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Effect of Dispersoid Size and Content (Silica) for Improved Mechanical Properties and Microstructure of LM-13 and Its Application

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***Abstract**: Aluminum Grid Composites (Amcs) Allude To the Class of Light Weight Superior Material. The Support In Amcs Could Be As Persistent/Intermittent Strands, Stubbles Or Particulates, In Volume Divisions. Properties Of Amcs Can Be Custom-Made To The Requests Of Various Modern Applications By Appropriate Blends Of Lattice, Fortification And Preparing Course. The Present Examination Is Gone For Considering The Impact On Microstructure And Mechanical Properties Of Aluminum Combination (Lm-13) A Cross Breed Metal Lattice Composites By Changing Dispersoid Size And Substance Silica (Sio2). The Measure Of The Silica (Sio2) Particles Shifts From 1, 3 And 5mm And Measure Of Expansion Differs From 4.25 To 11.76wt% In Ventures Of 4.25wt%. Mix Throwing Procedure Was Utilized To Create Cast Aluminum Amalgam - Silica Particulate Composites In Molds. The Microstructure And Hardness Of The Manufactured Composite Were Broke Down And Reported. The Manufactured Composites Were Tried For Their Hardness And Extreme Elasticity Properties As Indicated By Astm Models. The Impact Of Fortification Qualities Was Given And Thought About The Cross Breed Composite Material. Microstructural Investigations Of The Cast Composite Created Demonstrate That There Is Uniform Conveyance Of The Support In The Grid Compound With Noteworthy Grain Refinement And Maintenance Of Lingering Porosity. Mechanical Properties Uncover That The Nearness Of Silica Particulates Has Enhanced Altogether A Definitive Rigidity And Hardness As Thought About Against The Network Compound. In The Application Part The Analysis Of Ic Engine Piston Is Done By Applying The Mechanical Properties And By Applying The Certain Boundary Conditions To Study The Displacement And The Stress Distribution In Various Parts Of The Piston.*

INTRODUCTION

The present exploration (venture work) portrays generation of chilled Aluminum combination (LM13), Magnesium (Mg) based metal network composites (MMC) utilizing Silicon Carbide (Sio2) as the dispersoid in this examination. The dispersoid is shifted from 3 to 12% in ventures of 3%. AFS principles molds are readied embedded with metallic chills to acquire directional hardening. The subsequent throwing are then taken for smaller scale basic and mechanical property (quality and hardness) concentrates on. It is normal that they ought to be uniform appropriation of the dispersoid in the framework material (Al, Mg). Quality and hardness is likewise anticipated that would expand as a result of insertion of hard dispersoid in delicate lattice. When all is said in done Al composites are arranged into two noteworthy gatherings relying on the perspective proportion of the fortifications.

a) In the essential class the perspective extent (l=length, d=diameter) is varied in the extent of 100–10,000 in which the fibers are strengthened in metal system to perform properties required for fundamental applications.

b) In the second class the perspective proportion of the fortification is in the scope of 1-5 in which the fortifications are equi-axial fit as a fiddle (molecule/stubbles) such kind of Al composites are in awesome enthusiasm for tribological application.

LITERATURE SURVEY

Elite materials are of incredible enthusiasm for present day material applications because of the likelihood to create inventive materials with particular properties. Continuous from this potential, the half and half metal framework composites (HMMCs) meet the fancied ideas of the outline engineer, since they speak to hand crafted materials [1]. In HMMCs, two or more parts are blended in same or diverse proportions; the minor one that is more grounded and more unbending than the grid, in which it is inserted, enhances the quality of the blend. The target of having two or more fortifications is to exploit the predominant properties of both materials without trading off on the shortcoming of either [2].

The mold material decidedly affects the structure development. The utilization of end chills amid throwing favors directional cementing as well as quickens hardening. Quicker cooling rates offer ascent to better structures and enhanced mechanical properties. In this work an endeavor is made to shift the cooling rate of AL-B4C, composite cast utilizing stainless steel, cast iron and copper chills. The microstructure and smaller scale hardness of the chill cast examples are broke down and reported. It is watched that the chill material impacts the microstructure and hardness of the cast examples. Better structure and better hardness were seen with the examples cast utilizing copper chills, while, cast iron and stainless steel chills offered ascend to coarse structure with decreased hardness.

For the most part grease is remotely added to decrease the wear. This represents the issue when the materials require the occasional uses of ointment especially to wear parts which are hard to get to. For such applications self-greasing up materials are favored in light of the fact that the strong oil contained in them can be naturally discharged amid the wear procedure to lessen the wear. Graphite is a standout amongst the most broadly utilized strong oil materials. Prior analysts [32–35] have officially centered their examination on uses of aluminum graphite composite. There are additionally prior reports from a few examiners [36,37] who distinguished the pattern that aluminum graphite composite containing the little measure of graphite show better wear properties over the base combinations. The constraint with the aluminum graphite composite is in utilizing graphite as a strong oil whose presentation results in the loss of quality of the composite. It is, consequently, proposed to embrace a study on the viability of fortifications blended with Al 7075. Aluminum with 5 wt.% of graphite is strengthened with Al_2O_3 to shape a more grounded half and half composite (Al 7075/Al_2O_3/graphite).

