BALOCHISTAN UNIVERSITY OF INFORMATION TECHNOLOGY ENGINEERING & MANAGEMENT SCIENCE QUETTA.

BS in Department of Mechanical Engineering

(FYP Proposal)

Enhancing Thermal Conductivity in Aluminum Alloys

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1. Introduction

1.1 Background

Being mechanical engineers, we often study heat exchange processes. These processes are vital for the better functioning of mechanical systems. Temperature difference is the key parameter in such processes, but there are certain applications where much space and temperature difference cannot be available. In such applications, there comes another key player that is the thermal conductivity of the materials used in heat exchanging systems. For instance, extended surfaces are fin arrays used in electronics.

In our fast-paced world filled with technological marvels, the pursuit of better materials for efficient heat transfer is like searching for hidden treasures. Likewise, we are on a mission to create something extraordinary—innovative aluminum-based alloys crafted to revolutionize the way fins and extended surfaces work in various heat exchange systems.

The reason behind working with aluminum is the feature this metal possesses. It is lightweight, abundant, and cheaper than many good thermal conductors like copper. This study is about taking aluminum to new heights, exploring its potential with carefully chosen alloying elements that not only keep its essence intact but also turn it into a special alloy that possesses a very reasonable thermal conductivity.

1.2 Problem Statement

Thermal conductivity plays a vital role in heat exchange processes. Fins and extended surfaces are widely used in everyday life applications. Some applications have this problem of small spaces and low temperature differences available for the heat exchangers. This makes the process less efficient and hence, we need another parameter to play a better role and improve the efficiency of the process. There are some elements that have naturally higher thermal conductivities, but these are expensive. Copper is the best example. Although it is very efficient, it comes at a bigger price. Therefore, we need an alternate option that is good for the said application and has a lower price. Aluminum is cheaper, available in abundance and can be crafted to have a better thermal conductivity. Therefore, we propose an alloy of aluminum that can do our job.

1.3 Aims and Objectives

Our big goal is to open new possibilities in how heat moves through systems. Fins are everywhere in today's world. Think about the fins in your laptop, your car's engine, or the coils in your air conditioner. We are not just dreaming about making them better at transferring heat; we are working hard to make them easier to shape, rust-resistant, economical, and simple to produce.

As we dive into this adventure, we are not just mixing elements, we are looking for creating a symphony, finding that perfect harmony between strength and heat performance.

In summary, we have set the following objectives for the project.

1. To experiment with different compositions of aluminum alloys
2. To develop an aluminum alloy with optimal thermal conductivity

1.4 Scope and Justification

The most interesting part of this study is that we are not just simulating or suggesting, we are fabricating, testing, and validating our alloy for everyday life. This study is going to explore new horizons and make an impact in the field of alloys.

This project is going to bring a revolution in the fins industry especially, in the motorbike industry of Pakistan. Local manufacturers can utilize this idea and prepare a better fin array for the motorcycle engines at reasonable prices.

In a nutshell, this final year project is exploring the potential of aluminum-based alloys. We are excited to play a role in shaping the future of such alloys by bringing innovation into the field.

The next section of this report is the relevant literature that we have studied and referred to regarding our proposed work, while the third chapter is about the proposed methods and materials that we are going to use for this study.

2. Literature Review

In their experiment, the researchers prepared hypereutectic Al-3Fe alloys using pure Al ingot and proficient alloys of Al-5Zr, Al-20Fe, and Al-2Sc. They controlled the Sc/Zr mass ratios to be 2.5/1, with a highest Zr solubility in the Al3Sc phase of 50 atomic percent. The researchers mentioned that if the Sc/Zr atom ratio went beyond 4:1, the L12 structure would still be conserve, citing that Zr optimization could result in better phase strengthening.

The alloys were prepared in an SG2-5-10 pit-type smelting furnace and went through a handling of argon refining following smelting. The researchers poured each alloy into two molds for further treatment. The ingot underwent aging treatment in an SX2-4-10 box-type resistance furnace, where it was held at 350C for 5 hours and then air-cooled.

Afterward, Inductively Coupled Plasma was used to measure the alloy composition. (ICP) spectrometer. The researchers used JMatPro, a simulation software, Al-Fe alloy phase precipitation curves can be simulated with differing Zr and Sc contents. This involved calculating temperatures ranging from 750C to 100C in steps of 1C.

Metallographic samples were constructed from the casting slab's base up. In order to analyze macrostructure, they used Poulton's reagent for etching and then photographed the samples. Deep-etching was done to enhance the visualization of the eutectic phases' three-dimensional morphology[1].

In their respective research studies, several investigators have probed the advantageous effects of incorporating cerium (Ce) into aluminum alloys. Notably, Li et al. conducted a study wherein they introduced Ce in the range of 0.05−0.16 wt.% to an aluminum (Al) rod. Their findings illuminated a notable enhancement in electrical conductivity and tensile strength. This improvement was attributed due to the decrease in impurity solid solubility and the simultaneous refinement of (Al) grains within the alloy matrix.

Simultaneously, Kang et al. delved into the impact of the combined addition of Ce and magnesium (Mg) to an 0.3Mg−Al−7Si−0.2Fe alloy. Their investigation revealed a substantial strengthening and enhanced flexibility of the alloy, primarily attributable to eutectic silicon (Si) improvement, iron (Fe)- that includes grain and intermetallic compound refinement. Furthermore, Zhang et al. discerned a divergence between cerium (Ce) and lanthanum (La) regarding their influence on pure aluminium's electrical conductivity. They reported that Ce exhibited a more robust purification capability, particularly about impurities such as iron (Fe) and silicon (Si) within the α (Al) matrix.

