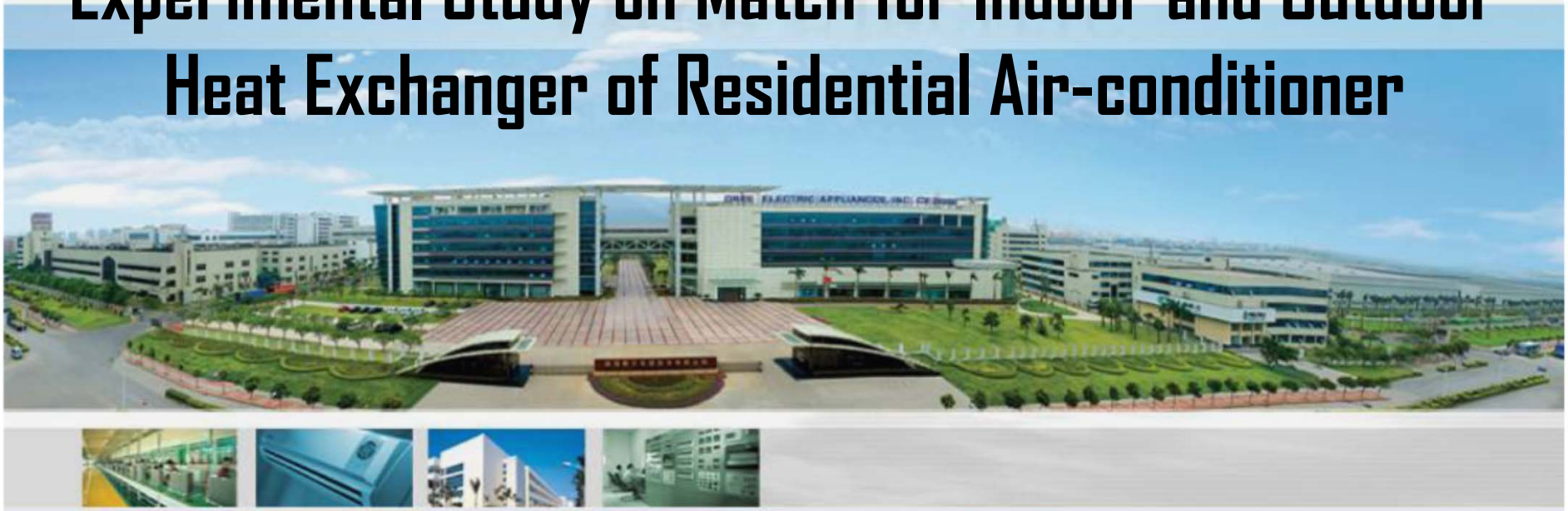
The 15th International Refrigeration and Air Conditioning Conference at Purdue, July 14-17, 2014

Experimental Study on Match for Indoor and Outdoor Heat Exchanger of Residential Air-conditioner



