

CONVERSION OF CONVENTIONAL ROTARY KILN
INTO EFFECTIVE SANDY ALUMINA CALCINER

M.Ishihara, T.Hirano and H.Yajima

Nippon Light Metal Co. Ltd., Shimizu Works, Japan

Using conventional rotary kiln for calcining sandy alumina in potlines, remarkable heat-saving and capacity-improving can be achieved. 83 liters of oil per tonne of alumina (3200MJ/tonne) were required for calcining 800 m.t.p.d. of sandy alumina in the rotary kiln at Shimizu Works. The kiln is installed with two stages of flash dryers and planetary coolers, and was originally designed for calcining flourey alumina at 550 m.t.p.d. This improvement in capacity and unit oil consumption was achieved mainly through shortening the flame by using a special burner and effective heat recovery. The quality of sandy alumina calcined by the kiln is good enough for potlines.

Introduction

In recent years, many aluminum reduction plants have been changed to dry gas-cleaning systems(1) instead of expensive wet systems in order to remove fluorine compounds from waste gas, and continuous alumina feed to cells has been adopted to reduce labor cost. Consequently, "sandy alumina", with high adsorption capability and high flowability, has been required.

As a result of the rise in energy cost caused by the oil crisis at the beginning of the 1970's, the requirement for an energy-saving alumina calciner has been accelerated. (2)(3)(4)(5)

In MLM Shimizu Works, sandy alumina is calcined by the rotary kiln. And we tried to improve the oil unit consumption and increase the capacity for calcining sandy alumina.

The rotary kiln was originally designed for calcining flourey alumina at 550 m.t.p.d. and it required 117 liters of oil per tonne of alumina (4500 MJ/tonne).

Through several test operations of sandy alumina calcination by the above mentioned rotary kiln, technology of capacity increase, heat control and quality control was developed. As a result, special oil burner and some heat recovery method were adopted. The energy consumption was decreased to 83 liters of oil per tonne of alumina (3200 MJ/tonne) and capacity was improved to 800 m.t.p.d. The alumina obtained from the trial was good enough for potlines.

Test Procedure

Process Description

The process is shown schematically in Fig. 1.

The main components of the calcining system are :

- o Rotary kiln (3.5m diameter, 60m length, with planetary coolers)
- o 2 stages of flash dryers
- o 2 stages of multiclones

Wet filtered hydrate cake is fed into the 1st stage of flash dryer, where the hot gas stream from the 2nd stage of multiclone removes free water of the cake.

The dried hydrate is separated in the 1st stage of multiclone and is carried to the 2nd stage of flash dryer, where hydrate is decomposed to alumina and water vapour.

The alumina is separated in the 2nd stage of multiclone and fed to rotary kiln and calcined.

The hot alumina is cooled in the planetary coolers followed by rotary cooler.

