

## Mini Furnace Project – An Educational and Green-Technopreneurial Project

Mohd Azman Yahaya<sup>1,a</sup>, Muhammad Hussain Ismail<sup>1</sup>, Nuraisyah Idris<sup>1</sup>  
and Muhammad Fazrul Mohammad Radzi<sup>1</sup>

<sup>1</sup> Faculty of Mechanical Engineering, Universiti Teknologi MARA, Shah Alam, MALAYSIA

(<sup>a</sup> Corresponding author email: [azman028@salam.uitm.edu.my](mailto:azman028@salam.uitm.edu.my))

### ABSTRACT

This project aims to promote recycling of waste aluminum among school children in Malaysia and to generate income through a program called STEM organized by the Ministry of Education Malaysia. A mini furnace was designed and fabricated according to the design standard for a good and practical furnace. Waste aluminum, in the form of discarded drink cans, are used as the main source of recycling by the furnace. The construction of the furnace commenced with a drawing process using Computer Aided Three-dimensional Interactive Application (CATIA) and ended with a business plan on how to market the furnace to generate income. Besides melting aluminum, the furnace can also be used as a barbeque pot and as a flower pot in order to increase its marketability. With a good marketing strategy and market analysis, the furnace has the potential to generate income. This is a good pilot project especially for university students who are planning in becoming an entrepreneur not only in technological sector but also in environmentally friendly (green) business sector.

**Key Words:** Mini Furnace, Green-Technopreneur, STEM.

### 1. INTRODUCTION

As entrepreneur is defined as a person who sets up a business or businesses, taking on financial risks in the hope for profit, a techno-preneur is also describing the same kind of person but rather concentrating in technologically based business. On the other hand, a Green techno-preneur is used to describe a person involved in setting up a business to make profit relating to technology that could save the environment. Today, most of products are produced by using recyclable material. Aluminum is among the most famous material wherein not only it is lightweight but also relatively easier to recycle. However, due to lack of knowledge and skills, recycling of aluminum is not fully practiced to the optimum. According to Alam Flora Sdn.

Bhd., the biggest waste management company in Malaysia, about 30,000 tons of wastes are produced by Malaysian yearly but only 10.5% of Malaysian practice recycling their waste [1]. There was also a campaign organized by the company in 2011 which was known as 3R (Reduce, Reuse, Recycle) program to promote awareness in recycling of waste, but the percentage did not improve much.

Scrap aluminum is a valuable resource that is set to become even more important. Fundamentally, all scrapped aluminum can be recycled into new products. The recycled aluminum or secondary aluminum has an acquisition of 95% in energy compared with primary aluminum. The positive aspect from recycling is the environmental impact. Recycling aluminum only emits 5% of the greenhouse gas compared with primary aluminum production, so that recycling of this metal saves 100 million tons of CO<sub>2</sub> (equivalent carbon dioxide) per year [2].

Normally, recycling of aluminum requires a furnace to melt the metal. There are several furnace design requirements in order to produce a satisfactory product at lower cost. For examples; a good furnace requires minimum fuel, constructed using low cost material, operates with lowest possible manning level and must be long lasting with minimum maintenance. These requirements are also similar with the furnaces operating in industrial production [3]. Furthermore, the industrial furnace exhibits critical step to gain the right temperature in order to get the right metallurgical properties of the treated work piece.

Therefore, in order to promote the recycling of aluminum, a mini furnace project is proposed. The mini furnace is a simple device that is easy to handle and use, in addition, could also generate income. The term “waste to wealth” is the main objective of this project. Aluminum reacts with oxygen in the air to form an extremely thin but dense layer of oxide where it provides excellent corrosion protection. The layer is also self-repairing if damaged. Therefore, aluminum is an excellent material to be used in the packaging industry especially for drink cans. The properties of aluminum are shown in Table 1.

