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NEWSLETTER

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Health and safety: Working in cyclone-preheaters

Facing the constant challenge of accident-free operation in hot areas of cement plants

Occupational health and safety has top priority within the cement industry. Hot areas and cyclone-preheaters in particular are among the most dangerous places in a cement plant. Dealing with hot meal can especially be a potential source of severe injury. Special attention therefore has to be directed towards working safely in these areas.

Coatings and blockages can often occur in the cyclone preheaters of rotary kiln plants for burning cement clinker. They result from the combined action of recirculating materials (alkalis, chlorides, sulphates), intermediate compounds from the decomposition of raw meal that have a tendency to stick together, and an extremely high dust loading in the atmosphere in the preheater. Blockages in the cyclone area or in meal ducts can be caused by the gradual closure of narrow cross-sections (e.g. top outlet ducts in cyclones) or through a sudden fall of coating which, for example, closes the cyclone outlet or meal duct. The frequency of cyclone blockages strongly depends on the specific situation on site and can vary between the extremes of several times daily and a few times per year depending on the raw materials and the plant technology. Many plants therefore have widely differing experience in dealing with the dangers involved when removing these disruptions to plant operation. There is no uniform technical equipment for preventing the disruptions arising and no generally recognized procedure for removing the blockages. **Fig. 1**, for example, shows the removal of coating with a pneumatic hammer.

Figure 1: Removing coating with a pneumatic hammer.

Serious accidents due to hot meal

Coating and blockages in a cyclone preheater are often the causes of serious accidents due to the hot meal that emerges suddenly at temperatures of up to 800 °C from the rodding openings during cleaning work and when removing the blockages. In addition, meal surges which are associated with considerable danger can occur. Due to cyclone blockages and kiln rings, and during starting and stopping large amounts of hot free-flowing material with great momentum can be released. It can flow from the kiln outlet into the clinker cooler and basement areas.

Figure 2: Basement area after an escape of hot meal.

When meal has escaped it is usually difficult to detect (**Fig. 2**). This is extremely dangerous since stepping into the meal can lead to serious injury. The connected accidents are mainly attributable to inappropriate actions by the personnel in charge of removing the coatings and cyclone blockages rather than to a lack of safety equipment. As well as the plant accidents in the maintenance sector, accidents in the clinker production sector are also particularly numerous and severe.

There is therefore a pressing need for the further improvement of occupational safety, especially in these areas. Typical injuries which can occur are burns due to the hot meal, dust-related eye injuries and mechanical injuries resulting from the handling of rodding equipment. In many cases these accidents can be avoided by simple measures, for instance by ensuring that no-one must ever stand underneath an open cleaning flap.
It can therefore be assumed that a significant number of accidents can be avoided through organisational measures and proper instruction.
In order to provide a safe working environment inside the preheater, however, various aspects have to be taken into account. These include the design of openings, staging and platforms, the handling of rodding tools or air blasters, procedures for the removal of coatings and blockages, and the selection and use of appropriate personal protective equipment. **Fig. 3**, for example, shows a suit intended for use in work areas where there is a high probability that hot meal will escape.

Figure 3: Suit for use when there is a high risk of meal escape.

Code of practice for hot meal

Different codes of practice exist which describe procedures and measures for the safe removal of coating and blockages in cyclone preheaters as well as possible ways to recognise blockages. Furthermore, strategies for dealing with meal surges and recommendations for the use of personal protective equipment have been developed. The wealth of information available shows the complexity of the influencing factors and the number of causes for possible accidents, but it also illustrates that there are numerous successful solutions for creating a safe workplace.

The persistent application of all measures together with the constant motivation of the entire personnel with regard to safety can enable the accident-free operation of a cyclone-preheater. Not least because nearly all accidents with hot meal lead to severe injury, it is necessary to reduce the number of such incidents to zero. Even experienced staff who are aware of the possible dangers can become involved in accidents due to their working routine, as many years of practice without incidents can create a feeling of "invulnerability". Maintaining awareness and ensuring safe working procedures is therefore a constant challenge for us all.

Developments in clinker cooling

A look at the progress of cooler technology in the past decade

Clinker coolers are one of the most crucial aggregates in the clinker production process in terms of product quality and energy efficiency. Although this piece of equipment is often neglected, its importance cannot be overlooked. A proper cooling process is important in order to achieve the necessary product quality and energy efficiency by recuperating the enthalpy of the hot clinker falling out of the kiln.

Throughout the cement industry different types of clinker coolers are currently in operation. The most common cooler types are the rotary cooler, the planetary cooler and above all the grate cooler. The use of shaft coolers has almost ceased.