INTRODUCTION TO COMPOSITES

Composite materials are developing the skylines of architects in all branches of designing but then the extent to which this is occurring can without much of a stretch pass unperceived. The eye after all doesn't see past the shiny outside or the race execution of a GRP1 yacht nor does it sense the intricacy of the structure of a composite helicopter rotor sharp edge or of a present day CFRP2 tennis racket. By and by this group of blended materials offers the likelihood of energizing new answers for troublesome designing issues. In any case, it is just in the last half century that the science and innovation of composite materials have created to give the designer a novel class of materials and the fundamental apparatuses to empower him to utilize them profitably.

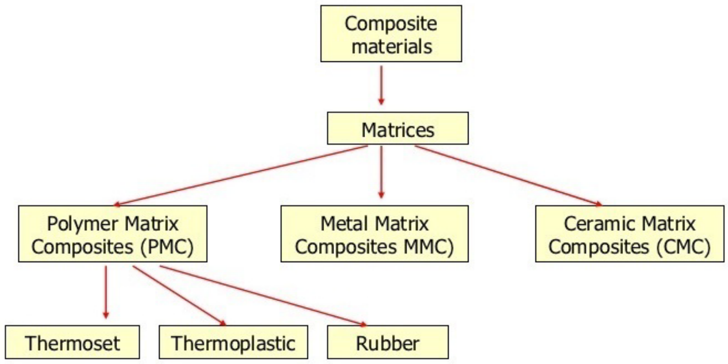


FIG: 3 CLASSIFICATION OF MATRIX

3.1 CLASSIFICATION OF COMPOSITES:

Composite materials are regularly ordered at taking after two unmistakable levels.
i. The filaments are main burden conveying individuals, while the encompassing lattice keeps them in the sought area and introduction, goes about as a heap exchange medium between them, furthermore, shields them from natural harms because of raised temperatures what's more, dampness, for instance. Hence, despite the fact that the filaments give support for the network, the last likewise serves various helpful capacities in a fiber fortified composite material.
ii. Laminar Composites materials are built out of layers of materials held together by framework. Combined structures fall under this classification.
iii. Particulate Composites materials are made out of materials passed on or embedded in a system body. These particles may be chips or in the powder structure. Concrete and the wood atom sheets are instance of the class.

3.1.1 METAL LATTICE COMPOSITE
3.1.2 CERAMIC MATRIX MATERIALS (CMM)
3.1.3 POLYMER GRID COMPOSITES (PMC)
3.1.4 REINFORCEMENTS
3.1.5 FIBER REINFORCED COMPOSITES (FRC)
3.1.6 PARTICULATE STRENGTHENED COMPOSITES (PRC)
3.1.7 LAMINAR COMPOSITE (LC)
3.1.8 WHISKERS
3.1.9 FLAKE COMPOSITES

4.2 MATERIALS:

4.2.1 ALUMINUM ALLOY LM 13:

The expansive utilization of aluminum composites is directed by an extremely attractive blend of properties, consolidated no sweat with which they might be delivered in an awesome assortment of structures. The concoction piece of network material is appeared in Table 1. The mechanical, warm and electrical properties of LM13 are appeared in the Table 2. LM13 amalgam is really an eutectic composite having the most minimal softening point that can be seen from the Al-Si stage outline. The principle piece of LM13 is around 85.95% of aluminum, 12% to 13% of silicon. Metal Matrix Composites (MMC's) have been produced to take care of the demand for lighter materials with high particular quality, solidness and wear resistance. Among Metal network composites particulate fortified aluminum framework composites are alluring because of noteworthy upgrades in mechanical and physical properties like, for example, better quality than weight proportion, great flexibility, high quality and high modulus, low warm development coefficient, phenomenal wear resistance, brilliant erosion resistance, high temperature creep resistance and better weariness quality. Aluminum based MMC's find wide applications in aviation, vehicles and marine segments, and soon.

4.2.2 SILICA:

Manufactured undefined silica (SAS) is utilized as a part of an extensive variety of uses, for example, fortifying fillers in elastic and tires, free-stream or against solidifying specialists in powder materials. Table:-3 demonstrates the compound synthesis of silica. Quartz/silica is a hard mineral and gives magnificent hardness on fuse into the delicate lead-composite, in this way improving it suited for applications where hardness is alluring. There are three noteworthy types of crystalline silica they are quartz/silica, tridymite and cristobalite. It is likewise generally idle and does not respond with weaken corrosive. Silica is utilized either alone or as a part of conjunction with lime to accomplish the coveted base/corrosive proportion required for refinement. These base metals can be further refined and altered with different fixings to accomplish particular properties, for example, high quality, erosion resistance or electrical conductivity. Ferroalloys are crucial to claim to fame steel generation, and mechanical sand is utilized by the steel and foundry businesses for de-oxidation and grain refinement. The properties of pure SiO_2 are mentioned in the Table 4.

