A new rotary kiln burner technology

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Heinz Lederer, Unitherm-Cemcon, presents the new M.A.S. rotary kiln burner with only one primary air duct.

Introduction

The cost-effectiveness and uniformity of rotary kiln operation depend to a great extent on the correct adjustment and mode of operation of the firing system. The rotary kiln burner not only affects the fuel energy consumption and the operation behaviour of a rotary kiln system, but also has a considerable effect on the clinker quality and the level of emission of pollutants. Environmental protection and rising energy prices have made it necessary for the manufacturers of rotary kiln burners to develop systems which can influence the shape of the rotary kiln flame over a wide range, even with a very small proportion of primary air. Carefully controlled management of the combustion system should also reduce the formation of NOx. The majority of rotary kiln operators now also demand combination burner equipment so that they can react to fluctuating prices and availabilities of the fuels used, and so that they can burn secondary low-grade fuels in dual-fuel operation.

Conventional rotary kiln burners

Most last generation rotary kiln burners were fitted with two air ducts in order to ensure maximum flame forming capability (Figure 1). The object of these primary air outflow systems is to use the two airstreams, an axial component and a swirl air component, to produce a resulting air flow to influence a flame shape. This system has the disadvantage that the air flow is created from two practically opposing flow components, which thus influence the flame form.

The fluid technology involved means that such systems lead to double friction losses in the nozzles, and energy losses when the two flow components are mixed and create uncontrolled turbulence. Also a very important disadvantage is that the narrow nozzle cross-sections also reduce the depth of penetration of the air jet into the kiln space.

These, and other considerations were the reasons why Unitherm looked for a burner system which could convert the whole primary air flow smoothly at the nozzle into a swirl of any intensity, and at the same time utilise all the available primary air for the purpose of cooling the outer air duct/nozzle.

The new M.A.S.-burner

The innovative solution for this problem, to bring the whole primary air flow to an adjustable swirl intensity, is a flexible swirl setting device built into the primary air duct (patent pending) consisting of flexible hoses in a planetary arrangement through which the primary air flows. The swirl intensity is determined by the angle of the deflections of the hose nozzles, which can be adjusted during operation from the cold side of the burner.

The primary air supply differs from the conventional burner in that the M.A.S. burners are equipped with only one primary air channel and all of the primary air streams out through one air nozzle (Figure 2).

Function of the flexible swirl setting device

The flexible swirl setting device is located in the annular primary air channel, approximately 0.3 m from the burner mouth (Figure 3). In the annular channel, flexible hoses are arranged around the circumference in a planet-like configuration (7) (Figure 4). The front of these flexible tubes are mounted in a rotatable and axially slideable manner. The rear end of the hoses are held in a ring which can be distorted around the axis. Distortion of the ring is performed by means of a linkage mechanism which is actuated from the cold end via a gear unit.

Figure 1. Outstream system of conventional burner.

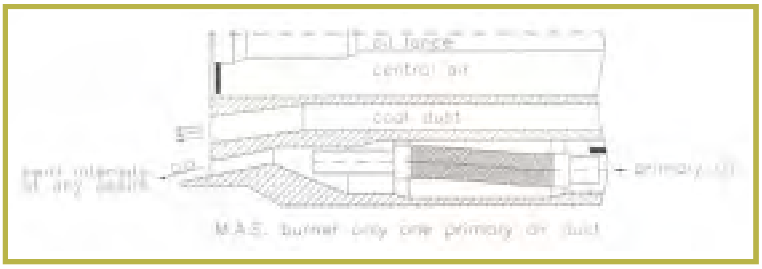

Figure 2. M.A.S.-burner (mono airduct system).

