THE BURNING QUESTION

WORLD CEMENT Q&A

World Cement invited one of the world's leading equipment suppliers, Fives Pillard, to share their insights and expertise on burner technology.

World Cement (WCT): Many cement plants are using increasing levels of alternative fuels. How does the use of alternative fuels impact burner performance? What can be done to mitigate these effects?

Fives Pillard: Alternative fuel is a generic term which covers a large range of residual waste: waste oil, animal meal, domestic and industrial waste, biomass, sewage sludge, and sawdust etc. The type of alternative fuel used greatly affects combustion and thus kiln performance.

The most important criteria, when looking at alternative solid fuel, is the granulometry, and notably the particle size (impact on combustion time), and shape (which impacts the ballistics of particles).

Moving from a finely pulverised fuel to large 3D solid waste particles, the combustion time can vary from some milliseconds to dozens of seconds. If the fuel burnout is not achieved inside the flame, the particle combustion will generate reduced conditions on the clinker bed, lowering its reactivity and increasing sulfur volatilisation.

The volatile matter percentage and the moisture content are also of great importance as they directly impact the ignition time, the flame temperature and thus the radiative thermal exchange.

To maximise alternative fuel burnout, fuel particles must be maintained in the most oxidising and hottest part of the flame with the maximum residence time. Burner design plays a key role in achieving this target as a properly designed burner will:

- Produce a very strong mix with secondary air. High momentum is mandatory, but this is not enough. Indeed, it is the way this momentum is produced, and how the air is injected that are also of importance.
- Produce internal recirculation to ensure a stable flame, especially for fuels which are considered 'difficult' to ignite and properly burn.

- Depending on the fuel shape and its ballistic behaviour, a tailor-made injection is also needed either through the burner centre or via dedicated satellite injection systems.

WCT: Emissions reduction remains an ongoing goal for many cement manufacturers. How can burner design play a role in achieving this aim?

Fives Pillard: The burner design and thermal profile on the kiln will directly impact NOx/CO and SOx emissions at the kiln inlet. To evaluate the emissions at stack, the burner designer needs to get an overview of the complete process of the cement pyro line and pay close attention to the combustion in the calciner. As all calciners are different, a specific approach with the help of experts is a must.

CO is generated if fuel volatile matter is released in oxygen lean conditions and within a temperature zone that is not high enough. A burner that provides enough mixing between fuel and air, with a flame properly anchored to the burner, will not produce CO, even with limited kiln back end oxygen. This is only achievable by using sufficient momentum, with the right level of swirl and an induced reverse flow zone at the burner tip, also known as a 'bluff body' effect.

SOx at the kiln inlet is driven by the sulfur cycle. A thin, short, and stable flame will help to minimise sulfur volatilisation. Nevertheless, the impact of a burner replacement in terms of stack SOx will be limited, as it is mainly driven by the reducing effect of the raw meal.

NOx is produced from the nitrogen in the air, called thermal NOx, and the fuel organic nitrogen, called fuel NOx. Thermal NOx is predominant in the kiln, and fuel NOx in the calciner.

To reduce thermal NOx in the kiln, which is highly sensitive to temperature, any unnecessary 'temperature peak' in the kiln must be avoided and a homogeneous thermal profile with progressive mixing of secondary air is required.

Another strategy is to maximise NOx reburning and generating reducing molecules in the flame core such as NH_3 and HCN. This is achieved by lowering O_2 at the flame root (primary air and conveying air flow must not be in excess) and generating an internal reverse flow zone, thanks to a precise adjustment of swirler.

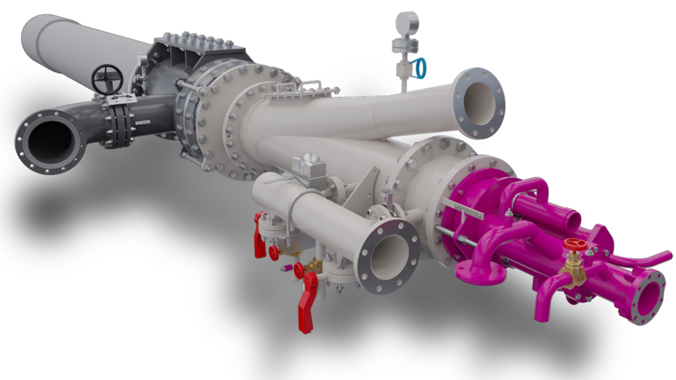

Figure 1. Pillard NOVAFLAM® Evolution. *Image courtesy of Fives Pillard.*

WCT: What steps can be taken to provide improved process stability?