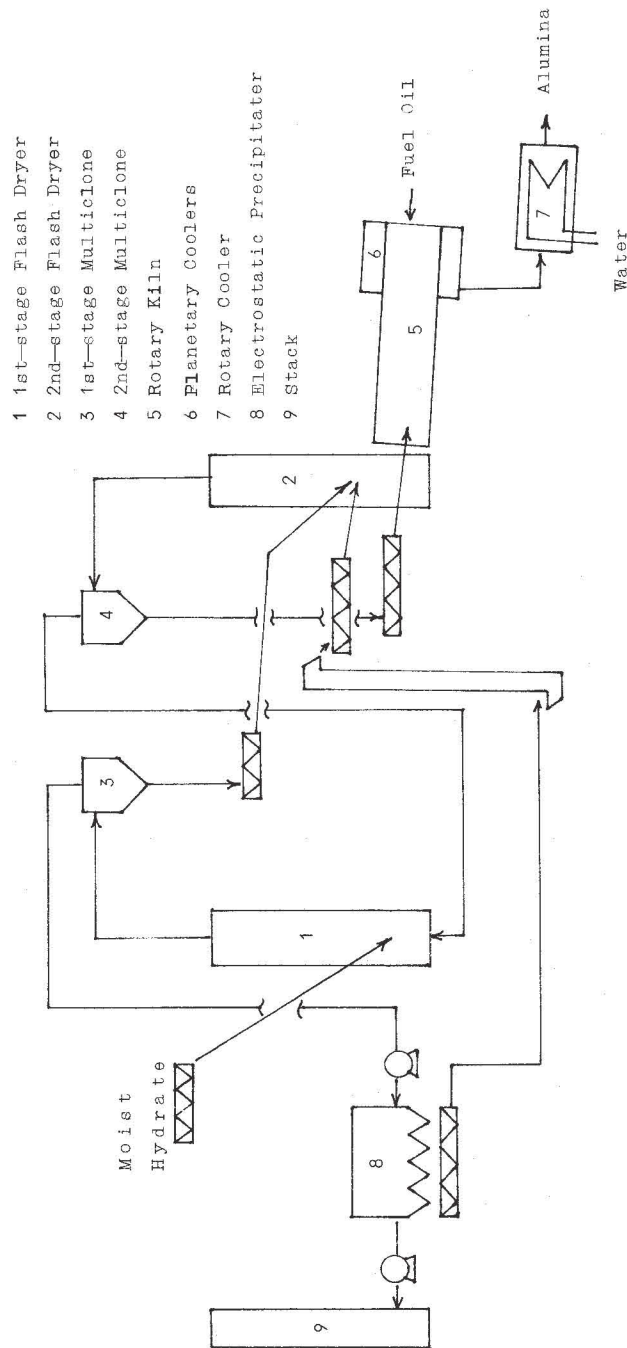


Fig. 1. Flow Sheet of Calciner

Test Procedure

We carried out test operation of sandy alumina calcination several times to find out the technology to be developed for improving efficiency of calciner.

The following are our main improvements as a result of our study.

- (1) In order to get high combustibility, the conventional kiln burner was turned into a short-flame special burner which was developed by a Japanese burner maker in cooperation with our company.
- (2) Radiation loss from the surface of planetary coolers was reduced by hooding them.
- (3) Hot air from (2) was used as primary combustion air of the burner.
- (4) Excess air of the burner and leakage air was minimized to reduce stack loss. And proper temperature distribution of the system was determined and standardized.

Results and Discussion

Energy Requirement

As fuel is the largest cost element in the calcining process, fuel-saving has been strongly desired.

We tried to calcine sandy alumina by means of the improvement of kiln burner and effective heat recovery. As a result, 83 liters of oil per tonne of alumina (3200 MJ/tonne) was achieved and capacity was improved remarkably.

The specific heat consumption for 800 m.t.p.d is shown in Table I.

<u>Table I. Specific Heat Consumption</u>		
	MJ/tonne	%
Fuel oil	3220	98
Hydrate	60	2
Heat input	3280	100
Heat of reaction	2010	61
Evaporation of moisture	460	14
Combustion gas	230	7
Product loss	260	8
Radiation loss	320	10
Heat expense	3280	100
Production Rate	800 m.t.p.d.	
Filter cake moisture	10 %	
Temperature of stack gas	130 °C	

Particle Breakdown

It is necessary for sandy alumina to have the properties of non-dust generation, good flowability and high mechanical strength during handling.

Particle breakdown in the calcination process mainly depends on the type of hydrate, calcining system and the degree of calcination.

It is generally said that the rotary kiln system has an advantage in the particle breakdown compared with fluid-bed systems, because breakdown by autogeneous grinding of the particles and by impact of the particles on the walls is low.

In order to investigate particle breakdown in our calcining system, we tried to calcine two types of hydrate. One was hydrate A, which is our ordinary product, and the other was hydrate B, which is a special product for the investigation. Hydrate A has higher mechanical strength than hydrate B.

We determined fragility of sandy alumina using a fluidization apparatus developed by Forsythe & Hertwig.(6) This fragility is expressed as the attrition index.

Two types of hydrate, which had different mechanical strength, were calcined in our system. The results are shown in Table II. Particle breakdown of the two types is almost the same. This indicated that our calcining system has an advantage in particle breakdown.