Table 1 Properties of Aluminum Metal [4]

<b>Properties</b>	
Atomic weight	26.98154
Specific mass at 20°C (g/cm <sup>3</sup> )	2.69890
Specific heat at 25°C (J/kg °C)	900.0
Latent heat of fusion (kJ/kg)	397
Combustion heat (MJ/kg)	31.07
Thermal conductivity at 25 °C (W/m °C)	247

The Education Ministry of Malaysia is encouraging students to enjoy science, technology, engineering and mathematics by introducing a program called (STEM) in primary and secondary school. The mini furnace can be integrated in to the program thus exposing students with science of metallurgy. Since training students to use it is easy, primary and secondary schools are encouraged to have the mini furnace as part of the program. Products from the recycled aluminum can be use as home decorations and tools. Once the products seem not attractive or not useful anymore, the product can be melted again to produce another product as one of the properties of aluminum is that it can be recycled many times. The mini furnace would be marketed among schools, colleges and individuals.

## 2. METHODOLOGY

There are two main steps in this project. The first step is to design and develop the mini furnace and the second step is the business planning to create a market for the product. The mini furnace must be designed in accordance with the design requirements of a reliable furnace. The design and development step was divided into several stages; drawing, fabrication, melting and moulding. Several techniques and combination were tested until a reliable mini furnace was ready. The steps taken are shown in a flow chart as shown in Figure 1.

During the drawing stage, engineering drawing software CATIA was used. Dimension for the furnace is small in size because this project's emphasis on a furnace that is mobile and easy to handle. Samples of the 3D drawings are shown in Figure 2. The fabrication stage was started by making the furnace wall. The wall is a combination of Plaster of Paris (POP), sand and water. The portions of the raw materials were 2.5 kg of POP, 2.5kg of sand and 3 liters of water. Mixture of POP and sand was poured into a steel bucket and a smaller in diameter plastic bucket was placed at the center of the steel bucket as shown in Figure 3. After the mixture was cured, the plastic bucket was pulled out to make an empty space at the center of the steel bucket. This is where the combustion takes place. A hole was drilled using a hole-saw to make an inlet for air to flow inside the combustion chamber as shown in Figure 4.

Melting stage is a stage where the mini furnace was tested to melt aluminum can to produce a new product from the casting process. The mini furnace uses charcoal as the heating element in the combustion chamber. Initially, the charcoals were heated outside the furnace before they were placed into the combustion chamber in the mini furnace. Then aluminum was put into a steel crucible when the temperature in the furnace is high enough. The melting point temperature for aluminum is 660°C. The processes involved are shown in Figure 5.

Molten aluminum was poured into a mold to get a new product from the waste aluminum drink can. The shape of end product of the cast aluminum can be varied with the mold design. After the molten aluminum solidified, the end products are shown in Figure 6.

