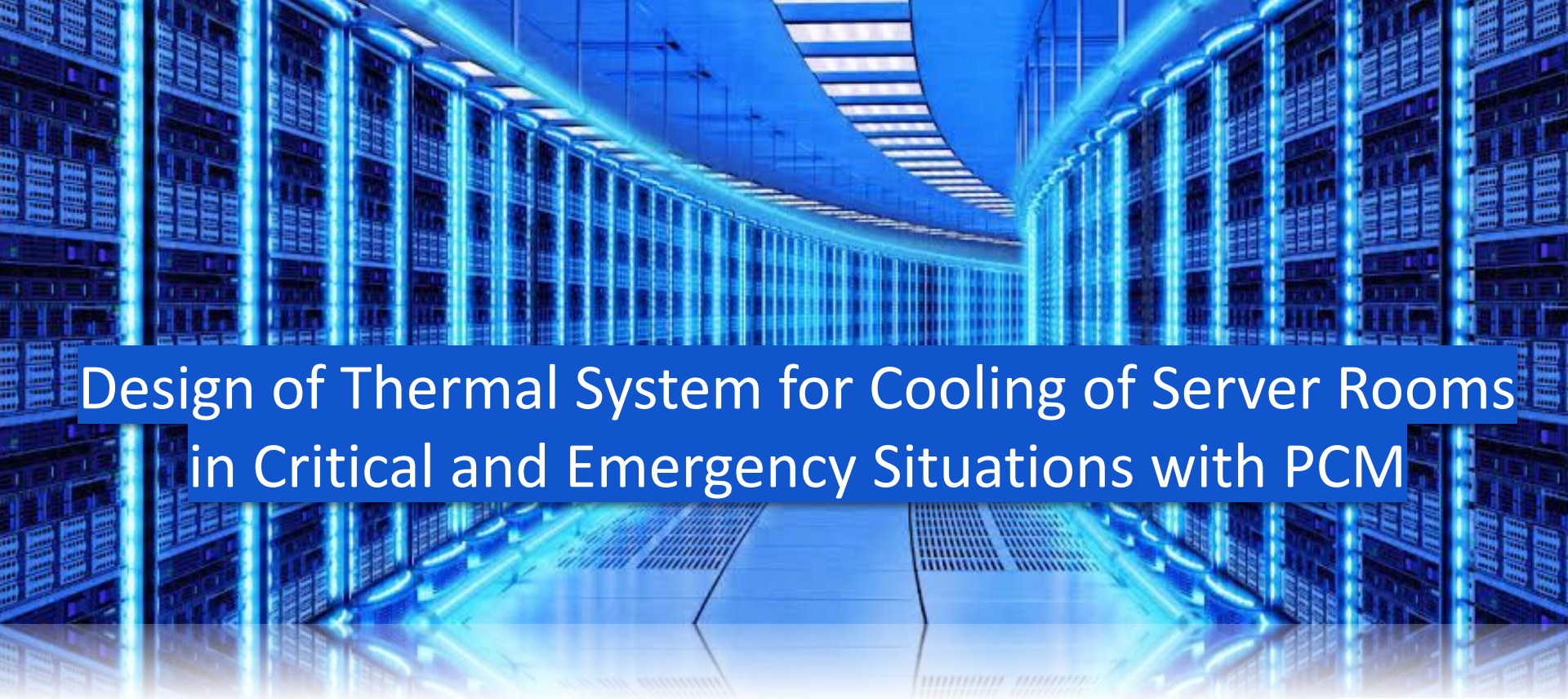

Design of Thermal System for Cooling of Server Rooms in Critical and Emergency Situations with PCM

ME 491 RESEARCH PROJECT PRESENTATION

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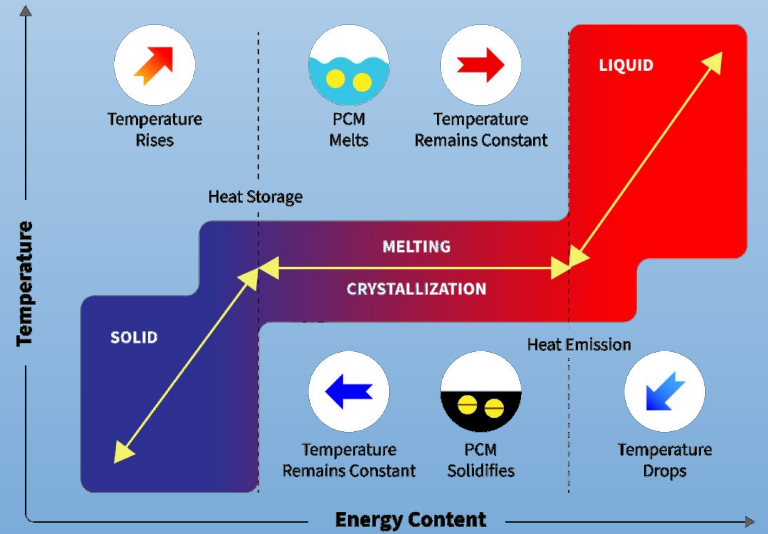
UNDER THE SUPERVISION OF PROF. DR. TARIK BAYKARA

