Innovations from Venti Oelde

Centrifugal fans in cement works –
Avoidance and elimination of deposits

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1. Introduction

In many industrial processes it is necessary to convey dust-laden gases. Caking in the fans and in the ducts used for handling dust-laden gases is always a problem when manufacturing cement and lime and in numerous other industrial processes. Deposits in the ducts cause a reduction in the duct cross-section, leading to an increase in the flow velocity and therefore to a higher flow resistance. The flow volume of the fan is reduced, i.e. throttled.

The throttle effect is considerable because the flow resistance increases to the square of the flow velocity. If the deposits grow substantially and the fan is operating left of the maximum on the performance curve, it can happen in extreme cases that the flow volume falls so far that the transport duct becomes blocked.

Normally the dust load in the gas flow is not sufficient to block the system completely. However, the flow volume is reduced, which can have a considerable effect on the process.

Deposits on the fan impeller have particularly serious consequences. They cause substantial unbalance and vibrations, resulting in increased load on the shaft and bearings, eventually causing damage. It is possible to measure the vibration velocity in mm/s with vibration monitors. The measuring point is the impeller-side roller bearing. Here the measurement is taken horizontally with a stationary monitor and transmitted to the process control desk, or else it is checked regularly by a hand measuring instrument. Important system fans are always fitted with fixed vibration monitoring systems.

The standards for evaluating mechanical vibrations of machines are laid down in the DIN ISO 10816. The limit values are determined accordingly and, with stationary vibration monitors, the limit contacts are set for “early warning“ and “switch off“. The size of the deposit is easy to estimate from the measured vibration velocity, and any necessary cleaning can be planned.

2. Influence of the deposits

2.1 Solid particle properties

The cause of a deposit can frequently be found in the composition of the dust. Examinations of sample deposits have shown that as a rule clay and/or alkali chlorides promote the formation of deposits. Sedimentary materials (usually from clay) cause a hard, firmly fixed, cake as a result of the high velocity with which the heavy dust particles hit the leading edge of the blade.

Alkali chlorides encourage deposits whenever the exhaust gas contains dust. For example, approximately 8 % gypsum contained in the material being classified in a cyclone air separator can lead to deposits on the trailing edges of the blades. It is well known that fine gypsum has a great tendency to cake. Very fine gypsum particles build up in the separator air because the fines are only partially removed from the air stream by the cyclone separators. Up to 25 % of the deposit on the trailing edges of the blades consist of very fine gypsum particles.

2.2 Particle size composition

The influence of the particle size composition of raw meal on the formation of deposits only becomes important if there are large concentrations of alkali chlorides in the gas flow.

2.3 Temperature

Experience has shown that two temperature ranges cause an increase in caking. The first is the low temperature range (starting up and running down) as a result of the temperature falling below the dew point. The second is the temperature range above 400 °C, although so far there is no adequate explanation for this phenomena.

2.4 Dust load in the transport medium

A higher than average dust load in the gas stream is caused by worn cyclones (damaged outlet ducts), or pendulum flaps or rotary valves which do not seal properly. The tendency to caking and wear in the fan and on the impeller also rises with increasing dust load. Alkalis and gypsum build up in the exhaust gas and in the recirculating separator air, and also tend to promote the formation of deposits.

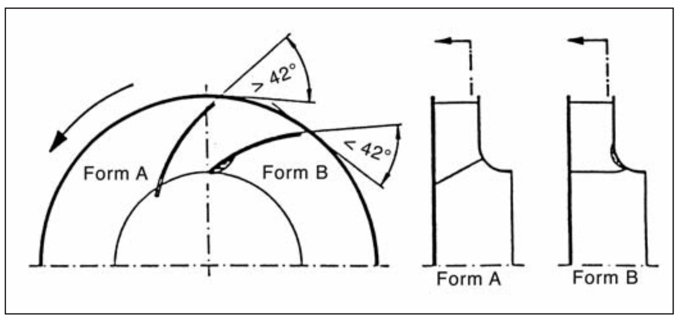

Figure 1: Blade form and blade angle in high-efficiency centrifugal fans

Form A: Blade edge set back into the inlet area, therefore no tendency to caking behind the impeller shroud

