جامعة أبوظبي
ABU DHABI UNIVERSITY

The 5th Undergraduate Research Competition (URC)

Research title:

Designing and building a cooling system with enhanced heat transfer features based on novel ideas utilizing superior heat transfer cooling media

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OUTLINE

- Introduction
- System configurations
- Theoretical calculation
- Results and discussion
- Conclusion
- Acknowledgement

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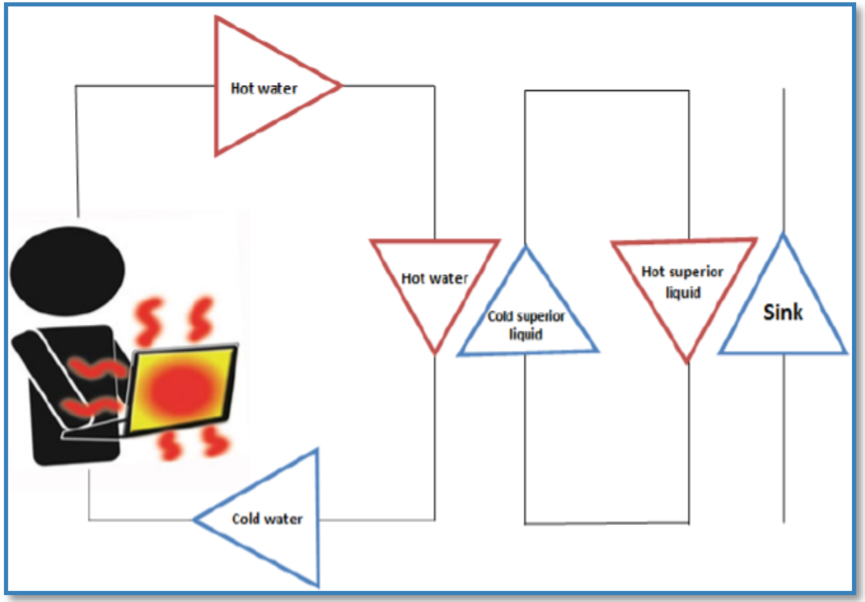
Introduction 📖

Introduction

- Technology is one of the leading industries of the 21st century is undergoing rapid developments
- Vital to all sectors of life

This research aimed to:

- Tackle the challenges of building an enhanced and compact cooling system
- Design an effective heat sink



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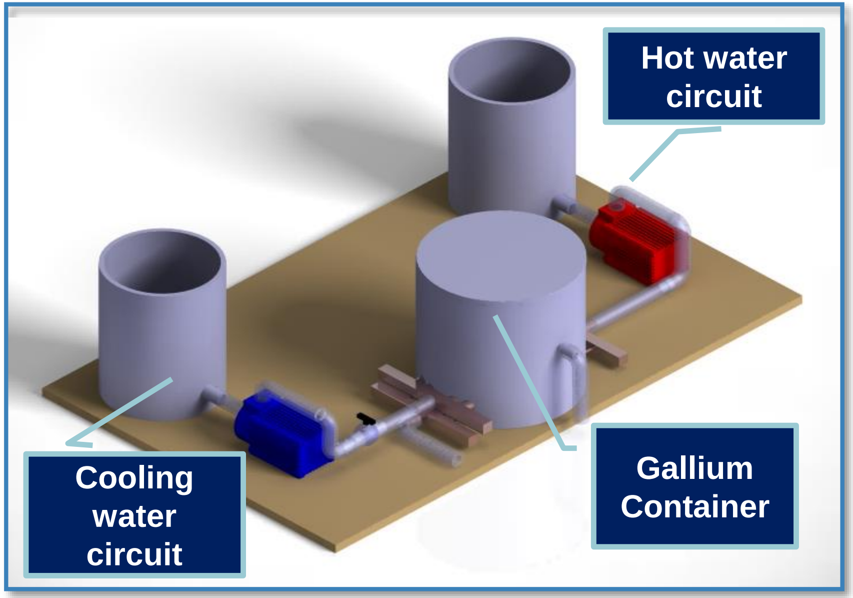
System configurations

