ISSN No:-2456-2165

A Review of Fundamental Application, Challenges and Opportunities of Aluminium 2024 Composite in Modern Technology

Bopanna KD[1], MS Sreedhav[1], V Varun Kailash[1]P,reetham Balu[1*],Rayani Tharun[1].
Department of Mechanical Engineering
New Horizon College of Engineering
Bengaluru-560103, India

Abstract:- This paper reviews the properties and uses of Al-2024 based on a metal matrix compound. These components of composite-based composite materials are highly preferred in modern industries because of their light weight, high fatigue life, and high impact strength. Strategies used to produce an aluminum heat sink are also being developed. The various structures that influence the combination of metal matrix are briefly discussed. The use of integrated aluminum 2024 in the automation industry is highlighted. This study showed that Aluminum 2024 is widely used in heat loss due to thermal high conductivity. This study demonstrates a comprehensive study of Aluminum 2024.

Keywords:- *Component; Formatting; Style; Styling; Insert.*

I. INTRODUCTION

Composites are a combination of two or more materials with physically and chemically distinct properties that are blended and they have distinct properties according to those of each constituent part. Composites can be classified into two major distinct levels with respect to the matrix and reinforced constituent. Further with respect to matrix constituent (Polymer, Metal, Ceramic, and Carbon) with respect to reinforcement which includes the chemical nature (Oxides, Carbides, and Nitrides) and the shapes (Fiber, Whiskers, and Articulates) Aluminum MMC are produced by casting, powder metallurgy in-situ development of reinforcement technique, it always has high-quality products with large quantities with major produces scaling up the production and reducing prices. Aluminum matrix composites are not a single material however it is a family of material whose stiffness, density, strength, thermal and electrical properties can be modified. The reinforcement material, the shape, volume, and location of the reinforcement and the fabrication can all be different to get the required properties. Aluminum composites are the low cost MMC's and they provide excellent thermal conductivity, high shear strength, non-Flammability, and minimal attack by fuels. Aluminum matrix composites are widely used in the transportation sector as it has lower noise and low fuel compared to other materials. Nowadays MMC is used widely in aircraft engines and the automotive industry [1]. Al2O3 and Sic reinforced with aluminum alloy matrix composite are used in automotive and aircraft industries are moderately increasing for piston, cylinder head, etc. The tribological properties of the materials are very important for the development of matrix pomposities. The Ceramic particles reinforced have a lot of machining problems. Reinforcement research is going on to eliminate the problems [2]. A different method of producing MMC has come up recently the particle reinforced aluminum alloy composites can be produced by various fabrication processes like melt process (liquid-Phase process), powdered metallurgy (Solid-Phase process III. Aluminum oxide (Al2O3), The powdered form of alumina has excellent mechanical, chemical and, thermal properties. The Aluminum oxide (Al2O3) particles are used in heat sinks. One of the main advantages is that it provided a solution to low-cost manufacturing and production. The problems faced by the ceramic particles are mostly not useful by metal matrix and it tends to float or sink depending on the density and relative liquid metal. It resulted in the uneven distribution of the ceramic particle but the powdered metallurgy gives uniform distribution to the reinforcement [3]. Due to improved thermal conductivity and thermal conductivity distribution, the Al-2024-based alloy with Al2O3 reinforcement composite is suitable for thermal extraction components. In the aerospace industry, the Al-2024 combination has a wide range of applications; in particular, it is used in heat sinks made of aluminum alloys. Heat management has been very important in the development of integrated neoteric materials for the production of heat sinks in recent years. In addition, lightweight composite materials are used as heat dissipation agents in the development of heat-generating components. One of the most important components of these combinations is their sensitivity to temperature fluctuations. When a load is delivered to a matrix, its response is temperature, which can lead to internal stress within the set as a result of thermal contraction and inflation in its components.

