International Journal of Research in Engineering and Science (IJRES)
ISSN (Online): 2320-9364, ISSN (Print): 2320-9356
www.ijres.org Volume 13 Issue 12 ǁ December 2025 ǁ PP. 102-107

Microstructure and properties analysis of the brazing alloy prepared from recycled Mobile-waste

S V Anil kumar[1*], Ganapathy Bawge[1], V C Chandra Shekara[1]
[1]Department of Mechanical Engineering
P E S College of Engineering, Mandya Karnataka-571401 India

Abstract
In order to realize the efficient and comprehensive utilization of mobile waste resources and short process preparation of brazing alloy. this study has analyzed the microstructure and properties of mobile waste recycled brazing alloys by the analysis methods of Energy Dispersive X-ray spectrometer method, the alloy's composition primarily includes aluminium, and silicon, with minor constituents such as sodium and chlorine. Experimental testing evaluates the alloy's melting temperature and hardness characteristics to assess its viability for metal joining. The melting temperature obtained is in the range of is 860-910 degrees Celsius. The project highlights the potential of recycling materials from waste mobile phones to address environmental concerns and promote circular economy principles in engineering practices.
***Keywords**: brazing alloys; aluminium based filler metal; mechanical properties; microstructure; recycled mobile waste.*

Date of Submission: 07-12-2025 Date of acceptance: 19-12-2025

I. INTRODUCTION

Brazing alloy refers to a filler metal used in brazing, a joining process that involves melting the filler metal and distributing it between two or more workpieces to create a strong, permanent bond. Brazing alloys typically consist of a combination of base metals, such as copper, silver, or aluminium, along with various additives to enhance the alloy's fluidity, wetting ability, and mechanical properties. These alloys have a lower melting point than the base metals being joined, allowing them to flow and form a metallurgical bond without melting the workpieces themselves. Brazing alloys are widely used in industries such as automotive, aerospace, and electronics for joining dissimilar materials and producing high-quality, leak-tight joints.

Mechanical properties are crucial indicators of the performance and applicability of materials and in the case of the brazing alloy derived from mobile waste, assessing hardness is particularly significant. Hardness, as measured by the Vickers hardness test, provides valuable insights into the material's resistance to plastic deformation and its ability to withstand applied loads. By conducting Vickers hardness tests on the brazing alloy, this study aims to understand how the alloy's hardness characteristics contribute to its mechanical behaviour, durability, and suitability for brazing applications.

Recycling mobile waste not only addresses environmental concerns but also offers significant economic benefits. The environmental impact of improper disposal of mobile phones is substantial. Toxic substances can leach into soil and water, causing pollution and health hazards. By implementing effective recycling strategies, these adverse effects can be mitigated. Moreover, the recovery of valuable metals from mobile waste supports the development of sustainable technologies and reduces the pressure on natural resources.

This work focuses on the comprehensive analysis of mechanical properties essential for evaluating the viability of recycled brazing alloys derived from mobile waste. The investigation employs various analytical techniques to elucidate key characteristics of the alloy. Firstly, Energy Dispersive Spectroscopy (EDS) is utilized to determine the elemental composition, offering insights into the alloy's chemical makeup and potential applications. Subsequently, the Vickers Hardness Test is conducted to assess the material's resistance to indentation, providing crucial information on its hardness and durability, thereby informing its suitability for metal joining applications. Additionally, the report addresses the determination of the alloy's melting temperature, vital for optimizing brazing conditions and ensuring effective metal fusion during the joining process. By analyzing these mechanical properties, this study aims to provide valuable data for optimizing the utilization of recycled brazing alloys, contributing to sustainable materials management and efficient metal joining practices.

II. METHODOLOGY

The initial phase of our sample preparation as shown in Figure 1 involved collecting three identical scrap models of Redmi Note-4 mobile phones. After collecting the mobile phones, we carefully took them apart to remove the necessary components for making the alloy. This process involved unscrewing and unfastening parts to reach the internal components. Once the devices were disassembled, we sorted and separated materials such as printed circuit boards (PCBs), back panels, and other metals from the dismantled mobile phones. Each component extracted from the mobile phones underwent a detailed categorization process to ensure efficient utilization and extraction of valuable metals and materials. After sorting and separating the metallic components, the next crucial step was to remove non-metallic waste materials such as plastics, adhesives, and other contaminants. This process ensured that only the metallic components suitable for alloy synthesis remained, minimizing impurities in the final brazing alloy. With the removal of plastics and other waste materials, the samples were now suitably prepared for the melting process. This preparation ensured that only the desired metallic components were present, facilitating the subsequent melting and molding steps in the alloy synthesis process.

