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INCREASED KILN CAPACITY *Through Hot Meal Routing*

Dr Hans Wilhelm Meyer and Piet Heersche, CEMCON AG, Switzerland, explain how the improvement of hot meal routing can achieve an increase in kiln capacity.

Introduction

CEMCON, Switzerland, specialises in the cement, mineral and environmental industries. The technical improvement described below serves as an example of the knowledge and experience of the company's engineers.

During the last decade, a drastic increase in kiln line production capacity (up to 12 000 tpd of clinker) has resulted in various design changes that are disadvantageous to the optimum production capacity. It is understood that optimum clinker production capacity is not equivalent to the rated (guaranteed) capacity of a kiln line. One of these design changes concerns the hot meal routing from the last cyclone stage to the inlet chamber. The main aim of the hot meal routing is to ensure a

smooth flow of hot meal against the exhaust gas flow from the kiln at the inlet chamber.

Avoiding swirl up of hot meal by the combustion gas is of paramount importance. Otherwise parts of the hot meal are swirled up into material circuits, consequently reducing the efficiency and capacity of the lowest cyclone stage and the entire preheater.

Moreover, coatings in the inlet chamber, the riser duct and the lower cyclone stages could deteriorate operational stability and capacity.

For the above reasons, the hot meal duct to the inlet chamber is usually routed at a similar angle to the meal slide at the back end of the inlet chamber (Figure 1). Excavations in the castables of the meal slide ensure the smooth flow of the hot meal against the combustion gas stream from the inlet chamber to the kiln.

The location of the final meal flap in the hot meal duct should also be designed with the aim of reducing to a minimum the hot meal velocity and the momentum of the hot meal whilst entering the inlet chamber. Again, the aim is to avoid any increase of hot meal swirl up into the combustion gas stream. Using this design, minimum dust circuits – and consequently maximum production capacity – with reduced pressure losses at the preheater could be achieved.

Figure 1. Usual routing of hot meal from the last cyclone stage to the inlet chamber.

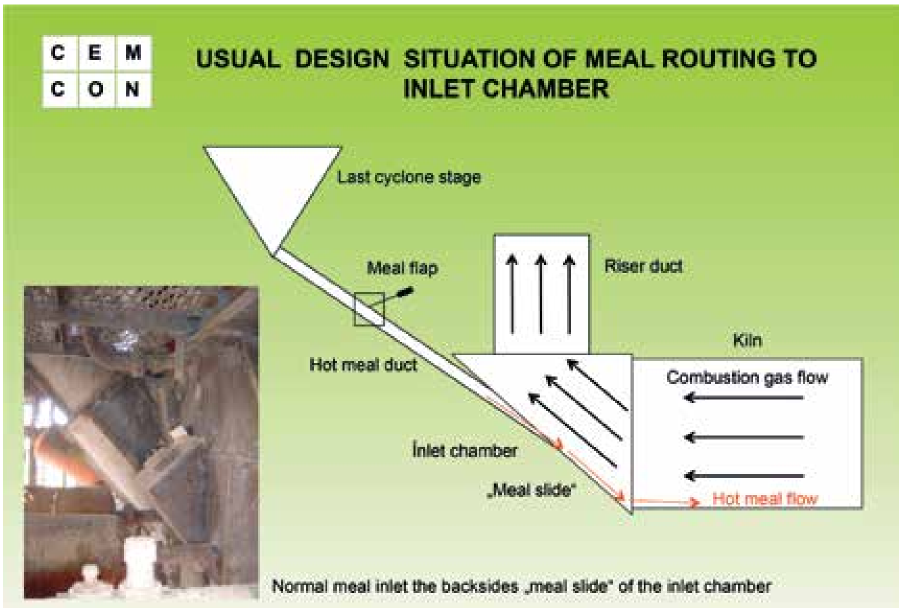
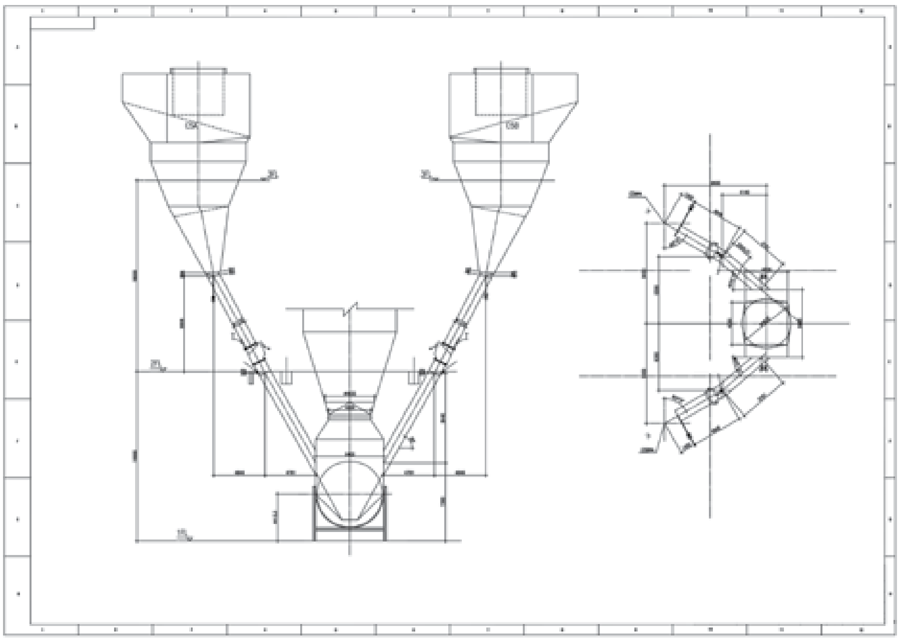


