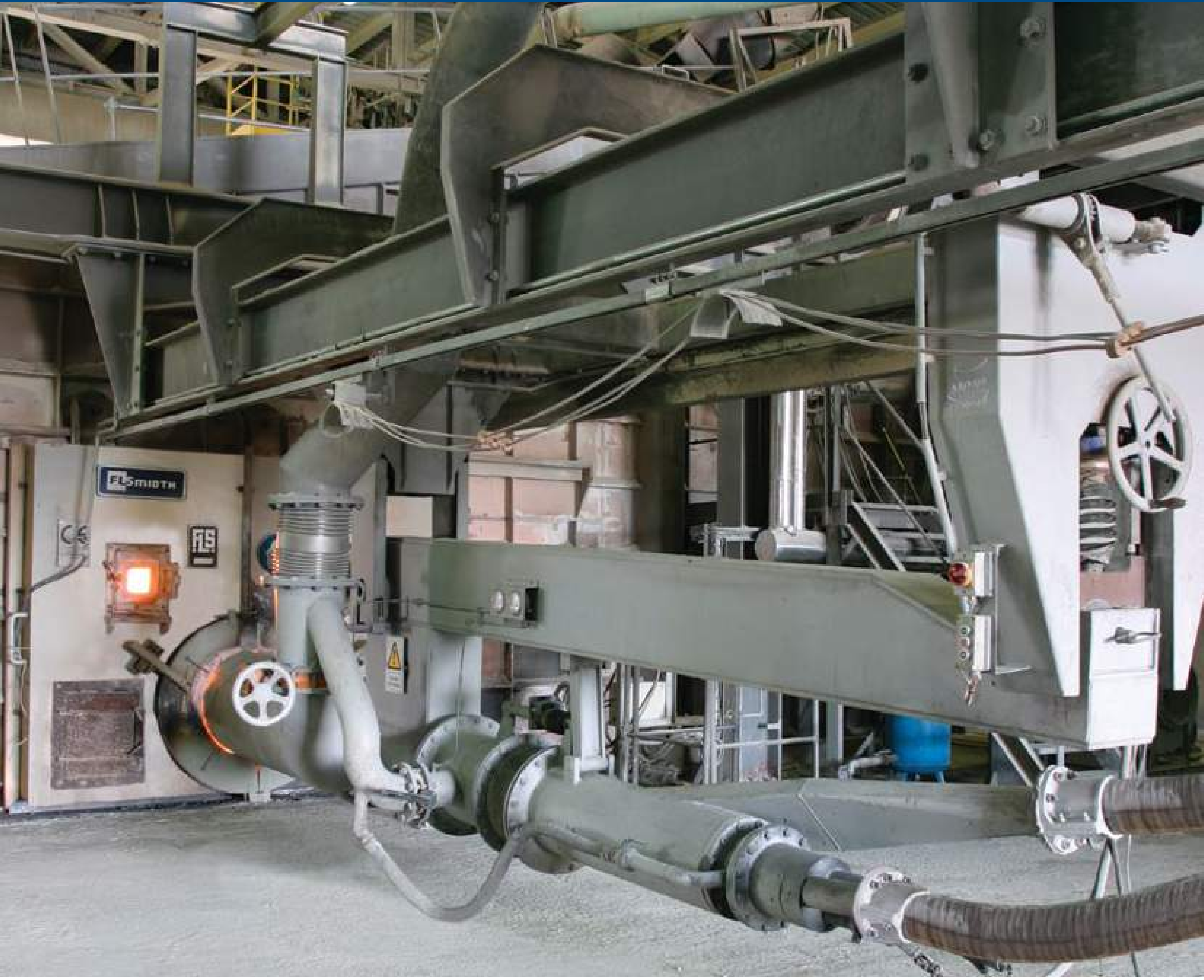
One Source

DUOFLEX™ burner



FLSMIDTH

Flexible and robust design

Key benefits

- **Robust design**
- **Low primary air consumption**
- **Adjustable swirl**
- **Adjustable air nozzle area**
- **Central fuel injection**

Application
The DUOFLEX™ burner fires rotary kilns with pulverised coal or coke, oil, natural gas or any mixture of these fuels. The burner may be fitted with extra ducts for secondary fuels such as plastic chips, wood chips, sewage sludge, etc. Standard types are available for any fuel combination and a maximum capacity ranging from 20 to 250 MW, catering for even the largest of rotary cement kilns.

