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Possibilities of using a magnesite fines waste as an important mineral resource

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Abstract

Magnesite is a valuable material with the broad utilization mainly as the refractory and basic substance. During the mining, beneficiation and thermal treatment of magnesite the large amounts of its fines are lost despite of its high grade quality. This fact is caused by the impossibility of fines upgrading using a heavy media washing. Moreover, thermal treatment of the fines in rotary furnace is also controversial. Magnesite and/or periclase fines are formed during the sintering in the rotary and shaft furnaces and they are usually collected from the flue dusts using special filters.

The paper is focused on an enhancement of the magnesite fines recovery from preparation and beneficiation lines as well as from the thermal treatment of coarse magnesite where the flue dusts are formed. Thus, firstly, the sources of magnesite fines are identified according to processing plant flowsheet. Secondly, the possibilities of their upgrading are presented. The structure and properties of magnesite fines, economic and environmental aspects of their use and new concepts of thermal plant are considered. Proposed concepts are based on reducing the amount of the dust waste and designing the new technologies, which enable effective thermal treatment of these materials and thus a full-value application of these technologies. New development was aimed at an improvement of the magnesite fines thermal treatment.

Key words: magnesite fines, new concept of thermal treatment

Introduction

Magnesite industry produces the basic refractory materials necessary in the metallurgical and cement industries. Chemically pure magnesite contains 47.8 % MgO and 52.2 % CO_2. The principal harmful components are represented by CaO, SiO_2, Fe_2O_3, which unfavourably influence its quality from the technological point of view, because only the magnesia (MgO) is a utility component. These impurities often occur in the magnesite deposit as accompanying minerals, namely the dolomite, calcite and quartz. Magnesite from the Jelšava deposit is typical by the higher iron content due to the isomorphous replacement of magnesium by iron in its lattice. This ferroan magnesite is called breunnerite – $(Mg_{0.9–0.7}Fe_{0.1–0.3})CO_3$ (up to 9 % FeO) and it is a member of magnesite – siderite isomorphous series (Šalát and Ončáková, 1966). The magnesite in Jelšava deposit is accompanied above all by dolomite.

Owing to the high losses of the utility component in wastes during beneficiation and calcination a new technique is proposed. Universal technology of magnesite fines recovering is as follows: gaining, beneficiation, dressing, calcinations, calcinate upgrading, calcinate final treatment (Staroň and Tomšů, 1992).

Magnesite fines recovering

Magnesite fines can be recovered from wastes of beneficiation plant and from the flue dust of the shaft and rotary furnaces (Fig. 1). Raw magnesite upgrading in the heavy media suspensions is aimed at an obtaining of suitable qualitative parameters of the feed to thermal units. Contents of impurities in the magnesite fractions bellow 40 mm as a dependence on the grain size are given in Tab. 1 (Anonymous, 1998). Only the fractions above 0.2 mm are subjected to washing in the heavy suspensions. Subsequently, upgraded material with the grain size above 1 mm is fed to rotary furnaces. As it can be seen in the flowsheet in Fig. 1 a significant amount of fines is removed from the technological process. These fractions have a very high potential for increasing the usability of mined out raw material.

Thermal treatment of magnesite fines

The magnesite flue dust forms during the calcination and sintering in the shaft and rotary furnaces. Raw magnesite with the grain size of 40 – 200 mm is sintering in the shaft furnaces. Rotary furnaces are working on the counter-flow heating system. Cap of the furnace on the clinker output forms hot bulb in which is situated the burner into which the fuel and primary combustion air is supplied. Material movement in the rotary furnaces is provided by its rotation. Thermal processing of magnesite includes the following steps: preheating, decarbonization, sintering and cooling. Firstly, the drying (removing of presented H_2O) and preheating of the feed is performed. Subsequently, the decomposition of magnesite (decarbonization) starts at the temperature 399 °C according to equation:

$$MgCO_3 = MgO + CO_2$$

The decomposition of $CaCO_3$ begins at the temperature 600 °C. During decomposition the mass loss of the feed attains approximately 50 % (CO_2). The product is a high--cavernous caustic magnesite with the porosity above 45 %. It does not have qualities of the refractory material and that is why the temperature must be increased so the sintering process occurs. To obtain dense sintered product, the temperature should be above 1 600 °C. Fine fractions are formed in the calcinations stage by decrepitation.

Exploitability of co-products originated after the heat treatment

Basic property of the breunnerite is the high break down of its grains through the decarbonization process called decrepitation. Owing to the contra current working mode of the shaft and rotary furnaces a large amount of the flue dust is typical. Their granulometry and chemistry depends on parameters of the thermal treatment. By calcination at 1 000 °C caustically calcinated magnesite is obtained. Such clinker has a high reactivity and its surface area attains tenths m^2/g. Decrepitation of crystalline types of magnesite through the calcination process is acceptable effect.