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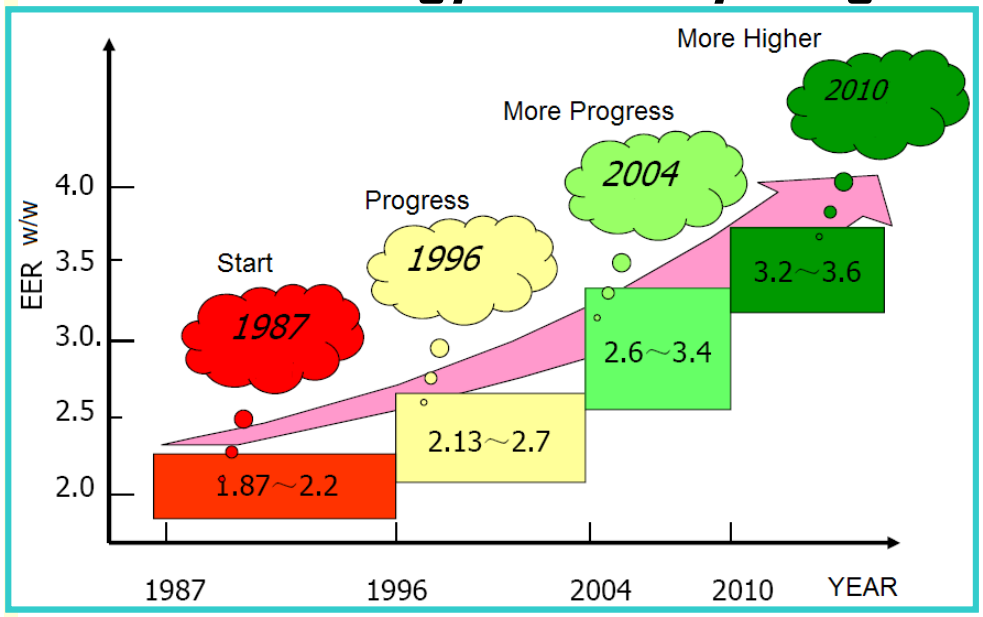
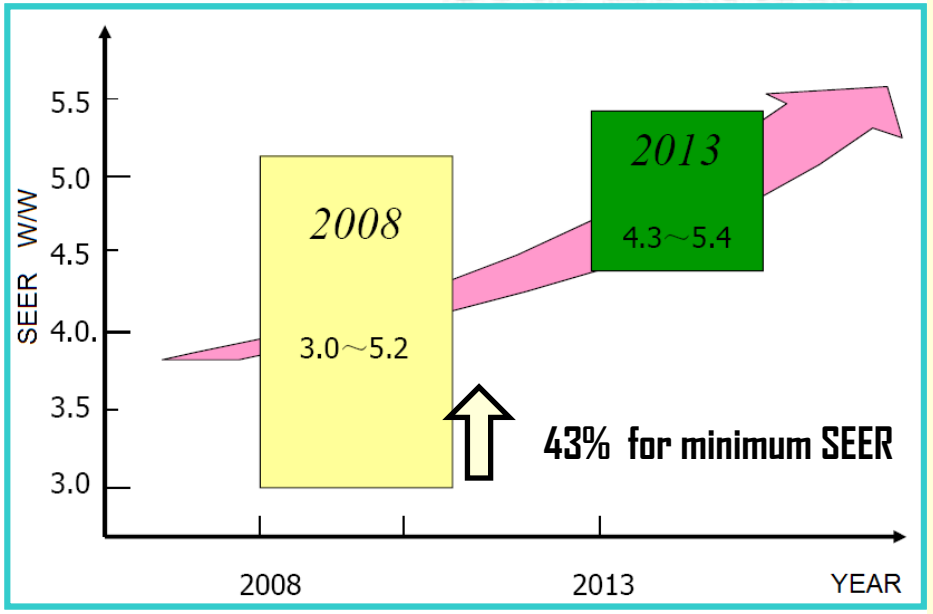
Contents

