INCREASING DUST-CHAMBER EFFICIENCY OF ROTARY FURNACE FOR MAGNESITE TREATMENT

doc. Ing. Jan Spisak, PhD.,
Ing. Dusan Nascak, PhD.,
Ing. Eva Oravcova
Development And Realization Workplace Of Raw Materials Extracting And Treatment, Faculty Of Mining, Ecology, Process Control And Geotechnology, Technical University of Kosice

Abstract

Magnesite is a basic carbonate material used as caustic magnesia in agriculture and industry and as raw material for the production of sintered magnesia. As a basic refractory material, the magnesite is mainly used for high-temperature aggregates in the mining and processing industry. In the mechanical and heat treatment of magnesite due to decrepitation of magnesite, a number of fine grained and dust particles are formed. Currently, only part of the material is processed. This paper presents new opportunities for improving the capture process of dust wastes (flue dust). The solution is focused on application to the rotary kilns (RP). The proposed solution allows a significant contribution to the capture and subsequent treatment of the flue dust. Thus, partially implemented adjustments create the possibility of effective recovery of this type of waste.

Keywords: Waste, dust-chamber, magnesite, rotary furnace

Introduction

Flue gas stream in the furnace aggregates with a high velocity entrains a part of the fine-grained particles which are moved in a fluid by the movement of the charge – flue dust is produced. Decrepitation magnesite with a low content of crystalline MgO, and the high surface area (very fine-grain) is therefore the primary source of flue dust. Dedusting the decrepitation magnesite from furnace aggregates is a technologically essential process because the extremely intermediate product is cumulated in the furnace flue dust.

The present status of the problem

Magnesite firing of the rotary furnaces is accompanied by the formation of large amount of flue dust entrained by combustion gases. From a qualitative point of view, the flue dust is incompletely calcined magnesite with a low content of incompletely calcined dolomite. The volume of CO_2 remaining in the entrained flue dust represents loss on ignition (we often use a term loss on ignition).

The value of loss on ignition of the flue dust depend on the type of furnace unit, i.e. whether it is a flue dust produced from rotary furnace or shaft furnace. The material entering to the rotary furnace has a high temperature and prior to flue dust entrainment, a thermal decomposition of carbonates is performed (a loss on ignition in flue dust in rotary furnace is from 10 to 20 %). The fine-grained material of rotary furnace is moved in a fluid intensively (autogenous milling), more evenly (due to the rotational movement of the furnace) and it is directly (horizontally - without condensation) entrained by the flue gas into the flue pipe. The occurrence of flue dust from the rotary furnace is approximately 300-450 kg/t of burned clinker according to the type of burden and the type of the rotary furnace.

The section of the rotary furnace of approximately 30 m from the cold furnace head to approximately 30 m in the direction of the furnace is considered a decarbonisation zone, where is the most intense entrainment of flue dust.

Dust exhaust and treatment of the furnace dustings after magnesite thermal treatment

The devices for collecting solid and liquid admixtures from the gas streams are called dedusting (separating) equipment - separators.

Separator systems are distinguished according to:

- the type and used physical process which is used for the exhausting aero dispersive admixtures from the gas stream,
    - mechanical separators – dry and wet,
    - electric separators – dry and wet,
    - filters dry and wetted,
    - equipment including a combination of different kinds of dust collectors;
- relative position in which the separator is given according to the source and appliance,
- what is the motive of its use in the integrated system.

At mechanical separators, the devices work on the principle of sedimentation. The principle of sedimentation depending on drop in velocity of entrained grain is shown in the following figure (Fig. 1).

