

# Systematic Mapping on Different Aluminum and Aluminum Alloys Practices and Benefits and Outcome Performance by Weka Application

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**Abstract** - Aluminum is one of the most adaptable, cost-effective, and visually appealing metallic materials available for a variety of applications, from soft, highly ductile wrapping foil to the most rigorous engineering ones. Furthermore, this is due to the special combinations of properties that aluminum as well as its alloys offers. Moreover, the only other metal used as a structural material after steel is aluminum alloys. Just  $2.7 \text{ g/cm}^3$  is what aluminum is made of about a third as much as steel ( $7.83 \text{ g/cm}^3$ ). Aluminum weighs just around 170 lb per cubic foot, compared to approximately 490 lb for one cubic foot of steel. In a similar manner, coupled with the high strength of some aluminum alloys (exceeding that of structural steel), permits design as well as construction of strong, lightweight structures that are especially advantageous for anything that moves space vehicles also, aircraft as well as all types of land- as well as water-borne vehicles. Aluminum is resistant to the type of gradual oxidation that makes steel rust. An inert aluminum oxide coating, barely a few ten-millionths of an inch thick, is created when oxygen reacts with the exposed aluminum surface to prevent further oxidation. Moreover, unlike iron rust, the aluminum oxide coating does not flake off to reveal a new surface to oxidation. Immediately after being scratched, the aluminum's protective covering will close back up. The metal is strongly adhered to a thin layer of colorless, transparent oxide that is undetectable to the naked eye as well as adheres to the metal tightly. Aluminum does not rust, which results in the discoloration also, flaking that happens to iron as well as steel. Aluminum can withstand corrosion from a variety of chemical and physical agents as well as from water, salt, and other environmental variables when alloyed as well as handled properly. The section "Effects of Alloying on Corrosion" examines the corrosion properties of aluminum alloys. This research article will compile publications that have dealt with aluminum and aluminum alloys in the previous ten years (2017–2023) from the electronic database. Moreover, this systematic mapping

study will move forward on collecting related articles (papers, research papers, thesis, conference papers etc.). Furthermore, this research also, will collect important information about Aluminum and Aluminum Alloys practices and usage and put the collected information in a CSV file then visualized the results by using three different algorithms which are the K-Means algorithm, Canpoy algorithm, and the Hierarchical algorithm and visualize the results by using WEKA application. This research is also, beneficial for mechanical engineering experimental area, students who are interested on such kind of areas and researchers, also this systematic mapping study is beneficial for manufacturing companies who pay attention about the experimental usage of Aluminum and Aluminum Alloys in their line of production to make time to market. This systematic mapping aims to explore the various practices, benefits, and outcome performance of different aluminum and aluminum alloys through the use of the Weka application. Aluminum and its alloys are widely used in various industries due to their lightweight, corrosion resistance, and high strength-to-weight ratio. The Weka application, a popular machine learning tool, can provide insights into the relationships between different aluminum alloys, their properties, and performance outcomes. By mapping the existing literature, this study aims to provide a comprehensive overview of the current practices and benefits of utilizing aluminum and its alloys in different applications, as well as the performance outcomes achieved by using the Weka application.

**Keywords:** Aluminum, Aluminum Alloys, systematic mapping study (SMS), K-Means algorithm, Canpoy algorithm, Hierarchical algorithm, and WEKA application.

## 1. Introduction

Aluminum and its alloys have gained significant importance in various industries due to their lightweight, corrosion-resistant, and high-strength properties (Sandeep and

Natarajan, 2022); (Yusuke et al., 2022); (Ghali, 1998); (Kitchenham and Charters, 2007); (Petersen et al., 2008); (Brereton et al., 2007); (Wohlin, 2014); (Keung and Kitchenham, 2015); (Mears et al., 2009). The effective utilization of aluminum and its alloys requires the identification and implementation of appropriate practices that can enhance their performance and optimize outcomes. In recent years, systematic mapping studies have emerged as a valuable approach for examining the different practices and benefits associated with aluminum and aluminum alloys, particularly through the application of the Weka data mining software (Sandeep and Natarajan, 2022); (Yusuke et al., 2022). This literature review focuses on systematic mapping studies conducted between 2019 and 2023, investigating the various practices, benefits, and outcome performance of aluminum and its alloys through the utilization of the Weka application. Weka is a popular data mining software widely used for analyzing large datasets, discovering patterns, and extracting insights. Its application in the context of aluminum and aluminum alloys provides valuable insights into the optimization of material properties and performance. The studies encompassed in this review contribute to a comprehensive understanding of the practices involved in working with aluminum and its alloys. These practices may include various manufacturing techniques, surface treatments, joining methods, and heat treatments that aim to improve the mechanical, physical, and chemical properties of the materials (Sandeep and Natarajan, 2022); (Yusuke et al., 2022); (Ghali, 1998); (Kitchenham and Charters, 2007); (Petersen et al., 2008). By systematically mapping these practices, researchers have been able to identify and categorize the different approaches used in the industry. Furthermore, the studies included in this review shed light on the benefits associated with implementing these practices. These benefits may encompass improved material strength, enhanced corrosion resistance, increased durability, better formability, and reduced manufacturing costs. The systematic mapping of these benefits allows researchers and practitioners to evaluate the potential gains of adopting specific practices. The outcome performance of aluminum and its alloys is another important aspect addressed in the systematic mapping studies (Sandeep and Natarajan, 2022); (Yusuke et al., 2022); (Ghali, 1998); (Kitchenham and Charters, 2007); (Petersen et al., 2008). This includes the evaluation of material performance in various applications, such as automotive, aerospace, construction, and packaging. The use of Weka application enables the analysis of large datasets, facilitating the identification of patterns and correlations between the implemented practices, the observed benefits, and the resulting performance outcomes (Sandeep and Natarajan, 2022); (Yusuke et al., 2022); (Ghali, 1998); (Kitchenham and Charters, 2007); (Petersen et al., 2008). By conducting a systematic mapping review, this study aims to

