Anti-Stall Fans for the Mining Industry

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ABSTRACT

Stable performance of mine ventilation fans is important not only for maintaining adequate ventilation of the mine, but also to maintain the integrity of the fan unit itself. It is demonstrated, herein, that a properly designed and applied stabilization device, integrated into the fan casing itself, will assure stable performance and actually extend the fan's capability.

KEYWORDS

Stalling Cause and Effect, Anti-Stall Design, and Effective Application.

INTRODUCTION

Adjustable pitch axial fans often provide substantial advantages in operating economy in their high efficiency over a wide range of operation. They have, therefore, seen extensive use in the ventilation systems of all types of underground mines.

Specifications for the acquisition of mine fans are developed from data resulting from the application of engineering principles and practices to an established mining plan and anticipated geological conditions. However, the actual fan requirement may deviate from what is expected due to incorrect or overly optimistic pressure drop calculations, unanticipated adverse geological conditions, changes in management philosophy regarding airway development, fans starting in parallel, or an array of influences, which may alter the range in which the fan must operate.

Fans are selected to include a safety margin (normally a minimum of 10% of the pressure at the stall point) between the maximum anticipated fan duty point and the fans stall zone, as indicated by the fan performance characteristic curve. If the point at which the fan must operate varies significantly from the point for which it was selected, the stall line could be reached or surpassed. This, then, could result in unstable fan performance, in turn, inducing a short fall in capacity, increased sound levels, and eventually, fatigue damage to the rotating element, if not total failure of the fan.

Obviously, fan stalling is not an acceptable condition, neither for the mine nor for the fan itself. This writing shall demonstrate that stable fan performance can be maintained by the integration of a stabilizing device, into the fan casing itself, using no electronics or moving parts.

FAN STALLING – CAUSE AND EFFECT

The performance chart of a variable pitch axial fan consists of a number of characteristics showing the performance at different blade angles. Each curve has a peak pressure. A line drawn across these peaks would indicate the stall line of the fan, as shown in Figure 1. Normally, the characteristics to the left of this stall line are not indicated on the performance chart, since the fan is neither selected nor expected to operate in this range due to the unstable performance that would result.

Airflow Reversal and Swirling

As the fan reaches the stall line pressure, the boundary layer separates on the convex side of the blade. Centrifugal force then directs this flow from the blade roots toward the blade tips, overloading the tips. The rotation of the blades then creates a swirl in the direction of rotation. With this, the flow reverses nearer the fan casing, off-loading the blade tips, and returns downstream. A temporary stabilization occurs until the overloading again occurs. Hence, the huffing sound emitted by the stalled fan.

The swirling back flow at the blade tips induces prerotation in the annular area nearer the hub, causing this area of the impeller to operate at reduced load, similar to the effect of an inlet vane control, resulting in reduced system pressure. The flow then stabilizes across the annular area of the impeller until pressure increases to the point where stalling again occurs.

This loading and unloading of the fan blades, during unstable operation, results in significant variations in pressure

and serious vibration. The damage incurred due to fatigue resulting, from these influences, has been demonstrated to be cumulative. That is, a sustained stall as well as a series of short term stalls may eventually result in a total breakdown of the impeller.

STALL WARNING DEVICES

Numerous devices are available to warn the occurrence of fan stalling. These may be either electrical, mechanical or a combination device. The conditions monitored, with preset warning levels, are flow or pressure variations or excessive vibration. Although many of these devices are reliable, they only provide indication that a stall has occurred, they warn and shut the fan down at a predetermined level, they do not prevent stalling, and the stall line remains the upper limit for fan performance. Again stall damage may accumulate, so any stall time is unacceptable.

ANTI-STALL DESIGN AND APPLICATION

Laboratory tests and hundreds of field applications have provided proof that a properly designed and applied stabilization ring can prevent fan stalling, and, in addition, extend the stable operating range of the fan into what had previously been the stall zone, Figure 2.

Design

The stabilization (anti-stall) ring is comprised of a peripheral duct shaped ring, with a number of imbedded guide vanes, integrated into the fan casing immediately upstream of the impeller, Figure 3. In reversible axial fans, two rings are installed, one on each side of the impeller. The integration of the anti-stall ring normally does not increase the length of the fan casing.

The purpose of the guide vanes is to capture the turbulent flows at the blade tips, restore them to stability, and return them to the normal direction of flow. Unstable preswirl in the fan inlet is totally eliminated.

Application

This not to say that an anti-stall device is an overall solution to stalling for all axial fans. Rather, it is a viable solution only when fans are developed and tested with anti-stall. The anti-stall (stabilizing device) is not compatible with all blade designs and hub to tip ratios.

Also, there is no substitute for accurate system loss calculations and appropriate fan selection and application.

CONCLUSION

When appropriately applied, such a stabilization device effectively eliminates the unstable preswirl at the fan inlet and provides stable performance over the entire range of fan operation. Thus, a measure of protection of the integrity of the fan's rotating assembly is afforded during operation and during starting of parallel fans; operations are not interrupted by inadequate ventilation or fan failure due to stalling; and the fan's performance range is extended. Also, fan efficiency is not compromised. For most fan designs, there is only a minor efficiency reduction for adding the anti-stall device.

REFERENCE

Bard, H., "Antistall Fans for VAV Systems in the Electronic Industry," ABB Flakt Industri, Vaxjo, Sweden.

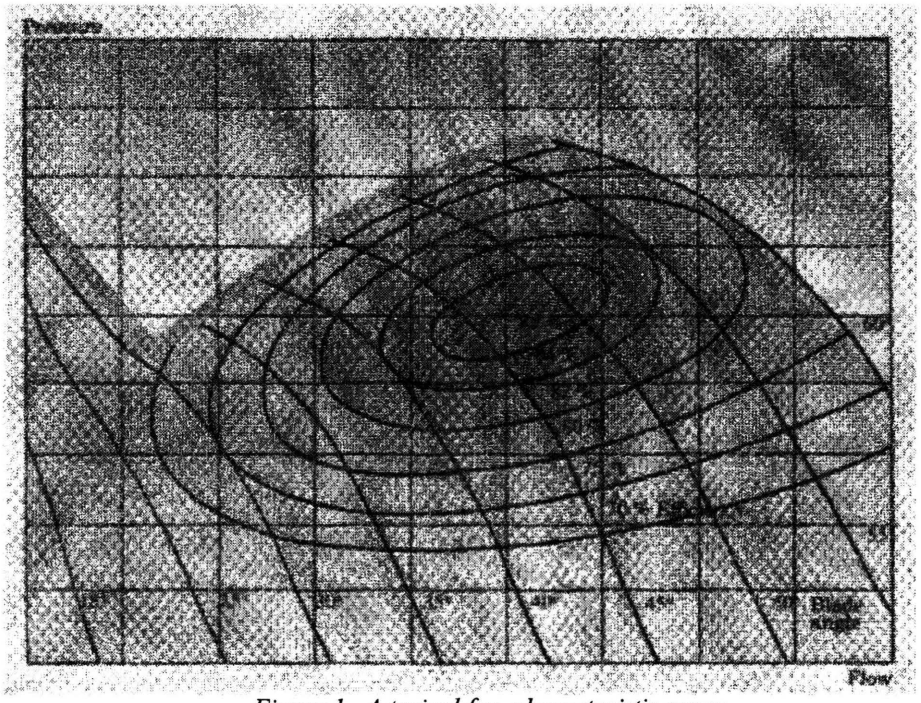

Figure 1. A typical fan characteristic curve.

