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Used-Engine Oil in Aluminum Metal Upcycling: A Proposed Circular Economy Strategy

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Abstract: This study analyses the upcycling of aluminium scraps to new training materials using charcoal and used engine fuel in a furnace. The author experimentally compares the performance of the charcoal from used engine as a fuel by measuring the melting rate, furnace efficiency and specific fuel consumption and the cost of each fuel when used. The study revealed that the melting rate (2.5 vs 3.1 kg/hr) and furnace efficiency (18% vs 63 %) in charcoal fuel is lower than used engine fuel. The specific fuel consumption (6 vs 0.28 kilogram / kilogram) and the cost ($1.5 vs 0) is higher in charcoal fuel than used engine fuel. The quality of the melted aluminium was studies and find that it meets the required standards for aluminium casting. In upcycling the aluminium scraps to aluminium sheet, the institution saves up to $250 per month per student. The success of DBTC-Cebu's upcycling program shows that upcycling is a viable circular economy strategy that promotes sustainable development. It also highlights the important role technical vocational institutions can play in promoting the circular economy model.

Keywords: *aluminium scraps, training materials*

1. Introduction

The circular economy concept has lately gained popularity as a sustainable resource-use method. Principles and practices of the circular economy are rapidly being introduced into technical and vocational education and training (TVET) programs across the world. TVET programs are intended to provide students with the information, skills, and competencies they need to join the workforce and execute certain occupations or crafts. Using circular economy ideas in TVET can assist educate students for shifting labor market demands and the growing demand for sustainable practices across businesses. TVET programs can teach students in areas such as waste reduction and resource efficiency, product design for circularity, remanufacturing, and equipment and infrastructure repair and maintenance. Furthermore, several TVET institutions are incorporating circular economy ideas into their own operations and management procedures, such as waste reduction, material recycling, and the use of renewable energy sources. TVET institutions are creating and revising their curricula to incorporate courses and modules on the principles and practices of the circular economy. Waste reduction and resource efficiency, eco-design, product life-cycle evaluation, and closed-loop supply chains are some of the subjects covered in these courses. Learners receive hands-on instruction in circular economy processes such as equipment repair and maintenance, remanufacturing, and material reuse through TVET programs. This course can assist students in developing the technical skills required to adopt circular economy techniques in a variety of businesses. TVET institutions are engaging with companies and industry organisations to identify the most in-demand circular economy skills and capabilities in the job market. This can assist ensure that TVET programs are linked with industry demands and that learners receive appropriate training. Research on circular economy practices and innovations, such as innovative recycling

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technologies, sustainable materials, and circular business models, is being conducted by TVET institutions. This research can assist design new TVET courses and programs, as well as provide new career possibilities in the circular economy.

Several studies highlight the growing importance of circular economy principles in TVET and provide insights into how TVET institutions can prepare learners for the jobs of the future by integrating circular economy into their curricula and pedagogy. The study of Karayannis, and Giannopoulou [1] analyzes the melting and casting processes used in the recycling of aluminum scraps. The authors review the various types of aluminum scrap that can be recycled, as well as the different furnace types and melting techniques used in the process. They also examine the factors that affect the quality of the recycled aluminum, such as impurities and gas content, and discuss the methods used to control these factors. The study concludes with a discussion of the economic and environmental benefits of aluminum recycling through the melting and casting process. Chips made of aluminum are not biodegradable. Upcycling, which entails repurposing waste materials into useful new goods, is one of the key tenets of the circular economy. An institution that has taken a circular economy strategy is Don Bosco Technical College – Cebu (DBTC-Cebu), and as part of this, it has put in place an upcycling program for aluminium scraps. Aluminum and iron scrap are produced as chips and sheets at Don Bosco's Machine Shop. These chips are leftovers from benchwork, lathe, and milling operations that are gathered and disposed of in recycling bins at the back of the shop. However, chips are crinkly and pointy and challenging to handle and stack. These materials cannot be simply disposed of or combined with other biodegradable garbage because they are not biodegradable. It can only be disposed of by selling it to scrap purchasers at a discount. However, before they would pick them up, scrap purchasers needed a sizable amount of chips. The need for a sizable space in the Materials Recovery Facility (MRF) area makes it difficult to stack waste management of these scrap materials. It will be difficult to stack and dispose of this waste material since it is sharp and curly. Because it was junk, scrap purchasers paid a low price for it. To address this issue and create new training materials, the researcher investigated how to upcycle waste aluminum chips by melting and casting using charcoal and used engine oil in a furnace.