II. COMPARING 2024 ALUMINIUM ALLOYS TO OTHER ALLOYS

- *Aluminum 2024*

The principal alloying element in aluminum alloy 2024 is copper. It's employed in applications where a high strength-to-weight ratio and exceptional fatigue resistance are required. It can only be welded by friction welding and has a machinability of around average. It is frequently wrapped with aluminum or Al-1Zn for protection due to its low corrosion resistance, albeit this may diminish the fatigue strength [4]

➢ *Aluminum 2024 Vs Aluminum 6061*

6061 is an alloy in series 6 with magnesium as its primarily alloying element. It is also known as structural aluminum. The aluminum 6061 has medium to high strength but it doesn't have tensile or yield strength like 2024. 6061 is not strong as 2024 aluminum alloy but it is more versatile and more corrosive resistant than aluminum 2024, easier to weld and, easy to machine. 6061 has a wide range of applications [5]. Some examples like building products, piping, automotive parts, furniture, bicycle frames, and the 2024 alloy used in cylinder and pistons, gear and shafts, aircraft wings and, Structural applications.

➢ *Aluminum 2024 Vs Aluminum 7075*

The 7075 alloy is most commonly used in the aerospace industry like 2024 because of its strong alloy and its availability. By hardening, it can achieve a high tensile strength of 83000PSI and a yield strength of 73000PSI as it is stronger than 2024 alloy. Aluminum 7075 alloy is best suited for applications that require high Stress Vs Strain resistance and 2024 is applicable for high fatigue cyclic resistance. The 2024 alloy is used in aerospace applications because of its high strength and fatigue resistance [6]. 2024 alloy is stronger than 6061 but less versatile and the 7075 is suitable for application than requires high stress and strain resistance, 2024 has high cyclic and fatigue resistance.

III. COMPARING ALUMINUM OXIDE REINFORCED AMC WITH OTHER REINFORCEMENT

Aluminum oxide (Al2O3) has excellent mechanical qualities and is less expensive than silicon carbide (SiC) or boron carbide (BC) (B4C). Impact resistance, chemical resistance, abrasion resistance, and high-temperature characteristics are all excellent in Al2O3. The increased density of Al2O3 compared to SiC or B4C is a disadvantage of Al2O3 for armor applications. The strength-to-weight ratio of Al2O3 is lower than that of SiC or B4C due to its high density[7]. For volume fractions ranging from 5 to 30%, researchers discovered that increasing the volume fraction of Al2O3 lowered the MMC's fracture toughness. This is because the inter-particle spacing between nucleated micro voids has shrunk. Park et al. investigated the high cycle fatigue behavior of Al2O3 microspheres reinforced with 6061 Al-Mg-Si alloys with volume fractions ranging from 5% to 30%. They discovered that the powder metallurgy-treated composite had a greater fatigue strength than the unreinforced alloy and the liquid metallurgy-produced composite [8].

IV. EXPERIMENTAL METHOD

Stir Casting is a liquid state process of fabricating comp osite materials in which a dispersed Phase (ceramic particles, shortfibers) is mechanically mixed with a molten matrix met al[10.

The liquid composite material is subsequently cast usin g traditional casting techniques, and it can also be processed using traditional metal forming techniques.

Stir casting is distinguished by the following characteristics:

1. The dispersed phase's content is restricted
2. The dispersed phase distribution in the matrix is not entirely homogeneous:

a) The dispersed particles form local clouds (clusters) (fibers)
b) Because the densities of the scattered and matrix phases differ, gravity segregation of the dispersed phase may occur.

3. The technology is straightforward and inexpensive.

If the matrix is semi-solid, the distribution of the scattered phase may be improved. Rheocasting is a process of churning metal composite materials in a semi-solid state[10]. The semi-solid matrix material's high viscosity allows for greater dispersed phase mixing.

