



SOLVING WINDMILLING PROBLEMS ON BELT ACHE FAN SYSTEMS

HOW TO IMPROVE WORKER SAFETY AND REDUCE MAINTENANCE



ACHE fan bank

Introduction

If your solution to stopping a back-spinning ACHE fan is to apply your hand to the belt as a brake, think twice! Fingers have been injured by maintenance technicians attempting this method. Pressing a 2x4 against the belt is another non-conventional, and dangerous, way to slow a free-spinning ACHE fan.

Free-spinning (or “windmilling”) occurs when ACHE fans are powered off, becoming free to rotate backwards. In this condition, fans not only pose a safety hazard to maintenance workers, but they also place a strain on motor system components when they power back up.

There is a simple, economical solution to this problem. It’s called an anti-rotation device, and it makes ACHE fans safer to work on while reducing wear and tear on fan system components.

ACHE Fan System Challenges

Air-cooled heat exchangers (ACHE) are an effective means of dispelling or transferring heat from industrial processes. They are typically used in the chemical, petrochemical and oil & gas sectors. Other common ACHE users include food and beverage, power generation, pulp and paper, and various other manufacturing industries.

ACHE fans (also known as “Fin-Fans®”) range in size depending upon the application. In refinery operations, Fin-Fan units may be 30 feet off the ground and have fan blades ranging from six feet to 17 feet in diameter. A typical ACHE installation might include large numbers of Fin-Fan systems operating intermittently to maintain preset temperatures within various processes.

Fin-Fans are typically driven by gears or belts (either V-belts or synchronous belts) powered by electric motors. A common configuration includes an electric motor with a V-belt drive. In recent years, however, synchronous (timing) belt drives have been replacing V-belt drives to increase efficiency.

Problems Caused by Windmilling ACHE Fan Systems

On an idle belt-driven ACHE, the force of air moving over or beneath the blades allows the belt to rotate backwards in the sheave or sprocket, since there is no counteracting force to keep it in place. This back-spinning or back-draft effect (commonly called “windmilling”) might be caused by other fans in the system or by environmental factors such as wind.

A MATTER OF EFFICIENCY: V-BELT VERSUS SYNCHRONOUS BELT DRIVE

An ACHE V-belt drive, even when properly installed and maintained, is 93% efficient or less. This low percentage results partly from the speed ratio between the large driven pulley and the smaller driver pulley, which minimizes belt wrap and lowers power transmission efficiency.

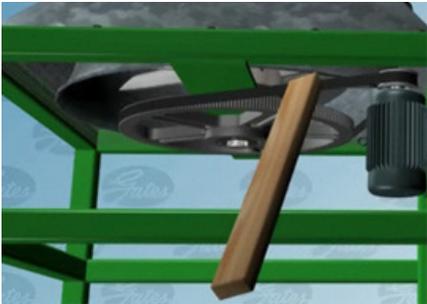
V-belt drive efficiency is further compromised by hard starts when ACHE drives are windmilling. When subjected to a hard start, a V-belt tends to slip before engaging the pulley wall. This belt slip reduces shock load, but over time the walls of the belt and pulley become glazed, reducing friction and making the drive less efficient. In addition, the high temperatures frequently found in the ACHE environment can harden the belt’s rubber compound, further contributing to belt slip and loss of efficiency.

Many users of ACHE systems have converted to synchronous belt drives for greater efficiency, which translates to higher energy savings. Synchronous, or toothed, belts run on toothed sprockets. Much like gears, positive engagement between the teeth of belt and sprocket provides a highly efficient transmission of power. A synchronous belt drive operates at 98% efficiency for the life of the drive, with no need for retensioning. This translates into significant energy savings and reduced maintenance activities.

However, when subjected to a hard start, a synchronous belt won’t slip and so the components of a windmilling fan driven by a synchronous or timing belt get a big jolt when the power is turned on—unless protected by an anti-rotation device.

Free-spinning Fin-Fans pose two major concerns:

- › Worker safety
- › Fan/motor system wear and tear



Using a 2x4 to slow a windmilling fan is hazardous.



Belt and pulley form a pinch point that can trap and sever fingers.



Beam cracked due to repeated shock loads during power up while unit was windmilling.

Worker Safety

Performing maintenance in the hot, cramped space around an ACHE unit sitting 30 feet above the ground with a freely rotating shaft poses a real threat to the safety of maintenance technicians.

A common method used by maintenance workers to stop a windmilling fan is to press a 2x4 against the belt to slow it by friction. This method is fraught with the potential for bodily harm. Workers have also been known to grab the belt to slow it down, only to have their fingers pinched, and sometimes lost, between the belt and pulley.

The issue of worker safety is compounded when maintenance crews must frequently retension belt drives or replace damaged equipment.

System Wear and Tear

Of and by itself, a windmilling fan poses no particular threat to the system. But consider what happens when the fan is powered up. The sudden reversal of motion is akin to shifting a forward moving car from drive into reverse gear. The belt receives a shock load which reverberates through the system—fan and motor shafts, bearings, mountings and attached equipment.

