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Investigating the effect of coke aggregate on gas consumption in anode plant

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Abstract: Aluminium is mainly produced from bauxite. Over 90% of the world's bauxite resources are concentrated on the tropical and sub-tropical belt in Australia, Guinea, Jamaica, Surinam, Brazil, and India.

Alumina — or Aluminium oxide (Al2O3) is produced from extracted ore. Alumina is then transformed into Aluminium through electrolytic reduction. One tone of Aluminum is produced from every two tones of alumina.

Due to less specific weight, corrosion resistance, good electrical conductivity, high thermal conductivity and other useful property; aluminum is used in wide range of industry such as aviation, and military.

Aluminium production technology applies pre-baked anodes, a method used at many European and American aluminum smelters. The anodes are baked in huge gas furnaces. The materials which are used for anode production include petroleum cock (60%), high softening point pitch (15%) and butts (25%).

The effectsof deferent size of packing cock which are used for covering anode in furnace on anode quality and gas consumption has been studied in this research.For this purpose, anode baking cycle time has been performed by three size of packing cock(Medium, coarse, very coarse.)Anode quality and gas consumption recorded in each cycle.Eventually, with due attention to result of research; the optimum size of packing coke is coarse.To avoid anode burning, usage of medium size packing coke even fine on top layer of anode coverage in baking furnace is recommended.

Keywords: ";Anode, Backing furnace, packing coke, Gas consumption."

Introduction

Almahdi Aluminum was established in Bandar Abbass , the center of Hormozgan province , in July 1990 with an approximate investment of 1.5 bUSD , targeting 110,000 Mt aluminium per year increasable to 330,000 Mt/y. The first phase was inaugurated in 1997 and by early 2002 , it reached to half capacity using 120 cells in operation.The erection of 2nd phase of line one was started in 2002 and completed in May 2005. In June 2006 , the 2nd phase , called hereafter Hormozal , was started with an investment of 600 m euros.The technology of 2nd phase was D20 with the line current of 230 kA and 228 cells aiming annual production of 147,000 Mt aluminium. With cooperation of Iranian experts and foreign EPC contractor , FATA Hunter s.p.a from Italy , the whole project finished in 40 months and inaugurated in October 2009.For the time being 124 cells are in operation and the plan is to achieve full line capacity by mid 2015.

Petcoke is over 90 percent carbon and emits 5 to 10 percent more carbon dioxide (CO_2) than coal on a per-unit-of-energy basis when it is burned. As petcoke has a higher energy content, petcoke emits between 30 and 80 percent more CO_2 than coal per unit of weight.[2] The difference between coal and coke in CO_2 production per unit energy produced depends upon the moisture in the coal (increases the CO_2 per unit energy – heat of combustion) and volatile hydrocarbon in coal and coke (decrease the CO_2 per unit energy).

Petroleum coke (often abbreviated pet coke or petcoke) is a carbonaceous solid delivered from oil refinery coker units or other cracking processes.[1] Coking processes that can be employed for making petcoke include contact coking, fluid coking, flexicoking and delayed coking. Other coke has traditionally been delivered from coal.

This coke can either be fuel grade (high in sulfur and metals) or anode grade (low in sulfur and metals). The raw coke directly out of the coker is often referred to as green coke.[1] In this context, "green" means unprocessed. The further processing of green coke by calcining in a rotary kiln removes residual volatile hydrocarbons from the coke. The calcined petroleum coke can be further processed in an anode baking oven in order to produce anode coke of the desired shape and physical properties. The anodes are mainly used in the aluminium and steel industry.

Fig1-Delayed coker operation, schematic (a) and delayed coker (b)

Calcined coke is the best material for making carbon usually calcined in a gas-fired rotary kiln or rotary heath at high temperatures, around 1200 to 1400 c, to remove moisture, drive off strength, and electrical conductivity of the material. Rotary kilns have been used successfully for many years to produce calcined coke for the aluminium industry and they offer a high level of automation, performance and flexibity. Shift caciners make high bulk density, coarse particle size product and several papers have been published recently highlighting these benefits

Experimental Procedure (Model)

In statistics, the residual sum of squares (RSS), also known as the sum of squared residuals (SSR) or the sum of squared errors of prediction (SSE), is the sum of the squares of residuals (deviations of predicted from actual empirical values of data). It is a measure of the discrepancy between the data and an estimation model. A small RSS indicates a tight fit of the model to the data. It is used as an optimality criterion in parameter selection and model selection. In general, total sum of squares explained sum of squares + residual sum of squares. For a proof of this in the multivariate ordinary least squares (OLS) case, see partitioning in the general OLS mo

The sum of squares represents a measure of variation or deviation from the mean. It is calculated as a summation of the squares of the differences from the mean. The calculation of the total sum of squares considers both the sum of squares from the factors and from randomness or error

In regression, the total sum of squares helps express the total variation of the y's. For example, you collect data to determine a model explaining overall sales as a function of your advertising budget.

