WaterFurnace
Commercial Solutions

Integrated EC Plenum Fan Technology

Abstract

WaterFurnace has brought innovation and industry leading integrated EC Plenum fan technology to several new products. WaterFurnace is the first water source equipment manufacturer to employ these high efficiency plenum fans in true multi-speed airflow water source applications. Starting with ASHRAE 90.1-2013, most applications will now require multiple airflow stages to match the compressor and economizer staging requirements. Single speed fans in HVAC equipment are quite limited when compared to integrated EC plenum fans ability to deliver the best airflow performance.

Integrated EC Plenum Fan: What is it?

The integrated electronically commutated (EC) plenum fan integrates three technologies: a high performance backward curve fan, a high efficiency communicating motor drive, and a direct drive permanent magnet external rotor fan motor. The integration of these three elements provides a host of features and benefits for the designer, maintenance team and building owner.

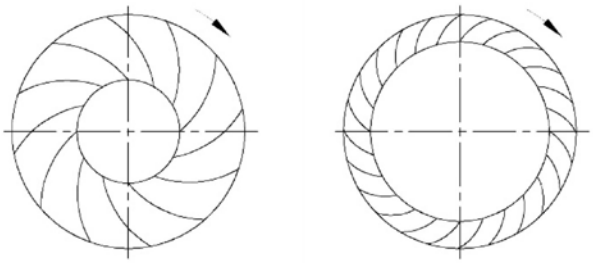
Fig 1. The EC plenum fan is the marriage of three important technologies

1. High Static Heavy Gauge Aluminum Backward Curved Fan
2. Integrated EC Drive Controller
3. Direct Drive External Rotor Permanent Magnet Fan Motor

Forward vs Backward Curve Fans

The most common type of fans used in the HVAC industry are centrifugal fans. The most common types of centrifugal fan blade style are the forward curved impeller and the backward curved impeller. Fig. 2 shows the blade diagrams of the forward curved and backward curved impeller blades. Because of the differences in the blade approach to the air mass, forward curved fans with a larger number of blades will operate at a lower speed for a given duty than a backward curved fan.

Fig 2. Backward and forward curved centrifugal wheels

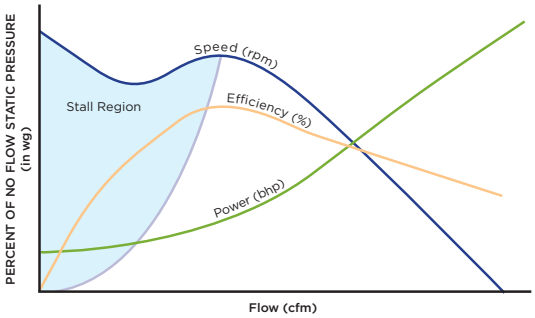


Backward centrifugal *blades facing backwards to direction of rotation*

Forward centrifugal *blades facing forward to direction of rotation*

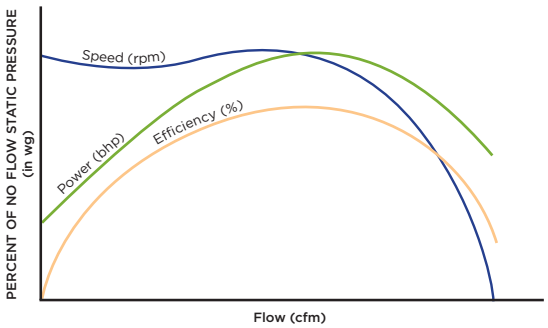
Forward Curved Fans operate at lower speeds (typically 900-1400 rpm) and pressures compared to its backward curved counterpart. Backward curved fans (75-80%) have an approximate 10-15% efficiency advantage over the forward curve cousin (65-70%).

Fig 3. Forward curved centrifugal fan performance



Backward Curved (Plenum) Fans operate at higher speeds (typically 900-3000 rpm) and pressures compared to its forward curved counterpart. In the case of integrated EC plenum fans, the fans are factory balanced and provide quiet vibration free operation. Backward curved fans can be used

Fig 4. Backward curved centrifugal fan performance

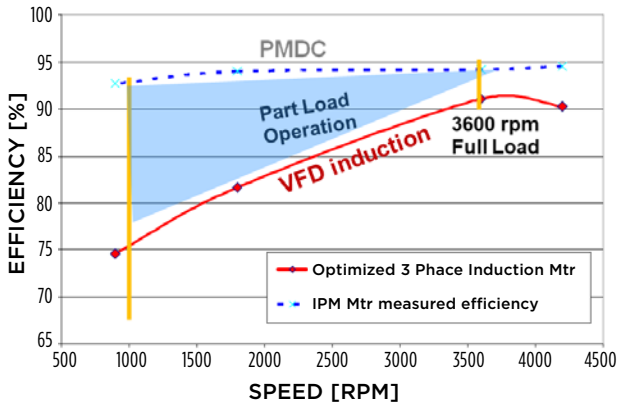


in different configurations. Those not applied with a housing surrounding the wheel are often referred to as plenum (or plug) fans. This type depends on the cabinet enclosure to provide the 'housing' for the fan. This 'open' arrangement is not possible with a forward curve blade.

