Experimental study of the coupling characteristics between vortex tube and refrigerants

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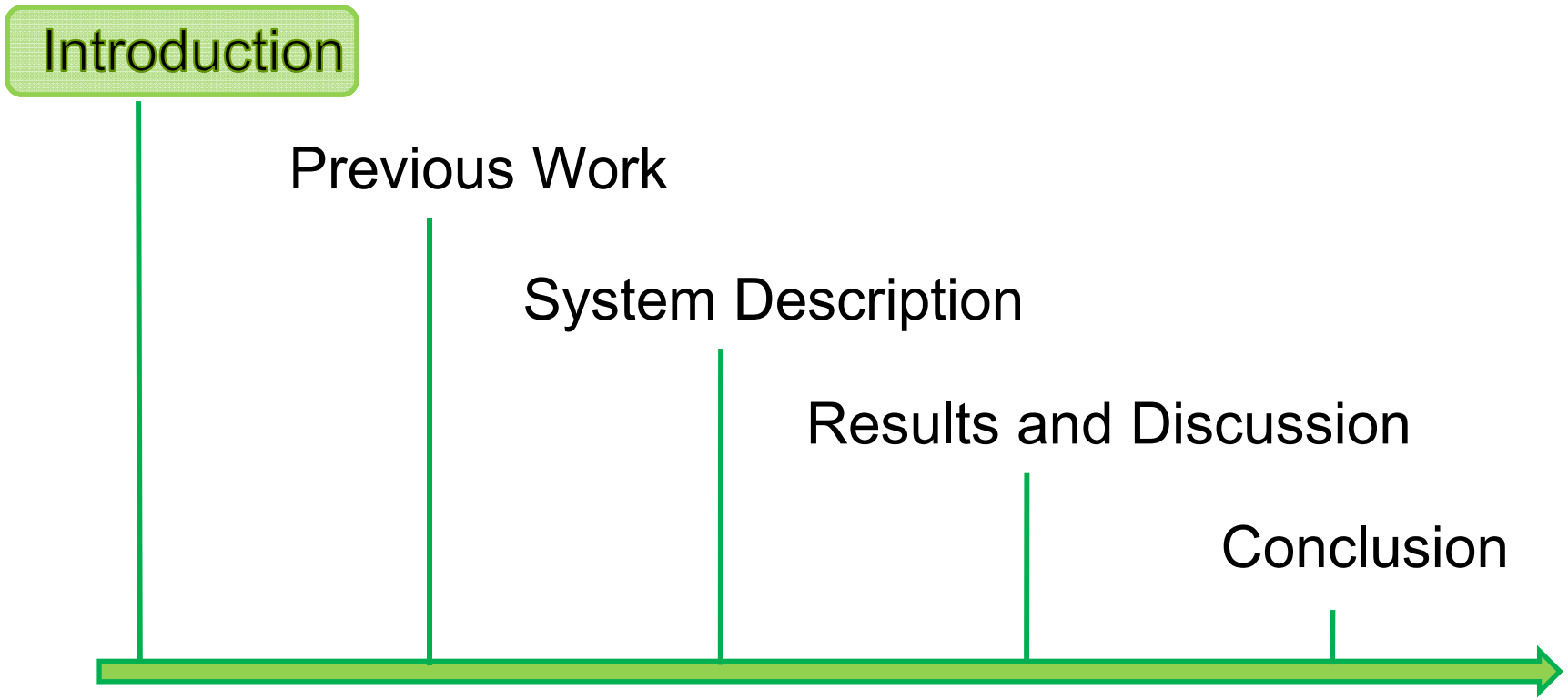
OUTLINE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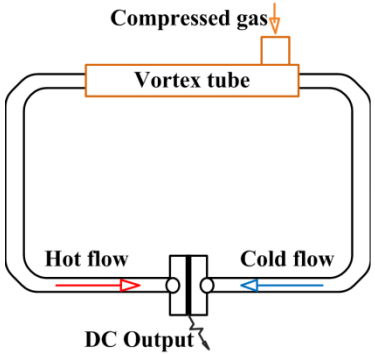
Introduction

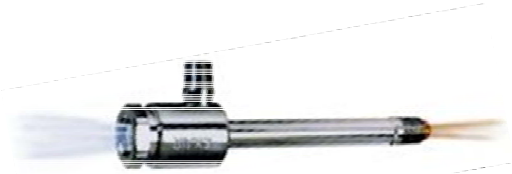
Cool machining operations

Provide heat to divers



Power generation by Seebeck effect

Separation of hydrates from gas/liquid streams



Applications

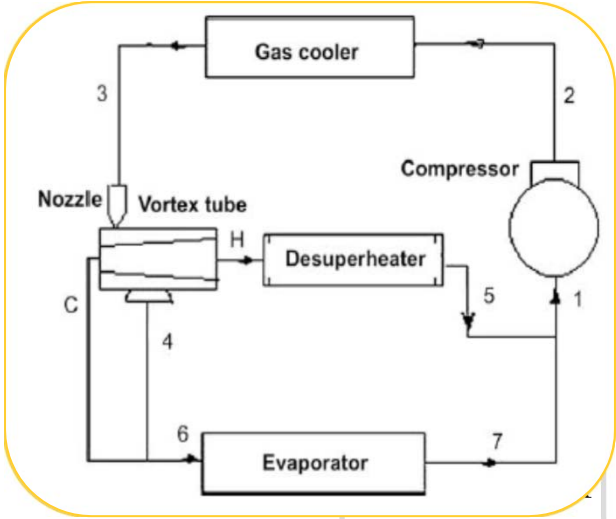
Introduction

Throttling effect

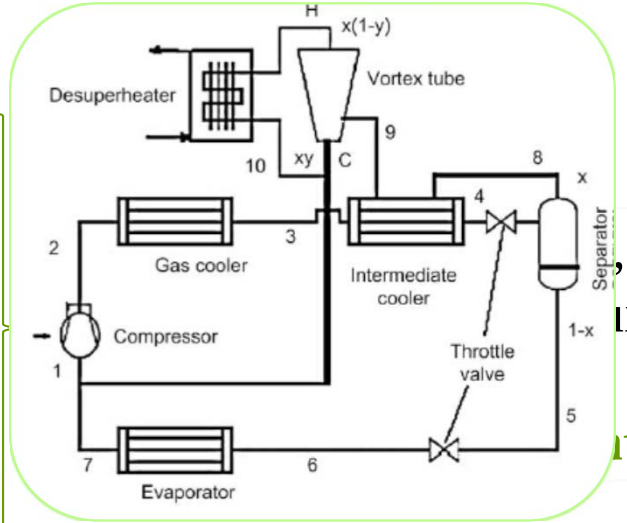
- expansion expander → structurally simple
- throttle valve → efficient

