In the firing line

H. Lederer, Unitherm-Cemcon, Austria, discusses the development of the new M.A.S. burner, which can burn different fuels together.

Introduction

Clinker burning is one of the most important processes in the production of cement. In the past, this process could be easily controlled by traditional fuels. Today, there are a lot of requirements that need to be fulfilled by state-of-the-art firing equipment. The aims are environmental pollution protection, saving natural fuel resources, using waste fuels to reduce fuel costs and finally to optimise plant economy with constant high quality clinker. The company has 50 yrs of experience in kiln firing systems, which allows it to define a technologically advanced burner system.

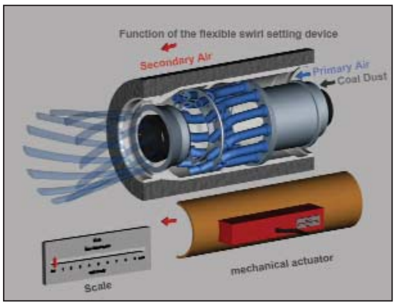

Figure 1. M.A.S. burner outstream system.

Figure 2. Combined M.A.S. kiln burner for coal, heavy oil, gas.

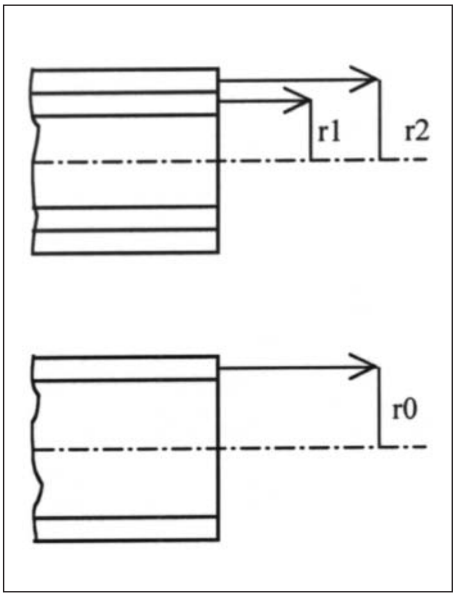

Figure 3 (top). Traditional burner tip.
Figure 4 (bottom). M.A.S burner tip.

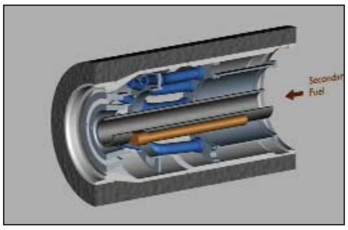

Figure 5. The pneumo-swirler.

Figure 6. M.A.S. kiln burner for secondary waste fuels.

History

The traditional three channel burner is able to fire regular fuels such as coal, fuel gas and fuel oil in either wet, semi-dry or dry processes. Unitherm has supplied over 200 kiln burners of this design, which are still operating today. The initial goal was to adjust the flame by radial air and axial air in order to influence the sintering zone, shell temperature as well as the kiln inlet temperature and to avoid refractory damage.

The changes of flame-shape due to different fuels were made by the distribution of the axial and radial component of the primary air momentum. Each adjustment of the flame caused a change in the mathematical burner momentum as well as in the recirculation zone, where hot secondary air recalculates and mixes with the flame root.

To minimise NOx emissions, it was necessary to keep air consumption to 5 - 6%, as well as to maintain a high flame momentum. As a result, the cross sections for axial air and radial air nozzles were very narrow and had a high outlet velocity and a high pressure drop at the burner tip. In fact a lower burner momentum and too little penetration depth of primary air, which is necessary to control a flame shape along the kiln, created problems for clinker production. A weak and hard to adjust flame as well as a lack of different pipe sizes combined with tolerance problems due to the narrow nozzle slot, especially at smaller burner diameters, had a negative affect on the burning process. At this stage of development, Unitherm was asked to improve this type of burner system.

The solution

The idea was to combine two different air ducts into one and to have a free adjustable device, which can create an airstream of axial and radial air. Due to its research and experience it developed a system called 'a swirl air setting device that is built into the primary air duct (Figure 1). This new development was tested successfully on several kilns and in 1995, it became the company's new kiln burner and was named the M.A.S. (Mono Airduct System).

M.A.S. burner

With this patented nozzle outstream system it is possible to create one airstream, where the total primary air is continuously adjustable and is guided in the outer burner duct to create a flame shape that can be altered in a wide range to meet the different kiln requirements (Figure 2).

Usually for combined burners the nozzle for coal/petcoke can be mixed on its axis to adjust the outstream velocity by an expansion joint. A special coal instreaming part was developed to equalise the coal flow when entering the burner to avoid wear in that area.

Primary air outstream-physics

To create the required flame-shape in a kiln, the primary air is divided into two airstreams 'axial-or jetair' and 'radialair', which are situated on a different burner diameter to reduce the burner swirl number. The main advantage of the M.A.S. burner is that the burner momentum is constantly available at any time and for any adjustments of the flame shape. Flame adjustment can be acheived by flexible hose nozzles and not by butterfly dampers, which reduce the amount of primary and therefore the momentum either of the axial channel or the radial channel.