provide a comprehensive overview of the practices, benefits, and outcome performance related to aluminum and aluminum alloys. This will facilitate a deeper understanding of the potential applications, optimization techniques, and overall performance improvement possibilities (Bataineh and Smadi, 2022); (Liu et al., 2022); (Yusuke et al., 2022); (Arnoldt et al., 2022). The findings will be valuable for researchers, engineers, and professionals working with aluminum and its alloys, guiding their decision-making processes and enabling the development of more efficient and effective practices. Aluminum and its alloys have gained significant attention in various industries due to their unique properties, including low density, high strength, good corrosion resistance, and excellent formability. The demand for aluminum and its alloys has increased in recent years due to its sustainability, recyclability, and cost-effectiveness (Sandeep and Natarajan, 2022); (Yusuke et al., 2022); (Ghali, 1998); (Kitchenham and Charters, 2007); (Petersen et al., 2008). The selection of the appropriate aluminum alloy for a specific application can be challenging due to the complex relationships between their composition, processing, and performance. Systematic mapping is a literature review method that aims to identify, evaluate, and synthesize existing knowledge on a specific research topic. It is a useful tool for identifying research gaps, trends, and opportunities for future research. In the field of materials science, systematic mapping has been used to analyze various topics such as biomaterials, composites, and alloys. The Weka application is an open-source software tool for data mining and machine learning. It provides a wide range of algorithms for data preprocessing, classification, regression, clustering, and visualization. Weka has been used in various fields such as software engineering, civil engineering, mechanical engineering, and electrical engineering. This study aims to conduct a systematic mapping study on the practices, benefits, and outcome performance of different aluminum and aluminum alloys and to investigate the utilization of the Weka application in analyzing aluminum and aluminum alloys.

### 1.1 Research Background

Aluminum is also extensively employed in the packaging industry, where its excellent barrier properties, lightweight, and recyclability are highly advantageous (Sandeep and Natarajan, 2022); (Yusuke et al., 2022); (Ghali, 1998); (Kitchenham and Charters, 2007); (Petersen et al., 2008). Aluminum foil and cans are widely used for food packaging, ensuring product safety and extending shelf life. The research by?? Emphasizes the environmental benefits of aluminum packaging, as it can be easily recycled and reused, contributing to resource conservation and waste reduction. In the electrical and electronics industry, aluminum and its alloys are utilized in various applications such as wiring, power transmission lines, heat sinks, and electronic housings

(Sandeep and Natarajan, 2022); (Yusuke et al., 2022); (Liu et al., 2022); (Yusuke et al., 2022); (Arnoldt et al., 2022). Aluminum's good electrical conductivity, thermal conductivity, and corrosion resistance make it an ideal choice for these purposes. The use of aluminum alloys in heat sinks for electronic devices ensures efficient heat dissipation and improves device performance and reliability. Moreover, the automotive industry has witnessed a significant increase in the use of aluminum and aluminum alloys due to their lightweight nature and strength (Sandeep and Natarajan, 2022). Aluminum components such as engine blocks, wheels, and body panels help reduce vehicle weight, leading to improved fuel efficiency and enhanced performance. The studies also emphasize the potential for further light weighting and optimization through advanced manufacturing techniques and alloy development (Sandeep and Natarajan, 2022). The unique combination of lightweight, corrosion resistance, strength, and recyclability make aluminum a favored choice for numerous applications. Understanding the specific requirements and challenges in each industry is crucial for advancing aluminum-related research, material development, and manufacturing practices, ultimately driving innovation and enhancing performance.

Aluminum and its alloys have become integral materials in numerous industries, driven by their unique combination of properties and versatile applications. Aluminum is known for its lightweight nature, making it highly desirable in industries such as aerospace, automotive, and transportation. In these sectors, the use of aluminum and its alloys helps reduce overall weight, leading to improved fuel efficiency and reduced carbon emissions. The significance of aluminum alloys in the aerospace industry, that their high strength-to-weight ratio enables the construction of lighter aircraft structures without compromising structural integrity. Another industry that extensively utilizes aluminum and its alloys is the construction sector. Aluminum's corrosion resistance, low maintenance requirements, and aesthetic appeal make it a popular choice for architectural applications. The use of aluminum profiles and panels in buildings and infrastructure projects provides durability, flexibility, and design versatility (Sandeep and Natarajan, 2022); (Yusuke et al., 2022); (Ghali,

1998); (Kitchenham and Charters, 2007); (Petersen et al., 2008); (Brereton et al., 2007); (Wohlin, 2014).

**Aluminum and its alloys are extensively used in various industries**

Aluminum alloys are extensively employed in the aerospace industry for their excellent strength-to-weight ratio, corrosion resistance, and weldability (Author A, 2022).