Significantly, Liang et al. ventured into the realm of rare earth (RE) elements, which encompass both cerium (Ce) and lanthanum (La), and how they affect the mechanical characteristics of Al−2wt.%Fe alloys. Their investigation unveiled a phenomenon wherein RE elements were enriched at the liquid/solid interface, ultimately that resulted in the development of Al8Fe2Ce combinations. Thus, α (Al) grains were refined as a result, contributing to improved mechanical properties.

Collectively, these studies have underscored the favourable influence of cerium (Ce) in enhancing the properties of aluminium alloys. Nevertheless, it is noteworthy that a comprehensive understanding of the intricate relationship between conductivity properties and microstructural variations in Al−2wt.%Fe alloys with varying Ce contents remains elusive. Consequently, this lacuna in knowledge has been identified as a pertinent area for prospective research. The primary objective of the study conducted by the researchers at hand was to meticulously investigate the modifying effects of Ce elements in a short while

-eutectic Al−2wt%Fe alloys' microstructure across various states, including as-annealed, rolled, and cast conditions. Furthermore, the researchers aimed to establish a coherent correlation between solidification parameters and microstructural attributes through the utilization of cooling curve thermal analysis (CCTA)[2].

In this review paper, the authors have meticulously curated and scrutinized a multitude of research investigations, shedding light on the profound impact of graphene nanoplatelets (GN) on aluminium properties composites' thermal conductivity. The inaugural study, conducted by Hahm et al., intricately examines the dynamic interplay between thermal conductivity and the pulverization duration of GN in aluminium-graphene composites. By subjecting GN to differing pulverization durations, specifically 10 seconds and 1000 seconds, prior to amalgamation into the composite matrix, appreciable enhancements in thermal conductivity were ascertained, registering increases of 5% and 13%, respectively. These enhancements were elucidated as resultant from heightened exfoliation of GN and a concomitant diminishment in the number of GN layers, a consequence attributed to prolonged pulverization.

The study by Zhang et al. systematically explores the intricate relationship between the content of reduced graphene oxide (rGO) within aluminium graphene nanocomposites (AGNC) and pertinent thermal properties. Their research unearths a directly proportional association between augmenting rGO content and the amplification of both the specific heat capacity and thermal conductivity of AGNC. Notably, their findings culminate in the revelation of an apex thermal conductivity enhancement of 15.3% upon the introduction of 0.3 wt% rGO.

A study conducted by Wejrzanowski et al. offers an insightful perspective on the correlation between the alignment of GN and its consequential impact on thermal conductivity. The research underscores the discernible advantage of aligning GN parallel to the direction of heat flow, resulting in heightened thermal conductivity when juxtaposed with GN oriented perpendicularly.

Saboori et al.'s investigation discerns that, in the context of as-sintered composites vis-à-vis as-extruded counterparts, the former exhibit superior thermal conductivity characteristics. The increase in grain boundaries and point defects that occur during the extrusion process and provide thermal resistance are thought to be the cause of this phenomenon.

The study conducted by Chang et al. underscores the importance of the quantity GN layers in shaping thermal conductivity outcomes. Their findings underscore that composite of metal-single layer graphene manifest twice the contact area thermal conductance when compared to their metal-bilayer graphene counterparts, a result assigned to the superior interfacial linking facilitated by metal-carbon interactions.

In summation, this scholarly treatise unequivocally endorses the notion that judicious manipulation of graphene attributes, encompassing aspects such as content, morphology, pulverization duration, alignment, and layering, engenders the potential for substantial amelioration in the thermal conductivity of aluminium composites. Nonetheless, it is incumbent upon the scientific community to engage in further research endeavours to attain a more comprehensive elucidation of the underlying mechanisms governing these phenomena [3].

This research paper delves into the utilization and adaptation of aluminium alloys within the realm of Additive Manufacturing (AM) for diverse applications, with a particular focus on the strategic manipulation of specific processes to augment their thermal conductivity and mechanical robustness. The inherent thermal conductivity of aluminium assumes a strategically advantageous position in AM, particularly in the case of aluminium alloys, such as Al-10Si-Mg and Al-12Si.

Selective Laser Melting (SLM), an established and prevalent AM technique for metal fabrication, emerges as a pivotal factor in influencing the thermal conductivity of the aforementioned alloys. The accelerated cooling rates integral to SLM operations can give rise to an undue oversaturation of alloying constituents within the aluminium matrix, thereby diminishing the thermal conductivity of aluminium alloys. Furthermore, the formation of voids or pores during the SLM process exerts an adverse impact on thermal conductivity.

Nevertheless, empirical findings demonstrate that the thermal conductivity of the Al-10Si-Mg alloy can be elevated through specific operational adjustments. Specifically, an increase in the polar angle, a reduction in hatch spacing, and a decrease in scan speed during the SLM process have been shown to have a positive influence the production of aluminium alloys that align with the exacting demands of various industrial applications. These alloys possess the coveted attributes of heightened thermal conductivity and mechanical robustness. Nevertheless, it is imperative to underscore that further research endeavours are imperative to fine-tune these processes and broaden the selection of aluminium alloys that are amenable to AM techniques [4].

