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The Need of Performing an Energy Audit in a Metallurgical Industry: A Case Study of The Ajaokuta Foundry Shop

Ocheri Cyril[1*] and Oyibo Alfred Onakemu[2]

[1]Dept. of Metallurgical and Materials Engineering, University of Nigeria Nsukka, Enugu State, Nigeria
[2]Dept. of Welding and Fabrication Engineering Delta State Polytechnic Ogwashi-Uku, Delta State
E-mail: cyril.ocheri@unn.edu.ng; oyiboalfred@yahoo.com

*corresponding author details: Ocheri Cyril; cyril.ocheri@unn.edu.ng

ABSTRACT

The research work focuses on the need to perform an energy audit in a metallurgical industry concerning the operations of the Foundry Shop of the Ajaokuta Steel Company Limited. Some basic components for performing the energy audits were discussed. The foundry processes and operations are based on the production of components for other basic industries where their components are used for manufacturing processes like the quarry industries, battery industries, manufacturing, and other process industries. To produce the desired components that the vessel used for the production processes like the Electric Arc Furnaces, the Induction furnace, the crucible furnace, and centrifugal furnaces must be utilized for the effective and optimal production processes tHrough constant monitoring and sustenance of the energy used during the production process. To achieve these production processes, there is always a need to perform energy audits of the facilities used. One method is to design methods of monitoring the power consumed per heat cycle, the duration taken for the production cycle to be completed, and cost expenditure. The need of performing research work was due to the anomalies observed during the melting processes of the two furnaces, the six-tonne Electric Arc Furnace and the One-tonne induction furnace. It was observed that the melting cycle of 2½ to 3 hours was not maintained rather more time, more energy, and more money are wasted on every melting process. To put these situations to check the production processes for the two furnaces were monitored from 5/10/ 2006 to 21/11/2007 for the Six tonnes capacity Electric Arc Furnace and from 03/06/2005 to 01/08/2007 respectively. The data generated were used for the analytical processes of the energy audits. Methods of presenting energy reports and energy action plans were brought to the fore. The performance of the energy audits indicated that much energy was consumed, more time was taken for completing a melting cycle as against the standard while a lot of money is being wasted whenever production processes take place.

Keywords: audit; capital cost; downtime; energy; industry; metallurgical; savings

INTRODUCTION

To corporations, businesses, and individuals alike, saving money on energy bills is appealing. For households with high electricity bills, there is an avenue to introduce a sustainable procedure for energy cost-effectiveness control program. [1] "Less cost or minimal cost of operational processes for the improvements that save between 15-25 percent on energy bills for a client or an industry. Capital cost investments will also save an average of 20-30 percent with payback periods of two years or less.[2] These energy cost mitigation initiatives may also result in reduced energy consumption as well as decreased emissions of pollution from the atmosphere in many cases. The energy audit consists of one of the first activities to be undertaken in implementing a successful energy cost management program.[3]. The energy audit consists of a thorough analysis of how an installation uses energy, what the installation pays for that energy, and, finally, a recommended initiative to strengthen working practices. [4] Installing a mechanism to reduce the cost spent on energy consumption for cost-effectiveness.

An energy audit is also referred to as an energy survey or an energy review, so the negative connotation of an audit is not impeded. [4] A good experience with major advantages for the organization or entity is the energy audit. The Ajaokuta Foundry is intended to be an Ajaokuta Steel Company Limited captive unit for the manufacture of both ferrous and non-ferrous spare parts for the Steel Plant and external customers, with a nominal capacity of seven (7,000) tonnes. The Ajaokuta Steel Plant is intended to supply 78% of its requirements for in-house spare parts in the form of machine components and spare medium to large unit weights, resulting from its unique geographical position far from urban areas. Most integrated steel plants worldwide, especially in third world countries, have been constructed from the outset to be self-sustaining in meeting their primary spare parts needs to minimize costly downtimes and loss of production hours. In the same way, the Ajaokuta Foundry is part of the ancillary service shops' interconnected network. Forge and Manufacturing, Machinery and Tools Shop

Power Equipment Repair Shops, etc. primarily meant captive units to the plant.[5] As a Jobbing outfit, the Ajaokuta Foundry, as would be the case for a precision Die-Cast foundry, is not capable of mass production of products or reproduces certain items in large numbers. Since vessels and furnaces and other handling facilities vary widely from one-ton induction furnace, six-ton Electric Arc furnace to 10-tonne induction furnace capacity, it was possible to produce only single unit products intermittently [6]. As defined in the international standard, the furnaces and vessels used in the production processes were intended to achieve a melting period of between 2½ to 3hours for batch production, which is to be closely followed by a further casting schedule of 35 to 50 minutes. Knocking-out and fettling process of 1 to 1½ hours for small components and another heat treatment time of 2½ to 15 hours depending on the composition of each mixture of the product.[7].