used in **refrigeration and heating system**

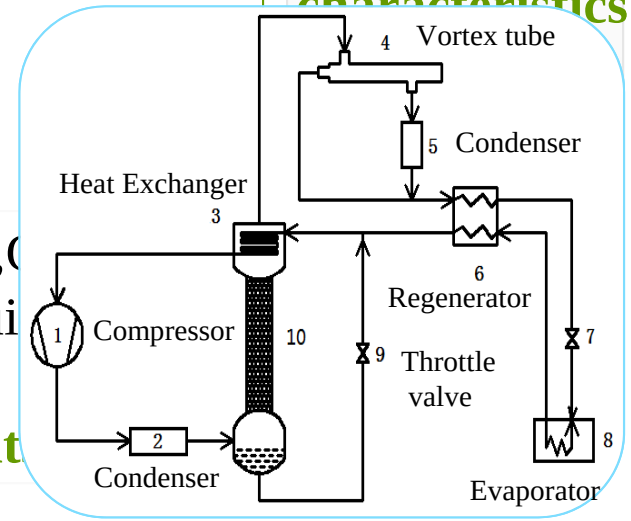
the coupling characteristics



Cycle layout of vortex tube expansion cycle for Maurer model [1]



Cycle layout of vortex tube expansion cycle for Keller model [1]



A self-cascade system with a vortex tube [2]

[2] K.X. Wu . 2013, Numerical simulation and experimental study of the coupling characteristics between vortex tube and refrigerant. Hangzhou, China.

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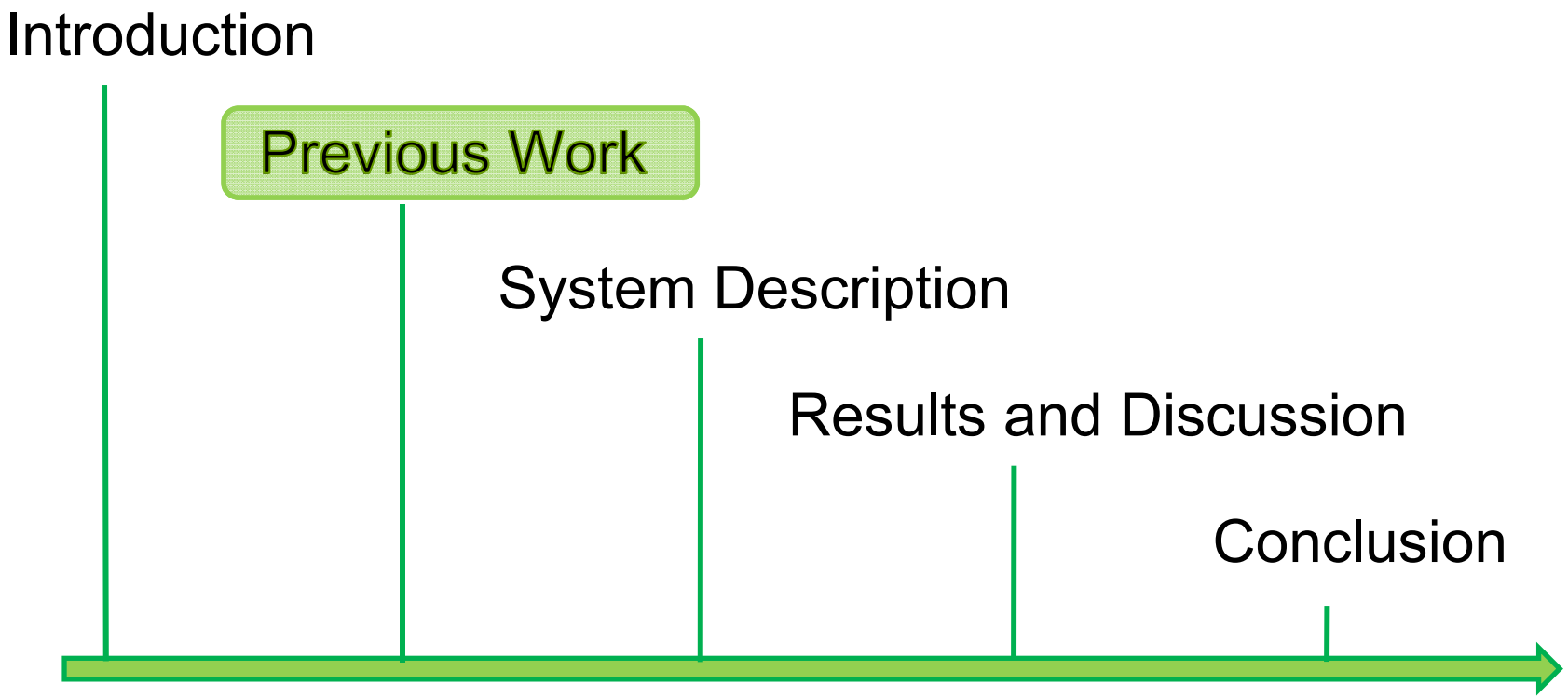
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Previous Work

Workingfluids : R728, R744, R32, R22, R161, R134a
Open system
Inlet pressure : 0.3MPa
Constant cold mass fraction ,Constant inlet temperature

Three fluid characteristics (**specific heat ratio , kinematic viscosity, thermal conductivity**) were considered as main influencing factors [3]

High-pressure conditions, the influence of **different inlet temperatures**, **different cold mass fractions** are not considered

[3] X.H. Han , et al.,2013, The influence of working gas characteristics on energy separation of vortex tube, *Appl. Therm. Eng.*, vol. 61,no.2:p. 171-177.

