Investigation of Rotary Compressor Heat Dissipation Model

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OUTLINE

Traditional method

Adiabatic model → Discharge temperature Td

Test → measured temperature Tdm

Td>Tdm

OUTLINE

1 BACKGROUND

2 COMPRESSOR MODEL

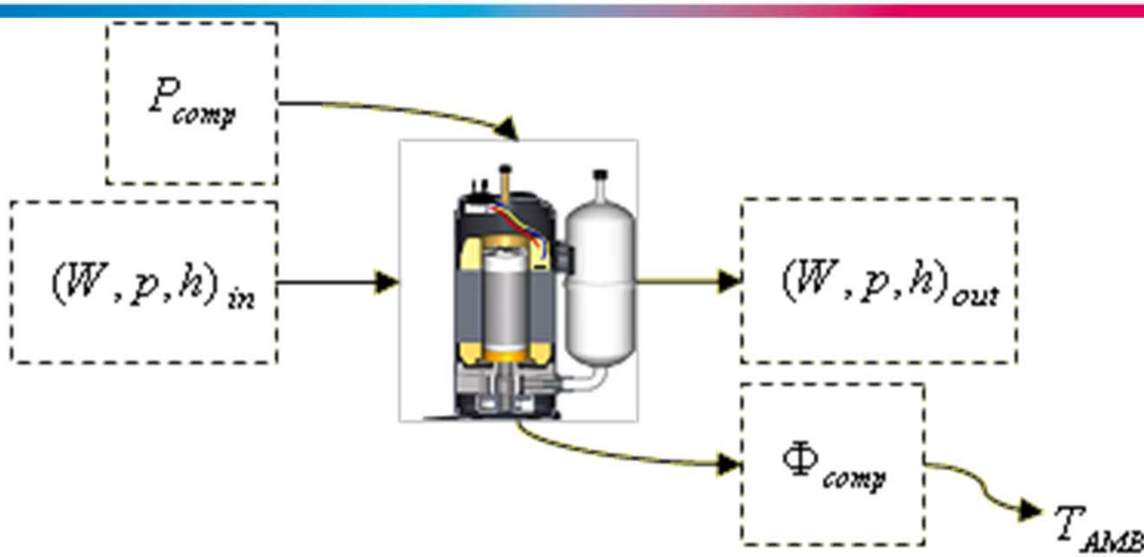
3 UNCERTAINTY ANALYSIS

4 HEAT DISSIPATION MODEL

5 COMPARISON RESULT

6 CONCLUSION

COMPRESSOR MODEL



academic equation

Conservation of Mass: $$m_{out} = m_{in} (= m_{comp})$$

Conservation of Energy: $$m_{in} h_{in} + P_{comp} - m_{out} h_{out} - \Phi_{comp} = 0$$

$$h = f(p, T)$$

OUTLINE

UNCERTAINTY ANALYSIS

1HP constant speed rotary compressor

Condition： Te=7.2℃，Tc=54.4 ℃， Ts=18.3 ℃， Td=97.2 ℃
Mass Flow: m=63.4kg/h，Input Power: P=936w

	Variable ±Uncertainty	% of uncertainty
heat dissipation/W	Φ=163.5±4.56	
input power/W	P=936±0.936	4.21%
discharge pressure/KPa	Pd=2147+5.368	5.56%
suction pressure/KPa	Ps=625±1.563	1.29%
discharge temp./℃	Td=97.2±0.2	48.49%
suction temp./℃	Ts=18.3±0.2	33.99%
mass flow kg/h	m=63.4±0.095	6.46%

There is 4.56W uncertainty of heat dissipation, about 2.8% of the whole dissipation. The discharge temperature makes the biggest contribution.

UNCERTAINTY ANALYSIS

冷暖伴终生 HICHLY 海立

1.5HP varible speed rotary compressor

Condition： Te=17.8℃，Tc=40.6 ℃， Ts=19.7 ℃， Td=53.5 ℃
Mass Flow: m=56kg/h，Input Power: P=318.5W

	Variable±Uncertainty	% of uncertainty
heat dissipation/W	Φ=28.52±6.66	
input power/W	P=318.55±0.3185	0.23%
discharge pressure/KPa	Pd=2445±6.113	10.37%
suction pressure/KPa	Ps=1352±3.38	5.53%
discharge temp./℃	Td=53.5±0.2	46.35%
suction temp./℃	Ts=19.7±0.2	37.10%
mass flow kg/h	m=56±0.084	0.43%

There is 6.66W uncertainty of heat dissipation, about 23% of the whole dissipation. The discharge temperature makes the biggest contribution.

OUTLINE

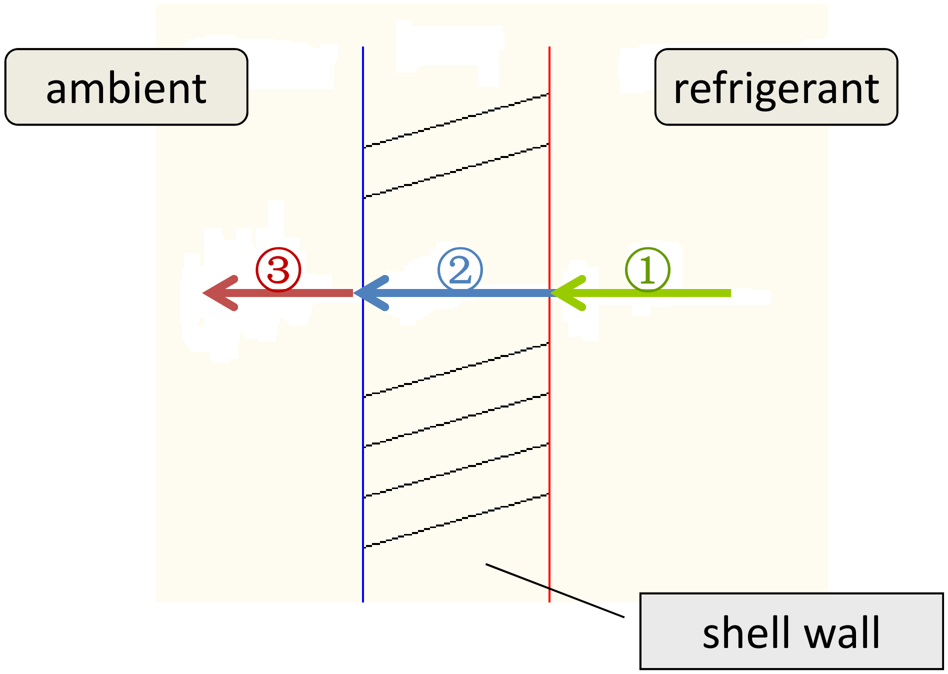
HEAT DISSIPATION MODEL

① heat transfer from the refrigerant to shell wall inside;

② heat transfer from shell wall inside to shell wall outside ;

③ heat transfer from shell wall outside to ambient air.

Heat flow Φ of each stage should be the same due to the steady state process.



HEAT DISSIPATION MODEL

The heat transfer coefficient k can be expressed:

$$\frac{1}{k} = \frac{1}{h_{ref}} + \frac{\delta}{\lambda} + \frac{1}{h_{amb}}$$

In the heat dispersion model, the air-side heat transfer includes convective heat transfer and heat radiation：

$$\Phi = \Phi_c + \Phi_r$$

Convective heat transfer

Convective heat transfer can be described as following :

$$\Phi_c = h \cdot A \cdot (T_d - T_{amb})$$

Heat transfer coefficient can be calculated as following :

$$h = N\mathbf{u} \times \frac{\lambda}{d}$$

Forced convective heat transfer

The forced convection is described :

$$Nu = C\,\mathrm{Re}^{n}\,\mathrm{Pr}^{1/3}$$

Pr is the Prandtl number, Renault number is listed :

$$Re = \frac{ud}{\upsilon}$$

Re is about 10,000 → C=0.193，n=0.618

Natural convective heat transfer

The empirical correlation of natural convection is shown as following:

$$Nu_m = C(Gr\Pr)_m^n$$

Here, Gr is the Grashof number .C=0.59， n=0.25.

Heat radiation

Environment is assumed as the black body, and the compressor is a gray body
emissivity ε and absorptivity α ratio of paint is 0.95.
The actual heat radiation is shown:

$$\Phi_r = A(E_1 - E_2)$$

E_1 is heat radiation from compressor to environment :

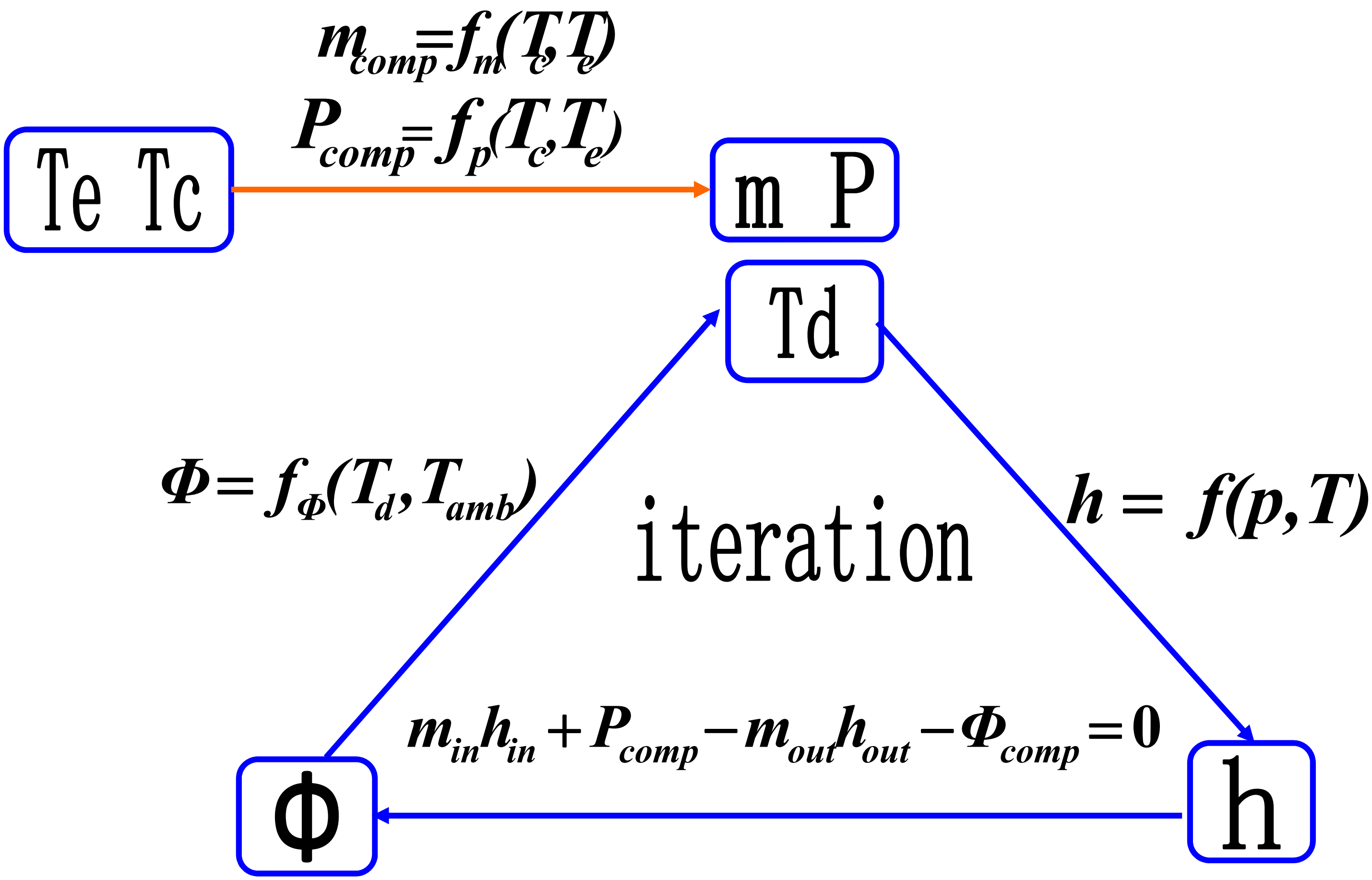
$$E_1 = \varepsilon \cdot \sigma T_d^4$$