The total sum of squares = regression sum of squares (SSR) + sum of squares of the residual error (SSE)

$$\Sigma(y - \bar{y})^2 = \Sigma(\hat{y} - \bar{y})^2 + \Sigma(y - \hat{y})^2$$

The regression sum of squares is the variation attributed to the relationship between the x's and y's, or in this case between the advertising budget and your sales. The sum of squares of the residual error is the variation attributed to the error.

By comparing the regression sum of squares to the total sum of squares, you determine the proportion of the total variation that is explained by the regression model (R^2, the coefficient of determination). The larger this value is, the better the relationship explaining sales as a function of advertising budget. For thermal conductivity values, see List of thermal conductivities. In physics, thermal conductivity (often denoted k, λ, or κ) is the property of a material to conduct heat. It is evaluated primarily in terms of Fourier's Law for heat conduction. Heat transfer occurs at a lower rate across materials of low thermal conductivity than across materials of high thermal conductivity. Correspondingly, materials of high thermal conductivity are widely used in heat sink applications and materials of low thermal conductivity are used as thermal insulation. The thermal conductivity of a material may depend on temperature. The reciprocal of thermal conductivity is called thermal resistivity.

Differential scanning calorimetry or DSC is a thermoanalytical technique in which the difference in the amount of heat required to increase the temperature of a sample and reference is measured as a function of temperature. Both the sample and reference are maintained at nearly the same temperature throughout the experiment. Generally, the temperature program for a DSC analysis is designed such that the sample holder temperature increases linearly as a function of time. The reference sample should have a well-defined heat capacity over the range of temperatures to be scanned.

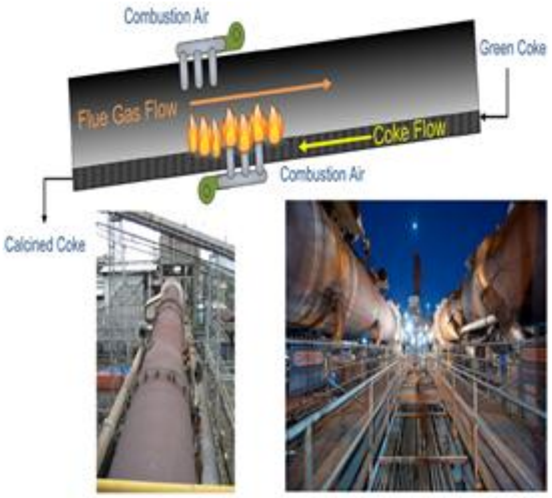

Figure2-. Rotary kiln schematic and kilns equipped with tertiary air fans**.**

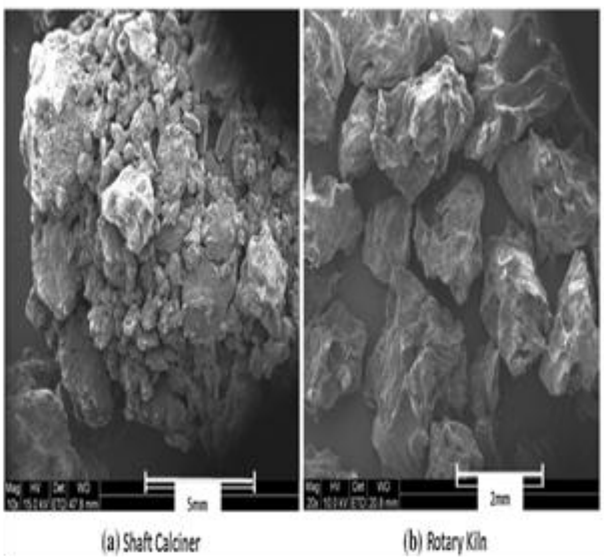

Figure 3- SEM images of shaft (a) and rotary kiln CPC (b).