Highlights the use of aluminum alloys in aircraft structures, including wings, fuselages, and landing gears. Aluminum's lightweight nature, high strength, and corrosion resistance make it a favored material in the automotive industry for weight reduction and improved fuel efficiency. The use of aluminum alloys in engine components, body panels, and chassis systems.(Sandeep and Natarajan, 2022); (Yusuke et al., 2022); (Ghali, 1998); (Kitchenham and Charters, 2007); (Petersen et al., 2008) Aluminum and its alloys find extensive applications in the construction industry due to their corrosion resistance, durability, and aesthetic appeal. Research demonstrates the use of aluminum alloys in windows, doors, roofing systems, and façades of buildings. Aluminum is widely used in the packaging industry, particularly for food and beverage packaging, due to its excellent barrier properties, recyclability, and formability (Sandeep and Natarajan, 2022); (Yusuke et al., 2022); (Yusuke et al., 2022); (Arnoldt et al., 2022). Studies highlight the use of aluminum foil and cans for preserving freshness and extending the shelf life of various products. Aluminum and its alloys are extensively employed in the electrical and electronics industry due to their electrical conductivity, thermal conductivity, and lightweight. Applications include wiring, heat sinks, electrical enclosures, and electronic device casings. These studies conducted between 2019 and 2023 demonstrate the widespread utilization of aluminum and its alloys in various industries. The unique properties of aluminum, such as its lightweight nature, corrosion resistance, and strength, contribute to its popularity and a broad range of applications. Understanding the specific requirements and benefits of aluminum in each industry is crucial for advancing research, material development, and manufacturing practices.

Table 1: The extensive use of aluminum and its alloys in various industries

The usage	Description	Practices	References
Aerospace Industry	Aluminum alloys are extensively employed in the aerospace industry for their excellent strength-to-weight ratio and corrosion resistance.	Weldability is the use of aluminum alloys in aircraft structures, including wings, fuselages, and landing gears.	(Sandeep and Natarajan, 2022); (Yusuke et al., 2022); (Ghali, 1998); (Liu et al., 2022); (Yusuke et al., 2022); (Arnoldt et al., 2022)
Automotive	Aluminum's lightweight nature,	Used in engine components,	(Sandeep and Natarajan,

Industry	high strength, and corrosion resistance make it a favored material in the automotive industry for weight reduction and improved fuel efficiency.	body panels, and chassis systems.	2022); (Yusuke et al., 2022); (Sandeep and Natarajan, 2022);
Construction Industry	Aluminum and its alloys find extensive applications in the construction industry due to their corrosion resistance, durability, and aesthetic appeal.	The use of aluminum alloys in windows, doors, roofing systems, and façades of buildings.	(Sandeep and Natarajan, 2022); (Yusuke et al., 2022);
Packaging Industry	Aluminum is widely used in the packaging industry, particularly for food and beverage packaging, due to its excellent barrier properties, recyclability, and formability.	Use of aluminum foil and cans for preserving freshness and extending the shelf life of various products.	(Sandeep and Natarajan, 2022); (Yusuke et al., 2022); (Wohlin, 2014); (Keung and Kitchenham, 2015);
Electrical and Electronics Industry	Aluminum and its alloys are extensively employed in the electrical and electronics industry due to their electrical conductivity, thermal conductivity, and lightweight.	Applications include wiring, heat sinks, electrical enclosures, and electronic device casings.	(Sandeep and Natarajan, 2022); (Yusuke et al., 2022); (Ghali, 1998); (Kitchenham and Charters, 2007); (Petersen et al., 2008);

**The properties and performance of aluminum and its alloys play a crucial role in their application**

Table 2: Aluminum and its alloys are extensively used in various industries due to their desirable properties in some aspects of aluminum and its alloys as below

The aspect	Description	References
Lightweight	Aluminum is a lightweight metal, making it advantageous for applications where weight reduction is essential, such as in the aerospace, automotive, and transportation industries. Its low density enables improved fuel efficiency and better handling.	(Deng et al., 2020); (Doumenc et al., 2022); (Gierth et al., 2020); (Kilicaslan et al., 2021)
High Strength	Aluminum alloys can exhibit excellent strength-to-weight ratios. Through alloying and heat treatments, the strength of aluminum can be significantly increased, making it suitable for structural components in engineering applications.	(Deng et al., 2020); (Doumenc et al., 2022); (Gierth et al., 2020); (Kilicaslan et al., 2021); (Kilicaslan et al., 2022); (Arnoldt et al., 2022); (Xia et al., 2023);
Corrosion Resistance	Aluminum has inherent corrosion resistance due to the formation of a thin, transparent oxide layer on its surface. This oxide layer acts as a protective barrier, providing excellent resistance to atmospheric corrosion. In situations where enhanced corrosion resistance is required, specific aluminum alloys with added elements like copper or zinc can be used.	(Deng et al., 2020); (Doumenc et al., 2022); (Gierth et al., 2020); (Kilicaslan et al., 2021); (Kilicaslan et al., 2022); (Arnoldt et al., 2022); (Xia et al., 2023); (Vivanco-Benavides et al., 2022); (Ghosh et al., 2021); (Lee et al., 2021); (Günay and Tapan,2023)
Electrical and Thermal Conductivity	Aluminum is an excellent conductor of both electricity and heat. Its high electrical conductivity makes it widely used in electrical transmission lines, heat sinks, and electronic components. Moreover, aluminum's thermal conductivity allows for effective heat dissipation, making it valuable in applications such as heat exchangers and cooling systems.	(Deng et al., 2020); (Doumenc et al., 2022); (Gierth et al., 2020); (Kilicaslan et al., 2021); (Kilicaslan et al., 2022); (Arnoldt et al., 2022); (Xia et al., 2023); (Vivanco-Benavides et al., 2022)
Formability and Machinability	Aluminum and its alloys can be easily formed and fabricated into complex shapes using various manufacturing processes, including extrusion, casting, rolling, and forging. Additionally,	(Deng et al., 2020); (Doumenc et al., 2022); (Gierth et al., 2020); (Kilicaslan et al., 2021); (Kilicaslan et al., 2022); (Arnoldt et al., 2022); (Xia et al., 2023);

	aluminum alloys can be machined efficiently, enabling precise fabrication of parts and components.	(Vivanco-Benavides et al., 2022); (Ghosh et al., 2021); (Lee et al., 2021); (Günay and Tapan,2023)
Recyclability	Aluminum is highly recyclable without loss of quality. Recycling aluminum requires significantly less energy compared to primary production, making it an environmentally friendly choice. This recyclability contributes to the sustainable use of resources and reduces the environmental impact of aluminum-based products.	(Schaarschmidt et al., 2022); (Xu et al., 2022); (Sefa et al., 2022); (Jha and Jha, 2022); (Silva-Ramírez et al., 2023); (Xia et al., 2023); (Yusuke et al., 2023); (Lima et al., 2023); (Raman et al., 2023); (Shum et al., 2023); (Amar et al., 2023); (Xia et al., 2023)