Figure 2. Example of hot meal routing to the sidewalls of the inlet chamber.



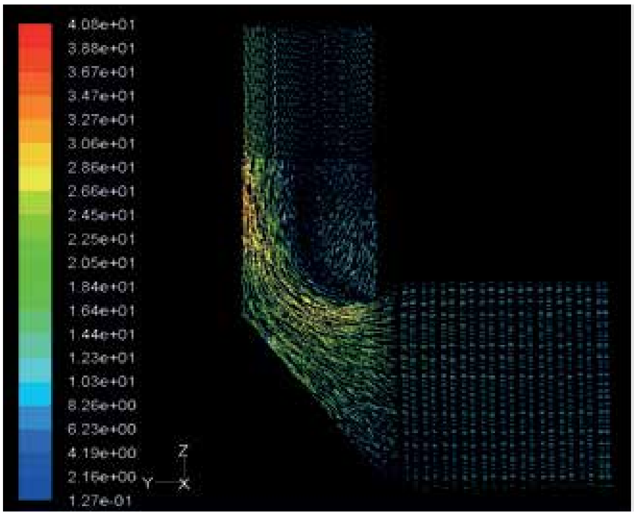
Technical development

In cement production lines, the routing of hot meal from the last cyclone stage is typically connected to the back end meal slide of the inlet chamber. More recently it has been observed that hot meal is often introduced to the sidewalls of the inlet chamber, generating a negative impact upon the maximum production capacity, and occasionally to the operational stability. Examples of this design are illustrated in Figure 2.

This inefficient routing of the hot meal duct to the sidewalls of the inlet chamber is due to an obvious common conflict of interests between cement producers (plants) interested in optimum production capacity and equipment suppliers, interested in delivery of rated capacity, profit optimisation and competitiveness.

The construction cost of a preheater (particularly with high capacity kiln lines) exponentially rises as its height increases. Arrangement of the cyclones to enable hot meal duct routing to the meal slide at the backend of the inlet chamber could result in a preheater height increase of approximately 2 m or more. In order to reduce construction height, the optimum process requirement of routing hot meal to the meal slide at the back end of the inlet chamber was obviously compromised by the construction (height) optimisation. Equipment suppliers rightfully explain that with this design the rated clinker production capacity can be

Figure 3. Example of dynamic numerical simulation of inlet chamber gas velocity.



reached. However, this does not mean optimum clinker production capacity.

Design criteria

Typically the inlet chamber is designed to maintain a gas velocity between 9 and 10.5 m/s. However, this is based on a static calculation. At optimum clinker production capacity, the kiln exhaust gas volume is at its maximum. Consequently, the gas velocity in the inlet chamber, normally designed to be in the range of 9 – 10.5 m/s, can reach values of above 12 – 13 m/s (based on static calculation). Such gas velocity increases the swirl up tendencies of the hot meal. The related dust circuit and pressure loss is one of the main reasons to limit further capacity increase.

