Fan Wear Fixes

Sabine Groh, TLT-Turbo, outlines strategies for extending the operational life of fans in cement plants through advanced wear protection and CFD analysis.

Fans in the cement industry can often be exposed to severe wear. TLT-Turbo supplies fans to the most challenging applications, such as raw mill fans and kiln exhaust fans in the cement industry.

For over 50 years, the company has gained expertise in the protection of all kinds of centrifugal fans and wear exposed parts. To determine the right solution for a specific application, it is necessary to analyse the type of wear that occurs and identify the specific location affected. Wear may manifest as uniform thickness reduction of blades in the impeller or as selective material loss, such as on specific nuts of replaceable wear blades. In some cases, wear even occurs right next to the wear protection. Figure 1 illustrates these different types of wear.

Influence factors on wear

The precise conditions leading to the wear need to be considered. After extensive research on wear and wear protection, TLT-Turbo identified the following key factors influencing wear: the velocity of particles in the airflow, the shape of the particles, and their impingement angle. Furthermore, the material properties of both the surface material and the particles – especially the hardness ratio between them – affect the wear system. Finally, of course, the size and number of the particles hitting the surface of the fan determine the degree of material loss in the impeller in the observed time. Since these factors (and others) together influence the location and extent of wear in the application, accurately predicting the effectiveness of different protective measures for the impeller is a complex challenge.

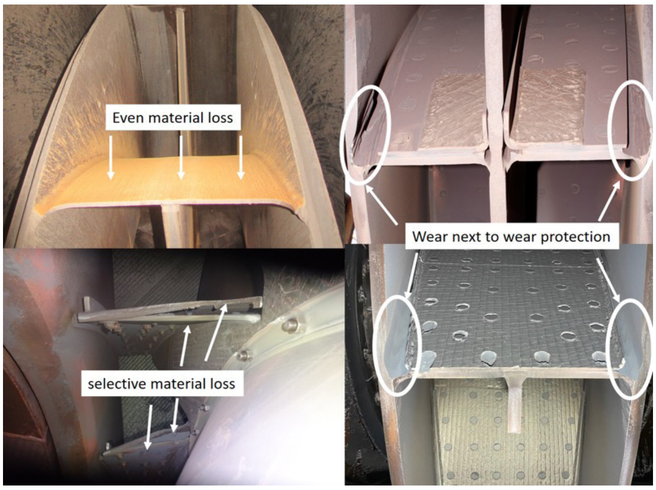

Figure 1. Different kinds of wear on a radial impeller.

Table 1. Hardness of particles and surface material.

		Hardness in Vickers (kp/mm²)
Dust particles	Al_2O_3	2100
	SiO_2	1100
	Fe_2O_3	1000 – 1100
Surface material	Steel	280
	Hardox 500	502
	Hardfacing A	748
	Hardfacing B	1013
	HVOF coating H-101	1145

Table 2. Hardness ratio between particles and surface.

Material of the surface	Hardness ratio for Al_2O_3	Hardness ratio for SiO_2	Hardness ratio for Fe_2O_3
Steel	7.5	3.9	3.75
Hardox 500	4.2	2.2	2.1
Hardfacing A	2.8	1.5	1.4
Hardfacing B	2.1	1.1	1.05
HVOF coating H-101	1.8	1	0.9

Interdependency of influence factors

Due to the quantity of factors influencing wear, the sole consideration of one or two factors is not sufficient. In addition, an interdependency between factors complicates predicting the effectiveness of countermeasures against wear even more. To give an example, there is an interdependency between the hardness ratio (between particles and surface) and the impingement angle.

To closer examine that interdependency, the first step is to analyse the potential particles in the air flow of a fan in the cement industry. One of the hardest particles is corundum (Al_2O_3), which has a much higher hardness than silicon dioxide (SiO_2) or iron oxide particles (Fe_2O_3). Table 1 shows the specific hardness in Vickers of the mentioned particles and surface materials. This results in different hardness ratios between the particles and surface materials (Table 2).