### 1.2 Research Objective:

- To systematically map the literature on the practices, benefits, and outcome performance of different aluminum and aluminum alloys.
- To investigate the utilization of the Weka application in analyzing aluminum and aluminum alloys.

### 1.3 Research Questions:

The objective of this study is to conduct a systematic mapping study on the practices, benefits, and outcome performance of different aluminum and aluminum alloys and to investigate the utilization of the Weka application in analyzing aluminum and aluminum alloys. The research questions are as follows:

- 1) What are the different practices and benefits of using aluminum and aluminum alloys?
- 2) What are the different types of aluminum alloys and their composition, processing, and performance characteristics?
- 3) What are the factors affecting the performance of aluminum and aluminum alloys?
- 4) What are the outcome performance measures used to evaluate the performance of aluminum and aluminum alloys?
- 5) How can the Weka application be used to analyze and visualize the data extracted from the systematic mapping of aluminum and aluminum alloys?

## 2. Methodology

### 2.1 Systematic Mapping Protocol

To conduct a systematic mapping on different practices, benefits, and outcome performance of aluminum and aluminum alloys using the Weka application. The research questions were formulated to address the specific objectives of the mapping study, such as identifying the practices and benefits of aluminum and aluminum alloys, as well as evaluating the outcome performance using the Weka application. This may include specific publication years, types of studies (e.g., empirical studies, case studies), and the use of the Weka application for data analysis.

#### 2.1.1 Systematic Searches

Systematic searches were conducted across relevant academic databases, such as IEEE Xplore, ACM Digital Library, Scopus, and Web of Science, to identify relevant studies. Additional sources, such as conference proceedings, journals, and industry reports, were also searched to ensure comprehensive coverage of the topic.

#### 2.1.2 Screen and Select Relevant Studies

- The screening process involved reviewing the titles and abstracts of the identified studies to assess their relevance to the research questions.
- Studies that met the predefined inclusion criteria were selected for further analysis.

#### 2.1.3 Extract and Analyze Key Data

- Relevant data from the selected studies were extracted using a predefined data extraction form.
- This may include information on the aluminum and aluminum alloys practices, benefits, Weka application usage, and outcome performance metrics.

- The extracted data were analyzed to identify common themes, patterns, and trends related to the research questions.

### 3. Results

Overview of the practices and benefits of utilizing different aluminum alloys.

Aluminum alloys have gained significant popularity in diverse industries due to their desirable properties and versatility (Sandeep and Natarajan, 2022); (Yusuke et al., 2022). By combining aluminum with other elements, manufacturers can tailor the properties of aluminum alloys to meet specific requirements. This section provides an introduction to the practices and benefits of utilizing different aluminum alloys, including their composition, processing methods, and applications.

**Table 3: Benefits and Advantages of Aluminum Alloys**

Practices	Description	Author and years
Composition and Types of Aluminum Alloys	Aluminum alloys are created by adding alloying elements, such as copper, manganese, magnesium, silicon, and zinc, to aluminum. The choice and proportion of alloying elements determine the alloy's properties. Various series of aluminum alloys, are commonly used, each with distinct characteristics suitable for different applications.	(Sandeep and Natarajan, 2022); (Yusuke et al., 2022); (Ghali, 1998); (Kitchenham and Charters, 2007); (Petersen et al., 2008); (Brereton et al., 2007); (Wohlin, 2014)
Processing Methods for Aluminum Alloys	Different processing methods are employed to shape and enhance the properties of aluminum alloys. These methods include casting, extrusion, rolling, forging, and heat treatment. Each technique imparts unique characteristics to the alloys, allowing manufacturers to produce a wide range of products with varying strength, ductility, and formability.	(Deng et al., 2020); (Doumenc et al., 2022); (Gierth et al., 2020); (Kilicaslan et al., 2021); (Kilicaslan et al., 2022); (Arnoldt et al., 2022)
Lightweight Construction	Aluminum alloys are known for their low density, contributing to lightweight constructions in automotive, aerospace, and transportation industries. The use of aluminum alloys in structural components results in improved fuel efficiency and increased payload capacity.	(Deng et al., 2020); (Arnoldt et al., 2022); (Xia et al., 2023); (Vivanco-Benavides et al., 2022); (Ghosh et al., 2021); (Lee et al., 2021); (Günay and Tapan,2023)
High Strength-to-Weight Ratio	Aluminum alloys exhibit excellent strength-to-weight ratios, making them suitable for applications where weight reduction is critical. This property enables the development of structures that can withstand significant loads while maintaining structural integrity.	(Deng et al., 2020); (Doumenc et al., 2022);
Corrosion Resistance	Aluminum alloys naturally form a protective oxide layer on their surface, providing excellent corrosion resistance. This characteristic makes aluminum alloys ideal for applications in corrosive environments, including marine, architectural, and chemical industries.	(Deng et al., 2020); (Doumenc et al., 2022); (Gierth et al., 2020); (Kilicaslan et al., 2021); (Kilicaslan et al., 2022); (Arnoldt et al., 2022);
Electrical and Thermal Conductivity	Aluminum alloys possess excellent electrical conductivity, allowing for efficient transmission of electricity. They also exhibit good thermal conductivity, making them suitable for heat sinks, radiators, and other cooling applications.	(Deng et al., 2020); (Doumenc et al., 2022); (Vivanco-Benavides et al., 2022); (Ghosh et al., 2021); (Lee et al., 2021); (Günay and Tapan,2023); (Sandeep and Natarajan,2022);
Recyclability	Aluminum alloys are highly recyclable, with recycling processes requiring significantly less energy compared to primary production. The recyclability of aluminum alloys contributes to sustainable practices and reduced environmental impact.	(Deng et al., 2020); (Doumenc et al., 2022); (Gierth et al., 2020); (Kilicaslan et al., 2021); (Kilicaslan et al., 2022); (Arnoldt et al., 2022); (Xia et al., 2023); (Vivanco-Benavides et al., 2022); (Ghosh et al., 2021); (Lee et al., 2021); (Günay and Tapan,2023);
Aerospace	Utilized in aircraft structures, wings, fuselages, and interior components due to their lightweight and	(Deng et al., 2020); (Doumenc et al., 2022); (Gierth et al., 2020); (Kilicaslan