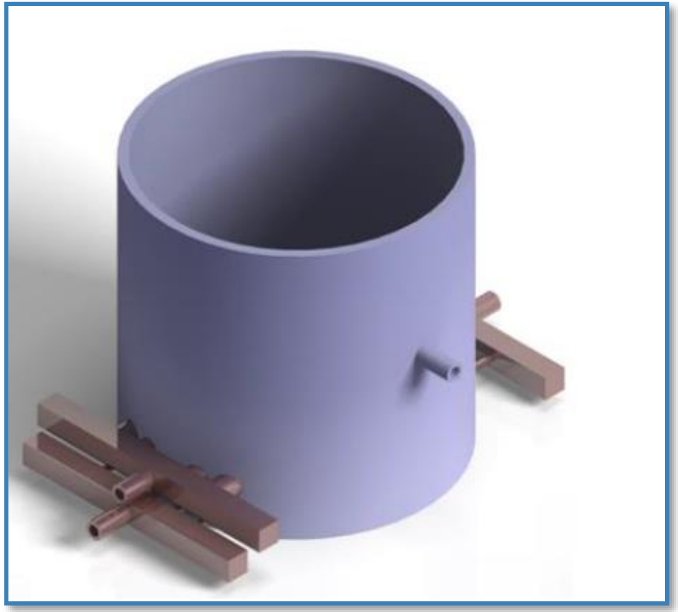
System configurations

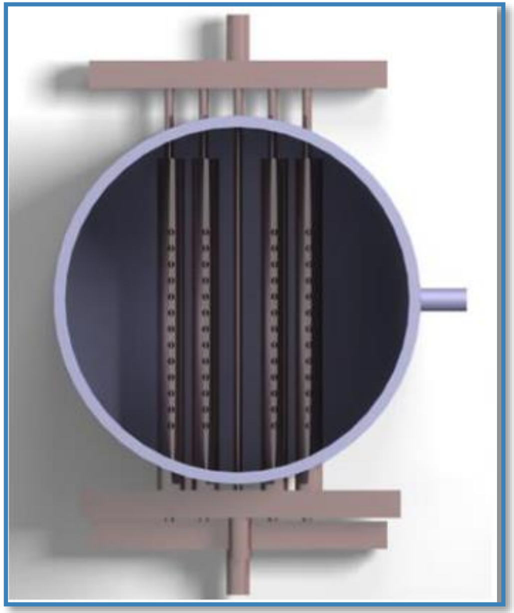
The system consists of:

1. Gallium container
2. Hot water circuit which consists of:
    a. Hot water pump
    b. Bubble distributor
3. Cooling water circuit which consists of:
    a. Cooling water pump
    b. Cooling water network
    c. Water reservoir