Direct Drive vs Belt Drive Fans

Direct drive fans couple the motor directly to the shaft of the fan. Direct drive fans not only eliminate the belt inefficiencies, but the maintenance and reliability costs of belt driven components as well. This is an important feature since belt and sheave maintenance is one of the most common HVAC service issues. Typical maintenance costs for a belt driven HVAC unit are $100-150 per year per unit and can be eliminated with the direct drive system. The integrated EC plenum fan utilizes the direct drive system.

Fig 5. Traditional induction vs permanent magnet motor efficiency



EC Plenum Fan Efficiency vs a VFD Belt Drive Blower

The integrated electronically commutated (EC) plenum fan is more efficient 'wire to air' than any belt driven forward curve system. First, let's look at the motor. Traditional 3 phase induction motors were designed to operate at synchronous (3600 rpm) speeds. With belts and sheaves, only this single speed selection is available. To operate at lower speeds a VFD is often employed. VFD's do allow lower speed operation but efficiency greatly suffers when operating off of the synchronous speeds. When the VFD drops the rpm, the fan motor is not operating at its design point of 3600 rpm and efficiency drops 15-20% as well, as shown in Fig. 5. Therefore it is operating not at the 90% efficiency design point but at 75%. New EC permanent magnet motors (PMDC) in the plenum fans don't exhibit this problem and will maintain the high 92-95% efficiency across the rpm operating range. Secondly, let's look at the whole fan system efficiency of the EC plenum fan vs. a belt drive induction with and without a VFD. We will also include two different airflow settings of rated airflow (350-400 cfm per ton) and 50% rated airflow (175-200 cfm per ton). Table 1 shows the resulting system efficiencies. At rated airflow the belt/sheave system is around 33% efficient. By adding the VFD we only improve slightly to 34%. The EC backward

Table 1. Application efficiency comparison

System Type	Airflow	Motor Efficiency	Belt Efficiency	Drive Efficiency	Fan Efficiency	Other System	Total System
Belt Driven Forward Curved w/Sheave	Rated (Full)	0.90	0.87	-	0.60	0.70	33%
Belt Driven Forward Curved w/VFD	Rated (Full)	0.90	0.87	0.90	0.60	0.80	34%
Direct Drive EC Backward Curved	Rated (Full)	0.94	-	0.90	0.75	-	63%
Belt Driven Forward Curved w/Sheave	50% Rated	Not Applicable					
Belt Driven Forward Curved w/VFD	50% Rated	0.75	0.87	0.85	0.60	0.80	27%
Direct Drive EC Backward Curved	50% Rated	0.94	-	0.90	0.75	-	63%

curve plenum system is nearly double the efficiency at 63% wire to air. At 50% rated airflow the belt/sheave is not an option since it is not capable of operating at half airflow, however the belt drive VFD results in only 27% efficiency and the EC plenum system maintains its over double efficiency at 63% wire to air efficiency.

EC Plenum Fan Savings in the Building Models

The real proof of efficiency is in annual operating costs of a building. Table 2 shows a Trace* analysis using building energy modeling where a detailed simulation is conducted to provide realistic operating costs for commercial buildings. In actual application you can see the dramatic operating savings. Here the 40 ton load building is a midrise office building in Chicago with four 10 ton water source rooftop units. The three blower alternative options are:

- **Baseline:** Belt/Sheave FC is defined as a forward curve blower belt driven with variable sheaves by a 3600 rpm induction motor.
- **Alt 1:** VFD belt FC is defined as a forward curve blower belt driven with a VFD on a 3600 rpm induction motor.
- **Alt 2:** EC backward curve plenum is defined as a backward curve blower direct driven by an integrated permanent magnet motor with integral drive.

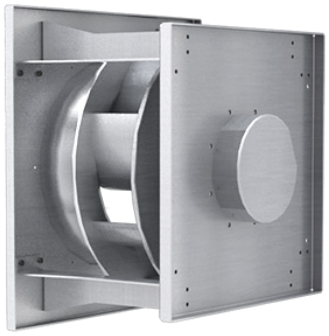
Table 2. Annual operating cost simulation 40 ton midrise office building in Chicago

	Baseline	Alt 1	Alt 2
	Belt/ Sheave FC	VFD Belt FC	EC BC Plenum
WSHP Clg [kWh]]	47735	47678	46524
WSHP Htg [kWh]	14732	14780	15286
Tower and Equipment [kWh]	14997	14993	14906
WSHP Rooftop Fan 1 [kWh]	4463	3433	1433
WSHP Rooftop Fan 2 [kWh]	4781	3602	1504
WSHP Rooftop Fan 3 [kWh]	4032	2848	1201
WSHP Rooftop Fan 4 [kWh]	4371	3230	1364
Total Electrical [kWh]	95112	90565	82218
Total Annual cost [$]	$10,462	$9,962	$9,044
Annual Savings [$]	-	$500	$1,418
Annual Savings [$/ton]	-	$13	$35

Based upon:
Midrise building with 40 ton load in Chicago, IL
Four 10 ton WSHP rooftop units with same refrigerant efficiency
Electric Rates of $0.11 per kWh

*Trace is a registered trademark of Trane.