The production process, energy consumption, the duration of achieving a complete cycle, and cost of production were monitored for two years. Two of the furnaces the six tonnes Electrical Arc Furnace and One-ton induction furnace were examined from 5 /10/ 2006 to 21/11/ 2007 for Six Electric Arc Furnace, while the duration of the One-tonne Induction furnace was from 03 /06 2005 to 01/08/2007 respectively. During these periods, it was observed that the duration and energy consumed to complete a batch of melting was very high thereby cumulating to the high cost of energy bills, making it very difficult for the shop to achieve the production process within the standard time due to increased energy bill and probably wastage of energy. Melting cards were used for the collection of the data and thereafter the obtained results were put in table forms as indicated in tables (1) and (2). The collected data were analyzed using charts to represent the variables. It was based on the discoveries that the research work became very necessary and important. The data indicated that there were a lot of flaws during the production processes as many times are spent to complete a heat cycle, lots of energy are consumed and a reasonable amount of monies is wasted. These findings necessitated the shop to perform energy audits on the furnaces to determine the possible reasons why these anomalies are taken place and to proffer alternate ways in curbing these problems associated with these excessive energy consumption/waste and high duration of completing a melting batch cycle.

RESEARCH METHODOLOGY

The audit process could start by gathering information about the operation of the equipment and its utility bill records. It is important to review the data collected to obtain an image of how the types of equipment use and likely to reduce energy costs, waste energy and to help the auditor understand the areas to be investigated [8]. To assess their advantages and their cost-effectiveness, related developments are known as Energy Conservation Opportunities (ECOs) that need to be identified and evaluated. These ECOs should be measured in terms of their costs and benefits, and to rank the various ECOs, an economic comparison should be made. Finally, when such chosen ECOs are introduced. An Action Plan should be generated and the actual process of saving resources and saving money starts.[9]

MATERIALS AND EQUIPMENT

- ***Materials***

The foundry Technology or operations consists of about 16 procedures ranging from Planning, design, Pattern making, sand Preparation processes, Moulding and Core making processes, drying of moulds and cores produced, Melting and Casting, Quality and Materials Analyses, Materials selection, Felting, and Heat Treatment processes, etc. To achieve these processes for the operations in the foundry shop therefore, some basic raw materials are used for these processes. Figures 1 to 4 indicate the types of raw materials used in the production mix in the foundry shop operations.

The Moulding and core making sand, the binding materials like the sodium silicate, bentonite, core oil industrial starch, the wood, and other materials used by the pattern markers to produce patterns and other materials needed for the production processes. The melting and casting materials consist of pig iron. Crop ends, foundry returns, Ferroalloys, chamotte, etc. To have a complete melting cycle, the necessary materials are put in place to produce steel or cast iron. The materials are further categorized as the case may be in such a way that in steel production there is the Manganese Steel, Stainless Steel, CHrome steel, etc., while the cast iron is categorized into malleable, grey, Nodular of spheroidal Graphite Iron (SGI), white cast iron, etc.

FIGURE 1: Pig iron

FIGURE 2: Crop end of steel scrap

FIGURE 3: Foundry Returns

FIGURE 4: Ferro Manganese

- ***Equipment***

Foundry operations are carried out by using some basic equipment like the Electric Arc Furnaces, induction furnaces, Crucible furnaces, Centrifugal furnaces. In this case, of the research work, the major focus is the Six (6) Tonne Electric Arc Furnace and the One (1) induction Melting furnace with a low-frequency capacity. These furnaces are used for the production of liquid metals tHrough the melting and casting processes. The figures below show the types of furnaces being used for this research work.

