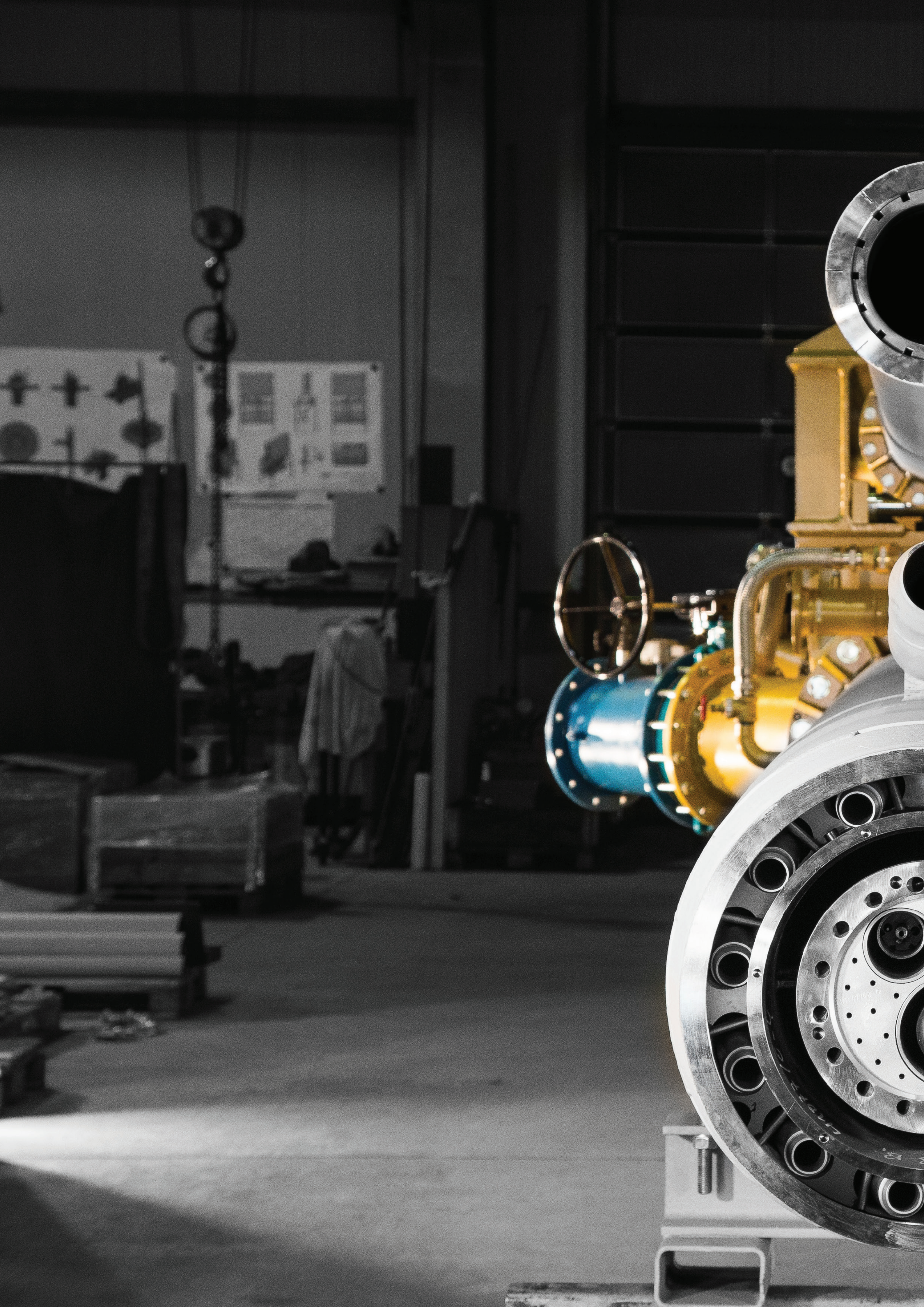
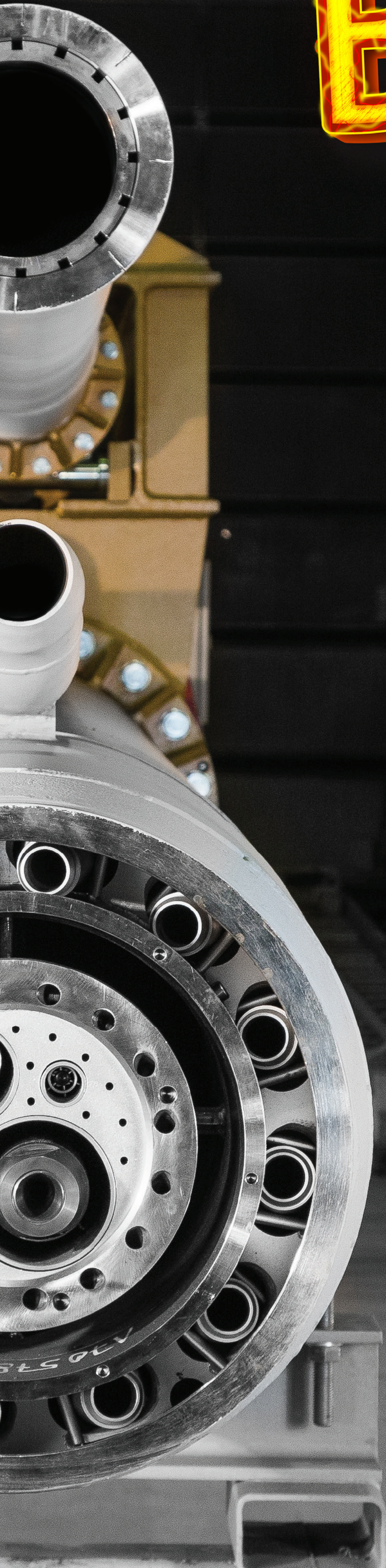