Design
The burner is based on a novel concept featuring a central duct for gaseous and liquid fuels placed inside an annular coal duct which is surrounded by two concentric ducts that form two primary air channels, one for radial air and one for axial air.

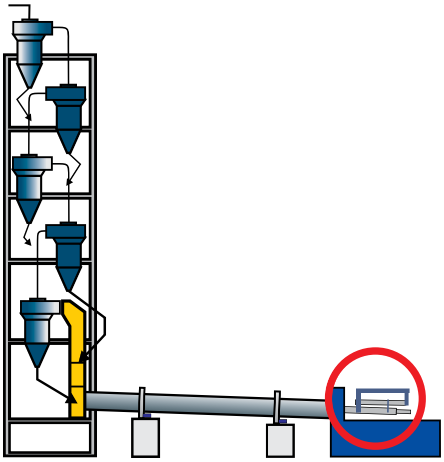
The two air flows are mixed before being injected via the conical air nozzle. The two outer ducts form a very rigid supporting structure, minimising deflection of the burner pipe and ensuring long refractory life.

The primary air is supplied by a high pressure fan that yields a maximum pressure of 250 mbar as standard, but on request pressures up to 400 mbar can be delivered.

The air nozzle area can be adjusted within the range 1:2. The axial/radial air ratio – and consequently the degree of swirl – is also adjustable.

These adjustments offer wide scope of shaping the flame.

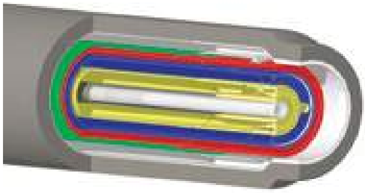
Process and function
From a process point of view, a burner used for heating the burning zone of a rotary cement kiln must fulfil the following requirements:



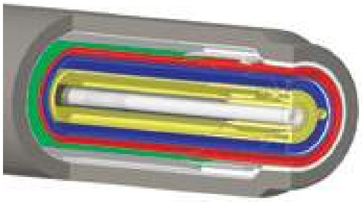
- The burner must be able to fire coal, coke, fuel oil and natural gas or any mixture thereof, ensuring complete combustion, low excess air and minimum formation of carbon monoxide (CO) and nitrogen oxides (NO_X). If relevant, the burner must be able to handle alternative fuels without requiring change of its original design. In this way, only minor modifications to meet the special requirements must be necessary.
- The burner must produce a short, narrow, strongly radiant flame, as this is a condition for good heat transfer from the flame to the material in the sintering zone of the kiln.
- Flame formation must be conducive to a dense, stable coating on the refractory in the burning zone of the kiln as well as a nodular clinker with low dust content and correctly developed clinker phases.
- The burner must use as little primary air as possible without compromising stability during normal or upset operating conditions. Primary air is basically false air, in other words air that has not been used for clinker heat recuperation while passing through the clinker cooler. The primary air is usually expressed as a percentage of the stoichiometric combustion air needed to burn the amount of fuel fired through the burner.

Multi-channel burners
Compared to a simple single-tube burner modern multi-channel burners offer much better possibilities for flame shape control because of their separate primary air channels, allowing for adjustment of primary air amount and injection velocity independently of the coal meal injection.

The most important flame control parameters are primary air momentum (primary air amount multiplied by discharge velocity) and amount of swirl (tangentially air discharge). A high momentum will give a short, hard flame whereas a low momentum will make the flame longer and lazier. Swirl will help creating recirculation in the central part of the flame. This will stabilise the flame and give a short ignition distance. Too much swirl however can cause high kiln shell temperatures due to flame impingement on the burning zone refractory. A good swirl control system is therefore important. The best solution would be a system where swirl could be adjusted independent of the momentum.