Introduction

Servers should be cooled instantly in critical times and their temperature constantly increases as they are working throughout the day.

Working principle of PCM



Temperature vs energy graph of PCM

Project steps

1. **Literature research** (cooling techniques of server cabinets, commercial paraffins with low melting point, examination of similar projects)

2. **Designing of the theoretical architecture** (studies to reduce the melting point of paraffin wax by using phase change diagrams)

3. **Experimental studies** (examination of the performance of paraffin wax and powder pcm in the experimental setup, application of the materials to the server cabinet)

Data Center Cooling Technologies

- Computer Room Air Conditioner (CRAC)
- Computer Room Air Handler (CRAH)
- Cold Aisle/Hot Aisle Design
- Calibrated Vectored Cooling (CVC)
- Evaporative Cooling
- Free Cooling
- Liquid Cooling - Chilled Water System
- Liquid Cooling - Immersion System
- **Passive cooling ✓**

Use of PCM in similar areas

Passive cooling

A passive cooling energy storage application designed to work the natural difference between the cooler night and warmer day time ambient temperatures and by storing the cold energy over-night, the daily heat gains both internally and externally can be handled without any mechanical refrigeration, thereby providing maintenance free passive cooling system. [1]

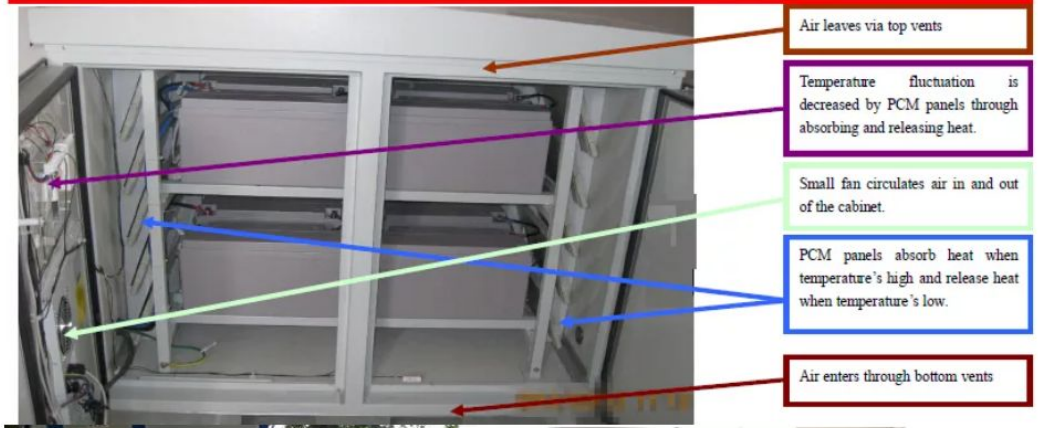
alibaba.com/product-detail/Phase-Change-Material-Plastic-Panel-PCM_60181144083.html

Product Details | Company Profile

Phase Change Material PCM panel back-up for Base telecom shelter battery cooling facilities

