composite.

Nugget locale encountering extraordinary plastic distortion and high-temperature introduction and described by fine and equi-axed recrystallized grains, TMAZ encountering medium temperature and disfigurement and portrayed by twisted only, and HAZ encountering just temperature and portrayed by precipitation coarsening. Prior heating is advantageous for refining the weld quality just as increment in the welding rate. So, diverse experimental approaches give the sound welded joint along with improved mechanical properties at the joint region.

Conclusions

In light of exploratory outcomes the accompanying ends can be drawn:

- The consolidation of the SiC, copper, graphite and iron particles in the polymer matrix as an auxiliary support expands the wear opposition of the composite brake square.

- Sliding separation and load are having more significant effect on wear as compared to sliding velocity.

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- It was likewise found to display commendable friction and hostile to wear qualities alongside giving steadiness at high temperatures.

- Composite turns out to be considerably progressively practical when made in mass for mechanical applications.

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