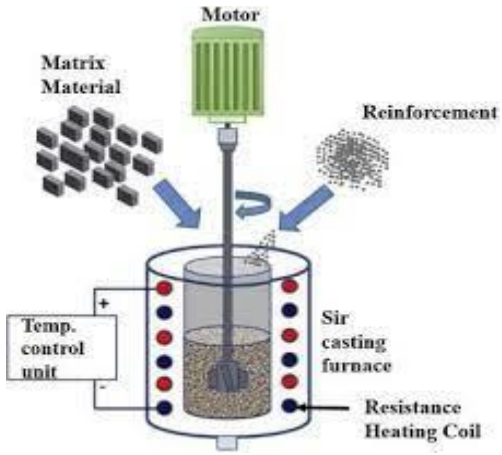

Fig 1:stir casting

Powder metallurgy: In this process, metal powder and reinforcement alloys are taken in a specific ratio and it is mixed by hand or machine Nearly any allowance can be produced. It has a low tool cost. There is no wastage of raw materials. Complex shapes can be made using this method. Products made by this technique do not require further finishing. Raw material cost is very high. The mechanical properties of these parts are low compared to cast or machined parts. This method works well only for mass production

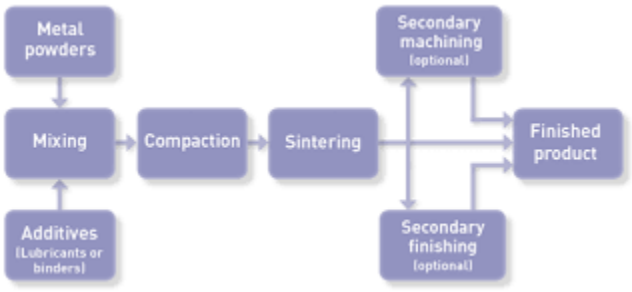

Fig 2: powder metallurgy

Centrifugal casting: The casting process is done by the action of centrifugal force by which the molten metal is streamed into the rotating mold. It acquires high density, high mechanical strength, and fine grain structure. Inclusions and impurities are higher Not all alloys can be cast this way[10].

Only a few shapes can be cast by this method. It uses complex types of machinery and is relatively expensive.

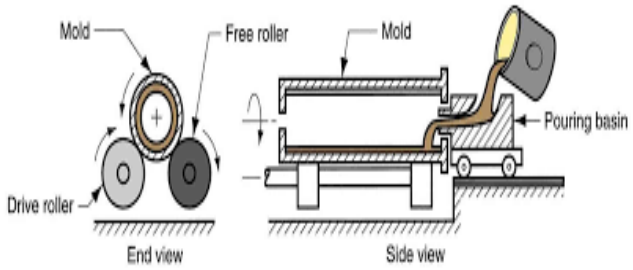

Fig 3 : Centrifugal casting

V. TYPE OF REINFORCEMENTS

Type of AMC	Highlights
Particle-reinforced AMCs (PAMCs)	The composites having an aspect ratio less than about 5 generally contain equiaxed ceramic reinforcements
Whisker-or short fiber-reinforced AMCs (SFAMCs)	They contain reinforcements with an aspect ratio of greater than 5 but are not regular. The first and the most popular AMCs which was developed and used as short alumina fiber reinforced aluminum matrix composites
Continuous fiber-reinforced AMCs (CFAMCs)	The diameter of the reinforcements is less than 20μm and they are in the form of continuous fibers of alumina, SiC, or carbon. These fibers are either a parallel or pre-woven and they are combined before the manufacture of the composites
Mono filament-reinforced AMCs (MFAMCs)	The chemical vapor deposition of SiC of B into a carbon fiber or wire (W) produces monofilaments fibers that are large in diameter (100 to 150 μm)

Table 1: Type of Reinforcement

VI. CHEMICAL COMPOSITION OF ALUMINIUM 2024 AND AL2O3 (ALUMINA)

- *Chemical Composition of Aluminum 2024:*

Copper	4.3 -4.5%
Manganese	0.5-0.6%
Magnesium	1.3-1.5%
Zinc, Nickel, Chromium, Lea, Bismuth	<5%

Table 2 :Chemical Composition of aluminum 2024

- *Chemical Composition of Alumina (Al2O3)*

Cu (wt.%)	±3.23
Mg (wt.%)	±0.81
Si (wt.%)	±0.74
Mn (wt.%)	±0.54
Zn (wt.%)	±0.13
Other (wt.%)	±0.05 -0.20
Aluminum (wt.%)	Balance

