INVESTIGATION OF THE EFFICACY OF USING A NON COKING COAL AS A BLEND WITH COKE FOR TIN SMELTING.

Ihom, A. Paul,[1] Alabi, Oladunni. Oyelola,[1] Wara .A. Usman,[1] and Ogbodo, J.[2]

[1]Department of Metallurgy, National Metallurgical Development Centre, Jos.P.M.B.2116, Jos, Plateau State, Nigeria.

[2] Dept. of Welding and Fabrication, Scientific Equipment Development Institute Enugu-Nigeria

Corresponding Author's Email:draondonaphilip@gmail.com

ABSTRACT

Investigation of the efficacy of using a non coking coal as a blend with coke for tin smelting has been undertaken. The work utilized Enugu Coal mixed with imported coke in various proportions. The smelting of the tin was carried out and the chemical analysis of the tin recovered, and that of the slag was done. The recovery of the tin metal was worked out through the material balance. The results clearly indicated that the recovery was 69.3% for 100% Coke, 68.90% for 5%/95% blend and 68.30% for 10%/90% blend. The grade of tin recovered was not so much affected by the proportion of the blend used, however, 100% Coke had the highest grade of recovered tin metal. It was also noticed that as the Enugu Coal in the blend increased the recovery of tin metal decreased. The range of 5% to 15% of Enugu Coal in the blend, which had a recovery of 68.9% to 62.30%, can be use for tin smelting, since it has a reasonable recovery percentage of tin metal.

Keywords: Investigation; Efficacy; Coke; Non Coking Coal; Blend; Tin Smelting.

1. INTRODUCTION

The history of metallurgy of iron making and tin smelting is closely knitted to the use of Charcoal and coal as reductants and fuels. Different forms of carbon and carbon source were used as fuel and as reductants in time past [1].

The dictates of which form of carbon source to use as a reductant in iron making and non ferrous smelting, particularly tin was determined by technology, scale of production, availability, quality, yield and cost [1] for instance charcoal was used in the blast furnace after the adoption of the blast furnace for iron making in the fifteenth century for nearly 200 years. A search for an alternative to charcoal only came when there was need for increased production rate, increase in the height of the furnace shaft and the need to reduce the cost of production. Charcoal was expensive because of the conversion of wood to charcoal which accounted for nearly half of the total operation cost. Another critical reason for an alternative to charcoal was the enormous amount of forest wood that was being consumed for this purpose, this finally led to the imposition of restrictive legislation on wood burning for Charcoal[1] obviously after this restrictions attention was focused on to coal which was far more widely available, several problems encountered by smelting led to changing from one form of coal to another; these problems included composition problem as well as physical nature of the coal. A major breakthrough came with the advent of the 'Coked Coal' which was purer that even the purest form of coal: the anthracite. Coke is a cellular structured mass with good strength and is produced as a result of the destructive distillation of coking coal [1, 2]. Compositional problems place a serious limitation on the type of coal to be used for tin smelting this explains why Nigeria has a lot of coal deposits and still imports anthracite and coke for tin smelting despite the high cost associated with importation. This work seeks to strike a balance between the use of local non coking coals and imported coke. This balance is to be addressed through blending. Blending means mixing up of two or more types of materials from two or more sources to even-out variations in physical and or chemical qualities to obtain a more uniform material of desired qualities over an extended period [1, 2].

The benefit of this research work is that hopefully the issue of cost associated with the importation of coke for tin smelting will be addressed. The use of the local coal in the blend will bring down the amount of coke consumed which will invariably translate into cost reduction.

The objective of this work is to investigate the efficacy of using a non coking coal as a blend with coke for tin smelting, non coking coal are plenty, cheep and locally available. Their use can complement the use of coke for tin smelting in other to reduce coke consumption and cost.

2. MATERIALS AND METHODS

2.1. Materials

The materials used for the work included: Tin concentrate assaying 70 percent tin from Dogo Na Hauwa Village, Kudedu Mines of Jos East Local Government area of Plateau state with chemical composition shown in Table 1. Coke was obtained from Minor Metals and Minerals, Dadin Kowa, Jos. Coal was sourced from Enugu Coal Mines, Enugu. Anambara State; Limestone was obtained from Jakura Mines, waste engine oil, diesel and firewood were sourced at Faringada Jos, Plateau state. The properties of some of the materials used are as indicated in Tables 2 – 4.