Form B: Tendency to caking behind the impeller shroud

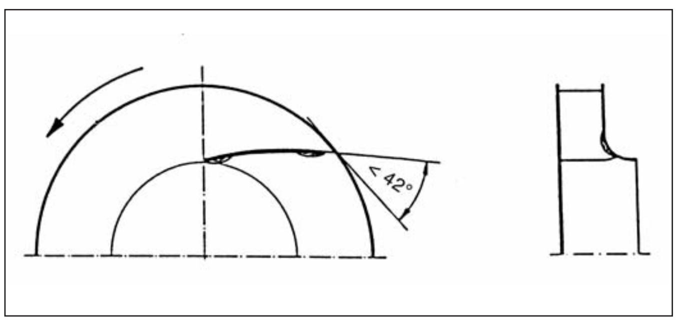

Figure 2: Blade angle less than 42°
with formation of deposits on blade circumference and at the impeller inlet

2.5 Moisture content

The tendency to caking increases where there is a high moisture content in the air and material. This always occurs when the temperature falls below the dew point during starting up and running down.

2.6 Angle of repose of the solids

Not only the opening angle of the impeller blades but also the natural angle of repose of the dust are important factors in the formation of deposits on the impeller blades. Practice has shown that deposits can be avoided if the dust has a low natural angle of repose and at the same time the opening angle of the impeller blades is more than 42° (Figs. 1 and 2).

2.7 Flow velocity

The flow velocity has a considerable influence on the formation of deposits because the impact forces and the separating effect from the gas stream grow as the velocity increases. That means, for example, that clay dust separates from the main flow when it changes direction in the impeller, hits the impeller at great speed, and remains attached.

2.8 Aerodynamics

A disturbed approach flow to the impeller on the fan inlet side will not only have a detrimental effect on the fan efficiency, but will also increase the tendency to caking. The installation of double bends, baffles, incorrectly dimensioned inlet boxes, regulating dampers, etc., leads to compression of the material flow, and to deposits.

3. Avoidance or reduction of deposits

The large number of conditions which favour the formation of deposits cannot be countered by a single measure. The following general measures can be taken to avoid deposits:

- steady operation and therefore steady material supply,
- steady material quality,
- steady fuel supply, fuel quality and temperature,
- suitable excess air, but no false air,
- correctly functioning cyclone separator preheater,
- correctly functioning rotary valves, double pendulum valves,
- correctly functioning circulating air separator or distributor disc separator,
- optimum recirculating air operation for mill and separator,
- avoidance of interruptions in operation and the consequent drop in temperature below dew point.

If these general measures do not produce the necessary success or if it is impossible to introduce these measures, then investigations must be carried out and countermeasures taken. An examination must first determine the exact points where deposits are formed and then establish the chemical composition and particle size of the deposits. Firmly fixed sediments (usually clay components) are generally found on the leading edges of the impeller blades. Clinker dust or quartz sand are also found on the leading edges of the impeller blades in grinding or separator systems. Clinker dust and quartz sand show less

