STUDY ON EFFECT OF HEAT TREATMENT FOR AL-CU METAL MATRIX COMPOSITES FABRICATED BY STIR CASTING METHOD

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Abstract - *Metal matrix composites are the composite material which includes the reinforcing mixture of aluminium, other metal and a ceramic material. Now days it is widely found in aircraft, sports kits, medicals, electrical items, and in military field application. . But my intension is to find the effect of heat on the hardness, compact strength, and wear resistance of the metal matrix composites. In this experiment a prescribed quantity of aluminium (85%) is reinforced with copper (10%) & alumina (5%) is prepared with stir casting and machined to make cavity into required dimensions as per ASTM standards. The 3 set of specimens (compression, hardness (Rockwell and brinell)) and wear tests are carried out with 3 different specimens.*

Key Words: Al alloy, Stir casting, Hardening , Mechanical properties, etc

1.INTRODUCTION

We knew that the composite material that consists of mixture and it includes the combination of two or more individual materials that has specific structural properties.Composite materials play an important role in the manufacturing of aerospace structures. Aircraft spares are like, fuselage, wing structures, etc. Before they were used aluminium weight savings. In the new generation composites are heavily used in aircraft spares. The saying here instances are the steel – concrete reinforcement, Gr – epoxy reinforcement and so on. An advancing conposite is manufactured by fibrous material which is embedded in the resin matrix, commonly laminated with fibers oriented in different directions to increase the material strength. The fibres are generally having many different types that commonly includes are Glass fibers, Carbon Fiber, Aramid Fiber, Natural Fiber.

1.1 Aluminium

Aluminium was not used earlier because it is difficult to extract from ore. But recently aluminium has got an engineering application at the end of 19^{th} century as an aluminium competitor. Innitially IC Engines was introduced. Aluminium plays an automotive material role. Before wright brothers our Indian Togere Subbaraya Shastree writes an constructional designs about the safe construction of aeroplanes. By referring shashtree's design sketch wright brothers developed aeroplanes. At this time aluminium industry starts growing.

1.2 Copper

Copper is an initially available in the form of natural ores. And is also we got alloys at rocks and soil. Before 600 B. C, the pure copper was found in reddish brown stone as a pure metal in the Mediterranean area and it is hammered into utensils Weapons and tools. Around 4000 B. C casting and smelting of copper developed. Last 20 years during the technical innovation of copper industry the open pit mining, flotation concentration, and the reverberatory smelter were adopted for copper ores.

1.3 Alumina

Alumina consist chemical compounds of aluminium and oxygen. Its chemical formula is Al_2O_3. In time of ancient days, aluminium is related with alum, where it found in alumina. And it is a mixture of potassium trisulphide and sulphuric acid also moves to contact with it. And it results in sulphurated minerals or gas. Sumerians, Egyptians were also used it for wide range of applications in medicals, woollen, anti inflammatory products.

2. MATERIAL SELECTION AND MANUFACTURING

Fig 1: Aluminium

Aluminium is a light weight and low density and its corrosion resistance is very high as compared to steel and other metals. It is a strong to mass ratio, and high reflective. Aluminium exhibits high strength at room temperature. For electrical power, and heating coil, aluminium is used because it is agood electrical and thermal conductor. Because of non-ferromagnetic behaviour exerted by aluminum, the application is widely usages in electrical and electronic industries. Because of no poisonous behaviour exerted by aluminium, it is also usedin medical, food, and other carriage items.

Fig 2: Copper

It exhibits behavior in softness, malleability and ductility characteristics. Copper turns into white colour when it undergoes oxidation. The important properties of copper are copper is a excellently conducting electricity, heat carrier. It is characterized with good resistance of corrosion, and excellent machining, and has highstiffness. And it is characterized with good and easily we can fabricate material.Copper is a nonferrous material, so it cannot behave like a magnet.Copper is a soft material so copper is used as a welding, brazing andsoldering.