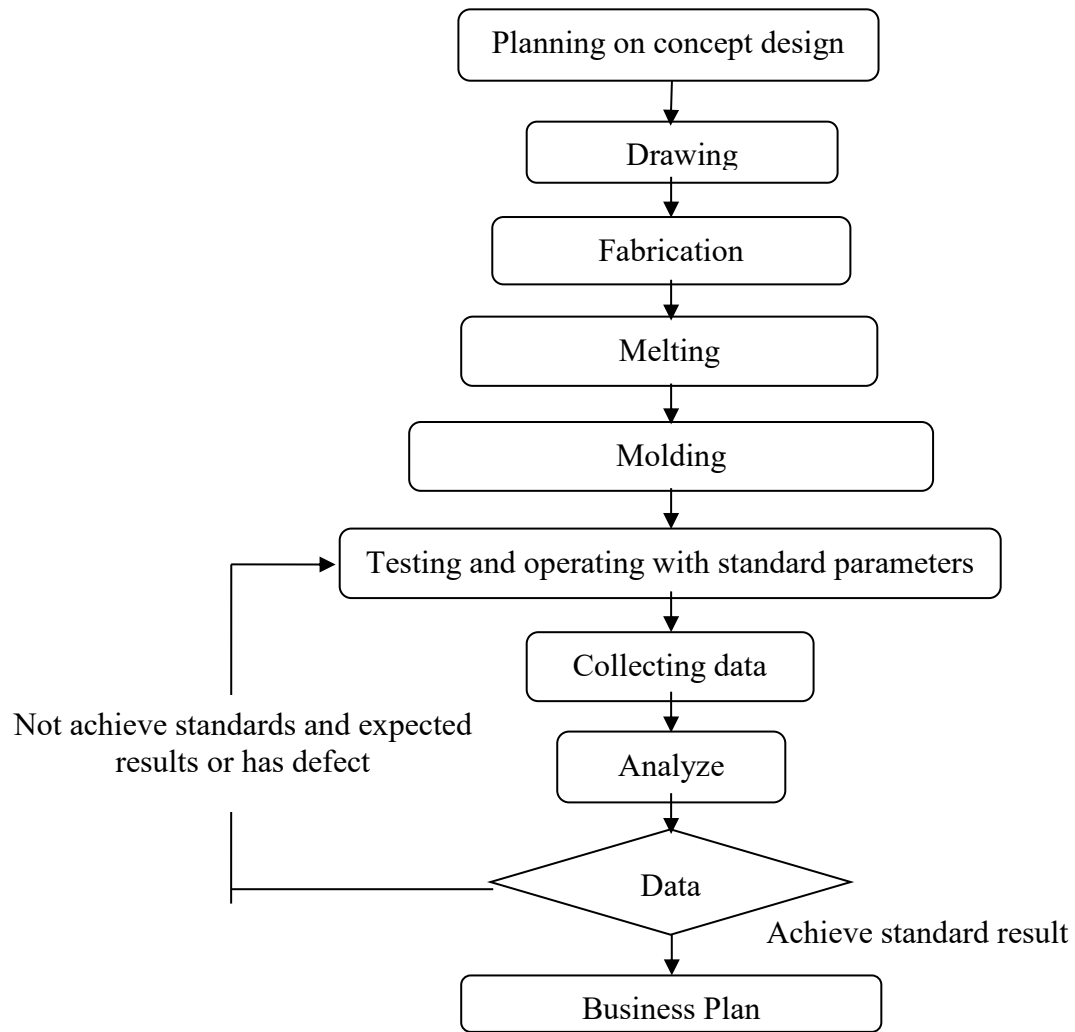


Figure 1: Flow Chart

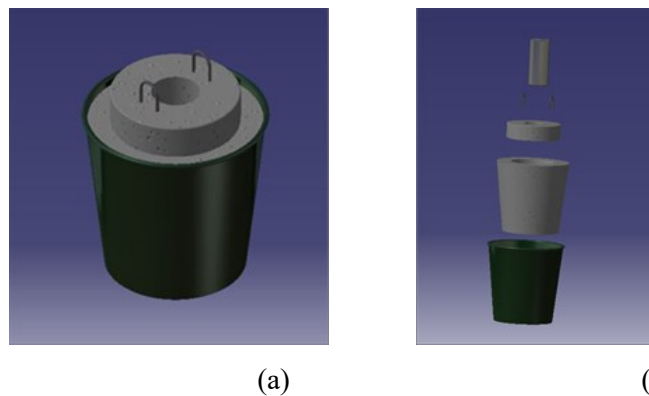


Figure 2: 3D drawing of the mini furnace (a) isometric view (b) Exploded view.

