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DO 1589

United Nations Industrial Development Organization

Distr.
LIMITED
ID/WG.11/3
29 April 1968
ENGLISH ONLY

First Meeting of Expert Consulting Group
on the Aluminium Industry
Vienna, 10-17 November 1967

REQUIREMENTS FOR ALUMINA FOR THE PRODUCTION OF ALUMINIUM IN AN AUSTRIAN ALUMINIUM REDUCTION PLANT [1]

by

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[1] The views and opinions expressed in this paper are those of the author and do not necessarily reflect the views of the Secretariat of UNIDO.

This paper was first presented at a meeting of experts consulting on the aluminium industry in Vienna at UNIDO headquarters, 10-17 November 1967.

SUMMARY

The Austrian aluminium industry is capable of high production based on water power from the Alps. In 1898 a Swiss company established a small aluminium reduction plant in Lend, Salsburg with a hydroelectric generating station. In 1940 significant aluminium reduction works were constructed in Ranshofen, Upper Austria. Both works produced about 78,000 tons of virgin aluminium in 1966. During the war the works in Ranshofen processed Hungarian bauxite. This bauxite was transported along the Danube and Naab to an alumina factory in Schwandorf, Bavaria for the production of alumina. After this procedure the aluminium was transported along the Naab and Inn rivers to Ranshofen.

Austria itself does not possess an alumina factory, therefore, it has to import aluminium oxide from several countries. By reason of the various supplies of alumina it is necessary to sign detailed agreements with the suppliers, especially to define quality. Quality requirements refer to the physical and chemical properties of alumina which are important for the economy of aluminium production and the purity of the produced aluminium. Among the physical properties most attention is paid to the modification and grain size of aluminium oxide. The impurities of aluminium oxide determine the purity of the produced aluminium and also influence the economy of the electrolysis process. The effects of physical properties and particularly impurities are treated in the paper and reference is made to special methods of researching aluminium oxide.

Contents

Tables

I. Development of the aluminium industry in Austria

1. The Austrian aluminium industry is capable of high production based on water power from the Alps. In 1898, at the beginning of industrial aluminium production, a Swiss company established an aluminium reduction plant in Lend, Salzburg, connected with a water-power station. The situation in the narrow valley of the river Salsach prevents an extension of this plant. Nevertheless, after setting up modern electrolysing cells the present output is 10,000 tons of aluminium a year. In 1940, during the war, efficient reduction plants with a capacity of about 65,000 tons were constructed in Ranshofen, Upper Austria. These plants produced about 78,000 tons of virgin aluminium in 1966.

2. The plants in Ranshofen used Hungarian bauxite during the war. This bauxite was transported along the Danube and Naab rivers to a factory in Schwandorf in Bavaria for the production of alumina which was then transported along the Naab and Inn rivers to Ranshofen. After the war the Ranshofen plant was separated from the bauxite in Hungary and the alumina factory in Germany by the newly established borders. Austria itself does not possess bauxite or an alumina factory; therefore, it must import aluminium oxide from several countries.

II. Alumina purchase

3. In recent years alumina has been purchased from the following factories: Gebrüder Giulini, Ludwigshafen, FRG; VAW Bonn, FRG; Lippewerk Lünen, FRG, Nabwerk, Schwandorf; Martinswerk, Bergheim on Erft (Alusuisse); Pechiney S.A., alumina plants of Gardanne, Salindres and Marcelle; Montecatini, Italy; SAVA, Italy; Yugoslavia plants in Kidrićevo and Moste; Hungary, Mineralimpex from the plants Almasfusitői and Moson Magyarova; FRIA over Conakry, Guinea, West Africa (by the firms Olin, Matison and NOSTA); Surinam - Alcoa Company (Suralco) from the Billiton plant in the United States.