Blazing A Trail



Dr. Robert Pachler, Unitherm Cemcon, provides insight into the factors impacting burner design in the modern cement industry.

As the cement industry undergoes an evolution on its journey to a decarbonised future, a whole range of processes and technologies will need to adapt to the new challenges. This article seeks to provide insight into some of the major considerations facing cement plant operators when it comes to selecting the right burner design for their process.

Adapting to the alternative

To mitigate the variability in consistency and quality of alternative fuels (AF) for reliable burner operation, several strategies and considerations must be employed.

Quality control measures

Rigorous quality control measures should be implemented throughout the supply chain to ensure consistency in the AF composition and properties. There are a range of parameters to take into account in order to enable a successful implementation of AF – they include, but are not limited to, the following:

- Particle size distribution.
- Ratio of 3-dimensional to 2-dimensional particles.
- Moisture content.

Standardisation and blending

Standards and procedures for AF collection, handling and storage should be developed and adhered to, in order to ensure consistent quality across different suppliers and batches.

AF from different suppliers or batches should be blended to provide greater consistency and stabilise combustion characteristics and heating values while improving reliability. Foster partnerships with reliable suppliers who demonstrate consistent quality and are committed to addressing any issues that may arise.

Adaptive burner technology

Invest in burners equipped with adaptive technology that can adjust combustion parameters based on fuel properties in real-time, thus optimising performance and reliability. Unitherm offers a wide range of products to fire AF with up to 100% thermal substitution rate (TSR) such as the Pneumo-Deflector or the UNISAT satellite burner. These dynamic burners are equipped with M.A.S. Technology, which provides a reliable and reproducible adjustment option with the highest momentum efficiency over the entire range. This gives operators the opportunity to optimise heat release and emissions according to fluctuating fuel quality.

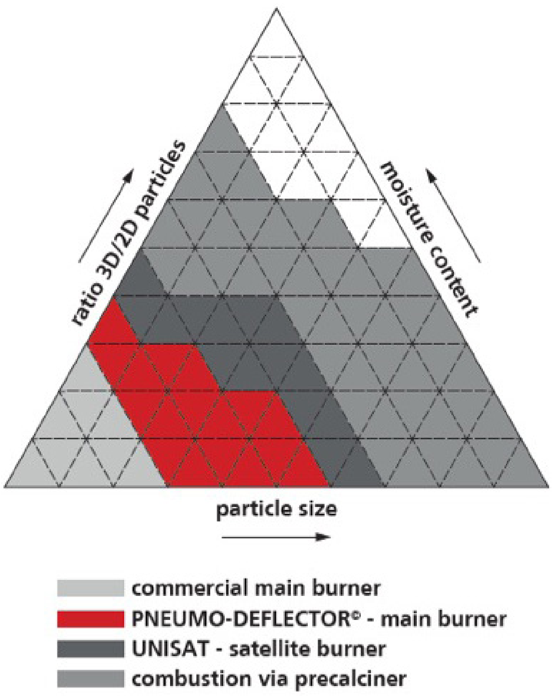


Figure 1. Main classification parameters of solid AF.