- Background
- Experimental Setup
- Experimental Results
- Conclusions

Background

Chinese Energy Efficiency Progress about Residential Air-conditioner





Constant speed AC

Variable speed AC

EER: Cooling Energy Efficiency Ratio

For Cooling Capacity < 4500W

Background

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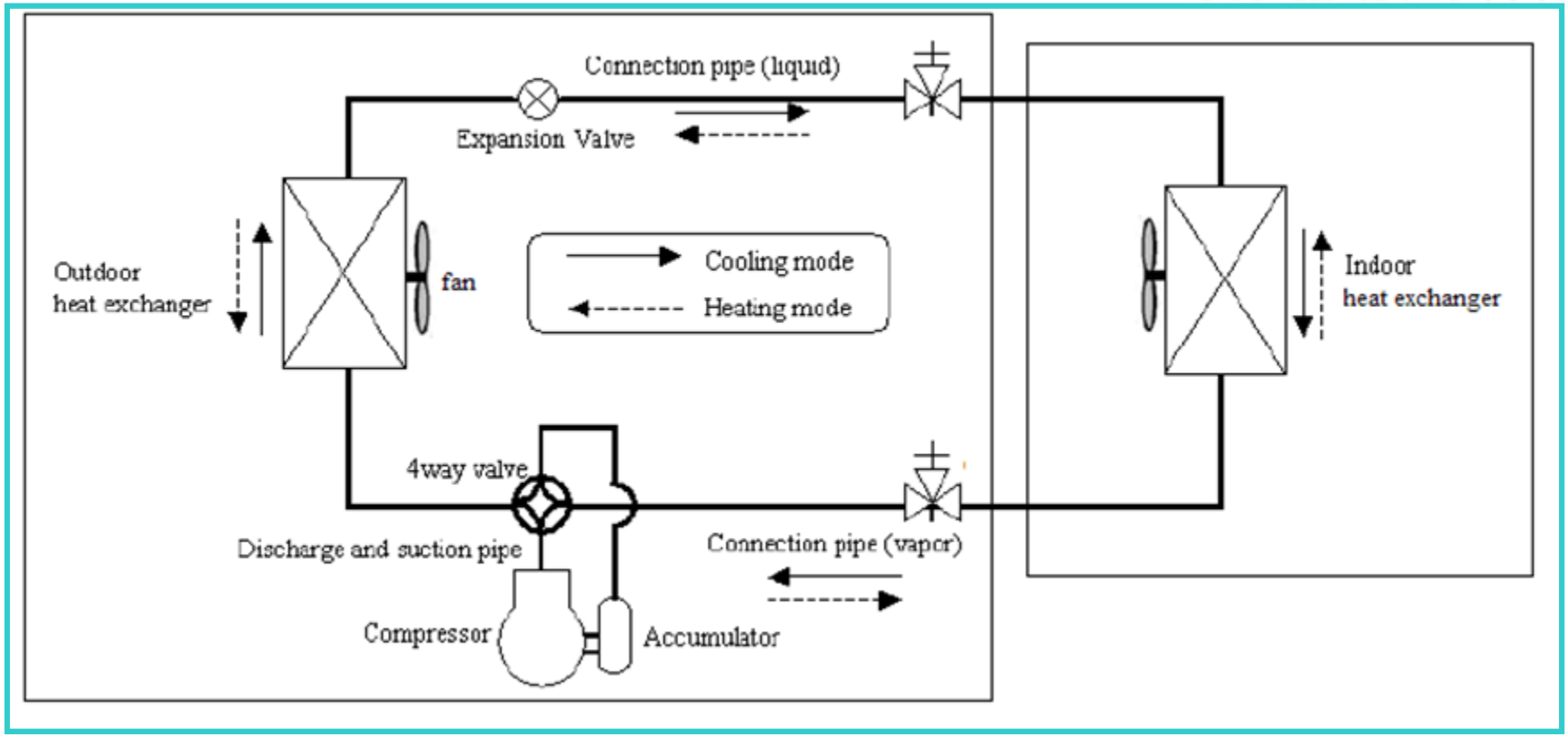

Is always effective to increase indoor unit and outdoor unit?

Is there existing proper match for indoor unit and outdoor unit?

Experimental Setup

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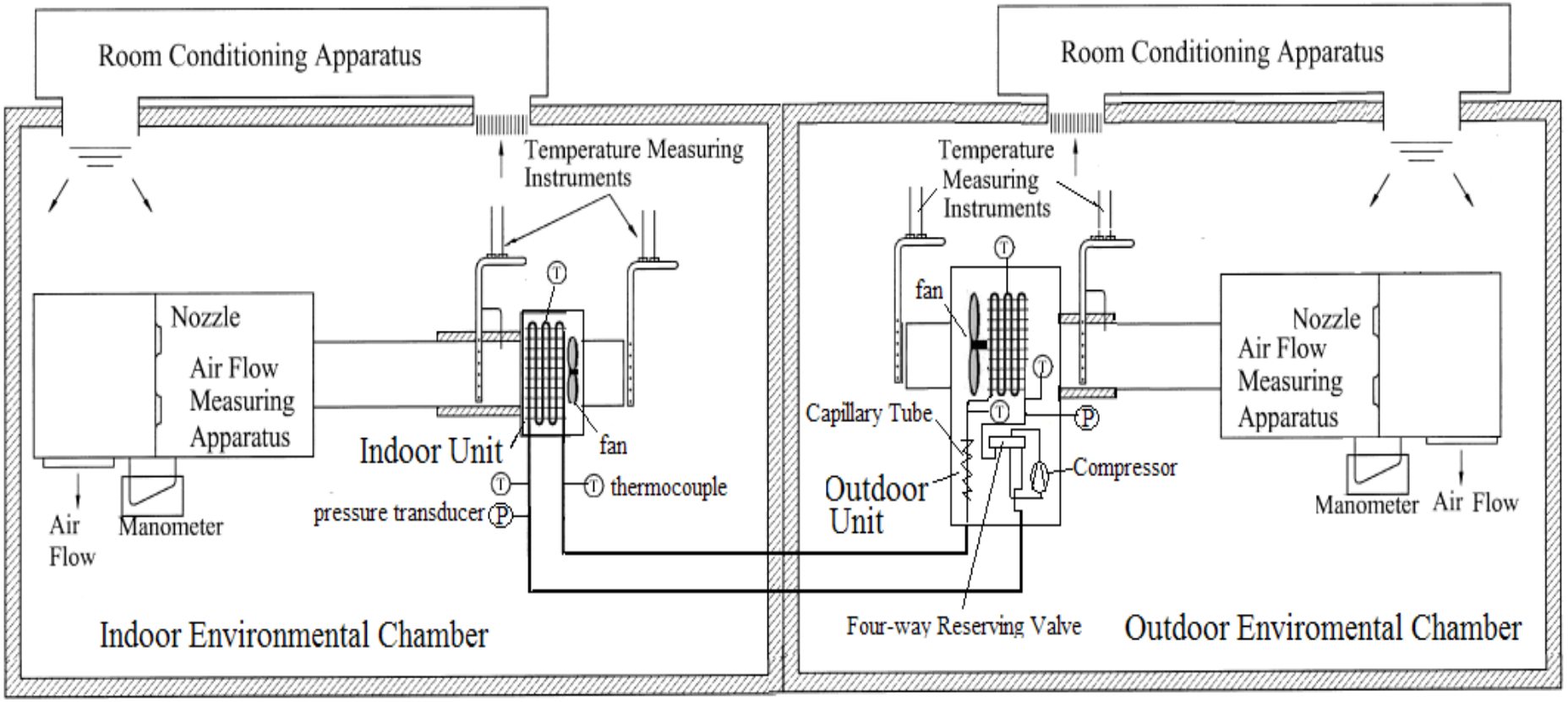
Schematic of Experimental Setup ➡ The air enthalpy-difference method proposed based on Chinese national standard GB/T 7725-2004



Experimental Setup

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Experimental Object

3 AC ----3 Indoor units separately match with the same outdoor unit

Unit	Name	Relative Heat Transfer Area
Indoor	A	0.23
Indoor	B	0.33
Indoor	C	0.37
Outdoor	D	1

- The outdoor unit: Used in 3500W constant speed heat pump air conditioner using R22 as a working fluid
- The HX of the three indoor units and outdoor unit are fin-and- tube type HX
- The optimal refrigerant charge for 3AC: separately determined based on the maximum energy efficiency in cooling mode
- Working conditions
  - ✓ Cooling mode: Indoor 27 °C/19°C, Outdoor 35 °C/24°C
  - ✓ Heating mode: Indoor 20 °C/15°C, Outdoor 7 °C/6°C

Experimental Results

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Experimental investigation

- The cooling performance and heating performance of the 3AC were tested under variable indoor unit air flow rate.
- The variable outdoor unit air flow rate was only performed for the C indoor unit system.

Experimental Results

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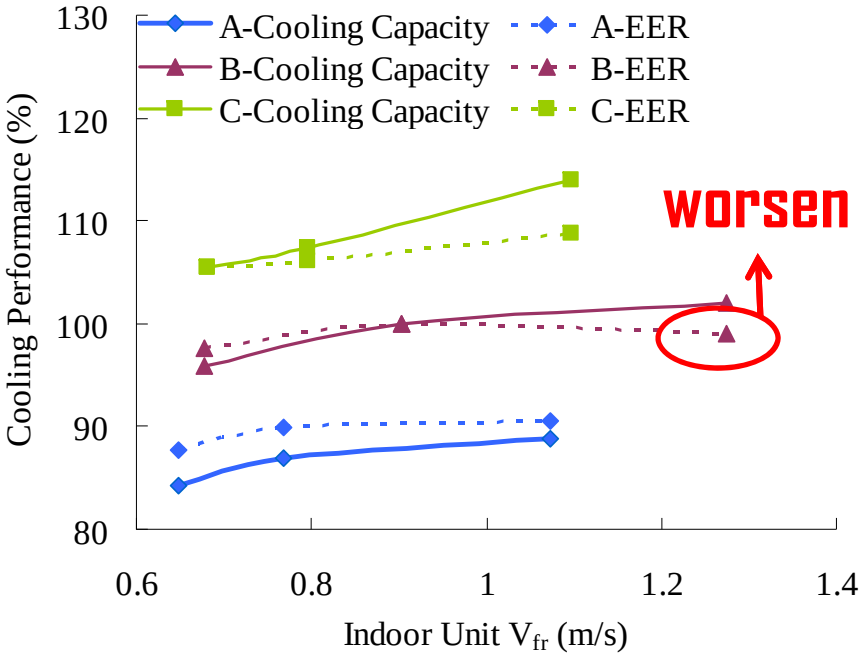
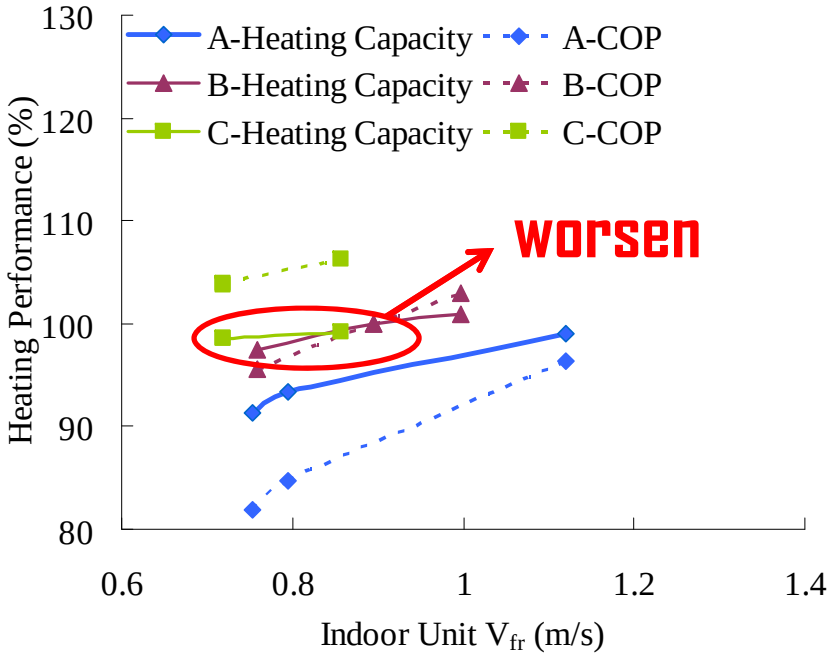
Effects of indoor unit HX area and air flow rate





- The maximum increase with the indoor unit (including increase of HX area and air flow rate): Cooling capacity 35.3%, EER 24%; Heating capacity 10.4% , COP 29.9%
- The effect of HX area was more dominant than the air flow rate on system performance.
- The increase of indoor unit was more advantageous for cooling mode than heating mode, but when the indoor unit was continuously increased, the system performance would be worsen.

Experimental Results

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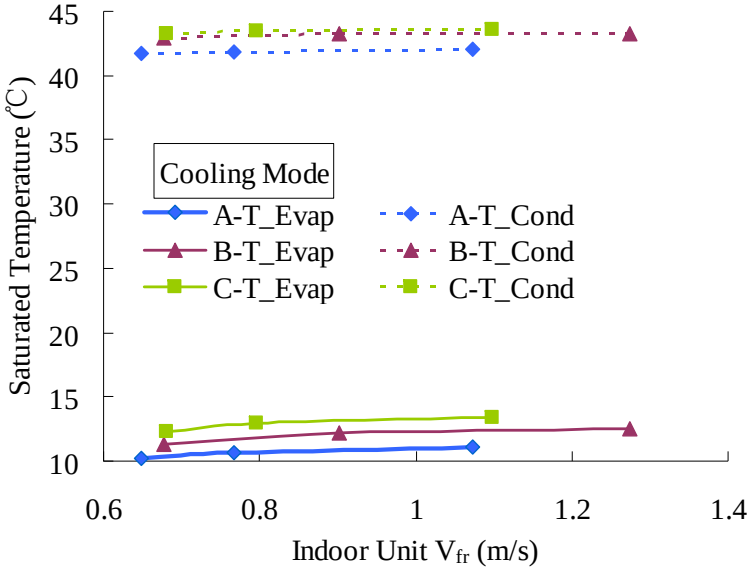
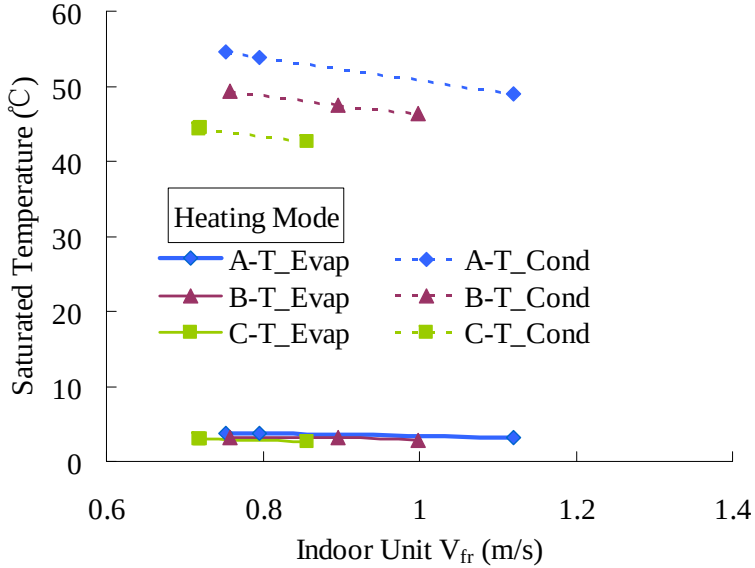
Effects of indoor unit HX area and air flow rate

