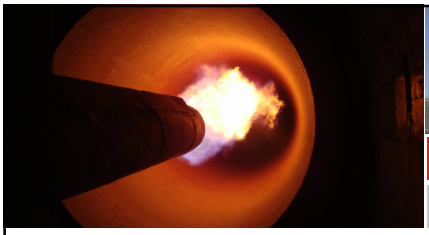

Green Cemtech
2010, Hyderabad

Future Trend
Waste Heat Recovery in Cement Plants.

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Process Engineering & Special Projects

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Common Process of WHR

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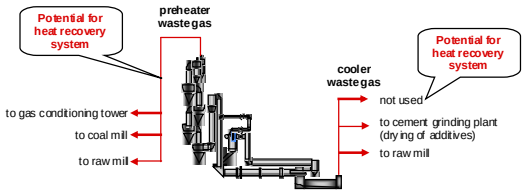
Future Trend - Waste Heat Recovery



Future Trend - Waste Heat Recovery

How much heat from pre-heater and cooler waste gas is available?

How much heat is required for drying of coal and raw material?

Application to use waste heat in the cement plant?

- Warm water, low pressure steam for preheating or drying (e.g. secondary fuels by an indirect dryer)

Application to use waste heat outside the cement plant?

- Process stream, overheated water (e.g. for a solar power plant; district heating systems)
- Climatization / air conditioning / ice production etc.
- Thermal demineralization of water

Application to produce electrical power?

- ORC, Kalina, water steam turbine

Future Trend - Waste Heat Recovery

§ First priority has the utilisation of the waste heat for drying raw materials and fuel.

§ Nevertheless, the remaining potential for generating electrical energy can be in a range of:

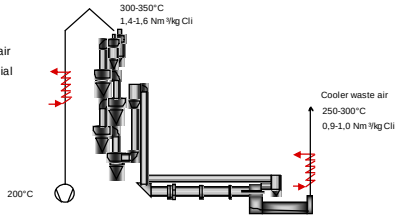
~ 30 kWh/t of clinker for 5 stage pre heater
~ 34 kWh/t of clinker for 4 stage pre heater

§ The increased waste gas volume due to the firing of secondary fuels can be used in a Waste Heat Recovery system (WHR) as a source for generating electrical energy.

Future Trend – Waste Heat Recovery

Common process of waste heat recovery

Installtion of two boilers
1.) preheater waste gas
2.) cooler waste air / mid air
Suitable for low raw material moisture (max. 4%) only



Innovation On Demand

Power Recovery

- Power available

It depends on the factors:

- Capacity of kiln, Number of stages of cyclones of the preheater
- Process mastery: heat consumption, temperatures and flowrates of waste gas from pre-heater, cooler
- Drying requirement of raw material and coal, which determines the minimum temperature at pre-heater boiler outlet
- The type of raw mill and coal mill? Ball mill or vertical mill? The lower the flow rate (in ball mill case), the higher the temperature of gas at outlet of PH boiler is needed to dry material, less heat can be used for power generation
- The type of de-dusting system on cooler side. If EP is used, higher gas temperature has to be kept compared with bag filter de-dusting, hence lower power can be generated

Innovation On Demand

Important Check Points for WHRS (Steam)

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§ Redundancy of the ID Fan/ Cooler vent fan pressure capacity.

ü It is estimated around 7 – 12 mbar pressure drop after boiler and one dust chamber /cyclone should be considered to Clinker cooler side.

§ Required temperature and air volume for Raw material and Coal drying. For high moisture content in Raw material or Coal, consider to install WHRS only at cooler side only.

§ Water availability and feasibility of developing new water source.

ü WHRS need a lot of water, the water requirement is in the range of 70 – 95 t/h.

Innovation On Demand

4 or 5 stages Preheater with a WHR?

The 4-stage concept :

The idea is to operate an existing 5-stage preheater as a 4-stage in order to generate more power
When the WHR is running the raw meal would be fed between Cyclone 3 and Cyclone 2. When the WHR is not running, the raw meal would normally be fed between C1 and C2
The calorific consumption will be 30kCal/kg.kk higher, and the power generation around ~7 kWh/t.kk higher.