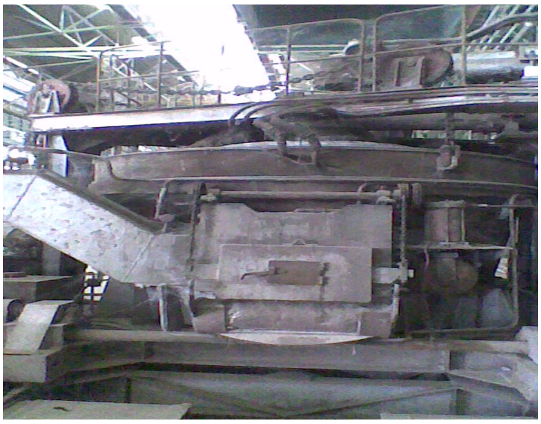


FIGURE 5: Electric Arc Furnace showing the charging view

FIGURE 6: the tapping spout

FIGURE 7: the de slagging process in the Induction furnace

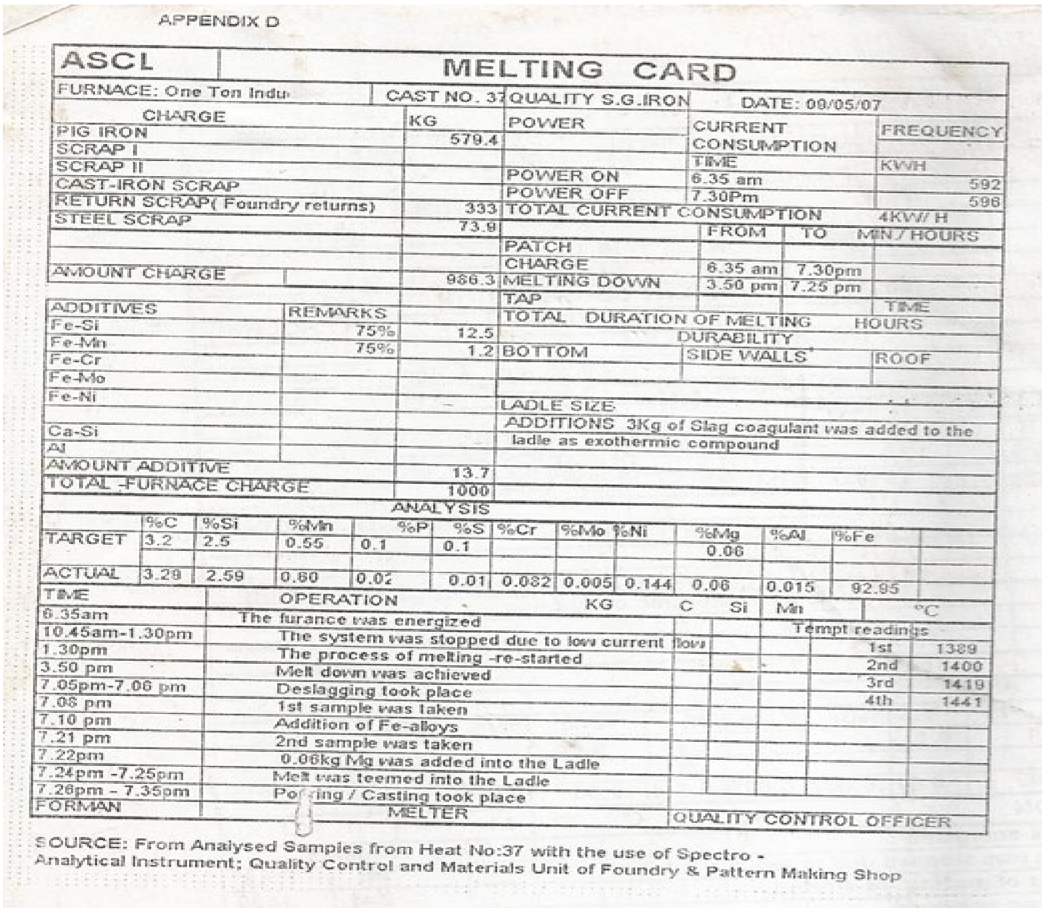
FIGURE 8: the teeming process from the induction furnace

These types of equipment operational data provide a good understanding of the main operations or facilities that consume resources. As a rule, it is first important to analyze the largest energy and cost operations, which will provide an overview of saved energy, duration, and production costs.[10].

METHODS

The methods adopted during the research work was based on the six electric Arc Furnace and one-tonne Induction Furnaces were used. During the processes, the electric arc furnace was used for the meeting of various grades of steel ranging from manganese steel to cHrome steel while the induction was used for the melting of various types of cast iron materials ranging from nodular, malleable, white, and grey cast iron. The processes were monitored with the filling of a melting card for the melting and casting processes. At various melting processes, the furnaces were powered and the time when the furnaces were powered and shut down were noted and recorded. The meters attached to each of the furnaces are read and recorded before the powering of the furnaces. The same processes/procedures are taken the furnaces are switched off after the melting processes. A sample of the melting card used for collecting data is indicated in figure 9.

The Electrical and Electronic section of the shop is mandated to monitor the operational procedures of the furnaces for effectiveness and efficiency. The personnel in the Melting and Casting section in conjunction with those in the Quality Control and Materials Analysis section are also involved in the monitoring of the processes.


APPENDIX D

ASCL MELTING CARD

FURNACE: One Ton Indu | CAST NO. 37 | QUALITY S.G.IRON | DATE: 09/05/07

CHARGE	KG
PIG IRON	579.4
SCRAP I	
SCRAP II	
CAST-IRON SCRAP	
RETURN SCRAP(Foundry returns)	333
STEEL SCRAP	73.9
AMOUNT CHARGE	986.3

POWER	CURRENT CONSUMPTION TIME	FREQUENCY KWH
POWER ON	6.35 am	592
POWER OFF	7.30Pm	596
TOTAL CURRENT CONSUMPTION		4KW/ H

	FROM	TO	MIN / HOURS
PATCH			
CHARGE	6.35 am	7.30pm	
MELTING DOWN	3.50 pm	7.25 pm	
TAP			

TOTAL DURATION OF MELTING — TIME HOURS

DURABILITY: BOTTOM | SIDE WALLS | ROOF

ADDITIVES	REMARKS	KG
Fe-Si	75%	12.5
Fe-Mn	75%	1.2
Fe-Cr		
Fe-Mo		
Fe-Ni		
Ca-Si		
Al		
AMOUNT ADDITIVE		13.7
TOTAL -FURNACE CHARGE		1000

LADLE SIZE

ADDITIONS 3Kg of Slag coagulant was added to the ladle as exothermic compound

ANALYSIS

	%C	%Si	%Mn	%P	%S	%Cr	%Mo	%Ni	%Mg	%Al	%Fe
TARGET	3.2	2.5	0.55	0.1	0.1				0.06		
ACTUAL	3.29	2.59	0.60	0.02	0.01	0.032	0.005	0.144	0.06	0.015	92.95

