

## AL34 - Analysis and Solution of Problems in Early Alumina Conveying System

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### Abstract

Early alumina conveying system uses dense phase pipes to transport alumina to the alumina silo, which consumes high energy and has a high alumina attrition rate, which directly affects the production efficiency of electrolysis pot. Nowadays, in order to reduce energy consumption and reduce the rate of alumina attrition, alumina conveying systems often use air slide or belt conveyor to transport alumina. Based on the analysis of the defects of early alumina conveying system, this article introduces the current popular conveying systems, providing a certain reference for the design of alumina conveying systems.

**Keywords:** Electrolysis pot, Alumina conveying system, Air slide, Belt conveyor.

### 1. Introduction to Early Conveying Systems

Under the current situation, energy conservation and environmental protection are eternal topics for national and global development. Especially in China, in recent years, under the policy of tiered electricity prices, various aluminum smelters have made great efforts to save energy and reduce its consumption, striving to reduce the production cost of aluminum per tonne and maximize profits. For established and operating aluminum smelters, in addition to local optimization design of electrolytic pots, the transformation and optimization of supply and auxiliary systems cannot be underestimated, such as anode assembly, crushed bath transportation and storage systems, and alumina conveying systems. If the above supply and auxiliary systems are well transformed and optimized, it will greatly reduce the production cost per tonne of aluminum and achieve the goal of energy conservation and consumption reduction for the smelter. This article focuses on analyzing the shortcomings of the early alumina conveying system, and introduces several typical cases of alumina conveying transformation based on the mature alumina conveying technology at home and abroad.

#### 1.1 Dilution Conveying Technology

When the material to gas ratio in the pipeline is such that bulk density ( $\rho$ ) is smaller than  $10 \text{ kg/m}^3$ , solid particles form a suspended dilute phase in the fluid and are carried out together with the fluid from the fluidized bed; this process is called dilute phase transportation. Dilute phase transportation is a traditional method for transporting alumina in aluminum smelters and belongs to the dynamic pressure technology in pneumatic transportation. It requires high air speed (the material flow rate in the conveying pipe is around  $35 \text{ m/s}$ ), so some energy is lost during the energy transfer process. Therefore, the energy consumption is high and the material-to-gas ratio is low, so that generally  $\rho = 7\text{-}10 \text{ kg/m}^3$ . The pipeline is severely worn, and the transported alumina suffers severe attrition. Currently, dilute phase transportation of alumina has been mostly replaced by dense phase transportation.

## 1.2 Dense-Phase Conveying Technology

In pipelines, when the material to gas ratio is such that bulk density  $\rho = 10\text{-}30 \text{ kg/m}^3$ , it is called dense phase transportation [1]. The dense phase conveying system is a system with a special structure that generates static pressure to push the material plug to transport materials. The dense phase transportation pipeline is composed of an inner tube and an outer tube, with a specially designed inner tube welded to the upper wall of the outer tube. The use of inner tubes is the key to dense phase transportation, and the opening distance of the inner tubes and the airflow speed during the transportation process have a great impact on the process. The entire transportation process is carried out based on the principle of minimum resistance.

## 2. Current Status of Alumina Conveying Systems

At present, domestic aluminum smelters in China mostly use dense phase conveying systems. Taking an aluminum smelter with an annual production of 200 000 tonnes of aluminum as an example, the maximum distance between the alumina warehouse and the fresh alumina silo is as far as 200 meters. The unloading platform inside the alumina warehouse uses manual bag cutting to unload the material, and then the fresh alumina is transported to the new fresh alumina silo through a dense phase pipe. The entire transportation process has a long distance and a large height difference (up to 30 meters), and the maximum transportation capacity of the dense phase pipe is only 50 t/h. This method not only has a long working time and high energy consumption, but also increases the attrition rate of alumina materials. To address this situation, we have combined the actual production of the factory to renovate the alumina conveying system. Through the transportation method of hyper dense phase conveying and bucket elevator lifting, we strive to reduce the cost of alumina conveying and achieve the goal of energy conservation and reduction of energy consumption.

## 3. Transformation of Alumina Conveying System

### 3.1 Introduction Transformation Plan

The transformation plan is shown in Figures 1 and 2. A new unloading funnel is built in the original alumina warehouse. After the bagged alumina is unloaded from the unloading funnel, it is transported to the bucket elevator through an air slide. Once being lifted to the buffer bin, it crosses the potroom through the air slide and ultimately reaches the number 1 and number 2 alumina silos. This plan is designed as two lines, located at the east and west ends of the alumina warehouse.

