Energy Wheel Performance and Optimization Opportunities for SDVAV AHU in a Hot & Humid Climate

Energy Systems Laboratory

International Conference for Enhanced Building Operations ICEBO

TEXAS A&M ENGINEERING TEES

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Outline

- Introduction
- Case study
- Methods
- Results
- Summary and Recommendations

Introduction

- Energy wheel

The air-to-air rotary energy wheel is used in building HVAC system to recover/reject both sensible and latent heat energy from/to the exhaust airflow. It is a widely-used energy recovery unit. It has advantages and limitations in application.

- Literature Review: research studies on energy wheel

Energy wheel performance testing/prediction: lab/field testing (ASHRAE Standard 84-1991), numerical modeling study to predict energy wheel performance.

- Purpose of this study

To use field-measured data to evaluate an energy wheel performance in a hot & humid climate and identify potential performance improvement opportunities based on current operation sequence for future CC® services.

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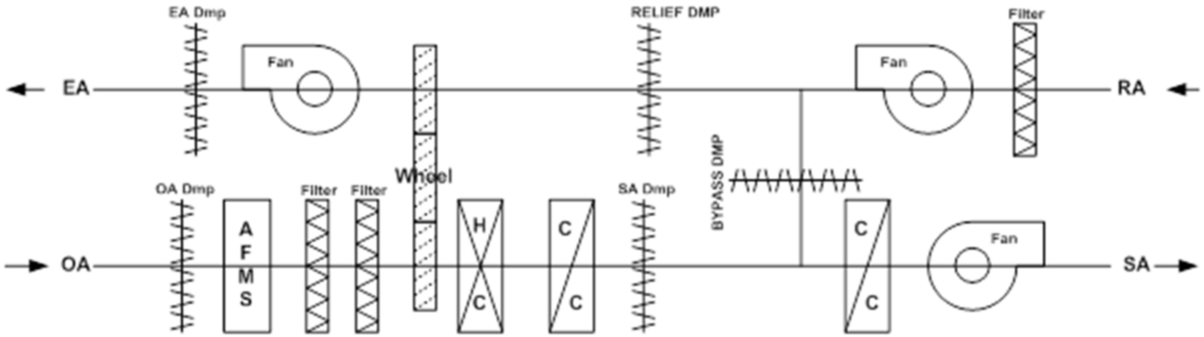
Case Study

- SDVAV AHU configuration



- Energy Wheel Design Info.

Supply Air				Exhaust Air			Total Eff.	Motor HP	Vol/PH/HZ	RPM
CFM	EAT DB/WB	LAT DB/WB	Wheel "H_2O	CFM	EAT DB/WB	Wheel "H_2O				
8,000	97/80	84.1/70.8	0.9	5,125	76.5/64	0.9	95 %	1.0	460/3/60	1725

- Supply and Exhaust Air Flow during Field Study

Supply Airflow, CFM	5,000 ~ 5,200
Exhaust Airflow, CFM	1,400 ~ 1,600

- Energy Wheel Speed Control Sequence

OAT, ºF	35	50	70	85
Wheel VFD SPD, %	100	20	20	100

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Methods

- Field measurements (Fluke thermometer, VELOCICAL ventilation meter)
  - ✓ Entering/leaving air temperature/relative humidity in supply/exhaust side
  - ✓ Pressure drop across the wheel at different VFD speeds

  (Location: mixing chamber bf/af wheel; Lock SA fan and EA fan VFD drives)
- Real-time data trending (24 hrs, every 5 minutes)

  Air dry-bulb temperature, relative humidity
- Energy wheel effectiveness calculation equations (evaluate energy wheel performance)

$$\varepsilon = \frac{Actural\ transfer\ of\ moisture\ or\ energy}{Maximum\ possible\ transfer\ between\ airstreams}$$

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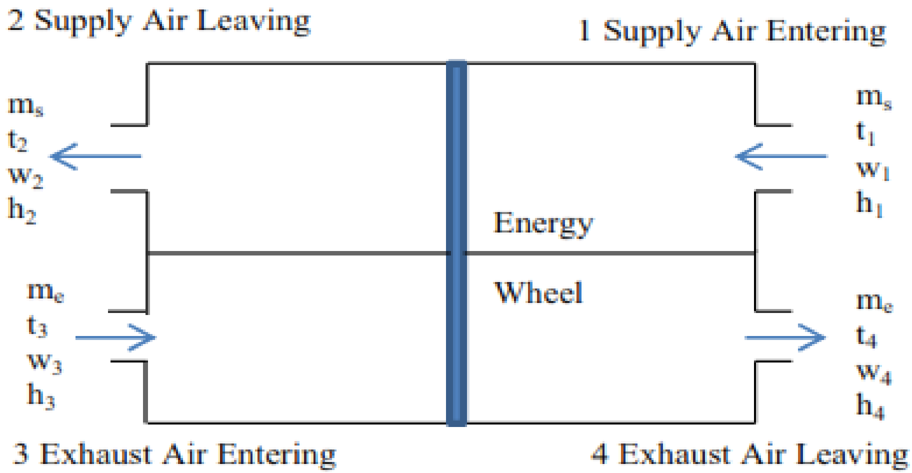