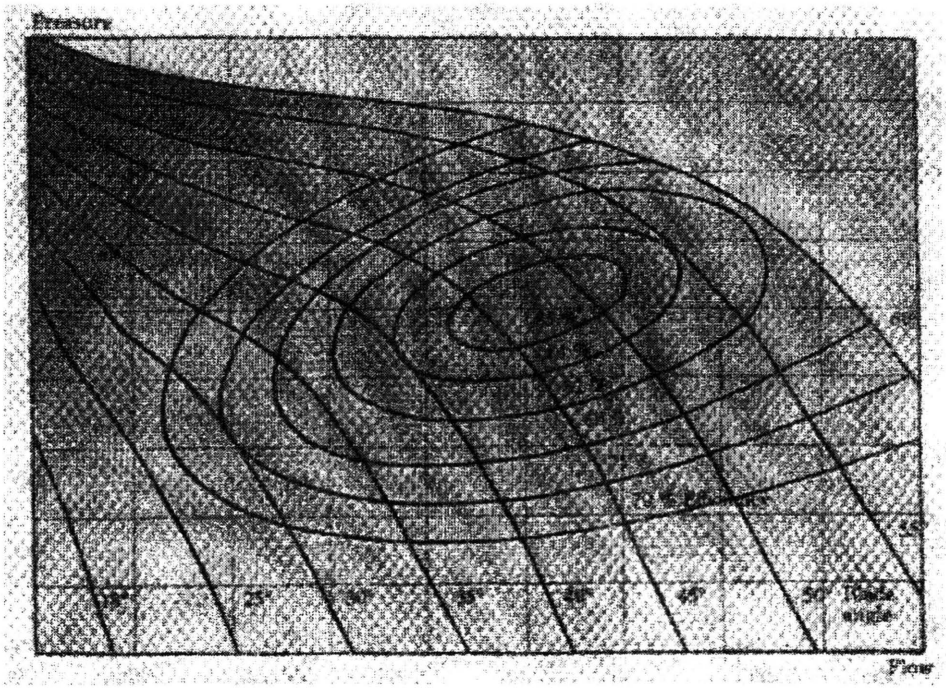

Figure 2. Stable operating range can be extended using properly designed stabilization ring.

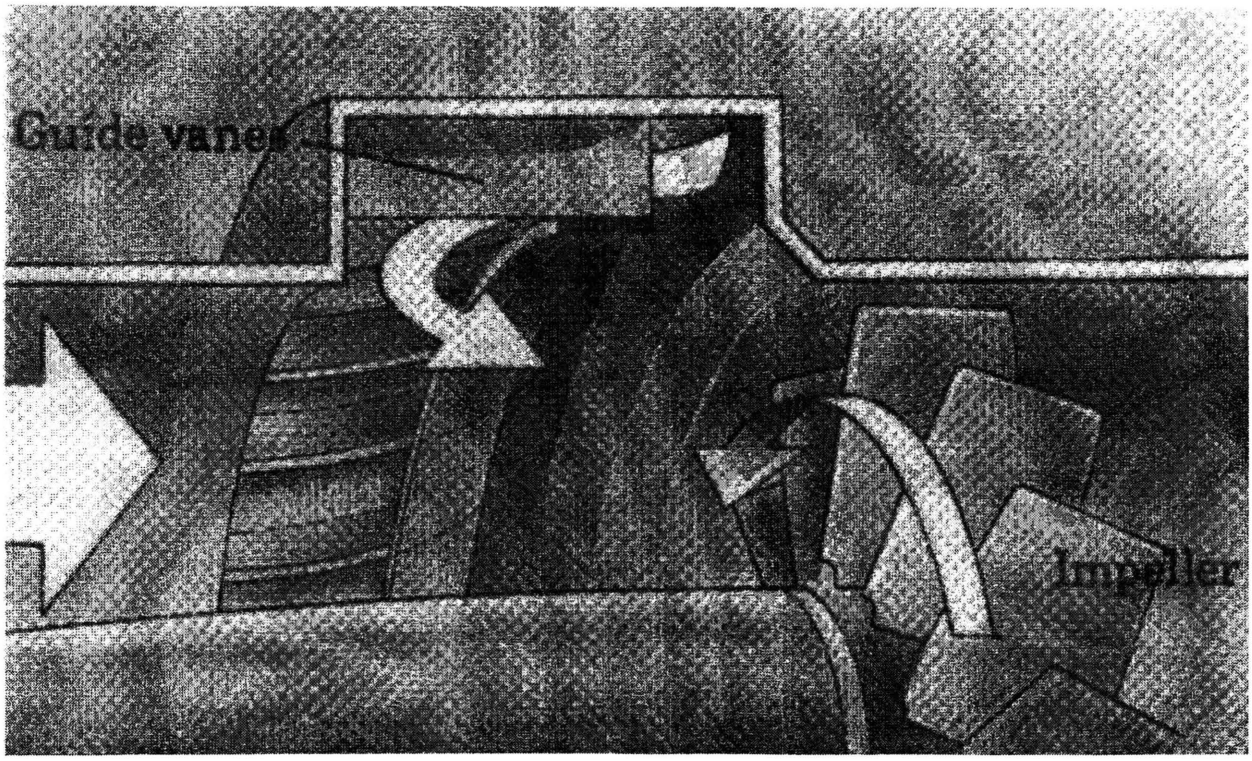

Figure 3. The design of stabilization ring.