III. Details of the Austrian aluminium plant "Vereinigte Metallwerke"

4. In the reduction plants of Ranshofen, about 1.3 milliard kWh are required and about 140,000 tons of alumina are used for the production process. The alumina is transported to the plants of Ranshofen from all the mentioned resources by large wagons with a volume up to 60 tons and is discharged pneumatically into silos with a height of 40 m. Two newly established deep-silos shaped like balls are covered with aluminium sheets. Six silos contain 5,000 tons each, amounting to 30,000 tons of alumina, the consumption of a quarter of a year.

5. From these silos alumina is dispersed directly to the electrolytic cells. By means of small trucks the alumina is brought to the cells and laid down over a freezed bath surface and about three times a day it is mixed in the liquid salt mixture, consisting of about 5 per cent alumina and 95 per cent cryolite. By reasons of the various supplies of alumina it is necessary to sign detailed contracts with the different suppliers, especially for defining quality. In the different agreements the various factory processes have to be taken into consideration. For example, Table 1 shows the agreed maximum chemical impurities from plants in South America and Hungary with important different values. In general, Hungarian alumina is much more impure than South American alumina.

Table 1

Alumina-Agreement - Maximum chemical impurities
(in percentage)

	South America	Hungary
SiO_2	0.03	0.06
Fe_2O_3	0.033	0.06
TiO_2	0.006	0.006
Na_2O	0.650	0.40
ZnO	0.020	0.02
V_2O_5	0.002	0.015
P_2O_5	0.001	0.025
CaO	0.060	0.04
MnO	0.001	0.015
CuO	0.005	0.015
moisture	1.5	1.0

6. The agreement also contains the methods of analysing and questions about claims in case of deviations in the purity of alumina according to the agreement. Higher impurities can be compensated by subsequent delivery, free of charge. In case of all matters in dispute a court of arbitration will be appointed.

IV. Quality requirements of alumina

7. Quality requirements refer to the physical and chemical properties of alumina and are important for the economy of aluminium production and the purity of the aluminium produced. The metallic oxide impurities of alumina in electrolysis are completely transmitted as reduced metal in the virgin aluminium, corresponding to the factors in the diagram. This passes mainly for Fe, Si, Ti, Cu, Zn, V, Cr, Mn, B and Ga. Table 2 shows the annual average of alumina analysis values from different resources. For example, alumina from Germany and Africa has a reasonably high purity while alumina from eastern countries is rather impure.

Table 2

Alumina-analysis - annual average

	South America	Africa	Germany	Yugoslavia	Hungary
Benzene sedimentation	19/16	17/15	16/15	16/13	20/16
Bulk density g/l	950	868	872	972	840
Vibration density g/l	1423	1258	1251	1286	1192
Angle of repose	44	42	41	35	46
% - Al_2O_3	44	91	94	83	80
Fe_2O_3 %	0.026	0.012	0.013	0.037	0.029
SiO_2 %	0.021	0.021	0.014	0.020	0.024
TiO_2 %	0.003	0.002	0.002	0.004	0.006
ZnO %	<.001	<.001	0.007	0.007	0.006
CaO %	0.009	0.060	0.017	0.012	0.023
SO_3 %	0.048	0.248 (max. 0.20)	0.041	0.073	0.060
Na_2O ges. %	0.26	0.69	0.34	0.37	0.51
CuO %	0.002	<.001	0.002	0.002	0.002
V_2O_5 %	<.001	0.002	0.002	0.001	0.006
Cr_2O_3 %	<.001	<.001	<.001	<.001	<.001
Mn_2O_3 %	<.001	<.001	<.001	<.001	<.001
P_2O_5	<.001	<.001	<.001	0.002	0.007
B %	<.001	<.001	<.001	<.001	0.001

8. Impurities are, of course, reduced also in a large amount from coal into virgin aluminium. Table 3 shows the impurities of coal blending in the anode, containing coke from pit coal or coke from petroleum. In consideration of the production of one ton of aluminium out of two tons alumina about 0.6 tons anode coke is used, impurity of coke in the virgin aluminium is also important.

