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WEAR BEHAVIOUR OF LM 25 / B_4C ALUMINIUM MATRIXCOMPOSITES

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ABSTRACT:

Aluminium based metal matrix composites have low density, relatively low price, available in largequantities, superior strength to weight ratio and corrosion resistance. So it is extensively used in automotiveand aerospaceindustries for drums,brake callipers, disc brakerotors, transmission casing, connecting rodsand oil pumps, where adhesive wear are predominant in these components. For adhesive wear, the influence ofapplied load, sliding speed, wearing surface hardness, reinforcement content and morphology are criticalparameters in relation to the wear rate encountered by the material. The reinforcements added to an alloy leadto variation in properties and improve the composite wear resistance. In this present work, it is to fabricate andstudy the wear behaviour of Aluminium matrix composites. Aluminium alloy reinforced with B_4C particles withvarious weight percentage will be fabricated their wear behaviour will be studied using computerized Pin-on-discweartestingmachine.

Keywords:Adhesivewear,Pin-on-disc,wearparameters,AluminiumMatrixComposites(AMCs)

1.INTRODUCTION:

Today searches in finding new materials superiorthantheconventionaloneshaveanincreasingdemand.Inthesestudies,AluminiumMatrixComposites(AMCs)havegainedgreatattentionespecially in the industries such as aviation, spaceand automotive.Recently, AMCs have been usedfor the automobile products, such as engine piston,cylinder liner, brake drum, brake disc due to theirlight weight, high strength, high specific modulus,lowco-efficientofthermalexpansionandgoodwearresistanceproperties.

AnimportantissueintheproductionofMetalMatrixComposites(MMCs)isthechemicalcompatibilitybetweenthematrixandthereinforcement, particularly when using liquid metalprocess.CastingofMMCsisanattractiveprocessing method since it is relatively inexpensiveandoffersawideselectionofmaterialsandprocessing conditions. But poor wetting betweenAl and B_4C below 1100°C means that it is difficultto produce Al - B_4C composites by mixing particlesintotheliquidphase.Inordertoenhancethewettabilityofceramicsandimprovetheir incorporationbehaviourinto Almetals,particlesareoftenheattreatedorcoated.

Therefore, K_2TiF_6 flux is used inorder to increasethe wetting between Al and B_4C and facilitate theincorporationofB_4Cparticlesintomoltenaluminium.To avoid insufficient reaction phase atthe interface and to lower the processing cost, noadditional processes except the traditional castingmethodwereusedinthis study.

2.EXPERIMENTALPROCEDURE:

MaterialSelection

Material has been selected based on the properties,cost and application.The boron carbide particlesare addedasreinforcementwithAluminumcastalloytoimprovethewearcharacteristicsofthecompositematerial.

Matrix Phase: ALUMINUM ALLOY LM 25Reinforcement:BORON CARBIDE(B_4C)

SPECIFICATION OF ALUMINIUMALLOYLM25:

Table 1 Chemical Composition ofAluminiumAlloyLM25

Contents	Chemicalcomposition
Copper(Cu)	0.01
Silicon(Si)	6.86
Magnesium (Mg)	0.37
Iron(Fe)	0.159
Nickel(Ni)	<0.001
Tin(Sn)	<0.005
Zinc (Zn)	0.01
Titanium(Ti)	0.02

Lead(Pb)	<0.002
Aluminum(Al)	Balance

APPLICATIONS OF ALUMINIUMALLOYLM25:

- UsedinAutomobileengineblocksandliner.
- Hydrauliccylindersandpressurevessels.
- Intricatecomponents
- InAutomotivebrakingsystem.

BORONCARDIDE (B_4C):

BoronCarbideisaextremelyhardceramicmaterial.BoronCarbideisoneofthehardestmaterials known, ranking third behind diamond andcubicboronnitride.Itisthehardestmaterialproducedintonnagequantities.Boroncarbidepowder is mainly produced by reacting carbon withB_2O_3 in anelectric arc furnace, throughcarbo –thermal reduction or by gas phase reactions.Forcommercial use B_4C powders usually need to bemilledandpurifiedtoremove metallicimpurities.