Table 1: Chemical Composition of an Matrix Material (Lm 13)

Elements	Cu	Zn	Mg	Si	Fe	Mn	Ni	Pb	Sn	Ti	Al
% by wt	0.7	0.5	1.4	12.0	1.0	0.5	1.5	0.1	0.1	0.2	Balance

Table 1: Mechanical, Thermal and Electrical Properties of an Lm13

Physical Properties	Values
Density (g/cm3)	2.7
Mechanical Properties	Values
Tensile strength (MPa)	170-200 0.2%
Proof stress (MPa)	160-190
Elongation %	0.5
Hardness (VHN)	130
Thermal Properties	Values
Coefficient of thermal expansion (/°C at 20-100 °C)	0.000019
Coefficient of thermal expansion (/°C at 20-300 °C)	0.000021
Thermal conductivity (cal/cm2/cm/°C at 25 °C)	0.28
Melting point (°C)	695
Electrical Properties	Values
Electrical conductivity (% copper standard at 25 °C)	29

TABLE 2: CHEMICAL COMPOSITION OF SILICA (SIO2)

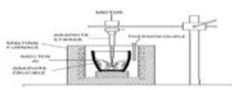
Elements	Si	O_2
% by wt	0.46	0.53

Table 3: properties of reinforcement silica

Properties	Values
Tensile strength	25 N/mm2
Melting point	1830 °C
Boiling point	2230 °C
Density	2.65 gm/cm3
Thermal conductivity	1.3 W/m-k
Compressive strength	2070 N/mm2
Poisson’s ratio	0.17
Modulus of elasticity	70 GPa
Thermal shock resistance	Excellent

4.3 CASTING PROCEDURE:

The materials utilized as a part of this work are aluminum compound (LM13) for the network and Silica (SiO_2) as particulates with various wt% (4.25 to 11.76 wt %) taking into account the variety in weight. The elastic test examples of SiO2 particulate strengthened LM13 amalgam composites utilized here is set up as indicated by ASTM E8M measures. The sturdiness and formability of Aluminum amalgam and silicon can be joined to expand quality of quartz particles. Solid metal changeless molds is utilized for handling composite castings. The present examination goes for delivering cast aluminum amalgam silica particulate composites in molds by scattering silica particles in liquid aluminum combination over the liquid's temperature. Economically accessible aluminum composite (LM13) material are utilized and is dissolved as a part of a resistance heater at around 9500C, Silica (Sio2) particulates were included at end of procedure. A blend throwing procedure is utilized to manufacture half and half composites fortified with different weight divisions of silica particulates. Properties of silica are Density = 2.196 kg/m3, Hardness = 7.0 Mohs. Figure.4.2.1 demonstrates a sectional perspective of the blend throwing game plan. Blend of dispersed shifts from 4.25 to 11.76wt% in ventures of 4.25wt% of silica particulates. Fortifications were brought equitably into the liquid metal composite by method for bolstering connections. The size silica particulates scattered are in the scope of 1, 3 and 5 mm. Then, the liquid HMMCs was very much upset by method for a mechanical blending which was done for around 15 min at a normal blending rate of 760 rpm. . Molds were readied utilizing silica sand with 5% bentonite as cover and 5% dampness as per American Foundry men Society (AFS) gauges, and were dried in an air heater. "N" number of molds were set up for "N" number of examples. The molds delivered roundabout formed ingots of measurements 120mm long and 25mm in breadth. The melt was next filled a sand mold. Figure.4.22 demonstrates the course of action of mold utilized for throwing examples. Examples for all the tests were warmth treated by maturing before testing. Properties, for example, hardness, rigidity of the created half breed composites were tried according to ASTM principles.



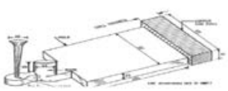


FIG 4.3.1: STIR CASTING SETUP
FIG 4.3.2: MOLD FOR CASTING SPECIMEN

Fig 4.3.3: Die Used For Composites Preparation.
Fig 4.3.4: Molten Metal Being Stirred

Fig 4.3.5: Molten Metal Poured Into
Fig 4.3.6: Casted Composite Metal
Preheated Molds

RESULTS AND DISCUSSIONS

5.1 MICROSCOPIC EXAMINATION:

Microscopic examination of the MMCs was executed by method for optical microscopy. Different etchant were attempted yet weaken Keller's etchant ended up being the best and was in this manner utilized. The microstructure of Al-Si, in as cast condition, demonstrates fine eutectic silicon scattered in the entomb dendritic area and fine encourages of alloying components in the network of aluminum strong arrangement. The dendrites of aluminum and eutectic silicon in the inter dendritic areas and around the dendrites. The micrograph of LM13 with 4.25 to 11.76 wt% silica composite, in as cast condition, indicates uniform dissemination of silica particles in aluminum lattice. Figure 5.1.1 to 5.1.4 demonstrates the microstructural perception of arranged composites. The mechanical properties of the composite materials are unequivocally reliant to small scale auxiliary parameters of the framework. These advancement of the micro-structure depends to a great extent on a cooling rate amid stage change. Despite these fact that the microstructure development relies on upon the numerous procedure parameters, the last structure has been chosen by cooling conditions amid cementing [17]. The present examination goes for creating cast aluminum combination silica particulate composites by scattering silica particles in liquid aluminum amalgam over the liquidus temperature. The dispersoid being added ranges from 4.25 to 11.76wt% in ventures of 4.25wt%. Thrown composites with 8.16wt% silica displays most noteworthy qualities for elasticity and hardness. Figure 5.1.1 to 5.1.12 demonstrates of these optical micrographs of an aluminum composites strengthened with 4.25 to 11.76wt% silica. Figure 5.1.1 to 5.1.4 shows microstructure of 8.16wt% silica. The Microstructure of 8.16 wt% is medium in light of the fact that the volumetric warmth limit (VHC) of the 8.16wt% favors directional hardening furthermore quickens cementing. Speedier cooling rates offer ascent to better structures and enhanced mechanical properties [18]. Optical micrographs of 1mm and 4.25 wt% sio2 is fine, it indicate plainly the uniform circulation of silica in the network, and there are no voids and discontinuities has been watched. There has a decent interfacial holding between these particles and network material. Optical micrographs of 5mm and 11.76 wt% Sio2 is vast, it demonstrates unmistakably the non-uniform appropriation of silica in the network, and there are no voids and discontinuities have been watched.