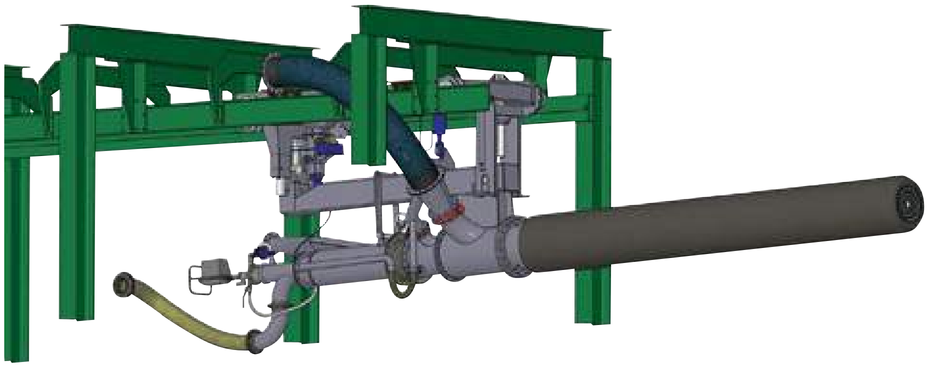


Nozzleopen



Nozzelclosed

The burner nozzle is adjustable both vertical and horizontally.



Traditional multi-channel burners normally have two air nozzles, one for axial air discharge and one with vanes or tangential slots for swirl air. Swirl is controlled by adjusting the swirl air amount (or the ratio between axial air and swirl air). This can be done in two ways, by dampers installed in the ducts upstream of the burner or – more effective - by adjusting the air nozzle areas. Most modern multi-channel burners therefore have adjustable air nozzles.

If all the primary air is supplied by one primary air fan, momentum and swirl cannot be adjusted independently. Adjusting the swirl air nozzle will also change the pressure at the axial air nozzle and vice versa. To overcome this problem many multi-channel burners have separate fans for axial air and swirl air. This however does not solve the problem completely because the momentum will still change if swirl air amount is changed.

A constant momentum can only be maintained by adjusting axial air as well as swirl air.

Duoflex Swirl Control

The unique Duoflex nozzle design eliminates these problems. Swirl is generated by fixed vanes, located upstream of the air nozzle. Since axial air and swirl air are mixed before entering the nozzle, air pressure – and momentum – remains almost unchanged when the axial/swirl air ratio is changed.

Axial/swirl air distribution is controlled by butterfly valves installed at the burner inlet. During operation the axial air valve must be minimum 50% open since the axial air is used for cooling of the burner pipe. Swirl air can be adjusted from 0-100%. The amount of swirl is characterised by the position only. Therefore no separate swirl air-flow measuring system is necessary. Since the swirler vanes are placed in a low velocity zone the degree of swirl will be reduced when the air velocity is increased in the nozzle. The swirler vane angle is dimensioned in order to compensate for this, meaning that an adequate amount of swirl can be applied without risking flame impingement on the refractory.

Flame momentum

The crucial parameter of flame formation is the primary air momentum which may be expressed as the primary air percentage (% of stoichiometric air requirement) multiplied by the injection velocity. Consequently, if the velocity is doubled, the primary air percentage may be reduced to half.

The primary air consumption will normally be in the range of 6-8%, corresponding to a primary air momentum of approximately 1250-1780% m/s. The adjustable air nozzle is ideally suited for adapting the momentum to the conditions for attaining the best flame shape.

The burner in a rotary kiln functions as an injector, the purpose of which is to draw the secondary air coming from the cooler into the flame in order to make the fuel burn as close as possible to the centre line of the kiln. This explains why the momentum of the burner is the parameter that determines flame formation. A higher momentum means faster mixing and a shorter and hotter flame.

Divergent feeding of fuel and primary air should be avoided as it inevitably leads to wider flames and higher temperatures on the inner surface of the burning zone. Good coating formation is only possible if the inner surface is cold enough for the liquid to solidify upon contact.

The use of a narrow flame in a cement rotary kiln is extremely important since a divergent flame that impinges upon the lining will strip off the coating, resulting in very high kiln shell temperature and short refractory life. Flame impingement upon the material charge will increase the evaporation of sulphates, which usually leads to increased coating formation in the kiln riser duct.