E_2 is heat radiation from environment to compressor：

$$E_2 = \alpha \cdot \sigma T_{amb}^4$$

$$\sigma = 5.67 \times 10^{-8}$$

APPLICATION

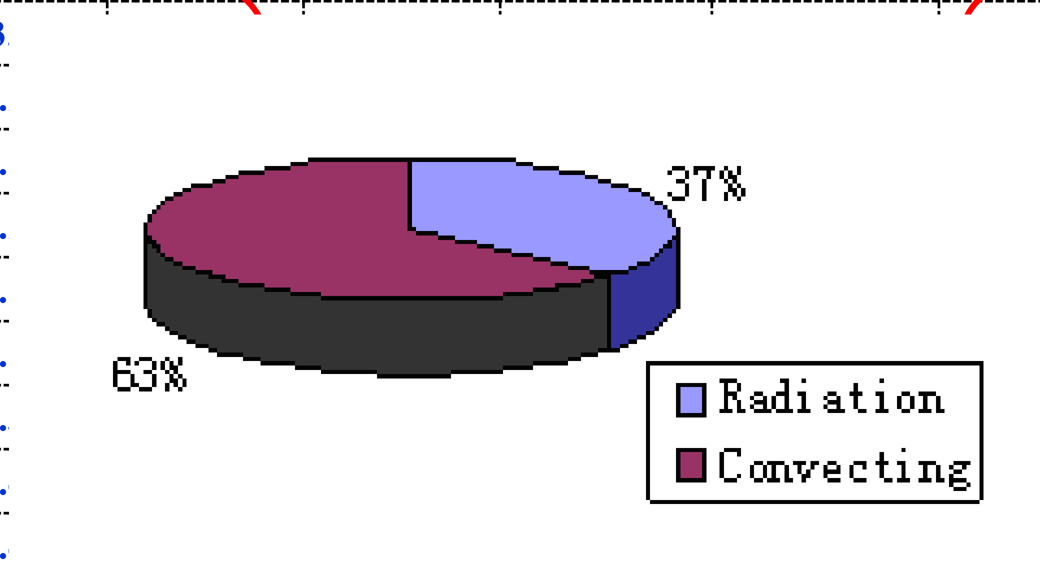


OUTLINE

COMPARISON RESULT

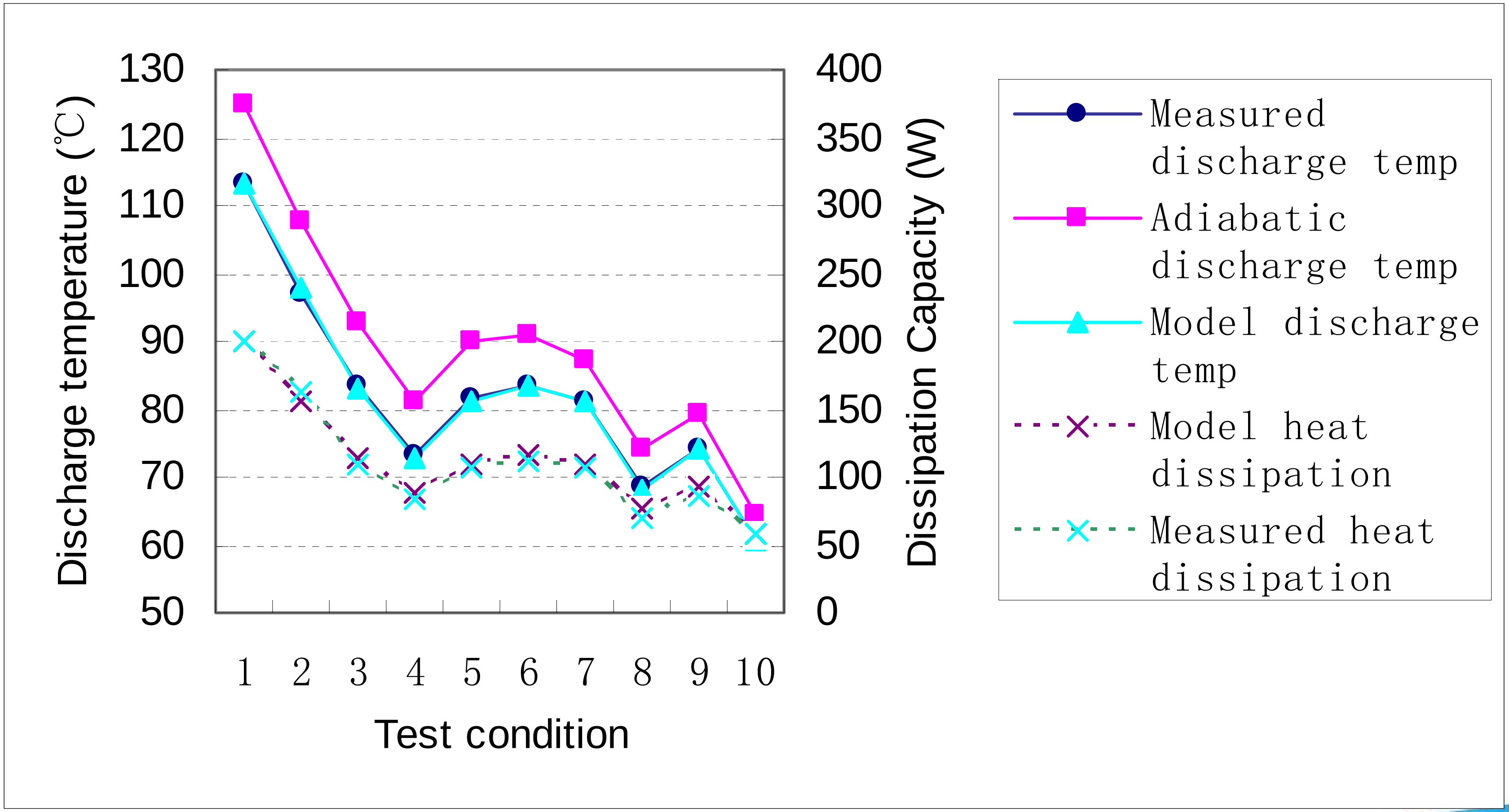
1.5HP constant speed rotary compressor data in forced-convection