Table 3: Chemical Composition of Al2O3

VII. PROPERTIES OF ALUMINIUM2024

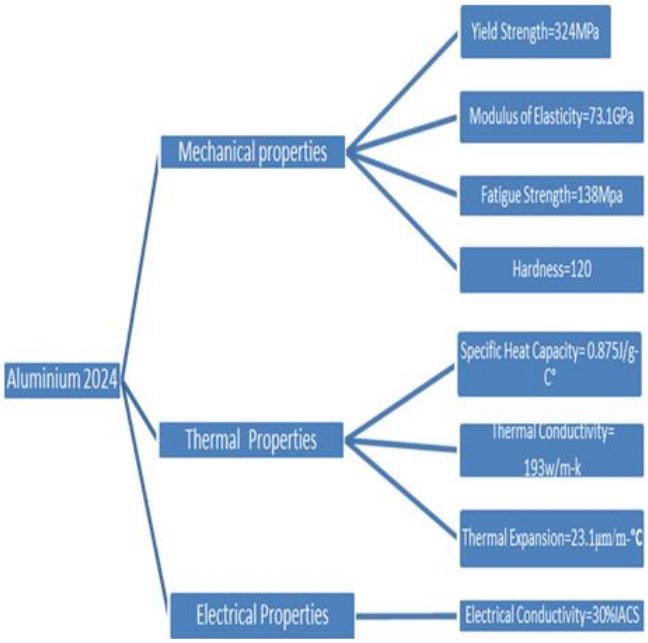

Fig 4:Properties of Aluminum 2024

The temper of 2024 has a significant impact on its mechanical properties;

2024-O : - Heat treatment is not required for 2024-O temper aluminum. It has a maximum yield strength of no more than 14,000 psi and a maximum tensile strength of 30-32 ksi (207-220 MPa) (96 MPa). The material has an elongation (stretch before ultimate failure) of 10 to 25%, which is within the acceptable range according to the applicable AMS requirements.

2024-T3 :- T3 temper 2024 sheet has a yield strength of at least 39-40 ksi (400-427 MPa) and ultimate tensile strength of 58-62 ksi (400-427 MPa) (269-276 MPa). It has a 10-15 percent elongation.

2024-T351:- T351 temper 2024 plate has a yield strength of 41 ksi and an ultimate tensile strength of 68 ksi (470 MPa) (280 MPa). It has a 19 percent elongation[11].