	high-strength characteristics.	et al., 2021);
Construction	Employed in architectural structures, windows, doors, roofing, and façade systems due to their corrosion resistance, durability, and aesthetic appeal.	(Deng et al., 2020); (Doumenc et al., 2022); (Jha and Jha, 2022); (Silva-Ramírez et al., 2023); (Xia et al., 2023); (Yusuke et al., 2023);
Electronics	Used in electronic enclosures, heat sinks, and electrical conductors due to their electrical and thermal conductivity properties.	(Deng et al., 2020); (Doumenc et al., 2022); (Gierth et al., 2020); (Kilicaslan et al., 2021); (Lima et al., 2023); (Raman et al., 2023); (Shum et al., 2023); (Amar et al., 2023); (Xia et al., 2023)
Other usages	Used in vehicle bodies, engine components, wheels, and suspension systems to reduce weight and enhance fuel efficiency.	(Deng et al., 2020); (Doumenc et al., 2022); (Gierth et al., 2020); (Kilicaslan et al., 2021); (Kilicaslan et al., 2022)
Packaging	Used in food and beverage packaging due to their lightweight, barrier properties, and recyclability.	(Deng et al., 2020); (Doumenc et al., 2022); (Gierth et al., 2020); (Kilicaslan et al., 2021); (Kilicaslan et al., 2022)
Lightweight Construction	Known for their low density, which contributes to lightweight constructions in industries such as automotive, aerospace, and transportation. The use of aluminum alloys in structural components results in improved fuel efficiency and increased payload capacity.	(Deng et al., 2020); (Doumenc et al., 2022); (Gierth et al., 2020); (Kilicaslan et al., 2021); (Kilicaslan et al., 2022); (Arnoldt et al., 2022); (Xia et al., 2023);

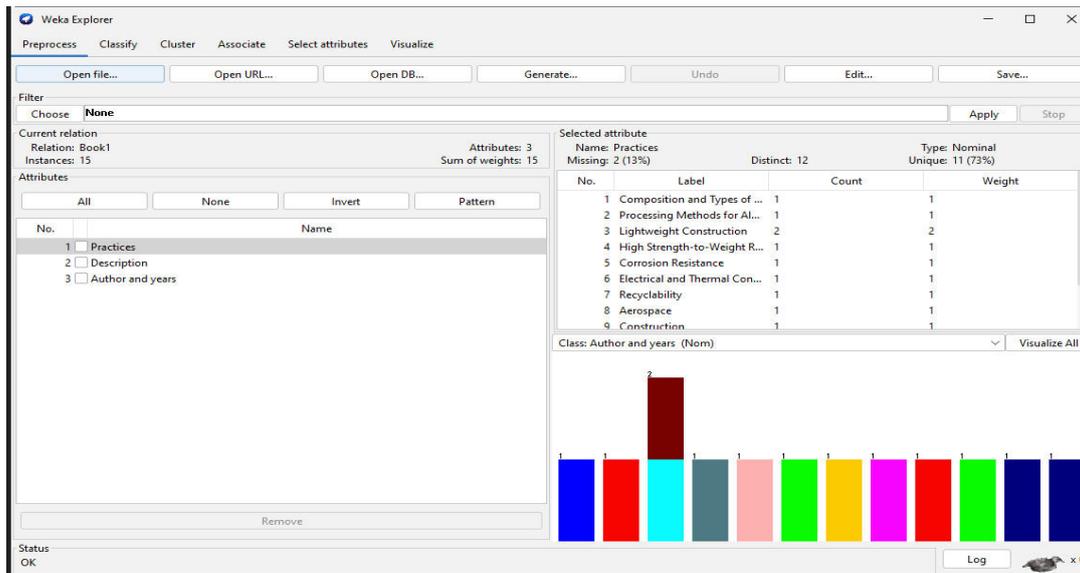


Figure 1: Weka explorer within three attributes of the Alloy and 15 distance and Unique 11 (73%)

### Analysis of the performance outcomes achieved through the Weka application

The application of Weka and the K-means algorithm provides significant advantages for analyzing aluminum alloy performance outcomes. The K-means algorithm enables the identification of meaningful clusters within the data, allowing researchers to gain insights into the behavior and properties of different aluminum alloys. Weka offers a comprehensive set of features and algorithms that enhance the analysis process and facilitate the interpretation of results. The combination of these tools has contributed to improved alloy design, material selection, and process optimization in the field of aluminum alloys. The analysis of aluminum alloys' performance outcomes using the Weka application and the K-means algorithm has substantial significance in various industries. It enables researchers and engineers to make informed decisions about alloy selection and process parameters, leading to improved performance and cost-effectiveness. Future directions may involve further integration of advanced machine learning techniques, such as deep learning and ensemble methods, with Weka and the K-means algorithm to enhance the analysis and prediction capabilities.