The feeding between C3 and C2 will always bring an higher Opex (see next slides) the global profitability depends on the Capex needed to feed the raw meal between C3and C2 as well as the margin on the design of the WHR system.

Innovation On Demand

Potential Problems or Impacts

- Clogging problem:

The pre-heater boilers use bare tubes with a rapping system (like an ESP) in order to get rid of the dust. It will not be a big problem with proper design.

- Wear problem

Lifetime, Based on chinese cement plant data they have experience on 3 years lifetime and the expected lifetime for internal parts is 12 years. They have faced some wear problem on the cooler boiler (top tubes at the end - see figure Nº1). The problem can be eliminated by protecting the end of the tubes.

If there is a hole in one of the pipes, the operator should be able to detect it via the parameters and various sensors installed in the circuit.

The power station is supposed to get a short overhaul period every three years (same time than kiln overhaul) and a big overhaul (1 month) every 5 years

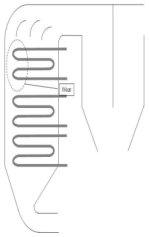

Figure 1: AQC boiler - Wear problem

Innovation On Demand

Potential Problems or Impacts

- Heat resource for coal drying

As the hot gases for coal mill are taken after the ID fan, the reduction of gas temperature (till 250ºC and below) may lead to coal drying problems if moisture is very high. If so, the hot gases should be taken at the top of the pre-heater.
When designing a coal mill ID fan, this has to be taken account,(may request to change the coal mill ID fan (negative pressure), as well as adequate new ducting, and slightly affecting power consumption in case of existing plant.

- Impact on kiln operation and Performance

üPressure Drop: The pre-heater exit boiler is said to have from 700~1200Pa of pressure drop. When designing the pre-heater ID fan, this has to be taken account (in case of existing plant the increasing of pressure drop will reduce the ID fan flow capacity, compensated by the reduction of temperature).

ü When ID fan is located before GCT, positive impact on ID fan KW.

ü Kiln hood pressure control when lack of margin on cooler exhaust
à the boilers are partially by-passed

Innovation On Demand

Potential Problems or Impacts

•**Other** Operational issues

Taking into account that steam turbine should be always feed very close to their nominal capacity (at least 75~80%). Hence, we can only operate the WHR when the plant is above 75% of capacity.

- Design issues

With the WHR system, the cooler de-dusting could have less work load. Since 95% of time (to kiln) WHR is running, the temperature hence the flow rate will be lower, the smaller bag filter will work. And the air-air heat exchanger before bag filter presents a big amount in investment cost can be lower sized, and since it will work 5% of the time, the wear will be less.
Hence the investment for the cement plant will be reduced.

Improvement Opportunities

- § Improving the existing installation
  - ü Losses reduction in the circuit, Temperature and Pressure
    - § foot print and lay-out
    - § False Air In leakage (shall be less than 3%)
  - ü Dust Management (charge, coating and reclaiming)
    - § Start Up heating to avoid sticking during cold start up and increase UF
    - § Design of boiler and tube
  - ü Reduce self consumption (natural circulation, reduced Dp)
- § Getting more from Thermodynamic Cycle
- § Turbine Efficiency
  - ü Double stage turbine
- § Increasing Gas Heat Recuperation
- ü Optimum SP Boiler temperature outlet to increase power generation
- ü Optimum positioning of AQC recuperation

Conclusion

- § Waste heat recovery is today a state of the art technology.
- § Waste heat recovery is an environmental friendly technology for saving fuels and therefore for saving CO_2.
- § The combination of secondary fuel utilisation and waste heat recovery delivers an efficient technology for saving fuels and therefore for saving CO_2.
- § The power produced depends on kiln capacity, number of stages of cyclones, process mastery (heat consumption, gas temperature and flow rate of pre=heater and cooler), required temperature for raw mill and coal mill drying.
- § To operate 5-stage pre-heater as 4-stage can be considered in the countries where power cost is high and fuel cost is low, For new burning lines a 4-stage pre-heater can be considered.
- § Production of power (net) could be around 34kWh/t.cl for 4-stage pre-heater and 30 kW.h/t.cl for 5-stage pre-heater.

Thank you for your kind attention.