SEALING THE DEAL

Anis Haider, ITECA SOCADEI, discusses the installation of graphite block seal technology at a cement plant in southern California.

Introduction

Cement manufacturing is highly energy intensive. Energy can account for up to 40% of production costs. While solid fuels make up the largest amount of energy use, electricity prices make it not only the highest cost energy, but also the single largest energy expense. The relative amount of energy used in a typical cement manufacturing plant is shown in Figure 1, while Figure 2 shows the breakdown of energy costs.

One of the largest opportunities for reducing electrical energy consumption is in optimising process gas utilisation. Since cement processes operate a negative pressure (for process and emissions requirements), ID fans pull not only process gases but also excess air (tramp air). Process gas optimisation projects focus on optimising production-related systems and processes, so that they utilise the minimum amount of process gas required for

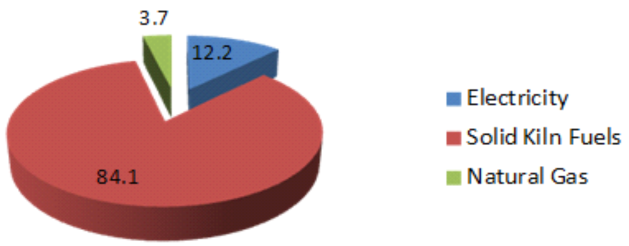

Figure 1. A breakdown of energy use at a typical dry kiln cement plant.[1]

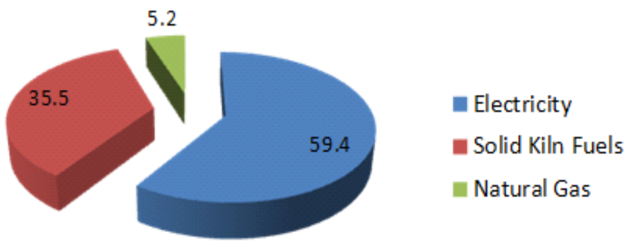

Figure 2. A breakdown of energy costs for a typical dry kiln cement plant.

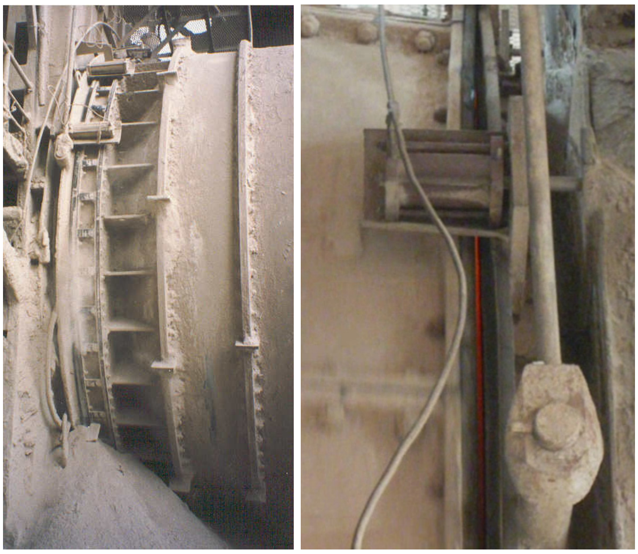

Figure 3. Piston seals.

Figure 4. Lamellar seal.

production. Often the biggest impacts were related to sealing technology (on the raw mill, preheater tower, and kiln systems) and structural repair or optimisation that reduced the amount of tramp air that was allowed into the system.

It may seem obvious, but these projects were most impactful at points in the system where negative pressure was highest, such as near the kiln inlet. In these cases, relatively small gaps or leaks allowed large volumes of tramp air to be introduced. The impact of these types of projects was seen and measured in the reduced power requirements for the large production fans (e.g. kiln and baghouse ID fans) that move process air. The presence of variable speed controls on the affected fans was required to realise the full savings.

This paper examines the actual measured savings of a kiln seal project installed in a cement plant in southern California in 2016. There are a variety of kiln seal technologies in place in the cement industry. The common problem with traditional seal technology is degradation over time, which produces gaps that allow tramp air into the main kiln airflow stream. This tramp air requires increased energy in the primary kiln ID fan, kiln/raw mill baghouse fans, and often in the raw mill up-draft and clinker cooler fans.

