european cement research academy

Newsletter 4/2005

Contents:

Next ecra events to come:

- Pretreatment, Handling, Storage
  and Feeding of Waste Fuels
  November 9-10, 2005 - Lixhe-les-Visé/Belgium
- Cement and Admixtures
  November 23, 2005 - Düsseldorf/Germany and Eindhoven/The Netherlands

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Which is the best cement grinding system?

Energy consumption, maintenance costs, drying capacity and cement properties deciding

If investments in new plant equipment for cement grinding are planned, it is of major importance to choose the most suitable grinding system. Apart from grinding energy demand and maintenance costs, the selection criteria include the variety of cement types to be ground as well as their respective quantities, and the cement properties to be expected. If moist cement constituents (e.g. granulated blast furnace slag) are added, drying capacity is another important factor.

Comminution processes account for more than 65 % of the electrical energy consumed during cement manufacture. Increasing electricity prices and replacement of clinker by other main constituents make it necessary to rethink the grinding processes.

The great majority of existing cement grinding plants are equipped with ball mills. The ball mill has been used for over 100 years for grinding cement and has proved to be universally serviceable and reliable in spite of the relatively high energy consumption. However, the limitations of ball mills have become apparent with the construction of large production units. Even if the energy costs were not a prime concern it would only be possible to construct a ball mill with very high output with great difficulty and high costs.

Over the past few years there has been a tendency to use vertical roller mills for cement and blastfurnace slag grinding in new plants worldwide. Roller mills are characterized by energy consumption that is by 30 to 50 % lower than that of ball mills, a high degree of availability, and good mechanical reliability. If corresponding wear protection is provided, maintenance costs are low as well. As roller mills are "air swept mills", they are particularly suitable for grinding moist materials because they allow simple and efficient drying. Their high flexibility during operation, which allows changeover from one cement type to another virtually without generating transition products, constitutes a further advantage. However, the capital costs of roller mills are higher than those of other grinding systems. Moreover the suitability of roller mills for achieving very high fineness of grind is limited; as a consequence grinding of cement in a ball mill may be necessary to obtain top cement qualities.

High pressure grinding rolls have been used in the cement industry for more than 20 years. The electrical power consumption of high pressure grinding rolls for cement grinding are 50 % lower than with ball mills. During the first years of application the durability of the wear protection has proved inadequate. In the meantime good results of lifetime up to 30.000 hours has been achieved. However, also in these mills cements of higher strength classes can only be produced if they are subsequently ground in a ball mill. Moreover, cements ground in a high pressure grinding rolls/classifier circuit usually have a narrower particle size distribution and thus a higher water demand, which makes final grinding in a ball mill necessary in most cases.

If the throughput of an existing cement grinding plant shall be increased, the installation of high pressure grinding rolls as a separate pregrinding circuit with a classifier and finish grinding in an existing ball mill is often the most cost-efficient option. On the other hand, the benefit of the high pressure grindings rolls concerning energy demand is partly reduced due to the required finish grinding in the less efficient ball mill. In this case the existing ball mill has to adapted to the new mill feed. The compartment for coarse grinding and the intermediate diaphragm are not necessary. Also the ball charge has to be modified. The downstream ball mills are usually charged with grinding balls having a size of 25 to 12 mm. Beneath particle size distribution the ball charge of the mill also has an effect on the required electrical energy demand.

At the Research Institute of the Cement Industry, the effect of the size of the grinding medium on the grinding energy consumption and the particle size distribution in the finish grinding of cement was studied on a semi-industrial grinding plant. As grinding feed for the grinding tests a clinker meal from a high

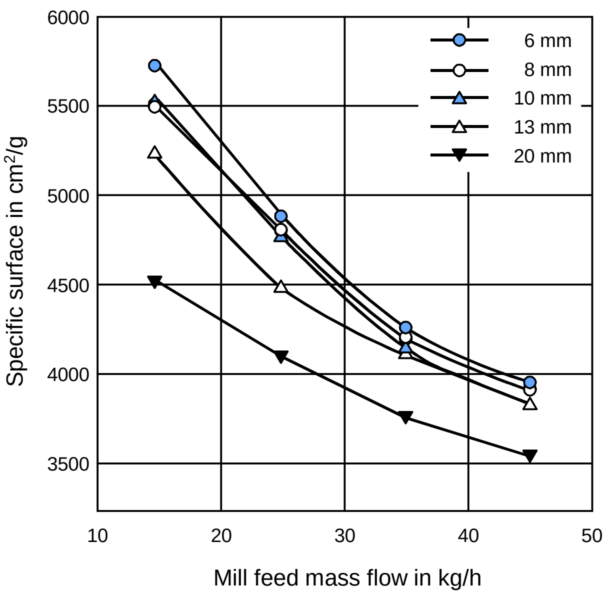

Fig. 1: Specific surface area in final grinding of a clinker meal in a ball mill with different monodisperse grinding balls

pressure grinding rolls/separator circuit from an industrial plant was used. The clinker meal with a fineness of 2450 cm²/g was mixed with grinding additive and further ground in a semi-industrial continuous ball mill with the dimensions 0.4 x 1.2 m. As grinding media ball sizes of 6, 8, 10, 13 and 20 mm were used. In all grinding tests the total mass of the grinding medium was the same. For every grinding medium filling the continuous mill was operated with feed mass flows of 45, 35, 25 and 15 kg/h.

