CEM
CON

GAS CONDITIONING TOWER (GCT) VS DOWN COMER DUCT SPRAY (DDS)

Dr. Hans Wilhelm Meyer and Piet Hein Heersche

CEMCON AG/SWITZERLAND

1. Introduction

Projects in the cement industry are investment intensive, of heavy industry character and are significantly influencing the competitiveness of a cement manufacturer. This is particularly concerning clinkerization plant projects which are mainly consisting of tailor made design. Optimization of such heavy equipment and processes are essential to the efficiency of capital investment. However proper functionality and operation cost are to be considered and this focus have to be maintained.

In the course of a 6500 TPD green field cement plant project in Indonesia intensive efforts have been made to investigate the option of replacing the common Gas Conditioning Tower (GCT) by a Down Comer Duct Spray (DDS) system. This paper serves to summarize and share those considerations and evaluations on this subject.

2. General process description and function of GCT and DDS

The standard pyorline of a clinkerization plant consisting of clinker cooler, kiln, preheater, GCT, preheater fan and system filter with fan. This system is operated in two different operation modes:

a) Combined operation of the pyro line together with the raw mill(s)
b) Direct operation of the pyro line (raw mill out of operation)

As per standard design combined operation modus covers 20-21 hpd. However in reality the raw mill(s) is operated 24 hpd and usually only stopped for maintenance once a week for 6-8 h (equivalent to approximately 5 % of total operation time). During this time the pyro line is in direct operation mode. Design reserves on the raw mill(s) are usually transferred into production capacity.

Furthermore the design of the preheater is tailor made following the raw material and coal moisture to be dried in raw mill and coal mill respectively by the heat content of the preheater exhaust gas (temperature and quantity) and the exhaust gas from the clinker cooler (if required). Hence in combined operation mode the complete exhaust gas of the preheater is utilized for raw material and coal drying .Typically based on a modern 5 stage preheater design a specific exhaust gas quantity of approximately 1.6 Nm^3/kg clinker at a temperature of 320 °C is available.

In direct operation mode of the pyro line however this quantity drying energy is not required and the exhaust gas needs to be cooled to a temperature of approximately 180 °C (considering a bag house type system filter). In this case the GCT is operated. Its function is primary to cool the excess heat of exhaust gases (see Fig.1). To do so, water is injected into the GCT by a ring of dual media (compressed air and water) water lances. To avoid water droplets (Fig.3) which in combination with the preheater dust contacts the walls of the GCT and causes uncontrollable coatings the diameter of the GCT is enlarged (typically for a 6500 tpd plant 4.0-5.5 m). In addition the GCT needs to be isolated. Considering the evaporation time of the water droplets a gas velocity of 9 m/s is typical for GCTs resulting in a length of approximately 50 m. Due to the required evaporation time of the droplets and the resulting low gas velocity the GCT´s secondary function is to collect and extract outfall of preheater dust particles. For this reason and to cover male function of the GCT (improper water spray) a dust transport system (and emergency slurry outlet) is installed at the bottom of the GCT. All the technical requirements result in large and heavy installation within the (congested) area between the preheater and the raw mill including the necessity of heavy foundations.

Fig.1: Typical view of a GCT system installed between preheater and raw mill section.

The DDS function is identical to the GCT´s primary function to cool down preheater exhaust gases in case of direct operation of the pyro system (see Fig.2). The DDS uses atomizing dual media nozzles (compressed air and water) (Fig.4). By the atomizing effect no water droplets but a mist of water is injected. For this reason a ring of atomizing water nozzles can be installed directly into the down comer duct at the preheater. The diameter of the down comer duct requires slight enlargement typically in the range of 200 mm in diameter. The diameter of the enlarged down comer duct is in the range of 3 m for a plant of the capacity discussed in this paper. For this reason the gas velocity remains at 20-22 m/s. At this velocity no precipitation of dust from the preheater exhaust gas occurs. Nevertheless usually a simple screw conveyor type of emergency outlet is installed at the bottom of the down comer duct. This material emergency outlet is not for regular dust transport as in case of the GCT and hence not connected to the system filter dust transport system.

Fig.2: Typical view on a down comer duct spray installed between preheater and raw mill section,

Fig.3: Standard dual media water spray nozzles creating water droplets.

