AHU Case Study: Benefits of oval tube coil & EC technology

Traditional AC fan with coil vs. oval tube coil & EC technology.

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Datacenter energy reduction *of up to 50%.*

Combining the latest advancements in fin and tube heat exchanger design and air movement technology.

Introduction

In 2016 Berkeley National Laboratory, under a Department of Energy grant, examined the energy consumption of data centers in the United States between years 2000-2014. The report states that in 2014 over 70 billion KWh was consumed by data centers, roughly 1.8% of all energy used nationally. Based on current trends this is expected to increase to 73 billion KWh by year 2020.

A 2014 survey conducted by the Uptime Institute showed that the average power utilization effectiveness (PUE) of datacenters was 1.7. This means that on average operating the datacenter requires 70% more energy than is utilized by the servers. A majority of this energy is used for cooling.

The goal of this study is to combine the latest advancements in fin and tube heat exchanger design and air movement technology with the goal of demonstrating significant energy reduction for datacenter air handler designs.

Next-Gen Products

The energy consumed by air movers can be reduced in three ways: reducing the total static pressure of the system, improving fan efficiencies, and improving motor efficiencies. The work in this project explores all three options.

Lowering Static Pressure with Oval Tube Coil

The total static pressure is a combination of internal and external static pressure. The external static pressure is a function of the facility for which the air handling unit (AHU) is attached. The internal static pressure is the resistance of air flow internal to the AHU. For most systems, the highest contributor to the internal static pressure is the heat exchanger coil. The legacy coil designs are fin and tube heat exchangers and their designs remain almost unchanged for the past 40 years. For data centers that utilize these heat exchangers in water cooled units or in vapor compression direct expansion applications, Coilmaster has a better solution: oval tube coil.

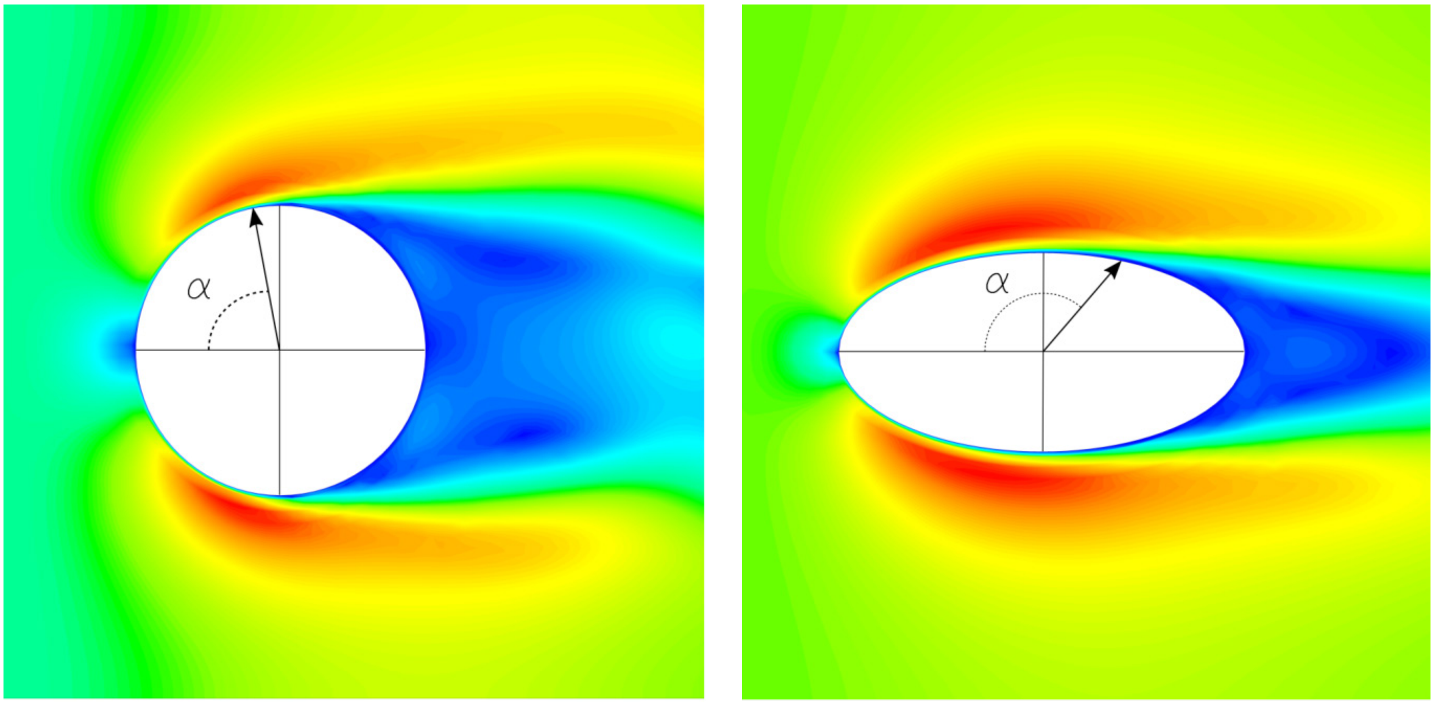


Figure 1. Separation angles for oval versus round tubes.

