DOCTORAL THESIS DEFENSE

Pool Boiling of Water–Glycerin Mixtures

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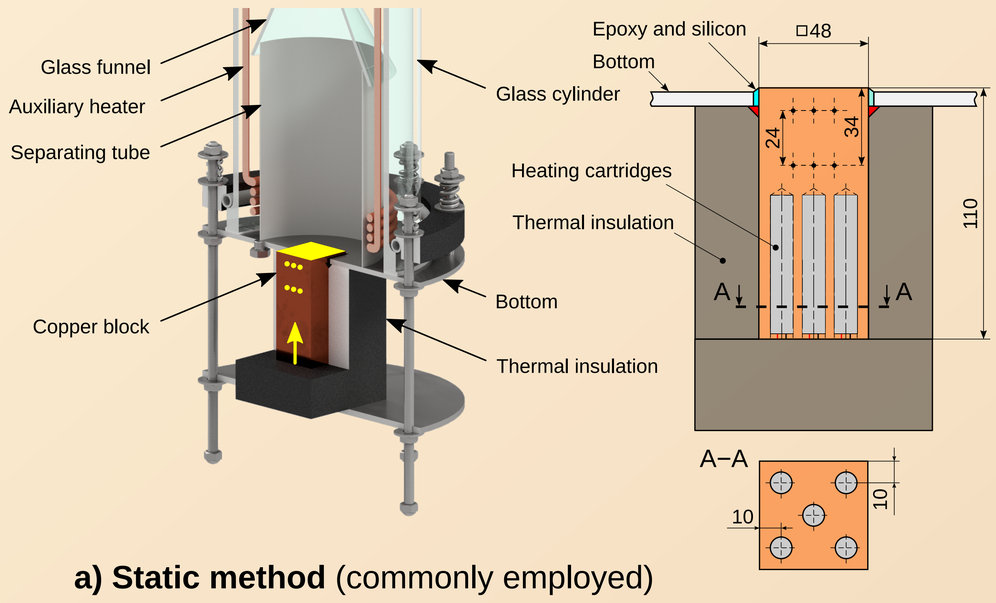
1. THESIS OBJECTIVES

The thesis experimentally investigates the following **research issues** related to heat transfer during boiling of **water–glycerin mixtures**:

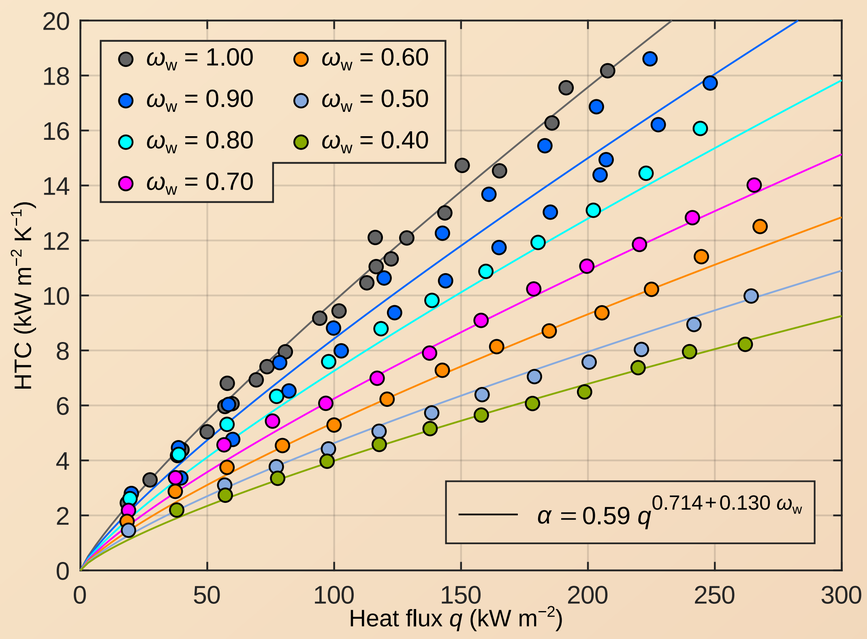
1. Is the heat transfer performance of water–glycerin mixtures reported in the literature comparable with the investigated **planar surfaces made of different materials**?
2. Are there some trends **universal** for water–glycerin mixtures instead of trends valid only for a certain liquid–surface combination?
3. Do HTCs in mixtures with **lower glycerin content** follow the same trend with respect to mixtures with higher amount of glycerin?
4. Are water–glycerin mixtures able to **enhance boiling HTC**?
5. How do the heat flux and mixture composition affect the most important **nucleation parameters**?
6. What is the impact of **subcooling** on HTC?
7. Is it possible to correlate the measured HTCs using **simple correlations** which do not require mixture properties?
8. Are the investigated surfaces prone to **interaction** with water–glycerin mixtures? Are the HTCs **stable** in time?