To illustrate the interdependency between the hardness and the specific impingement angle of the particles, it is important to take a closer look at two different angles. For a flat impingement angle like 20˚, a hard material for the impeller is quite beneficial. Usually hard materials are brittle. In Figure 2, a brittle material behaviour is illustrated by the red dashed line. It shows a quite low erosion rate in comparison to ductile material (black dashed line). While on the x-axis the hardness ratio is shown, the y-axis shows the volume-based erosion rate as indicator for wear. Below a hardness ratio of 1, only very limited wear occurs because the surface is harder than the particles hitting the surface. This applies for brittle and hard material as well as for ductile material. However, starting at a hardness ratio of 1, the hardness ratio between the particles and the surface increases, and the wear of the surface increases tremendously. However, above a hardness ratio of 2, increasing the hardness ratio further would not significantly increase the erosion rate. For corundum (Al_2O_3), silicon dioxide (SiO_2), and iron oxide (Fe_2O_3) particles, the specific erosion rates on steel, Hardox 500, and a HVOF coating (H-101) are shown. These rates are calculated using the hardness ratio from Table 2, with the measured volume-based erosion rates represented as specific points on the diagram. The H-101 coating tends to behave as a brittle material, similar to the red dashed line, while steel and Hardox 500 exhibit performance characteristics more typical of ductile materials.

To show the complexity in the interaction between the influence factors, Figure 3 illustrates the erosion rates for the steep 90° impingement angle between the particles and the surface material. In contrast to the 20° angle, now the ductile material for the impeller is much more beneficial. This observation is confirmed by the measured erosion rates for H-101 (as an example of a brittle material), as well as for steel and Hardox 500 (as examples of ductile materials).

While the hardest particles (Al_2O_3) cause the highest material loss, ductile materials for the impeller, such as Hardox 500, now show better wear resistance than H-101. Therefore, when selecting a material, it is important to consider the most likely impingement angle of the particles. However, only small areas within the impeller are typically affected by a 90° impingement angle. In most applications, a higher hardness of the impeller material is therefore beneficial.

A pragmatic approach to wear protection

While the reasons for wear lie in a complex interaction of different influence factors, TLT-Turbo increasingly chooses a pragmatic approach to help customers avoiding wear induced damages.

As a first step, the current situation of wear in the fan gets documented. A particular focus is to analyse the precise position within the impeller that is affected. Depending on this position, the most likely impingement angle can be concluded.

A second measure is to collect a sample of the particles the fan is exposed to. This

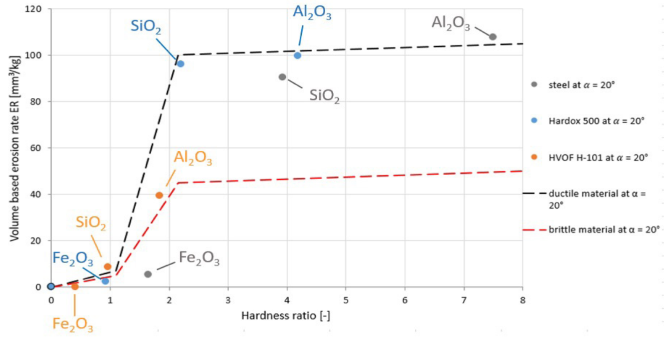

Figure 2. Volume based erosion rate for a 20° impingement angle.

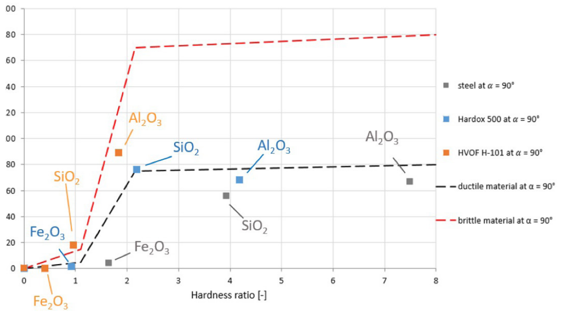

Figure 3. Volume based erosion rate for a 90° impingement angle.