The airside pressure drop for fin and tube coils is driven by two factors: form drag of the tube, which is a function of the tube shape, and frictional pressure losses for the flow between the fins. It is a reduction in form drag that sets oval tube coil apart from other fin and tube heat exchangers. By altering the shape of the tube from a round profile to an oval profile Coilmaster has significantly reduced the form drag of the tube. Figure 1 shows velocity contours of two tubes with the same free stream velocity. Also shown is the separation angle, α, and how it is impacted by the more aerodynamic profile of the oval tube. For the round tube the separation angle is less than 90 degrees and produces a large wake region which contributes to the large form drag. In contrast the oval tube coil tube produces a separation angle greater than 90 degrees and a much smaller wake region. This is the reason that oval tube coils will produce superior airside pressure drops. Actual pressure drop savings will depend on specific conditions but it is not uncommon to see pressure drop savings up to 50%. In this study the oval tube coil reduced the airside pressure drop in excess of 45%.

Motor:

The motor used in the AHU baseline (industry standard AHU) is a traditional AC motor. When AC motors were developed in the 19th centrury, they were designed to run at one synchronous speed. At synchronous speeds three phase motors can achieve moderately high efficiencies, however, forcing them to go slower, translates into energy wasted and the motor converts this to unwanted heat. The

Increasing fan efficiencies with EC RadiPac air movers.

heat affects the longevity of the motor. The range of speed control is limited for AC motors since the motor was designed to run at a single speed and motor efficiencies can drop rather quickly between ¾ and ½ nominal speed. The AC motor design has remained mostly untouched for the past few decades. This offers an opportunity for significant improvement.

The next generation AHU sample utilizes an ebm-papst EC motor. This modern motor using EC (electronically commutated) technology converts the AC mains power to high voltage DC power. The EC based design starts with very good efficiency but further excels when speed controlled because it maintains high efficiency over broad ranges of speeds. EC motors are the future of Data Center solutions as they continually operate over large ranges of speeds throughout the year and not 'on/off' style of operation (Figure 2).

Air moving wheel - RadiPac Plenum Fan:

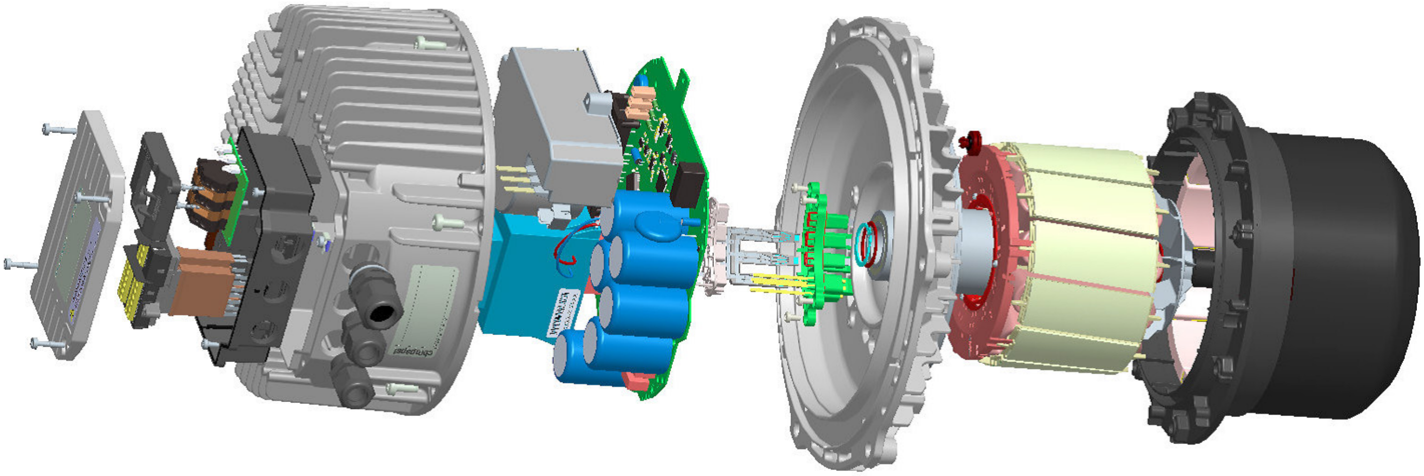
In both cases, a backward curved impeller was used. For the baseline 'standard' AHU, a 2 dimensional blade was used. This design is commonly found in industrial applications. ebm-papst has just introduced a new RadiPac design bringing together new geometries and aerodynamics that considerably increase the aerodynamic efficiency. This results in lower electrical consumption as well as lower acoustics. The air mover was designed specifically for AHU's where the air flow path tends to be in-line axial flow.

The air mover efficiency, commonly referred to as wire-to-air, includes impeller, motor and electronics as a fan 'system'. The impeller, motor and electronics system are all designed/built by ebm-papst and optimized as that system. This holistic design results in overall 'wire to air' efficiency well above 67% as compared to 50% for the AC fan.