In the research paper, the researchers delve into the intricate realm of thermal conductivity (TC) and the associated complexities surrounding silicon carbide (SiC) and metal composites. A significant impediment encountered in SiC/Cu composites lies in the imperative task of ameliorating wettability while concurrently suppressing a pronounced chemical reaction, involving the conversion of SiC and Cu into carbon (C) and Cu3Si. To enhance wettability, the introduction of materials for transitional alloys, such as Fe, Cr, Ti, Ni, and Al, is undertaken. This strategic incorporation augments the activity of silicon (Si), thereby mitigating the presence of the non-wettable SiO2-film on SiC particles and concomitantly diminishing melt fluidity. During the hot-pressing process, SiC is meticulously coated with various materials, such as TiN, TiN/TiC/Al2O3, diamond-like carbon, tungsten (W), and molybdenum (Mo), to impede the diffusion of copper (Cu). This coating endeavour yields appreciable improvements in thermo-physical properties and concurrently reduces porosity within the composite. Furthermore, the application of vapor-deposited Mo-coating has demonstrated a substantial enhancement in bonding power and thermophysical characteristics, ultimately culminating in a commendable thermal conductivity of 306 W/(m·K). Notably, the zenith of thermal conductivity attainment, at 323 W/(m·K), is realized through the utilization of TiN-coated SiC.

In the pursuit of overcoming the challenge posed by interfacial reactions during the squeeze casting process, various methodologies are explored. Peroxidation of SiC particles at a temperature of 1000 °C is one such approach, which modestly curtails the extent of the reaction while concurrently resulting in a diminished thermal conductivity, ranging between 40-70 W/(m·K). Additionally, the introduction of silicon (Si) into the SiC-Cu system, albeit intended to mitigate interfacial reactions, regrettably engenders a significant reduction in the thermal conductivity of copper (Cu). The augmentation of thermal conductivity within the SiC-Cu system during the process of liquid infiltration remains an enduring and formidable challenge in the realm of this research [5].

The focus of this research study is on adding a trace amount of strontium (Sr) to hypoeutectic Al−Si alloys at a concentration of 0.05 weight percent to increase their thermal conductivity. This study's objective was to induce microstructural modifications to enhance thermal conductivity of these alloys. The results unequivocally show that Sr modification significantly increases the hypoeutectic Al-Si alloys' thermal conductivity. In addition, it was observed that the rate of rise in thermal conductivity showed an increasing trend in conjunction with rising Si content.

The observed changes in the shape of the eutectic phases of silicon are mainly responsible for enhancement. The Al-Si alloys with Sr modification and their microstructure showed a characteristic combination of fine, flaky, and fibrous structures. As the Si content increased, the proportion of the flaky, fine eutectic Si phases gradually decreased. As a result, as soon as the Si content hit nine weight percent, the thermal conductivity of Sr-modified alloys peaked and remained steady.% [6].

The research paper examines the impact of the mixture handling on the thermal conductivity of the 7A56 aluminium alloy The dissolution of the individual particles is the main objective of the solution treatment. within the alloy into the base matrix, thereby creating a supersaturated solid solution. Following a solution treatment carried out at the temperature of 470 °C for a duration of 4 hours, the conductivity of the specimens subjected to quenching measures approximately 30.8%IACS. Notably, the conductivity experiences a swift reduction post-solution treatment, reaching its lowest point at approximately

30.7%IACS after an extended 6-hour hold period. Overall, the authors found that the conductivity of the 7A56 aluminium alloy can be improved by optimizing the solution treatment temperature and time [7].

The paper presents a study on creating a composite material with enhanced thermal properties using copper-coated graphite films and aluminium. The researchers used a physical vapor deposition process for the copper coating, which addresses the challenge of poor interfacial wetting between graphite and aluminium. This innovative method allows for better thermal conductance and increases the overall thermal conductivity of the composite. The graphite film, copper, and aluminium composite were created using vacuum hot pressing, which boosted the interfacial thermal conductance and enhanced the in-plane and out-of-plane thermal conductivity significantly. Hence, the resultant composite material holds promise for efficient thermal management applications [8].

In the research paper, the addition of aluminium (Al) to cast copper is investigated, and the following information can be extracted about the influence of aluminium alloy on heat conductivity. The addition of aluminium results in hardening of the cast copper. This hardening is attributed to solid-solution hardening, which suggests that the presence of aluminum atoms in the copper lattice contributes to the increased hardness of the alloy. This examining that age stiffen behavior occurs in the old alloy with Al addition. It caused by the development of stiff and smash able metallic compounds like copper aluminates. These compounds involve to the durability or strength of the alloy. The research mention that after heat treatment thermal coefficient is increase. This is likely occurring to stress relief effects. However, it's important to note that the formation of intermetallic precipitates can also decrease thermal conductivity. The research paper suggests that addition of Al to cast copper also affects the absorbance properties of the alloy. However, it does not provide detailed information about how Al influences these properties. Overall, the presence of aluminum in the cast copper alloy leads to changes in its mechanical and thermal properties, including an increase in hardness and some effects on thermal conductivity. However, specific quantitative data on the thermal conductivity changes is not provided in the given extract [9]

In their experiment, the research found that different alloying elements have varying effects on aluminum alloys thermal conductivity. the ranking based on elements thermal conductivity Cu > Mg > Si> Fe. Mathematical Model for Alloys of Al-12Si.this case of Al-12Si alloys, a mathematical model was developed to represent. Alliance between alloys metals and conduction coefficient This model is written as $\lambda = ax^2 + c - bx$ while then precipitates of 2nd order within forge. Optimized Composition. According to the first rule of CALPAD calculations, the study recommended solution of optimized chemical for aluminum alloys to achieve high thermal conductivity. This composition is 5Si- Al-11-0.4Fe-0.2Mg (wt.%), and it was associated with heat conductivity 137.50 $Wm^{(-1)} \cdot K^{(-1)}$ [10]