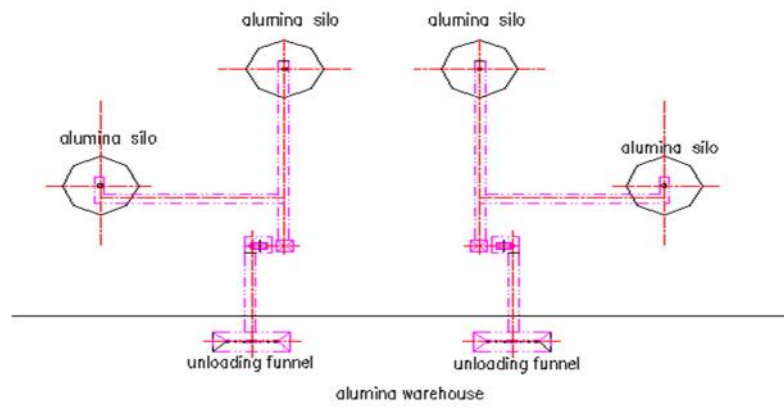
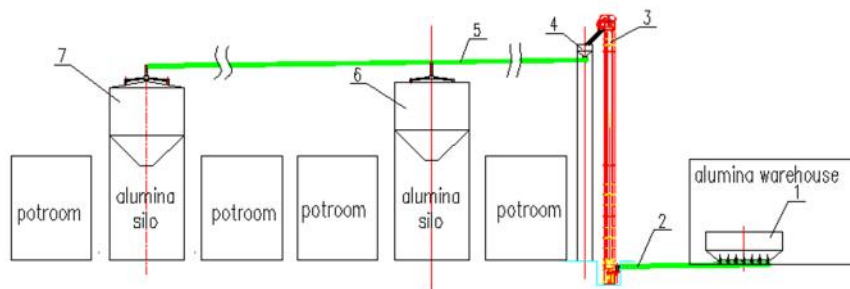


Figure 1. Layout of transformation plan.



1- unloading funnel; 2- air slide; 3- bucket elevator; 4- buffer bin;  
5- air slide; 6- 1# alumina silo; 7- 2# alumina silo

**Figure 2. Transformation plan for alumina conveying system.**

The smelter produces 200 000 tonnes of aluminum annually, requiring approximately 384 000 tonnes of alumina per year. Therefore, the two conveying lines need to transport 1052 tonnes of alumina per day. The designed conveying capacity of the air slide is 120 t/h per line, and a line only needs to work for 4.38 hours per day to meet demand.

The main process equipment newly added in this renovation is shown in Table 1.

**Table 1. Main process equipment added.**

<i>Equipment Name</i>	<i>Standard</i>	<i>Quantity</i>
L - Low resistance air slide	Air slide width B = 400 mm	A batch
Unloading funnel	300 t	2
Centrifugal fan	P = 10 020 Pa, Q = 8 858 m <sup>3</sup> /h	8
Bucket elevator	120 t/h	2
Buffer bin	15 t	2

### 3.2 Expected Economic Indicators

Before the transformation, the energy consumption for alumina transportation was 35 kWh/t Al. After the transformation, the direct energy consumption of the conveying section will be reduced to below 5 kWh/t Al. In electrolysis production, due to the reduction of alumina attrition rate, the electrolysis efficiency can be improved, which can save approximately 15 kWh/t Al of energy consumption. It is estimated that the two items can save more than 45 kWh/t Al in energy consumption.

### 3.3 Characteristics of the Transformation Plan

- 1) Combining advanced and mature alumina conveying technology both domestic and international sources, a combination of air slide and bucket elevator is adopted to greatly increase the alumina conveying capacity and reduce the working time of the conveying system.
- 2) The alumina conveying fan has frequency conversion control, which monitors the outlet pressure of the fan in real time by adding a pressure switch and automatically adjusts the fan speed based on the wind pressure, effectively reducing fan energy consumption.
- 3) By incorporating the silo level signal into the alumina conveying control system, workers can monitor the silo level in real time and automatically turn on or off the conveying system.
- 4) To facilitate timely maintenance of the conveying system by the staff, a wind pressure alarm device is installed at the end of the air pipe, and a blockage alarm device at the

material outlet of the bucket elevator is installed to facilitate timely maintenance of the conveying system by staff.