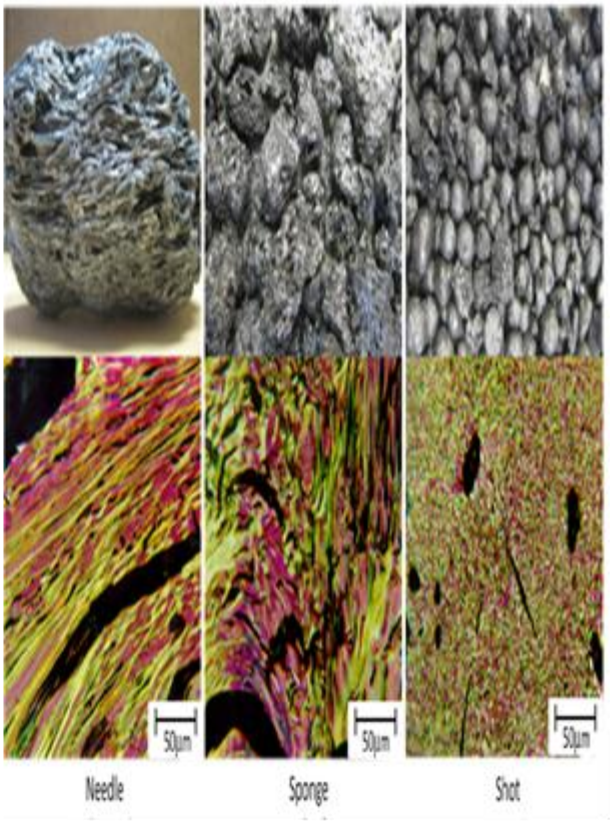

Figure 4- Delayed coke types and optical textures

Results and Discussions

One of the most important parameters for gas consumption during the annealing process is the percentage of bitumen in the raw anode. If the percentage of bitumen in the raw anode is high, it causes the coke to stick to the anode body during the baking process. On the other hand, low bitumen reduces anode strength and increases gas consumption. In the experiments conducted in this study, the percentage of bitum in the raw anode is between 14% and 15%. In table (1), the gas consumption in the Heating section is shown in the Annealing cycle for medium coke packing over time.

Table 1 - Gas consumption during the heating process for the sample medium

Gas consumption(Cubic meter)	Times of operation(Hours)
0	0
141	2
280	4
412	7
544	10
676	13
815	16
956	19
1092	22
1233	25
1365	27
1497	29
1639	32
1785	35
1942	38
2125	41
2256	44
2410	47
2472	50
2614	52
2755	54
2867	57
2990	60
3129	63
3251	66

In Fig6, the amount of gas consumed during the heating process is plotted for the medium-coke Pecking sample.

The accuracy of this diagram shows that the gas consumption rate changes linearly with a steady slope during the heating process.

And the total gas consumption during this process for medium aggregates is 3251 cubic meters.

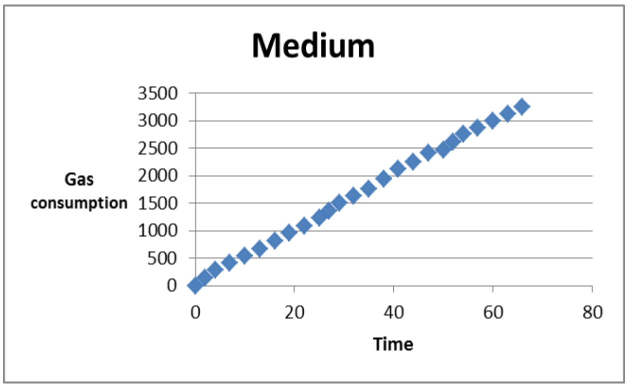

Fig6- - Gas consumption diagram during the Heating process for the medium sample

In Table 2, the gas consumption in the heating section in the Annealing Cycle for Cooking Cupcakes over time is shown.

Table 2 - Gas consumption during Heating process for Coarse sample

Gas consumption(Cubic meter)	Times of operation(Hours)
0	0
160	2
318	4
468	7
618	10
768	13
926	16
1086	19
1241	22
1551	25
1701	27
1863	29
1998	32
2207	35
2415	38
2563	41
2739	44
2809	47
2970	50
3131	52
3258	54
3398	57
3555	60
3694	66

On the fig7, the amount of gas consumed during the heating process for the Coarse coke sample is plotted.

The accuracy of this diagram shows that the gas consumption rate changes linearly with a steady slope during the heating process.
And the total gas consumption during this process for coarse aggregates is 3694 cubic meters.
Therefore, gas consumption in this case is more than the previous one.