The provided paper use of alloys Al2024 in different compositions of copper (30%, 40%, or 20%) in the context of heat sink fabrication. While it discusses their performance in terms of heat dissipation and temperature, it doesn't provide specific values. the conductivity of alloys aluminum, I can provide you with general information. (Al) alloys are known for their best thermal or heat conductivity. Aluminum heat coefficient is approximately 237 W/(m·K), making it an excellent choice for applications that require efficient heat transfer. The specific thermal coefficient of alloys of aluminum may reliance on the alloy composition, so it's important to refer to specific material properties or literature for precise values when using specific alloy compositions like Al2024. [11]

In their experiment, to enhance the mechanical properties silicon carbide is adding to composite. According to the study Al ADC 12 (1.5; 1; 2.5; 3; 2;) vf% or bland the silicon morphology was modified in the cationic order with 0.18wt% in situ and 0.15wt%(T) add 5 wt.% (Mg) as the Addition along with grain refiner Increase in humidity. materials are manufactured by Cast. Process. This experimentation has been accomplished to get the candidate Materials for used in breaks of trine shoes or bearings. That kind of use requiring high mechanical thermal resistance.

Here the rise of mechanical properties such as thermal conductivity of aluminum ADC 12 /due to greater mixer of SiC in aluminum. The result is better in thermal or physical properties for the composite [12]

the research paper mentions the use of aluminum alloys in the context of creating innovative materials with specific characteristics for advanced applications. These aluminum alloys were subjected to spark plasma sintering, which involved the inclusion of up to 50%vol of flakes graphite macroscopic This process allowed the adjustment the coefficient for thermal expansion the alloys of aluminum, potentially to approach to be lacking even negative values. Additionally, these aluminum alloys achieved a heat conductivity over 4 times greater than copper. also suggests that the aluminum alloys demonstrated adequate for various thermal management or mechanical stability application [13].

In their study vacuum hot pressing process used to combined the aluminum powder and 10-90% volume flake graphite to made aluminum graphite compassion.it finds it finds that composites with 10% to 90% graphite by volume achieve relative densities of 99%in powder mixtures. The thermal coefficient enhance up to 324 to 783 W/mk ; by adding flake graphite 10 to 90% volume in aluminum powder. Graphite flakes and aluminum in a parallel configuration effectively approximate the thermal conductivity using a parallel model. To the aluminum phase graphite flakes absurd expansion [14]

In their experiment they discuss about the influence of nickel Ni in Al-Si alloy thermal coefficient state. Ni plating alloy are described in two stage order.in where matrix are consists α-solid compound mixture liquids Si, secondary nickel plating boride or Mg_2Si precipitant order or first Al_{12} Si_2 $(Mn,Fe)_3$ order. On this solution as the nickel content increases the volume friction of the second order increases the transition occurs as the material property shift from a uniform matrix to a two-order composite informed by particles. Data of thermal coefficient are discourse by thermodynamic calculation [15]

This research explores how adding different amounts of Al-metal powder to AlN ceramics influences their thermal, mechanical, and dielectric properties. The most significant enhancements were observed with a 1.0 wt% dosage of metal aluminum powder, boosting heat coefficient, breaking hardness, and pliable potential. However, no substantial alterations were noticed in the dielectric properties, regardless of the Al-metal powder dosage. Therefore, the study concludes that small dosages of aluminum metal powder can successfully enhance certain qualities of AlN ceramics, offering a simple and effective method for improving their performances [16].

This study focused the thermal coefficient of a range of aluminum(Al) alloys, involve, Al-Cu, 30Al-Si, Al-10Si-Cu, Al-10Si-Fe, Al-Mg, Al-10Si-Mg well as pure Al and Al-Fe alloys was examined

Important conclusions about thermal conductivity include: 1. The heat conductivity of 99.8% unmixed aluminum decreased whenever one wt% of silicon (Si), copper (Cu), or iron (Fe) was added. It went from 213.5 $Wm^{(-1)}K^{(-1)}$ to roughly 190-210 $Wm^{(-1)}K^{(-1).}$

An increase in Mg content up to 1 wt% did not significantly affect the thermal conductivity of Al-Mg alloys. The study stressed the significance of taking into account the order, material, and microstructures of every stage inside when estimating alloys thermal conductivity using a variety of models [17].

influence of cobalt (Co) inclusion to the microstructures or mechanical characteristics, and thermal conduction of Al-2Fe alloys in different forms (as-cast, annealed, and rolled) is examined in this work. The findings show that by changing the composition of the Al3Fe phases, adding a moderate quantity of Co enhances the mechanical and thermal properties of the alloys. In comparison to their as-cast counterparts, annealed Al-2Fe-xCo alloys have better thermal conductivity, and this alteration holds promise for producing aluminum structural alloys with adequate thermal conductivity at reasonable costs. Thermal conductivity somewhat rises when Co is added in the region of 0 to 0.3% [6].

The results of the study show that the Si-Mg-Fe-Al alloy has an estimated thermal coefficient of 189 W/mK while The altered alloy A380 exhibits a thermal conductivity of 194 W/mK. The thermal conductivity exhibits an upward trend with increasing nickel content, reaching values of 194–200 W/mK with additions of 0.25 and 0.4 wt pct of Ni, accordingly. In addition, the authors discussed their findings regarding the microstructure and conductivity of binary alloys of Al- Ni and Al-Fe. In this case, the Al-Fe alloy was discovered to be sample's thermal conductivity was 190 W/mK, compared to 204 W/mK for the pure aluminum (Al) sample. The Al-Ni alloy, on the other hand, displayed a thermal conductivity of 201 W/mK.