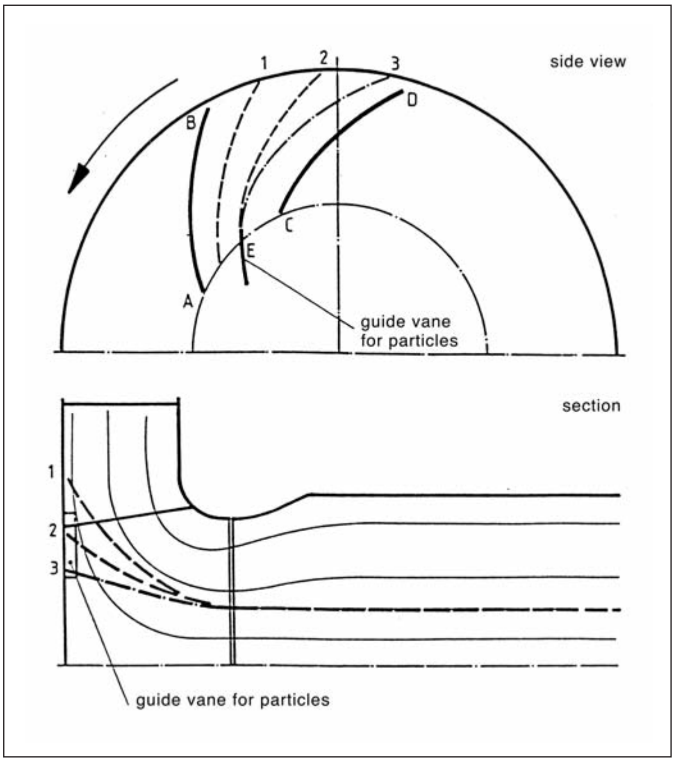

Figure 3: Particle trajectories 2 and 3 altered by guide vanes

A-B,C-D Blades
E Point of contact of the particles with the guide vanes

tendency to cake but, depending on the loading in the air stream, they can cause heavy wear on the impeller. Light, fairly fine, dusts such as fine raw meal or gypsum, and also alkali-rich dusts, form thick deposits on the blade trailing edge and behind the impeller shroud in the inlet area, but they do not adhere strongly. Figs. 1 and 2 show how it is possible to avoid deposits behind the impeller blades and the impeller shroud by design measures such as alteration of the blade form and blade angle. Blade angles larger than 42° up to 50° only have a slight tendency to caking on the reverse side, but still have good efficiencies of up to an optimum of 84 %.

Fig. 3 shows the gas flow paths and particle trajectories 1, 2 and 3. Trajectories 1 to 3 depend on the size of the particles. Trajectory 1 corresponds to a fine particle and virtually follows the flow path of the gas. With increasing particle size the particle trajectory – trajectories 2 and 3 – deviates further from the flow path of the gas. The particles on trajectory 1 flow through the channel between the blades, while the particles on trajectories 2 and 3 strike the impeller backplate and are deflected by the guide vanes into the blade channel. When the guide vanes are correctly positioned the trajectories of the particles can be directed so that the particles do not strike the blades. Deposits on the blade leading edges are therefore avoided. The size, position and angle of the blades are determined by the particle size composition, the density of the particles, the fan size and the tip speed of the impeller.

4. Cleaning methods

In practice it is often found that deposits can only be reduced or displaced, but not completely prevented, so cleaning becomes essential. Cleaning should be possible during operation, and the cleaning intervals should be predictable and scheduled. However, if it is only possible to clean the fan when it is stopped and opened, then it is absolutely essential that interruptions in production, use of the workforce, and costs, are kept as low as possible.

4.1 Compressed air cleaning with fixed injection nozzles

Specially developed injection nozzles have proved very effective for lightly adhering deposits in the inlet area and on the blade trailing edges (Fig. 5). The injection nozzle is fixed and directed onto those areas with deposits, and is supplied with compressed air at 6 bar. The cleaning frequency can be set visually (e.g. 1 second cleaning every 30 minutes) to suit the requirements by means of a solenoid valve and a timing relay. This makes it possible for the operator to reduce the cleaning frequency and compressed air consumption to a minimum.

It may be necessary to use two injection nozzles with very wide impellers so that the complete surface of the blade is blown free and cleaned.