2.2. Equipment

Some of the equipment used were; Mini reverboratory furnace of capacity 20Kg of Tin ore per charge, rambling metal rod, Ladle, launder, siphon, Mould, tapping or bleeding rod, tapping pot, ED-XRF spectrometer, Shovel, thermocouple for temperature measurement and a weighing balance (Salter of 25Kg).

2.3. Methods

3. RESULTS AND DISCUSSION

3.1. Results

10kg of high concentrate cassiterite was mixed thoroughly with 100% by weight of Coke amounting to 800g and limestone of weight 400g.These were then charged into already pre heated furnace at the temperature of 1400°C. Heating was continued for 8hours during which rambling or stirring with rambling rod was done frequently, especially during the later stage. The firing continued for 4 hours, till the concentrate became molten tin. The slag was on top and contained most unwanted impurities. Taping was then done, followed by continuous heating of the furnace for another 2 hours. The final bleeding of tin metal in molten form was then carried out through the tapping hole and poured into ingot. After the bleeding; firing of the furnace continued for another 2 hours till the slag became molten enough at a temperature of 1450°C, and was then tapped and allowed to solidify into granules in water tanks, leaving the furnace clean for the next batch of smelting process.

The tin metal and slag recovered were then weighed and analyzed. The next charge of 10Kg of cassiterite, 400g of limestone (remained constant) and variation of the 800g of reducing agents being blends of Enugu coal and imported Coke as follows 0%,5%,10%,15%,20%,25%,%50%,100% was smelted in sequence. Percentage recovery was then calculated using the two product formula (R=Cc/Ff X 100). The grade of the recovered tin was known through analysis using Energy dispersal X-ray fluorescence spectrometer (ED-XRF) analyzer.

TABLE 1
CHEMICAL COMPOSITION OF DOGO NA HAUWA TIN CONCENTRATE

Element	Si	Ca	Ti	Mn	Fe	Ni	Se	Y	Zr	Nb	Sn	Ce
Compound	SiO_2	CaO	TiO_2	MnO	Fe_2O_3	NiO	SeO_2	Y_2O_3	ZrO_2	Nb_2O_5	SnO_2	CeO_2
percent	0.02 %	4.28 %	1.89 %	0.11 %	3.19 %	0.007 %	0.007 %	0.059 %	0.341 %	2.20 %	85.4 %	0.54 %

Element	Nd	Ta	W	Hg	Bi	Th
Compound	Nd_2O_3	Ta_2O_3	WO_3	HgO	Bi_2O_3	ThO_2
percent	0.18 %	0.917 %	0.25 %	0.010 %	0.007 %	0.00 %

ISSN 2229-5518

TABLE 2
PROXIMATE ANALYSIS AND CALORIFIC VALUE OF BLENDS OF COKE/COAL "AS RECEIVED"BASIS.

	Moisture (%)	Ash (%)	Volatile matter (%)	Fixed Carbon (%)	Calorific Value.(Calories per gms)[2]
Enugu Coal	20.7	3.9	30.7	44.7	5572
Coke	1.4	1.8	26.0	70.8	8384

TABLE 3
ULTIMATE ANALYSIS – MOISTURE AND ASH-FREE BASIS.

	Carbon (%)	Hydrogen (%)	Nitrogen (%)	Sulfur (%)	Oxygen (%)
Enugu Coal	66.7	5.6	1.6	0.5	18.5
Coke	82.4	5.7	1.5	0.8	6.9

TABLE 4
CHEMICAL ANALYSIS OF JAKURA LIMESTONE AS DETERMINED USING WET ANALYSIS.

Composition	CaO	MgO	SiO_2	TiO_2	Fe_2O_3	Al_2O_3	K_2O	Na_2O	L.O.I
%	55.23	0.45	0.31	0.01	0.04	0.04	0.02	0.03	43.58

TABLE 5
EFFECT OF ENUGU COAL ADDITION TO COKE ON PERCENTAGE RECOVERY OF TIN METAL.

% Enugu Coal	Wt. of Conc. (kg) (F). Charge	Assay of Conc. (f)	Wt. of molten Tin (C)	Assay of molten Tin. (c)	Recovery Cc/Ff x 100
0	10.0	85.63	6.09	97.42	69.30
5	10.0	85.63	6.07	97.33	68.90
10	10.0	85.63	6.01	97.33	68.30
15	10.0	85.63	5.53	96.50	62.30
20	10.0	85.63	4.86	96.07	54.50
25	10.0	85.63	4.56	95.83	51.03
50	10.0	85.63	2.31	95.03	25.64
100	10.0	85.63	0.46	94.71	5.09

TABLE 6
EFFECT OF ENUGU COAL ADDITION TO COKE ON THE TIN METAL LOST TO SLAG.

