ANTI-BACKWARD ROTATION STRATEGIES FOR SERIES FAN POWERED TERMINAL UNITS

Dan Int-Hout
Chief Engineer

KRUEGER
Excellence in Air Distribution

STRATEGIES

Series Fan Powered Boxes have been in common use for nearly 20 years. Developed initially as a solution for heating perimeter zones, they have developed into a solution for all spaces, providing relatively constant airflow to a space, and having a consistent acoustical signature. Products have been developed with lower and lower sound generation, allowing higher capacities, and reducing first costs.

There are several issues that are debated regarding their use, including the energy consumption of the fan (which by design runs all the time when the space is occupied) vs. the central fan hp reduction allowed by their use (ASHRAE and ARI are funding a study to evaluate this issue). The major problem recognized with the Series design, is the potential for the fan to run backwards.
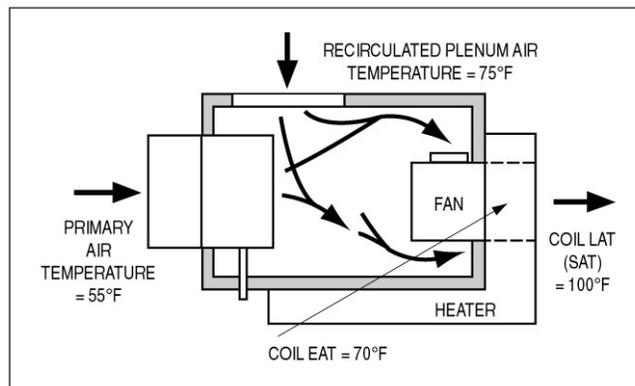
The figure above shows a properly operating series fan box (SFB). The SFB blends warm plenum air with cold primary air to control space temperature when cooling is required (as is the case in most interior zones). The box is balanced in the field so that with the primary airflow at design maximum, the fan speed is adjusted so that there is no air flowing out of the induction port. When cold air flows into the plenum, this reduces the plenum temperature, and there is a possibility that space temperature control can be lost in a cooling demand mode. This is seldom noticeable if a reasonable balance has been performed. In many cases, engineers will set the primary air maximum (often at $52^{o}F$) to be 80% of the fan cfm, avoiding this problem.

Any forward curved blower, however, when pressurized from the inlet (as would happen with a series box if the primary damper is open, primary air is supplied and the fan is not energized) will spin backward. The motor most commonly used in the SFB is a fractional HP Permanent-magnet Split Capacitor-start (PSC) motor. If spinning backward fast enough, and energized, a PSC motor can start and run backwards. This will not hurt the motor, nor will it be noticeable in the space (at first), but the capacity of the box will be significantly reduced. This will not be a problem until the space load calls for more cooling air than the fan can deliver. At this point cold primary air will spill into the plenum, significantly reducing plenum air temperatures. The first complaint will be from the person sitting under the ceiling plenum return air opening who complains of a cold downward draft. Eventually, temperature control throughout the space will be compromised as the SFB mixes cold primary with cold plenum air.

This potential problem has been recognized from the earliest days of Series Fan Box implementation. A number of strategies are available to prevent this occurrence. The first is obvious: Never supply primary air to the SFB unless the fan is energized. In the past, a common method employed has been to connect the fan contactor to the inlet sensor, so that whenever there was pressure in the primary supply duct, the fan was energized. This option was common with pneumatic systems, but has not commonly been specified now that DDC systems have become more standard. This option is available, however, and could probably be considered an "anti-backward rotation device". Modern DDC control sequencing can prevent any

Krueger Corporate Headquarters
1401 N. Plano Rd. • Richardson, TX 75081
Phone: (972) 680-9136 | Fax: (972) 497-0450 | E-Mail: kruegerinfo@krueger-hvac.com
www.krueger-hvac.com

inadvertent supply air / fan operation issues. One DDC supplier has a 'occupied start' routine that sequences (by box address) 1/20th of the units to go through a sequence where the fan is stopped, damper is closed (and the inlet pressure transducer is zeroed, and the damper position index is reset at 0), and after a minute (or so, allowing it to stop, should it be spinning) the fan is re-energized, and control of the primary damper returned to the temperature control loop.

To assure that the fan is operating properly regardless of the control sequence employed is a more difficult task. We have seen, in several manufacturers' catalogs, a listing of an "anti-backward rotation device". In fact, there has never been a "device" available to prevent anti-backward rotation. There are, however, strategies employed to reduce the occurrence of this effect. The PSC motors utilized in Series Flow Fan Boxes are not 'off-the-shelf" motors. They have custom windings to develop the optimum torque for each size and application. They also include designs that minimize motor hum when controlled by the Silicon Controlled Rectifier (SCR) speed controllers used for balancing the units, and to provide maximum energy efficiency. The starting capacitors are selected to provide the best compromise between maximize starting torque, cost and operating amp draw with these motors. All manufacturers of these boxes use essentially the same motor designs (with custom torque curves), provided by either of two primary manufacturers (GE and Fasco). No strategy can completely prevent backward rotation if the fan is spinning fast enough with a PSC motor.

Another solution is the ECM motor, and its derivatives. The first offering in this arena was the GE ECM motor that is a brushless DC motor. It has a computer control circuit (typically containing the fan curve) and which monitors rpm and torque in response to a control signal, and promises to deliver constant cfm regardless of external pressures. It is difficult indeed to make these motors run backward. Their initial cost is several times the cost of a PSC motor, however. The energy payback/savings is a function of a number of factors including load factors and utility rate, but can often be less than two years. There are other motor manufacturers entering this market as well, which was initially the residential market (several orders of magnitude greater than the commercial one), and with differing designs. These include different strategies than the GE design, but offer similar savings and will also likely prevent backward rotation.

In summary, the best solution to prevent backward rotation is to supply a control strategy that prevents it. Once programmed properly, this solution is free. Fan Box manufacturers all use custom PSC motors as a standard option, and most (including Krueger) have optimized the motor/capacitor combination to maximize starting torque. There is no "anti-backward rotation device", other than a primary airflow switch. (Challenge anyone who lists an anti-backward rotation device' in their catalog for a replacement part number!) There are no magic motors (we all use the same basic design). There are strategies that can overcome poor control logic. Our recommendation is for the design engineer to specify that the control contractor provide logic that prevents (not avoids) improper fan operation, or specify an airflow switch if you can't trust the control guys to do it right.

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1401 N. Plano Rd. • Richardson, TX 75081
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www.krueger-hvac.com