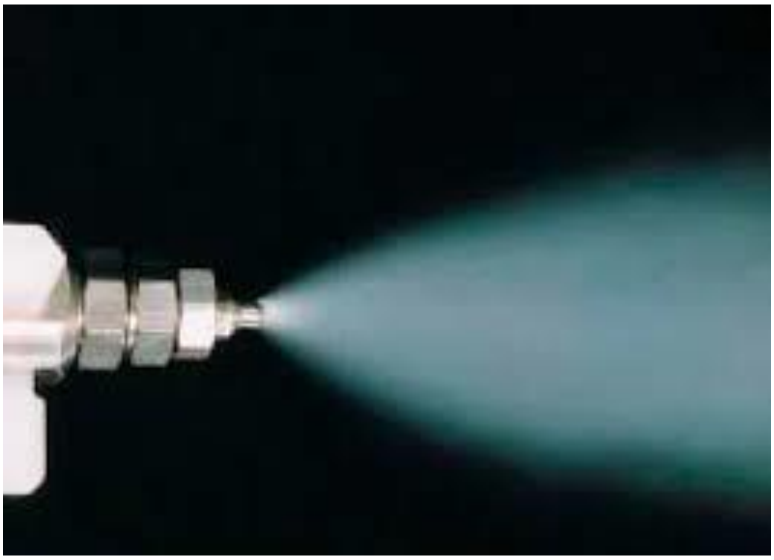

Fig.4: Atomizing dual media nozzles creating a water mist.

3. Differences in operation (as per example of a 6500 TPD clinker production line)

The 6500 TPD clinker production line is characterized by raw material moisture of around 9.9 % to be dried in the raw mill. The preheater consists of a double string 5-stage arrangement with a combined PH fan. The kiln line is operated with a lignite coal of net CV of maximum 4800 kcal/kg and moisture content (as received) around 34 %. The preheater is equipped to operate on 5 stage kiln feed with an exhaust gas temperature of 320 °C or at 4 stage kiln feed with an increased exhaust gas temperature of up to 380 °C. This option covers fluctuations and project risks mainly concerning the annual monsoon raining season and related raw material and coal moisture. Consequentially the complete available exhaust gases are used as per following balance:

PH exhaust gas at 320 °C available	853000	Am3/h
PH exhaust gas to coal mill	291000	Am3/h
PH gas to raw mill	562000	Am3/h
Cooler exhaust gas to raw mill	314000	Am3/h
Raw mill gas completely at 320 °C	876000	Am3/h

Fig.5: Exhaust gas quantities available in Am^3/h and distribution to coal and raw mill.

As listed in Fig.5 a total of 853000 Am^3/h of preheater exhaust gas at 320 °C (5-stage operation) and a pressure of -58 mbar (at the top of the preheater) is available for drying purposes. As the lignite coal mill can accept only partially inert gases (maximum O^2 content 10 % only preheater exhaust gases are suitable for operation of the coal mill. Hence 291000 Am^3/h of preheater exhaust gases are directed towards the coal mill. The remaining 562000 Am^3/h preheater exhaust gases are directed to the raw mill. In order to dry the raw mixture moisture of 9.9 % additional 314000 Am^3/h cooler exhaust air is directed to the raw mill.

The initial concept (Fig.6) was to install a GCT after the PH fan and extract the PH exhaust gas for the coal mill by a booster fan (with de-dusting cyclone) between the PH fan and the GCT as the pressure required by the booster fan is only in the range of -5 mbar.

In direct operation mode the GCT system of Fig.6 has to be commented as follows:

4. GCT (Gas conditioning tower) system in direct operation (all mills off)

- 853000 Am3/h of kiln exhaust gas (all PH exhaust gas) need to be transported at 320 °C.
- The preheater fan (=variable frequency drive VFD) is located before GCT. Hence this gas has to be processed by the PH fan at 320 °C at -58 mbar.

The alternative concept would be to install a DDS system (Fig.7) directly before the PH fan resulting in the following comments in case of direct operation mode.