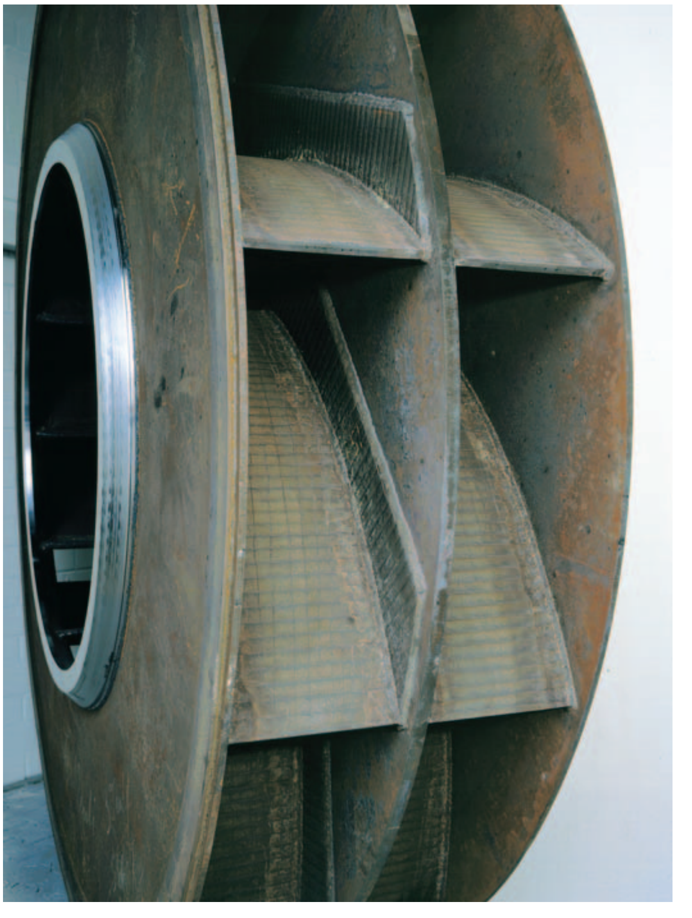

Figure 4: Wear-protected impeller with corresponding blade angles

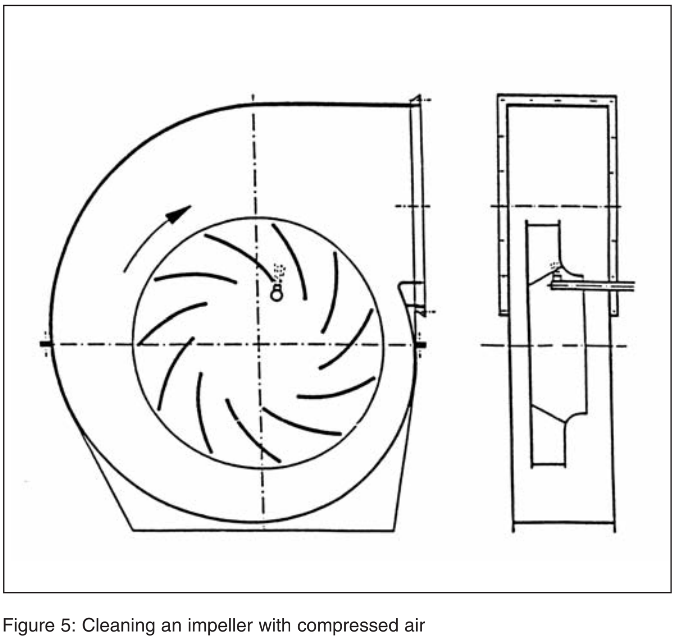

Figure 5: Cleaning an impeller with compressed air

4.2 Cleaning with coarse sand or gravel

The use of coarse sand or gravel is an extremely efficient method of cleaning off firmly fixed clay components on the leading impeller blade edges. The material is fed into the gas stream on the inlet side of the fan. The sand or gravel particles strike against the firmly clinging deposits on the impeller blade and wear them or blast them away. Coarse sand, foundry sand, gravel or clinker can be added to the gas stream, depending on how firmly the cake has adhered. The cleaning effect is excellent. However, care must be taken to ensure that the impeller blade surface does not become excessively roughened, causing further deposits to cling even more stubbornly to the rough surface.

The above cleaning process can also be automated. The gravel is filled into a feed hopper with a volume of about 2 m^3 which is connected to the fan inlet through a spigot with a rotary valve at the discharge side. A vibration monitor (Vibrocontrol 1000) is installed on the impeller-side fan bearing. The rotary valve is actuated when the vibration velocity of the fan exceeds a pre-selected figure; the gravel is then supplied in metered quantities and the cleaning process commences. When the vibration velocity of the fan falls below the pre-selected figure again, the cleaning process is stopped. Two pre-selected limit values are possible, a higher figure to initiate the cleaning process and a second, lower, limit value to end It. However, experience has shown that the trailing edges of the blades are not reached and cleaned, meaning that the use of this method is essentially limited to cleaning e.g. clay components, from the blade leading edges.

