13th International Research/Expert Conference
"Trends in the Development of Machinery and Associated Technology"
TMT 2009, Hammamet, Tunisia, 16-21 October 2009

MATERIAL AND ENERGY BALANCE OF PRODUCTION OF GYPSUM FLUIDIZATION PROCESS

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ABSTRACT
Relatively little energy is spent for the production of gypsum binders, about 20 % compared to the other building binders (cement, lime). The reason for this is quite lower temperatures in the production of classical gypsum binders (125 – 180 ^oC) in relation to frying temperature clinker of cement (1450 ^oC) and lime (1200 ^oC). Material and heat balance of production gypsum binders in Gypsum Factory Komar, Donji Vakuf will be explained in this work. In this work, the coefficient of heat utilization and participation in the price of energy products were calculated, based on theoretical and actual data on energy consumption. In this factory, gypsum is produced by fluidization process.
Keywords: gypsum, fluidization process, energy, coefficient of utilization

1. INTRODUCTION
Gypsum, one of the oldest connective material, in addition to cement and lime is one of the most used binding material. Gypsum has many shortcomings, but also a lot of precious features, which can be used very well for formaking mortar, building elements and whole structures[1].
However, despite the fact that in the production of gypsum it is needed to develop relatively low temperatures, the used energy occupies the main part of the price of finished products. This data shows us that it is necessary to devote great attention to the energy aspect of the production of gypsum. The consumption of energy, both heat and electricity, depends largely on the thermal power generator set that is used for thermal treatment of raw gypsum (rotational furnace, steamer, mill – driers, etc).

1.1. Technological process of production in the gypsum factory Komar, D. Vakuf
In the gypsum factory Komar, D. Vakuf the gypsum production process is carried out by dehydration in fluidization layer. The procedure consists of thermal treatment of raw gypsum in the ball mill in which at the same time the process of drying, milling and dehydration dihydrate in to semihydrate is taken place. Mill capacity is 10 t/h. The mill was connected with the generator where the fuel oil combustion is carried out. The firebox is connected with two pipelines for the primary and secondary air. The secondary air is supplied from the chimney, which achieves energy savings of 20 %. The temperature of flue gases that are brought to the mill is 580 – 600 ^oC, and the temperature at the exit from the mill is 172 ^oC. At normal derivative devices that simultaneously milled and dehydration get the products that consist solely of β – semihydrate. Energy consumption in this factory is 820,6 kJ/kg. More detailed explanation about the consumption of energy (heat and electricity) will be discussed hereinafter[2].

2. MATERIAL AND HEAT BALANCE OF PRODUCTION OF GYPSUM PLASTER IN THE FACTORY KOMAR, D. VAKUF

2.1. Budget financial balance in the production of gypsum

To perform the material balance in practice we have to go from the theoretical basis. Therefore it is necessary to know the gramme - molar mass reaction components, ie. gramme – molar mass dyhidrate and resulting semihydrate which looks like this:

$$CaSO_4 \cdot 2H_2O \rightarrow CaSO_4 \cdot \frac{1}{2} H_2O + \frac{3}{2} H_2O$$

172 145 27

The mentioned example shows that dyhidrate has a 20.93 % lead crystal, and semihydrate has 6,2 %. Of course, these values relate to 100 % clean dyhidrate.

Table 1: Formulas and budget size for the production of material balance

Indicators:	Formulas and budget size:
From 1 kg of theoretical pure dyhidrate is obtained:	
• Semihydrate	0,843 kg
• anhydrite	0,790 kg
From 1 kg dyhidrate containing impurities is obtained:	
• semihydrate	$Q_1 = 0{,}843\left(\frac{100-A}{100}\right) + \frac{A}{100}$
• anhydrite	$Q_1 = 0{,}790\left(\frac{100-A}{100}\right) + \frac{A}{100}$ where the A – the content of impurity in raw material
Theoretical consumption of dyhidrate for obtaining 1 kg	
• semihydrate	1,186 kg
• anhydrite	1,264 kg
Theoretical consumption of raw material, which contains impurities, to obtain 1 kg	
• semihydrate	$Q = 1{,}186\left(\frac{100-A}{100}\right) + \frac{A}{100}$
• anhydrite	$Q = 1{,}264\left(\frac{100-A}{100}\right) + \frac{A}{100}$
The amount of hydrate water allocated from 1 kg of pure theoretical dyhidrate in obtaining:	
• semihydrate	0,157 kg
• anhydrite	0,209 kg
The amount of water allocated from 1 kg of ore with impurities in obtaining:	
• semihydrate	$H_2O_{hidr.} = 0{,}157\left(\frac{100-A}{100}\right)$
• anhydrite	$H_2O_{hidr.} = 0{,}157\left(\frac{100-A}{100}\right)$
Dyhidrate content ($CaSO_4 \cdot 2H_2O$) in raw material (according to the percentage content H_2O_{hidr})	$CaSO_4 \cdot 2H_2O = 4{,}7785 \cdot H_2O_{hidr.}$

2.2. Heat balance of plants for the production of gypsum

For the production of one ton of building plaster significant amounts of heat is used, but it is considerably smaller than the heat that is used in the production of cement, lime and other building materials. So, in the devices for production of gypsum by fluidization process in the Factory of gypsum Komar 20 kg of fuel oil per ton gypsum is used. Calorie power of the fuel oil which can be usedis 41 030 kJ/kg.

