A QUESTION OF FANS

Narayana Jayaraman and Francisco Benavides, PEC Consulting, highlight the challenges associated with process fan selection in cement plants.

Introduction

Fans are critical to the cement manufacturing process and are a major consumer of electric power. The proper selection and optimisation of process fans is important in lowering the energy consumption in a cement plant. The selection of fans is governed by factors such as the plant capacity, elevation, ambient conditions, system configuration, and their ability to cope with different operating points.

The principles of fan operation and fan laws are a well-established science. This article does not discuss basic fan laws, but rather focuses on special situations in the cement process where careful diligence is necessary in selecting a suitable fan. Understanding the impact of these situations on fan performance is helpful in optimising their operation. Since most are centrifugal fans, only these are discussed here. Blowers and compressors are also not discussed in this article.

Process fans in cement plants

There are many fans in a cement plant. The critical ones that need special attention include the following:

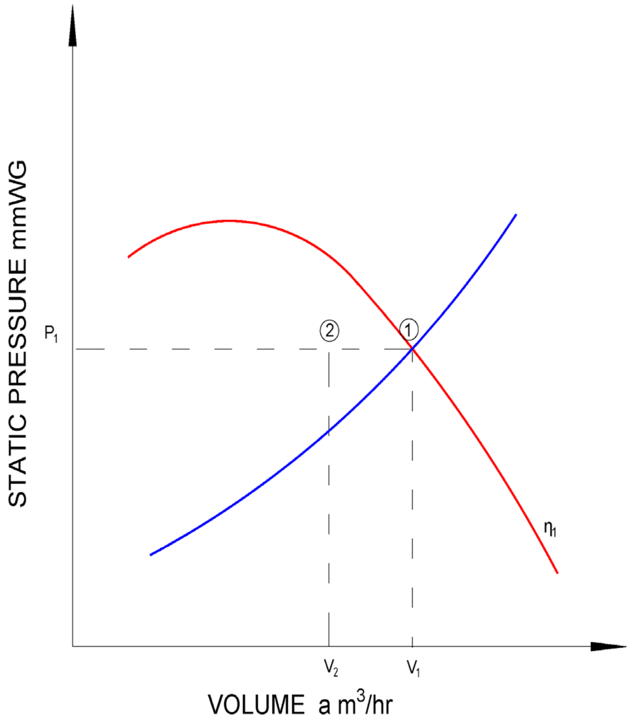

Figure 1. Shows how the operating point shifts from 1 to 2.

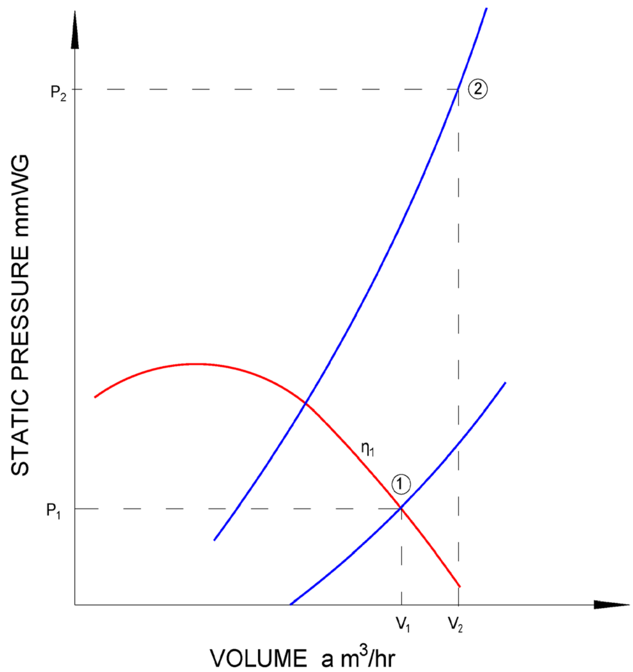

Figure 2. Shift in the operating point of main filter fan in a two-fan system.

- Kiln ID fan.
- Raw mill fan.
- Main filter fan.
- Bypass filter fan.
- Clinker cooler vent fan.
- Cooler under-grate fan.
- Booster fan for preheater gas to coal mill.

In addition, there are numerous other applications, such as airslide fans, nuisance dust collector fans etc., which are of small capacity and are not discussed in this article.

In the case of new installations, the equipment suppliers – who know the system's requirements – make the appropriate choice of fan. In such cases, only a due diligence is warranted by the owner or owner's engineer.

The choice of a new fan is more critical in the case of a retrofit application: for instance, when the plant has upgraded the capacity of a new filter installation or is considering a modification to the existing process.

In either case, the impact of the cement process situations on the fan operation and considerations for the selection of a suitable fan are discussed in the following section for specific fans.

Impact of process requirements on fan operation

Kiln ID fan

The kiln ID fan provides the oxygen for the pyroprocess. The fan draws the air and the combustion products through the kiln and preheater and deals with a high static pressure arising mainly from the pressure drop across the cyclones in the preheater.

To cope with changes in the production level, changes in the fuel composition or leakages in the system, the Kiln ID fan is chosen with a margin in addition to the theoretical flow conditions. It is traditional to provide a margin of 15% on the volume. However, the margin on pressure may or may not follow the square-law. The system pressure varies with the square of the air flow. By this rule, the pressure margin should be specified 32% above the calculated value.

However, in a kiln-preheater system, if excess gas flow is due to leakage, most likely this air enters somewhere in the preheater and thus the excess gas is not subject to the same pressure drop. Therefore, the increase in pressure drop may not follow the conventional square law.

Thus, the provision for the margin on pressure could be somewhat lower than what is determined by the square-law.

