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Investigation and Comparison study of Furnace Effectiveness in the Recycling of Aluminium Alloy

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ABSTRACT

Aluminium is the one of the most recycling metal in the world and its abundance in nature, aluminium has been extracted from the primary ore bauxite, but the gas emissions produced by the process have prompted researchers and industrialists to seek alternatives. Since then, the aluminium has been reprocessed and is now available in a secondary form with similar properties to its predecessor. There have been many recycling methods used; this research would provide a comprehensive overview of the induction (electrical)and gas furnace method used to obtain secondary aluminium alloys. aluminium scrap alloy was melted in both (induction & gas) furnace to accomplish this. complete comprehensive the furnace's recycling efficiency, as well as its performance in relation towards other combustion processes (coal, and oil). It was also necessary to keep an eye on the situation. furnace energy consumption and the best furnace It was also established that this is appropriate for the industry. by means of the work

Key Words: Secondary aluminium, aluminium scrap, induction, Gas furnace energy consumption, process efficiency.

1. INTRODUCTION

Bauxite, the ore from which most aluminium is currently extracted, is a hydrated aluminium oxide. Aluminium is an excellent electrical conductor; it is ductile and easily cast and machined. Aluminium is the ideal 'eco-metal.' The re-melting process wastes very little aluminium. Increased recovery, dismantling, and sorting of spent products has resulted in even more aluminium recycling. As recycling becomes more important, so does the life cycle of aluminium. In addition to energy savings, recycling aluminium reduces greenhouse gas emissions by approximately 95% when compared to the 'primary' production process. Because recycled aluminium is a valuable commodity, the majority of recycling facilities will accept your used scrap. Furthermore, there is no limit to the number of times aluminium can be recycled indefinitely. According to the Aluminium Association, a trade group for the aluminium industry, recycling just one can saves the amount of energy required to watch the Super Bowl, or the amount of energy required to power a television for three hours. Induction and gas furnaces have become more widely used in recent years for melting a wide range of nonferrous alloys.

2. LITERATURE SURVEY

This section contains a literature review on the evaluation of induction furnace and gas furnace efficiency in the aluminium recycling process, as well as process parameters. The furnace's requirement is to provide the necessary heating while ensuring that no by-products are produced in the process. The efficiency of the process is critical in any work environment.

Angela O. Nieckele et al -The factors that influence the choice of liquid or gas fuel to be used in an industrial furnace can be extremely important, having a direct impact on its performance. Performance, in terms of pollutant emissions, and in terms of Working life of the equipment These variables are highly interdependent. on the combustion process and other variables such as the flame within the shape, as well as the temperature and heat flux distributions the fireplace

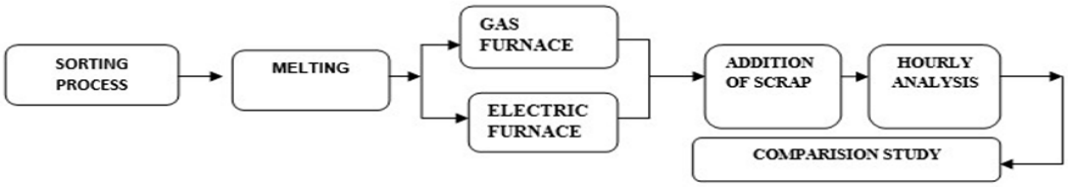
Numerical simulations were used in this study. carried out with the goal of using the finite volume method with the goal of analysing and comparing the combustion process inside an aluminium furnace when using two types of fuel: a spray of liquid oil and a jet of natural gas, both of which react with air. The findings revealed the potential harms that could occur. Caused by the combustion process if it is too long or too intense There are concentrated flames present, which raises the wall. temperatures, thereby jeopardising the heat flux on the surface made of aluminium.

William H. Macintosh- provides a critique of secondary aluminium recovery and evidenced that induction furnaces have several advantages over direct-fired furnaces: Low melt loss, high efficiency, and good metal quality This Such an paper outlines the advantages of using an induction furnace. for the rehabilitation of secondary aluminium.

3. EXPERIMENTATION

experimentation done by both electrical and gas fired furnace with minimum capacity of melt150kg.

Fig 3.1 experimentation furnace set up



SORTING PROCESS - Different sorts of scrap necessitate different sorting procedures, and different outcomes can be achieved. As a result, it's critical to know when the advantages outweigh the costs. investment. Sorting Al alloys, both cast and wrought allows for the fabrication of high-quality wrought iron, for example. alloys that are impossible to make with mixed scrap However, sorting systems for this problem are expensive. High up-front fees and ongoing expenses

MELTING IN THE INDUCTION FURNACE- An induction melting furnace for aluminium is designed primarily for melting lower density metals at precisely the right temperatures and with even heat distribution. This is critical when melting metals like aluminium if you want to keep the metal's expected lifetime and quality. The most suitable melting furnace for In order to achieve this goal, aluminium will provide precise temperature controls. The charge is placed in the furnace, and the melting process begins. The induction process is used to process aluminium scrap. The melting point of aluminium is nearly 720 degrees Celsius, and it is kept at that temperature. that temperature for a little longer to ensure uniformity.