In short the outcomes of this study indicate that the introduction of nickel into Al-Fe-Mg-Si alloys yields a substantial improvement in thermal conductivity, rendering these alloys as promising contenders for applications involving heat dissipation [18].

The thermal conductivity of a recently created alloy called R HPDC Al 7.5Si 0.8Fe was examined by the researchers. In comparison to the conductivity values reported for conventional HPDC alloys, they discovered that this alloy has a value of 186 W/(mK), which is about 6% higher. The new alloy can now effectively dissipate heat, ensuring the dependable and effective operation of electronic components. This increase in conductivity is a development, particularly for 5G communication base stations.

The study also shows that the R HPDC alloy has a more refined microstructure than other HPDC alloys. It displays granular eutectic silicon, fibrous Al5FeSi made of two Al grains, and one Al particle. The observed conductivity is a result of these microstructural upgrades. the refinement of iron intermetallic (Al5FeSi) and in particular silicons play a role, in improving heat transfer [19].

Cu-Zn alloys are unique because of their strength, excellent conductivity of heat and electricity, and ability to operate effectively in specific environments.

Previous studies focused mainly on the effects of a tiny amount of aluminum addition on the mechanical properties and visual characteristics of these alloys, with little attention paid to other aspects of their behavior. In a recent study, they increased the amount of aluminum and refined the structure of the alloy. They examined its conduct with regard to many features in addition to its strength. As expected, they discovered that the alloy's structure determines how strong it is. When they examined how effective it can be, the same thing occurred [20].

3. Materials and Experimental Procedures

There are different techniques used in the preparations and testing by researchers. We will choose the methods that are the most relevant and vital for our project. These methods will be finalised after we have reached to a final composition of the alloy.

In the next phase, we will change the composition and repeat the same steps. After preparing different alloys, we can compare the properties and choose the best alloy composition for future studies.

3.1 Materials and reagents

Material will be sourced from different suppliers in Pakistan in the form of salts and compounds. Aluminium hydroxides, aluminium sulphates, and aluminium oxides are available commercially in Pakistan that can have purity up to 99.6% at very low prices 22]. Other alloying element will be purchased in the form salts or compounds depending upon the composition of the final alloy. The alloying elements include titanium (Ti), silicon (Si), copper (Cu), nickel (Ni), magnesium (Mg), and graphite.

These elements will be extracted from the raw state that we purchase using different techniques.

3.2 Process for Preparation of the proposed Alloy

Molar solutions of the elements will be used first to fabricate the alloy. These elements will be heated in a furnace at a specified temperature and after a certain time that depends on the combination of elements, the alloy formation will occur. Temperature control and aging process: An electrical furnace will be utilized, and the operational temperature will be chosen based upon the Alloying elements as well as the aging process. The careful management of temperature, the use of specialized electrical furnaces, and the implementation of aging techniques are integral components of the formal alloy preparation process.

3.3 Characterization

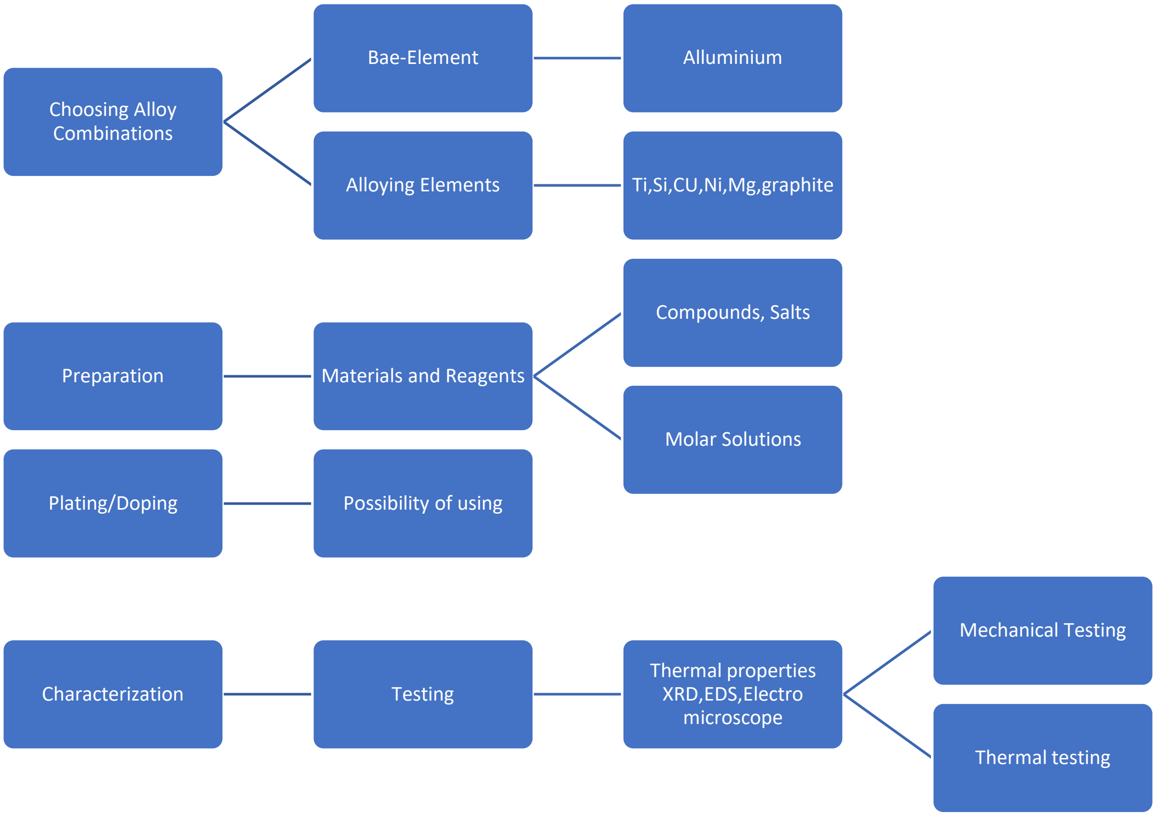
The examination the composition will be tested first. Once the composition is verified further tests will be conducted for the properties.