PROPERTIESOFB_4C:

- Extremehardness
- Difficulttosintertohighrelativedensities without the use of sinteringaids.
- Good chemicalresistance
- Goodnuclearproperties
- Lowdensity
- Lightweight
- Erosionresistance

Table2TypicalPropertiesofBoronCarbide:

Density(g/ cm^3)	2.52
MeltingPoint(^oC)	2445
Hardness (Knoop100g)(Kg/mm^2)	2900-3580
FractureToughness (MPa.$m^{-1/2}$)	2.9-3.7
Young'sModulus(GPa)	450-470
ElectricalConductivity(at25 ^oC)(S)	140

ThermalConductivity(at25^{o}C) (W/m.K)	30-42
ThermalExpansionCo–eff.X10^{-6} (^{o}C)	5
Thermalneutroncapturecross section(barn)	600

APPLICATIONSOFBORONCARBIDE(B_4C):

- Usedasanabrasiveinpolishingandlappingapplications
- Usedfordressingdiamondtools.
- Ceramictoolingdiesapplications.
- Usedforprecisiontool parts.

PROCESSINGOFTHECOMPOSITE:

LiquidstatefabricationofMetalMatrixCompositesinvolvesincorporationofdispersedphase into a molten matrix metal, followed by itsSolidification.Inordertoprovidehighlevelofmechanicalpropertiesofthecomposite,goodinterfacial bonding (wetting) between the dispersedphase and the liquid matrix should be obtained Thesimplestand the mostcosteffective method ofliquidstatefabricationisStirCasting.StirCastingisaliquidstatemethodofcompositematerialsfabrication, inwhichadispersedphase(ceramicparticles,shortfibers)ismixedwithamoltenmatrix metalbymeansofmechanicalstirring.TheliquidcompositematerialisthencastbyconventionalcastingmethodsandmayalsobeprocessedbyconventionalMetalformingtechnologies.

StirCastingischaracterizedbythefollowingfeatures:

- Contentofdispersedphaseislimited(usuallynotmorethan30Vol.%)
- Distribution of dispersed phase throughoutthematrixisnotperfectlyhomogeneous.
- Therearelocalclouds(clusters)ofthedispersedparticles(fibers).
- There may be gravity segregationof thedispersed phase due to a difference in thedensitiesofthedispersedandmatrixphase.
- Thetechnologyisrelativelysimpleandlowcost.

WEARTEST:

A pin-on-disc test apparatus was used to investigatethe dry sliding wear characteristics of the fabricatedAMCs. ASTM G99– 05 a standard test methodfor wear testing using a pin-on-disc apparatus wasfollowed.Thewearspecimen(pin)of6mmdiameter and 40 mm height was machined from thecast AMC samples.The disc material was chosenasAISI4140(EN19)steelalloy.Thediscspecimen of 55 mm diameter and 10 mm thicknesswascutfromthesteelrodandheattreatedtoachievethehardnessof55HRC.Thecontactsurfaces of the pin and disc material were surfacegrinded and polished metallographically inorder toachieve the surface roughness of0.8 µm or below.Surfaceroughnesswasensuredusingcontactsurfaceroughnesstester SurfCorderSE3500andthe R_a values are found to be less than 0.8 µm.Duringthetestthepinwaspressedagainsttherotating counterpartby applyingthe load. LVDTon the lever arm helps determine the wear at anypoint of time by monitoring the movement of thearm.Applied load helps to maintainthe pin incontact with the disc.This movement of the armgenerates a signal which is used to determine themaximum wearandthe coefficient of frictionismonitored continuously as wear occurs.The initialweight of the pin material is measured in a singlepanelectronicweighingmachinewithleastcount of 0.0001 g.After running through a fixed slidingdistance the specimen was removed, cleaned withacetone, dried and weighed to determine the weightlossdue towear.The difference inthe weightmeasured before and after the test gave the slidingwearofthecompositespecimenandthenthevolumelosswascalculated.