ISSN No:-2456-2165

VIII. PROPERTIES OF ALUMINA

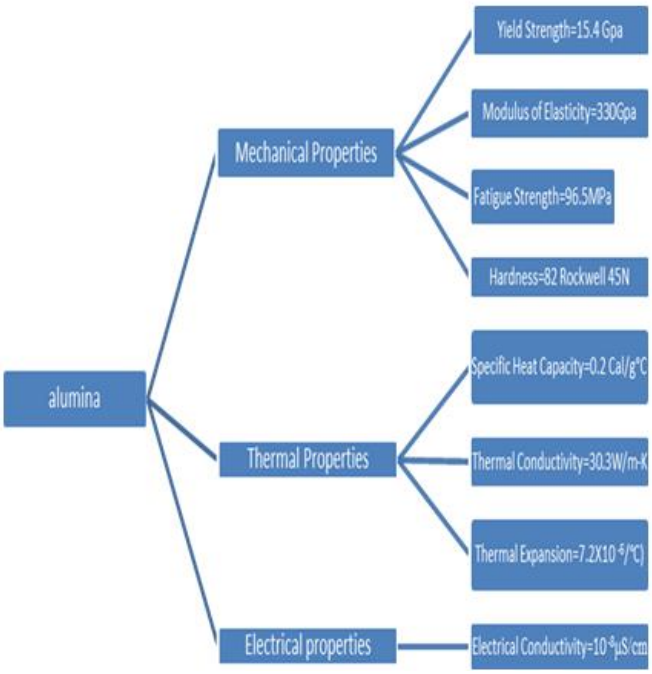

Fig 5: Properties of Alumina

IX. METHODOLOGY TO MANUFACTURE HEAT SINK ALUMINIUM

Extrusion is one of the processes used to produce heat sinks these days other than heat sinks there are various other methods like drowning, pressing, casting, welding, assembling, and machining, of all methods pressing, is most widely used to form heat sinks. Heat sinks produced in such a way are made of grooved aluminum. The hogging form of heat sinks is used for low and medium powder components [23]. Heat is dissipated through natural convection. Heat sinks of different forms are exposed to different surface treatments like anodizing and blanking. When such treatments are exhibited there will be a drastic decrease in thermal resistance (10-50%). The profiles of heat sinks are produced by the extrusion method. A heat sink is produced by cutting a profile being extruded to the desired dimensions. Smooth and threaded holes for attaching the electronic components are made in it [15].

Most often Aluminum alloys are used for making the heat sinks. The thickness of the fins in the heat sinks is approximately 0.64mm (minimum) and the maximum height to the distance ratio between the fins is 10:1. Even by drawing heat sinks can be produced and this is done by deep-drawing from sheet metal plates.

A method called assembling can also be used for producing heat sinks. In this method, milled grooves are used in plate form and aluminum is the most often used metal and their fins thickness will be ranging from 0.5mm and 1.2mm. The ratio of maximum height to the distance of fins is 40:1. The fins height amounts up to 100mm. The thermal resistance of such heat sink will be between 0.02 to 0.8K/W[15]. They also dissipate heat by a method of forced and natural convection, such cooling systems are used in military and aircraft applications Another method for producing heat sinks is machining, which consists of forming surfaces into the desired shape.

X. APPLICATIONS[12-13]

Automobile industry Applications	Features of MMC	Features of MMC	Highlights
Piston	Combined Weight, High Strength, Wear Resistance, and Special High Strength	Aluminum – Silicon Carbide	Mechanical properties for Piston in automobileand AC compressors were studied. So that material for automobileand AC compressors should have high strength, low wear resistance, and light weight
Connecting Rod	Low coefficient of thermalExpansion, High Specific Strength, Reduced reciprocating mass	1) Aluminum- Silicon Carbide (whiskers) 2) Aluminum – Aluminum oxide with long fiber. 3) Aluminum- Titanium Carbide (Particles) Al/Al2O3 Fiber	The progress of Al-SiC was analyzed for the manufacturing of connecting rods. In automobile engineering applications MMC is widely used to manufacture lightweight components.
Valve Stem	Lightweight	Al-SiC and Al-TiC	It is used to manufacture engine poppet valves becauseit was necessary to manufacture lightweight and better fuel-efficient engines

Table 4: Applications

➢ *Aerospace*

This is an Al-Cu alloy. The aluminum 2024 alloy is used in places where high tension is exerted during operation such as the wing and the fuse large structures. It is used when a high strength to weight ratio is required. These alloys have high standards so their main applications are in places where damage tolerance is required. This material is used in[16].

XI. CONCLUSION

The review reveals that composite metal matrix materials have good potential for developing automotive parts of the automotive industry and the aerospace sector. In more recent times, research shows that the need for fuel-efficient vehicles and electric vehicles has increased over the past 5 years. Demonstrates the need for lightweight and high-strength components in which the automotive industry focuses on the study of matrix-based auto production compounds for high strength, high fatigue life, and high level of resistance for these reasons, metal matrix's composite research. part tied aerospace due to its high strength and resistance to fatigue. Also, the formation of the intermetallic phase by the copper and metallic phase by copper and magnesium reactions reduces the corrosion resistance of the alloy. In fuse-like construction 2024-T3 alloy is used which offers yield strength and has better fracture toughness. 2024 alloy have sensitivity to high temperature that ranges from 200-250 degree Celsius.

and we focus on 2024 aluminum alloy and reinforcement Al2O3(alumina). To develop metal matrix composites are briefly explained powdered metallurgy, stir casting, centrifugal casting and the type of reinforcement are briefly explained. The chaotic release method is suitable for compound construction due to its cost-effectiveness and particle distribution The use of 2024 in the automotive and spacecraft components is described. This information helps researchers to investigate 2024 metal matrix compounds such as Alumina (Al2O3) such as reinforcing car parts and heat sinks. A thermal cooling system is like a heat sink in releasing heat from a battery. It provides a good way to advance the development needed by the world for a green and healthy environment.