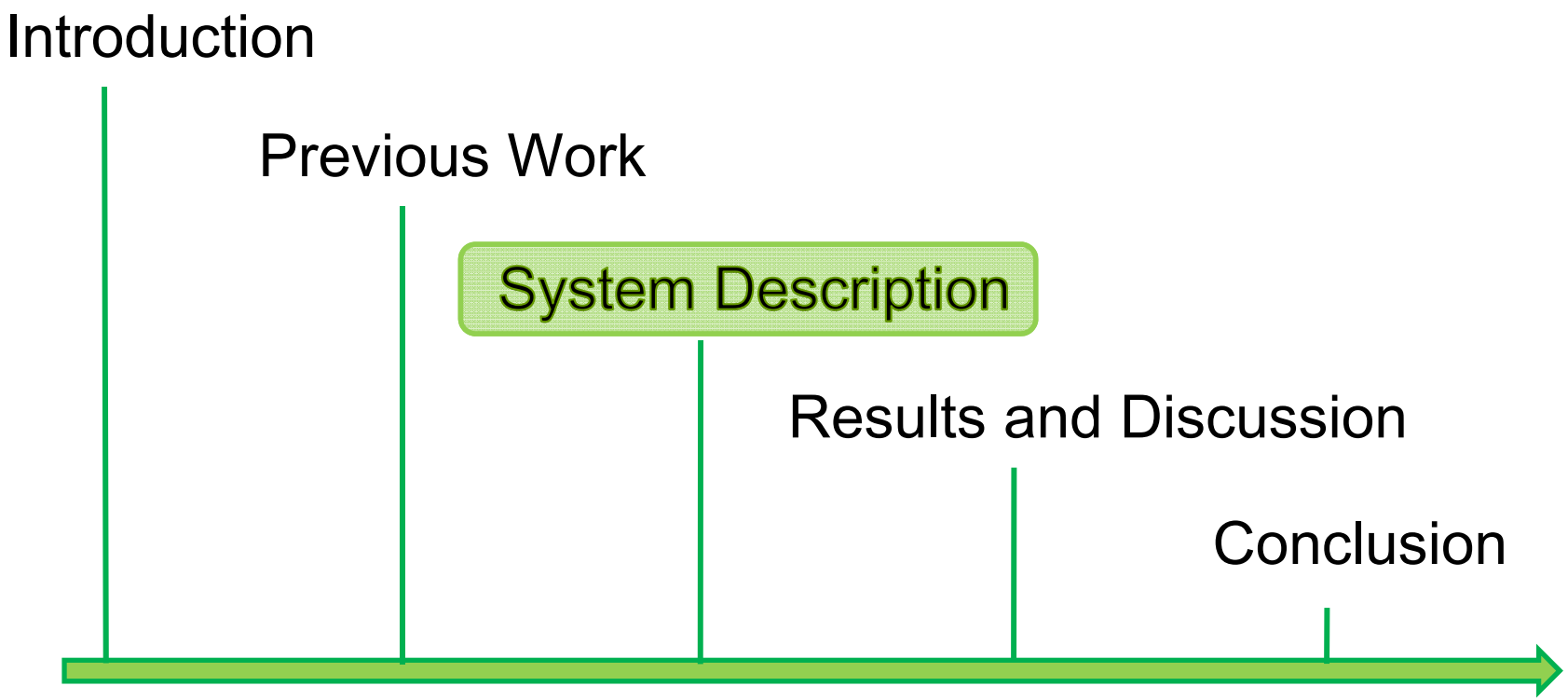
Our work

Working fluid: **R134a**
Different **inlet pressure** (500kPa～850kPa),
Different **inlet temperature** (308.15K～333.15K),
Different **cold mass fraction** (20%～97%).

Working fluids:**R134a, R744, R32, R227ea**
Inlet pressure p_{in}=700kPa,
Inlet temperature T_{in} = 313.15K.

Help understand the energy separation process in the vortex tube ; Provide theoretical guidance for the application of the vortex tube in refrigeration systems.