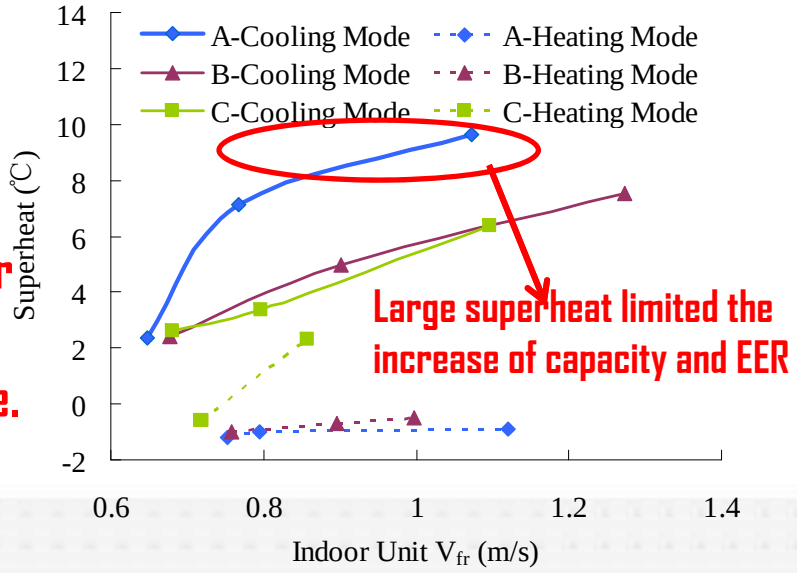




☐ High and low Pressure ratio

✓ Cooling mode: slowly decrease----fan consuming work will be dominant when increasing air flow rate, so EER will be soon no more increase or even decrease.

✓ Heating mode: significantly decrease----Compressor consuming work will be decrease and dominant when increasing air flow rate, so COP had an evident increase.



Experimental Results

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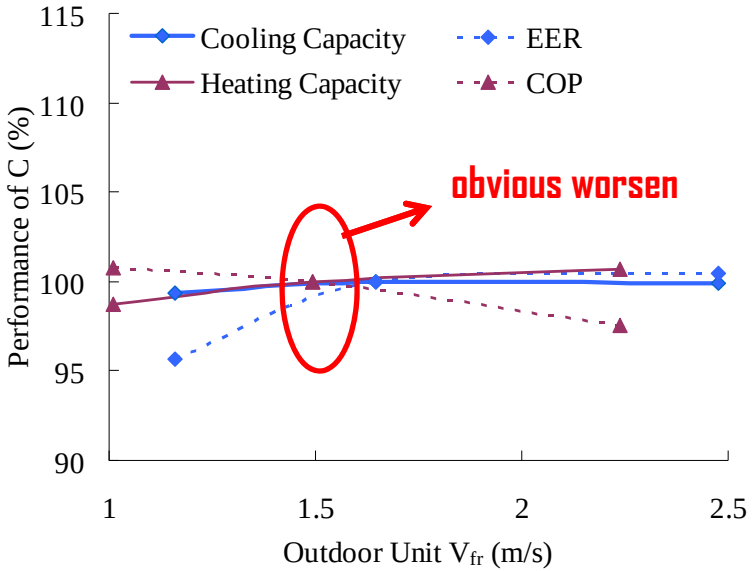
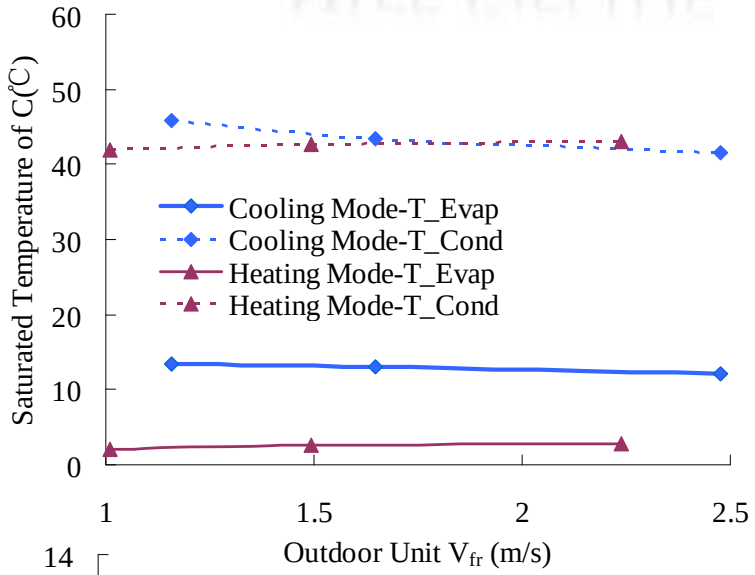
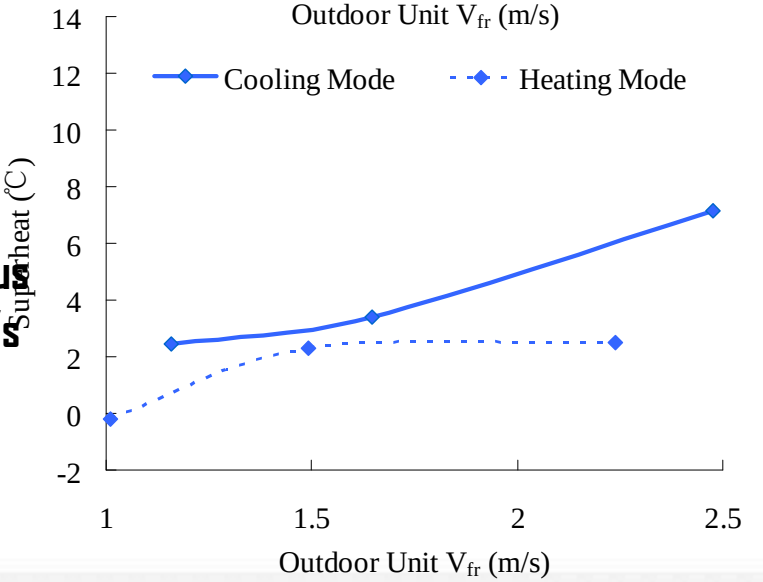
Effects of Outdoor unit air flow rate







- Mainly influenced the system EER or COP
- Excessive or insufficient air flow rate can cause the degradation of the system performance.
- The effect of the outdoor unit air flow rate not too obvious
- The average air velocity should not be higher than 1.6m/s especially under heating condition.

Conclusions

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- The system cooling and heating performances had an evident increase with the increase of indoor unit, but not too obvious with the increase of outdoor unit.
- The match for indoor unit and outdoor unit must considered both the air flow rate and HX area. The relative higher air flow rate should match with relative small HX. The larger outdoor unit should also match with relative larger indoor unit.
- With a rise of indoor unit, the increase of cooling capacity was more obvious than EER, while the increase of COP was more obvious than heating capacity. The system performance improvement with indoor unit air flow rate was more significant for smaller heat transfer area indoor unit system especially in the heating mode. The outdoor unit air flow rate mainly influenced the system EER or COP compared to the capacity, and excessive or insufficient air flow rate can cause the degradation of the system performance.
- Existing appropriate match with indoor unit and outdoor unit air flow rate and HX area to obtain the overall performance. In this study, the average air velocity should not be higher than 1.2m/s for indoor unit and 1.6m/s for outdoor unit, and the heat transfer area ratio of indoor unit and outdoor unit between 0.33 and 0.37 would be attained better overall performance.

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