Another example is when a gas conditioning tower is installed in the down comer for energy saving, which, other parameters remaining the same, should result in lower gas flow. However, this energy saving is only realisable if the new system operating point falls on the fan curve.

The static pressure remaining the same, the volume becomes lower depending on the temperature: see Figure 1, which shows the operating points (1) and (2) before and after installation of a gas conditioning tower upstream of the kiln ID fan, respectively. Even with a variable speed drive, the fan curve may not exactly pass through the new operating point 2 since, in reality, the fan must run faster to develop the same static pressure than the speed dictated by the volume drop.

This is achieved, to some extent, by a combination of a variable speed drive for the fan and dampers. In addition, the fan efficiency changes with the fan speed. These factors limit the realisable power saving.

Raw mill (VRM) fan

The raw mill fan for a vertical roller mill (VRM) typically handles a fixed volume of gases and does not have a variable speed drive, except when provided for electrical reasons. For better operational flexibility, some installations have a variable speed drive to ensure constant gas flow at the mill outlet. The margin on raw mill fans is typically lower: 10% on volume and 20% on pressure. The raw mill fan is of large capacity and its specifications are determined by the mill characteristics.

The cement mill and coal mill are similar to the raw mill requirements.

Main filter fan

The main filter fan (which evacuates the raw mill and kiln gases) is required to handle a wider range of gas conditions. The gas condition varies considerably when the raw mill is in operation versus when only the kiln is in operation, which may occur every day for a few hours. Therefore, the fan curve for a filter fan needs to be flatter without much drop in the efficiency from one condition to another. For this reason, this fan should also be provided with a variable speed drive.

The variation in the operating conditions is more severe in a two-fan system, where there is no separate raw mill fan and the main filter fan doubles as the raw mill fan. When the mill is operating, the filter fan will need to handle, at the inlet, a static pressure of -1000 mmWG compared to around –250 mmWG when only the kiln is operating. Such a large variation is achieved by a combination of variable speed drives and dampers. The fan efficiency also differs from one situation to the other.

In a two-fan system, Figure 2 shows how the operating point shifts drastically when the mill is not in operation (point 1) from the time when the mill is in the operating (point 2). Point 2 needs a marginally larger volume, but substantially higher static pressure.

In a three-fan system, which is more common, the variation is not this significant, but there will be a large variation in the volume and temperature in the two situations.

Bypass filter fan

Due to raw material requirements, some cement plants need a bypass system to bleed off a part of the kiln exit gases. Bypass affects the heat and power consumption of the kiln system adversely, resultingin a waste of the kiln dust. The extent of bypass is dependent on the raw material and fuel composition. The design provides for the worst conditions but tries to minimise the bypass as much as possible. A bypass provision of 0 – 15% is common.

This wide range of bypass provisions requires the fan to be designed for a similar range of operating conditions. A combination of variable speed drives and dampers should be provided to meet the requirements at various bypass levels.

Clinker cooler vent fan

The clinker cooler vent fan is subject to variations in kiln production capacity. Cooler upset conditions considerably alter the operating parameters of the cooler vent fan. To retain some flexibility, it is recommended to have a variable speed drive for the cooler vent fan in order to match the system conditions with the fan characteristic curve.

Cooler under-grate fans

Collectively, the cooler under-grate fans consume considerable power. They also operate at varying conditions depending on the cooler operation, upset conditions, etc. Cooler optimisation is an important target for lowering the heat consumption as it consistently attempts to lower the under-grate cooling air in terms of kilogram of air per kilogram of clinker. It is recommended that the cooler fans be provided with variable speed drives to obtain the benefit from lowering the cooling air requirement.

Booster fan for preheater gas to coal mill

This is a relatively small fan, which is used to draw the preheater gas before the gas conditioning tower for supplying the inert hot gas to the coal mill. If the gas conditioning tower is located in the down comer before the ID fan, due to the high draft conditions at the top of the preheater, a booster fan is required.

This fan has the unusual requirement of low volume of gas but with a high static pressure at the fan inlet. This makes the fan impeller narrow but with a large diameter.

The inertia power requirement is large as compared to the power needed to move the gas. The motor selection is very critical in this case, when compared with other large fans, where inertia power is a small percentage in relation to the gas flow power requirement.

PENTA has come across at least one case where the inertia power requirement was not given full attention and the fan failed to spin up to the full design speed.

It is important to check the spin up time of the fans considering the speed-torque curve of the fan and the inertia of the impeller.

Waste heat recovery retrofits

Due to the rising energy costs, many cement plants have added waste heat recovery to utilise the waste heat in the preheater and cooler vent for the generation of electric power.

Waste heat recovery is achieved by placing a heat exchanger in the gas duct out of the preheater and in the cooler vent duct. The effect on the preheater fan is similar to the addition of the gas conditioning tower, except for the following:

- The heat exchanger adds pressure drop.
- There is no increase in the mass flow as there is no water addition (which is the case for gas conditioning tower).

It is important to identify the fan's new operating point to estimate the full effect, although there should be an overall power saving with the waste heat recovery addition on the assumption that there is no gas conditioning tower in the existing configuration.

Conclusion

A good understanding of the process requirements is necessary for selecting or optimising the process fans in a cement plant. Wide operating ranges create a challenge. Choosing fans with appropriate characteristics for different applications is critical; the requirement also varies with individual configuration of the plants. In most cases, providing a variable speed drive helps in optimising the fan operation, however, the resulting benefits are subject to several other factors as discussed above in this paper.

About the authors

Narayana Jayaraman is Director-Technical Services at PEC Consulting. He has over 50 years experience in the cement and lime industries in various capacities with a major focus on process and technology.

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