PH-29 for outdoor use and PH-26 for indoor use

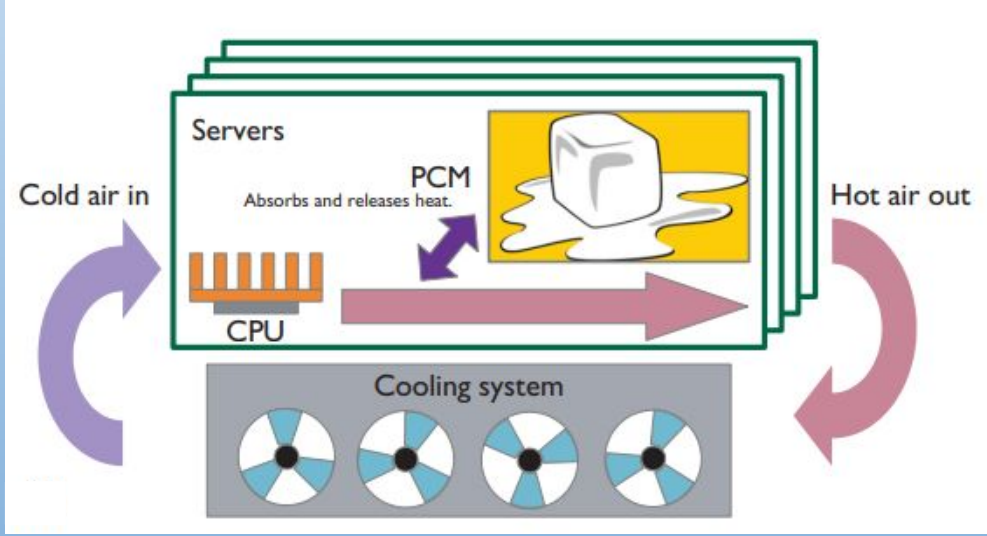
The PCM panels are filled with PH-29 PCM, either for indoor and outdoor cabinet, which freezes at below 25 ℃ and melts at above 29 ℃. In freezing and melting process, the PCM panels absorb and release much amount of heat, and the two kinds of PCM phase change help a lot in decreasing temperature fluctuation in the battery cabinet.
PCM panel help keeping the temperature in the battery cabinet at a normal working temperature range, largely increase life expectancy for the battery cabinet.



Use of PCM in similar areas

Chip Level Thermal Management

It aims to cool the heat which is generated from the electronic chip directly at the source area.[2] Heat can be transferred with an effective heat sink design or with the help of a micro heat exchanger. Micro-channel heat sinks are widely used.



Integrating PCM in a warehouse-scale computers (WSCs)

Recommended temperature values for air conditioning of server cabinets

	2004 publication	2008 publication
Temperature Lower Limit	20 °C	18 °C
Temperature Upper Limit	25 °C	27 °C
Humidity Lower Limit	40 % Relative Humidity (RH)	5.5 Dew Point
Humidity Upper Limit	55 % Relative Humidity (RH)	60 % RH and 15°C Dew Point

Recommended System Room Temperature and Humidity Values by ASHRAE (American Society of Heating, Refrigerating)[3]

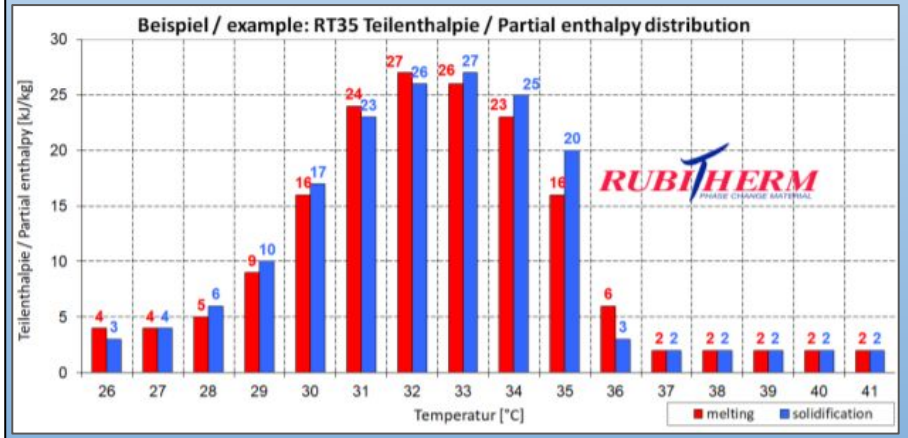
Server Name	Temperature
Dell PowerEdge R740	10°C- 35°C (50°F- 95°F) with no direct sunlight on the equipment.
IBM 8348-21C	10°C - 35°C (50°F - 95°F)

Environmental temperature for continuous operation for Servers[4]

Commercial Low Melting Point Paraffin Waxes

The most important data:	Typical Values	
Melting area	**29-36** main peak: 33	[°C]
Congealing area	**36-31** main peak: 35	[°C]
Heat storage capacity ± 7,5% Combination of latent and sensible heat in a temperatur range of 26°C to 41 °C.	**160**	[kJ/kg]*
	45	[Wh/kg]*
Specific heat capacity	**2**	[kJ/kg·K]
Density solid at 15°C	**0,86**	[kg/l]
Density liquid at 45°C	**0,77**	[kg/l]
Heat conductivity (both phases)	**0,2**	[W/(m·K)]
Volume expansion	**12,5**	[%]
Flash point	**167**	[°C]
Max. operation temperature	**65**	[°C]