Following the alloy's preparation phase, a critical step involves comprehensive testing to assess its mechanical and thermal properties. This entails the utilization of various advanced analytical techniques and instruments, including X-ray diffraction (XRD), Energy Dispersive Spectroscopy (EDS), and electron microscopy. These methodologies will be employed in a formal capacity to acquire precise and detailed data on the alloy's characteristics, ensuring a thorough evaluation of its quality and suitability for specific applications.

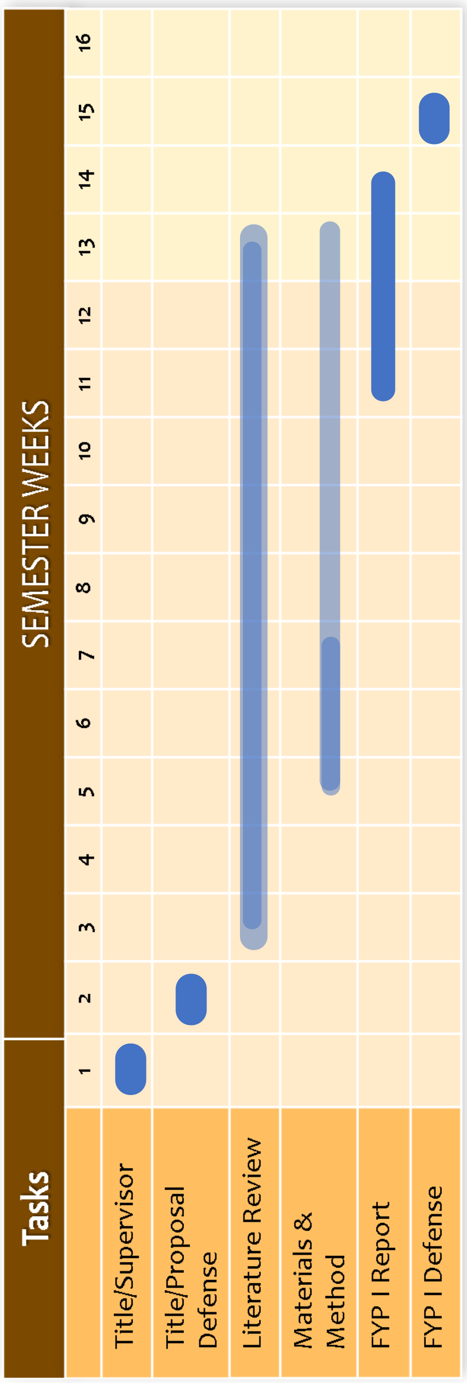
3.4 Plating/Doping

Plating and doping serve as potential techniques that may or may not be used, depending on the context and conditions at hand. These methods offer flexibility in tailoring the alloy's composition and properties to meet the desired specifications. We might use these techniques and study the effect on Thermal conductivity of the alloy.

3.5 Methodology Flow Chart



4. Gantt Chart – FYP I Week-wise Breakup



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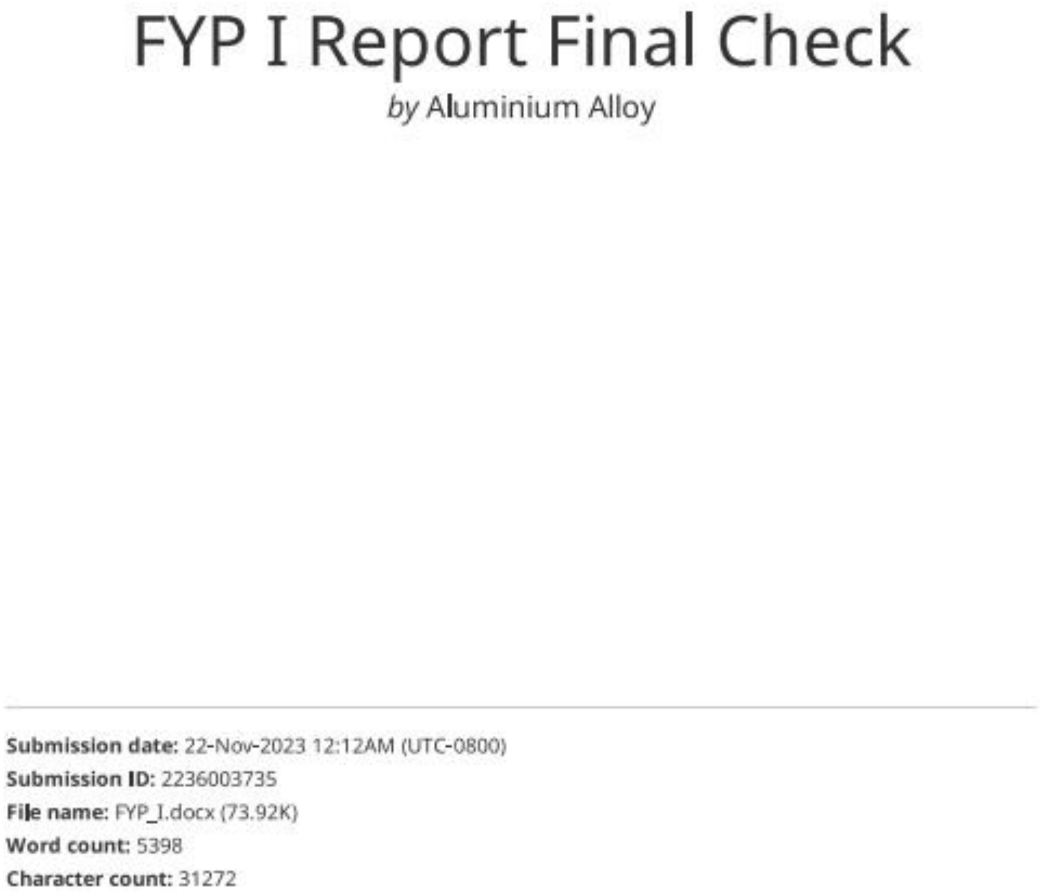