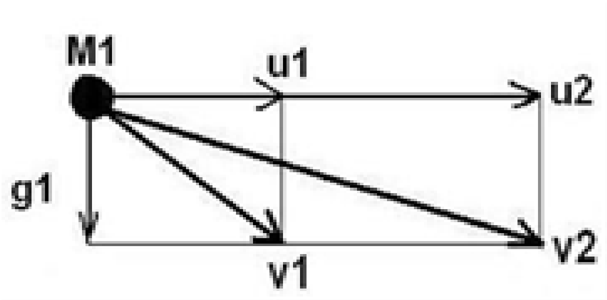

Fig. 1 Principle of sedimentation

Grain with weight of M_1 is entrained by medium (flue gases, exhausting air mass) with velocity entrainment of u_2 in a particular area (furnace, dust chamber). At the same time, a grain is attracted by own gravity g_1 perpendicular to the horizontal plane. The resultant vector of the two velocities will be the sedimentation velocity v_2 characterized by a vector of sedimentation determining the trajectory of the grain. However, if velocity entrainment u_1 falls to the value of u_2, the resultant vector of the two velocities – forces will be the sedimentation velocity v_1, characterized by a vector of sedimentation determining a new trajectory of the grain. The simplest sediment (settling) device is a settling chamber. This device is very simple and is used to capture the thickest particles (dust chamber behind the rotary furnace).

Gases exhausting in the SMZ, a.s. Jelsava technology

The creation of a large share of dusts is formed by disintegration of magnesite of breuneric type while the most valuable part of the raw materials is moved to the flue dust especially during firing in the rotary furnace. From environmental and economic point of view, flue dust capture and use is essential.

The Jelsava technology distinguishes several levels of exhausting:

1) 0° exhausting

In the flue gas line of the rotary furnace, a flue dust mixed with entrained non-decarbonized fine-grained particles is captured in Lepol grids, where it is moving back to the furnace space by elevators. Currently, Lepol grids present gravitational dust chamber. This material has a high loss on ignition and when the material is moving to the end of the furnace its granularity as well as the loss on ignition decreases.

2) 1° exhausting

1st level of the rotary furnace exhausting - multicyclone batteries which exhaust moderately thick particles.

3) 2° exhausting

2nd level of the rotary furnace exhausting - electrostatic precipitators (ESP). Due to the fact that ESP only operates as dust chambers without gravitational coagulation of dust, their separation rate is low.

4) 3° exhausting

3rd level of the cleaning equipment is built in order to reduce dust emissions into the ambient air. Each furnace has individual enlarged separator AMERTHERM.

At specific consumption of about 300 Nm^3/t of raw material in the rotary furnace, approximately 2,3 m^3 of CO_2 is entered from the burner to the flue gases due to burning of 1 m^3 natural gas. (1,74 m^3 from clinker and 0,56 m^3 from flue dust). The total amount of flue gases from the rotary furnace which is forming during operation with burning of 1 m^3 natural gas, presents a volume of approximately:

$$V_{real}(RF) = 11{,}57 + 2{,}3 = 14{,}07 m^3 NG \qquad (1)$$

At specific consumption of about 238 kg/t of raw materials in the rotary furnace, approximately 2,8 m^3 of CO_2 gets into the flue gases during burning of 1kg of heavy fuel oil. (2,19 m^3 from clinker and 0,61 m^3 from flue dust). The total amount of flue gases from the rotary furnace which is produced during operation during burning of 1 kg of heavy fuel oil presents a volume of approximately:

$$V_{real}(RF) = 13{,}15 + 2{,}8 = 15{,}95 m^3 / 1kg\ \ HFO \qquad (2$$

Reducing flue dust in rotary furnace

A self-regulating feeder and radial diffusive burner has been developed for the rotary furnace. Flue dust reducing has been achieved by increasing the thickness of the layer of the material passing through the furnace and increasing the intensity of the process using radial diffusive burner. A self-regulating burden feeder (Fig. 2) provides a desired thickness of the burden layer on the input side of the furnace. The layer thickness is decreasing towards the output side. Achieving the desired thickness of the layer of material along the length of the furnace can be reached by means of the retaining rings. Increasing the level to the burden tumbling level is carried out by placing the retaining rings on the end and along the length of the furnace. A structural arrangement of the burner is currently designed to enable the greatest amount of secondary air to enter into the combustion process. It is achieved by vortex arrangement of the stream, wherein the secondary air is drawn into a flame and the flame penetrates into the combustion air. A radial distribution of the fuel and the secondary in order to reach efficiently mixing and burning is conceptually different solution. Radial arrangement provides a cross-flame (Fig. 3) which is very short in the longitudinal direction. Thus a designed flame provides an intensive heat flow to the surface of the material.