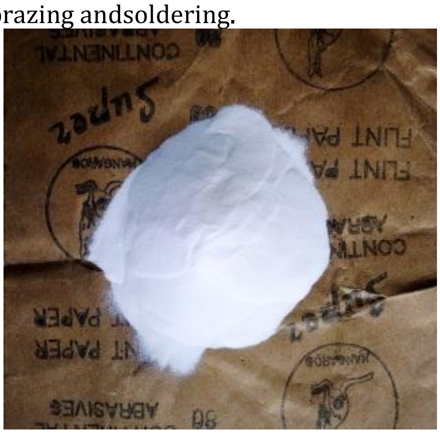

Fig 3: Alumina

Alumina is formed by the oxides of aluminium. It is also available in the form of corundum, diaspare and bauxite. Alumina is used in gas tubes, seal rings, ballisticrmor, laboratory instruments and sample tubes. The main property of aluminium is it exhibits different characteristics in physical and chemical. It exhibits excellent hard, as compared to diamond. The property of alumina is leads to using in the field of abrasive tool material and it is having high melting point (upto 2000oC).

HEAT TREATMENT: Heat treatment is carried out to change microstructures and mechanical properties of steels. Commonly, heat treatment operation is utilized to transform from one phase to another and cooled to change the microstructures in solid state. To change the properties of physical and mechanical by authorizing their heating and cooling of specimen with the method of heat treatment and no changes instructure. Steels are best suited for heat treatment, so it is excellently responsive toany type of heat treatment.By heat treatment process, the strength of metal can be increased, and it improvesmachining characteristics, forming ability, and other properties. And theefficiency of the product can be can also be improved by heat treatment method.

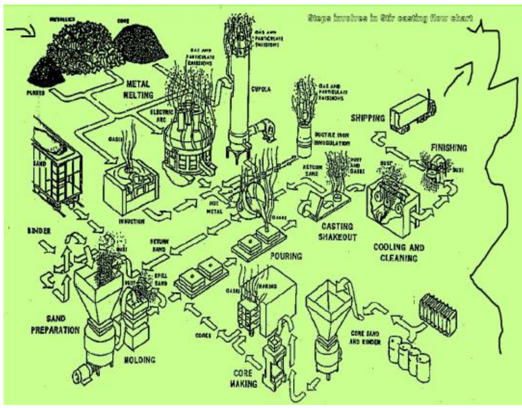

Fig 4: Stir casting

STIR CASTING: Stir casting is the procedure that involves the process of liquid state aluminiummetal is fabricated with ceramic, and fibers with the help of mechanical stirrer. Normal casting process is used to get the molten state of MMCs. Here few factors that affects in the preparation of MMCs using stir casting system considered arean uniformly distribution in a metal matrix reinforcement is achieved withthe method of stir casing usage. And theWettability between 2 important substrate individual metal matrixes isachieved with the method of stir casing usage.Metal casting has various forms like sand castings, investment casting, and steelcastings. In this process the metal's meltingpoint is higher than 1000 degree Fahrenheit, of 550 degrees Celsius so any onewho works with this must follow security and safety instruction.

3. EXPEMENTS AND RESULTS DISCUSSIONS

Specimens are prepared as per ASTM standards. Then chosen raw materials are selected on percentage basis. As given below

Table – 1: Specimen ingredients with %ge

MATERIALS	COMPOSITION
Aluminium 2618	85%
Copper	10%
Alumina	5%

Then by using this composition, the specimens are prepared with using stir casting method. After specimen preparation, make 3 specimens for each 3 tests that are compression, hardness (brinnel and Rockwell) and wear tests. And in that 3 specimens, each one specimen maintain at room temperature for 3 tests. And other remaining specimen are subjected to heat treatment with different temperature as given in table below.