Burner swirl number (Sb)

swirl number (Sb) =

$$\frac{\text{tangential momentum (N) x characteristical swirl radius (m)}}{\text{axial momentum (N) x characteristical channel radius (m)}}$$

Burner momentum (G)

The specific momentum (Gax) of a multichannel burner created by primary air and coal conveying air plus coal mass flow:

Gax =

$$\frac{\text{(Msw * vsw,ax + M(tr+c) * vtr + Max * vax,ax)}}{\text{Q fuel}} \quad \text{(N/MW)}$$

This common method to calculate the swirl number, shows that the swirl number is higher in the M.A.S. burner compared to conventional burners because the total primary air flows through the outer burner duct at radius (r0). The smaller radius (r1) and the axial flow mass to reduce the component of the swirl number for conventional burners.

Improvements

After further research and tests on the new M.A.S. burner design, the company discovered the following improvements:

- Low primary air rates of 5 - 10% according to kiln and fuel requirements, especially when using solid secondary fuels and smaller burner capacity higher primary air rates.
- Easy adjustment of the flame shape to improve heat transfer in the kiln. The company was informed by cement producers who changed from a traditional burner to the M.A.S burner, that the energy consumption in some kilns seemed to be reduced by 3 - 4% and the kiln capacity could be increased in that range without higher fuel consumption. This is still under observation, and will be commented upon later.
- Reduced pressure loss in the primary air nozzles, which improves the flame momentum.
- Efficient mixing of secondary air into the flame by single air streams caused by the injector principle.
- Low NOx emissions due to the single jet stream effect and the close flame stand-off distance. All primary air is outside, surrounding the fuel.
- Complete round and stabile flame in each load range, which improves the flame stability of a cold kiln while it is being started.
- High level of safety and service life.
- Easy to handle for the kiln operator, e.g. flame adjustment as well as quick removal of the single oil gun.
- High reproducibility of the flame shape, by the scale of flame adjustment especially at burning down ring formations in the kiln and re-adjustment to the regular flame shape.
- Total primary air available for cooling of the nozzles and outer insulated burner pipe.

Figure 7. Combined M.A.S kiln burner at W&P cement plant, Austria.

Figure 8. Rear view with fuel connections and new burner trolley.

Table 1. Fuel mix	
Coal/petcoke	13.3 - 50.3%
Animal meal	0.4 - 13.0%
Waste oil and solvents:	46.3 - 53.6%
Animal fat	Up to 18.5%
Solid plastic waste	Up to 14.6%
Natural gas	For start and stabilising operation

This design has been developed during the last few years. Various types of solid and liquid waste fuels have become more important in order to reduce fuel costs and save natural fuel resources by substituting regular fuels. Any types of secondary waste fuel have to be tested to see if they are capable of being burnt, as well as their affect on clinker quality.

Liquid secondary waste fuels

Liquid waste fuels can be atomised either by a high pressure atomiser gun, if it does not contain too much solid particles such as solvents, paint and waste oil, or by a compressed air atomiser gun, which has a high particle content. In this case the whole fuel preparation system has to be designed to prevent clogging and abrasion. Waste liquids usually do not have a high chemical influence on the clinker quality, because the transfer from the liquid phase to the gaseous phase is reached very quickly by fine atomisation and a long residence time at high temperatures.

Solid secondary waste fuels

Solid waste fuels are more difficult to handle, as their volatile, specific gavity, relation of size to surface and abrasion problems have to be taken into consideration. After long trials the company found that round pipes are preferable, due to the insensitivity against clogging and many fast changes in the solid waste fuel market. These are situated in the centre channel of the burner. At high mass flow, compact streams of solid waste fuels occurred and brown clinker was produced by unburnt fuel. This can cause problems in the satellite pipes in the kiln hood, which 'shoot' the waste through the main flame.

Unitherm improved upon this system by inventing the pneumo-swirler (Figure 5). The solid waste is rotated at the burner tip in order for the material to be spread up the compact stream. By adjusting the pneumo-swirler pressure, the flame shape can be controlled. The residence time of waste fuel will be enlarged and a good burn-out achieved. The adjustable pneumo-swirler to avoid two sintering zones and too high temperature peaks. The instreaming part for waste fuels is covered by special wear-resistant materials although the company try to use a strait entrance of the secondary waste material into the burner (Figure 6).

Case study

In spring 2001, a multifuel M.A.S. kiln burner on a Lepol kiln was commissioned at an 800 tpd Austrian cement plant.

The 20 yr old, three channel burner was running on coal, animal meal, waste oil and solvents. The decision to buy a new kiln burner was to be able to fire more and different secondary fuels at the same time. Unitherm Cemcon was selected as supplier as it could fire the seven different fuels at the same time as well as adjust the flame shape in order to adapt the flame to the kiln requirements. Table 1 shows the fuel mix that could be achieved without a negative influence on clinker quality. NOx emissions were reduced by 10% from 800 mg/Nm^3 and had the same burnability as the raw material. Ring formations can be burnt away by adjusting the flame and its momentum, and can also produce a high flame, therefore meaning that ring formations do not have to be removed.

At the same time, kiln capacity could be increased from 820 to 850 tpd due to the improved heat transfer to the clinker. The amortisation of the burner system using the high availability of secondary fuels is very short. The pneumo-swirler means that it is possible to influence the plastic waste fuel to maintain the sintering zone and to improve the burnout.

Conclusion

A multifuel kiln burner has to be tailor made for each kiln application and must also have the ability to be adjusted. The firing equipment must work without interruption and be easy to handle as well as producing good quality clinker. The burner should be designed for the future and not for the moment, as the cement market is changing its fuels and requirements very quickly. Therefore a wide range of adjustment and modifications of the burner are absolutely necessary.

Enquiry no: