Improving ID fan reliability

After years of frequent repairs and replacement fan rotors due to high particulate loading and resulting erosion, a cement operation in North America enlisted the services of Robinson Fans to explore options to improve the wear life of its induced draught (ID) fan. After approximately three years of testing, engineering, discussions and logistics planning, the cement producer installed an optimised fan for reduced wear, and increased operational reliability and efficiency.

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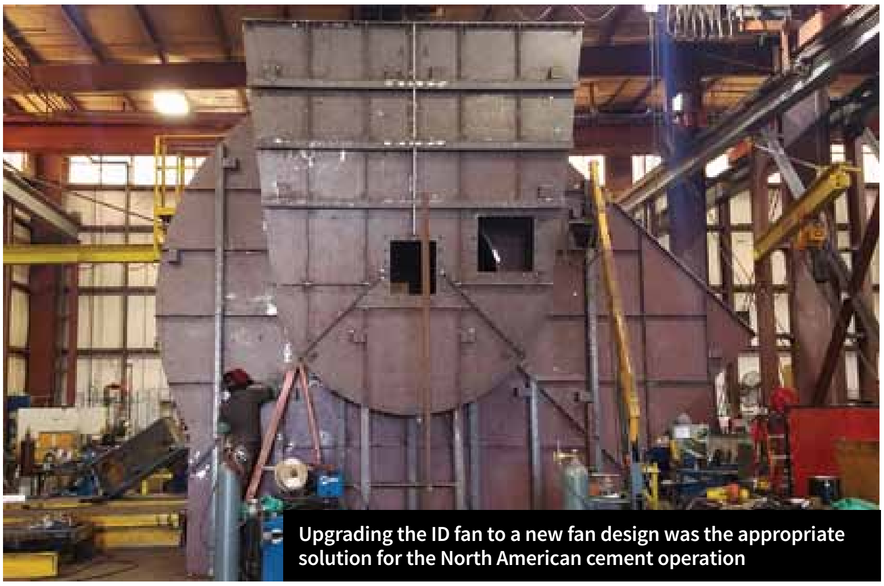
Prior to the new fan implementation, the original induced draught (ID) fan at the North American cement operation was forced to shut down approximately every 3-6 months for repairs or installation of replacement fan components. Production downtime, labour and capital spare usage was proving to be very costly. Reducing the dust load via implementation of a better gas cleaning system upstream of the fan was considered but was ultimately found to be a more complicated project with a higher cost. A more detailed evaluation determined that a new fan design, retrofitted to re-use most of the existing concrete foundation and ductwork, could extend the wear life significantly, at a lower cost than upgrading other system components.



Upgrading the ID fan to a new fan design was the appropriate solution for the North American cement operation

Project overview

During the design phase of the new ID fan, Robinson Fans carried out the necessary testing and research to accurately determine the existing fan's operating conditions. Completing a baseline field performance test was crucial to ensure successful implementation. The new ID fan would have to meet the existing fan performance requirements, without adding additional flow capacity to preserve the already-established environmental permitting for the cement plant. By conducting an AMCA 203-90 Field Performance Test, Robinson was able to gather all the necessary data to determine the fan's current operating state. The most important parameters determined from the testing included the ID fan flow rate, static pressure, power consumption and estimated particulate loading.

After reviewing the field performance test results for the ID fan, Robinson's engineering team began to evaluate potential solutions. It was clear that the measured operating conditions were not suitable for the fan in service. An optimised solution could not only reduce power consumption but also reduce erosion and significantly increase reliability. Several design iterations were completed and several fan types were reviewed before arriving at an ideal design. It was determined that a new fan with an increased diameter and tip-width, operating at a lower speed, would put the fan operating point at a more optimal point on the fan curve, while improving the wear life of the fan rotor.

The cycle of the entire project spanned approximately 32 months – from field testing, through the design phase, to installation and start-up of the new equipment. This seems like a long time for an optimisation project. However, cement production demand delayed the installation of the replacement ID fan by approximately 12 months. The field air performance study of the original ID fan was completed in July 2015. Fan design, discussions between the plant and fan vendor and project approval spanned through July 2016. The new ID fan was delivered in December of the same year, and installation and start-up were finalised in early March 2018.

Operational efficiency

Fan efficiency is often thought of in terms of its simplest form, ie: how much performance (flow and pressure) is the fan generating and how much electrical power is it consuming? This is often how fans are evaluated to determine if it is a good fan for the application. This is a suitable metric for fans that are handling clean air, other non-abrasive gas constituents, moisture, etc. However, in the cement industry, fans can be, and often are, subject to high particulate dust loading that has the potential to wear the fan components out rapidly. Like most plants, the system has dust collection equipment upstream of the ID fan. However, there is still a considerable

Table 1: timeline of replacement ID fan components by Robinson Fans

Delivery date	Replacement fan components
March 2015	Replacement fan wheel
June 2015	Replacement scroll section with chrome carbide scroll liners
July 2015	Replacement fan wheel and chrome carbide scroll liners
February 2016	Complete replacement fan housing and housing liners
May 2016	Complete replacement fan rotor (fan wheel and shaft)
February 2017	Replacement inlet piece
July 2017	Complete replacement fan rotor and inlet piece
August 2017	Replacement inlet damper

amount of dust that is not removed from the gas stream and eventually conveyed through the fan. The deterioration of the fan due to wear can and will lead to issues such as imbalance/vibration, loss of structural integrity, leakage and reduced fan capacity.

In the three years leading up to the installation and start-up of the newly-designed ID fan, the original ID fan often had to be shut down for repairs and installation of replacement fan components. There were a total of 4-5 spare fan rotor change-outs, a complete fan housing change-out and several other critical component replacements. Table 1 shows a timeline of the replacement components, supplied by Robinson Fans, and delivered to site between March 2015 and August 2017.

With unplanned costs associated with purchasing replacement capital spares, labour/services to perform the change-out work, and most importantly, cement production downtime, it was clear that a more durable fan design would have a quick return on investment.

The original ID fan was a single width/single inlet design with a nominal operating speed of 1200rpm. The fan was operating at a high point of rating (high flow rate) on the fan curve, resulting in reduced efficiency. High inlet throat velocities through the fan also led to high wear characteristics. As mentioned, the new ID fan design has several upgraded design characteristics including, but not limited to: a double-width housing with two inlet boxes, an increased fan rotor diameter and tip-width, and a lower nominal operating speed of 900rpm. This new design allows the fan to operate at a more efficient point on the fan curve which reduces power consumption. The larger double-width design also drastically reduces the fan inlet throat velocities. To quantify, assuming a flow rate of 300,000afcm, the original single-width design had an inlet air velocity of approximately 11,500ft/min. At the same flow, the new double-width design has inlet velocities of approximately 3700ft/min. Since kinetic energy decreases with the square of the velocity, the kinetic energy of the dust particles entering the new fan is 90 per cent less than the original equipment. This results in significantly-improved wear characteristics.

Operational efficiency in the business sector is defined as the ratio between output gained and an input to run a business operation. In the cement industry, inputs are repair/labour costs, time, people and other resources. Output is ultimately revenue that comes directly from cement production. Operational efficiency should be evaluated not only by fan performance and power consumption. The evaluation should also include consideration of reliable operation. When the critical fan is shut down to perform repairs and to replace worn-out fan components, the operational efficiency is essentially zero per cent. This compares poorly with the operational efficiency achieved through continuous, uninterrupted operation.

Conclusion

While the project was lengthy and required modifications to some interfacing structures, upgrading the ID fan to a new fan design was the appropriate solution for this cement operation. Data received from the plant shows that it is using less electrical power as a result of designing the new fan to the actual operating conditions. More importantly, the new ID fan has been operating since March 2018 without any major overhauls. It has saved the plant considerable downtime, allowing for continuous production of cement product. The result of this implementation has proved that the goal of increased operational efficiency has been met. ■

Severe wear on the original ID fan rotor

Complete wear through hard surface protection and the structural portion of the fan blade on the original ID fan rotor

The new ID fan rotor – ready for installation