5.1.1 MICROSCOPIC VIEWS FOR VARYING SIZE AND WEIGHT'S:

Size of Sio_2=1mm, Weight of Sio_2=60gram

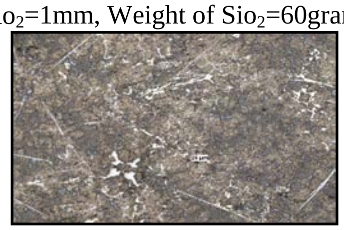


FIG: 5.1.1 UN-ETCHED (100X)

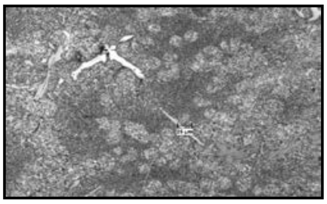


FIG: 5.1.3 KILLER'S ETCHED (200X)

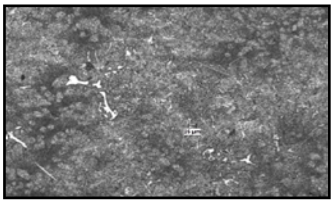


FIG: 5.1.2 KILLER'S ETCHED (100X)

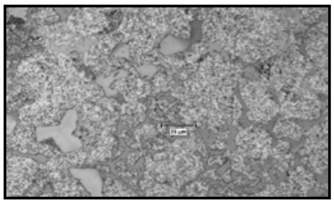
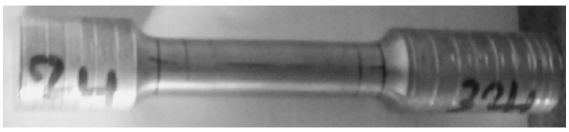


FIG: 5.1.4 KILLER'S ETCHED (500X)

- Size of Sio2=5mm, Weight of Sio2=60gram

5.2 ULTIMATE TENSILE STRENGTH (UTS):

Hardness tests were performed with a Brinell small scale Hardness testing machine on the cleaned examples utilized for microstructural investigation. The particulars measurement, and state of the example utilized are appeared as a part of the Figure 5.21 and a reasonable clarification in given underneath. SiO2-particulate strengthened with LM13 combination composite cast test examples are prepared by blend throwing process. Distinctive wt% rate of SiO2 particulates are added to deliver the cast test tests. The photo of the pliable test examples prior and then afterward testing is appeared in the Figures 5.2.1 and 5.2.2. A 150 KN servo pressure driven UTM is utilized to direct the pliable tests. The test tests are subjected to a pliable burden and the mechanical properties are resolved. Subsequently, the rigidity, and youthful modulus qualities are computed.



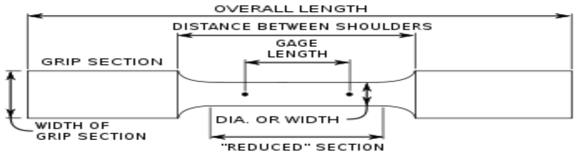


Fig 5.2.2: Tensile Test Specimen as Per Astm Standard

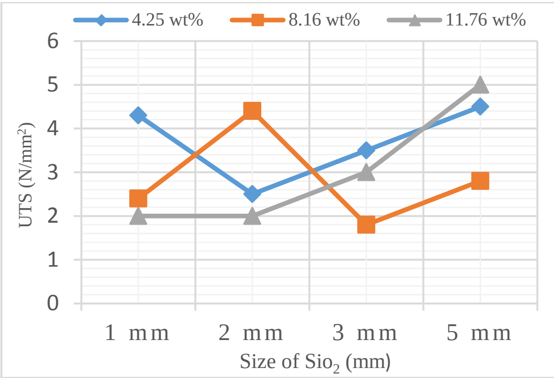
To study the pliable conduct of the cross breed composites, examples were arranged and tried according to ASTM E8M standard. Figure 5.23 demonstrates the plot of UTS v/s dispersed substance of the HMMC's. It is apparent from this plot, the UTS of the composite increments as silica substance is expanded. It is obvious from these outcomes that the HMMC's with the most noteworthy UTS is 3mm in size and 11.76wt% sio2 cast composite, trailed by those cast with 1mm and 5mm in a specific order. The outcomes affirm the positive relationship amongst UTS and the dispersiod content. The elasticity of Figure 5.24 demonstrates the plot of Size of Sio2 v/s Deflection. The rigidity of size 3mm and 8.16 wt% sio2 cast composite is 75.31N/mm2 and youthful's modulus=50KN/mm2. 11.76wt% silica fortified half and half composite is really lesser than that of the cross breed composite strengthened with 4.25% silica. The conceivable reason could be; expanded agglomeration of the fortified particles and expanded porosity content as the molecule rate increments. The extensive contrast in co-proficient of warm development (CTE) confuse between the aluminum and mixture fortifications could really incites the huge measure of separations in the half breed composites. These incited separations go about as a hindrance for the disengagements development. Subsequently the quality of the half breed composites are expanded fundamentally notwithstanding for the expansion of low weight rate of the fortifications.