Fig. 2 Self-regulating continuous burden feeder

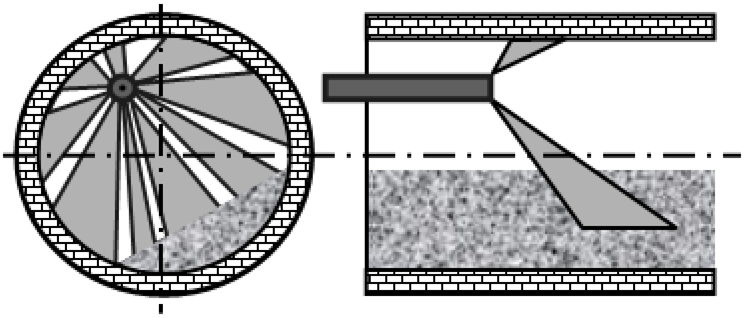

Fig. 3 Radial diffusive burner

Reconstruction of the dust chamber of the rotary furnace no. 3:

The effectiveness of exhausting the dust chamber is particularly affected by speed ratios of the flue gas flow. To increase the efficiency of the exhausting in the dust chamber, different installations are used - flow conditioners.

A design of a new form of the installation is a part of the solution. In terms of design, a vertical wall (Fig. 4) is considered. The vertical wall will guide and accelerate the flue gases stream towards the bottom of the dust chamber. In addition, it will cause a significant reduce in the flow behind the wall and a gravitation motion of dust in front of the exhausting hole in the wall of the chamber which result in increased sedimentation of dust in the dust chamber. Adjusted state with the installation and its comparison with an initial state of the dust chamber are shown in Fig. 4 and 5. The flue gases with a temperature of 300-350°C will pass through four steps of the separation of dust particles. The first step is dust chamber located behind the rotary furnace, where the coarsest particles are captured by impact of flue gas velocity change and flow refraction on vertical barrier. The same principle is used for the separation performed by cyclones, where the barrier is vertical metal spiral. Granularity of this flue dust is finer in compare with previous case. In the dust chamber and the cyclones, 75 % of the total flue dust is captured. The third step is the chamber of electrostatic precipitator which currently serves as a large-capacity dust chamber. Pipe link of the chamber of electrostatic precipitator and a cloth separator AMERTHERM located behind the shaft furnaces was built due to meet the new limits of dustiness. It currently creates a final stage of exhausting and meets emission limits with a high reserve.