OUTLINE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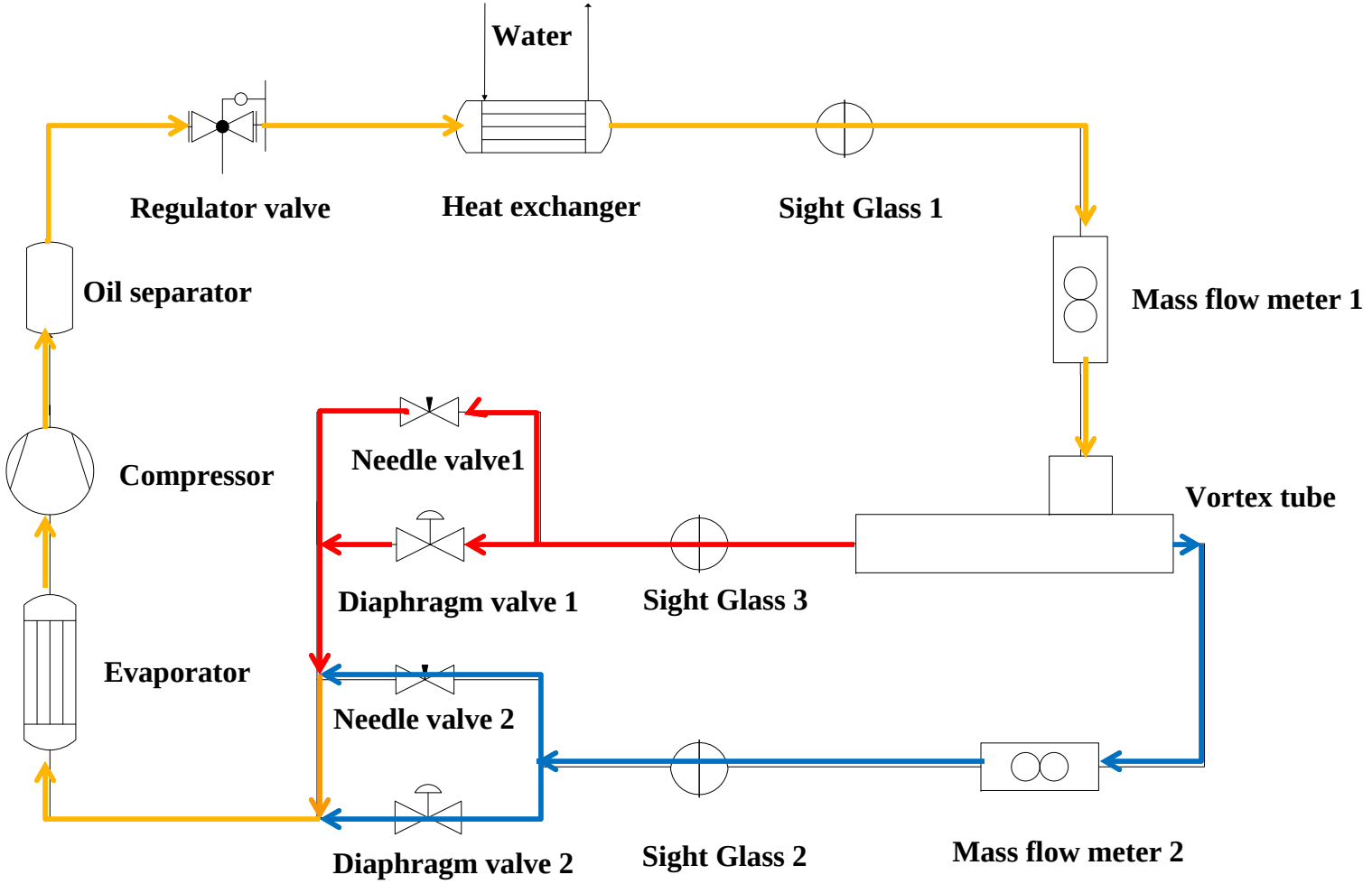
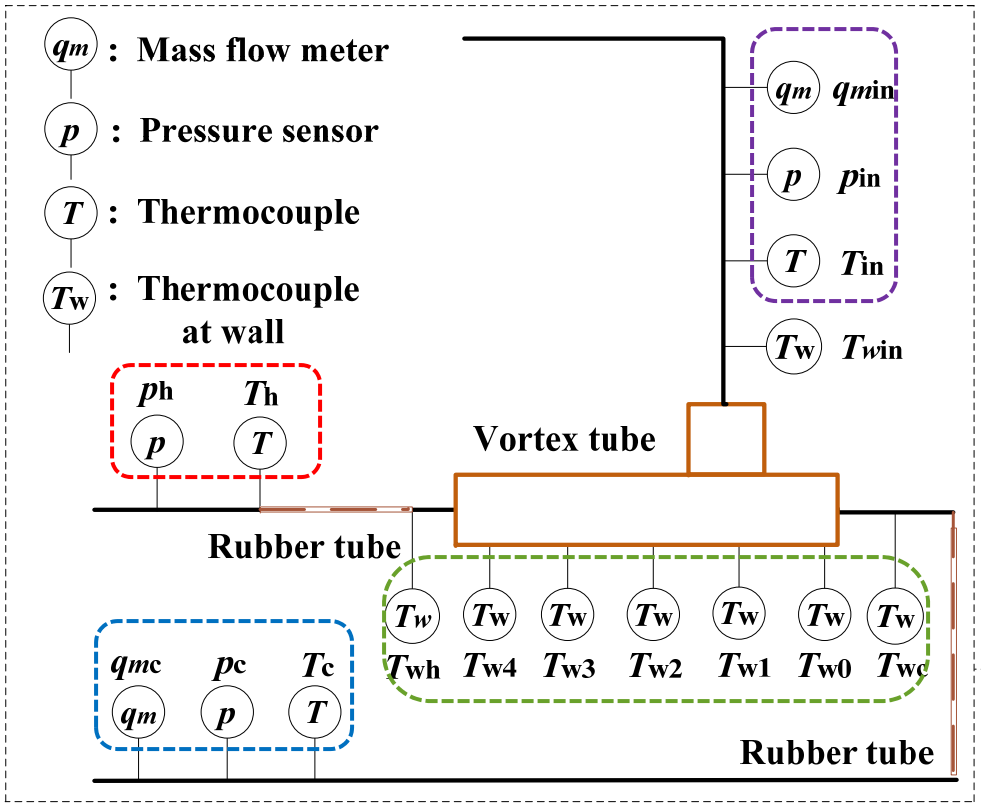
System Description

Schematic diagram of experimental apparatus:



System Description

Schematic diagram of experimental measurement:



- **Cooling effect:**

$$\Delta T_c = T_c - T_{in}$$

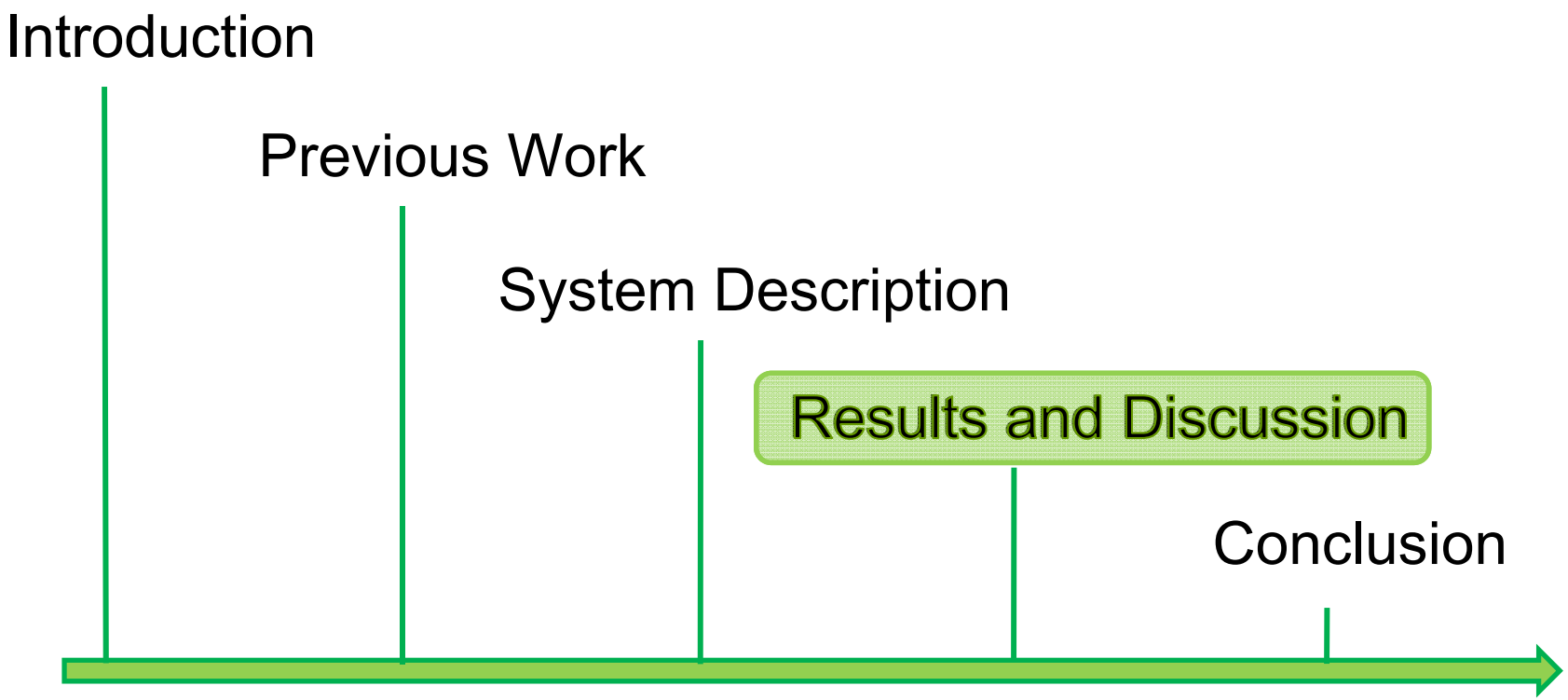
- **Heating effect:**

$$\Delta T_h = T_h - T_{in}$$

- **Cold mass fraction:**

$$\mu_c = q_{mc} / q_{\min}$$

OUTLINE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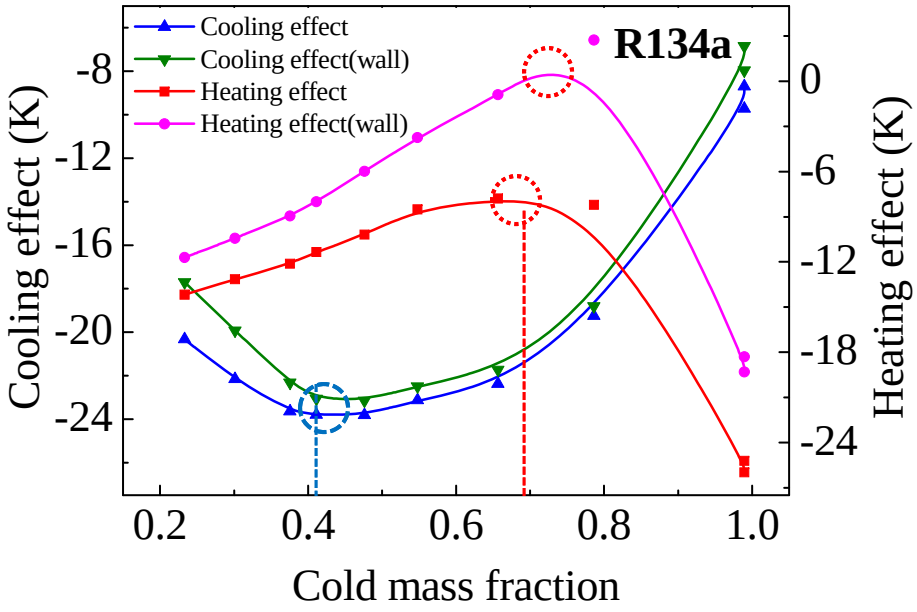
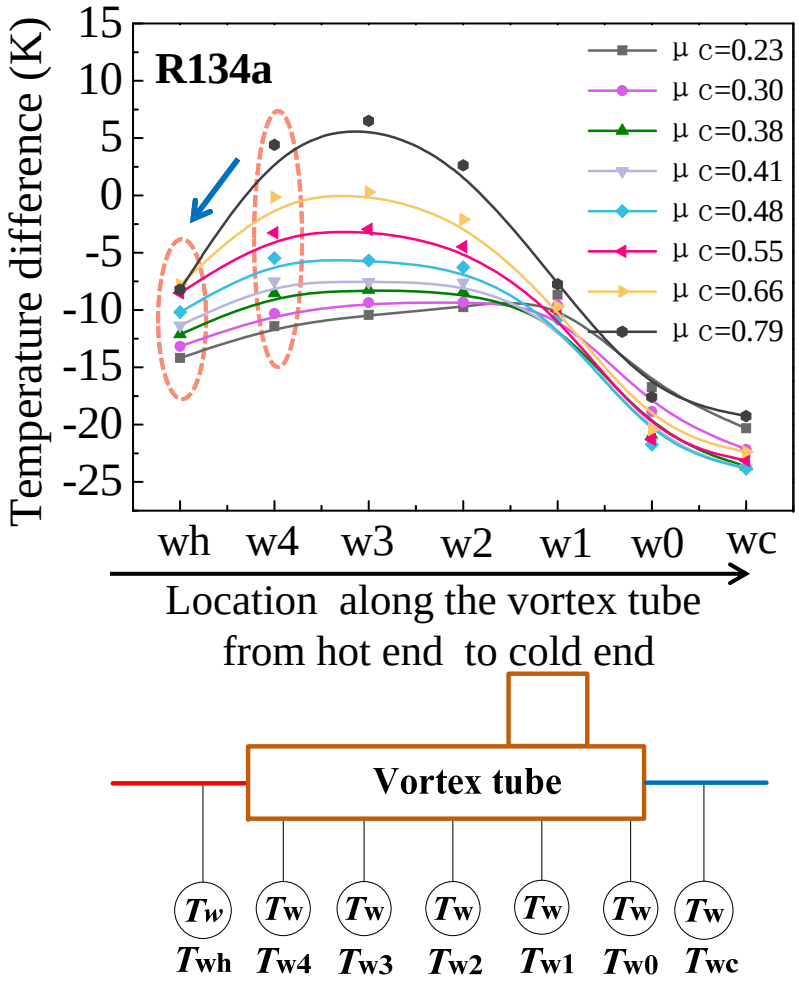
Results and Discussion