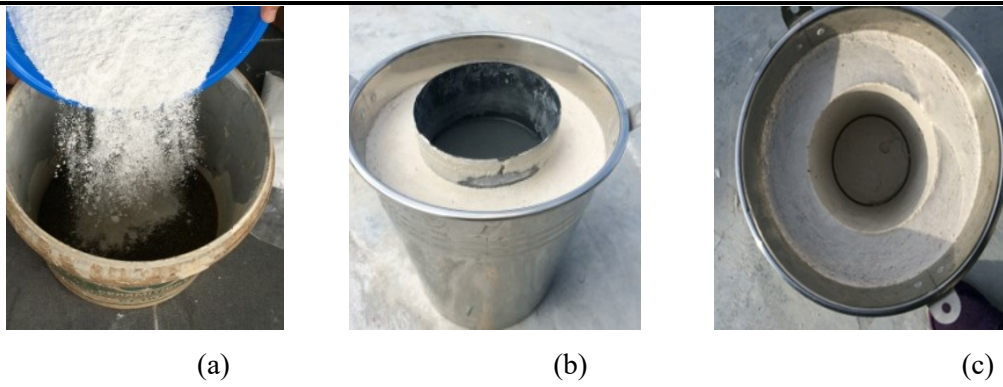


Figure 3: Mixture of POP, sand and water (a) mixture of POP and sand (b) After curing (c) Top view



Figure 4: The air Inlet

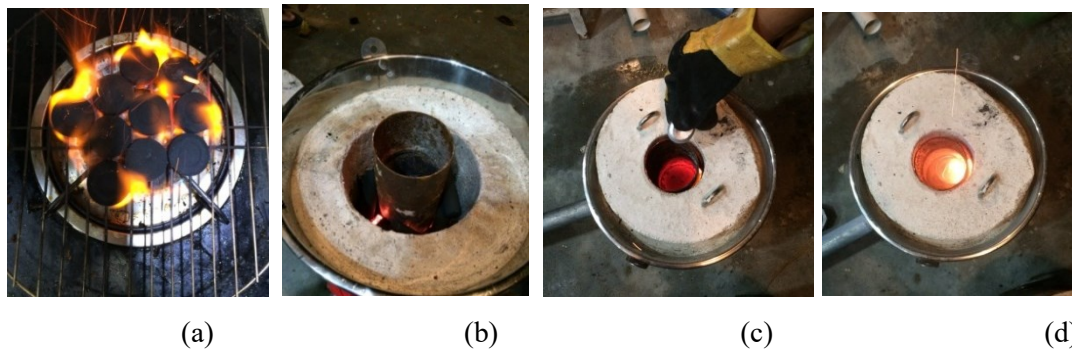


Figure 5: Melting Process (a) Charcoal heating process (b) Steel crucible (c) Putting aluminum into steel crucible when the temperature is right (d) Melting of aluminum.



Figure 6: Products of mini furnace

### 3. BUSINESS PLANNING

The business planning step was drafted to market the product throughout Malaysia as well as Asian countries. The business planning involves 5 steps; Market Analysis, Market Size, Target Market, Marketing Strategies and product Costing. However, for now market analysis is concentrated on Malaysian Market and STEM Project.

#### Market Analysis

The need to recycle is growing among people around the world as there are several issues related to environment such as Global Climate Change that promotes hurricanes, floods and global warming. In Malaysia, can drinks could be found in all grocery stores and petrol stations as well as vending machines. Drinks such as carbonated soft drinks, fruit juice, coffee, tea and herbal are among famous drinks that are stored in aluminum cans. As can drinks are popular among Malaysians especially those who are always on the go, aluminum can waste are easy to get. Currently, the waste aluminum cans are primarily collected by vagrants and poor people to get extra income by selling them to the recycling center. Even now, there is no special procedure practiced by the local authority to recycle aluminum cans. As a result, aluminum cans are not recycled fully and most of them are dumped in the drain. As the environmental awareness among Malaysians is increasing, there should be a tool to recycle aluminum cans that is easy to use and affordable to them. Therefore, the mini furnace is a good product to be introduced among Malaysian.

#### Market size

The market for the mini furnace could be everyone because it is very convenient and easy to handle. However, for now, the main targets are students at primary and secondary schools as they have less exposure towards science and engineering especially related to recycling. Plus, student will understand the importance of recycling and the energy consume for recycling. Furthermore, there is a possibility that this furnace could be incorporated into

STEM program thus increasing its market size to all primary and secondary schools in Malaysia.

### **Target Customer**

Even though the customers could be all Malaysians that love to recycle, but our main target customers are students at primary and secondary schools which have less exposure towards engineering fundamental knowledge. Talks and promotions were conducted at schools for the purpose as shown in Figure 7.



