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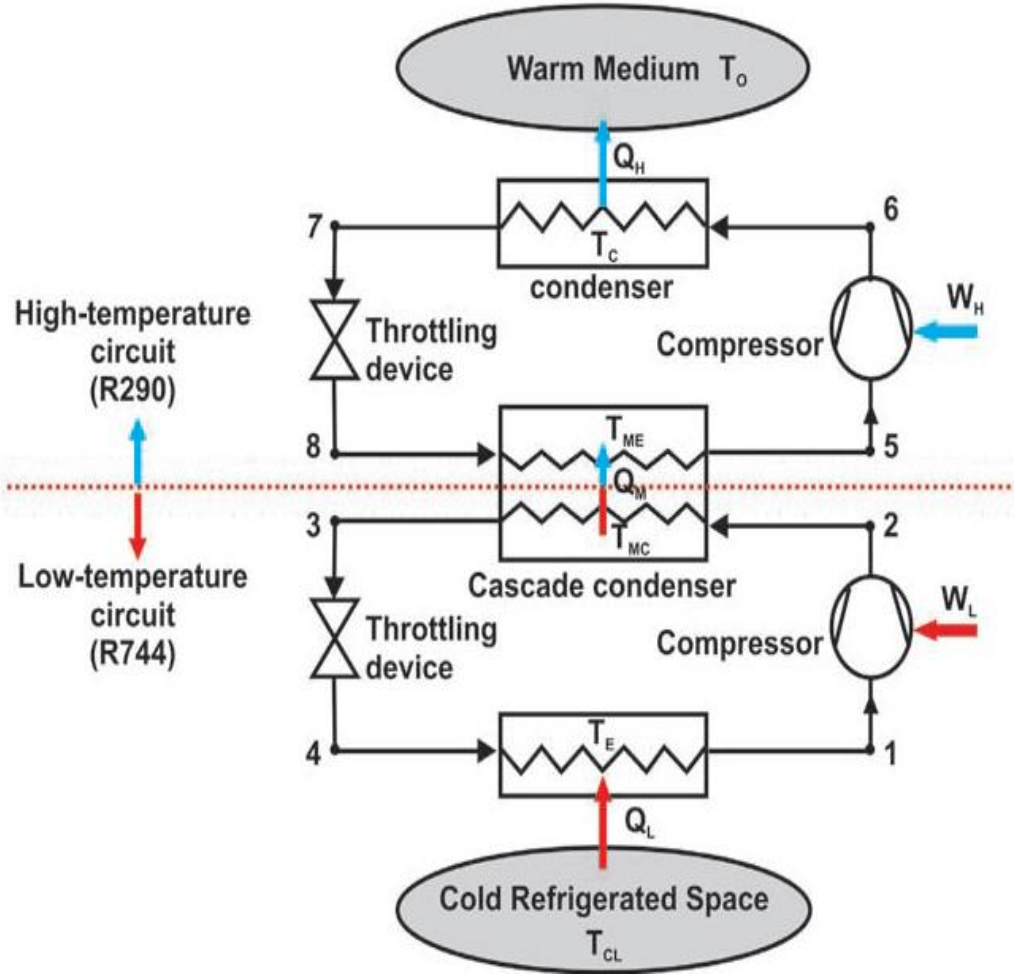
PERFORMANCE STUDY OF CASCADE REFRIGERATION SYSTEM USING NATURAL REFRIGERANTS

Robin Singh Suhail Ahmad Sanjeev Jain

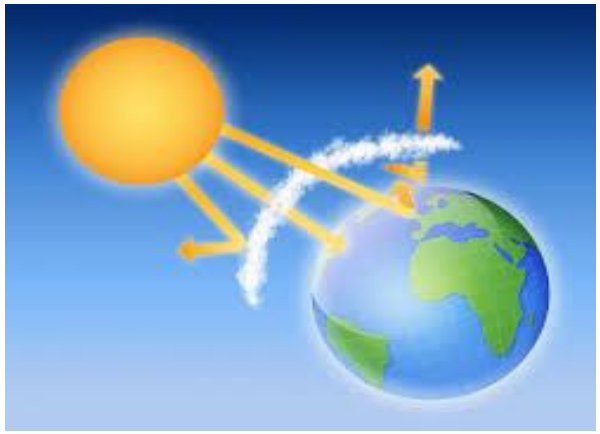
Department of Mechanical Engineering
Indian Institute of Technology Delhi