Clinker coolers in use in the cement industry today

The simplest cooler system is the rotary cooler. It usually consists of a steel drum and is located directly behind the kiln. The basic principal of operation is that the hot material which is discharged by the kiln falls down into the rotary cooler. The material is cooled according to the counter flow principle. By installing different kinds of lifters inside the tube of the cooler (**Fig. 1**) the clinker is lifted to a certain degree and falls down onto the material bed. With this action the cooling surface is increased by a significant amount and the heat exchange improved, but a significant amount of dust is also created which is drawn back into the kiln causing a certain energy loss which in turn leads to higher fuel consumption rates. The heat exchange and therefore the recuperation rate are not optimal because of the drum shell's heat losses. It is also not possible to control the cooling progress, which limits its influence on the clinker quality.

An improvement on the rotary cooler was the development of the planetary cooler (**Fig. 2**). This cooler consists of several tubes which are placed on the periphery of the rotary kiln in parallel and symmetrically. Each cooling tube is connected separately to the kiln. The entire cooling air is sucked in at the end of the cooling tubes from the ambient environment. The clinker is cooled in counter flow and all the preheated air flows as secondary air through the inlet openings into the rotary kiln. The only way to adjust the amount of cooling air is to change the draft of the main fan. The mounting of a satellite cooler to the kiln must be taken into account in the kiln construction design. The additional weight of the cooling pipes requires a stronger kiln shell which must also be extended over the kiln outlet. The refractories at the inlets of the individual cooling tubes are subjected to high wear and therefore require a high amount of effort to maintain them properly. The cooling path in a cooling tube of the planetary cooler behaves similarly to that inside the rotary cooler. It is not possible to create different cooling zones which can be controlled separately. It is therefore also not possible to influence the product quality to any great extent.

Nowadays the most commonly implemented cooler is the grate cooler. This type of cooler has remained

Figure 1: The inside of a rotary cooler.

Figure 2: Example of a planetary cooler.

state of the art in the cement industry since its development. The design of a grate cooler can differ in several details such as the number of cooler exhaust air take offs for different purposes, the type and design of the moving/static grate or the amount of cooling fans. Each manufacturer building and selling grate coolers has its own individual developments relating to specific details. Nevertheless, all grate coolers work according to the same principle. The material falls out of the kiln into the cooler and as a rule is transported with a moving grate to the discharge point. The hot clinker is cooled down with ambient air in cross flow manner. Normally the amount of used air by far exceeds the amount of air needed for the combustion. A certain amount of cooling air with usable enthalpy can therefore be channelled off as tertiary air for other applications such as the drying of coal or waste heat power generation. With this cooling technique the hot material can be cooled down to a temperature range of 70-100 °C, so with the right equipment, regular maintenance and proper settings very high cooling efficiencies can be achieved. A drawback of this cooler type is the high amount of separate drives and fans requiring high maintenance efforts and costs as well as higher specific power consumption compared to other cooler types. On the other hand, however, several cooling zones can be created by using multiple air fans and staging the air to the different zones. It is therefore possible to greatly influence the product quality. With a proper fan set-up it is also possible to regulate the air flow to the kiln precisely and gain better control of the burning process.

Latest clinker cooler developments

The latest development in clinker cooler technology regarding design and cooling technique is the Revolving Disc Cooler. This cooler type is an adaption from the steel industry. It was introduced to the cement world several years ago but has not yet been built. The cooler consists of a steadily moving round disc which moves at a constant speed. The clinker falls down onto the disc and is distributed across the diameter by fans installed beneath the disc. The substructure is divided into several compartments which are equipped with individual fans. Through this a well-defined and controlled cooling process should be possible.

Against the background of the developments in the field of oxy-fuel technology, which is intended to decrease the overall CO_2 emissions of the clinker production process, fundamentally new cooler designs with respect to gas separation in the recuperation and cooling zone are needed. During Phase III of ECRA's CCS research project, four different design concepts using three different methods were developed. To meet the requirements for the oxy-fuel process a two-stage cooler in different design versions for a proper separation of the oxygen enriched flue gas (recuperation zone) and the ambient air (cooling zone) along the cooling path was proposed by IKN. Although two concepts are favoured, it has yet to be determined which final design will be chosen for further development in the future course of this ongoing research project.

Taking the upcoming challenges facing the industry worldwide and the increasing demand for cement into account, kiln lines nowadays are built with capacities as high as 12.000 t clinker/d. These huge material flows are a serious challenge for all known cooler types. Cement companies are looking for a cooler solution which promises a stable and efficient operation. Many years of positive experience gathered during daily operation, the very high availability and the high recuperating efficiency have led to the fact that the grate cooler is favoured above all other cooler types. The cooler manufacturers have been able to meet the expectations of the cement industry and its demand not only by adjusting the cooler size but also through several optimisations of crucial details and components of the cooler. The total number of grate cooler installations worldwide has therefore grown steadily over the past years whilst the use of other types has decreased.

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