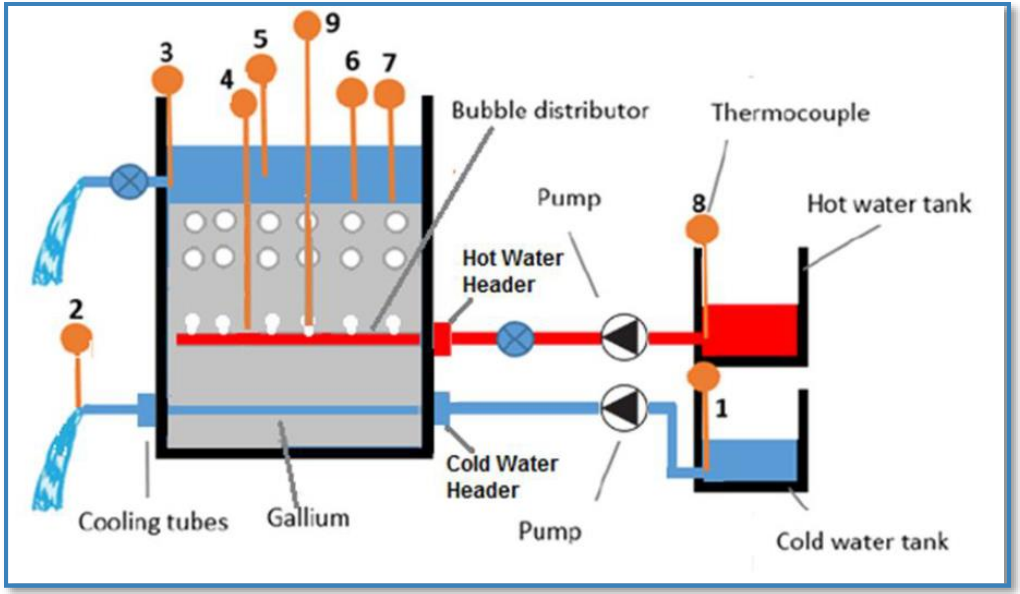
System configurations





Experimental System configurations

Thermocouple number	Thermocouple position
1	Cold water tank
2	Cold water at the exit
3	Cooled water at the outlet
4	Gallium
5	Cooled water
6	Bubble exit
7	Bubble exit
8	Hot water tank
9	Bubble distributor opening



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Theoretical calculation

Theoretical calculation

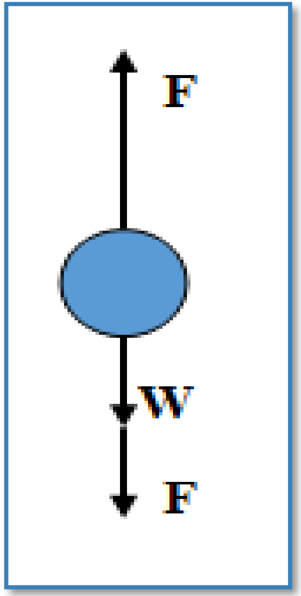
Bubbling system Calculation:

- To illustrate bubble motion inside gallium bath, Newton second law is applied:

$$F_B - W - F_D = ma$$

$$\rho_g v_w g - \rho_w v_w g - \frac{1}{2}\rho_g V^2 A C_D = ma$$

- By using ODE45 and curve-fitting tool in MATLAB, the above equation was solved



Theoretical calculation

Velocity

$$V = 0.2862 * e^{-0.2269t} - 0.288 * e^{-226\,t}$$

Reynolds Number

$$Re = \frac{\rho_g v D}{\mu_g}$$

Nusselt Number

$$Nu = 2 + +0.47 Re^{1/2} Pr^{0.36}$$

Heat transfer coefficient

$$h = Nu \times \frac{k}{D}$$

Heat transfer

$$\dot{Q} = hA_s(T_s - T_\infty)$$

Theoretical calculation

- Fixed gallium bath temperature values are considered; 30oC, 40oC, and 50^{o}C
- A bubble diameter range of 1mm to 5 mm has been selected for the computations.
- The initial bubbles’ temperatures are comparable to the ones encountered in the experiment namely 50^{o}C and 60^{o}C

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Results and discussion

Computed results

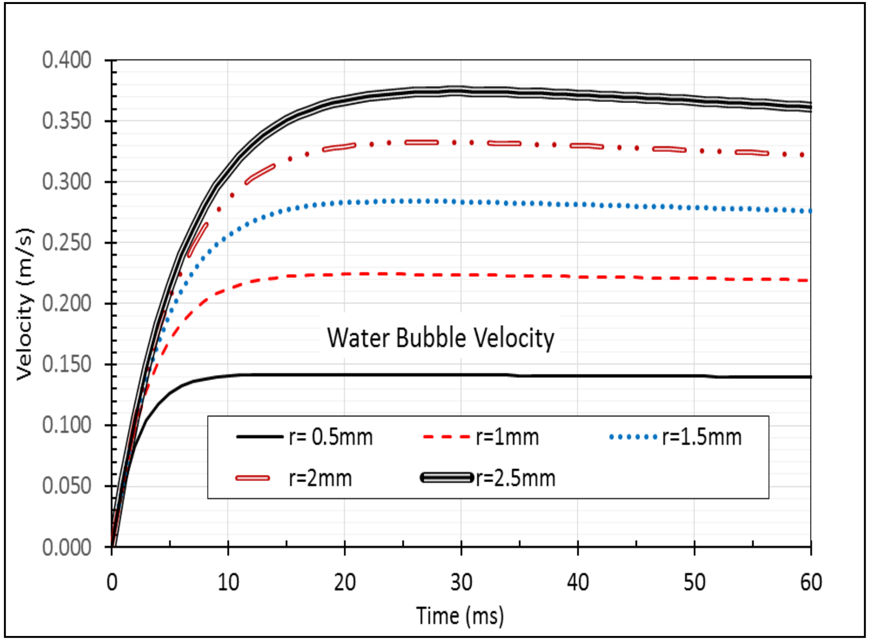
- Based on Newton's Second Law, the following