Fig 3.2 Induction furnace melting process

MELTING IN THE GAS FURNACE- Aluminium recycling process are incentivized to improve the energy efficiency of their melting processes, which means both opportunities for cost savings and regulatory compliance. Preheating the burner air with a heat exchanger will significantly reduce a furnace's gas consumption, and increasing the flame temperature will shorten the melting process and repurpose exhaust heat, both of which will have a positive environmental impact.

Fig 3.3 Gas furnace set up for melting process

ADDITION OF SCRAPS IN TO FURNACE- The melting processes do not use a single loading process; the addition of scraps may take longer in the recycling process. Once the initial melt is obtained, preheated and measured aluminium scraps are added to determine the efficiency of the process, the furnace was loaded with scraps ranging in weight from 70kg to 150kg in steps of 40kgs at a time. This was done to determine the efficiency of the process at various loads. The yield obtained from the various processes must be determined.

HOURLY ANALYSIS - 150kg aluminium scraps were melted individually, with the parameters of the furnaces being recorded every hour to monitor the melting process while keeping the process parameters in mind. Each hour, the metrics recorded would be the temperature of the materials inside the furnace, the energy rating, and the state of the metal. A thermocouple is used to gauge the temperature because the display can change. Meanwhile, the energy efficiency of the display is highlighted. In the meantime, gas consumption is calculated using the original and end weights of cylinder.

Fig 3.5 continuous monitoring process

4. RESULT AND DISCUSSION

Table 4.1 Gas fired vs Electrical furnace energy and time study

Description	Gas fired furnace	Electrical furnace
Material loaded	Aluminium scrap	Aluminium scrap
Weight	150kg	150 kg
Energy consumed	35kg	102unit
Cost /kg/unit	90Rs	15Rs
Time taken in minutes	330	420

Although an electrical furnace is preferable in terms of production, the quality of the melt and the loss of elements is quite significant, as seen by the loss of zinc and magnesium during the casting process. It can be seen in the chemical composition of the final product. Electrical furnaces are easier to manage the heating process, and their cost per unit may be slightly lower than gas-fired furnaces. The energy consumed of gas fired furnace would be calculated by weighing the cylinder before and after melting. Digital metres are used to calculate the unit size of a electrical furnace.

Table 4.2: Chemical Composition

Types of furnaces	Si	Fe	Cu	Mn	Mg	Zn
Electrical furnace	6.10	0.50	0.30	0.15	0.14	0.20
	6.10	0.49	0.27	0.14	0.10	0.15
Gas fired furnace	5.99	0.49	0.29	0.13	0.14	0.16
	5.98	0.48	0.26	0.12	0.07	0.11

When comparing the efficiency of electrical and gas furnaces, the electrical furnace outperforms the gas fired furnace. The blower in a gas-fired furnace causes melting on the bottom and top of the furnace, whereas the heat in an electrical furnace is distributed equally. As a result of this type of melting concept, oxidation in the electrical furnace is reduced, making element loss easy to avoid.

YIELD ANALYSIS

Table4.3 Yield analysis results

Description	Gas fired furnace	Electrical furnace
Materials loaded	ALUMINIUM SCRAPS	ALUMINIUM SCRAPS
Weight (Kg)	150KG	150 KG
Yield (Kg)	130	135
Dross (Kg)	13.5	10.7
Loss (%)	6.5	4.3

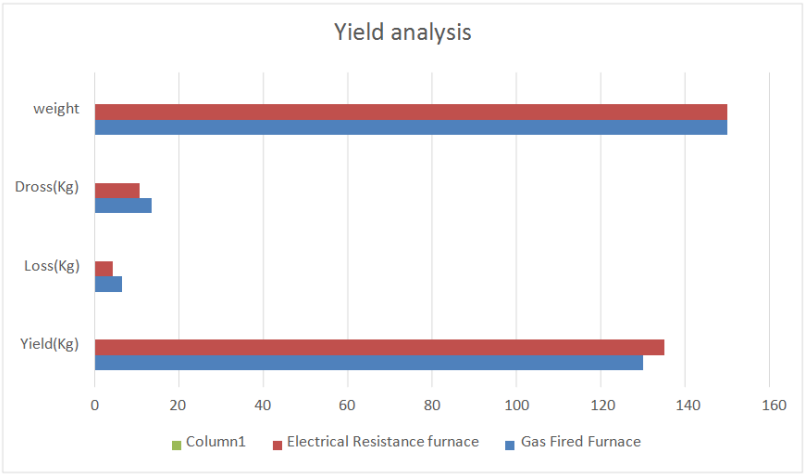


Fig.4.1. Graphical representation of yield analysis

There is a significant difference between the two types of furnaces that heat your home's air through the ducts. Natural gas-fired burners are used in gas-powered furnaces, while heated coils are used in electric furnaces.as per result study electrical furnace gives more yield and prevent the dross losses, when compared to other furnaces, the oxide generation and free iron mixing and dilution is greater in electrical furnaces; this is the primary reason for reducing oxide and impurity mixing in the melting process.