Fig 5.2.3: Specimen after Tensile Test

The estimation of elasticity and % of SiO2 is appeared in the Table 5. The Figure 5.2.4 shows variety in elasticity of Al-SiO2 particulate composites for 106 µ molecule size. The rigidity expanded with expanded weight rate of SiO2 up to 8.16 wt% and diminished for 11.76 wt%. Since the expansion in the percent of shut pores with expanding SiO2 particulate substance would make more destinations for break start and consequently drop down the heap bearing limit of the composite. Other than if the quantity of contacts between SiO2 particulate builds, then the particles is no more disconnected by the bendable aluminum compound lattice.

TABLE 5: TABULATED TENSILE STRENGTH

Weight percentage of silica	Tensile strength in (MPA)
4.25	74.71
8.16	75.31
11.76	72.95



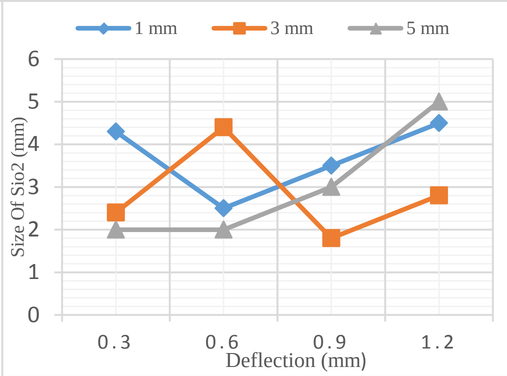


Fig 5.2.4: Plot of Uts V/S Size of Silica5.2.5: Size of Sio2 V/S Deflection

5.3 HARDNESS STUDIES:

Hardness tests have been performed on the cast tests with an Brinell hardness test machine. A precision ball indenter is asked material at a store of 250 kilograms for 10sec. Figure 5.31 shows the hardness of HMMCs cast with different weight % of silica. The aftereffects of miniaturized scale hardness test directed on MMCs tests uncovered an expanding pattern in framework hardness with an expansion in fortification substance (up to 8.16 wt% silica). Aftereffects of hardness estimations additionally uncovered that 1mm in size and 4.25

wt% of Sio2 has hardness estimation of 93.2. This noteworthy increment in the hardness can be credited basically because of the nearness of harder silica fired particulates in the lattice, a higher requirement to the confined twisting amid space because of their nearness and diminished grain size amid nucleation [19, 20]. In let go strengthened composite, there is generally a noteworthy difference between the mechanical properties of the dispersoid and those of the system. These results in disarray and a high thickness of detachments near the interface between the dispersoid and the system. The plot of hardness of composite with various wt% of dispersiod substance which asserts the positive relationship amongst hardness and the dispersiod content. Hardness of 11.76wt% silica cast hybrid composite is lower and additions as silica substance is lessened up to 4.25wt% by weight, past which it drops again. It is clear from the results that 8.16 wt% Sio2 sets most quickly from the HMMC in the midst of tossing. Hardness estimations of the creamer composites are higher than that of the remaining accomplice and the mix 4.25wt% Sio2 and 1mm in size give unrivaled hardness regard.

Fig 5.3.1: Brinell Hardness Testing Machine And Specimen After Brinell Hardness Test

Hardness tests were performed on composites to know the impact of silica in grid material. The cleaned examples were tried utilizing Brinell smaller scale hardness testing framework. The hardness was controlled by recording the slanting lengths of space created. The test was done at six unique areas and the normal worth was taken as the hardness of the composite examples. Table:-6 demonstrate the consequences of smaller scale hardness test on composite containing distinctive wt% of silica in it. From the Figure 5.32 it is apparent that hardness of an composite material has much more higher that of its guardian metal. It is likewise demonstrated that the hardness of the composite material increments with wt% of silica substance. This might be a direct result of expansion of silica makes the bendable Al amalgam into more weak in nature with expansion in the silica content. Furthermore the scattering of silica particles upgrades the hardness, as particles are harder than Al combination, and render their inborn property of hardness to delicate grid.