Figure 2. Unitherm Cemcon's dynamic M.A.S. kiln burner with two integrated solid secondary fuel channels equipped with the patented PNEUMO-DEFLECTOR nozzles.

Training and education

Provide training for operators and maintenance personnel on the specific requirements and challenges associated with AF, empowering them to identify and address issues effectively.

By implementing these strategies, it is possible to effectively mitigate the challenges presented by the varying consistency and quality of AF, ensuring reliable burner operation while maximising efficiency and sustainability.

Success with satellites

Satellite burners can play a significant role in modern cement production, primarily in enhancing the use of biogenic secondary fuel and therefore reducing environmental impact. Especially above a certain TSR (70 – 100%), the satellite burner is the tool for success. The following factors explain why this is the case:

- Temperature control: Together with a flexible main burner, satellite burners can be strategically placed within the kiln to provide localised heat input, allowing for more precise temperature control and uniform heat distribution even with very high substitution rates. This helps optimise the cement clinker formation process, leading to a more stable product quality.
- Fuel flexibility: Satellite burners offer flexibility in fuel selection, enabling cement plants to utilise a variety of AF, including biomass, waste-derived fuels, and other low-carbon alternatives. This diversification reduces reliance on fossil fuels, mitigates environmental impact, and enhances sustainability.
- Emissions reduction: By facilitating more efficient combustion and enabling the use of cleaner fuels, satellite burners contribute to lower emissions of greenhouse gases and pollutants, helping cement plants meet stringent environmental regulations and sustainability targets.
- Cost savings: By improving the TSR of secondary fuels, thereby reducing fossil fuel consumption, and minimising CO_2 emissions, satellite burners contribute to cost savings for cement manufacturers in the mid and long term. Additionally, their modular design allows for easier installation, maintenance, and scalability, enhancing overall operational efficiency and profitability.

Overall, satellite burners offer numerous benefits for modern cement production, including enhanced fuel flexibility, emissions reduction, and operational flexibility. Their integration into cement kiln systems can help drive sustainable development and improve competitiveness in the global cement industry.

Handling hydrogen

When looking at ways to decarbonise the cement industry, a diverse range of approaches has to be considered. Green hydrogen is one such approach, as the lack of any carbon involved in hydrogen combustion is well known. Using hydrogen, however, is not without its technical challenges, particularly when used on a large scale. Focus must be placed on understanding and adapting to hydrogen's thermodynamic characteristics (Table 1).

Control of flame propagation when using hydrogen is especially important as it has a flame speed eight times greater than methane and a very low density that results in a high nozzle outlet velocity of up to 1300 m/s (depending on pressure difference). This needs to be intelligently controlled in order to avoid double flame formation in combination with other fuels. Unitherm's dynamic burners with their M.A.S. technology, are well suited to these conditions.

Several additional burner design considerations must be made to ensure safe and efficient combustion when working with hydrogen:

Burner material compatibility

Hydrogen combustion produces high-temperature flames and can lead to increased corrosion rates and embrittlement of materials. Burner components must be made from materials compatible with hydrogen combustion, such as stainless steel or nickel alloys, to ensure durability and longevity.

Flame stability and propagation

Hydrogen has a wide flammability range and burns at a high flame speed. Burner design should prioritise stable flame characteristics to prevent flashback and ensure reliable, efficient and safe combustion over varying operating conditions such as start-up or full operation.

Heat management

To counteract the fast flame propagation which can impact temperature distribution along the kiln, the burner design, ideal with dynamic adjustment possibilities, should incorporate features to manage heat transfer, to obtain a similar heat distribution as with ordinary fuel mixes and maintain equipment integrity. By addressing these burner design considerations, cement plants can effectively leverage green hydrogen as a clean and sustainable fuel source while ensuring safe and efficient combustion processes.

