TURN UP THE HEAT

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Introduction

It is well known that the role of a burner is to improve secondary air entrainment into the fuel region, as well as allowing high operational flexibility, turbulence indexes, recirculation zones, and keeping emissions low.

To maximise secondary air entrainment and its mixture with fuel, high levels of turbulence are created, using primary air high pressure and high injection velocities for primary air flows. Also paramount is the burner tip geometry: the discrete injection of external air leaves a free path for secondary air influx (Figure 1).

Recapping the research

Dynamis has previously scrutinised the impact of different burner tip geometries on the mixture of secondary air and fuel through computational fluid dynamics (CFD) and found that, for the same burner, with the same primary and secondary air flow rates and the same power, significantly different air entrainment efficiencies were attained.[1] To indicate these differences, a temperature profile from that publication is reproduced in Figure 2. It shows a section along the kiln length, near the burner region, for the D-Flame design with 18 nozzles for the injection of external air, and for a burner with an annular channel for axial air. It can be seen that, near the tip, the temperature is lower in the annular configuration, indicating that the gaps between the pairs of external

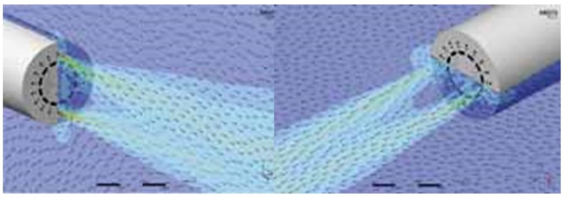

Figure 1. Velocity vectors and contours show secondary air entrainment between pairs of external air nozzles.

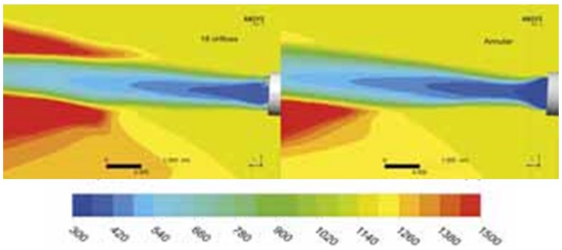

Figure 2. Temperature (K) profile for two different burner designs: (a) D-Flame and (b) annular configuration.

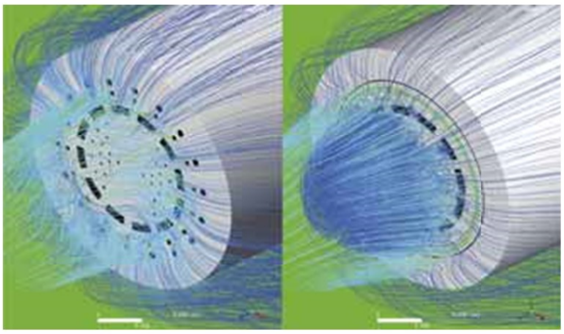

Figure 3. Streamlines for primary and secondary air flows.

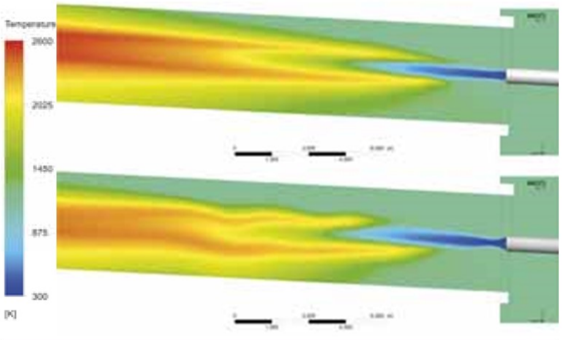

Figure 4. Temperature profile.