Specifications of Rubitherm RT35 [5]



Enthalpy Distribution of Rubitherm RT35 [5]

Constraints for this project

1. Heat of fusion
2. Thermal conductivity of solid and liquid
3. High specific heat and density
4. Long term reliability during repeated cycling
5. Dependable freezing behavior
6. Cost
7. Weight
8. Volume that covers the place(dimensions)
9. Average phase change temperature

Parameters for design

An ideal PCM will have **high heat of fusion**, **high thermal conductivity**, **high specific heat** and **density**, **long term reliability** during repeated cycling.

The materials we use

Petroleum Wax
Melting point: 58-66 °C

Petroleum Oil
Melting point: -24 °C

Powder PCM

Studies on reducing the melting point of paraffin wax

By mixing (melted) paraffin wax with petroleum oil, paraffin wax with a lower melting point will be obtained.

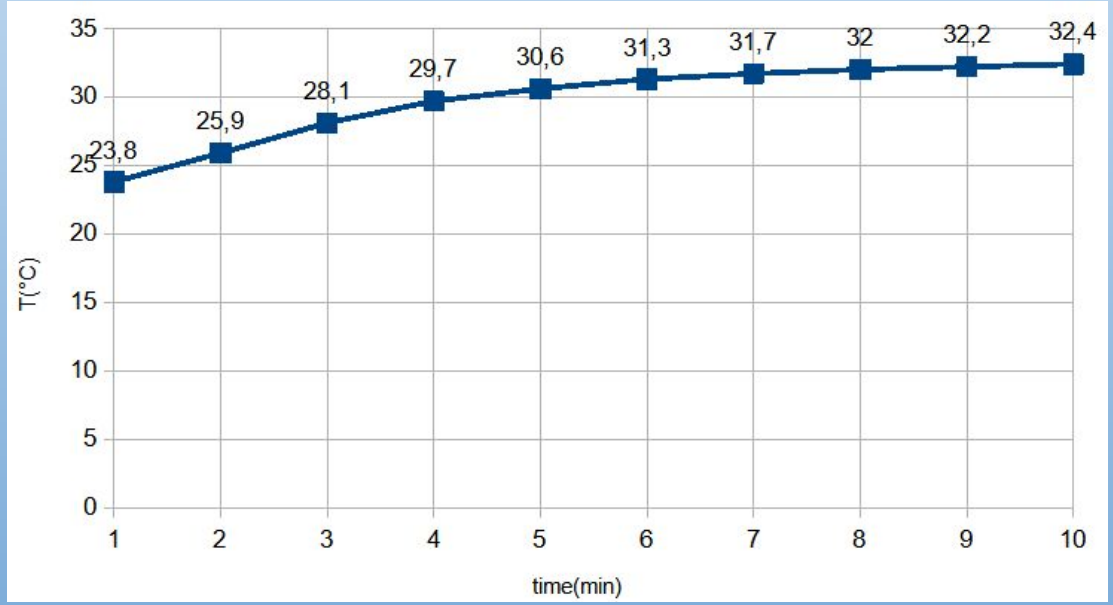
Mixture of solid and liquid paraffin wax

Determining paraffin wax suitable for the desired properties

<u>50 grams of solid paraffin</u>

<u>75 grams of liquid paraffin</u>

The result of this experiment gave the desired result. The ratio we should use is 1:1.5.



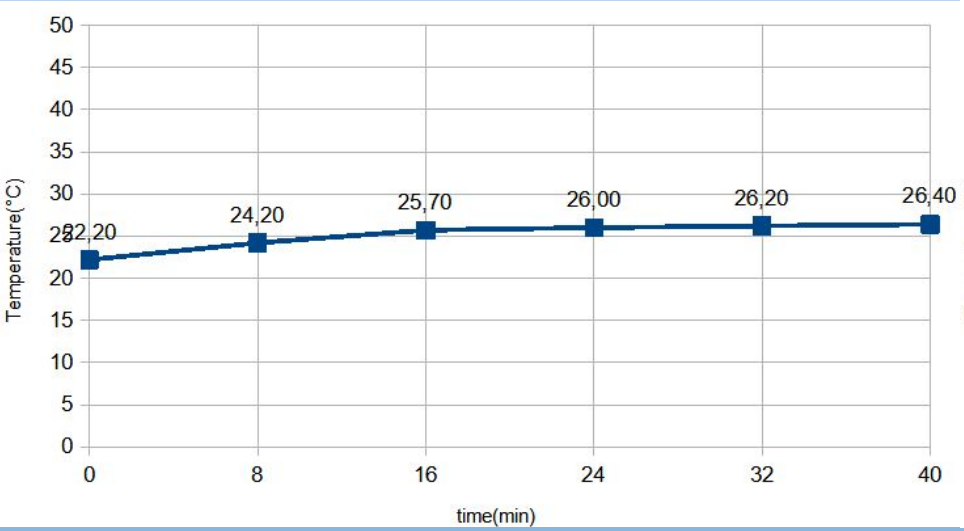
Application of materials to the server cabinet