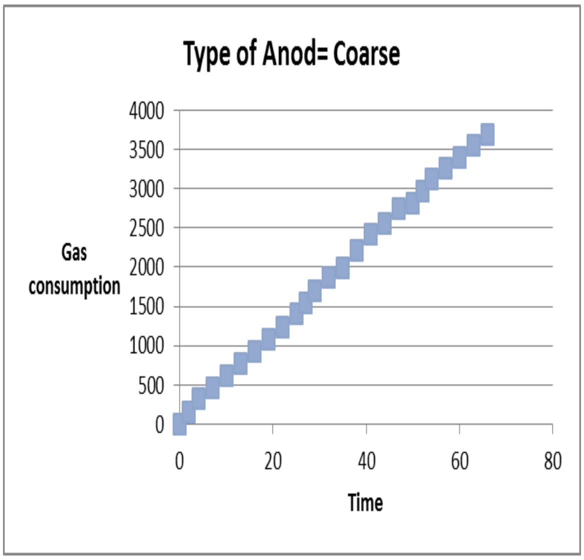

Fig7- Gas consumption diagram during heating process for coarse sample

The last experiment of aggrate anode was very coarse. Which is shown in Table 3 of the gas consumption during the heating process

And this is illustrated in fig8.

Table 3 - Gas consumption during the heating process for the sample very coarse

Gas consumption(Cubic meter)	Times of operation(Hours)
0	0
176	2
350	4
515	7
680	10
845	13
1019	16
1195	19
1365	22
1541	25
1706	27
1871	29
2049	32
2198	35
2428	38
2657	41
2819	44
3013	47
3090	50
3267	52
3444	54
3584	57
3738	60
3911	63
4063	66

The accuracy in fig8 shows that the consumption of gas during the cooking of the anode with a very coarse coating is 4046 cubic meters.

Which is significantly higher than the previous experiment.

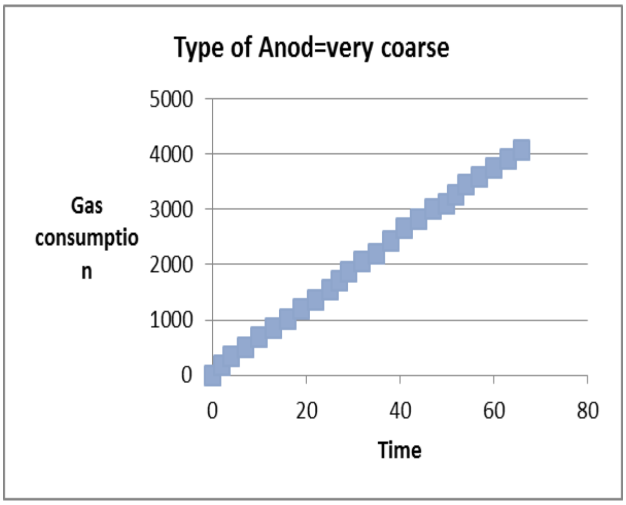

Fig8 - Gas consumption diagram during the heating process for the very coarse sample

On the fig9, a comparison is also made between gas consumption during the annealing process for all three types of aggregation.

The accuracy of this graph shows that the amount of gas consumed by meduiam paking coke is about 12% less than that of Coarse packing coke.

And the very coarse gas consumption is about 9% more than Coarse.

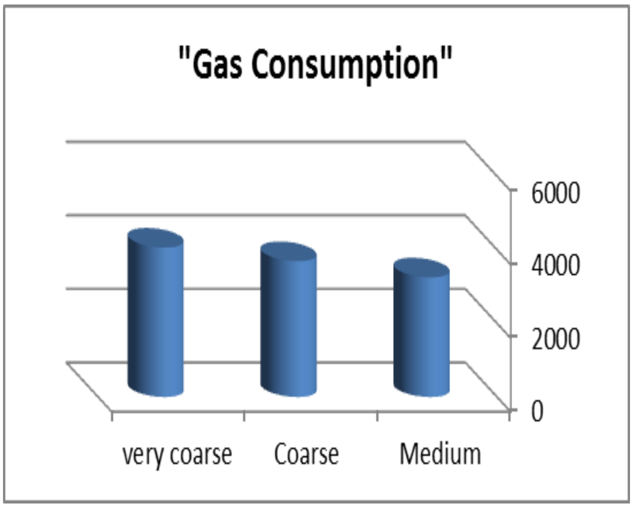

Figure 9- gas consumption by type of aggregation

Conclusion

This study show that increases the consumption of gas by increasing the particle size of the coke, during the baking process, Increasing gas consumption with increasing particle diameter is due to the fact that Heat is transferred from the free space between the particles and the heat loss due to the high porosity of the aggregate will increase.
Increasing heat losses will increase gas consumption

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