TABLE 4: TABULATED HARDNESS NUMBER

Weight Percentage of Silica	Hardness (VHN)
1mm	93.2
3mm	83.3
5mm	68.4

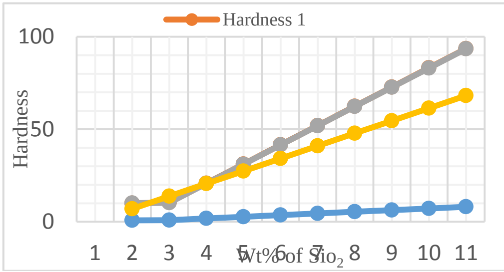
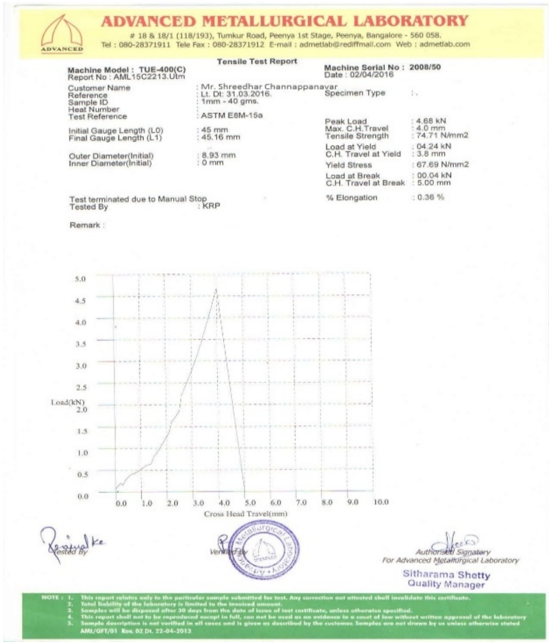


Fig 5.3.2: hardness v/s wt. % of silica


ADVANCED METALLURGICAL LABORATORY

18 & 18/1 (118/193), Tumkur Road, Peenya 1st Stage, Peenya, Bangalore - 560 058.
Tel : 080-28371911 Tele Fax : 080-28371912 E-mail : admetlab@rediffmail.com Web : admetlab.com

Tensile Test Report

Machine Model : TUE-400(C)
Report No : AML15C2213.Utm
Machine Serial No : 2008/50
Date : 02/04/2016

Customer Name : Mr. Shreedhar Channappanavar
Reference : Lt. Dt: 31.03.2016.
Sample ID : 1mm - 40 gms.
Heat Number :
Test Reference : ASTM E8M-15a
Specimen Type :

Initial Gauge Length (L0) : 45 mm
Final Gauge Length (L1) : 45.16 mm

Outer Diameter(Initial) : 8.93 mm
Inner Diameter(Initial) : 0 mm

Peak Load : 4.68 kN
Max. C.H.Travel : 4.0 mm
Tensile Strength : 74.71 N/mm2
Load at Yield : 04.24 kN
C.H. Travel at Yield : 3.8 mm
Yield Stress : 67.69 N/mm2
Load at Break : 00.04 kN
C.H. Travel at Break : 5.00 mm
% Elongation : 0.36 %

Test terminated due to Manual Stop
Tested By : KRP

Remark :

Load(kN)
Cross Head Travel(mm)

Tested By
Verified By
Authorised Signatory
For Advanced Metallurgical Laboratory
Sitharama Shetty
Quality Manager

NOTE : 1. This report relates only to the particular sample submitted for test. Any correction not attested shall invalidate this certificate.
2. Total liability of the laboratory is limited to the invoiced amount.
3. Samples will be disposed after 30 days from the date of issue of test certificate, unless otherwise specified.
4. This report shall not to be reproduced except in full, can not be used as an evidence in a court of law without written approval of the laboratory
5. Sample description is not verified in all cases and is given as described by the customer. Samples are not drawn by us unless otherwise stated
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Tel : 080-28371911 Tele Fax : 080-28371912 E-mail : admetlab@rediffmail.com Web : admetlab.com

HARDNESS TEST REPORT

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Test Report No: AML 15C2211 Date: 01.04.2016

SAMPLE ID: 15C2211 Received on: 31.03.2016 Tested on: 01.04.2016

CUSTOMER: Mr. Shreedhar Channappanavar

Reference: Lt. Dt: 31.03.2016.

Sample details: 1mm - 20 gms.

Type of Test: HARDNESS
Test reference: IS:1500 - Pt.1-2013 Machine Model : MRB 250 Brinell hardness tester.

TEST RESULT

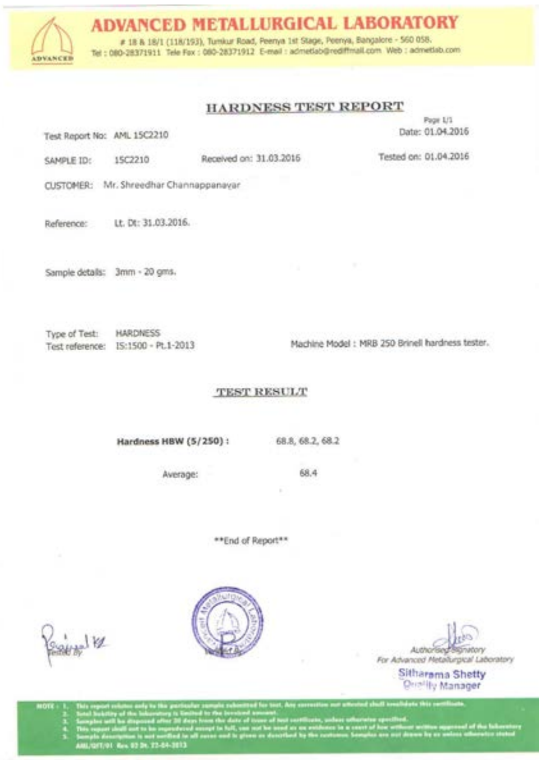
Hardness HBW (5/250) : 93.9, 92.8, 92.8

Average: 93.2

End of Report

Tested By Verified By Authorised Signatory For Advanced Metallurgical Laboratory
Sitharama Shetty
Quality Manager