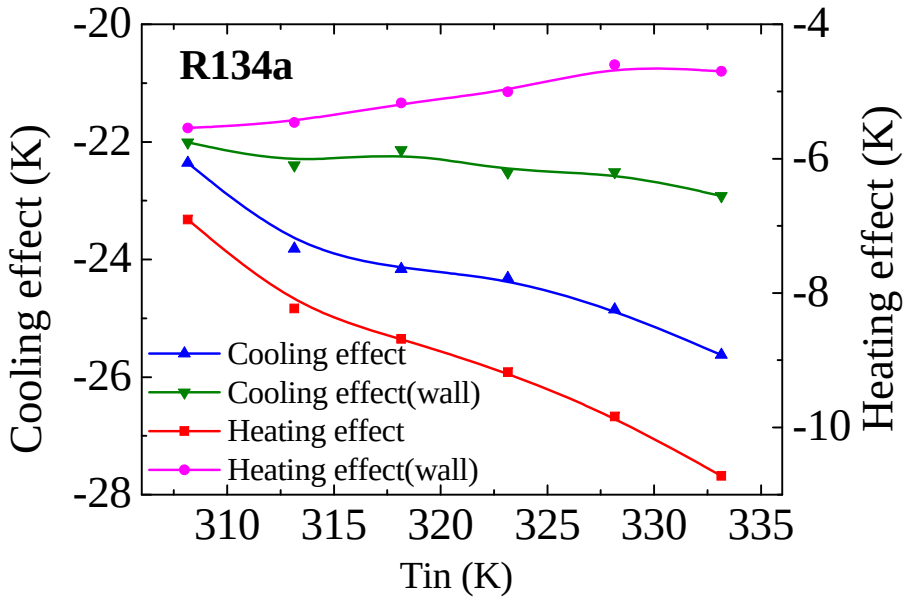
The effect of **cold mass fraction** on the performance of the vortex tube :

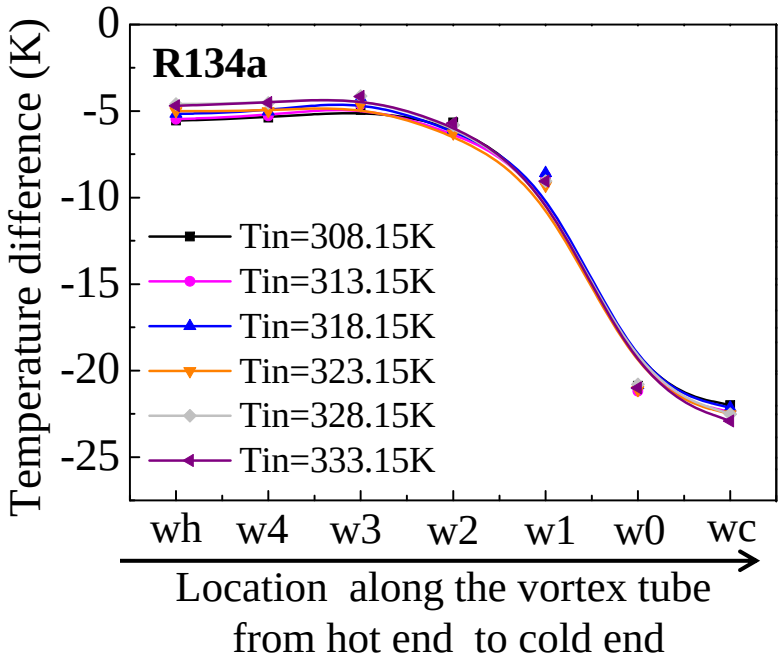


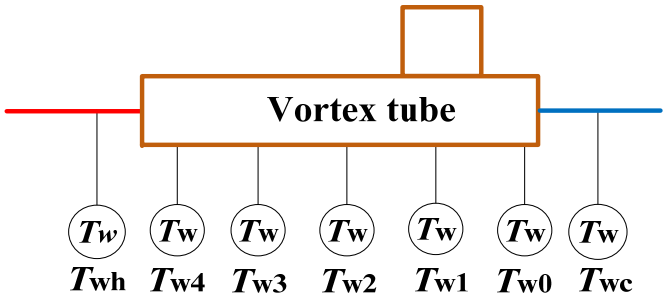


Results and Discussion

The effect of **inlet temperature** on the performance of the vortex tube :