Figure 7: Circulated air fan for cement mill

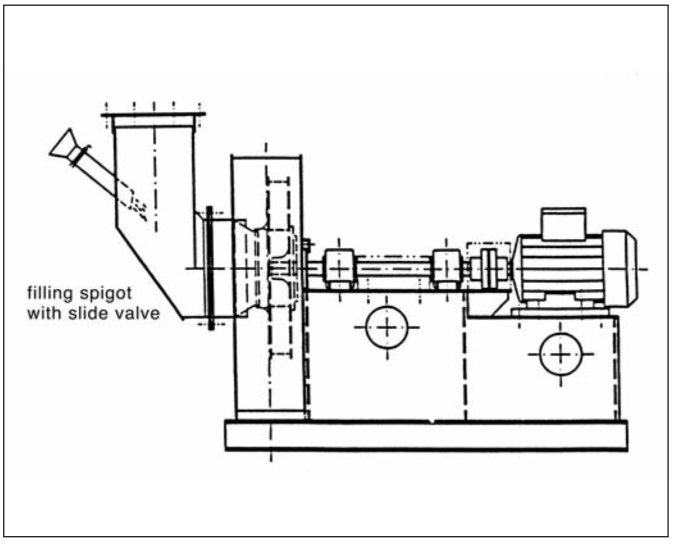

Figure 6: Removing fixed deposits by adding coarse sand or gravel

4.3 Cleaning with sound waves

This method offers a large number of technical and economic advantages. Caking is removed with the aid of vibrations. A frequency between 150 and 250 Hz, depending on the hardness of the deposit, is emitted by a sound generator which is driven by compressed air and controlled by a solenoid valve. The equipment is very robust and reliable.

Further information can be found in our special article “Sound waves free fan impellers from dust deposits“.

4.4 Cleaning with fan opened and stationary

Sandblasting is a widely used method, aimed specifically at removing firmly fixed and loose deposits (Fig. 8). When the impeller has been fixed in the required position, it is cleaned with a compressed air lance and blasting media (foundry sand or coarse sand). An experienced team of two will, for example, take about two hours to clean the system fan after a cyclone preheater.

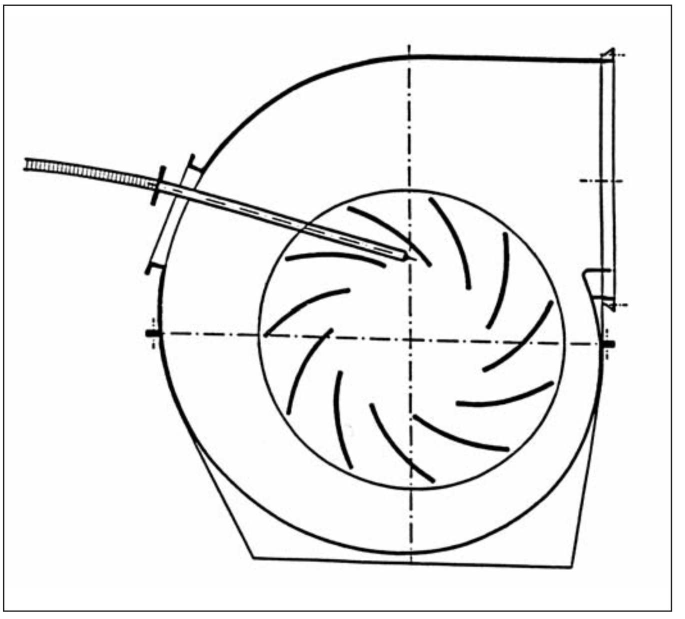

Figure 8: Cleaning the trailing edges of the impeller blades with compressed air lance and blasting media while stationary

Subject to alterations B 0/10/20/8.Stu

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