Cascade Refrigeration

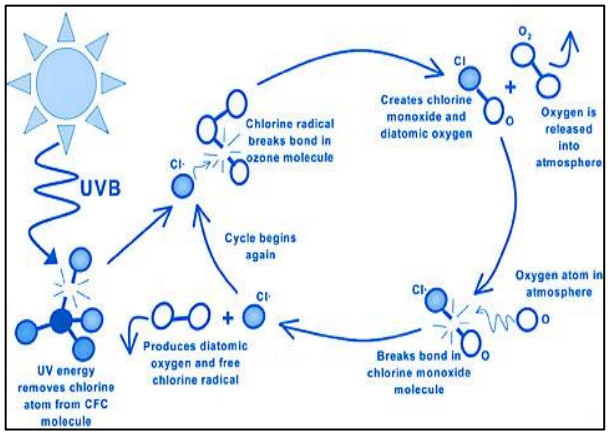
- Low temperature refrigeration in the range(-30°C to -100°C)
- Higher efficiency than single and multi-stage systems
- Employing suitable refrigerants for temperature ranges used
- Use of natural refrigerant helps fight the twin menace of global warming and ozone depletion



~~Global Warming~~



~~Ozone Depletion~~



Natural Refrigerants

CARBON DIOXIDE as Refrigerant!

Advantages

- GWP=1 , ODP = 0
- Low toxicity
- Non-Flammable
- Excellent thermo-physical properties

Disadvantages

- High operating pressures
- Difficult availability of CO_2 components

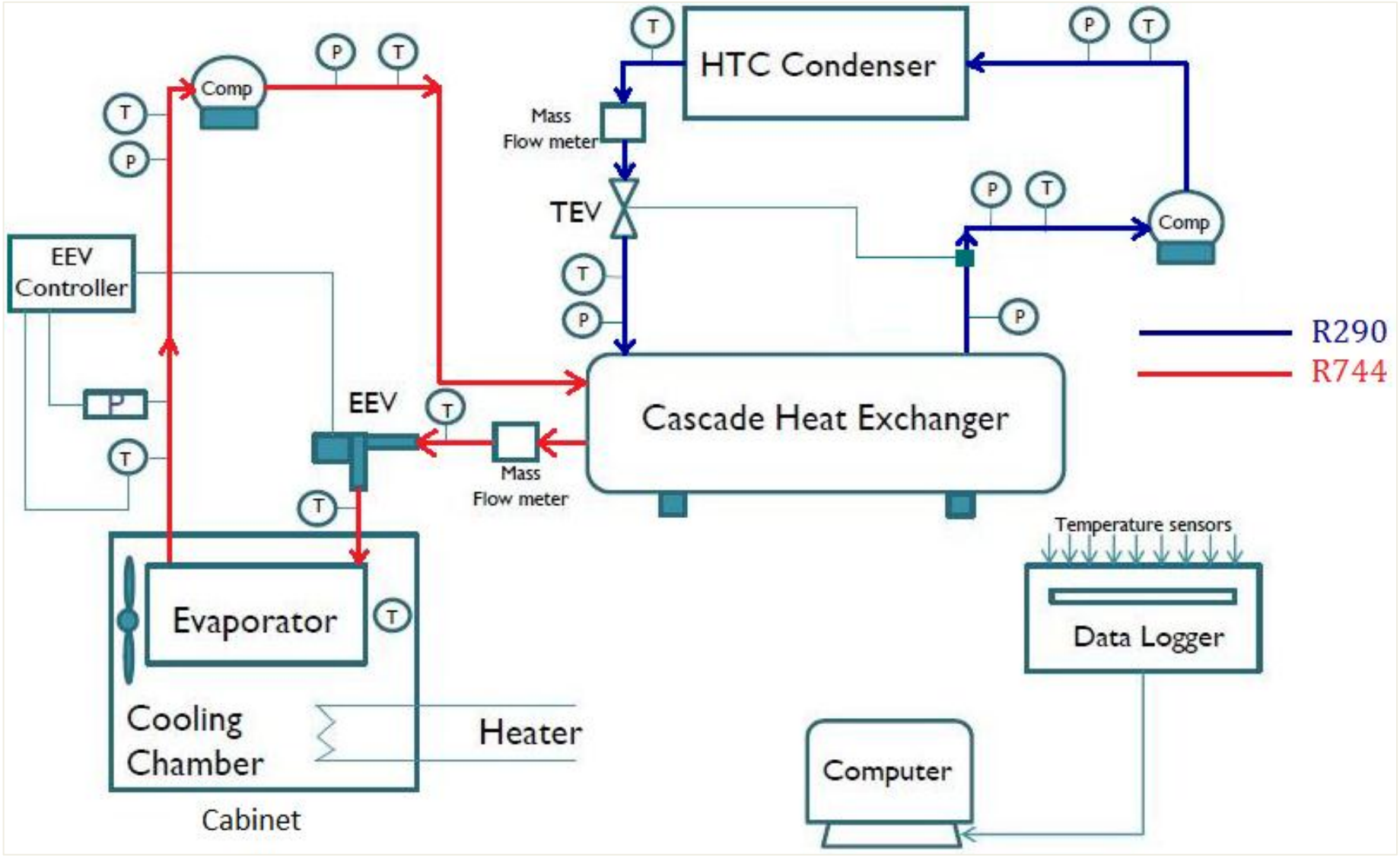
Objectives

- Performance analysis of Cascade refrigeration system
- Performance dependence of Cascade refrigeration system
    - evaporator temperature,
    - Ambient Temperature and
    - Cascade temperature
- Comparison of Simulation and experimental results for 2 different types of heat exchangers