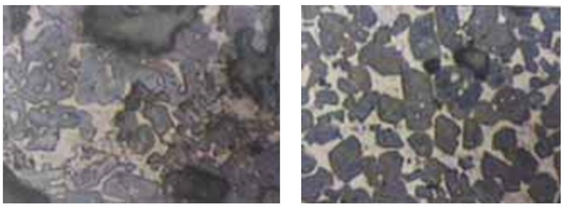

Figure 5. Images of clinker samples, before D-Flame (left) and after D-Flame (right).

air nozzles allow for a more effective intake of secondary air. The study also corroborated the fact that the consumption of petcoke fixed carbon starts nearer to the burner tip in the D-Flame than in the annular configuration. A further indication of greater secondary air entrainment is the temperature at the burner tip. The tip is assumed to be adiabatic for modelling purposes, so temperature gradients for both tip configurations are solely due to secondary air entrainment.[1] It is worth mentioning that the annular configuration of axial air injection creates a barrier, isolating the inner region of the burner tip and therefore delaying coal combustion.

In analysing the streamlines for primary and secondary air flows (Figure 3), it is observed that the barrier created by the annular configuration can be clearly seen, while the gaps on the D-Flame configuration improve the secondary air entrainment into the inner region of the burner, allowing the secondary air flow to reach the region where fuel is injected.

The difference in the kiln thermal profile for the D-Flame and the annular configuration for external air injection is presented in Figure 4. The flame formed by the D-Flame burner is highly stable, whereas the flame produced by the annular design oscillates and impinges on the refractory lining and/or clinker.

The same article also reported the measurements of calculated secondary air entrainment for a number of different burner tip designs, and found that, while the influence of the external air jets is significant, a larger distance between these nozzles will improve secondary air aspiration into the inner region of the burner.

Burner tip geometry is indeed extremely important and must be taken into account.

Putting it into practice

Based on these theoretical studies, the D-Flame burner design underwent an upgrade and has begun operating in a number of plants. The case presented here is for the D-Flame installed at Votorantim Cimentos' Rio Branco plant.

The D-Flame was installed in January 2016 in the W8 kiln at the Rio Branco plant. According to the operators, the operation retrieve was faster than usual for kiln heating, having a stabilisation time of 4 hr for 3800 tpd, with increased flexibility. The speed of the feeding and time stabilisation for this project becomes apparent when compared to that of previous start-ups, following a scheduled stoppage:

- January 2016: 3800 tpd in 4 hr.
- June 2015: 3600 tpd in 12 hr.
- September 2014: 3600 tpd in 6.5 hr.
- January 2014: 3420 tpd in 13.5 hr.
- May 2013: 3220 tpd in 5.5 hr.

Image analyses were also performed. It was found that C_3S crystals were approximately 14% smaller, with alita crystals having a mean diameter of 23.35 μm before installing Dynamis burner, and 20.33 μm afterwards. They were also well formed, regular, and did not have any imperfections. Figure 5 shows two clinker samples, one from December 2015 and another from January 2016, after the installation of the new D-Flame burner.

There was also indication of good performance of the burner operating with petcoke of high sulfur content. Despite evidence of more dust recirculation inside the kiln, such as clinker porosity, the higher burner momentum was enough to compensate for the negative effects of the sulfur, maintaining the size and form of the crystals.

The electrical energy consumption of the mill decreased from 55.7 kWh/t in December 2015, to 51.6 kWh/t in February 2016, improving its productivity. Figure 6 presents the mill specific consumption for February 2016 and the four months before the D-Flame installation.

The new design also involved the injection of tangential primary air at 30° instead of the previous 45°. With a smaller angle for tangential primary air injection, it was possible to use higher pressures for tangential air without negative consequences on the kiln shell temperature.

Figure 6. Mill specific electrical energy consumption (kWh/t) before and after D-Flame installation.

Conclusion

A theoretical study was conducted in order to optimise the D-Flame burner by ensuring that more hot secondary air reached the inner region of the burner. Based on these findings, a new burner design was conceived and installed at Votorantim Cimentos' Rio Branco plant. The improvements seen in the simulated results, such as an increase in secondary air entrainment and flame stability, were confirmed once the burner was put into operation, including increased operation flexibility, good performance when used with high sulfur content petcoke, improved clinker quality, and a decrease of mill-specific electrical energy consumption.

References

1. FAVALLI, R. C., FABIANI, L.F., and DE PINHO, L.F., 'Enhancing the performance of kiln burners.' *World Cement*, (November 2015), pp. 111 – 117.