Blend	Wt of conc.	Assay of feed	Wt. of slag (kg)	Assay of Tin in slag	Tin lost in slag.
0	10	85.63	3.59	16.1	6.74
5	10	85.63	3.64	17.1	7.27
10	10	85.63	3.58	16.7	6.98
15	10	85.63	4.11	10.3	4.94
20	10	85.63	4.69	8.45	4.63
25	10	85.63	4.94	8.95	5.16
50	10	85.63	7.21	28.42	23.42
100	10	85.63	8.93	33.7	35.14

3.2. Discussion

Table 1 shows the chemical composition of Dogo Na Hauwa tin concentrate used for the research work. The result indicates that the concentrate is a high quality one. It has 0.02% silica. Other impurities are equally less. The cassiterite (SnO_2) in the concentrate is 85.4%, which is high and meet the standard of tin smelting [2,3].

Tables 2 and 3: has the result of the proximate analysis and the ultimate analysis of Coke and Enugu coal. The Tables show the percentage carbon content as follows; Coke 82.4% and Enugu Coal 66.7%. The corresponding calorific values are 8384 Cal /g for coke and 5572 Cal /g for Enugu Coal. This values fall within the required minimum standard of 60-90% carbon and minimum of 5500 Cal/g for tin ore concentrate smelting [1, 5].

Table 5 is the effect of Enugu coal addition to Coke on percentage recovery of tin metal. The result showed that 100% coke used for smelting tin had the highest recovery of 69.30%, followed by 5% Enugu coal in blend with coke. The trend of the result indicates that as the amount of Enugu coal in the blend increases the recovery decreases [6,7]. The grade or assay of molten tin did not however degrade much with the increase of the usage of the Enugu coal in the blend. In any case 100% coke had the highest grade of tin metal (97.42) smelted. Judging on the basis of recovery 68.90 to 62.30% corresponding to 5-15% of Enugu Coal is adjudged to be a reasonable recovery [2].

Table 6 shows the effect of Enugu Coal addition to Coke on the tin metal lost to slag. The result in the table shows that the highest amount (35.14) of tin metal lost to slag occurred at 100% Enugu Coal, the lowest amount (4.63) occurred at 20% Enugu Coal blended with coke. More tin was lost to the slag when the Enugu Coal in the blend reached 50% and above. Enugu coal is a low grade coal with low carbon content. The higher the carbon content the better the coal in terms of serving as a reductant [7]. Considering Tables 5 and 6, the efficiency of the non coking coal used in the smelting of the tin was established. The non coking coal can be used in the blend economically between the ranges of 5% to 15%. This is because within this range the recovery of the tin metal is not so different from that of the 100 percent coke.

4. CONCLUSION

Investigation of the efficacy of using a non coking coal as a blend with coke for tin smelting has been carried out. The result of the work has shown that the non coking coal can be used in the range of 5 to 15%.The recovery at this point is close to that of 100% coke. The work however established that as the amount of the non coking coal in the blend increased the recovery decreased. The grade of tin metal produced did not however produce a drastic or dramatic change.

5. ACKNOWLEDGEMENT

The supervisory role of Prof. Shehu Aliyu Yaro in seeing to the success or the research work is appreciated.

REFERENCES

[1] R.H.Tupkary, and V.R.Tupkary, *An Introduction to Modern Iron Making,* 5Th reprint Khanna publishers, pp42-85, 2007.

[2]. O.O. Alabi, ''Comparative Study of Tin Smelting Using Blends of Anthracite/Coal and Coke/Coal'' M.Sc (Met.Eng) thesis proposal, ABU Zaria 2009.

[3]. A.Cottrell, *An introduction to metallurgy*, 5th Edition Edward Arnolds publishers Cambridge, pp98-99 1980.

[4]. J. Fisher, *Energy Density of Coal*, The physics Factbook International, 2003.

[5].O.P.Gupta, *Elements of fuels, furnace and Refractories,* 5th Edition, Khanna publishers pp4-100, 2008.

[6]. Http/hypertextbook.com/facts/2003 /juliyafisher.shtml.retrieved on 2006-08-25

[7]. J.B.Long, *Tin and its alloys, metal Handbook,*Vol.2,9th ed, America Society for Metal International, Ohio pp613-625, 1979.