Paraffin wax filled cells

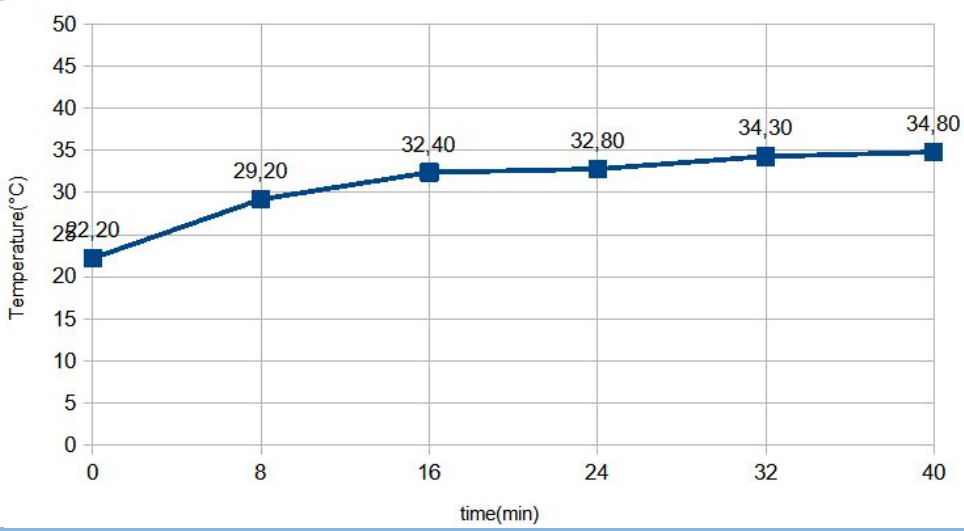
Server cabinet configuration with PCM

Configurations for our experiments

Examination of paraffin wax performance in the experimental setup (for configuration 2)



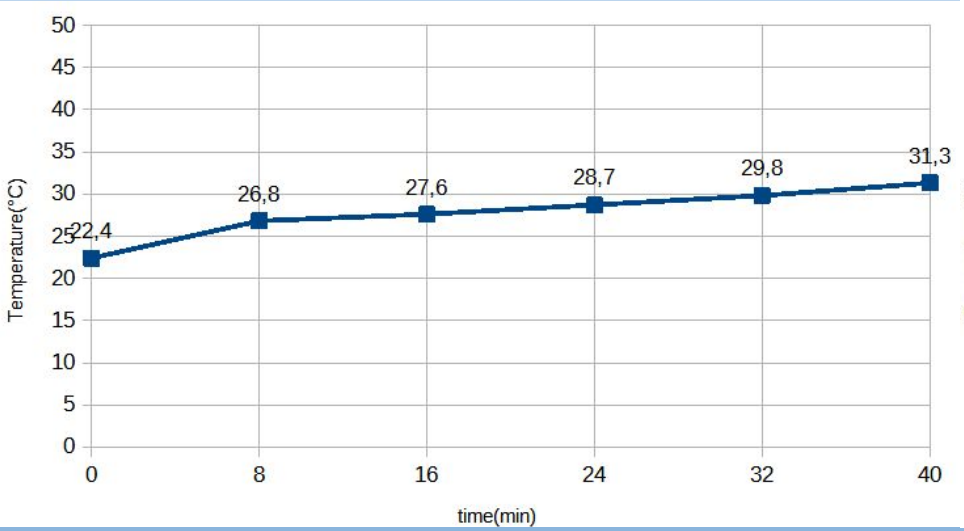
Server cabinet cooling using paraffin wax