Fives Pillard: Various parameters have to be taken into account to improve process stability: Fuel quality or preparation (especially alternative solid fuel) is never stable. The percentage of moisture, granulometry, or ash content can vary from one day to the other. Clinker burnability also varies and can require higher or lower temperatures on the kiln charge to get the right level of free lime. The chemistry variation, and notably the temperature at which the liquid phase or the content of minor volatile elements start to form, can make kiln operation more complicated. The risk is that the kiln temperature can change, sometimes overheating and sometimes being too cold. This can cause uneven coating, and in the worst cases, clinker, ash, or sulfur rings. If the burner cannot by itself stabilise the fuel or meal chemistry, it can minimise their impacts on the thermal profile and overall process performances. A stable and strong flame, properly anchored to the burner tip and mixing efficiently with secondary air, will help to compensate the fluctuation of fuel quality, as well as to keep a more stable temperature profile in the upper transition zone or at the kiln inlet. A stable and strong flame will also help the granulation of the clinker, reducing dust circulation in the kiln, and improving the lifespan of the cooler. Finally, an efficient combustion will minimise sulfur volatilisation, thus reducing sulfur rings.

WCT: Minimising downtime is key to plant profitability. How can burner maintenance requirements be reduced?

Fives Pillard: If the burner pipe is properly cooled (which is normally the case if the burner is equipped with an automatic cooling fan and is designed with sufficient velocity), the maintenance is limited to the burner tip (that can suffer from extreme temperature, chemical attack and abrasion) and to the inner pulverised fuel channel (which runs the risk of wear).

Regarding the tip, the first key to success is to ensure an excellent refractory quality. The choices of material, anchor type, pouring and curing are of main importance.

The burner tip design is also of a great importance. Fives Pillard has developed the Pillard NOVAFLAM® Evolution for the cement industry with a sturdy and simple design that has:

- No moving parts exposed to fire.
- No dust recirculation in the tip front face thus reducing its consequential wear of the steel surfaces exposed to flame radiation.
- A new mechanical design of the axial tip, allowing free expansion under wide temperature variations, thereby reducing potential 'steel cracking' issues.

Regarding the risk of abrasion on the pulverised fuel channel, it is mandatory to comply with velocity criteria in all parts of the burner.

For highly abrasive pulverised or solid fuels, a ceramic kit using 3D printing technology for specific parts suffering from abrasion (centring plate, coal inlet, etc.), can be provided as an option.

With regard to the risk of chronic sticking of dust at its tip, the burner can be fitted with a special patented air-cooled scraper, to clean the tip during operation.

Furthermore, the burner tip must be designed for easy assembly/dismantling to reduce kiln downtime.

WCT: Looking ahead, what do you see as the next steps in burner design evolution?

Fives Pillard: SMART technology is definitely the next step for the future. The next generation of burners will be digitalised.

This shift has already begun, and notably our latest technology includes digital features, through a Pillard NOVASMART™ device specially developed to facilitate burner maintenance (including preventive maintenance) and optimisation, such as:

- Detection of a burner position fault.
- Detection of burner refractory problems.
- Detection of a burner tip fault.
- Continuous calculation of swirl number, momentum, and fuel injection velocity, with the possibility of controlling the momentum for an improved thermal profile and reduction of NOx emissions.
- The possibility of correlating the burner settings to the process operating conditions in order to facilitate burner optimisation.

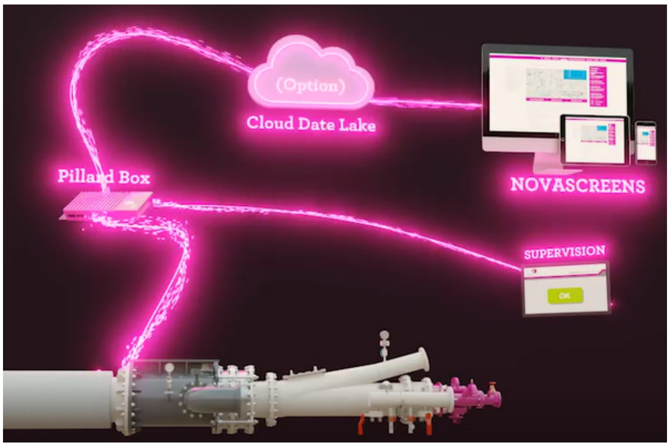

Figure 2. Features of the Fives NOVASMART™ system. ***Image courtesy of Fives Pillard.***

The next step will be to automatically adjust the burner, depending on the process parameters, maintaining the right level of momentum and swirl to optimise both clinker quality and NOx emissions.

Some new services to carry out remote maintenance inspection or commissioning, are also being deployed at the moment, using for example connected glasses, and are showing great potential for the future. ■

Contributors

Fives Pillard: Responses for Fives Pillard, a subsidiary of the industrial group Fives, were provided by Gaël Le Piver, R&D Engineer.