TIME	OPERATION	Tempt readings °C	
6.35am	The furance was energized		
10.45am-1.30pm	The system was stopped due to low current flow	1st	1389
1.30pm	The process of melting -re-started	2nd	1400
3.50 pm	Melt down was achieved	3rd	1419
7.05pm-7.06 pm	Deslagging took place	4th	1441
7.08 pm	1st sample was taken		
7.10 pm	Addition of Fe-alloys		
7.21 pm	2nd sample was taken		
7.22pm	0.06kg Mg was added into the Ladle		
7.24pm -7.25pm	Melt was teemed into the Ladle		
7.26pm - 7.35pm	Pouring / Casting took place		

FORMAN | MELTER | QUALITY CONTROL OFFICER

SOURCE: From Analysed Samples from Heat No:37 with the use of Spectro - Analytical Instrument; Quality Control and Materials Unit of Foundry & Pattern Making Shop

FIGURE 9: Sample of the melting card use for collecting data for the energy audit

RESULTS AND DISCUSSION

- ***Operating Hours***

Operating hours should be obtained for the facility. The considered shift structure is two movements, tHree brigades (2 shift 3 brigades) [11]. From an energy cost perspective, it would be cost-effective to add a three-shift, since a greater amount of kWh would be distributed over the fee for demand fee. Figure 9 shows the type of melting cards used during the use of the furnaces to track the operating processes. For accurate and efficient tracking, the imputation of the activates is recorded in the melting cards.

- ***Energy Audit***

Some preliminary parameters were put in place. The meters attached to the two furnaces were and observed and monitored, while the data obtained were recorded. The processes commenced before the furnaces were energized by reading off the last meter values and similar processes performed at the end of each operational procedure [11] [12]. Data obtained during these periods on the usage of energy by facilities through the analysis of utility bills were used, which included meter bills, melting cycle completion times, and the amount of energy consumed during each operating procedure. The processes include physical description and operation of the equipment, as well as some preliminary details, which were compiled to give a better understanding of the energy audit processes. The collected data were analyzed to determine energy efficiency. [13][14][15].

- **Electrical Demand Charges**

At each melting cycle/heat, The demand charge was focused on the reading of the maximum KW/h capacity required for the shop. Power is the energy used between facilities as they are varied very rapidly. The power reading is averaged over periods of twenty –five (25) minutes to 90 minutes by electric utilities. The operation of the furnaces is not adversely affected by very brief fluctuations. [16][17] [18]. [16]. The shop could then be compensated for heat demand based on the full value of an optimized melting cycle/heat average of the power consumed. [19] [20]. The data generated as Energy bills were broken down into the components that regulate the equipment. These cost elements were described in the tables separately and then plotted for better graphical presentation. The electricity bills were divided against the cost per kW per heat, length in hours/minutes (Hr. /mins), and electricity cost per kWh into energy consumption. In terms of steel and cast-iron materials, the Foundry Shop manufactures liquid metal, which relies on customer demand. The bulk of the energy supply comes from the National Grid and also from the Ajaokuta Steel Company Limited power station, known as the Thermal Turbo Plant and Thermal Power Station (TPP& TPS). The energy structure rate was set at = N9 per kWh.

- ***Summary of Results***

The energy consumption in an Electric Arc Furnace and Induction furnace was put at average at 3kw/h, the duration of completing a melting cycle was put at an average of 2½ to 3 hours and the cost of production was supposed to be cost-effective. Tables 1 contained the data Obtained as energy consumption in Electric Arc Furnace from 5/10/2006 to 21/11/2007, while table 2 gave details on the energy consumed in one-tonne induction furnace from 03/06 2005 to 01/08/2007. The research was done for a total duration of 26 heats totaling 182.78Hr/Mins. If the furnace were operated at the standard duration of 2½ to 3 Hr./mins a minimum duration time would have given 122.98Hr/mins thereby saving 59.8Hr/mins for the entire 26 heats as indicated in figure 10. The level of energy consumed for 26 heats was put at a total of 20,600kw/h as against 10,200kw/h if the furnace was operated with an energy input of 3kw/Hr as indicated in figure 11. In these processes, a total of 10,400kw/h of energy consumed could have been saved. The amount of Moines expanded on the furnace was put at ₦185, 400 as cost-effectiveness for

26 heats at ₦9 per kw/h as against what could have expended at a minimal cost of ₦91, 800, which could have saved at N93, 600 as indicated in figure 12.

In a similar trend, the one-tonne Induction furnace operated in line with what was obtained from the electric arc furnace figure 13. The total duration of time taken for 45 heats (melting cycle for the complete batch) was put at 335.82Hr/mins in which a minimum of 223.32Hr/mins could have to be the standard duration, thereby saving a total of 103.5Hr/mins.