Figure 1 Separation of metal from Mobile scraps

After the initial sample preparation, which involves removing plastics and other non-metallic waste materials, the prepared samples are subjected to a high-temperature smelting process. This process occurs within controlled environments, typically in a specialized electromagnetic induction furnace. The temperature within these furnaces is meticulously regulated to reach levels sufficient for melting the constituent metals. The temperature is carefully monitored to ensure the proper transformation of the alloy into a molten state. Once the alloy has reached the appropriate molten state, it is carefully poured into pre-designed mould as shown in figure 2. These mold, crafted from materials such as steel, graphite, or ceramic, determine the final shape and dimensions of the brazing alloy pieces. The pouring process requires precision to ensure uniform filling of the molds and the creation of high-quality alloy pieces as shown in figure 3.

Figure 2 Pouring the molten brazing alloy

Figure 3 Obtained Brazing alloy after the mould Solidified

After pouring, the molten alloy undergoes controlled cooling to solidify. The cooling process is as vital as the melting itself, as it impacts the microstructure and mechanical properties of the final alloy. Cooling rates are carefully controlled to prevent defects such as cracks or voids, ensuring the uniformity and structural integrity of the alloy pieces. Slow, controlled cooling is typically employed to achieve optimal results, although specific cooling rates may vary based on the alloy composition and desired properties.

The melting process begins with heating the prepared alloy components to reach the specific temperature required for melting. This temperature is determined based on the alloy's composition and melting characteristics, with careful consideration given to factors such as melting point. Throughout the heating process, continuous monitoring of temperature is essential. Observations are made visually and through temperature readings to ascertain the temperature range within which the alloy undergoes the transition from solid to liquid phase. This meticulous monitoring ensures that the alloy remains within the desired temperature range for optimal melting. Before starting the melting process, we accurately measure and record the weight of the prepared samples of mobile waste. This initial weight serves as a baseline for calculating the yield of the extracted metal. After the molten alloy has solidified and cooled, the resulting brazing alloy pieces are removed from the mould. We then measure and record the weight of the solidified alloy. By comparing the initial weight of the prepared samples with the final weight of the extracted brazing alloy, we can determine the efficiency and yield of the recycling process. This calculation provides valuable insights into the amount of usable metal obtained and the overall effectiveness of the recycling method.

The EDX analysis process begins with the focused bombardment of the sample with a beam of electrons. These electrons interact with the atoms in the sample, causing them to emit characteristic X-rays in response. As the electrons bombard the sample, they excite the inner-shell electrons of the atoms, causing them to move to higher energy levels. When these electrons return to their original energy levels, they emit X-rays with characteristic energies corresponding to the specific elements present in the sample. The emitted X-rays are collected and analyzed using a detector system. This system measures both the energy and intensity of the X-rays emitted by the sample. By comparing the detected X-ray spectra with reference spectra of known elements, the elemental composition of the sample can be determined. Each element produces X-rays with characteristic energies, allowing for the identification of the elements present in the sample. Once the elements have been identified, quantitative analysis is performed to quantify their respective concentrations in the sample. This involves measuring the intensity of the X-ray peaks corresponding to each element and correlating these intensities with the concentrations of the elements present. The data obtained from EDX analysis is interpreted to provide valuable insights into the elemental composition of the sample. This information can be used to assess the purity of the sample, identify trace elements, and characterize the material's chemical composition.

The Vickers hardness testing begins with the setup of the testing apparatus. A Vickers hardness tester equipped with a diamond-shaped indenter is used for this purpose. The sample surface is prepared by ensuring it is clean and flat, ready for indentation. Once the sample is prepared, a load is applied to the diamond-shaped indenter, causing it to penetrate the surface of the alloy. The applied load is typically in the range of a few kilograms-force (kgf) to several tens of kilograms-force, depending on the material being tested. After a specified dwell time, the load is removed, and the dimensions of the resulting indentation are measured. The diagonals of the indentation are measured using a microscope or optical system with high precision.