The granulometry of the test hydrates is shown in Fig. 2.

Particle breakdown in our system, expressed by the % difference of minus 325 mesh between alumina and hydrate, is 2-3 % for both hydrates.

Table II. Particle Breakdown

	Hydrate A	Alumina A	Hydrate B	Alumina B
Particle size + 325 mesh (%)	96	93	95	93
Breakdown 325 mesh (%)	3	3	2	2
Attrition index on 325 mesh (%)	3	10	7	12

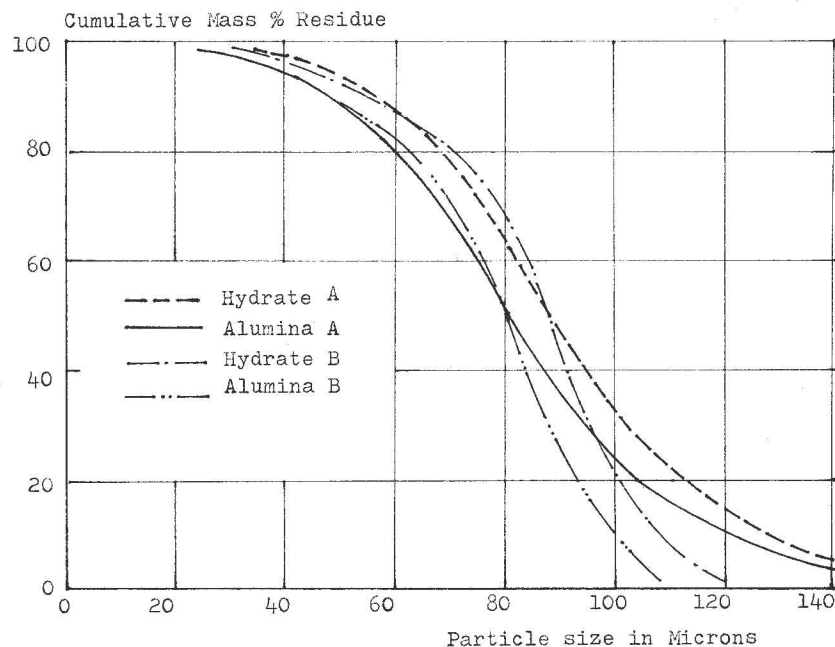


Fig. 2 Granulometry of Hydrate and Alumina

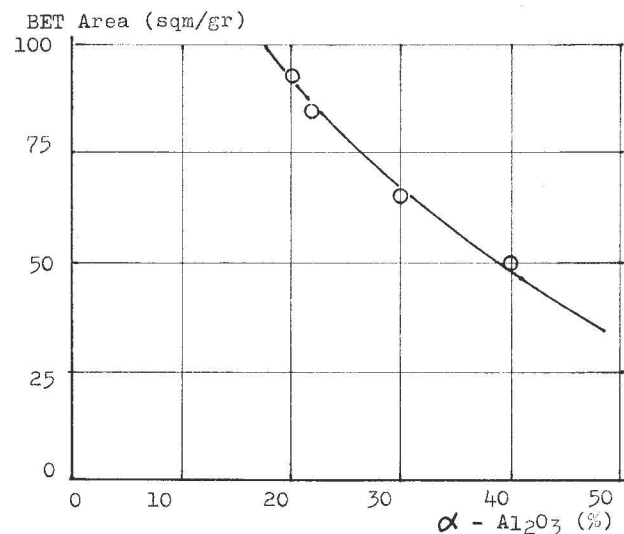


Fig.3 BET Area and Alpha Alumina Content

Alumina Characteristics

Physical properties and chemical composition of alumina from hydrate A in our system are shown in Table III.

Fig. 3 shows the correlation obtained between alpha alumina content and BET specific surface area of alumina A. In our calcining system, we can control any BET surface area along this curve.