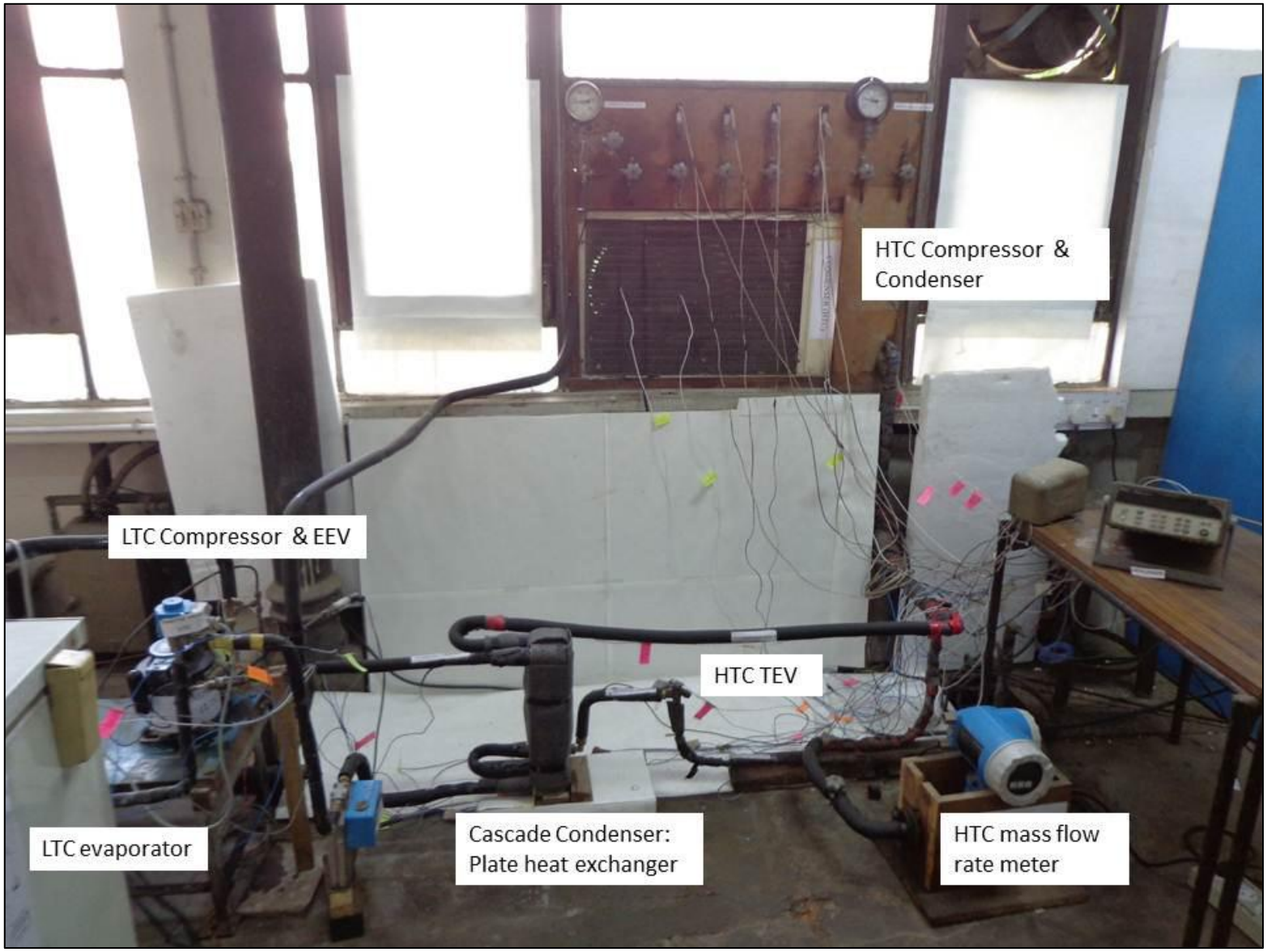
❑ Shell-tube heat exchanger

❑ Brazed Plate heat exchangers

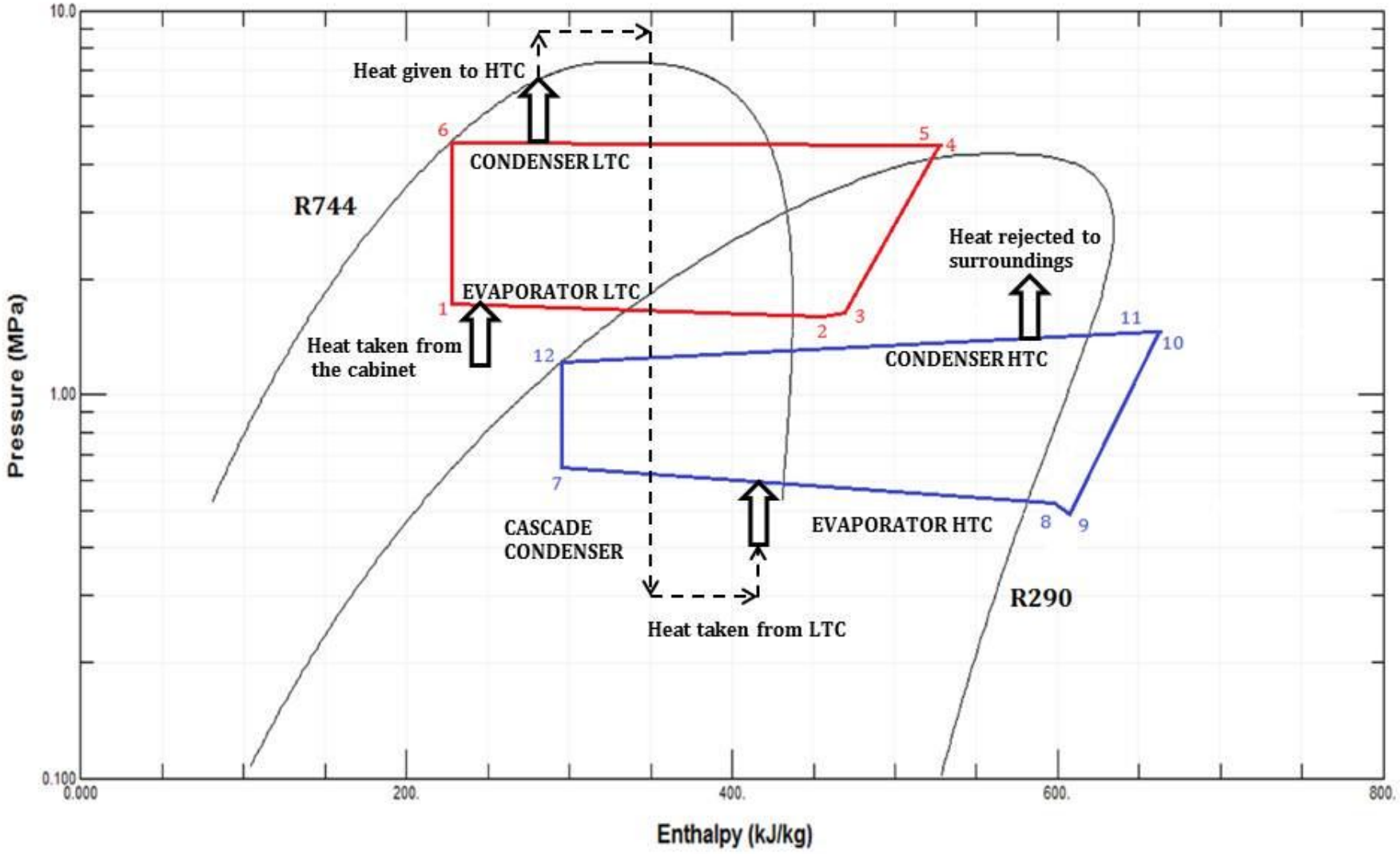
Experimentation