  equation was obtained:

$$202x10^3r^3 = 9.3x10^3V^2r^2C_D + 4.2x10^3r^3\dot{V}$$

- Solving the above equation gives:

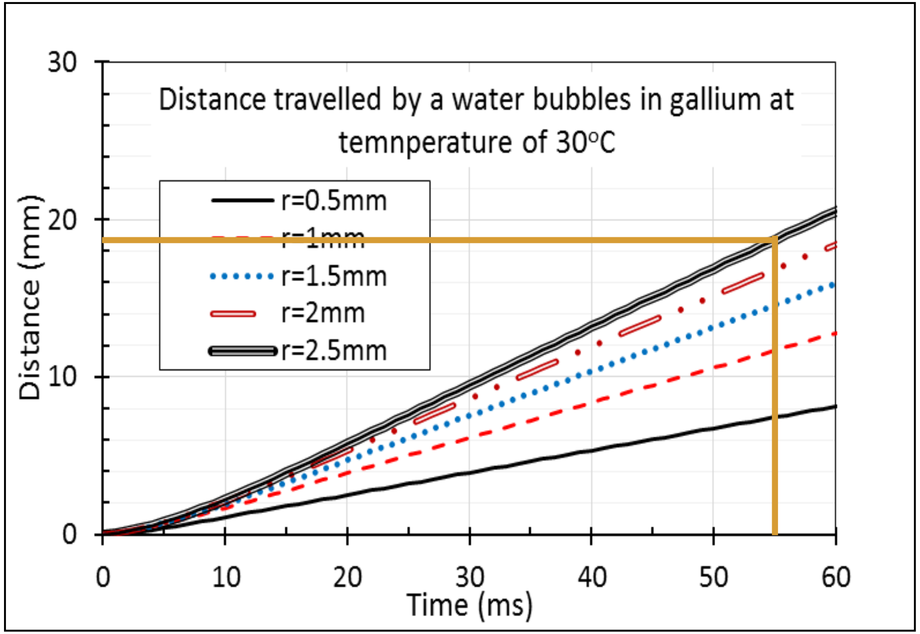
$$V = 0.2862 * e^{-0.2269t} - 0.288 * e^{-226\,t}$$