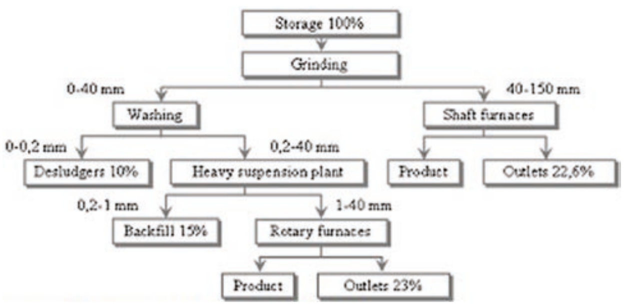

Fig. 1. Sources of fine granular magnesite fractions.

Accompanying minerals are practically undecomposed up to 900 °C and for this reason they can be separated by screening. Especially the fractions below 1mm, which are rich in MgO may be simply obtained and in such way can contribute to increased utilization of the raw material.

The calcination of breunnerite at temperatures above 750 °C results in the magnesioferrite formation as a substantial part of the calcinated material. Thus, a part of the calcinated material becomes ferromagnetic and can be magnetically separated. Calcination has to be controlled in conditions suitable for the magnesioferrite creation with sufficiently long time for its formation. The magnetic separation of calcinated material is usually carried out at a magnetic field induction of 0.1 – 0.2 T. The separation efficiency depends on CaO content, i.e. on dolomite content in the feed. Naturally, the separation sharpness can be unfavourably influenced by the intergrowth of magnesite and dolomite. Generally, described technique enables iron removing from the magnesia and in such way to obtain valuable product.

Improvement of thermal approaches

The economic recovery of the valuable minerals using the thermal treatment is influenced by the energy consumption and costs, which cover a pollution control (Repiský, 1997).

Present technologies

Shaft and rotary furnaces produce the dust in an amount of 15 – 20 % and 30 – 35 % of the fed material, respectively. For this reason their improvement was focused on the decreasing of the dust creation. Basic solution is to increase the furnace thermal efficiency. In the case of the shaft furnaces it was achieved by rearranging of the combustion system. The homogenization of the sintering temperature through the furnace cross section can result in the decreasing of the dust formation by 25 %.

So in the case of rotary furnaces the complex rearrangement results in 40 % reduction of the dust formation. For instance the flue dust amount was decreased by 25 % only by the increasing of material layer thickness. Despite of very favourable chemical composition of the flue dust its high value of loss on ignition makes the waste from it. It is caused by the contra current process, i.e. formed dust can not by separated and it is subsequently mixed with not fully calcinated dust from previous sections.

Tab. 1
Contents of impurities in magnesite fractions bellow 40 mm

Fraction (mm)	Content (%) CaO	Fe_2O_3	SiO_2	Al_2O_3	Lost on ignition LOI (%)
0 – 0.2	5 – 7.5	4.5 – 6	2.0 – 7	1.5 – 3.0	47 – 49
0.2 – 1	3 – 5	3.6 – 4.0	0.3 – 2.0	0.1 – 0.3	48 – 50
1 – 5	8 – 12	3.5 – 3.8	0.3 – 0.8	0.2 – 0.3	48 – 50
5 – 10	10 – 16	3.4 – 3.7	0.5 – 1.5	0.4 – 0.8	48 – 50
10 – 40	14 – 20	3.0 – 3.5	0.5 – 1.2	0.3 – 0.6	48 – 50

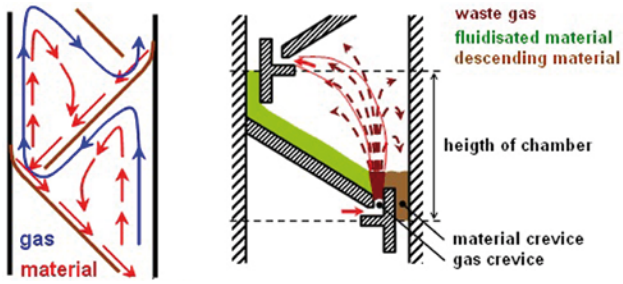

Fig. 2. Fluidization principles in the microfluid furnance.