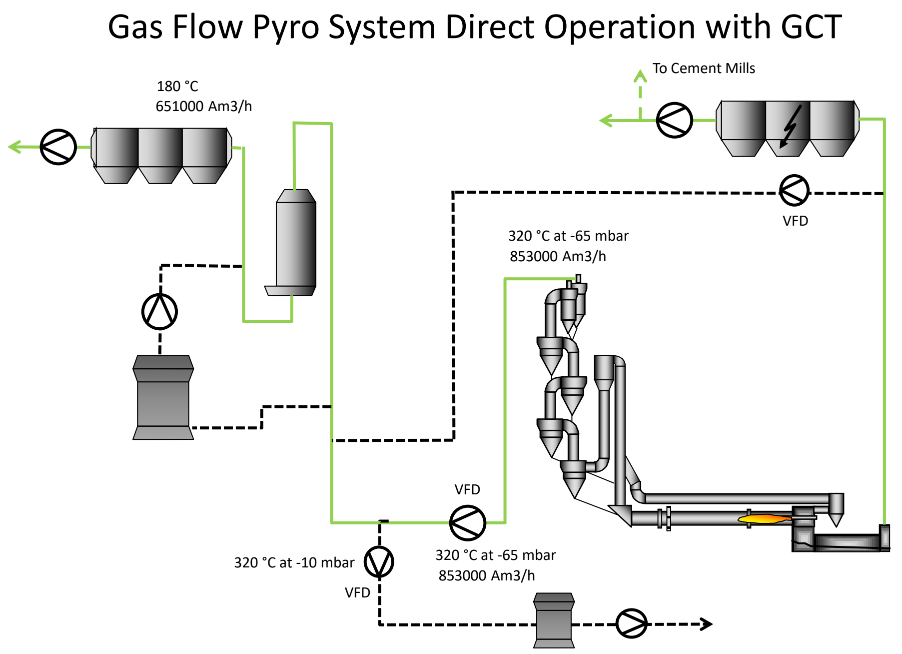

Fig.6: Typical flow sheet of a GCT after preheater fan in direct operation mode.

5. DDS system in direct operation (all mills off)

This operation mode has to be commented as follows (Fig.7).

- In this case water cooling by DDS the water is injected before PH fan.
- The gas temperature will be reduced to 180 °C and the gas quantity will be reduced from 853000 Am3/h to 651000 Am3/h (equivalent to 76 % of fan nominal capacity). The pressure is still -58 mbar.
- Consequently the VFD PH fan will achieve a reduction in power consumption.

However the direct operation mode of the pyro system will cover only about 5 % of the total operation time. For this reason the following calculation of the combined operation (raw and coal mills in operation with the pyro system) covering 95 % of the total operation time is of higher relevance.

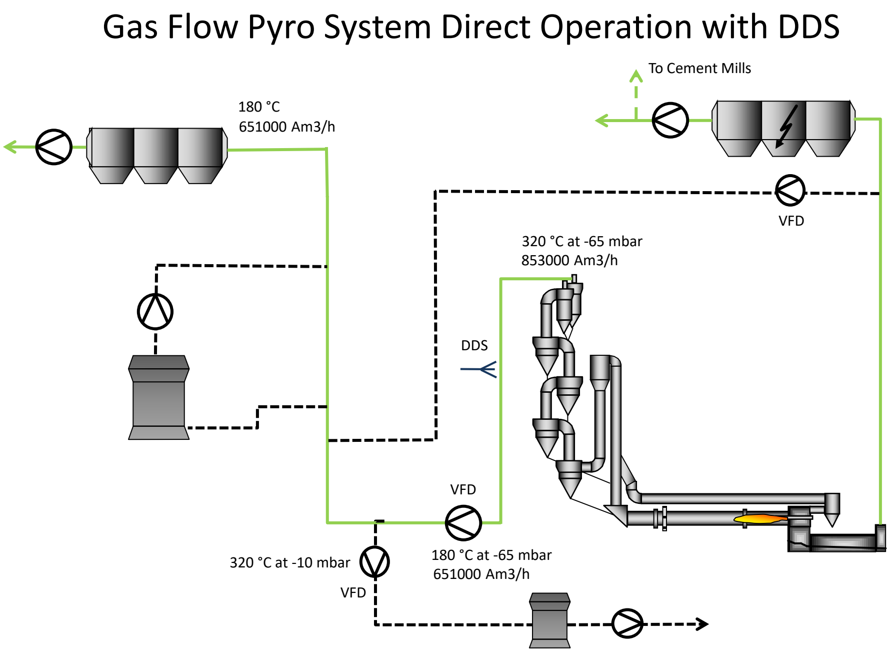

Fig.7: Typical flow sheet of a DDS before preheater fan in direct operation mode.

6. GCT (Gas conditioning tower) system in combined operation (all mills on) and extraction location of coal mill gases after PH fan.

- All gas from the PH (e.g. 853000 Am3/h) has to be processes at -658 mbar by the VFD PH fan at 320 °C. Hence preheater fan is on full nominal operation.
- After the PH fan at a pressure of maximum -5 mbar (design) 291000 Am3/h are directed away to the coal mill by the booster fan at 320 °C. This fan should be also of VFD drive technology.
- The rest of the PH exhaust gas (plus cooler waste air) is directed to the raw mill (561000 Am3/h at 320 °C).

In case of combined operation with the GCT, the DDS process is similar compared to the GCT and both water spray facilities are out of operation. The difference is the extraction location of the preheater exhaust gases by the coal mill booster. The differences are graphically illustrated in the flow sheets of Fig.8 and Fig.9:

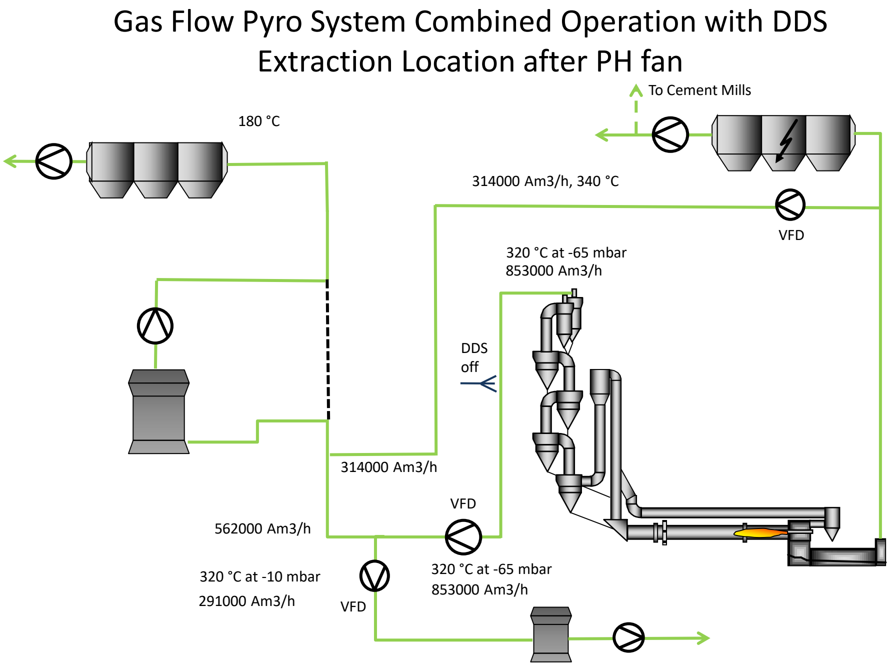

Fig.8: Typical flow sheet of a DDS in combined operation mode. Extraction location after PH fan.