Figure 3 illustrates an example of dynamic numerical simulation of the kiln and inlet chamber exhaust gas velocity. As expected, in the kiln and upper riser dust the gas velocity is relatively homogeneous and slightly reduced at the walls. The inhomogeneity of the gas velocity within the critical inlet chamber and riser duct area is visualised, and caused by the rectangular deflection of the exhaust gas towards the preheater. In this area, exhaust gas velocities of up to 28 m/s can be reached. The calculation results in low gas velocities at around or below 10 m/s, only at the lower slide area of the inlet chamber. This determines the best introduction point for the hot meal to the inlet chamber.

Nevertheless, this area of low gas velocity is not only referring to the back end meal slide but also to the side of the inlet chamber. However, this dynamic numerical simulation does not consider the impulse of the meal and its angle towards the gas flow. It is clear that impact between hot meal and exhaust gas at a rectangular, or almost rectangular, angle will result in the significant swirl up of hot meal.

Moreover, the numeric simulation does not consider dynamic changes caused by coatings within the inlet chamber during operation and the related disturbances from this "ideal" gas flow.

Optimisation examples

Successful modifications of existing kiln lines (with sidewards meal inlet), with hot meal routing to the back end meal slide of the inlet chamber, validates the above theoretical approach and simulation (Figure 4). These modifications are based on actual analysis and measurement of the design and operation situation, combined with engineering competence and experience.

The authors of this paper have initiated and been involved in two such modifications:

- Kiln line A: 3100 tpd maximum capacity kiln line in Southeast Europe (single string, 5-stage preheater).
- Kiln line B: 5800 tpd maximum capacity kiln line in India (double string, 5-stage preheater).

Before the modification, the actual maximum production capacity was determined with consideration towards the operational behaviour of the kiln line. An example of the meal routing to the back end of the meal slide of the inlet chamber is provided in Figure 4. The difference in the angle of the hot meal duct and the meal slide is small, allowing a smooth flow of the meal into the kiln.

At kiln line A, an increase of the maximum capacity by 80 tpd to 3180 tpd of clinker was registered. The pressure loss remained identical at the maximum speed of the preheater fan. This capacity increase is equivalent to 2.58%, or an annual clinker quantity of 25 600 t.

In the case of kiln line B, an increase of 120 tpd of clinker output was determined. This is equivalent to a capacity increase of 2.06%, or an annual clinker quantity of 38 400 t. Again, the pressure loss of the system remained as the plant was operated on a maximum preheater fan capacity.

Both kiln lines have been in operation for years at maximum capacity and no other equipment changes or processes have been carried out. Therefore, the capacity increase can be exclusively attributed to the change in hot meal routing. The capacity increase was sustainable.

Apart from some design and manufacturing drawings, all work for the modification of the hot meal ductwork, relocation of the double flap valve and the connection to the inlet chamber were carried out using the internal resources of both cement plants. The works were executed and completed during the regular annual maintenance stop.

At both kiln lines the modifications were possible due to the suitable civil as-built situation. However, it was also observed that in other plants such modifications are no longer possible due to insufficient duct routing height and/or interfering support structures and concrete floors.

Conclusion

Modification of the hot meal routing and introduction from the side of the kiln inlet chamber to the back end meal slide of the inlet chamber at two cement plants resulted in an increase of maximum clinker production capacity of 2 – 2.6%. The pressure loss of the pyro system remained unchanged. Aside from engineering, all modification

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Figure 4. Example of smooth introduction of hot meal via the hot meal slide at the back end of the inlet chamber.

works were carried out locally during the regular annual maintenance stoppage.

At existing plants with sideward meal introduction to the inlet chamber, a careful analysis of the maximum production capacity is recommended. The civil as-built situation at the area of the lowest cyclone stage and the inlet chamber need to be carefully considered. Unfortunately, the as-built situation of the preheater (columns, floors, beams, etc.) often prevents any suitable modification to the redirection of the meal duct from the lowest cyclone stage to the back end of the inlet chamber. This is particularly relevant to concreted preheater structures as limited structural modifications can be implemented. A detailed analysis of the process design, civil as-built and operation situation, including necessary process relevant measurements, are recommended in plants that introduce sideward hot meal to the inlet chamber.

During new cement plant projects, details such as hot meal inlet positioning are often not considered at the tendering and contraction stage and are left until a contract is awarded to an equipment supplier. This situation is pronounced as project planning time and internal engineering capacities at cement manufacturers are cut down in many cases.

Later recognition of this problem during the engineering stage of the project often results in a request for expensive change orders from the equipment supplier due to the increase in the height of the preheater. To avoid a final and unchangeable situation at a new kiln line project, qualified contractual provisions, as well as the engagement of competent and experienced consulting engineers, are recommended.