Table III Physical Properties and Chemical Composition

Physical Properties			
BET specific surface area	(sqm/gr)		65
Alpha alumina	(%)		30
L.O.I. (300-1100°C)	(%)		0.68
Angle of repose			33
Bulk density	(gr/cm ³)	min.	0.95
		max.	1.08
Particle size + 325 mesh	(%)		93
Chemical Composition			
Na ₂ O	(%)		0.35
SiO ₂	(%)		0.014
Fe ₂ O ₃	(%)		0.011
TiO ₂	(%)		0.005

Improving Capacity and Energy Consumption at Rotary Kiln

In recent years, the demand for non-smelting grade alumina, mainly for refractories and electrical ceramics, has been increasing. The most important property of these aluminas is well-controlled ultimate crystal size of alpha alumina corresponding to the usage.

Now, we have calcined not only smelting grade alumina (sandy & flourey alumina) but these non-smelting grade aluminas in the rotary kiln system.

Thus, the rotary kiln has the advantage of flexibility to be able to calcine various kind of aluminas.

We have improved capacity and energy consumption by means of adding flash dryers to the rotary kiln for flourey alumina.

The history of the improvement is shown in Table IV.

Table IV. The history of Improving Rotary Kiln

	Year	Operating Rate (m.t.p.d.)	Oil Unit Consumption (liters/t)
1) Original Design (for flourey alumina) Main components o Rotary kiln o Rotary cooler	1941	90	195 (7600MJ/t)
2) Addition of 1-stage flash dryer (for flourey alumina) o Rotary kiln o 1 stage flash dryer o Rotary cooler	1951	200	160 (6200MJ/t)
3) Addition of 2-stage flash dryer (for flourey alumina) o Rotary kiln o 2 stages flash dryers o Rotary cooler	1958	350	125 (4900MJ/t)
NLM's technology of calciner for flourey alumina was completed.			
4) Calciner for flourey alumina based on NLM's technology o Rotary kiln o 2 stages flash dryers o Planetary coolers o Rotary cooler	1969	550	117 (4500MJ/t)
5) Conversion into sandy alumina calciner	at Present	800	83 (3200MJ/t)
6) In the case that fludized cooler is installed after planetary coolers and air is utilized as combustion air, oil unit consumption will be improved.	future possibility	(800)	(79) (3100MJ/t)

Conclusion

- (1) In the rotary kiln system, remarkable heat-saving and capacity improving can be achieved through adding flash dryers, remodelling burner and reinforcing heat recovery.
- (2) 83 liters of oil per tonne of alumina (3200MJ/tonne) has been achieved for calcining 800 m.t.p.d. of sandy alumina in the rotary kiln with two-stage flash dryers and planetary coolers. The kiln was originally designed for flourey alumina at 550 m.t.p.d.
- (3) The advantage of the rotary kiln is to be able to calcine non-smelting grade alumina for refractories and electrical ceramics.

References

- (1) C.C.Cook and G.R.Swamy, "Evolution of Fluoride Recovery Processes in Alcoa Smelters", Light Metals, 1971, pp. 465-478, AIME
- (2) H.W.Schmidt et al, "Flexibility of the Fluid-Bed Calciner Process in View of Changing Demands in the Alumina Market", Journals of Metals, Feb. 1980.
- (3) L.Reh et al, "Application of Circulating Fluid Bed Calciners in Large-size Alumina Plants", Light Metals, 1973, pp. 519-532, AIME
- (4) E.W.Lusky, "Experience with Operation of the Alcoa Fluid Flash Calciner", Light Metals, 1980, pp. 69-79, AIME
- (5) B.E.Raahauge et al, "Industrial Prospects and Operational Experience with 32 mtpd stationary Alumina Calciner", Light Metals, 1980, pp. 81-101, AIME
- (6) B.E.Raahauge et al, "Application of Gas Suspension Calciner in Relation to Bayer Hydrate Properties", Light Metals, 1981, pp. 229-249
- (7) W.L.Forsythe jr and W.R.Hertwig, "Attrition Characteristics of Fluid Cracking Catalysts", Ind. Eng. Chem. vol 41, 1949, pp. 1200-1206