Experimental setup

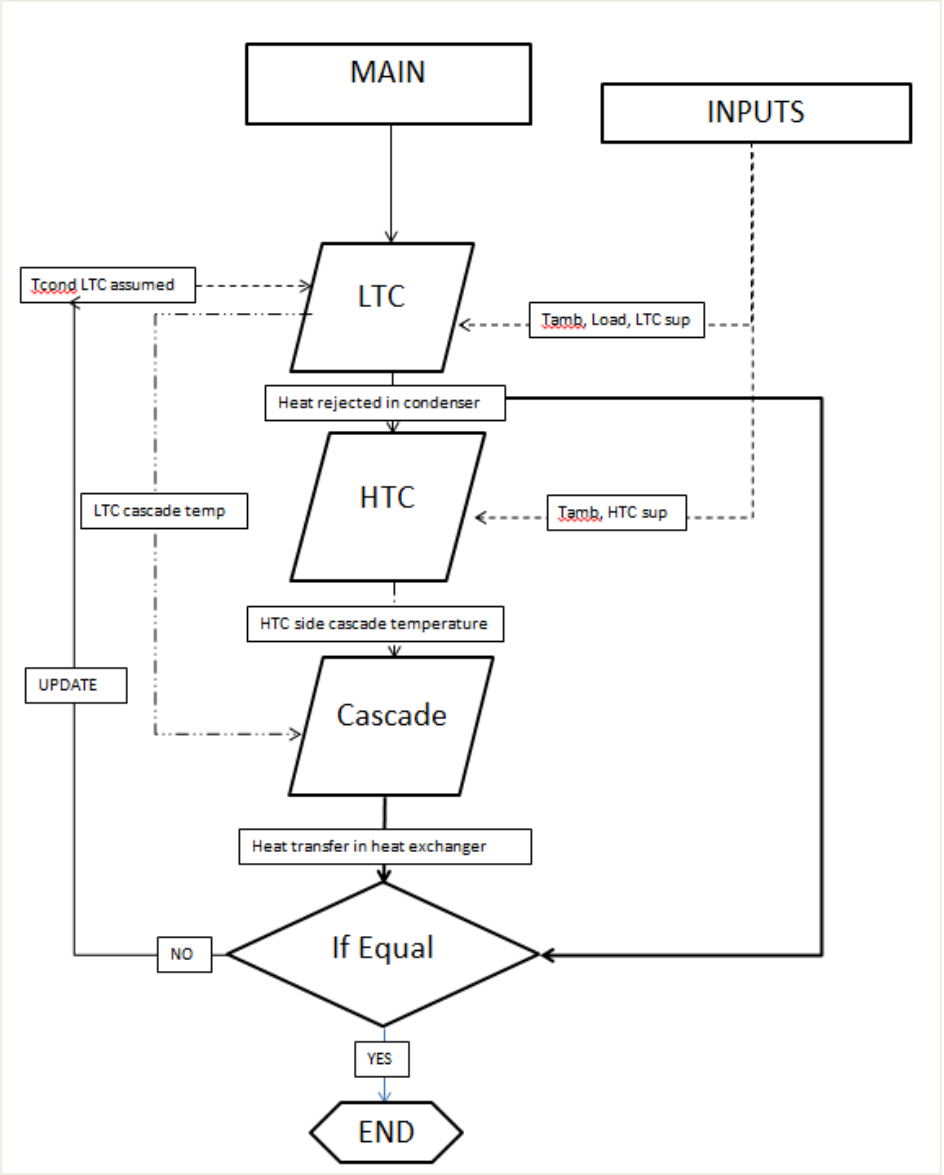


P-h Diagram of a typical experimental result



Simulation Algorithm

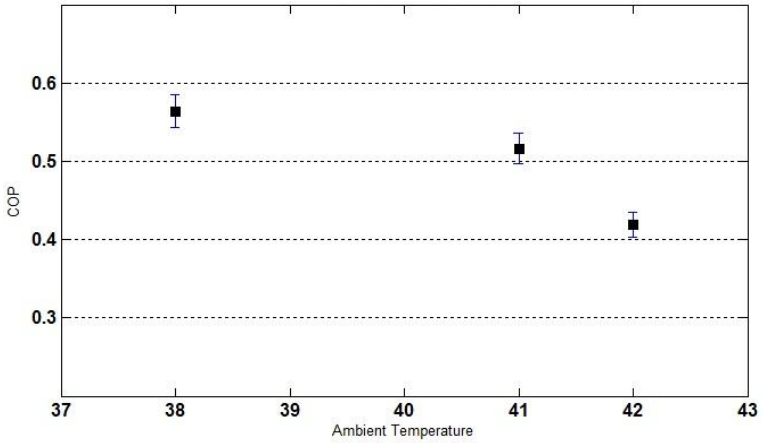
- Use of MATLAB computational software
- Use of iterative procedure
- Primary function- Main
- Subroutines – HTC, LTC and Cascade
- Use of minimum assumptions