Adjustable for alternative fuels

In order to explore the economical opportunities on the waste market to the maximum a high degree of freedom is desired when adjusting the kiln feed rates of various alternative fuel types.

On the other hand are the requirements that the heat input to the kiln remains stable, that the firing of the fuels does not have a negative impact on the clinker quality and that the coating profile in the kiln remains unchanged.

The combination of the quest for optimum flexibility and the desire to maintain steady kiln operation conditions puts high demands on the kiln burner which - to the extent possible - must be capable of compensating for the variations of the alternative fuels introduced into the kiln.

These demands are met by the superior flame control of the DUOFLEX construction, and the ability of operating with a narrow flame provides for the best possible burnout of the waste particles in the flame itself, so ensuring that the particles do not land in the charge or on the coating.

Precise momentum control

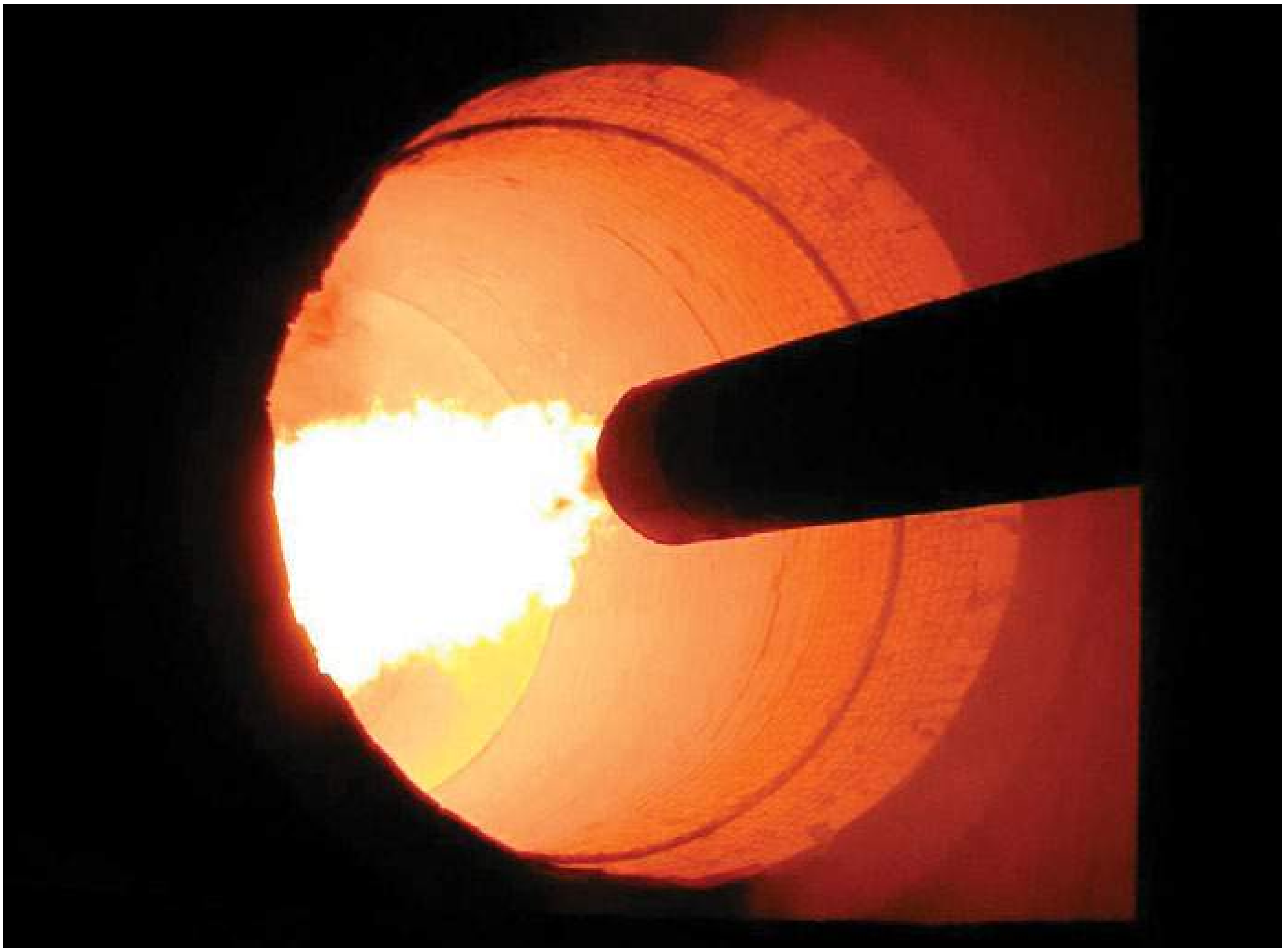
Since good flame formation in the kiln permits operating with very little excess air and without the formation of CO, a burner operating with correct flame momentum despite the higher flame temperature will result in less formation of NO than a low momentum burner operating with more excess air.