AML/QFT/01 Rev. 02 Dt. 22-04-2013



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HARDNESS TEST REPORT

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Test Report No: AML 15C2210 Date: 01.04.2016

SAMPLE ID: 15C2210 Received on: 31.03.2016 Tested on: 01.04.2016

CUSTOMER: Mr. Shreedhar Channappanavar

Reference: Lt. Dt: 31.03.2016.

Sample details: 3mm - 20 gms.

Type of Test: HARDNESS
Test reference: IS:1500 - Pt.1-2013 Machine Model : MRB 250 Brinell hardness tester.

TEST RESULT

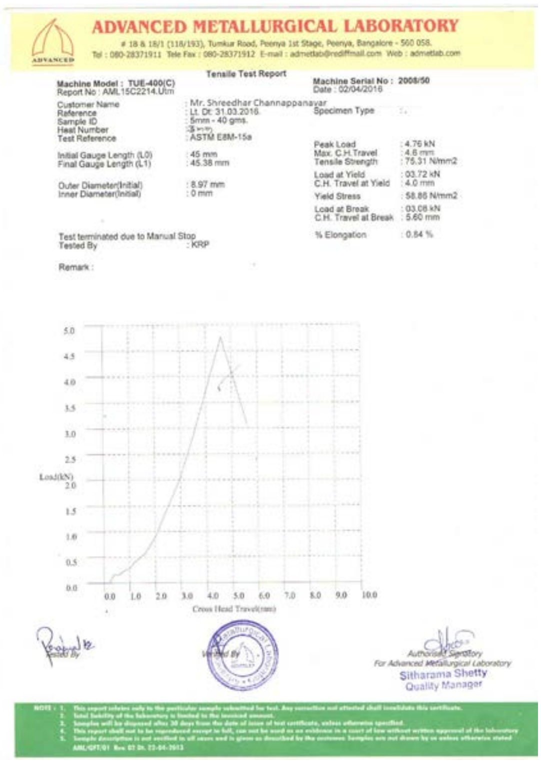
Hardness HBW (5/250) : 68.8, 68.2, 68.2

Average: 68.4

End of Report

Tested By Verified By Authorised Signatory For Advanced Metallurgical Laboratory
Sitharama Shetty
Quality Manager

AML/QIT/01 Rev. 02 Dt. 22-04-2013



ADVANCED METALLURGICAL LABORATORY

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Tensile Test Report

Machine Model : TUE-400(C) **Machine Serial No : 2008/50**
Report No : AML15C2214.Utm Date : 02/04/2016

Customer Name	: Mr. Shreedhar Channappanavar	Specimen Type	:
Reference	: Lt. Dt: 31.03.2016.		
Sample ID	: 5mm - 40 gms.		
Heat Number	: 5 mm		
Test Reference	: ASTM E8M-15a	Peak Load	: 4.76 kN
		Max. C.H.Travel	: 4.6 mm
Initial Gauge Length (L0)	: 45 mm	Tensile Strength	: 75.31 N/mm2
Final Gauge Length (L1)	: 45.38 mm	Load at Yield	: 03.72 kN
		C.H. Travel at Yield	: 4.0 mm
Outer Diameter(Initial)	: 8.97 mm	Yield Stress	: 58.86 N/mm2
Inner Diameter(Initial)	: 0 mm	Load at Break	: 03.08 kN
		C.H. Travel at Break	: 5.60 mm
		% Elongation	: 0.84 %

Test terminated due to Manual Stop
Tested By : KRP

Remark :

Tested By Verified By Authorised Signatory For Advanced Metallurgical Laboratory
Sitharama Shetty
Quality Manager

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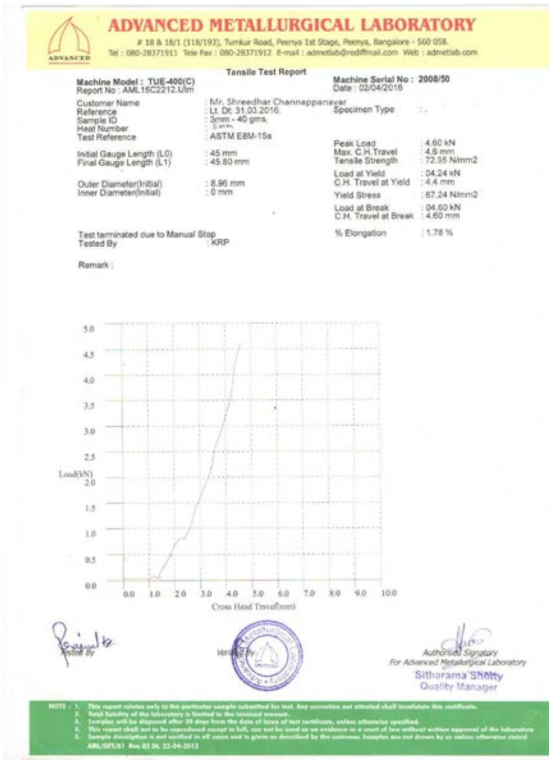