Computed results

A single bubble takes 55 ms to drop its temperature by 20 ^oC

Corresponds to distance of 18 mm



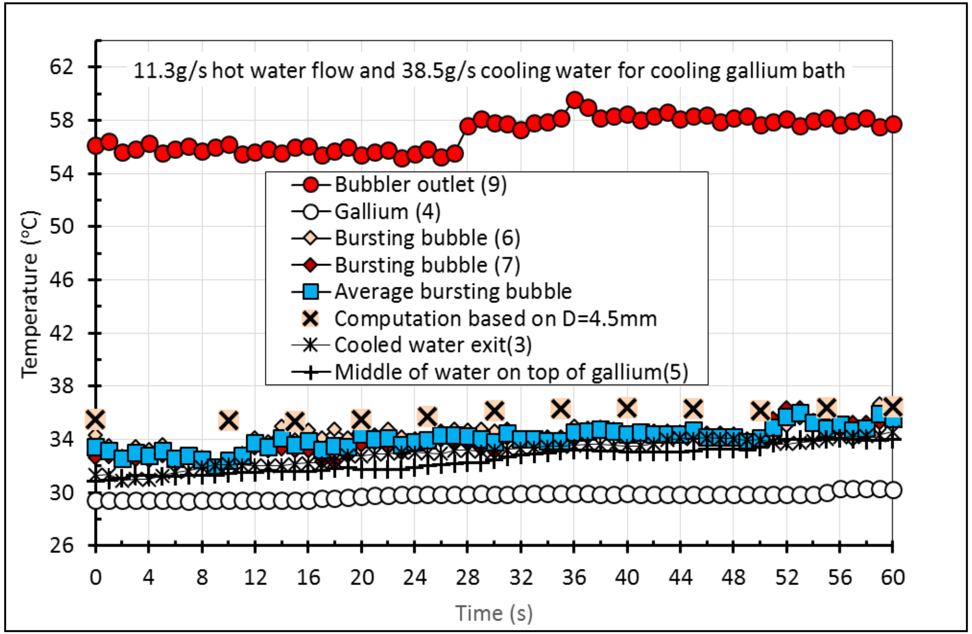
Experimental results

Testing conditions:

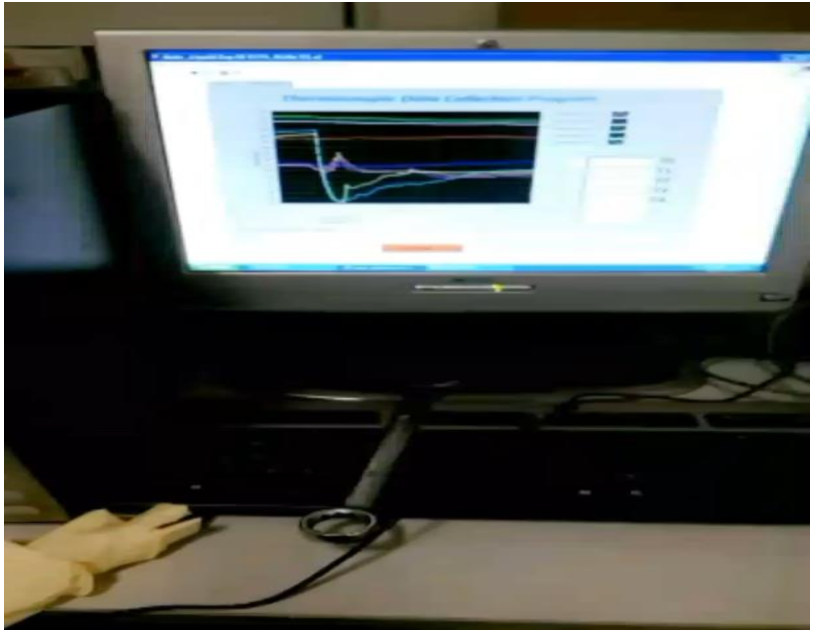
- Cooling water circuit flow rate: 38.5 g/s
- Hot water flow rate: 11.3 g/s
- Gallium's bath temperature: 30 ºC
- Initial bubbling temperature: 60 ºC.
- Monitoring time: 1 minute

Results:

- Heat removal rate: 1 kW
- Hot water experiences cooling by about 20ºC
- Gallium's temperature kept constant



Experimental results



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Conclusion

Conclusion

- **A direct-contact heat exchanger with imbedded cooling water tubes within the gallium bath has been designed, built, and assessed experimentally and it was found:**

- It's possible to cool down water by 20 ^{o}C using a 18 mm layer of gallium
- The computed results have satisfactory agreement with the experimental results
- Conventional heat exchanger systems requires 70 to 80 cm length comparing with 18 mm gallium thickness for the same heat removal rate

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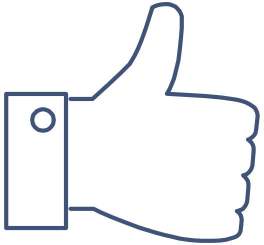
Acknowledgement ♡



THANKS!

Any questions?