On V-belt drives, hard starts eventually glaze the walls of the belt and pulley, causing the belt to slip and lose efficiency. Maintaining efficiency requires frequent retensioning—not an easy task for maintenance workers who must expose themselves to the elements and wrangle huge, free-spinning fans to a stop.

Often, to reduce the number of times a belt must be retensioned, maintenance technicians will set belt tension on the tight side. Overtensioning the belt puts a strain on motor shafts, fan shafts and bearings. Over time, these components are weakened or damaged. Ultimately, the belts, motors or bearings fail. When the drive stops, so does the cooling of the associated process. The operation must be shut down until repairs are made. This downtime is costly, particularly for facilities that operate 24 hours per day, and when the failure occurs during times when maintenance crews aren't readily available.

Preventing Hard Starts with Variable Frequency Drives

One solution to avoiding shock load when starting up a windmilling ACHE fan is to install a variable frequency drive (VFD). A VFD regulates motor speed electronically by changing the frequency of the alternating current supplied to the motor.

Starting a motor with reduced voltage and reduced frequency results in a “soft start.” This places less mechanical stress on motor system components. There is, however, a price to pay for this ability to adjust motor speed. First, VFDs are costly to acquire. Second, motors with VFD controls will operate at a lower efficiency than non-controlled motors when both are delivering full rated power.

Nonetheless, adding VFD controls to a motor is easier on belt drive systems, since motor speed can be ramped up slowly, avoiding the high starting torque of a non-controlled motor.

While VFDs may ease wear and tear on motor system components, they are costly, require additional wiring and they do not address the safety issue caused by windmilling ACHE fans.

A Simple, Economical Solution:

Anti-Rotation Devices



Gates Draftguard™ anti-rotation device

Clearly, a method is needed to secure windmilling ACHE fans and prevent their backward rotation while power to the motor is shut off. This method is needed both to allow safe maintenance on the equipment, and to prevent hard-starting shock loads that can break belts or damage equipment. The answer is the anti-rotation device.

Anti-rotation devices are comprised of a one-way clutch which allows the ACHE fan shaft to rotate in one direction only. When the motor is shut off and the fan system slows to a halt, the clutch prevents the ACHE fan shaft from rotating backwards when air currents circulate over the fan blades. When the motor is turned back on, the system accelerates from a standstill to normal operating speed.

One version of an anti-rotation device is called Spin Doctor™. Its mounting options are limited to E, F or J type QD® bushings. Another design of a fan backstop is manufactured by Formsprag® Clutch. Called the Model FB, it includes a line of low-torque clutches in three size/bore ranges. While it's a more compact design than the Spin Doctor, it is suited only for fans with horizontal shafts.



Torque arm mounts to frame to prevent accidental rotation.

Gates designed Draftguard™ anti-rotation device to be flexible and to fit on nearly any ACHE drive. The core of the product is a high-torque, one-way clutch. The device is engineered to mount to any bushing commonly used in ACHE belt drive systems, including QD (E, F and J) and Taper-Lock® (3020, 3525, 3535, 4030), or directly to the shaft.

The torque arm mounts to the frame to prevent accidental rotation of the ACHE fan shaft during maintenance. The device adapts to clockwise or counter-clockwise rotation, and fits within most fan cages or guards without modification. Bearings are greased-for-life, so the device requires no maintenance.

ORIGINS OF THE ANTI-ROTATION DEVICE

In 1993, a refinery worker in Canada badly injured his hand and nearly lost a finger trying to stop a windmilling Fin-Fan. In addition to safety concerns, refineries and petrochemical plants with large ACHE systems were also dealing with the frequent replacement of broken belts caused by windmilling Fin-Fans.

Some of these refineries and petrochemical plants were customers of Nick Agius, a technical sales representative for a Gates industrial distributor in Alberta, Canada. Nick specialized in rotating equipment, so he devised an anti-rotation device, called AR412C, that was patented in Canada and the U.S. in 1994.

The device was a one-way clutch system comprised of a shaft bushing, clutch adaptor, clutch housing, clutch bearing with seal, clutch shaft, bottom plate and fixed surface. The clutch adaptor also included a locking plate and pin. The first iteration was somewhat large and bulky, and could only accommodate QD® bushings.

Gates Draftguard™ anti-rotation device is the newest generation designed to fit on nearly any ACHE drive without modification to the fan cage.

Conclusion

Anti-rotation devices like the Gates Draftguard unit provide an economical solution to the two major problems created by windmilling ACHE fans. From a safety standpoint, they secure fan drives and prevent them from rotating freely when not receiving power, allowing maintenance technicians access to the fan cage without risk of injury. Secondly, they prevent hard starts by allowing fan drives to power up from a neutral, standstill position, minimizing damage to drive components caused by shock loading.

Engineering assistance with anti-rotation devices for ACHE fan systems is available from Gates Corporation. Contact a Gates Product Application Engineer by calling (303) 744-5800 or emailing ptpasupport@gates.com. Or visit www.gates.com/draftguard for more information.

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