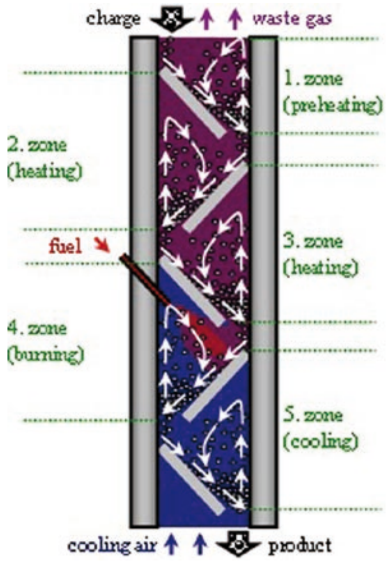

Fig. 3. Microfluid furnance.

Fig. 4. Experimental microfluid furnance.

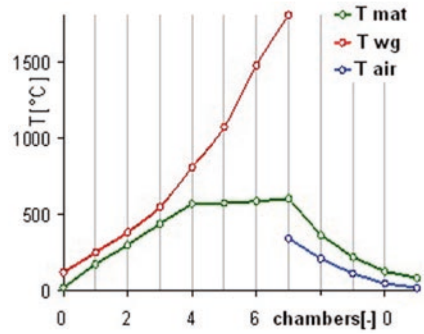

Fig. 5. Simulation of experimental microfluid furnance.

New thermal devices

Microfluid furnace

Microfluid furnace is based on hydromechanical fluidization principle (Fig. 2). Furnace consists of fluidization chambers in the counter current arrangement (Fig. 3). Material is fed from the upper part of the furnace and is discharged at its lover part. Material is gradually dried, heated, calcinated and cooled. Gas flow – cooling air is in the upward direction. It enables independent fluidization and material flow to the subsequent chambers. Furnace process is executed as follows. Fine-grained material is fed from the upper end of the furnace. It passes through the drying zone, preheating zone, heating zone, burning zone and cooling zone. Product discharge is at the lower end, where cooling air is introduced. Heat generation is in one or more combustion chambers (Koštial et al., 2007).

Experimental microfluid furnace (Fig. 4) has 9 fluidized chambers, which are providing: drying, heating, calcination and cooling of material. Burner is placed in the 7th chamber. A verification of functionality and operational parameters of furnaces were performed. Obtained results were used for the calibration of mathematical model. The specific capacity attained 652 kg of product per 1 m^3 of the furnace. The specific gas consumption was of 127 m^3/t.

Full-scale microfluid furnace was designed using the calibrated mathematical model (Fig. 5). The furnace has vertically 11 chambers, a burner is placed in the 7th chamber. Volume output of microfluid furnace is 1.88 m^3/t. For the comparison a volume output of the rotary furnace is about 70 m^3/t. Calibrated mathematical model is utilized for the simulation and for design requirements (Mikula et al., 2009).

High speed rotary furnace (HSRF)

The high speed rotary furnace performs thermal treatment of the fine grain materials in the fluidized layer created on the principle of mechanical fluidization. Mechanical fluidization carries out through the centrifugal and gravitational forces. Formation of fluidized layer depends on material parameters, equipment and conditions of fluidized process. Filling of the furnace space with particles at different revolutions of furnace is illustrated

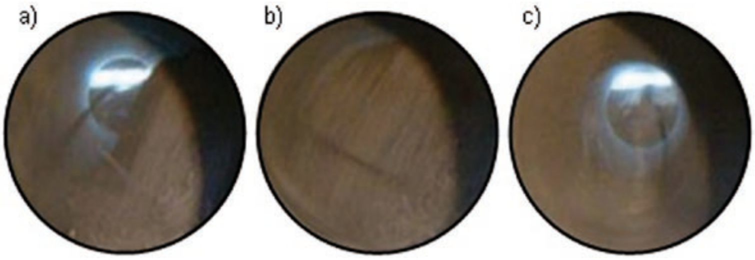

Fig. 6. Material fillingrate by the mechanical fluidization. a – low, b – optimal, c – high-speed.

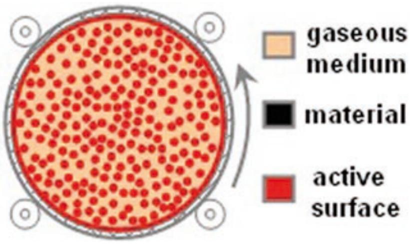

Fig. 7. Material distribution through the furnance cross-section.

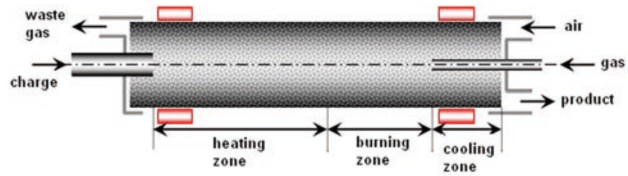

Fig. 8. Scheme of the high revolutions rotary furnance.