### 3.4 Summary of Transformation

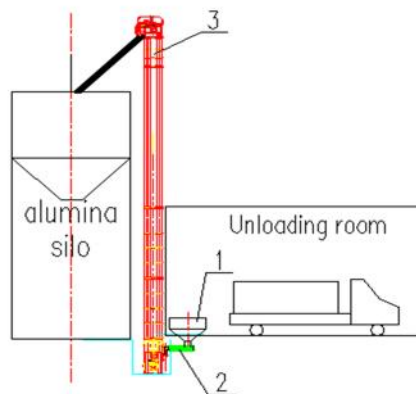
- 1) This transformation fully utilizes the existing site conditions. Based on retaining the original dense phase conveying system, a new hyper dense phase conveying system is added. The original dense phase conveying system can temporarily inject materials in the event of a malfunction in the new hyper dense phase conveying system, ensuring normal production in the potroom.
- 2) Due to limitations in on-site space and the source of alumina from production plants (bagged alumina), this transformation still retains the manual bag cutting and unloading method, without effectively reducing labor costs. At the same time, manual bag cutting and unloading can easily cause alumina to fly, which is harmful for the workshop environment.
- 3) The above transformation case is limited by the on-site space and the source of alumina, and still retains the manual unloading method. At present, in China, the use of containers for alumina transportation has gradually become the mainstream. In subsequent transformations, we have also gradually abandoned manual bag cutting and unloading, and instead adopted car tipping unloading. At the same time, we fully take into account the on-site conditions to make the transformed conveying system more reasonable.

## 4. Other Transformation Cases

Taking a smelter in southern China as an example, this smelter also has a dense phase conveying system. The space between the two potrooms is open, and transportation vehicles can be driven directly to the alumina silo. At the same time, the smelter will gradually abandon bagging for alumina transportation and use car containers instead. Therefore, when transforming the alumina conveying system, the above two points should be fully taken into account to make the transformed conveying system shorter and more reliable.

### 4.1 Transformation Plan

As shown in Figure 3, a new alumina unloading room will be built next to the existing alumina silo. The unloaded alumina from the container will be transported to the silo using a bucket elevator combined with an air slide. From the perspective of production and operational costs, the combination of bucket elevator and air slide has the lowest operating cost, with the operating cost per tonne of alumina conveyed only about one-fifth of that of dense phase conveying.



1- unloading funnel; 2-air slide; 3- bucket elevator

**Figure 3. Transformation plan diagram.**

#### 4.2 Characteristics of this Transformation

- 1) Compared with the above transformation case, after this transformation, alumina is directly transported to the unloading room next to the alumina silo by car containers, and the material is directly dumped and unloaded in the unloading room, eliminating the process of manual bag cutting and greatly saving labor costs.
- 2) Only the air slide is used between the unloading funnel and the bucket elevator, and the air slide is only 3 meters long. There is no need to add a centrifugal fan for the air slide, and it only needs to be connected to the compressed air pipeline network of the potroom, which not only saves energy but also reduces the attrition rate of alumina.
- 3) The process flow of the conveying system is simple, and the main electrical equipment is a bucket elevator, greatly simplifying the control system, reducing the failure rate of the system, and facilitating its maintenance and repair.
- 4) The power consumption for dense phase transportation is about 35 kWh/t Al. The transformed conveying system consumes about 15 kWh/t Al, down from previous 20 kWh/t Al. Additionally, compared to the original dense phase transportation method, it can effectively reduce the attrition rate of alumina, improve current efficiency by about 0.5 %, and reduce energy consumption by about 60 kWh/t Al. The total energy saving of the above two items is estimated to be 80 kWh/t Al.
- 5) Based on the annual production capacity of 320 000 tonnes of the factory, and considering electricity price of 0.5 yuan/kWh, the annual cost savings can be approximately 12.8 million yuan. Namely:  $80 \times 0.5 \times 320\,000 = 12\,800\,000$ . Note that the cost of truck logistics was not considered in this saving.

#### 5. Conclusion

Energy conservation and consumption reduction have become the trend, and for aluminum smelters, transforming and optimizing the alumina conveying system is an important step in achieving these goals. The original alumina conveying system had technical limitations and high energy consumption. For smelters, reasonable transformation and optimization of the alumina conveying system, based on their own production situation can effectively reduce the energy consumption of the alumina conveying system.

#### 6. References

1. Lingzhi Dai, Analysis of causes and preventive measures for wear of alumina dense phase transportation pipeline, *Gansu Metallurgy*, 2007 Volume 29 (5), 86-87.