HARDNESS AND TENSILE TESTING

Table;4.4 hardness and tensile analysis

s. no	furnace	Hardness value	Tensile value	Elongation value
1.	Gas fired	58	101.25	0.8
2.		51	114.23	0.91
3.	Electrical resistance	62	98.53	0.89
4.		60	109.61	0.96

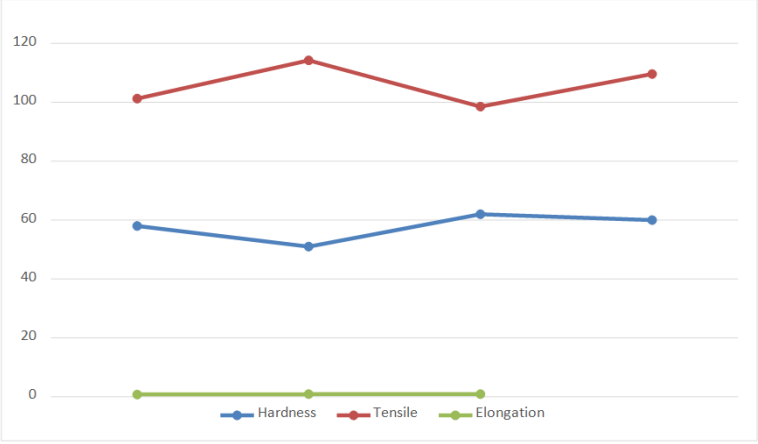


Fig:4.2. Tensile and hardness graphical representation

SPECIFIC ENERGY CONSUMPTION: ELECTRIC FURNACE

102kwh energy is used to produce135 kg of aluminium ingot Therefore, Specific Energy Consumption =102/135 = 0.756kwh Quantity of Heat required to melt the Charge Melting point of aluminium is about 660oC at standard atmospheric conditions. Thus in order to obtain enough fluidity, choose pouring point of aluminium, Tp =8000C. Q = ρv (Ca (Ta– To) + hfo+ Ca (Tp – Ta)) Where, Density of aluminium, ρ = 2700kg/m3,

Volume of material V = 0.08792m3

Specific heat of aluminium, Ca = 0.9kJ/kg0C

, Melting point of aluminium, Ta = 660oC

Latent heat of fusion of aluminium hfo= 398kj/kg; Atmospheric Temperature to = 280C
Q = 2700 x 0.08792 (0.9(660 -28) + 398 + 0.9 (800-660)) Q = 237.4((0.9x 630) + 398 + (0.9 x 140)) = 900 MJ

COMPARISON STUDY OF COST ANALYSIS:

For the commercial purposes, a cost comparison analysis is required. Every idea and technology that becomes commercial is a true innovation that must be calculated using certain parameters. Cost analysis is one of the parameters, and we have provided some cost analysis specifics.

1Kg of gas =90Rs, consumed gas of 150kg melt 35kg ,35*90=3150, thus 1kg melt cost 21Rs

1unit of electric =15Rs, consumed unit of 150Kg melt 102 units, so 102*15=1530,1kg melt cost 10.20Rs

According to studies, an electrical furnace is more cost effective than a gas fired furnace; an electrical furnace costs only Rs.10 per kilogramme of melt, but a gas fired furnace costs Rs.21 per kilogramme of melt.

CONCLUSION

According to the case study of gas fired and electrical furnaces, both are similar types of melting processes that help in the aluminium recycling method, but it's good for primary melting and closed loop melting process. However, in assorted scraps and open loop melting process, electrical furnace is more efficient than gas fired furnace in terms of cost and element losses prevention, but melting time is longer If a single loading method for both electrical and gas-fired furnaces could be used, the result may be a clear confirmation of commercially viable furnaces.in single loading process could be optimizing the element loss and dross and time and oxides,

The use of electrical energy to melt aluminium alloys for the creation of secondary aluminium scrap has been discovered to be a beneficial method. The findings clearly suggest that the amount is insufficient. The amount of aluminium yielded is larger than expected. Combustion of fuels It is carried out with the use of gasoline.

The material is melted by induction in the electric process, whereas in the combustion process, there is always a loss due to the reactions of the components in the melt with the gas burned, which escape as combustion by-products. When energy usage is minimal, a certain industry or organisation will profit substantially by saving money, which may then be used to cover other incidental or overhead costs. The most crucial attribute of the procedure is that it is environmentally friendly. Almost every mechanical operation pollutes in some way, but they pollute the most when they consume.

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