Key Considerations for Cooler Retrofit

The need of the hour is to get the best performance from a cooler. When the kiln capacity goes up, one needs to understand the design considerations and what best can be done under the changed conditions.

The cement manufacturing process is highly energy intensive and consumes between 700 to 780 kcal/kg clinker of thermal energy in a dry type process with inline calciner. Cooler losses contribute to about 105-115 kcal/kg clinker for a modern fourth/fifth generation cooler. In order to get a better perspective on the basic engineering revolving around coolers, this article discusses some of the fundamental principles behind the working of the cooler as well as the design considerations that become paramount while upgrading coolers.

Clinker Cooler Basics

The clinker cooler is the part of the pyro-process where the solid reaction mass is quenched on exiting the kiln. The cooler is basically a heat exchanger which cools the hot clinker from the kiln while transferring this heat to the ambient air and consists of two zones. The clinker first enters the heat recuperation zone where the heat from the clinker is transferred to optimised amount of cooling air, so that the requisite amount of secondary and tertiary air can be obtained for combustion at the maximum possible temperature. The second zone is the cooling zone where the rest of the air is supplied to cool the clinker and the heat from the vent air can be recovered by drying of coal in coal mill or by waste heat recovery boilers.

The efficiency of the cooler depends on its ability to recover the heat from the clinker entering the cooler, and cooling the clinker. The cooler also fulfils the key role of transporting the clinker away from the kiln in a reliable manner.

Cooler housing.

Cooler design would include some of the following requirements: low capital cost; optimum cooling rate for good clinker quality; low clinker discharge temperature; least possible impact upon the environment; high heat recovery; low power consumption; low wear and maintenance cost, operational reliability, causing minimal downtime; ease of control so that it delivers a steady flow of combustion air at an unvarying temperature to the kiln and calciner.

Leading manufacturers of coolers today are FLSmidth, IKN (Ingenieurbüro Kühlerbau Neustadt), CemProTec, Claudius Peters, KHD Humboldt Wedag, ThyssenKrupp Polysius AG, FONS technology, etc. The coolers designed by these vendors have undergone significant modifications over the years. The major differences lie in the manner in which material is conveyed over the grates, the mode of aeration and the solid-gas heat exchange, the type and presence of self-regulating valves for airflow and the hydraulic system for moving parts.

With advancement in clinker cooler technology, the requirement of cooling air has gradually gone down from about 3.5 kg/kg clinker to 2.2 kg air /kg clinker (1.6-1.8 Nm^3/kg clinker) in new fifth generation clinker coolers and the specific cooler area has gone up from 20 tpd/m^2 to around 45 tpd/m^2. The operating efficiency hovers around 70 – 74 per cent in modern coolers (based on coal as fuel). Various developments have taken place with respect to the mode of aeration of grates, the mechanism of forward movement of the clinker as well as with the protection of the wear parts at the high operating temperatures. The issue of segregation of fine and coarse particles of clinker as received from the kiln on the bed of the cooler, causing maldistribution of cooling air flow through the bed is also to be prevented by the mechanism of transport within the cooler. Cooler manufacturers have developed various techniques to overcome issues of bypass of cooling air, red river formation as well as snow man formation at cooler inlet which have brought down the cooler power requirement to around 3-3.6 kWh/t of clinker from earlier design grate coolers which consumed around 6-7 kWh/t of clinker cooled.

The clinker cooler auxiliary system is generally similar in most modern coolers, where the cooling air enters through multiple fans and the positive pressure of the fan being controlled by the height of clinker bed on the cooler grate. The height of the bed is controlled by the grate speed or the speed at which crossbars push the material out of the cooler with an automatic closed loop control system. The vent air circuit usually consists of a heat exchanger, and baghouse or an ESP and a fan before the stack. In some designs the cooler has individual under-grate compartments, each being supplied with air from their respective cooler fans. For control of the air through the grate plates within the individual compartment, each cooler grate plate has a flow regulating device. Nowadays, cooler fans are also provided with variable drives so that the specific power consumption can be reduced in case the kiln is operated for prolonged periods at varying capacity levels. Some vendors provide circuits that can recycle the cooler vent air back to the cooler inlet, reducing the overall heat loss. This may be advantageous in the case a mid-tapping is taken at the cooler for a waste heat recovery boiler and the vent air after the boiler is at a low temperature of around 100-110 °C.

A clinker crusher is usually provided after the cooler grades to ensure that any oversize lumps are broken down. The clinker discharges from the cooler across a grizzly to a hammer mill or hydraulic roll crusher located in the cooler outlet. The crusher may be sometimes installed in the middle of the cooler, before the last grate, to break up lumps and large clinker, and to ensure their efficient cooling.