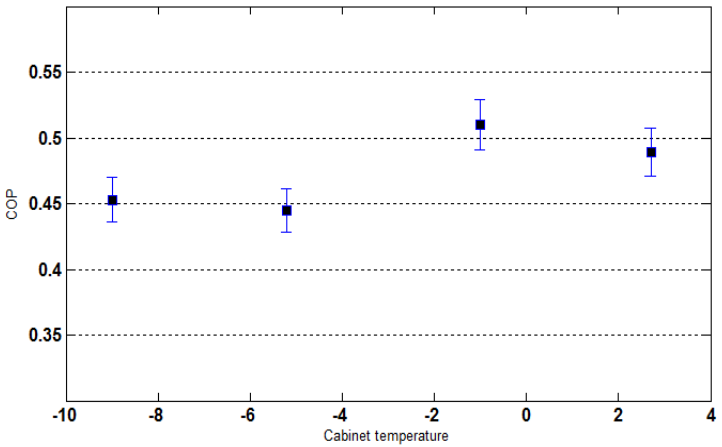
RESULTS

Experimental Results

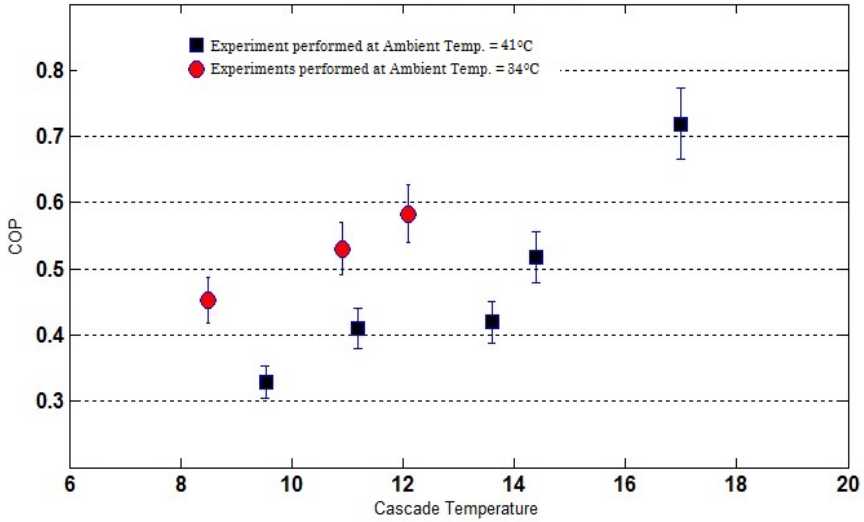
COP v/s Ambient Temperature



COP v/s Cabinet Temperature

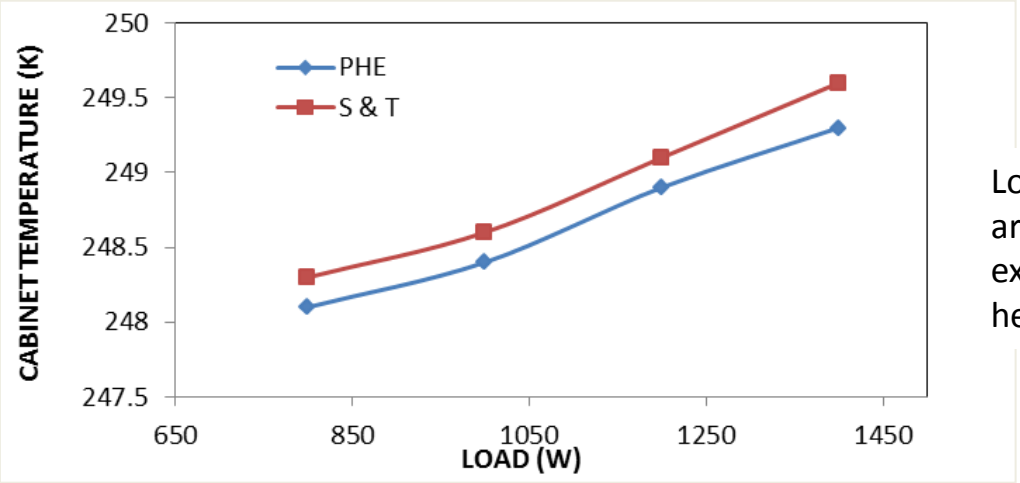


COP v/s Cascade Temperature



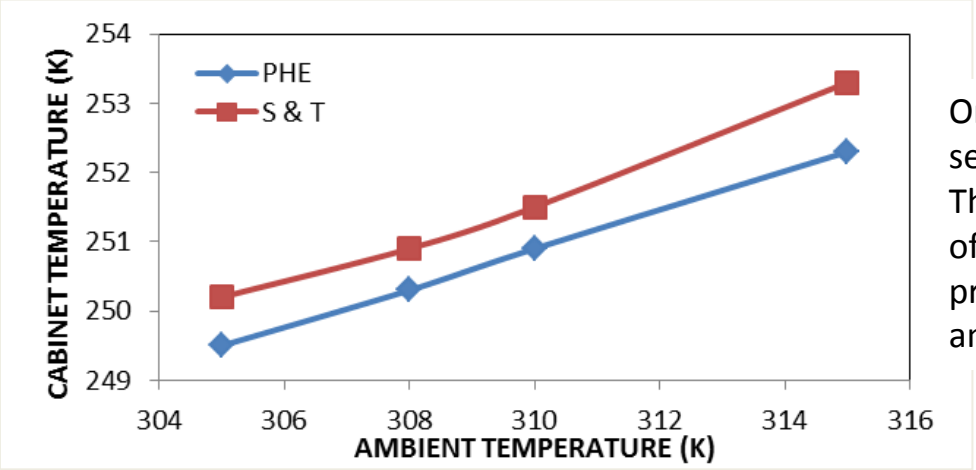
Simulation results

Effect of change in load on cabinet temperature



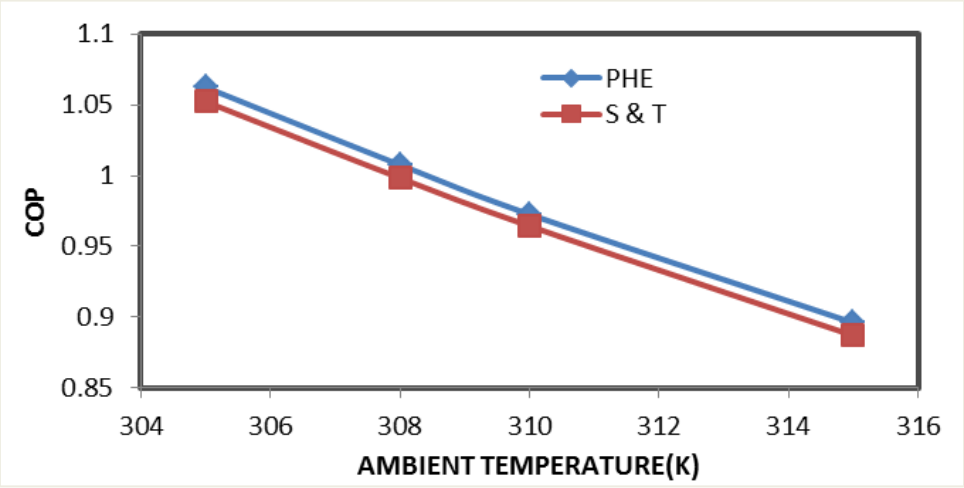