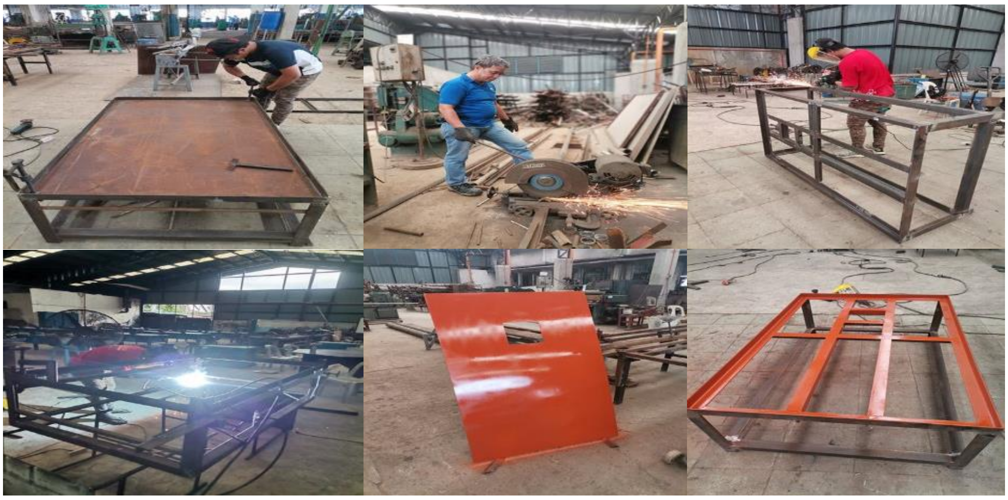
2. Method

The furnace is prepared for the melting and casting of aluminum scraps. The process in making the furnace involves several steps as shown below:

a. Burner (Cutting)

b. Mould (Clamping, Lay outing and Machining)

c. Table (Assembly, Cutting, Grinding, Welding and Painting)



To upcycle the aluminium scraps, melting and casting technique is used. This process involves melting down the aluminum scrap in a furnace and pouring it into a mold to create a new product. It is also a relatively energy-efficient process compared to other manufacturing methods, as aluminum has a low melting point and can be easily melted and cast into new shapes. The steps conducted includes:

1. Sorting and preparation: The first step in the melting and casting process is to sort and prepare the aluminum scrap. This involves removing any contaminants, such as paint, coatings, or other materials that could affect the quality of the final product.
2. Melting: Once the aluminum scrap is prepared, it is melted down in a furnace. The temperature of the furnace varies depending on the type of aluminum being melted, but typically ranges from 660°C to 740°C for aluminum alloys.
3. Refining: After the aluminum scrap is melted, it is typically refined to remove any impurities, such as oxides or gases, that could affect the quality of the final product. This is done using fluxes or other refining agents.
4. Pouring: Once the aluminum is melted and refined, it is poured into a mold to create a new product. The mold can be made of various materials, including sand, steel, or graphite, and can be designed to create a wide range of shapes and sizes.
5. Cooling and finishing: After the aluminum is poured into the mold, it is left to cool and solidify. Once the part is solid, it is removed from the mold and any finishing operations, such as machining, polishing, or painting, can be performed to achieve the desired surface finish and shape.

In melting the aluminium scraps, a charcoal and a used engine oil was used. The melting rate, furnace efficiency, specific fuel consumption and cost were compared.

3. Result

	Charcoal	**Used-Engine**
Melting Rate	2.5 kilogram/hour	3.1 kilogram /hr
Furnace Efficiency	18 %	63%
Specific fuel consumption	6 kilogram / kilogram	0.28 kilogram / kilogram
Cost	$1.5 per kilo	0

4. Discussion

The melting rate was measured as the weight of aluminium cans melted per unit time, and it was found to be 2.5 kg/hr for the charcoal-fueled furnace. This was lower than the melting rate of 3.1 kg/hr for the used engine-fueled furnace, which was used as a comparison in the study. The lower melting rate of the charcoal-fueled furnace can be attributed to its lower thermal efficiency and slower heat transfer rate compared to the used engine-fueled furnace. The furnace efficiency is a measure of how effectively the furnace converts the fuel energy into heat, and it is expressed as a percentage. The furnace efficiency was found to be 18 % for the charcoal-fueled furnace, which was lower than the furnace efficiency of 63% for the used engine-fueled furnace that was used as a comparison in the study. The lower furnace efficiency of the charcoal-fueled furnace can be attributed to its lower operating temperature, slower heat transfer rate, and incomplete combustion of the fuel, which results in heat losses. The lower furnace efficiency of the charcoal-fueled furnace can be attributed to its lower operating temperature, slower heat transfer rate, and incomplete combustion of the fuel, which results in heat losses. The specific fuel consumption is a measure of the amount of fuel required to melt a unit weight of material, and it is expressed as a ratio of fuel weight to material weight. In this study, the specific fuel consumption was measured as the weight of charcoal consumed per unit weight of aluminium melted (kg/kg). The specific fuel consumption was found to be 6 kg/kg for the charcoal-fueled furnace, which was higher than the specific fuel consumption of 0.28 kg/kg for the used engine-fueled furnace used as a comparison. This indicates that the charcoal-fueled furnace required more fuel to melt the same amount of aluminium compared to the used engine-fueled furnace. The higher specific fuel consumption of the charcoal-fueled furnace can be attributed to its lower thermal efficiency and incomplete combustion of the fuel, which results in higher fuel consumption. With regards to the cost, the charcoal is $1.5 per kilogram, while the used engine oil is an upcycled fuel from the automotive shop of Don Bosco. In upcycling the aluminium scraps to aluminium sheet, DBTC saves up to $250 per month per student. The success of DBTC-Cebu's upcycling program shows that upcycling is a viable circular economy strategy that promotes sustainable development. It also highlights the important role technical vocational institutions can play in promoting the circular economy model. Therefore, it is recommended that other institutions adopt similar upcycling programs to reduce waste and promote sustainable development.

5. References

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