Increasing Efficiency with a High Temperature Kiln ID Fan Upgrade

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***Abstract* -- In October 2013, a cement plant in South Carolina completed a successful upgrade of their Kiln Induced Draft (ID) fan rotor. The specialized fan upgrade supplier conducted in-depth system testing according to AMCA standards to determine the actual system resistance and flow distribution characteristics. The new rotor was modeled in the existing fan housing to deliver an increased flow at continuous temperatures of 500^{0}C (932^{0}F). The high temperature fan capabilities enabled the plant to significantly reduce cooling water, fossil fuel and electrical power consumption. The project was completed reusing the existing fan housing, motor, and coupling. Verification testing was conducted after commissioning, confirming the fan performance and efficiency improvements.**

***Index Terms*—Industrial Centrifugal Fans; High Efficiency; High Temperature Operation; System Optimization.**

I. Introduction

The commitment of the cement company toward sustainable development has led to investment in technologies to reduce their environmental impact. A group within the cement company has been tasked with identifying and supporting projects that offer increases in energy efficiency. In 2010 making improvements to their preheater gas system at the South Carolina plant were investigated, promising to yield significant reductions in fossil fuel use and electrical power consumption. In October 2013, the Kiln ID fan upgrade was completed with an advanced high-efficiency rotor design capable of very high temperature operation (see Fig. 1).

Fig. 1. High temperature fan technology was installed for the main Kiln ID fan at the South Carolina plant.

Process fan improvements were first presented to the plant in 2006, when an evaluation of the process fan efficiencies was conducted. The preliminary investigation included a system heat-mass balance and reviews of the Baghouse, Raw Mill and Kiln ID fan operating conditions. It was found that the Kiln ID fan was operating at a system resistance well below the original design, and a low operating efficiency of approximately 65%.

Like many cement plants, the facility had been dealing with significant maintenance problems on the Kiln ID fan. The fan suffered from wear across the top of the blades, on the blade noses, and the centerplate. A rotor which had been removed after 5 years of service was inspected, revealing holes in the centerplate.

In addition to the excessive wear, a hard slate-like build up was observed on most rotor surfaces (see Fig. 2). The build up required frequent shutdowns and cleaning to minimize the unbalance as accumulated material broke away unevenly. In hot environments dust particles become sticky and after striking fan surfaces, they fuse and harden.

The plant was forced to waste a considerable amount of heat in order to protect the fan from extreme temperatures. The existing fan's design limited operation to maximum gas temperature of 425^{o}C. This required a large amount of cooling water to be sprayed into the gas upstream of the fan. After exiting the fan, the gas was then reheated using natural gas prior to circulating into the raw mill. This process was identified as an area for environmental and cost improvement. It was determined that a higher fan operating temperature would allow the process to be optimized.

Fig. 2. Thick hard build up and wear on the old fan surfaces, requiring frequent maintenance.

Site performance tests were conducted in accordance with AMCA publication 203-90 to verify the existing system resistance and operating conditions. Field performance testing was chosen by the supplier because it measures fan capacity in the actual operating environment, the system characteristics and system effects that affect fan efficiency and wear life. The tests revealed that the fan was underperforming and operating at a total efficiency of only 65%.

Development of a custom high efficiency rotor capable of continuous operation at 500^{o}C was carried out the fan engineers using special design techniques and advanced high-strength materials (see Fig. 3). The final design was given a detailed FEA to confirm all parameters.

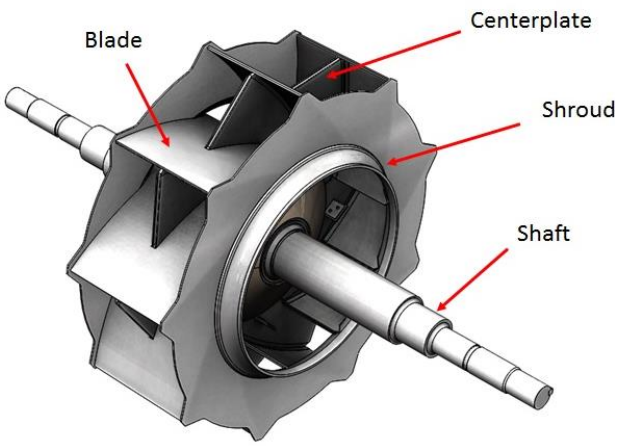

Fig. 3. High efficiency rotor designed for high temperature operation.

The rotor was installed during the 2013 shutdown in the existing fan housing, reusing the existing motor (Fig. 4). The follow up performance test conducted in May 2014, verified the fans design efficiency of 81%, and power savings of 335 kW. During the test the fan was operating at a temperature of 456ºC.

During the first year of operation the fan was inspected during regular maintenance stops with the support of the fan engineers. No evidence of hard build up was present. Acoustic cleaning has been used to address soft build-up on the back side of the blades, which need to be cleaned approximately half as often as the previous fan. Wear rates have been drastically reduced, minimizing annual maintenance efforts.

Fig. 4. The new 152.75" diameter rotor delivers a 10% volume flow increase and 16% efficiency improvement at the new high temperature operation, in the existing fan housing.

In addition to the fan power savings, increased capacity, wear reduction, and elimination of hard build-up on the ID fan, the operational project benefits also included:

- Significantly reduced plant cooling water use, saving 8176.5 litres/hour;
- Reduction in thermal energy consumption of approximately 64 MJ/t raw meal, equal to 4,600 tonnes/year of natural gas;
- Virtually eliminated the need for the 600kW raw mill hot gas booster fan and other associated infrastructure.

In conclusion, the Kiln ID Fan upgrade project has resulted in measurable benefits, including reliable high-temperature operation, enhanced flow capacity, improved wear life, and increased efficiency. Secondary benefits include a reduction in water and fossil heating fuel consumption and power at the raw mill hot gas booster fan. Overall, the project has improved electrical and thermodynamic efficiencies, with the associated reduction in operating costs.