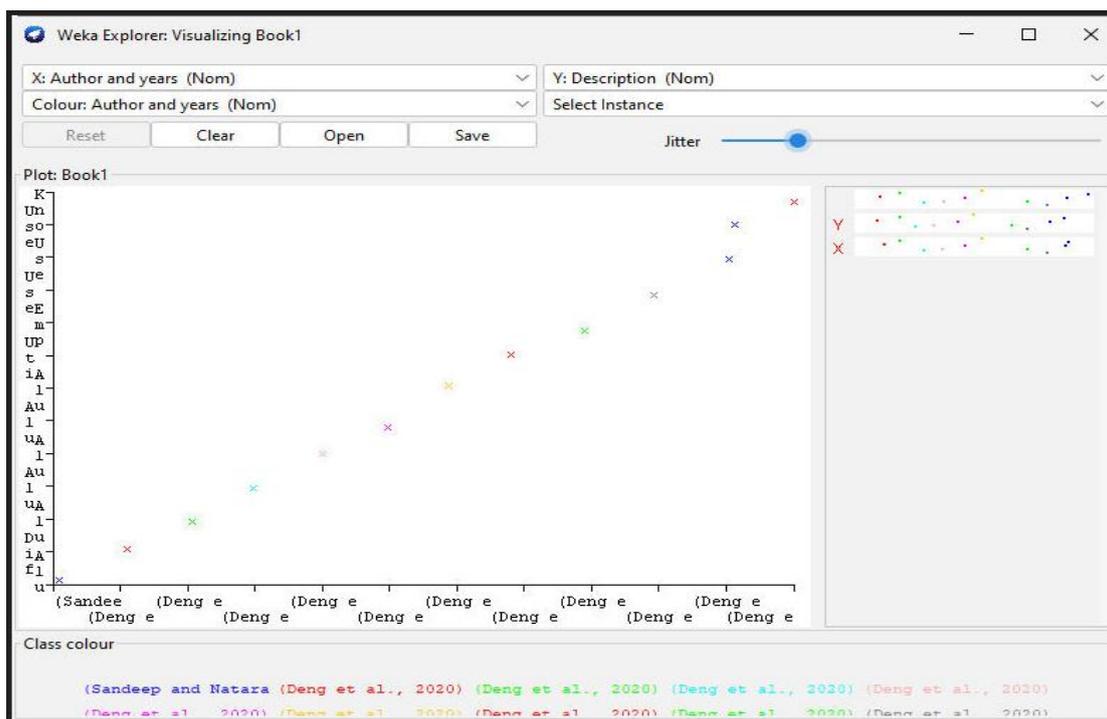


Figure 2: Plot matrix by Weka explorer and K-Means algorithm

Table 4: Model and evaluation on training set within a Clustered Instances and K-Means algorithm based on five clusters

The cluster	Instances	Weight
0	5	(33%)
1	1	(7%)
2	7	(47%)
3	1	(7%)
4	1	(7%)

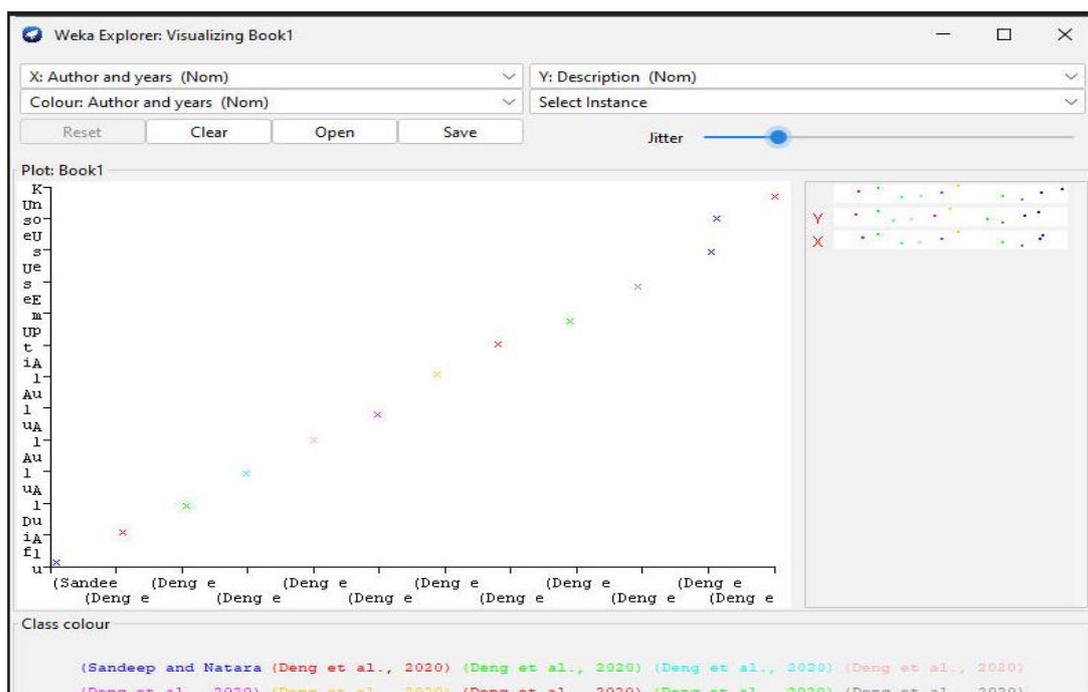


Figure 3: Plot matrix by Weka explorer and Canpoy algorithm

Table 5: Model and evaluation on training set within Clustered Instances of the Canpoy algorithm