Practical experience has shown that the formation of a strong, stable, short and narrow flame requires a momentum of minimum 1400-1600% m/s dependent on fuel type. A flame momentum below this range will result in too long a flame, high kiln shell temperatures above the burning zone and in the kiln back end as well as unstable kiln operation with a too long and cold burning zone thereby permitting undesirable clinker crystal growth.

The two different kiln temperature profiles, before and after introducing the DUOFLEX burner, clearly show the huge effect on both coating formation and kiln shell temperature. NO lining repairs were made while exchanging the two burner installations.

The very easy adjustment of the nozzle area and the different air flows, helped by clear position indicators, make it possible to find and maintain any precise setting during operation as well as between the different production campaigns.

The DUOFLEX burner normally operates with 6-8 % primary air but is designed for maximum 10% as standard and on request up to 15%. This will in all cases provide the kiln operator with the necessary “tool” to quickly stabilise any upset conditions.



Momentum control, example

Calciner kiln:	7000 tpd
Burner output:	118 MW
Max. momentum:	8.7 N/MW (at 12.5% PA)
Momentum required:	5 N/MW

1. Reducing nozzle area:

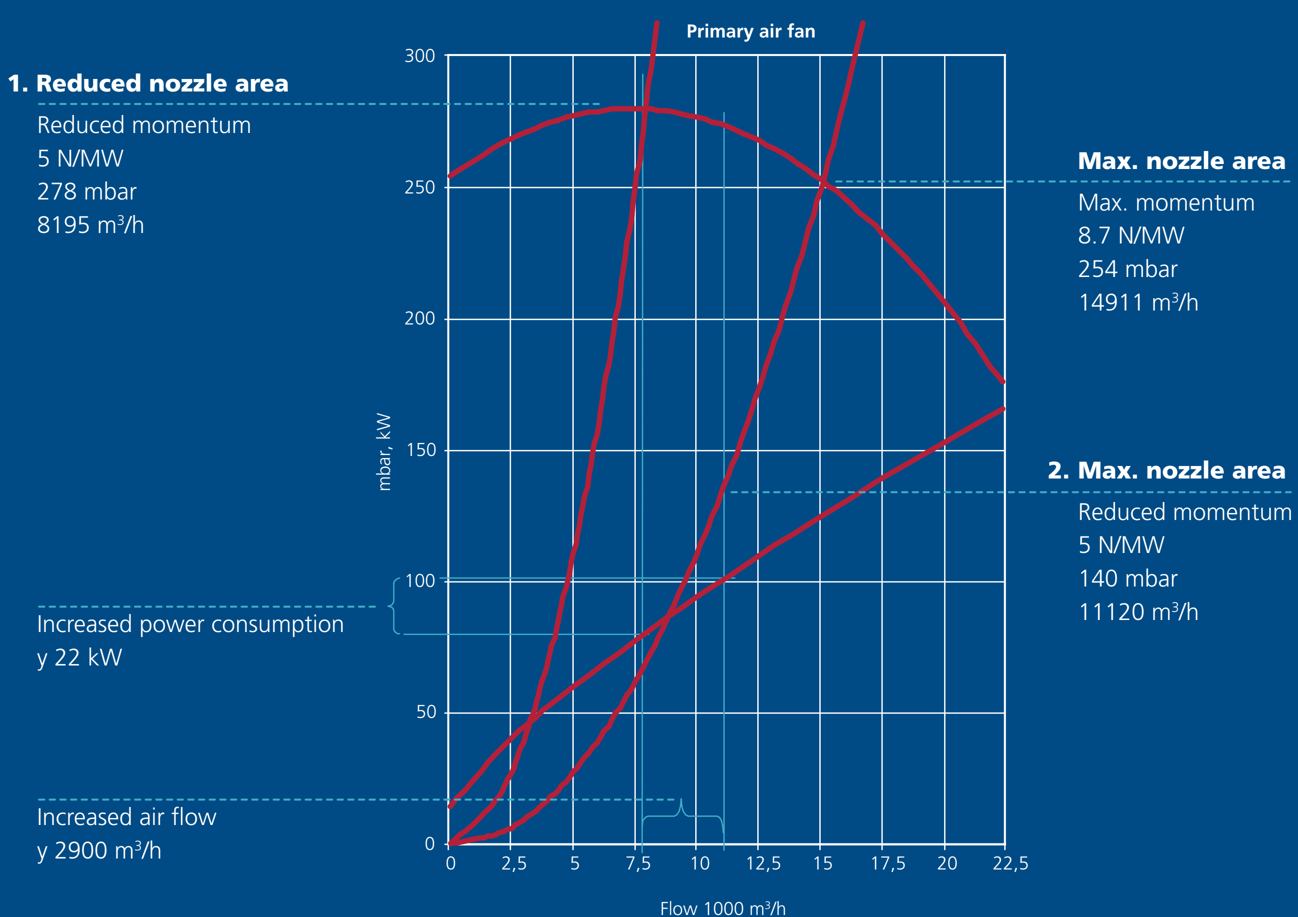
Air flow:	8195 m³/h (6.9% PA)
Air pressure:	278 mbar
Power consumption:	80 kW