$$\varepsilon_s = \frac{q_s}{q_{s,max}} = \frac{m_s c_{ps}(t_2 - t_1)}{C_{min}(t_3 - t_2)} = \frac{m_e c_{pe}(t_3 - t_4)}{C_{min}(t_3 - t_1)} \text{ (Sensible Effectiveness)}$$

$$\varepsilon_L = \frac{m_s(w_1 - w_2)}{m_{min}(w_1 - w_3)} = \frac{m_e(w_4 - w_3)}{m_{min}(w_1 - w_3)} \text{ (Latent Effectiveness)}$$

$$\varepsilon_t = \frac{m_s(h_1 - h_2)}{m_{min}(h_1 - h_3)} = \frac{m_e(h_4 - h_3)}{m_{min}(h_1 - h_3)} \text{ (Total Effectiveness)}$$

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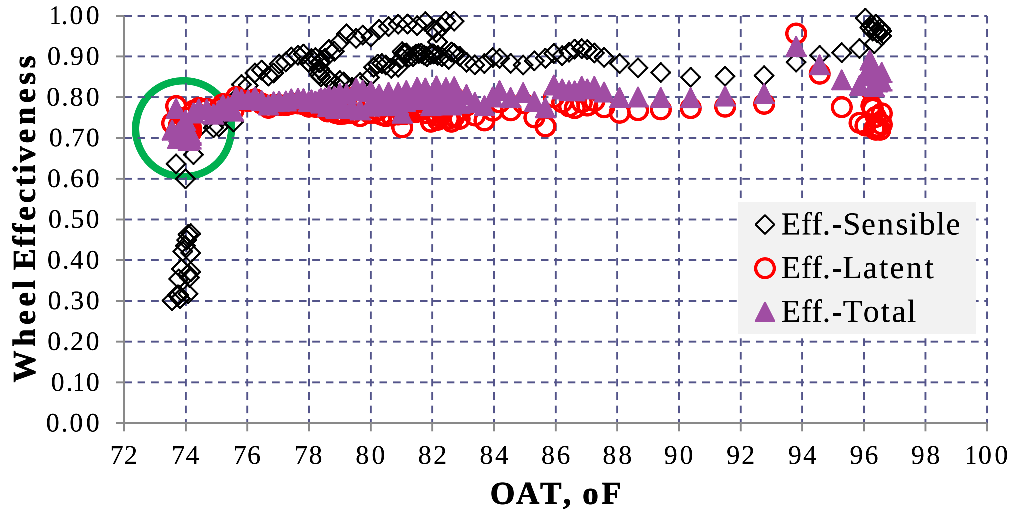
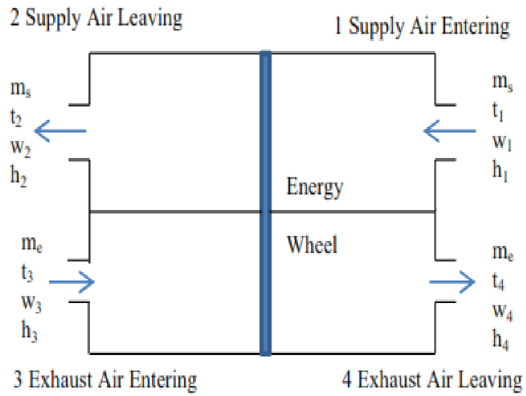
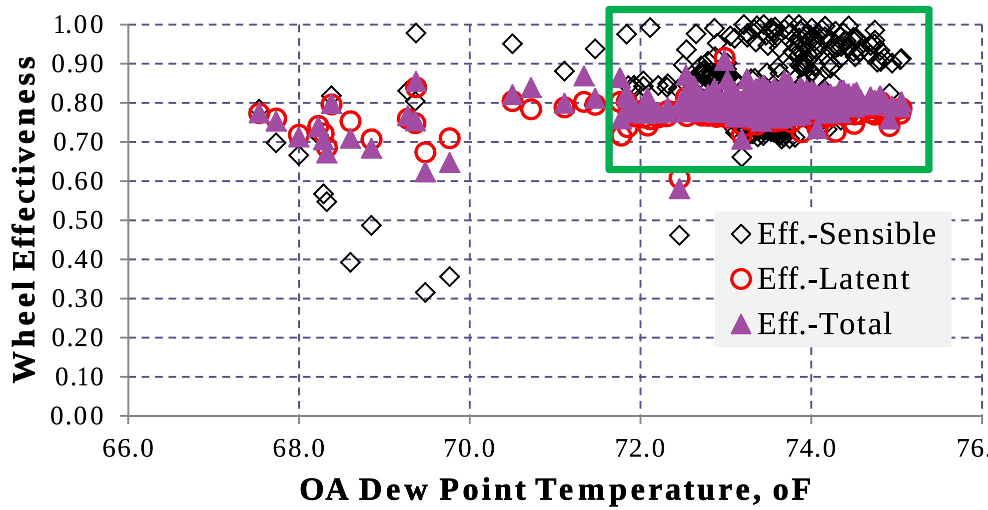
Results (trending data)