Figure 7: Marketing of the mini furnace at schools.

### **Marketing Strategies**

Marketing is very essential to ensure our product is successfully sold and profitable. Our strategy is to combine awareness, education and promotion through conventional and on-line media such as Facebook, Instagram and WhatsApp Group. The strategies are compiled into the following marketing steps;

1. Promoting the mini furnace to schools by joining the STEM program or through the faculty CSR project.
2. Conducting free talks on ‘the science of material’ and ‘recycling of aluminum’ to schools.
3. Encouraging schools to have at least 10 mini furnaces stationed at their schools and set up Aluminum Recycling Club for the students to enjoy activities related aluminum.
4. Incorporating the mini furnace system as part of Government STEM program.
5. Introducing the mini furnace to the related Small Medium Industries as tool for melting aluminum.

The mini furnace was also designed to serve other purposes. Every household should have one mini furnace not only for recycling but also for cooking in traditional style (BBQ set) as well as decorating house as flower pot as shown in Figure 8.

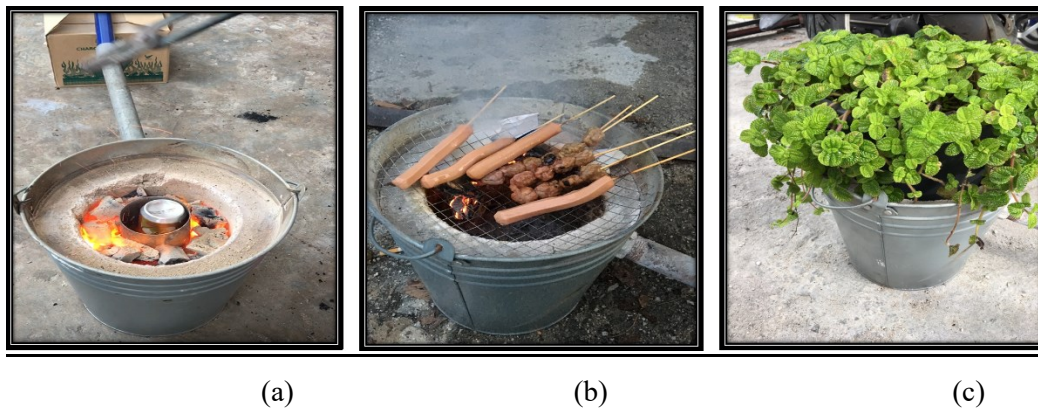


Figure 8: Other use of the mini furnace; (a) Furnace (b) BBQ set and (c) Flower pot.

### **Product Costing**

This mini furnace is not only simple and easy to operate but also relatively cheap to produce. The total cost is shown in Table 2.

**Table 2 Cost For Fabrication of Mini Furnace**

Material	Cost
Steel bucket	RM 40.00 The old or unused steel bucket is preferable because this bucket is strong and can resist corrosion.



Plaster of Paris	RM 2.80 per kilogram (3kg = RM 8.40)
Sand	RM 10.00
U-bolt	RM 30.00 Use for lid handle.
Steel crucible (high melting temp.)	RM 60.00
<b>TOTAL</b>	<b>RM 148.40</b>

The introductory price was set to RM 500.00 per furnace include 12 months warranty and training modules. The normal price is in the range of RM 1000.00 to RM 1200.00.

## 6. CONCLUSIONS

The furnace was successfully fabricated and tested. The mini furnace was fabricated according to the standard requirements of a good and practical furnace. The furnace is also manually operated using charcoal as the heating element in the combustion chamber. Temperature in the furnace can achieve the melting point temperature of aluminum which is 660°C. The market analysis indicated that the mini furnace has the potential to be marketed thus encourage engineering students to become an entrepreneur. The furnace system is a good platform to introduce and encourage students in primary and secondary school to get involve in recycling activities to save the environment. The furnace has also the potential to be the incorporated into STEM program, thus to ensure the program achieve its objectives. Therefore, the mini furnace system is a good and profitable project to be taken up by students as their stepping stone to becoming a successful green techno-preneur.

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