FIGURE 14 It was observed that the total energy of 13,500 kw/h was consumed as energy as against 4,500kw/h that could have to be the minimal energy consumed. A total of 9,000kw/h could have been saved from these processes. Figure 15 it was observed that a total cost of ₦121, 500 was expended for the 45 heats at ₦9 per kw/h as against a minimal cost of ₦81, 810, from these processes, a total sum of ₦39, 690 could have been saved. If we are to put these obtained values together (six tonnes Electric Arc Furnace & one-ton Induction Furnace), then the following could have been saved on the duration of time taken, energy consumed and cost expended of the furnaces

TABLE 1: Energy Consumption in the Electric Arc Furnace (5/10/2006 to 21/11/2007)

Date	Time (HR/ MINS)	Duration (Hr/Mins)	Standard (Duration) Hr/Mins)	Duration Hr/Mins)	Max (EC) (Kw/h)	Standard (Kw/h)	Min (EC) kW/h	Min Cost (N1)	Max Cost (N)2	Cost Benefit (₦)
5/10/2005	10.50 AM -7.40 PM	8. 1	2½ -.3	5.8	600	400	200	1800	5400	3600
12/12/2005	10.59 AM-6.15 PM	7. 44	2½ -.3	5.14	900	400	500	4500	8100	3600
14/12/05	11.00 AM-8.45 PM	9.15	2½ -.3	6.85	1100	400	700	6300	9900	3600
5/1/2006	8.55 AM-5.25 PM	8. 30	2½ -.3	5	1000	400	600	5400	9000	3600
9/2/2006	9.10 AM-4.15 PM	7. 05	2½ -.3	4.75	900	400	500	4500	8100	3600
13/02/06	12.00 PM-8.10 PM	8.1	2½ -.3	5.8	900	400	500	4500	8100	3600
15/02/06	8.50 AM-4.14 PM	7. 36	2½ -.3	5.06	940	400	540	4860	8460	3600
23/02/06	9.00AM-6.00PM	9	2½ -.3	6.7	970	400	570	5130	8730	3600
1/3/2006	8.50 AM-6.20 PM	9.3	2½ -.3	7	790	400	390	3510	7110	3600
13/03/06	8.25 AM- 6.10 PM	9.15	2½ -.3	6.85	1200	400	800	7200	10800	3600
23/03/06	9.10 AM-4.13 PM	7. 3	2½ -.3	5	900	400	500	4500	8100	3600
3/4/2006	9.45AM-2.45PM	5	2½ -.3	2.7	500	400	100	900	4500	3600
1/9/2006	9.30AM-4.30 PM	7	2½ -.3	4.7	300	400	-100	-900	2700	3600
3/11/2006	9.30 AM-8.45 PM	11.15	2½ -.3	8.85	1600	400	1200	10800	14400	3600
17/11/06	9.18 AM-3.09 PM	5. 9	2½ -.3	3.6	500	400	100	900	4500	3600
28/12/06	1.45 PM-7.25 PM	5.2	2½ -.3	2.9	900	400	500	4500	8100	3600
17/01/07	8.53 AM-2.12 PM	5.41	2½ -.3	3.11	400	400	0	0	3600	3600
27/03/07	12.13 PM-4.10 PM	3.03	2½ -.3	0.73	600	400	200	1800	5400	3600
30/04/07	9.55 AM-4.00 PM	6.05	2½ -.3	3.75	400	400	0	0	3600	3600
30/04/07	8.12 AM-4.01 PM	7. 59	2½ -.3	5.29	900	400	500	4500	8100	3600
4/6/2007	9.15AM-2.05PM	4.1	2½ -.3	1.8	700	400	300	2700	6300	3600
17/07/07	10.30 AM-4.10 PM	5. 40	2½ -.3	3.1	700	400	300	2700	6300	3600
15/08/07	11.35 AM-5.00 PM	5.25	2½ -.3	2.95	700	400	300	2700	6300	3600
17/08/07	11.30 AM-5.00 PM	5. 25	2½ -.3	2.95	700	400	300	2700	6300	3600
4/10/2007	9.30 AM-5.50 PM	8.2	2½ -.3	5.9	600	400	200	1800	5400	3600
21/11/07	9.25AM-5.25 PM	8	2½ -.3	5.7	900	400	500	4500	8100	3600
Total		**182.78**	**59.8**	**122.98**	**20600**	**10400**	**10200**	**91800**	**185400**	**93600**

TABLE 2: Energy Consumption for One Tonne Induction Furnace (03/06 2005 – 01/08/2007)