III. RESULT AND DISCUSSIONS

In this experiment, the weight of metal extracted from recycled mobile waste was measured to evaluate the efficiency of the recycling process. After the samples were melted, molded, and allowed to solidify, the resulting brazing alloy pieces were removed from the molds and weighed again. The final weight of the solidified alloy, measured using a digital electronic balance, was 32.01 grams[1-2]. By comparing the initial and final weights, we were calculated the extraction efficiency, providing valuable insights into the amount of usable metal obtained and the effectiveness of the recycling method.

The Energy Dispersive X-ray (EDX) analysis was employed to determine the elemental composition of the brazing alloy synthesized from recycled mobile waste. This technique provides both qualitative and quantitative data regarding the constituent elements within the sample. The obtained results are summarized in the table and spectrum below. The table presents the weight percentage (Weight %), weight percentage error (Weight % Error), and atomic percentage (Atom %) for each detected element. The primary elements identified in the brazing alloy are Oxygen (O), Aluminum (Al), Silicon (Si), Sodium (Na), and minor traces of Carbon (C) and Chlorine (Cl).

- **Carbon (C)**: Present at 0.36% by weight, with an error margin of ± 0.84%, and constituting 0.59% of the atomic composition.
- **Oxygen (O)**: The most abundant element, accounting for 50.85% by weight, with an error of ± 0.76%, and representing 63.22% of the atomic composition. This high percentage indicates the presence of oxides in the alloy.
- **Sodium (Na)**: Detected at 3.57% by weight, with an error margin of ± 0.38%, and forming 3.09% of the atomic composition.
- **Aluminum (Al)**: The second most prevalent element, comprising 38.98% by weight, with an error of ± 0.44%, and making up 28.73% of the atomic composition. Aluminum's significant presence suggests it is a primary component of the alloy.

- **Silicon (Si)**: Present at 5.82% by weight, with an error margin of ± 0.39%, and contributing 4.12% to the atomic composition. Silicon is often used in alloys to enhance their properties.
- **Chlorine (Cl)**: Found in trace amounts at 0.42% by weight, with an error of ± 0.11%, and constituting 0.24% of the atomic composition.

The sum total of these elements equates to 100% in both weight and atomic percentages, confirming that all significant components were accounted for during the analysis. The EDX spectrum analysis identified the primary elements in the recycled mobile waste derived brazing alloy as shown in figure 4 is oxygen, aluminum, silicon, and sodium, with minor traces of carbon and chlorine. The high oxygen and aluminum content suggests the presence of aluminum oxide, which enhances corrosion resistance and mechanical strength, making the alloy suitable for brazing applications. Minimal contamination from carbon and chlorine further ensures the alloy's purity and performance. These findings highlight the potential of recycling mobile waste to produce valuable materials, promoting resource conservation and waste reduction[3-5].

Element Line	*Weight %*	*Weight % Error*	*Atom %*
C K	0.36	± 0.84	0.59
O K	50.85	± 0.76	63.22
Na K	3.57	± 0.38	3.09
Al K	38.98	± 0.44	28.73
Si K	5.82	± 0.39	4.12
Si L	---	---	---
Cl K	0.42	± 0.11	0.24
Cl L	---	---	---
Total	100.00		100.00

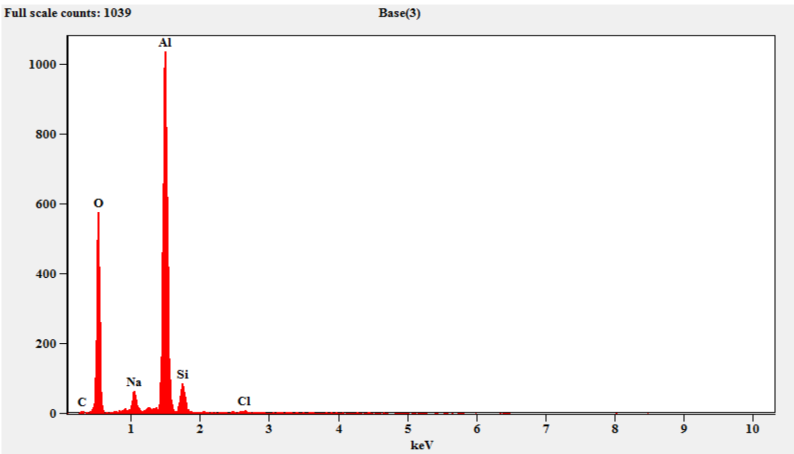

Figure. 4 Energy Dispersive X-ray Spectroscopy (EDS)