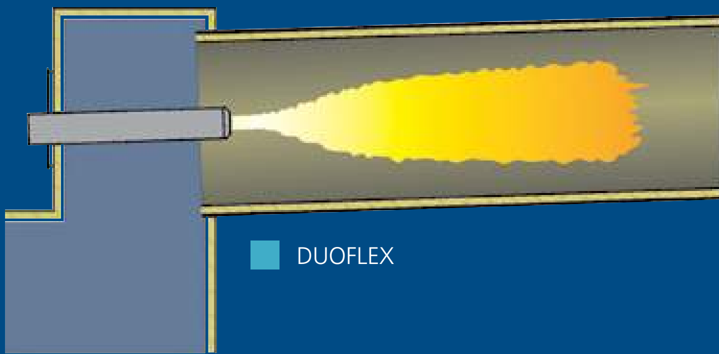
2. Reducing nozzle pressure:

Air flow:	11120 m³/h (9.3% PA)
Air pressure:	140 mbar
Power consumption:	102 kW

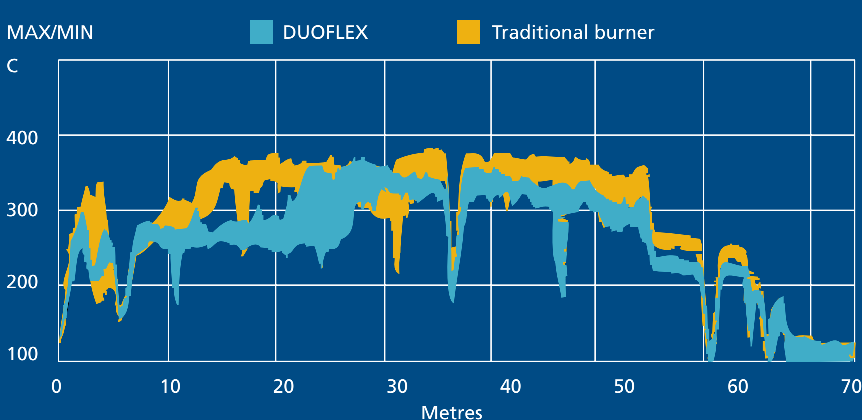
Savings by reducing nozzle area instead of pressure:

Power:	22 kW
Fuel:	2.4% PA y 2.4x0.75 = 1.8 kcal/kg clinker y 12.6 Mcal/24H





Kiln shell temperature



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