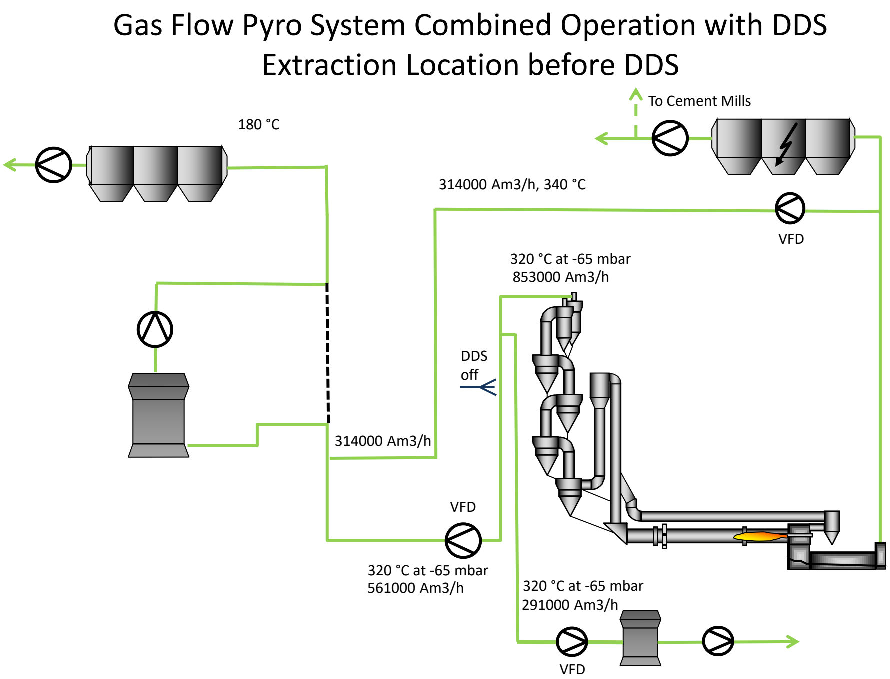

Fig.9: Typical flow sheet of a DDS in combined operation mode. Extraction location before DDS.

7. DDS system in combined operation (all mills on) and extraction location of coal mill gases before DDS.

- The coal mill booster fan is extracting PH exhaust gas before the DDS and the required 291000 Am3/h at 320 °C are routed to the coal mill. However in this case at a pressure of -58 mbar is required for the coal mill booster fan. Consequently the booster fan requires upsizing and resulting in increased energy consumption.
- At the same time the PH fan does have to process a reduced gas capacity of 291000 Am3/h at 320 °C and -58 mbar meaning only 562000 Am3/h equivalent to 66 % of nominal capacity are transported to the raw mill. The PH fan VFD-speed will be reduced resulting in direct energy savings. Another option is to transfer the available PH fan capacity (at least a part of it) into additional draft on the PH and into clinker capacity.

8. <u>Summary of advantages and disadvantages of GCT and DDS</u>

The technical data of the GCT (based on the project example of a 6500 TPD line) are summarized in Fig.9. There are no specific data for the DDS as the down comer duct will be extended only by approximately 200-300 mm.

351-CT01 GCT		
Diameter	9500	mm
Height	50000	mm
Weight	238000	kg
Capacity	1000000	Am^3/h
Inlet temperature	330 (Max. 450)	°C
Outlet temperature	150 (Max. 220)	°C
Water injection	29 (Max. 45)	m^3/h
Diameter	12000	mm
Footprint	161	m^2
Foundations	YES	
Piling	YES	

Fig.9: Technical data of GCT.

- The GCT requires a significant footprint of 161 m^2 whilst the DDS is basically using a slightly extended but existing duct work.
- The atomizing nozzles cannot create water steams at male function. Only blockage is possible. Hence there is no risk of water and dust coatings/blockings of the duct work.
- The GCT requires piling and heavy foundations. The GCT weight is in the range of 238 T.
- The function of both systems is identical.
- The area between PH and raw mill is usually congested with duct works, raw meal transport, etc. Installation of a GCT is increasing this congestion.

- Both systems can be installed directly after PH. Gas for direct operation of the coal mill can be extracted directly after PH (high pressure draft required for coal mill booster fan but reduction of capacity of PH fan).
- Both systems can be installed after PH fan with extraction of coal mill gases after PH fan (low pressure draft of the coal mill booster fan but full capacity of the PH fan).
- GCT required fully equipped additional dust transport.
- DDS requires no dust transport. Only an emergency outlet is installed.
- As per experience the area of GCT often is neglected by maintenance and hence is a “dirt area”.
- More space available for the Waste Heat Recovery System (WHR) in case of DDS.
- The investment cost for a GCT are much higher compared to a DDS (in the range of 650000-900000 USD).

9. Summary and conclusion

As demonstrated above the advantages of a DDS prevail against a conventional GCT. The main advantages of the DDS can be characterized in:

a) Reduced construction of pilings, foundations, steel support structure and ductwork and related reduction of investment cost.
b) Energy and cost savings at booster fan and PH-fan capacity.
c) Easier and safer operation by now to now danger of male function by water droplets.

For the above reasons it is recommended to replace standard GCT´s by DDS. This is valid for existing and in particular for new pyro line installations.