2. POOL BOILING EXPERIMENTS

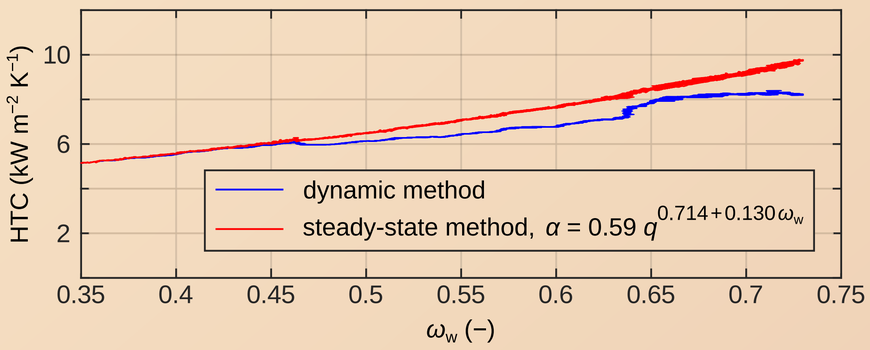
① COPPER SURFACES:



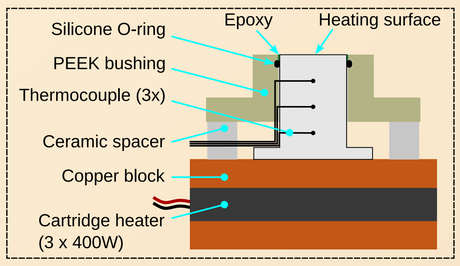
a) Static method (commonly employed)

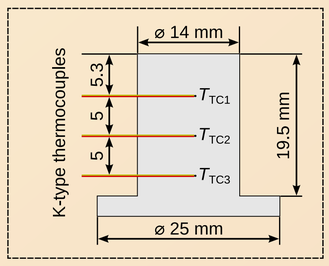


b) Dynamic method (own method of measurement)

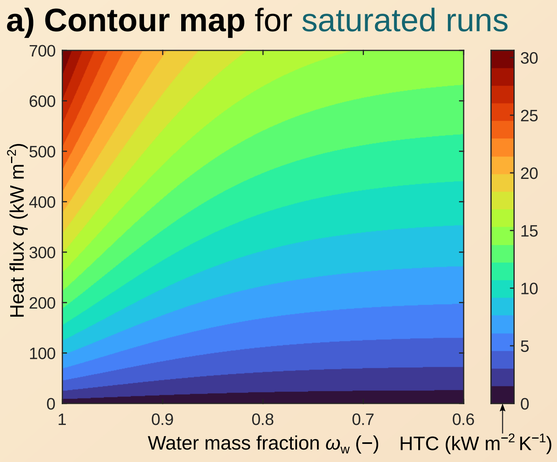


② NICKEL-PLATED SURFACES:

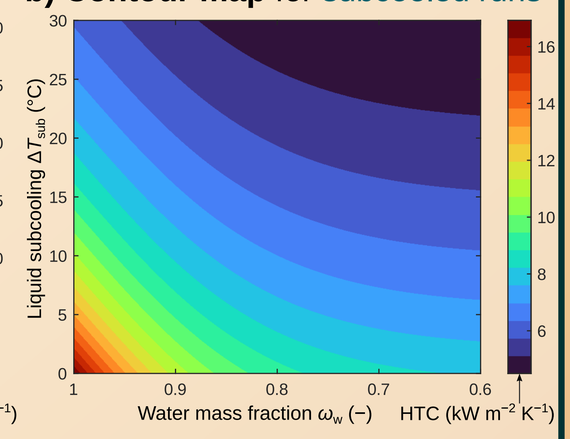




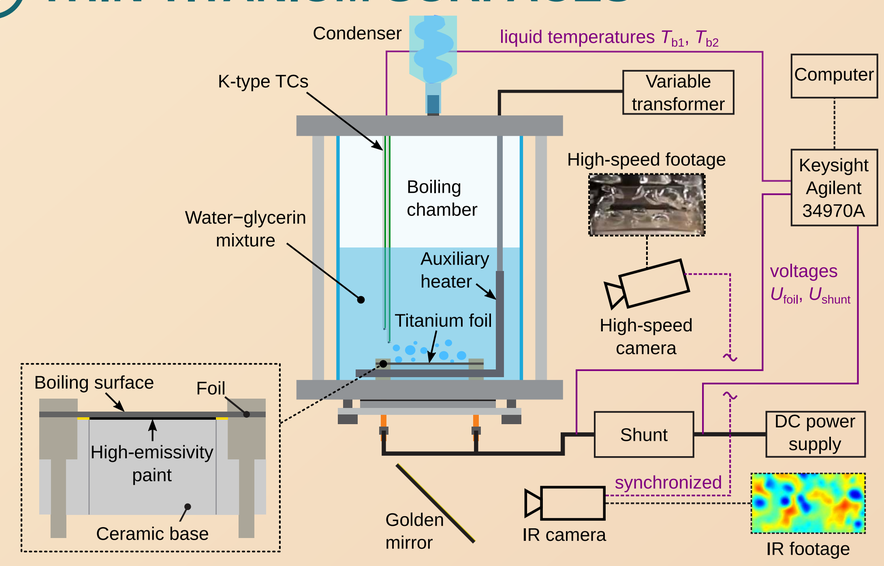
a) Contour map for saturated runs



b) Contour map for subcooled runs



③ THIN TITANIUM SURFACES



Investigation of the most important nucleation parameters

- Bubble departure diameter $D_b = 6.53 \times 10^{-2}\, q^{-0.19}$
- Nucleation frequency $f_n = 8.88 \times 10^{-9}\, q^{1.73}\, \omega_w^{-1}$
- Bubble growth rate $f_n D_b = 5.80 \times 10^{-10}\, q^{1.54}\, \omega_w^{-1}$
- Thermal energy Q_b transferred per single nucleation event

Table of measured values and trends

Quantity	Measured values	Adding glycerin	Increasing q
D_b	$3.7 \le D_b \le 5.3$ mm	Independent	Decreases
f_n	$3.7 \le f_n \le 16.5$ s^{-1}	Increases	Increases
$D_b f_n$	$19 \le f_n D_b \le 74$ mm s^{-1}	Increases	Increases
Q_b	$Q_b \approx 46$ mJ	Independent	Independent

3. CONCLUSIONS

- **HTC deteriorates** with increasing concentration of **glycerin**. The decrease is steeper for mixtures with a lower glycerin content.
- ***Mixture effects*** have a **substantial impact** on HTC. No HTC enhancement was detected for any of the investigated mixtures.
- Effect of **subcooling** and **composition** is more important for **less subcooled** mixtures with **lower glycerin** content. Correlations applicable for saturated boiling were found to be suitable for **developed subcooled boiling of mixtures**.
- Heat transfer **into the liquid phase** was found to be **more important** than transport of latent heat by bubbles.
- Heating surfaces made of **copper** were found to be **less stable** compared with the nickel-plated and titanium surfaces.
- **Suitable correlations** adopted from the literature were identified and **empirical correlations** were **proposed** which does not require thermophysical properties of investigated mixtures.