TYPE OF SPECIMENS	TEMPERATURE	COOLING MEDIA
COMPRESSION	1) 300 – 350 2) 350 – 400	OIL TREATED
HARDNESS(ROCKWELL AND BRINNEL HARDNESS)	1) 300 – 350 2) 350 – 400	OIL TREATED
WEAR TEST	1) 300 – 350 2) 350 – 400	OIL TREATED

Compression test (Stir Casting)

In Compact test we took 3 specimens (1 Room temperature, one at Heat treated 300°C, one at 400°C) of specimen of 20mm diameter and 20mm length and this specimen is placed between the table and lower cross heads of the universal testing machine. Apply the load gradually make simultaneous observation of load and compress meter reading. After this measure the diameter and final length of the specimen. Finally the graph stress v/s strain for different temperature of specimens obtained.

Table – 3: Compression test for Stir Casting

SPECIMEN TYPE	LOAD	DEFORMATION	TIME	STRESS	STRAIN	YOUNGS MODULUS
STIR CASTING	3	0.04	0.3281	4.24	0.0013	3261.53
	350.52	5.36	49.218	495.89	0.178	3785.89
	320.64	5.48	54.796	453.61	0.182	2492.36

From the above table it shows that the specimen of room temperature, the load increases with increasing deformation. Here deformation does not changes but load increasing and decreasing at some point. And at load value 350.52 KN and 5.36 deformation values is a maximum load and from this value load starts decreasing but deformation never decreases. At load value 320.64 KN, and deformation 5.48 the specimen breaks.

TABLE4: Compression test for heat treated 300°C

SPECIMEN TYPE	LOAD	DEFORMATION	TIME	STRESS	STRAIN	YOUNGS MODULUS
HT 300°C	3.24	0.02	1.4218	4.58	6.66×10^{-4}	6876.87
	324	4.1	307.56	458.37	0.136	3370.36
	261.42	5.01	321.01	369.83	0.165	2214.55

From the above table it shows that the specimen of heat treated 300°C, here load increases up to deformation value of 4.1 and its load is 324 KN. After this load decreases gradually. And at 261.42KN specimen break. And its deformation was 5.01. this heat treated 300oC shows that heat treated specimen exhibits highest stiffness and has high strength.

TABLE 5 : Compression test for heat treated 400°C

SPECIMEN TYPE	LOAD	DEFORMATION	TIME	STRESS	STRAIN	YOUNGS MODULUS
HT 300°C	3.24	0.02	1.4218	4.58	6.66×10^{-4}	6876.87
	324	4.1	307.56	458.37	0.136	3370.36
	261.42	5.01	321.01	369.83	0.165	2214.55

From the above table it shows that the specimen of heat treated 400°C, here load increases up to deformation value of 4.02 and its load is 246.3 KN. After this load decreases gradually. At load 220.17 KN specimen breaks. And its deformation was 6.34. This heat treated 400°C shows that heat treated specimen of highest temperature having higher stiffness than above two materials.

Fig 5 Graph of Stress v/s strain

Confirmations: In strain v/s stress, stress is lower in heat treated specimens where as stress is higher in room temperature specimens. In heat treated stress is lower in 400oC andas heat treated temperature increases stress value decreases.

In Rockwell hardness testing using diamond indenter (1.6mm or 1/6" diameterand 120°degree apex angle) with an applied load of 150 Kg for 30 seconds.as well as in Brinnel hardness testing uses Ball indenter of 5mm diameter with anapplied load of 250 Kg for 30 seconds the results of brinell and Rockwell tests are shown in below.

Table – 5: Rockwell Hardness tests for 3 type specimens

TYPE	LOAD	TIME REQUIRED TO LOAD (IN SEC)	ROCKWELL NUMBER	AVERAGE ROCKWELL HARDNESS NUMBER
NON HEAT TREATED	150	15	65	65
			66	
			62	
HEAT TREATED (300–350°C)	150	15	41	43.33
			46	
			43	
HEAT TREATED (350–400°C)	150	15	32	31.33
			42	
			20	

Confirmations: By the Rockwell hardness tests, After Rockwell hardness test by seeing the alues after test, wecame to know that hardness of specimen increases with increase in emperature ofspecimen. The aluminium MMC changes its internal molecular structure uponincrease in temperature of specimen. At zero temperature aluminium is smooth innature. Upon increase in temperature and sudden cooling aluminium lost theirductility nature. And at 400oC aluminium became very hard in nature.