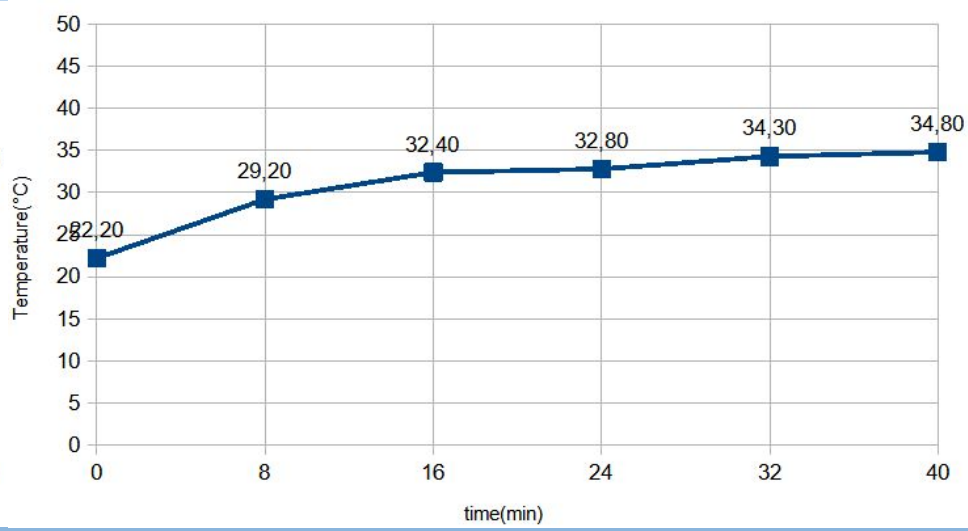
Server cabinet without any PCM

Examination of powder pcm performance in the experimental setup

(for configuration 2)