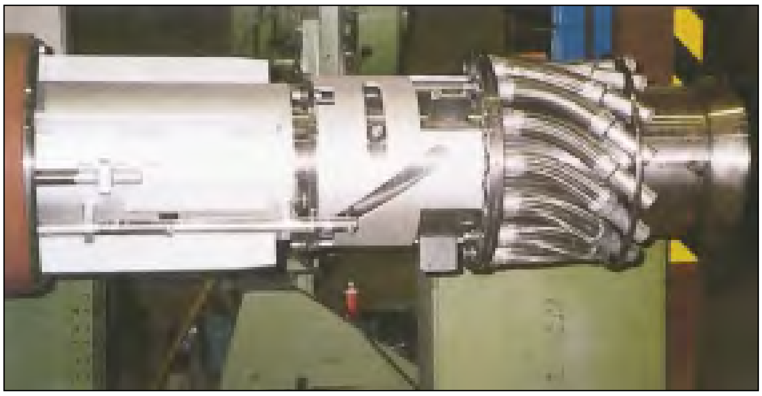

Figure 3. Burner front without frontier jacket tube, showing the swirl setting device.

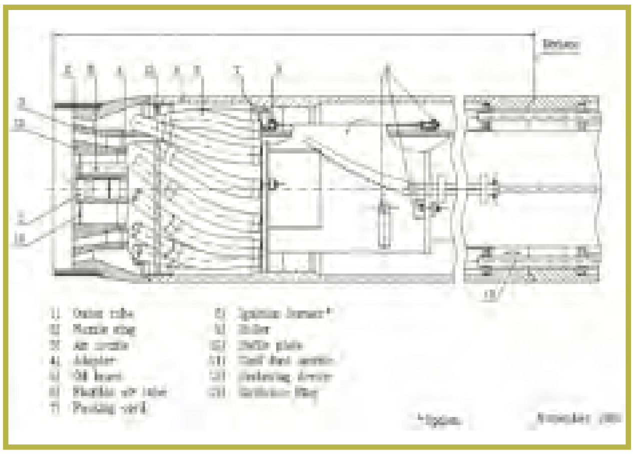

Figure 4. M.A.S. / . / KO.SO Nozzle outstream system with flexible swirl setting device.

If the ring is rotated, the flexible tubes (6) will fit snugly to the inner tube in a helical manner. Depending on the distortion angle of the ring, the hose ends will be deflected in relation to the burner axis. The air will flow through the flexible tubes to the rotation chamber in front of the outlet nozzle. There, the air flow is swirled at an intensity which depends on the deflection angle of the flexible tube ends, and it then passes through the air nozzle (3) into the kiln.

Influence of the M.A.S.-system on NOx-formation

The basic parameters which are important for the formation of NOx in rotary kilns can be divided as follows:

Non-burner dependant parameters

- combustion chamber conditions,
- thermal kiln loading,
- total excess air,
- kiln dynamics,
- sintering zone temperature,
- secondary air temperature,
- fuel conditions, composition, grinding, feeding, ignition properties,
- raw mill conditions, burnability, lime standard.

Burner dependant parameters

- percentage of primary air,
- configuration of the fuel channel,
- exit flow momentum,
- ignition distance, oxygen supply, flow conditions.

Due the unique outflow system the M.A.S. guarantees minimum NOx formation because of its:

- Specific primary air momentum in the range of 3-9 N/MW (according primary air fan).
- Coal channel position at the inside of the primary air channel to create a fuel reach internal reverse flow zone.
- Flame ignition as close as possible to the burner nozzle. The minimum amount of air is mixed with the coal volatiles prior to ignition. This is achieved by low primary air inputs and the optimisation of the internal recirculation zone generated by wrapping the flame with the primary air cover.