Te(℃)	Tc(℃)	Measured discharge temp (℃)	Model discharge temp (℃)	Adiabatic discharge temp (℃)	Radiation (W)	Forced-convection heat transfer(W)	Model heat dissipation(W)	Measured heat dissipation(W)
10.4	65	113.						201
7.2	54.4	97.						163
-0.4	40	83.						110
-4	30	73.						84
1.5	40	81.						106
7.2	45	83.						112
10	45	81.						106
1.5	30	68.						70
10	40	74.						87
10	30	60.8	60.8	64.2	20	38	58	58



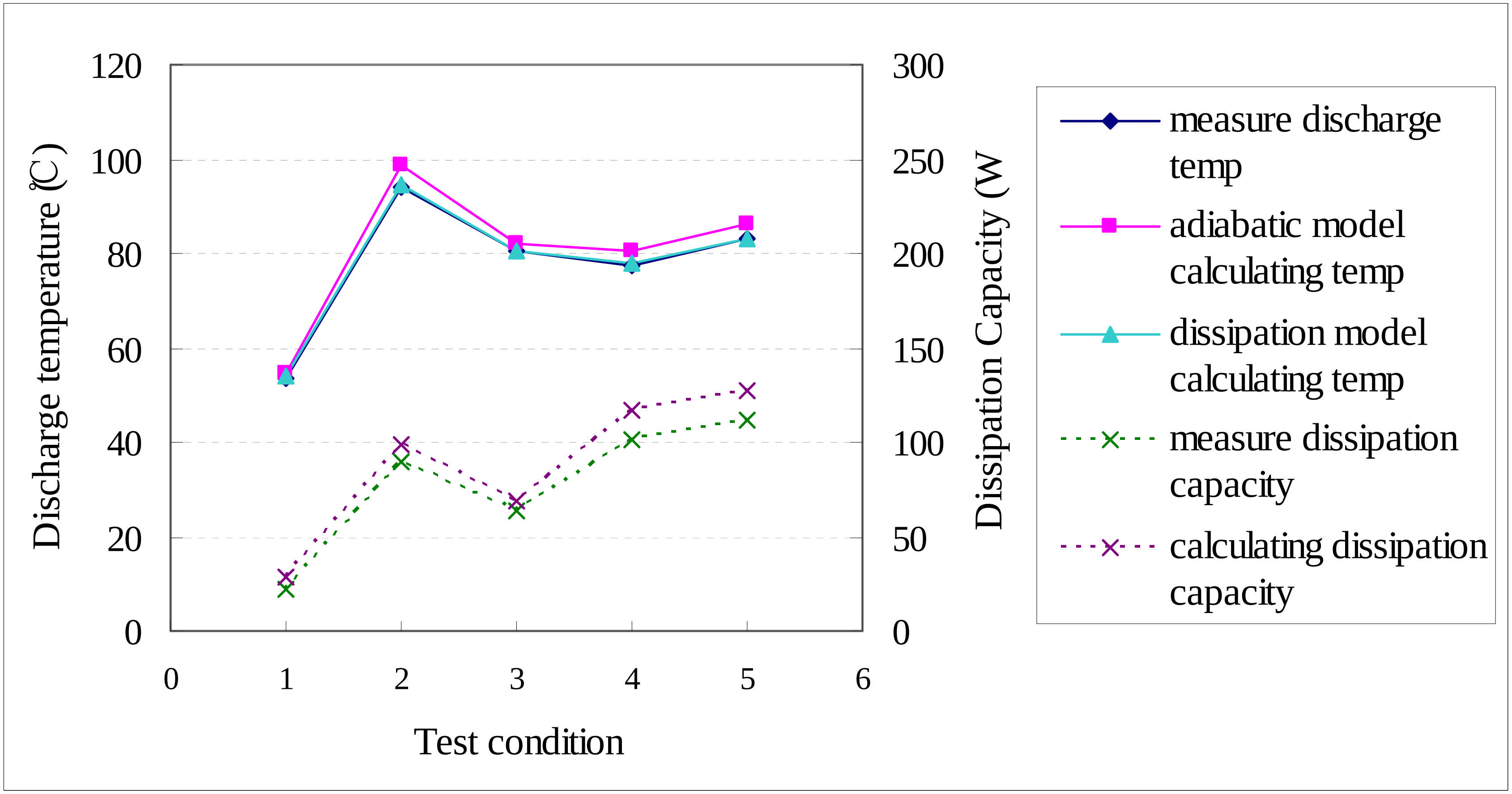
COMPARISON RESULT

- **Comparison in discharge temperature and heat dissipation of 1.5HP constant speed compressor in forced-convection.**



COMPARISON RESULT

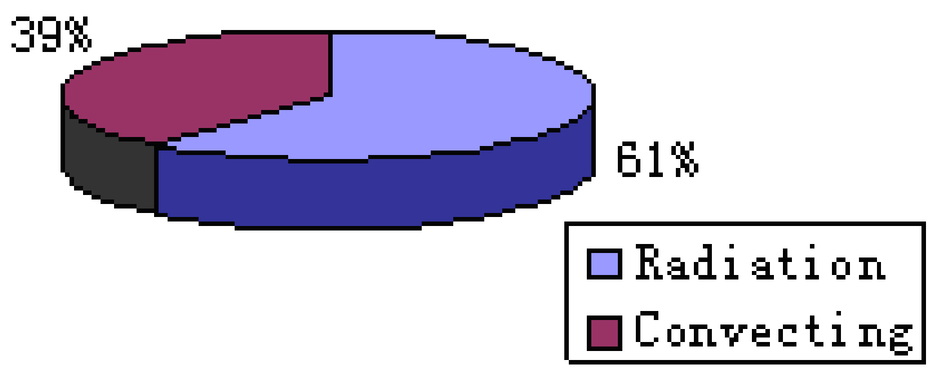
- **Comparison in discharge temperature and heat dissipation of 1.5HP variable speed compressor in forced-convection**



COMPARISON RESULT

1.5HP constant speed rotary compressor data in natural-convection

Te(℃)	Tc(℃)	Measured discharge temp (℃)	Model discharge temp （℃）	Adiabatic discharge temp (℃)	Radiation(W)	Natural-convection heat transfer(W)	Model heat dissipation(W)
10.4	65	113.1	116.7	124.9	83	56	139
7.2	54.4					42	105
-0.4	40					30	76
-4	30					23	57
1.5	40					29	72
7.2	45					30	75
10	45					28	70
1.5	30	68.4	70.2	74	29	19	48
10	40	74.4	76.1	79.5	35	23	58
10	30	60.8	62.2	64.2	21	13	35



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CONCLUSION

- **Heat dissipation model**
  - **forced-convection**
  - **natural-convection**
  - **heat radiation**

- **The discharge temperature model deflection is less than 4 ℃, the average heat dissipating error is below 15%,**

- **Calculate an accurate value for discharge temperature**

THE END

THANKS！