Minimising harmful emissions

Burner design plays a crucial role in minimising the production of harmful emissions, like NOx, in cement production. This section highlights some ways in which burner design can achieve the goal of reduced emissions:

- Efficient combustion: Proper burner design can optimise combustion efficiency by ensuring that the fuel is thoroughly mixed with the combustion air, resulting in complete combustion of the fuel. This can minimise the production of harmful emissions such as carbon monoxide (CO) and unburned hydrocarbons (UHC). Unitherm Cemcon's burner designs are

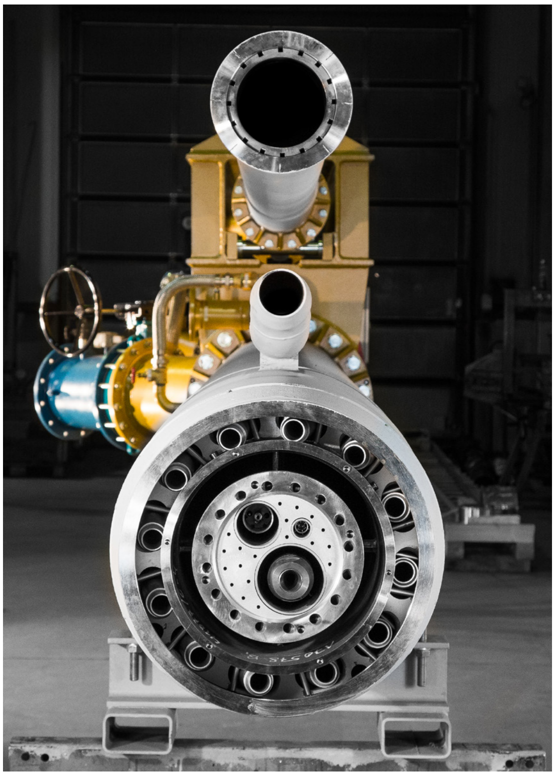


Figure 3. Unitherm Cemcon's M.A.S. kiln burner with integrated satellite burner.

Table 1. Important fuel properties of hydrogen and methane.

	Hydrogen (H_2)	Methane (CH_4)
Density (kg/m³)	0.08988	0.7175
Ignition temperature in air (°C)	585	540
Max. flame speed (cm/s)	346	43
Ignition limits in air (Vol. – %)	4 – 73	5 – 14
Flame temperature in air (°C)	2130	1970
Flame temperature in oxygen (°C)	3080	2860
Lower heating value (MJ/m³)	11	36

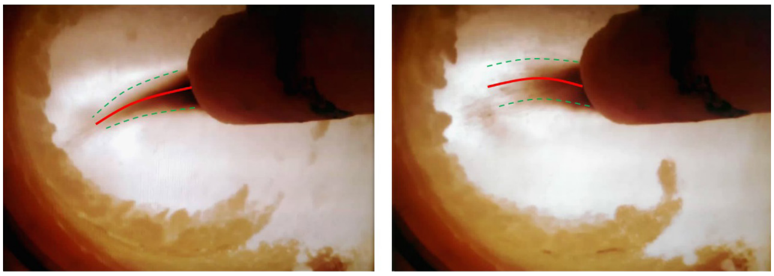


Figure 4. Particle trajectory comparison: a burner operating with a Pneumo-Deflector turned off (left image) and on (right image).

engineered to provide efficient combustion, resulting in reduced emissions.

- Low-NOx technology: NOx emissions in combustion processes are mainly produced through temperature-driven reaction kinetics. Unitherm Cemcon's burner designs incorporate low-NOx technology, such as staged combustion, flue gas recirculation (FGR), which can significantly reduce the formation of NOx emissions at the main burner.
- Precise control: Burner design can also enable precise control of combustion parameters, such as temperature, excess air, flame shape and fuel-to-air ratio. This allows for optimal combustion conditions, minimising the formation of emissions. Unitherm Cemcon's burner solutions such as the M.A.S. technology incorporate advanced control systems that allow for precise and automated control of combustion parameters, resulting in reduced emissions.
- AF: Cement producers are increasingly using AF, such as biomass, waste-derived fuels, and other low-carbon fuels, to reduce their carbon footprint. Burner design can accommodate the use of AF by providing appropriate fuel injection systems like the Pneumo-Deflector© (Figure 4) when using AF through the main burner only or the UNISAT satellite burner when maximising the TSR between 70 – 100%, that ensure efficient combustion and minimise emissions. The sometimes-high moisture content in AF 'cools' the combustion process and thus leads to lower NOx emissions.