Advantages of the M.A.S.-burner

Burning process advantages

- Complete smut round the defined flame shape because the homogeneous primary air flow surrounds the fuel, due to the deep penetration of the flame on the kiln axis. This primary air cover also avoids the fall out of unburned coal particles onto the clinker bed.
- Easy adjustment and high reproducibility of the flame shape (Figure 5).
- High penetration depth of the primary air flow.
- Efficient mixing of secondary air into the flame (after ignition), because of a hank outflow formation. This phenomena allows a very low primary air rate of approximately 5%.
- Reduction of pressure losses in the nozzles up to 50 %
- Lower pollutant emissions (NOx) because of less turbulence in the nozzle area and a closed ignition distance of the flame to the burner mouth.
- All primary air volume available for cooling the outer pipe.
- Possibilities of re-equipping for waste fuels due to the large central channel.
- The central air channel can be used for installing the ignition burner, several burner lances, or dust media (clarified sludge saw dust etc.).

Table 1. Measurements taken from a 1000 tato kiln without precalciner with a combined coal/oil rotary kiln burner type M.A.S. / 2 / KO.SO

Date	Kiln 2								
	Temperature ˚C	Secondary air ˚C	O_2	Capacity tpd	Coal tpd	Oil tpd	NO mg/m^3	NO 10% O_2 mg/m^3	NO_2 10% O_2 mg/m^3
30.04.1995	1360	735	4,2	900	128	0	450	295	454
01.05.1995	1360	730	4,2	900	130	0	350	231	355
02.05.1995	1340	620	4,5	890	127	0	350	233	359
03.05.1995	1340	680	4,5	900	128	0	350	233	359
04.05.1995	1350	665	4,6	900	129	0	350	235	362
05.05.1995	1380	680	4,5	900	130	0	360	240	370
06.05.1995	1380	690	4,8	900	130	0	390	265	408
07.05.1995	1395	680	4,8	900	131	0	350	238	366
08.05.1995	1360	680	4,7	900	131	0	450	304	468
09.05.1995	1395	690	5,0	900	130	0	350	241	371
10.05.1995	1385	690	5,3	880	129	0	475	333	513
11.05.1999	1410	680	5,0	850	39	56	750	516	794
12.05.1995	1380	650	4,3	900	0	75	700	461	710

Figure 5. Burner rear end with swirl setting scale actuator.

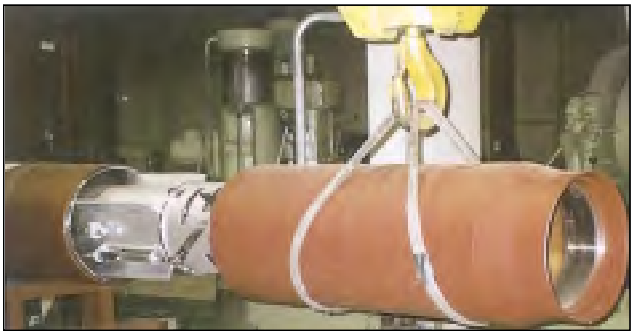

Figure 6. Divided frontier jacket tube half pulled off.

Service and maintenance advantages

- Divided outer pipe (front section 1400 mm) without any flanges or fastening devices in the hot zone. This makes the handling and replacement of insulation much easier (Figure 6).
- Simple replacement of nozzles, due to the type of catch joint.
- Up to 30 % weight reduction.
- High levels of operational safety and service life due a better cooling effect of the outer pipe.
- A simple and cheap nozzle wearing ring which is easy to replace.

Conclusion

The homogeneous annular primary air flow discharged around the fuel core results in a flame core which is rich in fuel and low in oxygen, and which can be expected to reduce the formation of NOx. The required proportion of primary air was between 5 % and 7 % (without transport air) when burning heavy fuel oil or coal. Due to the greater depth of penetration of the primary air jet, it is possible to control the flame over virtually its entire length. Therefore extension of the lining life and a better heat transfer to the kiln feed can be expected.

Also the possibility of adapting existing M.A.S. burners with simple amendments using the central channel for secondary fuels, gives the clients the flexibility for different low grade fuels in future. Last but not least, the divided 1400 mm length outer pipe guarantees a easier and faster service in case of insulation damage.

Bibliography

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