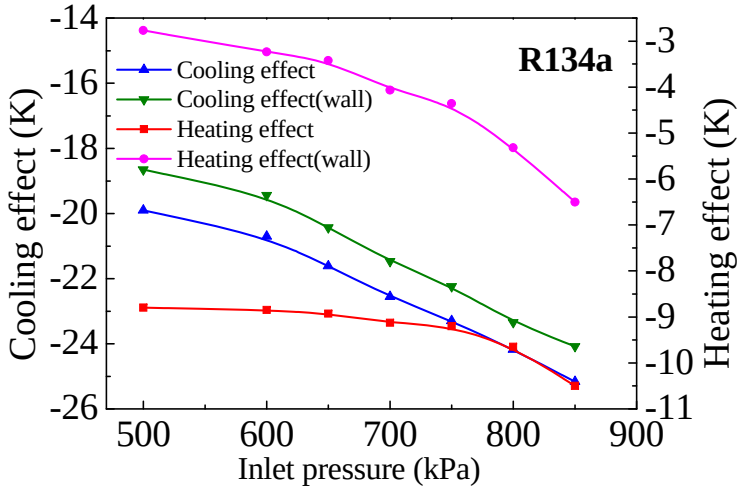


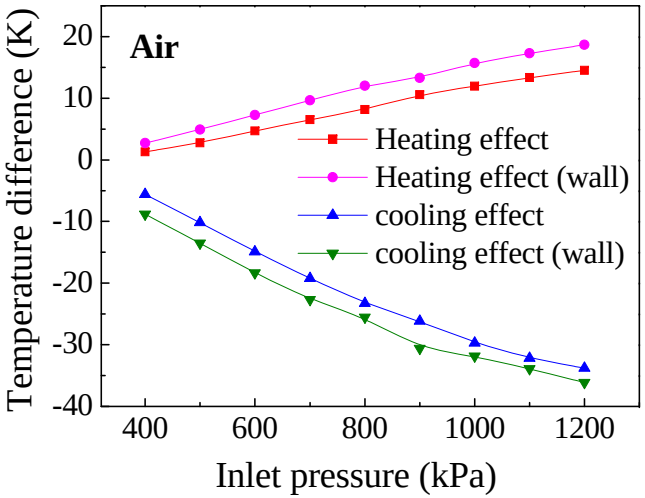


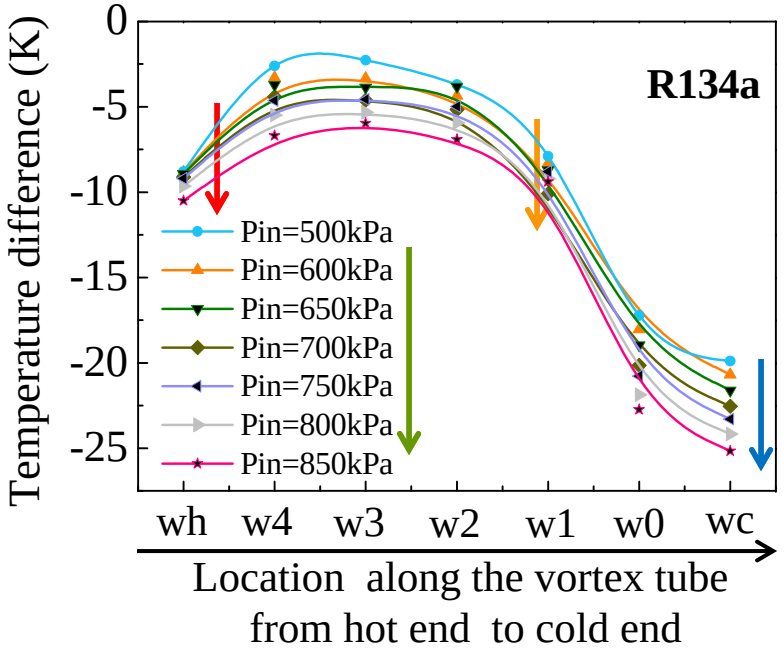


Results and Discussion

The effect of **inlet pressure** on the performance of the vortex tube :