Table 3

Söderberg substance - coke and pitch

	of pit coal	of petroleum
Ash %	0.277	0.322
Fe %	0.034	0.043
Si %	0.017	0.022
Zn %	0.038	0.017
Pb %	0.039	0.017
V %	<.001	<.003
Ca %	0.006	0.025
S %	0.590	1.170
Mn %	0.0008	0.0006

9. Impurities have to be taken into consideration. Therefore, as far as possible rather pure coke should be used. Fe and Cu reduce the corrosion resistance of aluminium. Ti, V and Mn reduce the electric conductivity of aluminium, but Ti can be eliminated from the aluminium-melt by addition of B as an intermetallic compound TiB_2.

10. In the electrolysis itself there are disturbing and undesirable impurities. Moisture caused pyrohydrolytically by formation of fluorine hydrogen results in important loss of fluorine. Moreover the moisture, in cases of immediate evaporation, results in the formation of dust. Sodium oxide must be compensated for by the addition of expensive AlF_3 in the molten cryolite-alumina-electrolyte. Calcium increases the density of the melted electrolyte. Therefore the sedimentation of virgin aluminium is more difficult and by repeated reduction and oxidation at cathode and anode, losses of electric energy can occur. But this disturbance is noticed only over a content of 9 per cent CaO in the electrolyte. It should be mentioned that in alumina of FRIA and Pechiney the Ca content is remarkably high because there is CaF_2 added to obtain a better calcination. P_2O_5 content causes losses in electric energy during repeated reduction and oxidation at cathode and anode. SO_3 is undesirable only because of pollution of exhaust gases. It does not disturb the progress of the electrolysis. B eliminates Ti forming the intermetallic compound TiB_2. This is desirable for the use of virgin aluminium in electrical engineering to improve the electric conductivity, but for the production of Ti-containing alloys it is undesirable because of the loss of Ti.

V. Chemical and physical properties of alumina

11. The physical properties of alumina are effective as follows: sise and shape of the grain influence the loss on alumina dust (fine grain) and the solution speed (large grain). The component of modification α Al_2O_3 has different effects. α Al_2O_3 is not hygroscopic, on the contrary γ Al_2O_3 absorbs moisture quickly. Therefore, for long transportation a high content of α Al_2O_3 and a low content of γ Al_2O_3 is preferred because of the low tendency to absorption of water. This is of great importance for the reduction plants in Ranshofen (desirable is more than 90 per cent of α Al_2O_3). But in the molten electrolyte the solubility of α Al_2O_3 is lower. Therefore, in South America a lower content of α Al_2O_3 (44 per cent) is preferred.

VI. Control of alumina

12. The chemical and physical control in the enormous quantity of 140,000 tons of alumina a year, which arrives in wagons with a volume of 20 to 60 tons each coming from different plants, requires many selections of samples and analyses. Today analyses are made mainly by a physical method with X-ray fluorescence apparatus. For this

method the alumina sample is pressed into a ring and is irradiated in the apparatus with X-rays of chromium or gold tube. By this treatment the components of the sample are stimulated to the fluorescent radiation and those rays can be analysed. The X-ray fluorescence method is used for the analysis of metallic compounds. The determination of the concentration of modification on alumina is done in the diffraction method.

13. The development of alloys follows a production of materials with increased purity; this refers mainly to the impurities Fe and Si. For example, just recently it had been noticed that the mechanical properties of heat-treatable alloys are more favourable if those impurities are lower. This occurs in the casting alloys AlSi10Mg and AlCu4Ti. The demand on a better corrosion resistance increases the requirement for purer virgin aluminium and aluminium alloys. Therefore, there exists a requirement of lower contents of impurities, mainly Fe and Si, in alumina and furthermore of uniform production methods in the alumina industry, resulting in uniform contents of impurities in alumina.

Table 4

Virgin aluminium in different grades
(DIN 1712, Blatt 1, ÖNORM M 3426)

		Maximum %	
	Al 99	Al 99.5	Al 99.9
Si	0.5	0.30	0.050
Fe	0.6	0.40	0.035
Ti	0.03	0.03	0.035
Cu	0.02	0.02	0.005
Zn	0.08	0.07	0.04
V	0.03	0.03	0.003
Mn	0.03	0.03	0.003

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