Technologies considered

Several traditional seal technologies are available for cement kilns. The cement plant had in place an overlapping leaf-type seal. Over time the design of this type of seal has evolved in a variety of ways in attempts to reduce ambient air in-leakage. Leaf seals are available with one or two layers of metal leaves. They can be laid flat away from the seal connection or mounted ‘reversed’. Some designs have added heat-resistant tensioning cables or have added fabric layers between the plates to increase their durability

The ongoing challenge with leaf seals is that the sections are designed to flex to adapt to variations in kiln ovality. The problem is that, to obtain this flexibility, spring steel is used. As a result, as soon as there is a process instability, hot gas and material escape from the seal, the high temperature causes the spring steel plates to deform and lose their flex characteristics, and the plates open up. Also, once any material escapes, leaves deform under the weight of the material and gaps increase further. Regular maintenance/replacement of leaf sections is required to maintain the seal.

Other available options include hydraulic or pneumatic pressure plates. These plates are forced together in line with the axis of the kiln. The contact surfaces can be metal-to-metal or carbon fibre wear plates against metal surfaces.

The challenge for this type of seal is the difficulty of maintaining continuous contact on a large, rotating, circular surface, against a stationary surface. An out-of-shape surface can be created by the normal run-out of the kiln. The seals on the hydraulic or pneumatic pistons can also be damaged, due to the high ambient temperature at the back of the kiln and, in such case, a non-uniform pressure is applied to the floating pressure plate, and the plate may not touch the whole circumference of the kiln.

Graphite plate design seals include graphite blocks riding against a track mounted on the outside of the kiln shell. The pressure of blocks against the track is maintained by a cable-and-counter-weight system. This system allows the seal plates to move perpendicularly to the kiln axis, and thus follow the kiln barrel to maintain a constant pressure of the graphite plates on the bearing race, regardless of the wear level on the bearing race or graphite plates.

This system is able to reduce the in-leakage of tramp air to a small fraction of the preexisting conditions and was therefore selected for installation on the kiln inlet at the cement plant.

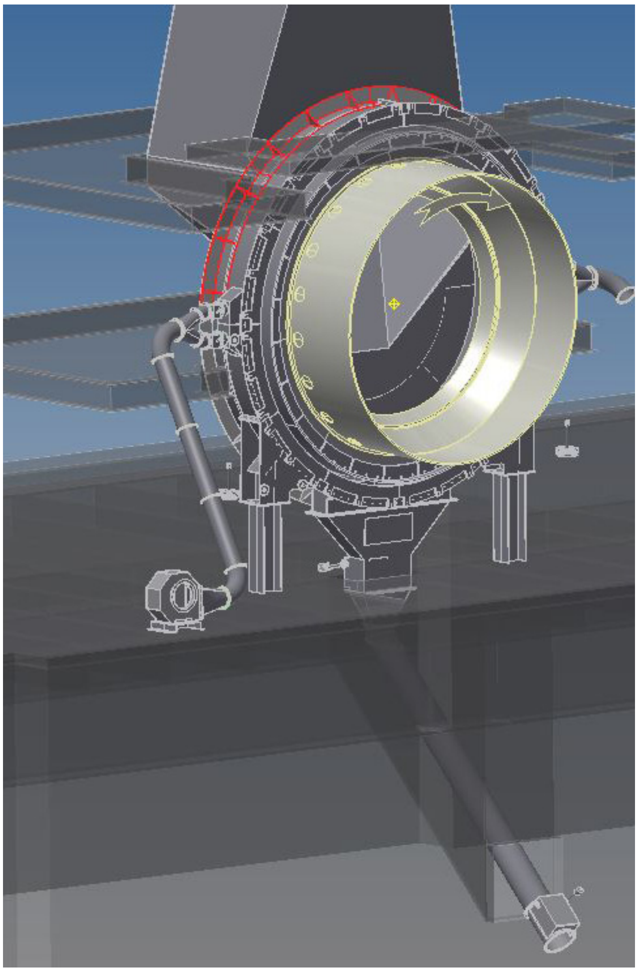

Figure 5. Graphite block seal diagram, specifically designed for a southern Californian cement plant.

Project results: electrical energy savings

Measurement and verification (M&V) of the electrical savings for this project were required to justify an energy-efficiency incentive from the utility company. The M&V comprised three weeks of measuring the kilowattage on the fans involved in moving the process gases: the main kiln ID fan, the kiln/mill dust collector fan, and the clinker cooler ID fan. Other fans that are interrelated in the system, such as the raw mill ID fan, were evaluated. However, this article considers only the impact on the primary loads.

Raw data was taken from the plant's VXL and CMNT SCADA systems. Three weeks of raw data was supplied as 15 min. averages.