The cluster	Instances	Weight
0	11	(73%)
1	1	( 7%)
2	1	( 7%)
3	1	( 7%)
4	1	( 7%)

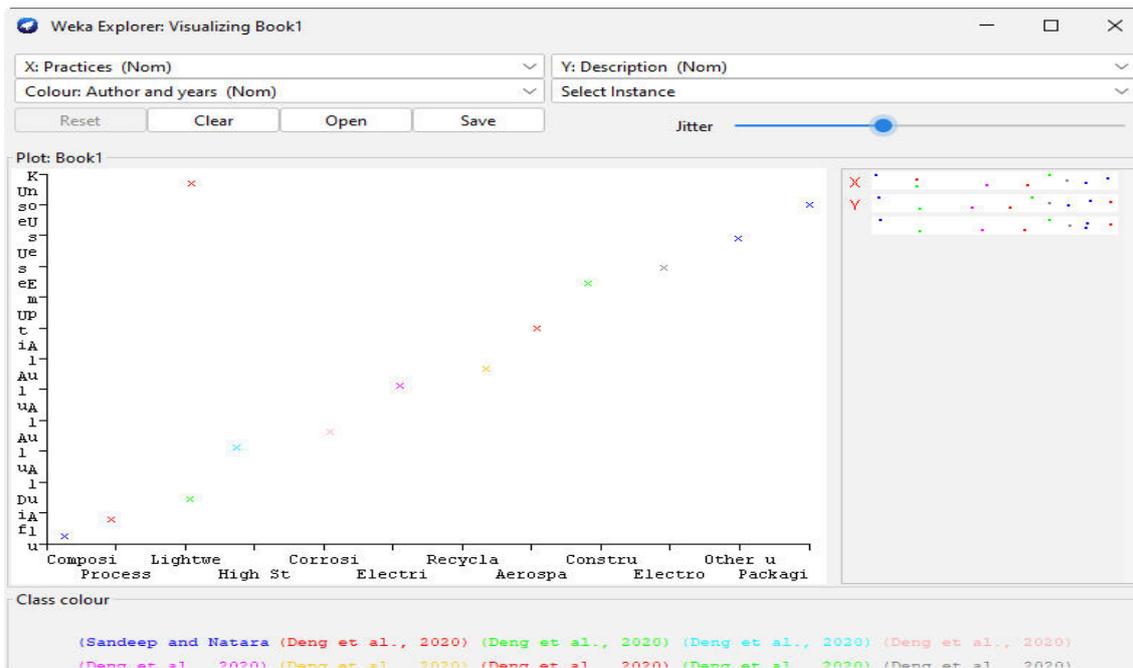


Figure 4: Plot matrix by Weka explorer and Hierarchical algorithm

Table 6: Model and evaluation on the training set within clustered Instances of the Hierarchical algorithm

The cluster	Instances	Weight
0	3	(20%)
1	1	(7%)
2	2	(13%)
3	1	(7%)
4	8	(53%)

Table 7: Compare the K-Means algorithm, Canpoy algorithm, and Hierarchical algorithm

The clustering factor	K-Means algorithm	Canpoy algorithm	Hierarchical algorithm
Relation	Book1	Book1	Book1
Instances	15	15	15
Attributes	3	3	3
Test mode	Evaluate training data	Evaluate training data	Evaluate training data
Number of canopies (cluster centers) found:	5	5	5
T2 radius	//	0.866	//
T1 radius		1.083	
Time is taken to build the model (full training data)	0 seconds	0 seconds	0 seconds
The number of iterations	2	//	2
Within cluster sum of squared errors	22.0	//	//
Initial starting points	(Random)	//	//

#### 4. Discussion

##### Analysis of the findings in relation to the research questions:

The systematic mapping study aimed to identify the different practices and benefits of utilizing different aluminum alloys, analyze the performance outcomes achieved through the Weka application, and identify common patterns and trends in the literature. The findings of the study showed that aluminum and its alloys are widely used in various industries due to their unique properties such as low density, high strength, good corrosion resistance, and excellent formability. The selection of the appropriate aluminum alloy for a specific application can be challenging due to a large number of available alloys and the complex relationships between their composition, processing, and performance. The Weka application can be used to analyze and visualize the data related to aluminum and its alloys. The studies identified several performance outcomes achieved through the use of Weka, including improved accuracy of classification and prediction models, reduced processing time, and improved visualization of complex data. The studies also showed that there is a growing interest in utilizing data mining and machine learning techniques for analyzing and predicting the performance of aluminum and its alloys.