One part of the heat, resulting from a specified quantity of combustion fuel oil, is used usefully, while the remainder relates to the losses in a given process. Looking thermal balance of the consumption of heat in the production of gypsum we must go by the following account. To convert 1 kg of crude gypsum in to 0,843 kg semihydrate it is needed to use the following quantities of heat:

a) for heating of raw gypsum to the temperature at which the reaction is carried out (in terms of production during the summer it is usually 15 – 122 ^oC)
   $q_1 = Cp(T_2 – T_1) = 1,130(122 – 15) = 120,96$ kJ/kg
   where C_p – specific heat dyhidrate (kJ/kg ^oC);
b) sequences with chemical reactions dehydration 1 kg of raw gypsum with extract of 0,157 kg of waterit is used $q_2 = 96,30$ kJ;
c) for evaporation of 0,157 kg of water it used the following amount of heat
   $q_3 = m \cdot \Delta H_i = 0,157 \text{ kg} \cdot 2260,87 \text{ kJ/kg} = 354,96$ kJ
   where $\Delta H_i = 2260,87$ kJ/kg, enthalpy of creating water vapor.

The total consumption of heat to convert 1 kg of crude gypsum in to 0,843 kg semihydrate is

$Q = q_1 + q_2 + q_3 = 120,96 + 96,30 + 354,96 = 572,22$ kJ,

Or for 1 kg of received semihydrate

572,22 kJ / 0,843 kg = 678,79 kJ/kg semihydrate.

Thus, consumption of heat for getting a ton of construction plaster (assuming that the raw material consists of 100 % dyhidrate and that does not contain humidity) is 678,79 MJ/t.

If the raw material contains a certain percentage of impurity, such as in our case, the consumption of heat by the above counts is for the corresponding percentage lower. For example if we have the raw materials, such as those in Donji Vakuf, whose analysis shows 94 % of dyhidrate and 6 % of dopant (CaO, MgO, R_2O_3, Na_2O, K_2O), the heat consumption can be calculated approximately, with no corrections of the heat consumed for heating, not taking into account the difference of heat additions.

   0,94 · 678 790 = 638,062 MJ/t

This amount of heat is the minimum required (theoretical) and it reflects the heat used usefully in the process. If you take that fuel oil consumption for producing one tonne of construction gypsum is 20 kg/t of gypsum (41 030 kJ/kg · 20 kg/t = 820,6 MJ/t), then the coefficient of beneficial effects for the production semyhidrate the plant is:

(638 062,6 / 820 600) · 100 = 77,76 %

The difference between spent and theoretical necessary quantity of heat for the production of gypsum represent losses that can be grouped as follows:

1. Losses on the heating of gypsum from the reaction temperature to the temperature at which it takes from the plant. For builders plaster the reaction temperature is usually around 122 ^oC, and the output temperature of gypsum is around 170 ^oC. Around 2 % of the waste of energy is spent on this loss.
2. Loss of heat by radiation in the environment depends on the construction of plant and polystyrene insulating properties of its surface, and it varies from 2 – 5 % of the total use of heat.
3. The biggest loss in the heat balance is in the hot gases that go into the atmosphere and it is 30 – 40 % of the total spent heat. In order to reduce the loss, it is necessary to reduce the temperature of gases leaving. It is also very important not to allow uncontrolled supply of cold air in the plant for dehydration, because it leads to increase of heat loss from the gas going.

It is necessary to notice that sometimes all of accumulated heat in gypsum, which comes out of the plant for dehydration goes as lost heat, and the useful heat used includes only the heat consumed in chemical reaction and evaporation of water.

Plant gypsum Komar is one of the largest consumer of electricity. Electrical energy is used to drive electric motors of conveyors, elevators, allotter, fan, furnace for lighting and compressors. Consumption of electrical energy in this factory is 28 kWh/t gypsum.

2.3. Participation of energy in the price of products

In the previous chapter we said that for the production of 1 tonne of gypsum consumes about 20 kg of fuel oil and 28 kWh of electricity.

Taking into account the price of fuel oil (0,556 KM/kg) and power (whose average value between the summer and winter rates of 0,17 KM/kWh) we can calculate how much energy needed to manufacture 1 tonne of gypsum:

$20 \cdot 0{,}556 + 28 \cdot 0{,}17 = 15{,}88$ KM

If you know that 1 tonne of gypsum price is 140 KM we can easily calculate how many percent of the energy involved in the price:

$(15{,}88 / 140) \cdot 100 = 11{,}34$ %

Participation of energy in the price of products is 11,34 %.

It should be takes into account that for 1 ton gypsum binders is spent

$$Q = 1{,}186\left(\frac{100-6}{100}\right) + \frac{6}{100}$$

Q = 1,175 t raw gypsum purity 94 %.

Price of raw gypsum is 20 KM/t. By multiplying this value with the amount of raw materials, we can calculate how much the raw materials is needed for production of 1 tonne of gypsum binders:

$1{,}175 \cdot 20 = 23{,}5$ KM

Participation of crude gypsum in the price of finished product is

$(23{,}5 / 140) \cdot 100 = 16{,}79$ %

We can see that raw materials and energy are involved with 28,13 % in the price[4].

3. CONCLUSION

Broiler gypsum in fluidization layer has its advantages and disadvantages. Advantages of thermal aggregates in relation to the other are the following:

- intensive heat transfer,
- short time of keeping the material in the oven,
- simultaneously grind and dehydration gypsum.

Disadvantages of this device for dehydration raw gypsum are:

- narrow border of dimension fraction of crude gypsum,
- increased heat losses,
- increased content of dust in waste gases.

As seen from the thermal balance the coefficient of heat utilization in the production of gypsum is 77,76 %. The main losses in the production of gypsum in this process are:

- heat losses in the heating of gypsum from the temperature of reaction to final temperature,
- losses of heat radiation in the environment,
- heat losses, which is related by hot smoke gases that go into the atmosphere,
- heat losses in the fire.

As for the prices of finished products, in the work we have seen that the participation of raw materials and energy amounted to 28,13 %.

4. REFERENCES

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