During the fabrication of brazing alloys, one of the fundamental procedures conducted is the determination of their melting point. This critical parameter influences the brazing process significantly, as it marks the temperature at which the alloy transitions from a solid to a liquid state. In our experiment, the melting temperature of the brazing alloy was tested and recorded at 860-910 degrees Celsius as shown in figure 5. This temperature signifies the precise point at which the alloy transforms into a molten state, allowing it to flow and create bonds between the surfaces being joined. Understanding the melting point of the brazing alloy is crucial for ensuring the success of the brazing process. It enables precise control over the temperature conditions required for effective bonding, ultimately contributing to the quality and strength of the final brazed joint. By accurately determining and documenting the melting point of the brazing alloy, we can optimize the brazing process parameters and ensure consistent and reliable results in our fabrication operations[6-9].

Figure. 5 Shows real-time temperature displayed on the furnace.

Figure 6 shows hardness results of the fabricated brazed joints. Hardness values are approximately similar to that of the Aluminium based filler alloy. The study showed that the magnitude of the hardness of the aluminium based filler alloy. As it described earlier, according XRD results determine the elemental composition of the brazing alloy synthesized from recycled mobile waste, elemental composition of the brazing alloy the different reactions are produced[10]. This might be the reason for increasing the hardness of brazing alloy synthesized from recycled mobile waste. Vickers hardness tester equipped with a diamond-shaped indenter is used for this purpose.

Figure 6 Microscopic view of indentation.

IV. CONCLUSIONS

Based on the experimental results and theoretical considerations, it is evident that the brazing alloy synthesized from recycled 3 numbers identical Redmi note 4 mobiles waste demonstrates promising characteristics for metal joining applications. The determination of its melting temperature at 860- 910 degrees Celsius establishes a crucial parameter for the brazing process, ensuring optimal conditions for effective bonding between workpieces. Moreover, the elemental composition analysis conducted through Energy Dispersive X-ray (EDX) analysis reveals the presence of essential elements such as aluminium, silicon, and sodium, along with minor constituents including carbon and chlorine. These findings collectively highlight the potential of recycling materials from waste mobile phones to produce functional brazing alloys, contributing to waste reduction efforts and promoting sustainable material utilization practices. Overall, the results support the feasibility and effectiveness of utilizing recycled materials for sustainable alloy production, aligning with the broader goals of environmental conservation and circular economy principles.

REFERENCES

[1]. Zhao, Y., Shen, P., & Pan, Y. (2019). Microstructure and mechanical properties of brazing alloys prepared from recycled electronic waste. *Journal of Materials Science & Technology*, 35(12), 2768-2775.

[2]. Kim, S., Park, J., & Lee, H. (2018). Characterization of brazing alloys fabricated from waste printed circuit boards. *Materials Science and Engineering: A*, 713, 254-259.

[3]. Li, Y., & Sun, Z. (2020). Recycling of waste electronic materials: Brazing process and properties of alloys. *Journal of Alloys and Compounds*, 818, 152883.

[4]. Liu, Y., & Chen, X. (2017). Development of brazing alloys from recycled aluminum alloy chips for electronic waste recycling. *Journal of Materials Processing,

[5]. Technology*, 240, 99-107.

[6]. Yang, Y., Wang, S., & Wu, W. (2019). Microstructural evolution and mechanical properties of aluminum-based composite materials prepared from recycled electronic waste. *Journal of Alloys and Compounds*, 810, 151878.

[7]. Zhang, S., Liu, J., & Zhang, L. (2018). Preparation and properties of brazing alloys from recycled aluminum and magnesium alloy scraps. Journal of Materials Research and Technology, 7(3), 261-267.

[8]. Singh, D., Kumar, S., & Pathak, D. (2016). Studies on the microstructure and properties of brazing alloy prepared from recycled aluminum scraps. Materials Today: Proceedings, 3(10), 3651-3657.

[9]. Xu, S., & Wang, C. (2020). Characterization of brazing alloys synthesized from recycled aluminum chips for electronic waste recycling. Journal of Materials Science & Technology, 42, 144-150.

[10]. Li, J., Liu, Y., & Chen, X. (2019). Microstructure and properties of Sn-Cu-Ni brazing alloys fabricated from waste electronic materials. Materials Letters, 243, 105-108.

[11]. Wang, H., Tang, J., & Wang, L. (2017). Synthesis and properties of a novel brazing alloy from recycled aluminum and copper scraps. Journal of Cleaner Production, 148, 245-251.