With the grinding plant in stationary state, specific surface area and particle size distribution were determined in each case. **Fig. 1** shows the results of the grinding tests. It can be seen from the figure that the highest surface areas were attained with the smallest balls. When using grinding balls with a diameter of 20 mm the output of the grinding plant at a target specific surface area of 4500 cm²/g was approx. 15 kg/h and the grinding energy requirement was 47 kWh/t. An output of 25 kg/h can be achieved when using 13 mm balls so that the power requirement is then only 30 kWh/t. When the mill is filled with 8 mm balls then the throughput as high as about 30 kg/h could be achieved with a power requirement of only 18 kWh/t.

The slope of the particle size distributions of the ground clinker meals are shown in **Fig. 2**. As can be seen from the diagram, the slope of the particle size distribution of the cement was reduced during finish grinding in the ball mill when relatively large grinding balls were used. On the other hand, narrower particle size distributions of the cement were obtained when smaller grinding balls were used, resulting in an increased water demand of the cement.

All in all, these results demonstrate that the utilization of smaller grinding elements allows a certain optimization potential of the energy consumption of the downstream a ball mill. On the other hand, the saving potential is limited by the expected higher water demand of the cement.

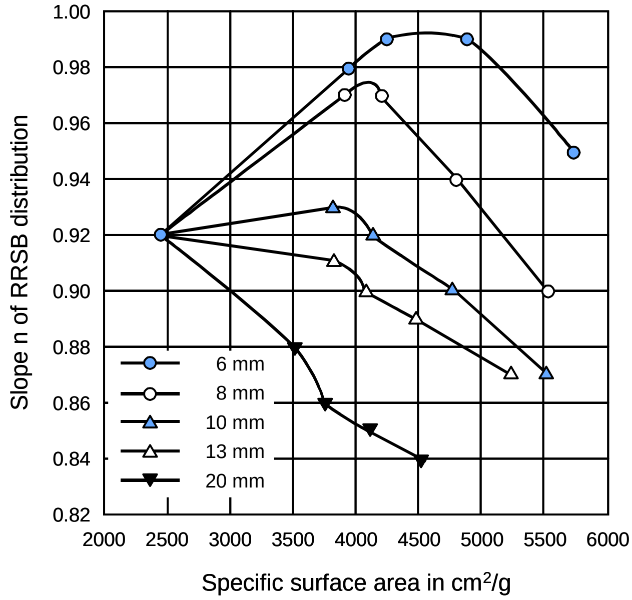

Fig. 2: Slope of the particle size distribution for final grinding of a clinker meal in a ball mill with different monodisperse balls

Alternative fuels and raw materials have to meet specific quality

Pretreatment has proven to be indispensible for fuels derived from mixed wastes

The clinker burning process offers excellent opportunities for environmentally beneficial waste-to-energy and material recovery. This is mainly due to some very specific process characteristics like e.g. very high temperatures in the burning zone in combination with high retention times in the kiln-preheater system.

Since the European Waste Incineration Directive (2000/76/EC) came into force nearly two years ago the cement industry has had to meet in practical terms the same requirements as dedicated waste incinerators. The Directive sets very ambitious emission limits regardless whether the fuels used are derived from hazardous or non- hazardous wastes.

The characteristics of the clinker burning process require that each fuel has to meet certain quality criteria. To start with, the sulphur and the chlorine content have to be taken into consideration as well as the calorific value. But apart from that there are other parameters like the moisture, the physical properties like lumpiness or stickiness or the burning behaviour and the ash content that must be oberserved as well. Many of these parameters require especial attention for the sake of the production process or the product quality, respectively. Additionally the individual permits can contain further requirements referring e.g. to the content of some trace elements.

In recent years the European cement industry has made huge progress in using suitable wastes as alternative fuels of raw-materials. For example, countries like France, Belgium, Switzerland, the Netherlands or Germany have reached average substitution rates between 35 % and up to more than 70 % of the total energy demand. Some individual plants were even able to substitute their primary fuels to 100 % via appropriate waste materials.

In order to reach such an impressive level, the waste-fuel mix has to be selected carefully. Furthermore depending on the source of the wastes the materials have to be pretreated and blended. Also the mixture between solid and liquid fuels has to be taken into consideration as well as the other parameters like burning behaviour and calorific value. Very high substitution rates can only be achieved if a tailored pretreatment and surveillance system is implemented.

The cement industry can take advantage of a growing amount of waste fuels derived from industrial mixed waste fractions. However, more and more alternative fuels are also derived from municipal wastes. This is mainly due to the fact that an increasing number of states have implemented taxes or even a ban – due to European legislation to come- on the landfill of certain wastes. As a consequence, an increasing amount of wastes are now available which can be pretreated in order to gain suitable fuels. Experience has shown that the pretreatment is indispensible for fuels derived from these mixed wastes in order to obtain homogenous calorific values and feeding characteristics (**Fig. 1 and 2**). Thus the quality of these fuels can be perfectly adjusted and assured allowing them to be recovered in industrial processes like clinker production.

Fig. 1: The pretreatment of mixed waste fractions to get a suitable fuel requires various processing steps.

Clinker production can take advantage of wastes independent of whether they are declared hazarous or non-hazardous. As a consequence the excellent characteristics of the clinker burning process have not only proven to be suitable for the use of fuels derived from non-hazardous wastes. For a long time it has been proven that hazardous waste can be used in the same environmentally friendly way. Especially due to the high temperatures and the long retention times the clinker process becomes in many cases an economically and environmentally viable option to destroy wastes which could otherwise turn into a threat to the biosphere. For example in countries where other high temperature disposal processes are not available cement clinker kilns are considered more and more as a reliable process to eliminate hazardous materials like e.g. pesticides.

Fig. 2: View on a typical intake material for a pretreatment plant gaining alternative fuels from municipal wastes

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