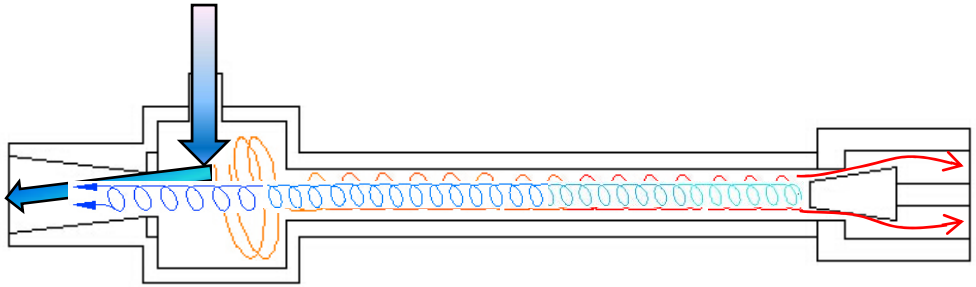


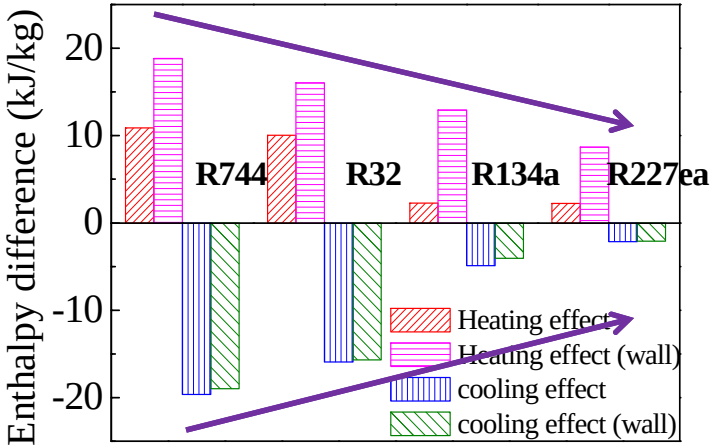


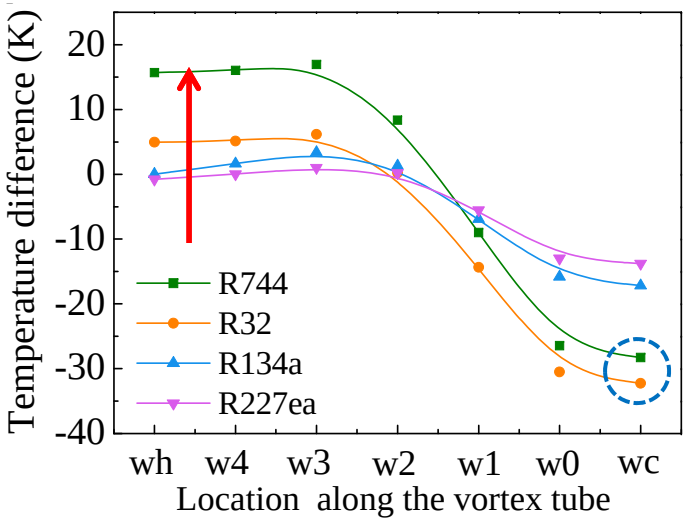
Working gases	v/ $m^2 \cdot s^{-1}$
R134a	0.391×10^{-6}
Air	2.469×10^{-6}

Results and Discussion

The effect of **working fluids** on the performance of the vortex tube :



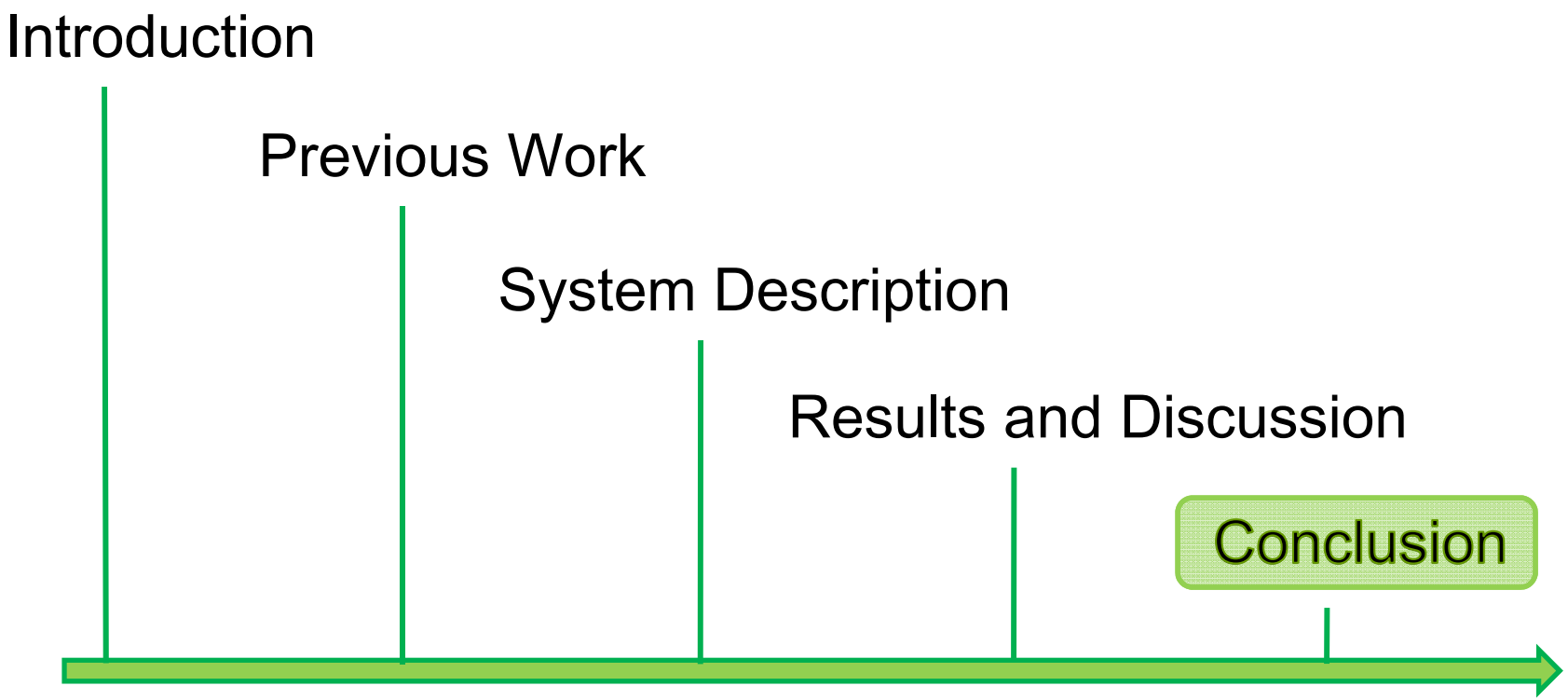




The basic properties of different working gases

Working gases	k	v/ $m^2 \cdot s^{-1}$	z
R744	1.317	1.288×10^{-6}	0.9699
R32	1.314	0.879×10^{-6}	0.9252
R134a	1.197	0.391×10^{-6}	0.869
R227ea	1.168	0.218×10^{-6}	0.813

OUTLINE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Conclusions

The effect of the cold mass fraction μ_c, inlet pressure p_{in}, inlet temperature T_{in} of R134a on the performance of the vortex tube is explored:

- The effect of **cold mass fraction** on the temperature separation effect is similar to those when air and other gases are used. The maximum heating effect ΔT_h and cooling effect ΔT_c are obtained when cold mass fraction is about 0.4 and 0.7, respectively.
- When the **inlet temperature** of R134a is larger than the saturation temperature at the same pressure, the increase of temperature has little influence on the temperature separation effect of the vortex tube.
- When **the inlet pressure** p_{in} of R134a increases, the cooling effect ΔT_c increases while the heating effect ΔT_h reduces gradually.

Energy separation effects of different working fluids **(R134a, R744, R32, R227ea)** are discussed:

- The **specific heat ratio *k*, compressibility factor *z*, and kinetic viscosity *v*** are considered as the main factors affecting the temperature separation process in the vortex tube.

Thank you !