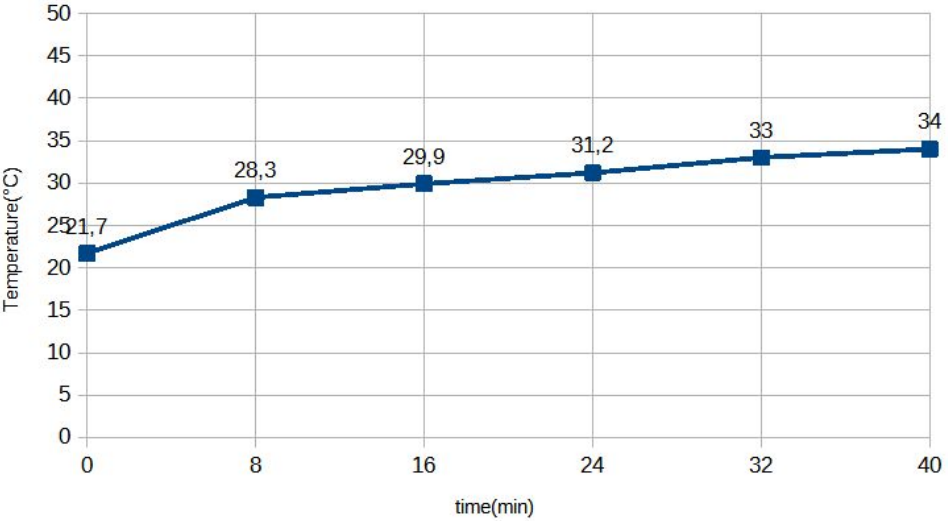
Server cabinet cooling using powder PCM



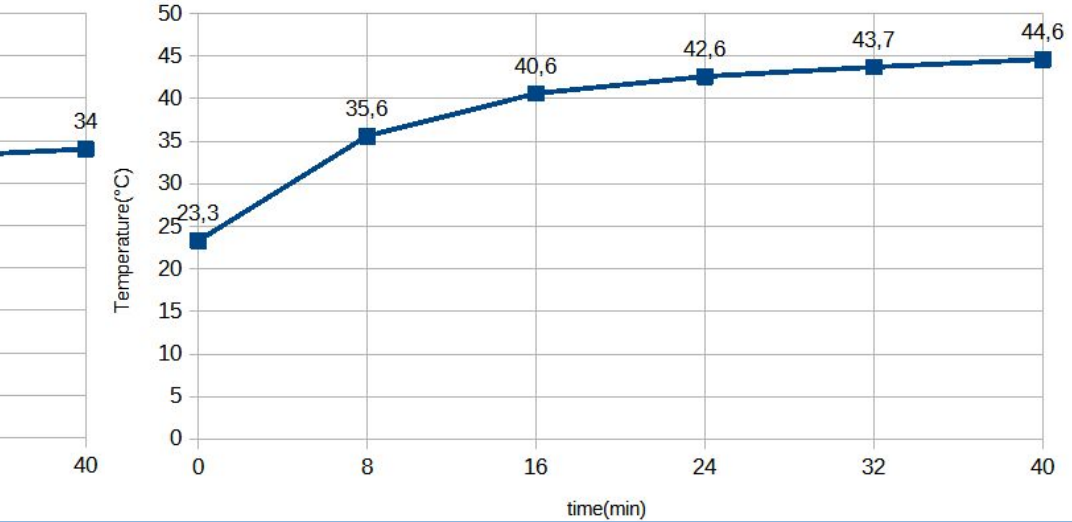
Server cabinet without any PCM

Examination of paraffin wax performance in the experimental setup

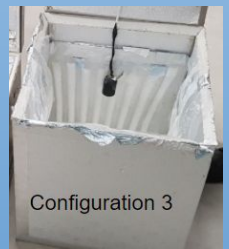
(for configuration 3)



Server cabinet cooling using paraffin wax



Server cabinet without any PCM



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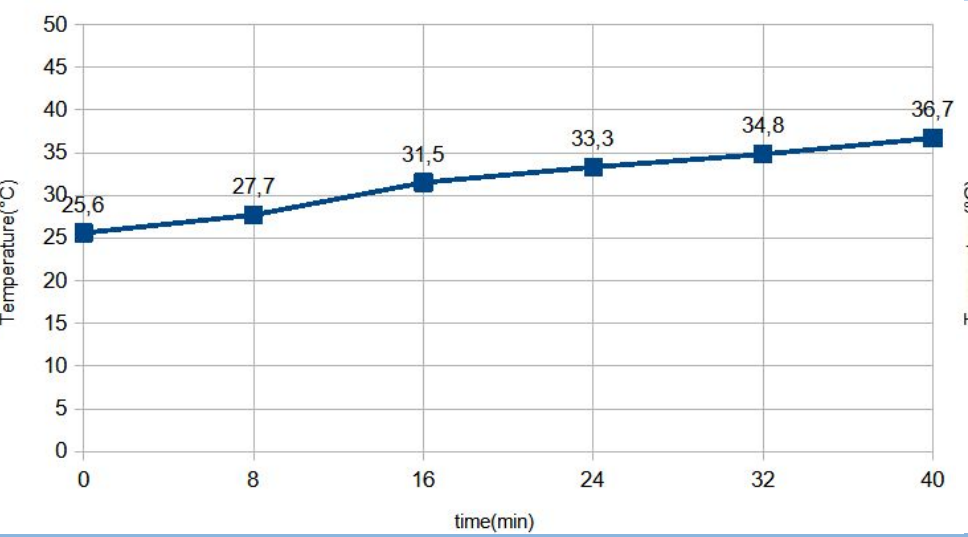
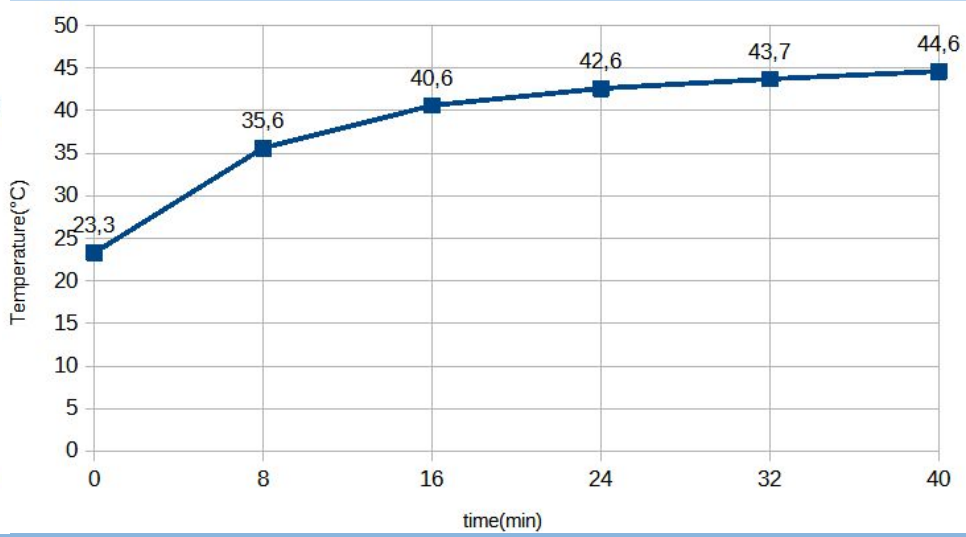
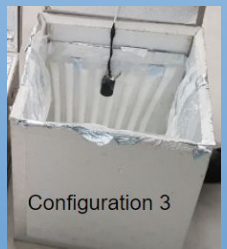