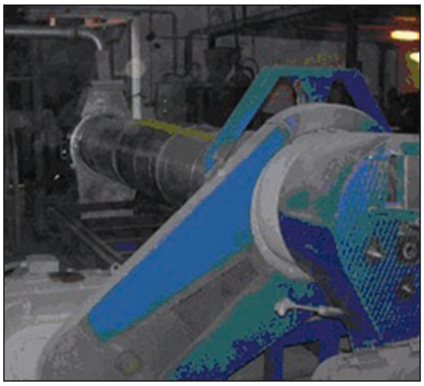

Fig. 9. The high revolutions pilot rotary furnance.

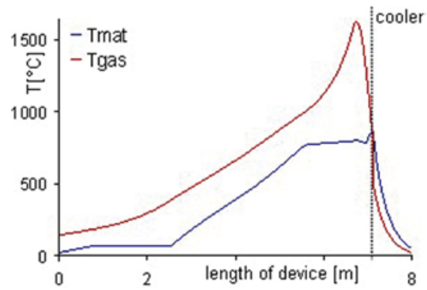

Fig. 10. Simulation of experimental device.

in Fig. 6. Active surface of the feed is determined from the surface of the fluidized particles, which are allocated at cross-section of the furnace (Fig. 7).

The major advantage of this unique technology of the raw material thermal treatment is a formation of dispersed layer, which allows a perfect contact of gaseous media with the surface of processed material particles. Material fluidization brings a significantly increase of the intensity in the heat and mass transfer. For the calcination of magnesite it is possible to reduce existing facility approximately tenfold. The main advantage of proposed solution is that ratio of the substances can be relatively in the large scale (Koštial et al., 2007).

Experimental research was carried out in the pilot HSRF. The working part of the furnace creates a cylinder with diameter 600 mm and length 5 500 mm. Rotation speed of furnace can be continuously changed by power drive in the range of 0 – 60 rpm. The material is fed to the furnace by the screw conveyor. Material is fluidized after entering the furnace. At the output side of the furnace material is taken away by the screw conveyor and on this side natural gas is supplied through the diffuse burner. Furnace is thermally divided into the cooling area, combustion area, heating area and pre-heating area. The high intensity of the heat transfer due to the mechanical fluidization enables to integrate all these operations into one facility (Fig. 8).

The pilot high speed rotary furnace is in Fig. 9. Based on these experimental results mathematical model of the furnace was calibrated. Using the mathematical model simulation a full scale operating high speed rotary furnace for the calcination of magnesite was designed (Fig. 10). Internal diameter of the furnace is 1.3 m, length 8 m and volume output is 10.9 m^3/t (Mikula et al., 2009).

Conclusion

The paper presented the possibilities of utilization enlargement of magnesite fractions 0 – 1 mm and the flue dust particles from the thermal treatment of magnesite. It also described a formation of the fine fractions and possibilities of their processing, which are based on the application of existing and new developed technologies.

In the shaft furnaces it is possible to increase their thermal efficiency. So, the achieved decreasing of the dust formation was by 25 %. In the case of the rotary furnaces the complex rearrangement results in 40 % reduction of the dust formation. For the calcination of fine fractions new types of thermal facilities – microfluid furnace a high-speed rotary furnace were developed. Thermal treatment in these furnaces is performed in fluidized layer. Accomplished studies have confirmed, that these conceptually new thermal units have very high efficiency during the treatment of grainy and dusty material and they enable to perform the calcination process on the border of technological optimum. These proposed solutions are verified in the pilot and full scale operating conditions.

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References

Anonymous, 1998: Annual report of the mine division. SMZ, jsc. Jelšava.

Koštial, I., Terpák, J., Spišák, J., Mikula, J. & Gloček, J., 2007: Advanced process manipulation. *In: Proceedings of the 8th International Carpathian Control Conference ICCC´2007 Štrbské Pleso, May 24 – 27, 2007. Košice, FBERG TU, ISBN 978-80-8073-805-1, 342 – 354.*

Mikula, J. et al., 2009: Mathematical modelling of lumpy and granular material thermal treatment. *Acta Metallurgica Slovaca, 15, 1, 197 – 204.*

Repiský, R., 1997: Economic evaluation of furnace units operations in SMZ, jsc. Jelšava, Research report, Jelšava.

Staroň, J. & Tomšů, F., 1992: Refractory Materials. *Bratislava, Alfa.*

Šalát, J. &087Ončáková, N., 1966: Mineralogy II. *Košice, VŠT, Bratislava, SVTL, 672.*

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