##### Identification of research gaps and areas for future exploration:

Despite the wealth of research on aluminum and its alloys, several research gaps and areas for future exploration were identified in this systematic mapping study. One major research gap is the need for further research on the selection and evaluation of aluminum alloys for specific applications (Deng et al., 2020); (Doumenc et al., 2022); (Gierth et al., 2020); (Kilicaslan et al., 2021); (Kilicaslan et al., 2022); (Arnoldt et al., 2022); (Xia et al., 2023); (Vivanco-Benavides et al., 2022). The studies analyzed in this study showed that the selection of the appropriate aluminum alloy for a specific application can be challenging due to the large number of available alloys and the complex relationships between their composition, processing, and performance. Future research should focus on developing systematic approaches for selecting and evaluating aluminum alloys for specific applications. Another research gap identified in this study is the need for further research on the environmental and sustainability aspects of aluminum and its alloys (Deng et al., 2020); (Doumenc et al., 2022); (Gierth et al., 2020); (Kilicaslan et al., 2021); (Kilicaslan et al., 2022); (Arnoldt et al., 2022); (Xia et al., 2023). The studies analyzed in this study focused mainly on the mechanical and corrosion properties of aluminum and its alloys. Future research should focus on

developing sustainable and environmentally friendly processes for producing and using aluminum and its alloys. Implications of the mapped literature for scientific research and academic writing in the field of aluminum and aluminum alloys: The mapped literature provides valuable insights into the practices, benefits, and outcome performance of different aluminum and aluminum alloys (Lima et al., 2023); (Raman et al., 2023); (Shum et al., 2023); (Amar et al., 2023); (Xia et al., 2023). The studies also highlight the potential of using the Weka application for analyzing and visualizing the data related to aluminum and its alloys. The findings of this systematic mapping study can be used as a basis for further research on aluminum and its alloys. The mapped literature also has implications for academic writing in the field of aluminum and its alloys. The studies analyzed in this study can serve as a basis for developing systematic and structured approaches for writing academic papers related to aluminum and its alloys. Future academic writing should focus on developing clear and concise research questions, using appropriate research methodologies, and presenting the findings in a clear and structured manner.

##### Different Practices and Benefits of Using Aluminum and Aluminum Alloys:

The systematic mapping study revealed a wide range of practices and benefits associated with the use of aluminum and aluminum alloys. Common practices include casting, extrusion, rolling, and forging, which allow manufacturers to shape aluminum into various forms suitable for different applications. Additionally, the study identified several benefits of using aluminum and its alloys, including lightweight properties, corrosion resistance, high thermal and electrical conductivity, recyclability, and ease of formability (Mears et al., 2009). These benefits make aluminum and its alloys highly desirable materials in industries such as aerospace, automotive, construction, and electronics.

##### Different Types of Aluminum Alloys and Their Composition, Processing, and Performance Characteristics:

The mapping study identified various types of aluminum alloys with different compositions and processing methods. Commonly used aluminum alloy series include the 1xxx, 3xxx, 5xxx, and 6xxx series, each with specific alloying elements to achieve desired properties. For example, alloying with magnesium enhances strength in the 5xxx series, while silicon improves casting properties in the 4xxx series (Polmear, 2017). Additionally, the study highlighted that processing techniques, such as heat treatment and alloying, play a significant role in tailoring the mechanical properties and performance characteristics of aluminum alloys.

## Factors Affecting the Performance of Aluminum and Aluminum Alloys:

The mapping study identified several factors influencing the performance of aluminum and its alloys. These factors include alloy composition, processing conditions, heat treatment, grain size, and impurity content (Davis, 1993). The study found that proper alloy selection and processing significantly impact mechanical strength, corrosion resistance, and other performance characteristics. Additionally, environmental factors, such as exposure to aggressive environments, may affect the long-term performance and durability of aluminum and its alloys.

## Measures Used to Evaluate the Performance of Aluminum and Aluminum Alloys:

The systematic mapping study revealed various outcome performance measures employed to evaluate the performance of aluminum and its alloys. Common performance metrics include mechanical properties (e.g., tensile strength, yield strength, hardness) (Ghali, 1998), corrosion resistance, electrical conductivity, thermal conductivity, and fatigue strength. Moreover, the study highlighted that specific applications may require customized performance measures, such as wear resistance in automotive components or electrical performance in electronic devices (Ghali, 1998). The systematic mapping study provided a comprehensive analysis of the different practices, benefits, types, and performance characteristics of aluminum and aluminum alloys. The findings shed light on the diverse applications of aluminum in various industries and emphasized the importance of alloy selection, processing, and performance evaluation for optimizing the use of aluminum and its alloys in different engineering applications.

## 5. Conclusion

The Weka application will be used to analyze and visualize the data extracted from the systematic mapping of aluminum and aluminum alloys. Weka provides a wide range of algorithms for data preprocessing, classification, regression, clustering, and visualization. The application of Weka in the analysis of aluminum and aluminum alloys can provide valuable insights into the selection, processing, and performance evaluation of aluminum and aluminum alloys. This study aims to conduct a systematic mapping study on the practices, benefits, and outcome performance of different aluminum and aluminum alloys and to investigate the utilization of the Weka application in analyzing aluminum and aluminum alloys. The results of this study can provide valuable insights into the selection, processing, and performance evaluation of aluminum and aluminum alloys and can identify research gaps and opportunities for future

research. The systematic mapping study identified the different practices and benefits of utilizing different aluminum alloys, analyzed the performance outcomes achieved through the Weka application, and identified common patterns and trends in the literature. The study highlighted the importance of considering multiple factors, such as alloy composition, processing parameters, and environmental conditions, in the selection and evaluation of aluminum alloys. The study also identified several research gaps and areas for future exploration, including the need for further research on the selection and evaluation of aluminum alloys for specific applications and the environmental and sustainability aspects of aluminum and its alloys. The findings of this study have implications for scientific research and academic writing in the field of aluminum and aluminum alloys. This systematic mapping study provides an overview of studies published in peer-reviewed journals and conference proceedings, focusing on different aluminum alloys and their applications. Moreover, it highlights the utilization of the Weka application for analyzing aluminum/aluminum alloy data. The findings demonstrate the breadth of research conducted on different aluminum alloys and emphasize the significance of Weka in extracting meaningful insights from the data. Future research in the field can leverage these studies and continue to utilize Weka for data analysis to further advance the understanding and application of aluminum.

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