Figure 4. Example of particles a centrifugal fan is exposed to.

sample will be sent to TLT-Turbo's material lab in Zweibrücken.

In the material lab, these particles are dried and prepared for sieving to obtain the size distribution. After microscopic inspection of the particles (Figure 4), finally the hardness of the sample is determined by a specially developed test procedure. This procedure enables the representative hardness of the particles to be determined within a few days.

Using this particle hardness, TLT-Turbo can preselect wear resistant materials with a beneficial hardness ratio.

Finally, volume-based erosion rates with the dust particles of the customer plant can be measured in the material lab. These erosion rates will only be taken for the preselected materials. With TLT-

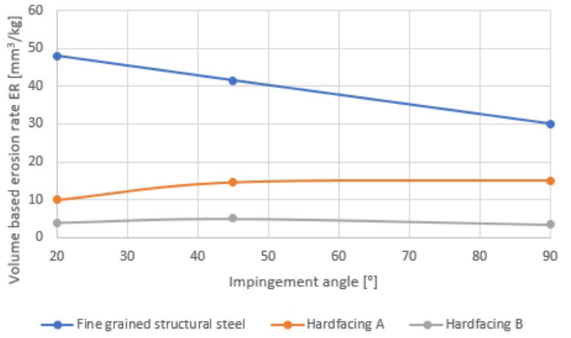

Figure 5. Volume based erosion rate for a specific set of erosive particles.

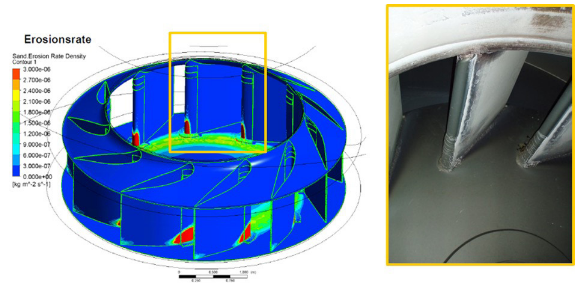

Figure 6. CFD of a radial fan.

Turbo's extensive database, it is becoming increasingly possible to predict erosion rates when dust samples from similar applications have already been tested. As an example, Figure 5 shows exemplary erosion rates for a specific set of particles. This time, different impingement angles are on the x-axis and the erosion rate is on the y-axis.

In this case, Hardfacing B is the most promising candidate for wear protection of the impeller, offering more than twice the lifetime of Hardfacing A and more than 10 times the relative lifetime of fine-grained structural steel at a 20˚ impingement angle.

As aerodynamical specialists, TLT-Turbo can also use computational fluid dynamics (CFD) analysis in order to protect a fan against wear. There are plenty of possibilities, to utilise it:

In the case of a new plant with unknown wear in the fan, CFD can be used to show potential locations of wear or the specific impingement angles. In Figure 5, the wear locations of an operating impeller match to the predicted ones according to the CFD.

Using this method, various countermeasures against wear on the impeller can be simulated. In addition to changing the impeller geometry, aerodynamic optimisation of the general flow conditions in the ductwork can also significantly reduce wear.

Conclusion

For more than 50 years, TLT-Turbo has conducted extensive research on wear, its influencing factors, and their most important interdependencies in industrial applications. These findings have led to significant expertise in addressing various types of wear in fans and wear-exposed parts, as well as in implementing the most effective countermeasures. It is possible to extend the operational life of fans in industrial plants by inspecting damage and wear locations, as well as analysing the dust particles to which the fan is exposed.

Using existing erosion rates or the measurement of erosion rates with a dust sample from the customer's application, the extension of running time for a fan can be predicted. In conclusion, by using its experience and database of experiments, TLT-Turbo finds the best cost performance ratio in its countermeasures against wear within a short time. Furthermore, CFD can be used to verify countermeasures or aerodynamically optimise the general flow. Depending on the specific needs of the customer, TLT-Turbo uses its experience, research, and methods to multiply the lifespan of fans and wear-exposed parts. ■