S/NO	Date	Time (HR/ MINS)	Duration (Hr/Mins)	STD. (Duratio) Hr/Mins)	Duration (Hr/Min)	Max Energy Consumpt ion (Kw/h)	STD Energy Consumpti on (Kw/h)	Min Energy Consum ption kW/h	Min Cost (₦1)	Max Cost (₦)2	Cost Benefit (₦)
1	3/6/2005	6.25 PM-5.40 AM	11.14	2½ -.3	8.84	300	200	100	2700	900	1800
2	4/4/2005	10.45AM-6.45PM	8	2½ -.3	5.7	500	200	300	4500	2700	1800
3	27/ 04/05	11.45AM -7.45PM	8	2½ -.3	5.7	200	200	0	1800	0	1800
4	6/5/2005	8.30AM- 5.30 PM	9	2½ -.3	6.7	300	200	100	2700	900	1800
5	15/06/05	12.00 PM -9.25 PM	9.25	2½ -.3	6.95	300	200	100	2700	900	1800
6	27/06/05	8.30AM- 5.30 PM	8	2½ -.3	5.7	200	200	0	1800	0	1800
7	9/8/2005	11.35AM -7.04 PM	8	2½ -.3	5.7	300	200	100	2700	900	1800
8	30/08/05	10.30 AM- 6.55 PM	8.25	2½ -.3	5.95	400	200	200	3600	990	2610
9	14/10/05	8.45AM -4.45 PM	8	2½ -.3	5.7	300	200	100	2700	900	1800
10	6/12/2005	8.45 AM -5.58 PM	9.13	2½ -.3	6.83	300	200	100	2700	900	1800
11	8/12/2005	8.10 AM - 4.40 PM	8.3	2½ -.3	6	300	200	100	2700	900	1800
12	12/1/2006	10.00AM - 6.00PM	8	2½ -.3	5.7	300	200	100	2700	900	1800
13	24/01/06	6.45 AM -2.30 PM	8.45	2½ -.3	6.15	300	200	100	2700	900	1800
14	24/01/06	2.40 PM -5.00 PM	2.2	2½ -.3	-0.1	200	200	0	1800	0	1800
15	10/2/2006	10.15 AM-6.20 PM	8.05	2½ -.3	5.75	300	200	100	2700	900	1800
16	26/06/06	9.43 AM -10.50 PM	13.07	2½ -.3	10.77	400	200	200	3600	1800	1800
17	27/06/06	9.15 AM -5.20 PM	8.05	2½ -.3	5.75	300	200	100	2700	900	1800
18	29/06/06	10.51AM-9.00PM	10.09	2½ -.3	7.79	300	200	100	2700	900	1800
19	30/06/06	9.10 AM -4.30 PM	7.2	2½ -.3	4.9	300	200	100	2700	900	1800
20	30/06/06	5.00 PM -6.55 PM	1.55	2½ -.3	-0.75	200	200	0	1800	0	1800

21	4/7/2006	8.00 AM - 4.15 PM	8.15	2½ -.3	5.85	300	200	100	2700	900	1800
22	4/7/2006	4.15 AM-7.50 PM	3.35	2½ -.3	1.05	300	200	100	2700	900	1800
23	5/7/2006	6.45 AM 5.55 PM	11.1	2½ -.3	8.8	300	200	100	2700	900	1800
24	11/7/2006	7.30 AM-4.50 PM	9.2	2½ -.3	6.9	300	200	100	2700	900	1800
25	14/07/06	7.30 AM-4.20 PM	8.5	2½ -.3	6.2	400	200	200	3600	1800	1800
26	14/07/06	4.35 AM-7.00 PM	2.25	2½ -.3	-0.05	200	200	0	1800	0	1800
27	18/07/06	7.20 AM- 5.07 PM	9.47	2½ -.3	7.17	300	200	100	2700	900	1800
28	26/07/06	12.00PM-8.20PM	7	2½ -.3	4.7	300	200	100	2700	900	1800
29	27/07/06	8.15 AM-4.20 PM	8.05	2½ -.3	5.75	200	200	0	1800	0	1800
30	28/07/06	7.10 AM -2.10 PM	9.55	2½ -.3	7.25	300	200	100	2700	900	1800
31	21/09/06	8.20 AM-9.25 PM	13.05	2½ -.3	10.75	400	200	200	3600	1800	1800
32	27/09/06	10.00AM- 6.03PM	8.03	2½ -.3	5.73	300	200	100	2700	900	1800
33	27/09/06	6.15 AM -9.07 PM	2.52	2½ -.3	0.22	200	200	0	1800	0	1800
34	17-18/10/06	6.15 AM-3.00 PM	8.45	2½ -.3	6.15	400	200	200	3600	1800	1800
35	20/01/06	6.45AM2.00PM	5.15	2½ -.3	2.85	100	200	-100	900	-900	1800
36	27/04/06	9.20AM- .55PM	10.35	2½ -.3	8.05	400	200	200	3600	1800	1800
37	9/5/2007	6.35AM- .30PM	12.55	2½ -.3	10.25	400	200	200	3600	1800	1800
38	11/6/2007	6.15 AM -.40PM	12.25	2½ -.3	9.95	500	200	300	4500	2700	1800
39	12/6/2007	8.30 AM -.50PM	6.2	2½ -.3	3.9	400	200	200	3600	1800	1800
40	12/6/2007	3.00AM-.16PM	1.16	2½ -.3	-1.14	100	200	-100	900	-900	1800
41	29/06/07	6.15 AM -.54PM	8.39	2½ -.3	6.09	300	200	100	2700	900	1800
42	29/06/07	3.05 PM-6.20 PM	3.15	2½ -.3	0.85	300	200	100	2700	900	1800
43	29/06/07	6.30 AM -.53PM	2.23	2½ -.3	-0.07	300	200	100	2700	900	1800
44	1/8/2007	6.15 AM -.31PM	2.44	2½ -.3	0.14	300	200	100	2700	900	1800
45	1/8/2007	3.31 PM-5.30 PM	1.55	2½ -.3	-0.75	200	200	0	1800	0	1800
Total			**335.82**	**103.5**	**232.32**	**13500**	**9000**	**4500**	**121500**	**39690**	**81810**

TABLE 3: The duration of time taken (Hr./mins)

Furnace	Max	Min	Save
EAF	182.78	122.98	59.8
IND.	335.82	232.32	103.5
Total	518.6	355.3	163.3