The WaterFurnace Integrated Electronically Commutated Plenum Fan Solution



Integrated EC Plenum Fan Features

Recent improvements in the EC plenum fan have resulted in a very compact efficient design.

1. 2 in. wg. external static capability
2. High efficiency thru range of up to 900-4500 rpm
3. Heavy gauge welded aluminum or molded composite vanes
4. Factory balanced wheel results in quiet and low vibration operation
5. Electronically commutated permanent magnet external rotor motor
6. Integrated EC drive controller with power factor correction
7. ModBus RS-485 communication
8. Heavy gauge mounting frame

Integrated EC Plenum Fan Benefits

Easier Specification: With an integrated solution, the engineer no longer needs to worry about ensuring the fans and VFD's work together. The EC plenum fans are optimized and airflow is completely flexible providing practically any airflow at any static up to 2" without the use of belts or sheaves. With software selectable fan speeds, setup is easy in the field. This means getting the correct airflow the first time. The compact design allows tighter cabinets that fit into smaller legacy replacement applications but at 21st century efficiencies. Recent studies for ASHRAE 90.1 have shown that variable sheave blower systems are rarely operating at the desired point. This has led to some code authorities such as California Title 24 to require VFD's on all HVAC units and the elimination of all variable sheave designs.

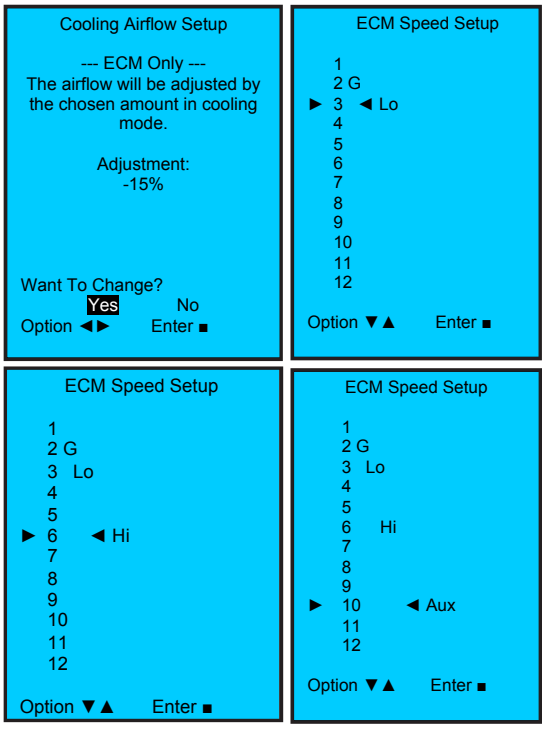
Faster Installations: The integrated fan motor and drive means no belts or sheaves to tension or adjust. With software selectable fan speeds, setup is easy in the field. This means getting the correct airflow the first time. Fan speeds can be field selectable airflow using a hand-held device or a DDC network connection for adjustments.

Better Reliability: The backward curve design includes a welded heavy gauge aluminum or molded composite wheel for long term stability and the wheel is factory balanced for quiet, vibration free, operation. The integrated drive means no belts or sheaves to fail and slip out of adjustment. As mentioned earlier, typical maintenance costs for a belt driven HVAC unit are $100-150 per year per unit and can be eliminated with the direct drive system.

Industry-Leading Technology: Integrated EC plenum fans represent industry leading technology. By communicating directly to the motor, fault codes and temperatures can be monitored by the unit controller providing better fault detection and troubleshooting. Energy usage is also available to be coupled with WaterFurnace industry leading Aurora Controls.

When combining the Aurora controls with the EC plenum fan, the fan now can electronically select fan speeds and they also can be remotely configured as well as locally via software. Figure 6 shows the typical Aurora firmware fan speed selection. Fan speeds can be commanded directly by the controller without relays or jumpers that historically limit flexibility and operation. Also no other base control system allows: **1.** Software configurable airflow that is different in heating and cooling; **2.** Employs separate dehumidification airflow settings in cooling; **3.** Configurable fan speeds that can all be set locally at the unit, in the room at the zone sensor (DDC) and at the building console through DDC commands (DDC).

Fig 6. Easy software selectable Aurora fan speeds



This industry-leading fan control technology allows complete airflow control and flexibility that has not been seen in the industry.

In bringing this fan innovation and industry leading integrated EC Plenum fan technology to several new products, WaterFurnace is well positioned to comply with the requirements of ASHRAE 90.1. The days of single speed fans in HVAC equipment are clearly numbered and integrated EC plenum fans are the obvious solution.

Learn more at ***waterfurnace.com/Commercial***

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