Testing

To validate the performance benefits of the aforementioned products two fan-coil air handlers were built for testing. A representative schematic of the air handlers is shown in Figure 3. Each unit consists of a filter, a coil, and a fan. The specifics of each unit, along with the design conditions, can be found in Table 1. The testing was performed by Intertek at the facility in Cortland, NY. The tests were conducted in accordance with ASHRAE standard 37-2009.

Figure 2. EC motor exploded view.



AHU specifications and test conditions.

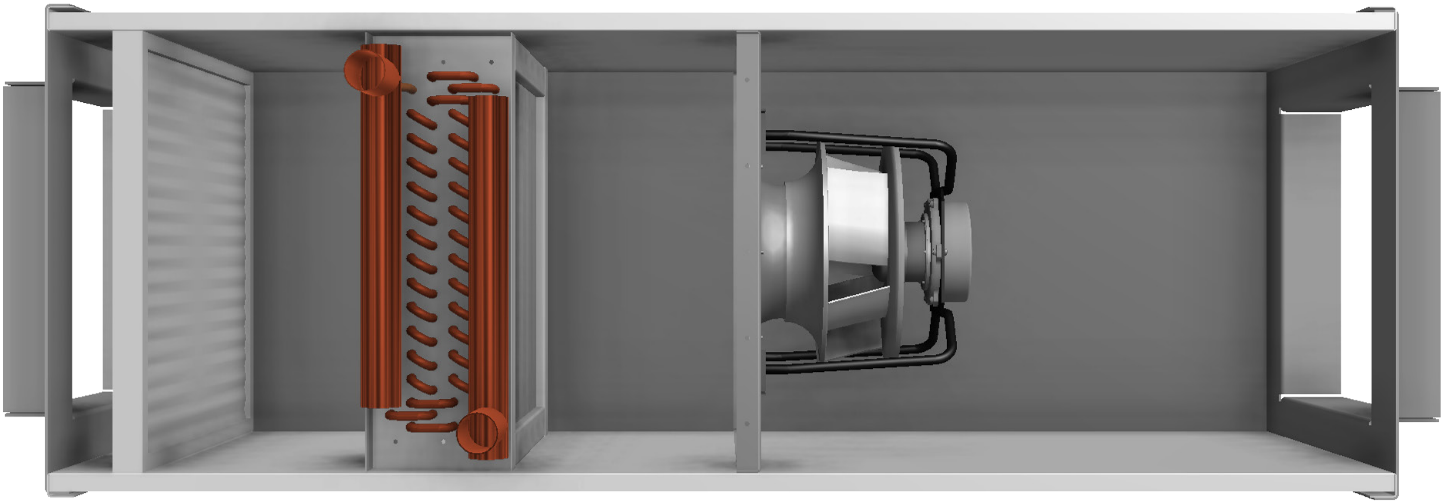


Figure 3. Layout of AHU with fan coil handler.

Table 1. Air handler specifications and test conditions:

Item	AHU-RAC	AHU-OEC
Unit Power	460V–3 phase	460V–3 phase
Motor	**A**C motor with VFD	**E**C motor
Fan Type	Plenum	Plenum
Coil Geometry	Round – Waffle fin	Oval – Raised Lance fin
Filter	2" MERV-A 8-A	2" MERV-A 8-A

Design Conditions	
Ent. Air Dry Bulb/ Wet Bulb	105°F/70°F
Airflow	3500 SCFM
Fluid	Water
Entering Fluid Temp / GPM	70°F / 13.5 GPM
External Static Pressure	0.25 in H2O
Target Fluid Pressure Drop	3.5 Psi
Target Capacity	90,000 Btu/hr

Results & summary of testing.

The results from the testing are summarized in table 2.

Table 2. Air handler specifications and test conditions:

Item	AHU-RAC	AHU-OEC	Percent Difference
Net Capacity	89,420 Btu/hr	92,524 Btu/hr	+3.47%
Fluid Pressure Drop	3.4 Psi	3.8 Psi	+11.8%
Fan Motor Watts	1,583 Watts	744 Watts	-53%
Motor	**A**C motor with VFD	**E**C motor	
Coil Geometry	Round - Waffle fin	Oval - Raised Lance fin	

As highlighted in the table above the AHU-OEC unit achieved a wattage reduction of 53 percent, this is significant. Furthermore, because the heat gain from the motor is less, the net capacity is higher. In fact, it would be possible to reduce the fin density on the oval tube coil to meet the same capacity as the round tube. This reduction would further reduce the airside pressure drop for the oval tube coil which in turn would allow for additional fan watt savings due to a reduction in fan RPM.

Summary

The goal of reducing energy consumption was achieved - the result being a 53 percent reduction. As well, the 53 percent energy savings increased heat rejection performance. Therefore, the true savings would be in excess of this if the net capacity was matched. While the application in this study focused on data centers, the technologies are suitable to many commercial and industrial HVAC applications. We invite you to contact us with your projects to allow us to help you save energy.

Notes.

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