Cooler operation issues

Ideally, the cooler is designed to cool the clinker which enters at 1,300°C to around 100°C (ambient +65°C). When a cooler runs at an optimised level, the secondary air temperature is around 1,050°C, the tertiary air leaving the cooler is at 950°C and the vent air is at 250-300°C. Sometimes a mid-tapping from the cooler may be taken to the coal mill and/or to waste heat recovery boilers. Temperatures at such mid-tapping outlets are around 450-500°C. A typical mass balance for the cooler would be thus: of the cooling air of around 2.2 kg air/kg clinker that enters the cooler, around 1 kg air/kg clinker leaves as secondary and tertiary air for combustion, and the rest could be vented as exhaust. In case of a mid-tapping around 0.35 kg air/kg clinker may be removed (depends on coal moisture) and the

SOME OF THE TYPICAL PROBLEMS FACED BY MANY USERS ARE:

The cooler is unable to cool the clinker. Hot clinker at 150- 200 °C leaves the cooler and is subsequently sprayed with water. In such cases it is found that the vent gas is also at high temperature, around 350 °C.

1. The design of cooler or the installation of the cooler is such that quenching action does not happen at the immediate cooler inlet at the stationary grate section. This will lead to lower secondary and tertiary air temperatures, thus affecting the kiln operation.
2. The raw meal chemistry and the subsequent burning in the kiln may result in higher proportion of fines. If the cooler is not designed to handle fines there may be insufficient heat exchange, red rivers formation, carryover of material in the TA duct to cause blockages in cyclones, etc.
3. Snowman formation in the cooler could occur due to inefficient kiln operation with excessive fines, fall of clinker coating and due to the deficiency in number and locations of air blasters.
4. In some cases, the temperatures that were expected from cooler mid-tapping for coal mills or waste heat recovery systems are not achieved.
5. Higher power consumption in cooler drives occurs, which could be a result of coolers handling greater than design loads.
6. Frequent stoppages of cooler could take place due to failure of mechanical parts or high temperatures in gear box lubrication systems. Maintenance issues may also arise due to designs in which hot clinker falls out of the grate plates, and jamming of plates are frequent.

rest 0.85 kg air/kg clinker is vented at lower temperatures of 150 to 200 °C. Cooler disruptions may occur once in a while, however, most coolers are designed to handle higher temperatures or higher volumes of vent air for short periods (30 mins), and during such periods the coolers can be brought under manual control without major disruptions.

Ercom personnel have come across real plant situations where coolers perform at sub-par levels.

A COOLER UPGRADATION WILL HAVE TO BE CARRIED OUT BASED ON THE FOLLOWING PARAMETERS:

1. A design basis based on any envisaged upgradation in clinker capacity, plans to use alternate fuels (may affect the burner assembly), and plans to install waste heat recovery systems.
2. The specific heat consumption at baseline level should be determined along with existing cooler efficiency levels. This should be compared against industrial benchmarks for similar systems. Any changes in raw mix and clinker chemistry should also be considered.
3. An analysis of cooler downtime over the last two-three years will give a good idea of the failure mechanisms of the cooler. This will highlight the mechanical/electrical or automation related deficiencies in the existing installation.

Considerations for cooler upgrades

Ercom has been able to solve most of the problems by studying the operation of the coolers and optimising the operating parameters. However for a given make, model and age of cooler, there will be a limit to the improvements that can be gained by tweaking operations alone. The cooler may become a bottleneck after capacity enhancement of the preheater-precalciner is carried out.

Ercom typically carries out a baseline audit to determine the above and then the project proceeds along the following lines:

1. Comparison of available cooler technologies to determine the best fit for the upgrade.
2. The choice of technology can be made for upgradation, on the following points:
   a. Possibility to reuse the existing cooler building/foundation. Constraints due to existing layout and possibility of increasing cooling modules have to be evaluated.
   b. Existence of other pyro-lines and hence reduction of spares cost by installing similar coolers. Improvement in the maintenance requirement by incorporation of new design.
   c. Modifications required to the cooler hood, burner assembly, etc.
   d. Requirement of new cooler fans or reuse of existing ones.
3. Basic engineering is carried out keeping in mind that the main reason for installing the upgrade is to reduce the specific heat consumption of the pyro process, by reducing cooler losses and to also match higher clinker production level achieved from optimising the kiln operation. In this context, it is important to mention that a waste heat boiler for cooler exhaust gases should be designed on the basis of efficient operation of the cooler after upgrade. Any design that increases the power rating of the waste heat recovery system by reducing the heat recuperation to the kiln, thereby causing more fuel consumption, would not be a sustainable design (unless the cement plant was paid for burning fuel).
4. In a retrofit project, lead delivery times and hook-up times will play an important role in selection of vendors.
5. Since access to plant areas will be restricted in an operational project, project planning and execution will have to be carried out efficiently so that there are minimum hurdles to the movement of men and materials while maintaining a safe working condition at all times.
6. The enhanced requirement of certain utilities as well as necessity of automation upgrades when modifying the cooler should be studied upfront so that there will be fewer surprises during site installation and commissioning.

Ercom has been involved in cooler retrofitting projects both in India and the Middle East. Typically for upgradation from the cooler alone, say from 4,000 t/d to 5000 t/d, the cost of the project (retrofitting of existing cooler) is between Rs 6-9 crore depending on the extent of modifications required. However, the same may substantially vary on a case-to-case basis.

Upgradation of coolers in cement plants will be successful only when the entire project is conceived with an in-depth study of techno-economic feasibility and executed with adept and experienced engineering and project management. With assistance from partners like Ercom, all stakeholders will come out with positive outputs that will help the sustainability of both the environment and the cement business. ICR

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