TABLE 4: Energy Consumed (kw/h)

Furnace	Max	Min	Save
EAF	20,600	10,200	10,400
IND.	13,500	4500	9000
Total	34, 100	14, 700	19, 400

TABLE 5: Cost Expended (₦)

Furnace	Max	Min	Save
EAF	185, 400	91, 800	93, 600
IND.	121, 500	81, 800	39, 690
Total	306,900	173, 600	133, 290

The values obtained in the table (3), (4) & (5) were used to plot graphs as shown in figures 16, 17, 18, 19, 20, and 21. In figure 16 it was observed that a total time of 163.3 Hr/mins could have been saved if the two furnaces were operated at a standard melting time of 2½ Hr/mins for each cycle. Figure 17 shows that the total energy consumed 19,400 kW/Hr could have been saved from the operation of these furnaces. Figure 18 shows that the total cost of ₦133,290 could have been saved from the operation of these furnaces. From the data analyzed it could be seen that it has become very important and necessary to perform an energy audit to reduce economic wastes on resources.

The processes could only be achieved by reducing the duration of time to complete the melting processes, energy consumption, and cost on the operation of these furnaces. Figure 19: The duration of time Taken (Hr/Mins) for the Melting Processes for the two furnaces considering the maximum time taken the supposed minimum and the duration of time saved after the auditing was performed, Figure 20: The Energy Consumed (kw/h) for the melting processes for the two furnaces indicating the maximum, the minimum, and the saved energy consumed and finally figure 21 indicate the Cost Expended in Naria values during the melting processes for the two furnaces as regards the maximum amount, minimum value and the saved amount when the audit was carried out.

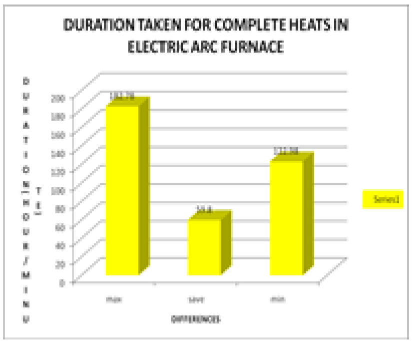


FIGURE 10: Show the max saved & min time cost (Hr./mins)

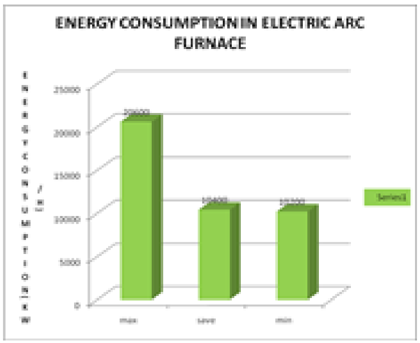


FIGURE 11: Show the max saved & min (Hr./mins)

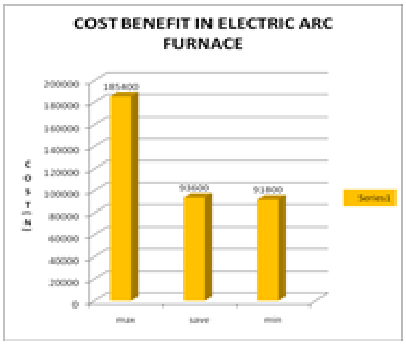


FIGURE 12: Show the max saved & min Cost(₦) energy consumed (kw/h)

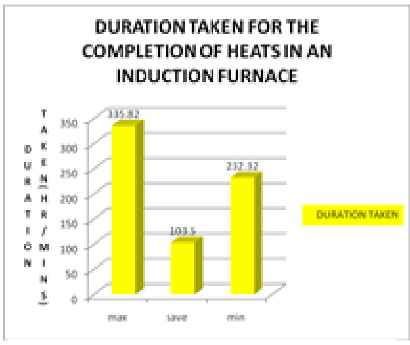


FIGURE 13: Show the max saved & min time taken (Hr./mins)

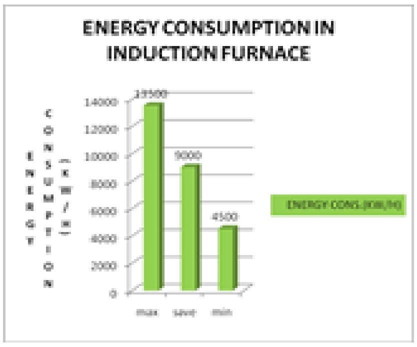


FIGURE 14: Show the max saved & min time (Hr./mins)

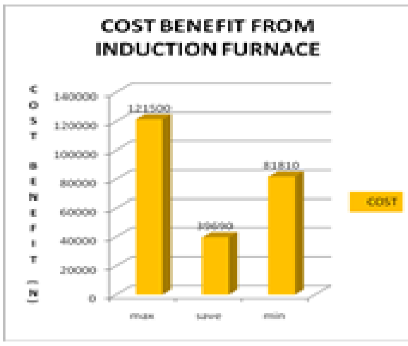


FIGURE 15: Show the max saved & min energy consumed (kW/Hr)