Lower cabinet temperatures are observed for plate heat exchanger than shell-tube heat exchanger

Effect of change in ambient on cabinet temperature



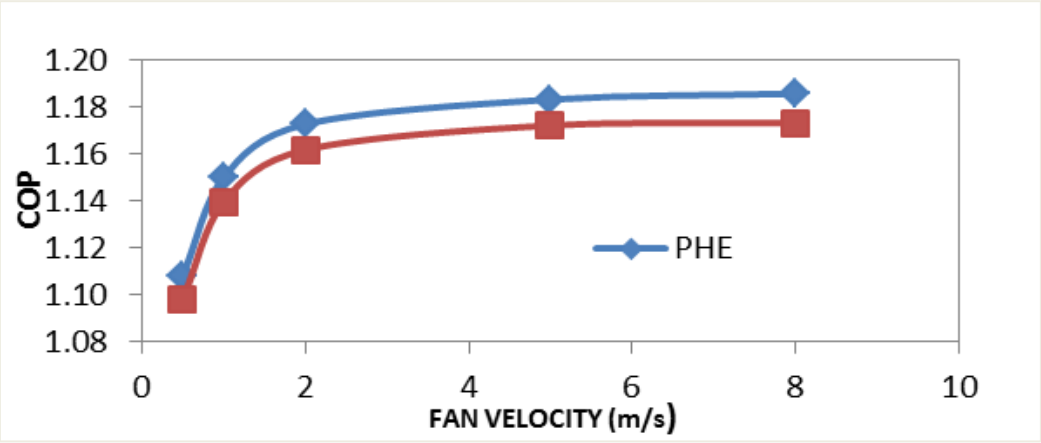
On higher ambient temperatures the separation between the two curves widens. The influence of ambient temperature in case of Shell-tube HE progressively gets more pronounced as compared to PHE suggesting an advantage of PHE.