REFERENCES

[1]. D.B. Miracle, Metal matrix composites - from science to technological significance, Compos Sci Technol. 65 (2005) 2526–2540
[2]. The Study on Improvement of Aluminium Alloy for Engineering Application: A Review
[3]. S. Divagar, M. Vignashwar, S.T. Selvamani, Impacts of Nano- Particles on Fatigue Strength of Aluminum Based Metal Matrix Composites for Aerospace, Mater. Today:. Proc. 3 (2016) 7334– 7339.
[4]. A Review on Mechanical properties of Aluminium 2024 alloy with various reinforcement metal matrix composite Gaurav Srivastavaa , Dr. S.S Banwaitb , Dr. Deepak Mehrac , Dr.S P Harshad
[5]. T.S. Senthilkumar, S.A. Venkatesh, R. Kumar, S.S. Kumar, Evaluation of Mechanical Properties of Al-6082 based Hybrid Metal Matrix Composite, Journal of Chemical and Pharmaceutical Research 8 (2016) 58–64
[6]. Manufacture of Aluminium Metal Matrix Composite (Al7075-SiC) by Stir Casting Technique
[7]. Applications of aluminum oxide and nano aluminum oxide as adsorbents: review
[8]. B. Vijaya Ramnath, C. Elanchezhian, R.M. Annamalai, S. Aravind, T. Sri Ananda Atreya, V. Vignesh, C. Subramanian, Aluminium metal matrix composites—a review. Rev. Adv. Mater. Sci. 38, 55–60 (2014)
[9]. P. Kulkarni, Evaluation of mechanical properties of AL 2024 based hybrid metal composites. J. Mech. Civil Eng. 12(5), 108–122 (2015)
[10]. ALUMINIUM METAL MATRIX COMPOSITES - A REVIEWB. Vijaya Ramnath 1 , C. Elanchezhian 1 , RM. Annamalai1 , S.Aravind 1 , T. Sri Ananda Atreya 1 , V. Vignesh 1 and C.Subramanian 2 1Department of Mechanical Engineering, Sri Sairam Engineering College, West Tambaram, Chennai-600 044, India 2Department of Mechanical Engineering, Shinas College of Technology, Oman Received: October 19, 2013
[11]. P. Kulkarni, Evaluation of mechanical properties of AL 2024 based hybrid metal composites. J. Mech. Civil Eng. 12(5), 108–122 (2015
[12]. A review on metal matrix composite for automobile applications Harmeet Singh a , Gurinder Singh Brar b , Harish Kumar c , Vikrant Aggarwal d
[13]. A. Morita, Aluminium alloys for automobile applications, in: Proc. of ICAA-6, Toyohashi, Japan, 5–10 July 1998, in: Aluminium Alloys, vol. 1, 1998, pp. 25–32.
[14]. Thermal Characterization of Aluminium-Based Composite Structures Using Laser Flash Analysis K. D. Bopanna1 • M. S. Ganesha Prasad1
[15]. Thermal management analysis of li-ion battery-based on cooling system using dimples with air fins and perforated fins Karim Egab a,* , Saad K. Oudah b,c a Department of Electromechanical System Engineering, Thiqar Technical College, Southern Technical University, 64001, Iraq b Mechanical Engineering Department, University of South Carolina, Columbia, USA c Research and Development Department, Ur State Company, Ministry of Industry and Minerals, Nasiriyah, 64001, Iraq
[16]. J.P. Karthik, T.A. Sai, A.A. Praneeth, Design and Optimization of Metal Matrix Composite (MMC's) Spur Gear, International Journal Advanced Design and Manufacturing Technology 9 (2016) 49–56.