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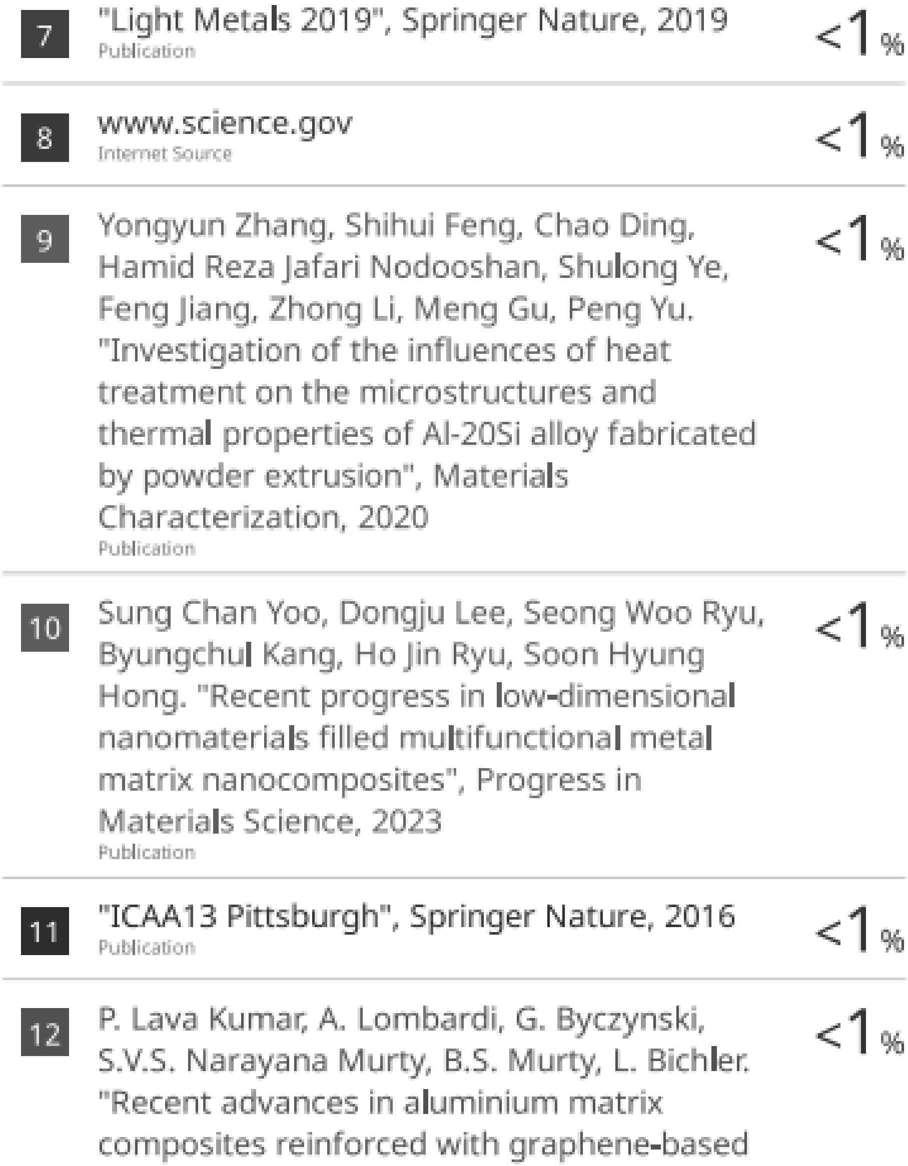