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Tensile Test Report

Machine Model : TUE-400(C) **Machine Serial No : 2008/50**
Report No : AML15C2212.Utm Date : 02/04/2016

Customer Name	: Mr. Shreedhar Channappanavar	Specimen Type	:
Reference	: Lt. Dt: 31.03.2016.		
Sample ID	: 3mm - 40 gms.		
Heat Number	: 5 mm		
Test Reference	: ASTM E8M-15a	Peak Load	: 4.60 kN
		Max. C.H.Travel	: 4.8 mm
Initial Gauge Length (L0)	: 45 mm	Tensile Strength	: 72.95 N/mm2
Final Gauge Length (L1)	: 45.80 mm	Load at Yield	: 04.24 kN
		C.H. Travel at Yield	: 4.4 mm
Outer Diameter(Initial)	: 8.96 mm	Yield Stress	: 67.24 N/mm2
Inner Diameter(Initial)	: 0 mm	Load at Break	: 04.60 kN
		C.H. Travel at Break	: 4.60 mm
		% Elongation	: 1.78 %

Test terminated due to Manual Stop
Tested By : KRP

Remark :

Tested By Verified By Authorised Signatory For Advanced Metallurgical Laboratory
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Quality Manager

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HARDNESS TEST REPORT

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Test Report No: AML 15C2209 Date: 01.04.2016
SAMPLE ID: 15C2209 Received on: 31.03.2016 Tested on: 01.04.2016
CUSTOMER: Mr. Shreedhar Channappanavar

Reference: Lt. Dt: 31.03.2016.

Sample details: 5mm - 20 gms.

Type of Test: HARDNESS
Test reference: IS:1500 - Pt.1-2013 Machine Model : MRB 250 Brinell hardness tester.

TEST RESULT

Hardness HBW (5/250) : 84, 83, 83

Average: 83.3

End of Report

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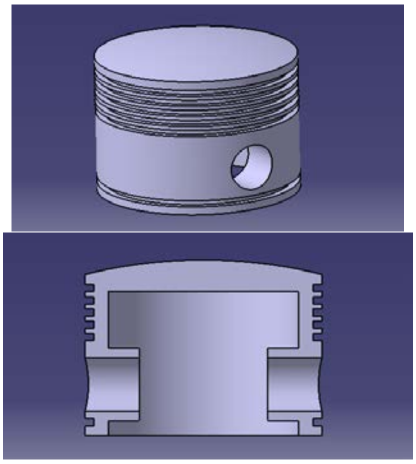
For Advanced Metallurgical Laboratory
Sitharama Shetty
Quality Manager

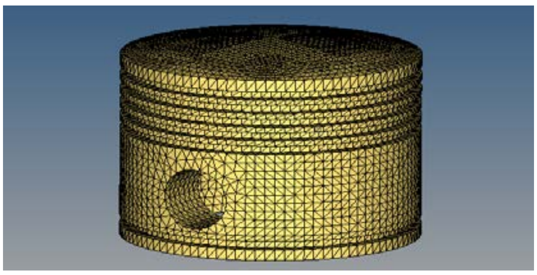
NOTE : 1. This report relates only to the particular sample submitted for test. Any correction not attested shall invalidate this certificate.
2. Total liability of the laboratory is limited to the invoiced amount.
3. Samples will be disposed after 30 days from the date of issue of test certificate, unless otherwise specified.
4. This report shall not be reproduced except in full, can not be used as an evidence in a court of law without written approval of the laboratory
5. Sample description is not verified in all cases and is given as described by the customer. Samples are not drawn by us unless otherwise stated
AML/QFT/01 Rev. 02 Dt. 22-04-2013

5.5 FINITE ELEMENT ANALYSIS OF PISTON

CAD MODEL OF PISTON:



The above figures shows the CAD Model of Piston in catia v5



FE MODEL OF PISTON

MATERIAL PROPERTIES OF ALUMINIUM ALLOY:

YOUNGS MODULUS	70 GPa
POISSONS RATIO	0.17
DENSITY	2.6898 e^{-3} g/mm^3
YIELD STRESS	210 MPa

LOADING CONDITION: BMEP = 5 MPa

VON-MISES STRESS

DISPLACEMANT PLOT:

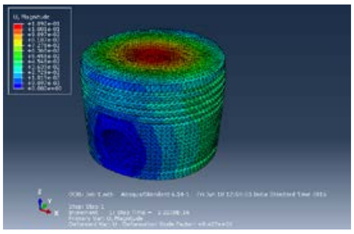


FIG: DISPLACEMENT PLOT

Von-Mises Stress = 147 MPa
Maximum Displacement Criteria = 0.010 mm

Conclusion

- The analysis of automotive IC engine piston by using material properties of LM13 composites is successfully.
- By this analysis results, it is conclude that the deformation of the piston high pressure is less as compared to that of the monolithic material piston.
- Also the stress distribution along the piston is within the allowable stress. So that the material properties adopted in the analysis is fulfills the requirements.

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