Brinnel hardness testing uses Ball indenter of 5mm diameter with an applied load of 250 Kg for 30 seconds. 3 different specimen of different heat treated MMCs are to be taken from each sample at different sections for testing to ensure the validity of results.

TABLE 6 : Brinell Hardness tests for 3 type specimens

TYPE	LOAD	TIME REQUIRED TO LOAD (IN SEC)	DIAMETER OF INDENTER	AVERAGE DIAMETER OF INDENTER	BHN IN Kgf/mm
NON HEAT TREATED	250	30	1.6	1.63	116.53
			1.5		
			1.8		
HEAT TREATED (300–350°C)	250	30	1.5	1.73	103.73
			1.8		
			1.9		
HEAT TREATED (350–400°C)	250	30	1.8	1.9	84.86
			2.0		
			1.9		

Brinnel hardness testing uses Ball indenter of 5mm diameter with an applied load of 250 Kg for 30 seconds. 3 different specimen of different heat treated MMCs are to be taken from each sample at different sections for testing to ensure the validity of results.

By wear test, the wear rates of the testing specimens were calculated by the weight loss technique. Pin – on – apparatus is used to conduct wear test (dry sliding) wear test apparatus of cylindrical pin specimens of 10mm diameter and 30mm length against a steel disc at different load with constant load and speed.

Fig 6: Testing Machines for varies test

TABLE 7: Wear tests for 3 type specimens

TYPE	DISC SPEED	TIME TAKEN	LOAD	WEIGHT WI	WEIGHT W2	REDUCTION IN WEIGHT (W1-W2)	WEAR RATE
NON HEAT TREATED	300	10 MIN	1	7.234	7.229	0.053	0.5202
			2	7.229	7.217	0.127	1.24
			3	7.217	7.191	0.276	2.7
HEAT TREATED (300-350)	300	10MIN	1	7.562	7.559	0.031	0.308
			2	7.559	7.549	0.106	1.043
			3	7.549	7.538	0.116	1.13
HEAT TREATED (300-350)	300	10MIN	1	7.826	7.824	0.021	0.202
			2	7.824	7.818	0.063	0.617
			3	7.818	7.809	0.095	0.936

From above table we see that the highest heat treated specimen exhibit more wear resistance than room temperature and in 300°C exhibit little bit improved wear resistance. And 400°C has highest wear resistance.

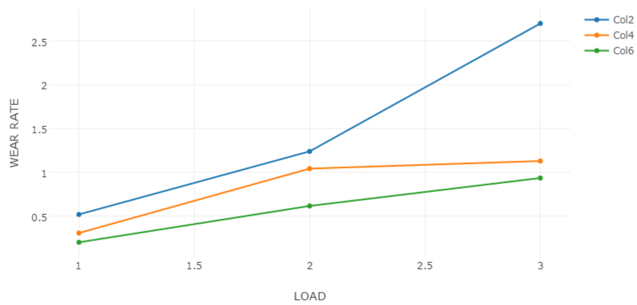

Fig7: Graph of Load v/s Wear rate

And also from below graphs comparing these values, we came to know that wear resistance of specimen increases with increase in temperature of specimen. At zero temperature aluminium is smooth in nature. Upon increase in temperature and sudden cooling aluminium lost their ductility nature. And at 400° C aluminium became very hard in nature. And wear resistance is more.

3. CONCLUSIONS

By this experiment, it shows that stir casting is a good fabricating method for aluminum MMCs, Then the copper and alumina is mixed with aluminium matrix composites are developed by Stir casting. And heat treatment shows that the strength, hardness, stiffness and wear resistance of material increases with increase in temperature upon sudden cooling.

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