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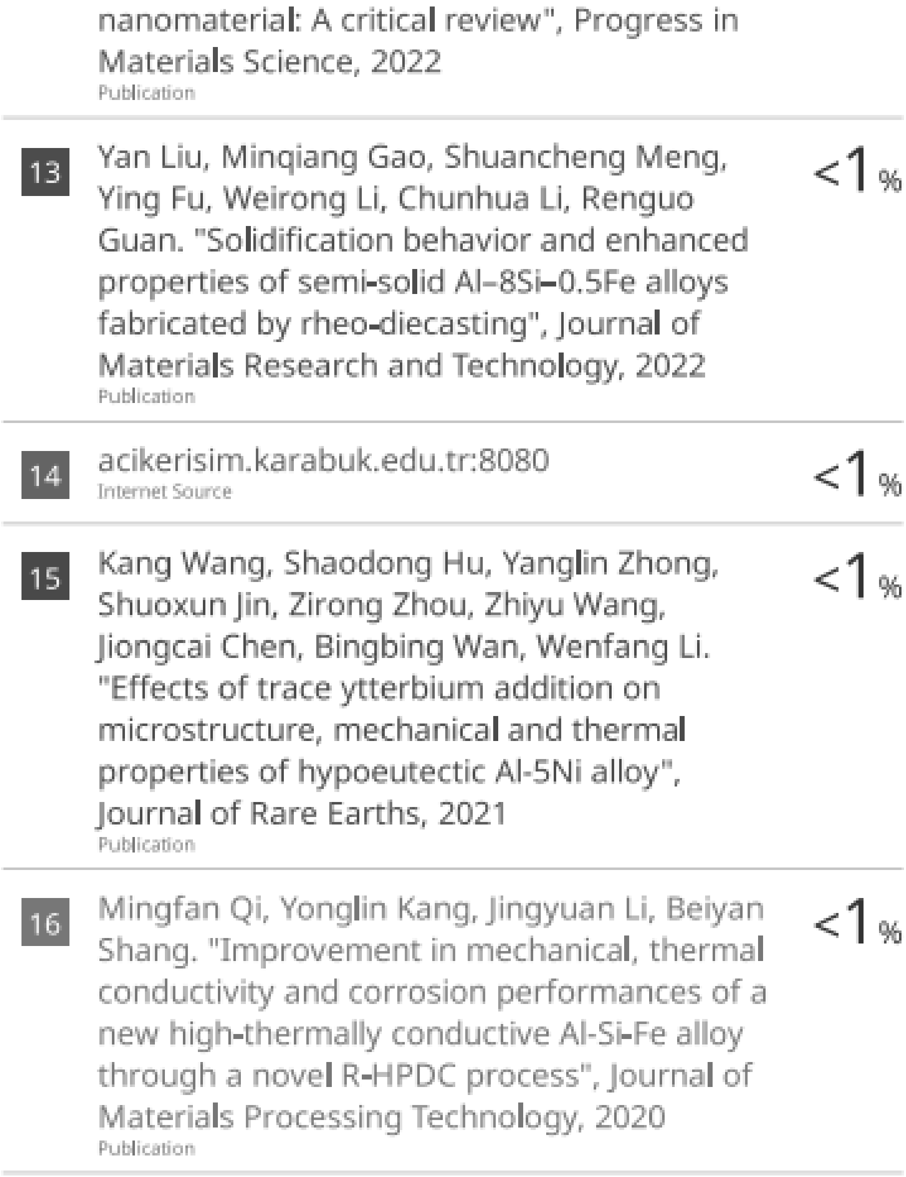

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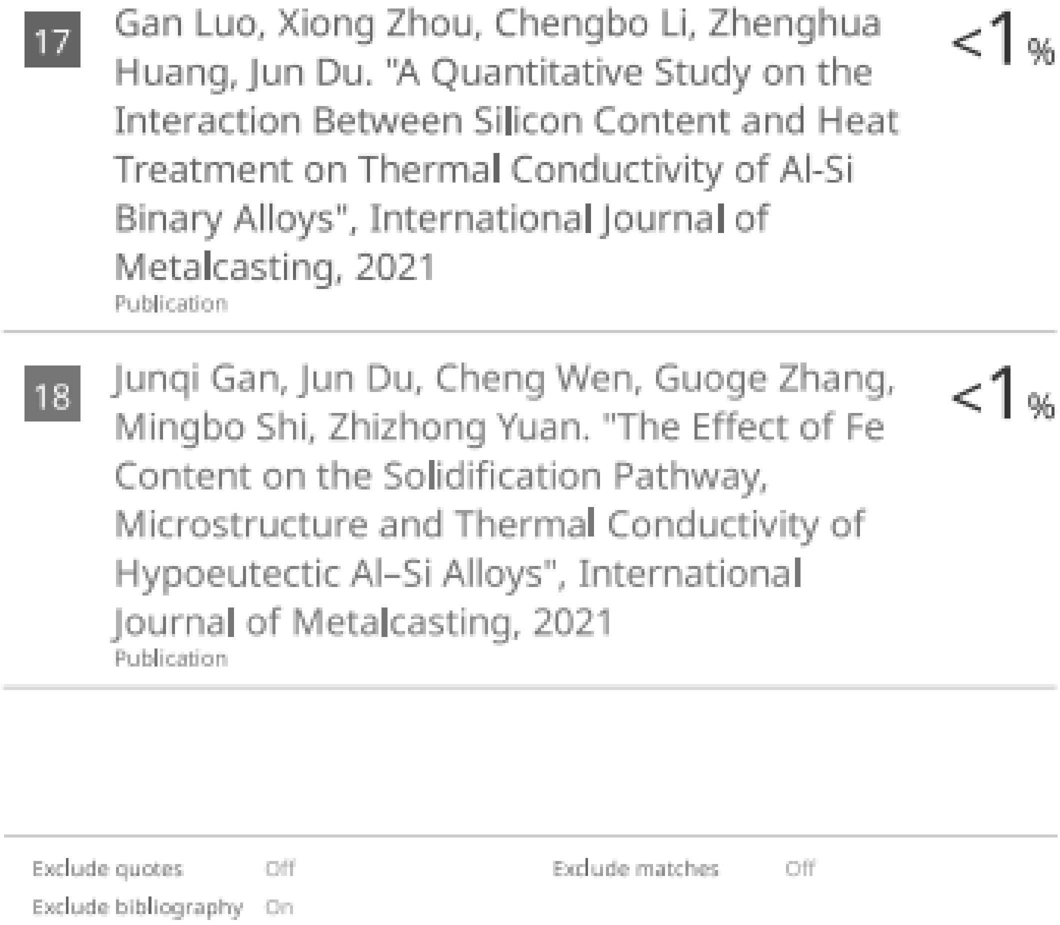

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