3. RESULTSANDDISCUSSION:

Theexperimentalplanisdesignedtofindthefactors influencing the wear process to achieve theminimum wear rate and maximumcoefficient offriction.Theexperimentsweredevelopedbyinvolvingthefollowingfactors,sliding speed,slidingdistance,loadandweightpercentagereinforcement of the material. These parametersarehelpfulindeterminingthecompositeperformance.

Table3ResultsofAMCs

Sl. No	Sliding speed (m/s)	Sliding Distance (m)	Load (N)	% reinforcement	Wear rate(mm 3/m)	COF
1	1.5	1000	15	Base Alloy	0.002217161	0.4065
2	1.5	1000	30	Base Alloy	0.00339448	0.3811
3	1.5	1000	45	Base Alloy	0.003699875	0.3334
4	2.0	1000	15	Base Alloy	0.004077313	0.4045
5	2.0	1000	30	Base Alloy	0.001889111	0.3672
6	2.0	1000	45	Base Alloy	0.004087481	0.3372
7	1.5	1000	15	3	0.002355	0.4568
8	1.5	1000	30	3	0.002973514	0.3929
9	1.5	1000	45	3	0.003854201	0.3437
10	2.0	1000	15	3	0.003476429	0.4451
11	2.0	1000	30	3	0.003350712	0.4040
12	2.0	1000	45	3	0.00380004	0.4445
13	1.5	1000	15	6	0.0020522	0.4735
14	1.5	1000	30	6	0.002272276	0.4513
15	1.5	1000	45	6	0.003402355	0.4032
16	2.0	1000	15	6	0.004108788	0.4631
17	2.0	1000	30	6	0.003412572	0.4235
18	2.0	1000	45	6	0.002272722	0.3912
19	1.5	1000	15	9	0.001859952	0.5336
20	1.5	1000	30	9	0.002616557	0.4812
21	1.5	1000	45	9	0.003347977	0.4436
22	2.0	1000	15	9	0.001861809	0.5032
23	2.0	1000	30	9	0.002246064	0.4712
24	2.0	1000	45	9	0.002981587	0.4335

Figure1WearRateVs Load

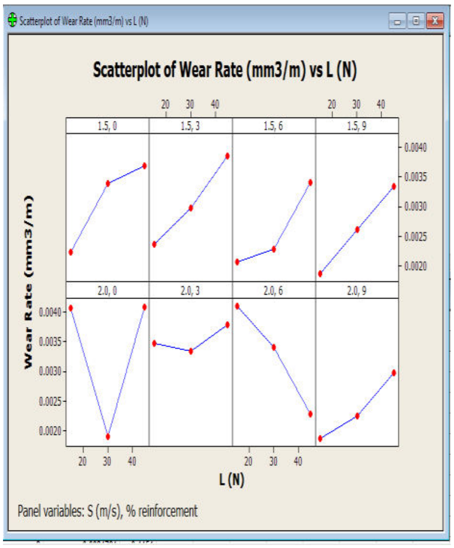
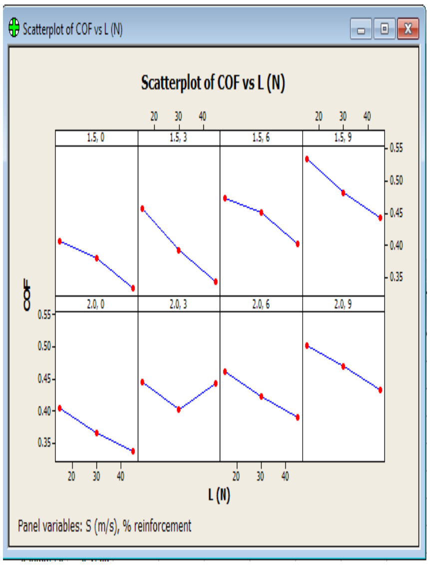


Figure2 COFVsLoad



4.CONCLUSION:

The experimental study reveals followingconclusions:

1. For a given load, the cumulative wear volumesof composites and pure aluminium pins increaselinearlyunderdrysliding

2. Thewearrateincreaseslinearlywiththeincreaseinnormalload
3. The average co-efficient of friction decreaseswithincreaseinloadinbothpurealuminiumahigherco-efficientoffrictionthanthatobservedinpurealuminium

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