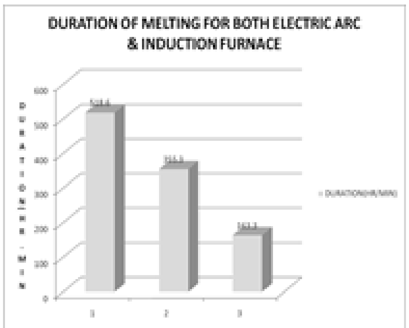


FIGURE 16: Show the time (163.3 Hr./mins) time (₦133,290) that Could be saved for both furnaces

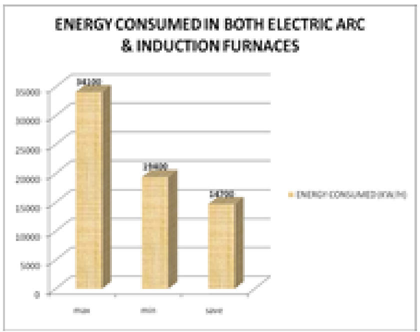


FIGURE 17: Show the level of energy (14700kw/Hr) that could be saved for both furnaces

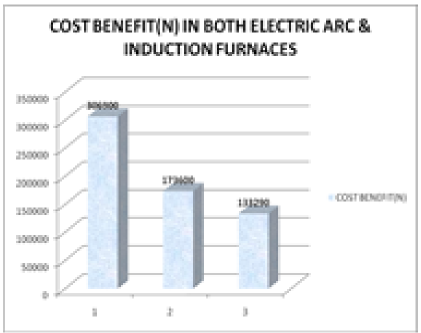


FIGURE 18: Show the level of energy (14700kw/Hr) that could be saved for both furnaces

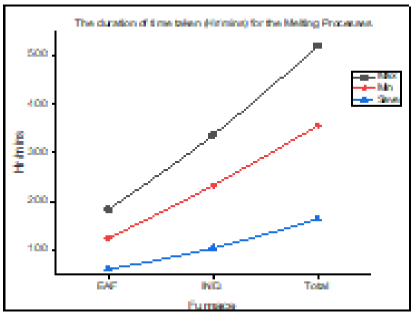


FIGURE 19: The duration of time Taken (Hr/Mns) For the Melting Processes, the Melting Processes

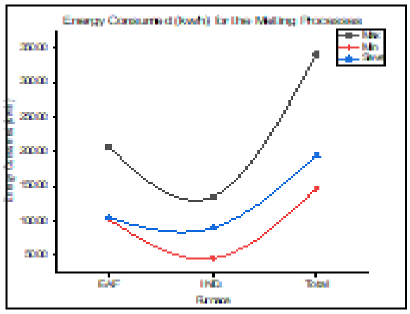


FIGURE 20: The Energy Consumed (kw/h) the Melting Processes

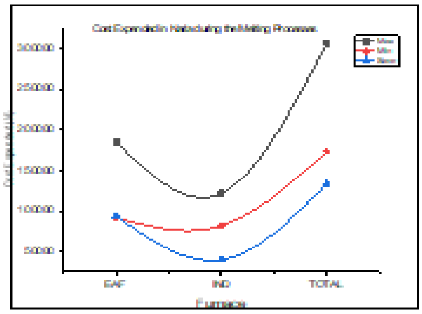


FIGURE 21: Cost Expended in Naria during

CONCLUSION

Performing energy audits in the metallurgical industry are very important due to the nature of its operational processes and the kind of furnaces used. The types of components being produced also make it very crucial for undertaking such procedures. Figures 22 to 25 show some kind of products from the shop, which includes the conical flask use in the quarry industries, the fixed jaw crusher also in figure 23. The pallets of 4.5 tonnes use in the Delta steel company limited is also indicated in figure 24. Figure 25 shows the railway brakes produced for Nigerian Railway Corporation. For the management of the shop to continue to produce for these industries, there is the need therefore to perform energy audits as indicated in the values obtained. The data obtained indicated that more times are spent in completing melting cycles for the two furnaces, more energy is consumed and a lot of amount of monies are also wasted during the production of the components or items. The energy audit programme for such a metallurgical industry could be performed to reduce or eliminate all the issues identified in the research. There is, therefore, an urgent need energy Unit of the company to perform an energy audit of the two melting furnaces as the purpose is to reduce wastage of energy consumption, duration of completing the melting cycle, and cumulate the signs of progress to be cost-effective. The arrangement and monitoring process could be coordinated through the data generated from the research work. Performing Energy audits will reduce downtime on the equipment and make them efficient in subsequent usage Pro - energy audits are the important steps taken for the reduction of energy cost in any manufacturing industry. A thorough audit will identify the existing problems associated with the operational procedures in the shop. The furnace study would result in improvements in equipment and procedures that will result in a cost-effective decrease in energy costs, a decrease in energy usage, and the time required to complete the melting cycle of the casting batches. The suggestions and recommendations made by the auditors of the furnaces should be adhered to for the wholist successes of the continuous operation of the shop.

In the effective conduct of energy audits, energy auditors are critical to the implementation and recommendations for solving energy cost and consumption.

FIGURE 22: Conical flake for the quarry industries

FIGURE 23: Fixed jaw also for the quarry industries

FIGURE 24: Pallets used at the Delta Steel Plant

FIGURE 25: Railway brakes for the Railway Corporation

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