Method of data analysis

For each subsystem, average post-measure kilowatt values were subtracted from average baseline values to get a kilowatt value saved for that subsystem. These values were then multiplied by the annual operating hours for the corresponding subsystem and summed to get kWh/year savings for each subsystem/load. These were then be summed to yield total project annual energy savings.

- Kiln ID fan: the kiln ID fan operates at all times that the plant is making clinker. Kilowatt data was sampled from the SCADA once per second, averaged, and written to the M&V data file every 15 min., such that each value in the M&V data file represents the average of 900 one-second values.

Figure 6. New graphite block seal installed.

- Kiln/mill baghouse ID fan: the kiln/mill baghouse ID fan operates at all times that the plant is making clinker. Kilowatt data was sampled from the SCADA once per second, averaged, and written to the M&V data file every 15 min., such that each value in the M&V data file represents the average of 900 one-second values.
- Clinker cooler ID fan: the clinker cooler ID fan operates at all times that the plant is making clinker. Kilowatt data was sampled from the SCADA once per second, averaged, and written to the M&V data file every 15 min., such that each value in the M&V data file represents the average of 900 one-second values.

Results

The results of the M&V actually exceed the savings estimates made before the project. The savings described below include the total impact on the three fans described in the M&V boundary above:

- Peak power savings were greater than 390 kW.
- Annual electricity savings were greater than 3.2 million kWh/year.
- The plant's blended rate for electricity was approximately US$0.09/kWh.
- 3.2 million kWh x 0.09 US$/kWh = US$290 000/year in power savings.

This cost savings easily justified the investment that the cement plant made to improve its kiln inlet seal. In addition, the project qualified for energy efficiency incentives from the local electric utility. The total impact was that the simple payback on this project was much less than one year.

Project results: non-energy benefits

While the replacement of the kiln seal in this project was done primarily for energy efficiency benefits, there are some additional benefits to the graphite-plate kilns seal. While these non-energy benefits were not quantified as a part of this paper, they are worth mentioning here.

Maintenance benefits

An additional advantage of this graphite-plate seal is that it is practically maintenance free. The wear parts of the seal are the graphite blocks rubbing on a smooth steel ring that is rotating with the kiln. After the initial wear when the graphite blocks adopt the shape of the steel riding ring, the wear is very limited, and the average life of the graphite blocks is around 4 – 5 years. Some plants have reported that they only replaced the blocks after more than 10 years. As graphite is softer than steel, there is no discernible wear on the steel riding ring, even after many years of operation.

The only part that needs to be regularly replaced is the pair of steel cables that are weighted to provide a tension to keep the graphite blocks in position. These are typically replaced once a year during the major shutdowns.

The seal also provides a gravity evacuation system for spill situations; therefore, any maintenance-intensive mechanical equipment for material removal below the seal is no longer needed.

Process benefits

Cold false air entering the back end of the kiln has several repercussions on the plant process:

- Because of a localised drop in temperature, cold air entering the back end of the kiln can increase the risk of precipitating sulfur or alkali in the tower and/or in the kiln, causing build ups. This can lead to ring formation at the back end of the kiln and/or buildup in the riser duct.
- Cold air entering the back end of the kiln will also decrease downcomer temperature, resulting in less hot gas being available, for example, for drying raw materials or if the heat is to be recovered in waste-heat recovery systems.
- If the process is air limited, the extra false air will restrict the possibility of adjusting the ID fan, depending on the process requirement, due for example to a change in the burnability of the raw meal or due to the increased usage of alternative fuels.
- With a more stable seal with the new design, there may also be some benefits related to safety and environmental compliance. These have not been evaluated as part of this paper.

Conclusions

The seal has been installed for more than two years and is still performing to specification, with very limited maintenance. The power and fuel savings have been consistent with no loss in performance, as compared to other seals the plant had used in the past.

The inlet and outlet graphite seal solution, as developed by ITECA, has now gained a worldwide acceptance in the cement industry. This was achieved because of its reliability and proven design, with more than 200 seals in operation. This was also helped by the confirmation of the long-term fuel and electrical power savings that have been achieved by all of the plants that have invested in this technology.

References

1. SPERBERG, R. T., HAIDER, A., and ROYER, J.C., 'Kiln Seal Retrofits for Energy Efficiency', paper presented at the IEEE-IAS/PCA Cement Industry Technical Conference, Calgary, Canada, 2017.

About the author

Anis Haider is President of ITECA SOCADEI SAS.