In summary, burner design plays a critical role in minimising emissions in cement production. Unitherm Cemcon's burner solutions are designed to optimise combustion efficiency, incorporate low-NOx technology, enable precise control, and accommodate AF, all of which contribute to emissions reduction objectives for cement producers.

Enhancing operational lifetime

To reduce maintenance costs and maximise the lifetime of kiln burner, the following steps can be taken:

Regular inspection and maintenance

Regular inspection and maintenance of the burner are essential to identify and address any potential issues before they become major problems. This includes cleaning, checking for wear and tear, and replacing worn-out components as needed. Unitherm Cemcon provides recommended maintenance procedures and schedules for its kiln burners, which should be followed diligently to ensure optimal performance and longevity.

Proper fuel and air quality management

Ensuring that the fuel and air quality meet the specifications recommended by the burner manufacturer is critical for efficient burner performance and longevity. Poor fuel quality or contaminated combustion air can lead to increased wear and tear on the burner components, reduced combustion efficiency, and higher emissions, which can result in increased maintenance costs and decreased burner lifetime.

Correct burner operation

Following the recommended operating procedures and guidelines provided for the kiln burners is crucial to ensure optimal performance and extend burner lifetime. This includes proper start-up and shutdown procedures, correct fuel and air settings, and operating within the recommended temperature and pressure ranges.

Training and expert support

Proper training of operating and maintenance personnel on the correct operation, maintenance, and troubleshooting procedures for Unitherm Cemcon's kiln burners is crucial to minimise maintenance costs and maximise burner lifetime. Unitherm Cemcon provides training and technical support to their customers, which should be utilised to ensure that the burner is operated and maintained correctly.

Using genuine spare parts

Using genuine spare parts from Unitherm Cemcon for any repairs or replacements is important to ensure that the burner components are of the highest quality and designed specifically for the burner. Genuine spare parts are likely to have better durability and compatibility with the burner, reducing the risk of premature failures and minimising maintenance costs in the long run.

Automation advantages

Automation and burner management systems significantly enhance burner operation through precise control, real-time monitoring, and safety features.

These systems enable optimal combustion efficiency, fuel savings, and product quality by controlling parameters like fuel flow rates and air-to-fuel ratios with precision. Real-time monitoring detects deviations from set parameters, allowing prompt corrective actions to maintain optimal operation. Safety interlocks prevent unsafe conditions like flame failure or overpressure, reducing risks of accidents and environmental hazards.

Remote monitoring and control enable oversight and adjustment of burner performance from a centralised control room or mobile devices, improving efficiency and safety. Data logging and analysis provide insights for performance optimisation, predictive maintenance, and compliance reporting.

Integration with process control systems ensures coordination and optimisation of burner operation with other processes, enhancing energy efficiency and product quality. Energy management features optimise burner operation schedules, load distribution, and fuel switching strategies based on energy pricing and demand, minimising costs and environmental impact.

In summary, automation and burner management systems offer precise control, real-time monitoring, safety features, remote access, data analysis, integration, and energy management capabilities. These contribute to improved efficiency, reliability, safety, and sustainability in industrial burner applications.

Looking ahead

Across the cement industry, there is a strong focus on reducing carbon emissions and improving energy efficiency in the cement industry, and this has led to the development of innovative burner designs (e.g. M.A.S. technology, UNISAT) that are able to efficiently combust an extraordinary amount of solid AF and emit fewer greenhouse pollutants.

This path will continue to be followed in the future, but at the same time the variety of fuel specifications is becoming ever wider, as certain fractions will no longer find their way into the combustion process in the pursuit of a functioning circular economy.

Additionally, the trend towards the use of gaseous AF, such as biofuels and green hydrogen, is likely to impact burner design.

These fuels have different combustion characteristics and require specialised burners to achieve optimal performance either under ambient or oxyfuel conditions.

Another trend that is likely to influence burner design is the increasing use of digital technologies, such as artificial intelligence and IoT, in industrial processes.

Burner manufacturers are likely to incorporate these technologies into their products to optimise performance, reduce downtime, and improve safety. ■