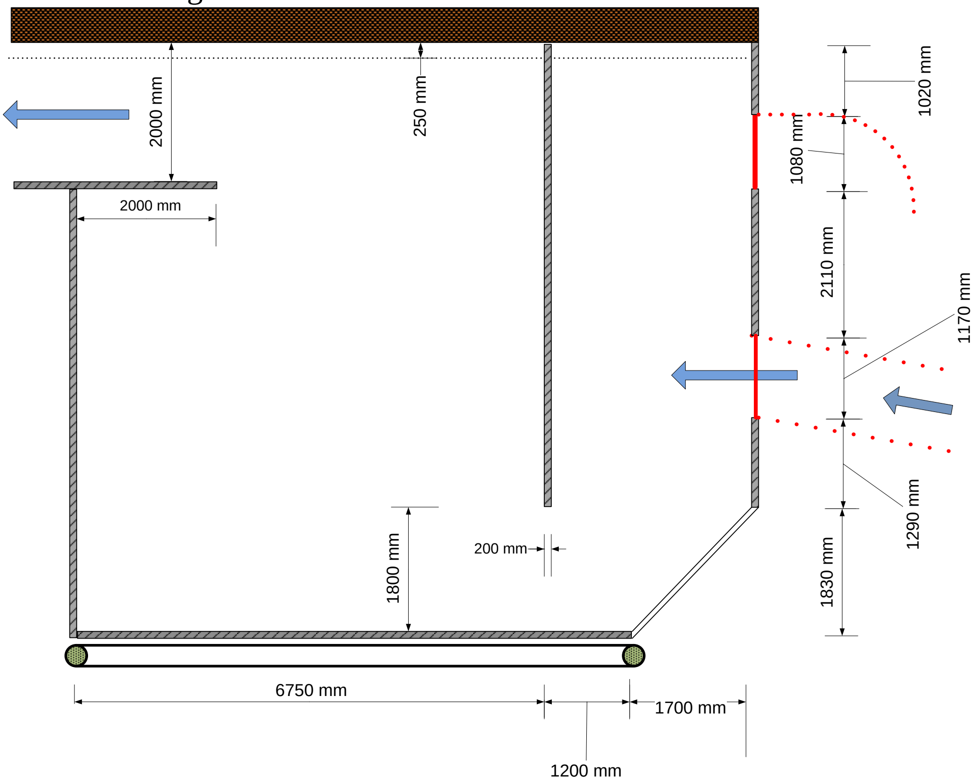

Fig. 4 Adjusted state of the dust chamber with installation utilization

Conclusion

Wastes arising from the treatment of magnesite occur in several phases of processing and adjustment (see Fig. 6). The objective of the proposed adjustment is to increase the amount of treated material that was a part of the unused waste. Use of the proposed installation will increase efficiency of dust chamber several times and will collect a greater amount of “waste” material. Captured flue dust presents a valuable semi-product which is suitable without further adjustment for magnesium processing or it can be commercially implemented under the name of Agromag after chemical and grain size treatment.

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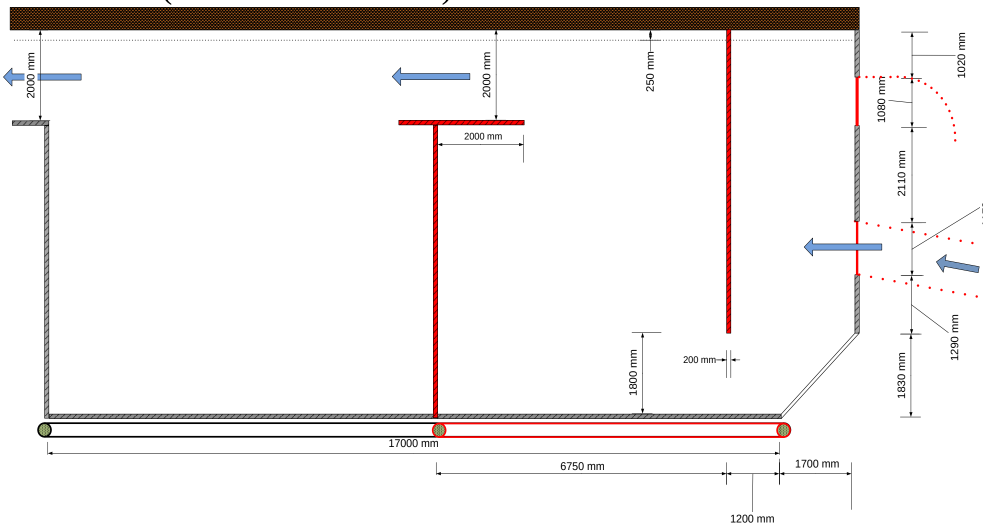

Fig. 5 Comparison of the original and the adjusted state

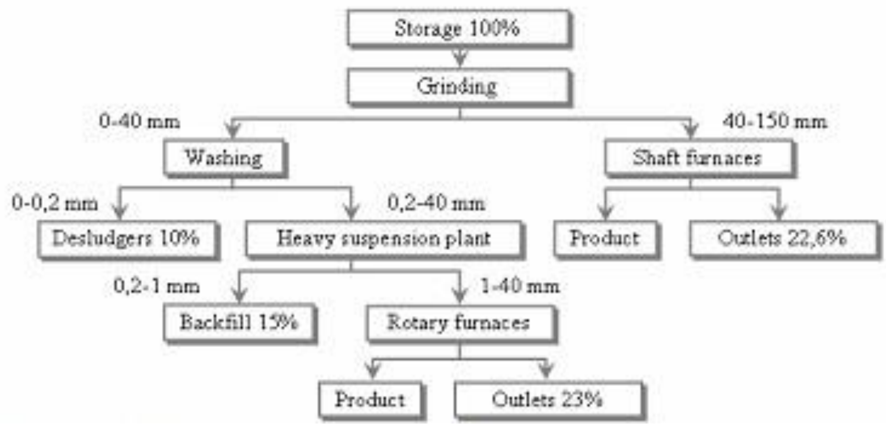

Fig. 6 Sources of fine granular magnesite fractions

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