- Effectiveness vs. OA dry-bulb temperature



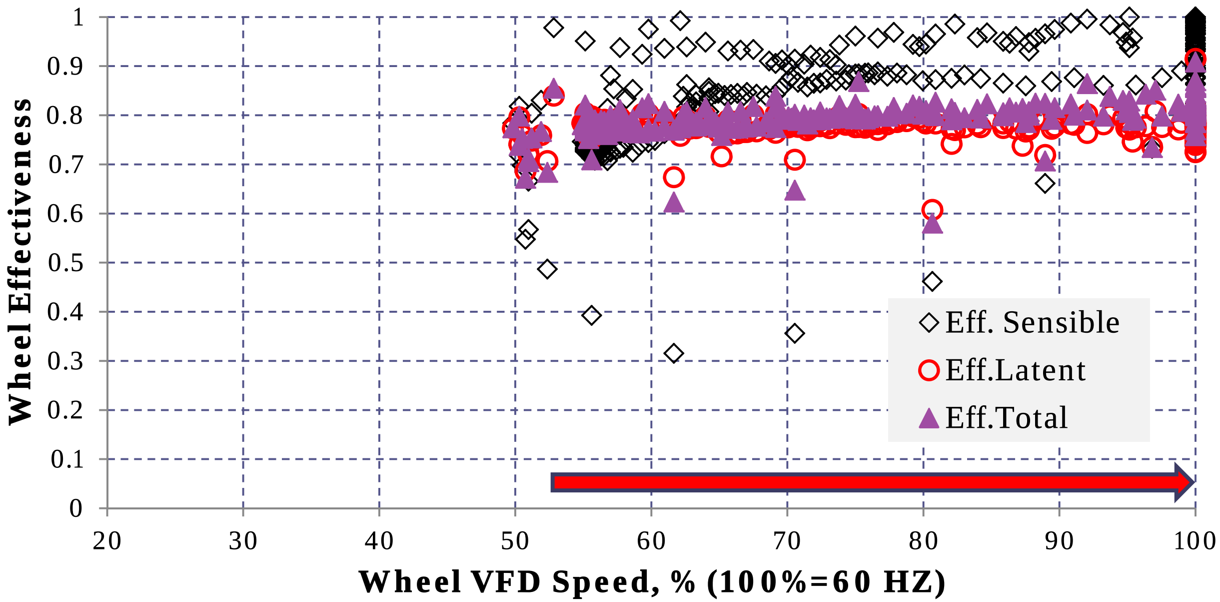


- Effectiveness vs. OA humidity (DWP)



Results (Cont.)

- Effectiveness vs. Wheel VFD Speed



Results (field measurements)

- AHU Power Recovery at Different Wheel VFD Speeds (Field measurements)

WHL SPD, %	Wheel Pressure Drop, inch WC [1]	WHL electrical power consumption, kw	Wheel power recovery, kw[2]	Supply fan power consumption, kw	Net power recovery, kw
20	0.65	(0.0039)	11.74	(0.84)	10.90
60	0.62	(0.168)	10.98	(0.82)	9.99
80	0.57	(0.434)	15.24	(0.67)	14.14
100	0.64	(0.746)	16.39	(0.84)	14.80

[1] Supply air-side pressure drop.

[2] Central plant efficiency used here: 0.85 kw/ton

Summary

- The total effectiveness calculated from real-time trending data is lower than the design value (80 % vs. 95 %).
- The performance of the wheel declines when OA dry-bulb temperature is closed to space temperature (exhaust air entering temperature).
- The wheel speed has not significant influence on the studied wheel effectiveness.
- The application of the energy wheel under hot and humid weather recovers energy.

Recommendations

- The by-pass damper in supply side of the AHU with the energy wheel installed should be available to implement economizer mode when the wheel is off (reduce fan power consumption from overcoming pressure drop across the wheel).
- The OA dry-bulb temperature based wheel speed control should be optimized according to weather condition.

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Thank You!