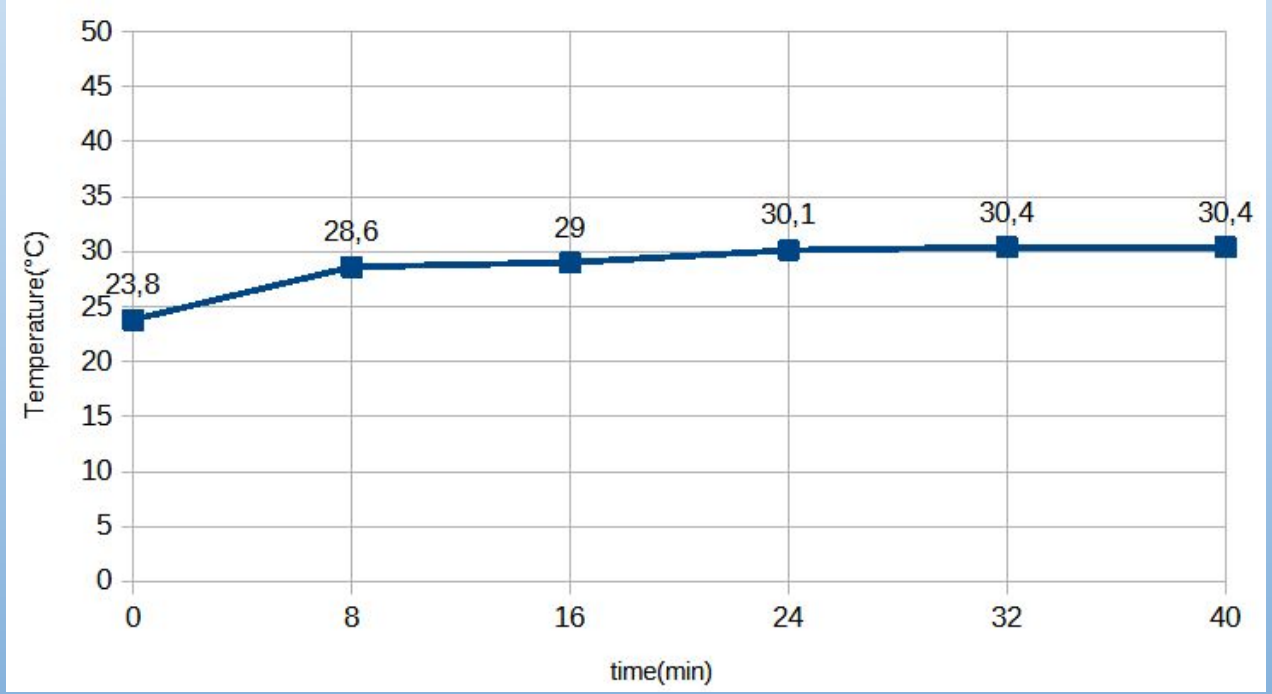
Server cabinet cooling using powder PCM



Server cabinet without any PCM



Temperature test of powder pcm and paraffin wax mixture in cabinet (for configuration 2)



Things to do for ME 492

We will design an air based cooling system for data centers and be focusing on simulation and analysis.

References

(1) “Phase Change Material Plastic Panel PCM for Outdoor Telecom Cabinet Cooling”, https://www.alibaba.com/suppliersubdomainalibabacom/product-detail/Phase-Change-Material_Plastic-Panel-PCM_60181144083.html

(2) ‘’Thermal Time Shifting: Leveraging Phase Change Materials to Reduce Cooling Costs in Warehouse-Scale Computers, Manish Arora, Dean M. Tullsen, page 3’’

(3) “How to Use ASHRAE Data Center Cooling Standards”, https://www.dataaire.com/how-to-use-ashrae-data-center-cooling-standards

(4) “Dell EMC PowerEdge R740 Technical Specifications”, https://www.dell.com/support/manuals/tr-tr/poweredge-r740/per740_techspecs_pub/standard-operating-temperature?guid=guid-7c06327e-0776-43bd-8347-0604f24b1598&lang=en-us

(5) “Rubitherm RT35 Datasheet”, https://www.rubitherm.eu/media/products/datasheets/Techdata_-RT35_EN_09102020.PDF

Thank you for your attendance.