Effect of change in ambient temperature on COP



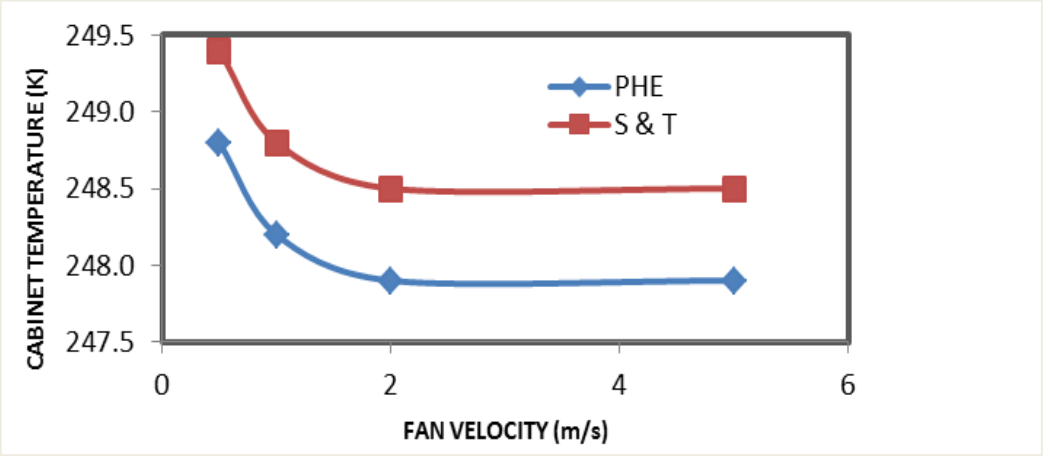
Similar behavior by both heat exchangers

Effect of change in condenser fan velocity on COP

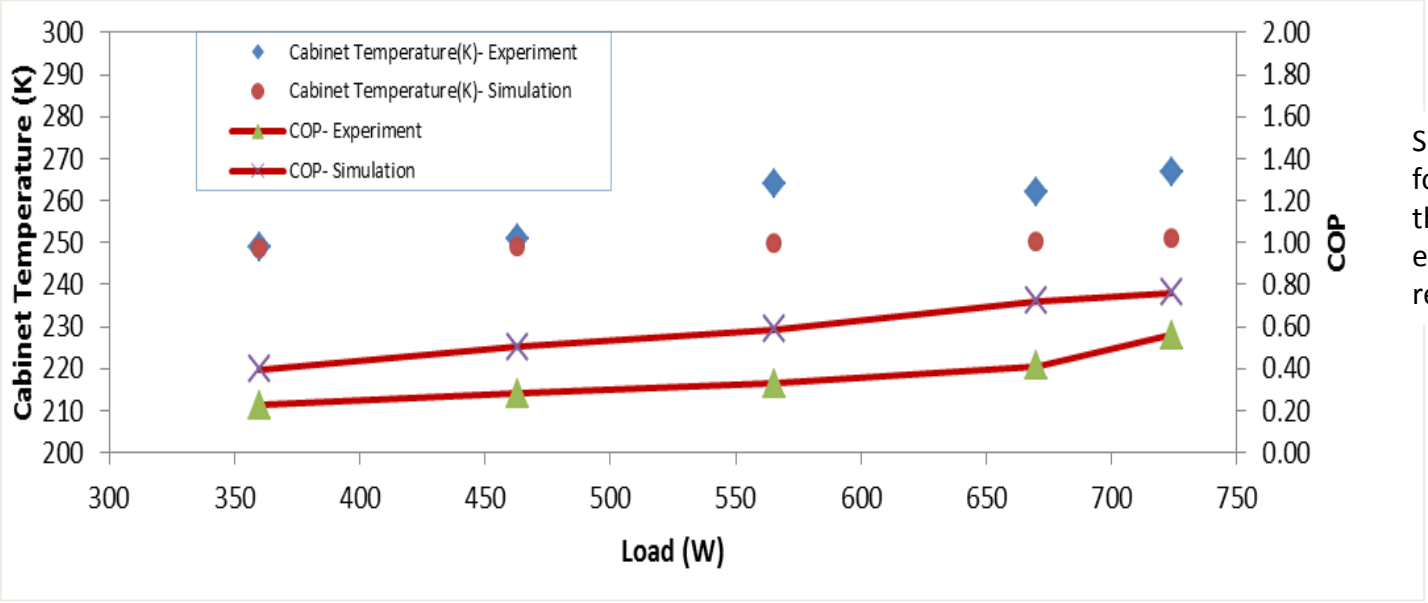


At higher velocities the outer surface temperature becomes ambient and hence no effect of further increase in velocity

Effect of change in condenser fan velocity on Cabinet Temperature



Comparison of experimental and simulation results



Simulation model fails to account for heat ingress in pipes, hence the difference between the experimental and simulation results

Conclusion

- Cascade temperature has a significant effect on the performance of system
- Experimental performance closely follows the simulation results.
- it is possible to achieve lower cabinet temperatures with Plate heat exchanger as compared Shell-Tube heat exchanger for the same heat transfer area for different load and ambient temperature conditions.

Sources of image

- www.earthtimes.org/encyclopaedia/environmental-issues/global-warming/

- climatechange.thinkaboutit.eu/scripts/tinymce/jscripts/tiny_mce/plugins/imagemanager/files/ozone_depletion.jpg

Thank you!