Microbubble Emission Boiling Dataset

Description

This dataset contains boiling curve data extracted from figures and tables in 14 published papers on microbubble emission boiling (MEB) [1–14]. The compiled dataset totals 333 digitized points across 35 curves drawn from 14 papers. Two normalized quantities are derived for every row: wall super heat and heat flux . All other digitization metadata, which figure or table a point came from and the extraction method, is preserved per row so any curve can be traced back to its source and re-checked.

Data structure

The compiled dataset and its supporting files are:

[d1] digitized_boiling_curves.csv — the compiled dataset: 333 rows, one per digitized point, covering 35 curves from 14 papers. Column schema in the table below.

[f1] comparison_all_curves_combined.png — a single larger combined figure (log-scale heat flux) with all curves and a shaded literature-range envelope where ≥ 2 curves overlap in wall temperature.

[i2] boiling_curve_analysis.ipynb — an executed Jupyter notebook that loads [d1] directly and reproduces the comparison plots inline, with additional examples for plotting a single paper or a hand-picked subset of papers.

Column schema of the compiled dataset [d1]

Column	Description
paper_id	Identifier for the source paper (folder-name style, e.g. inada_2016_cavitation_bubble_blow_pit). See References for the full citation of each paper_id.
curve_id	Identifier for one curve/series within a paper's figure (e.g. a specific subcooling, surface, or condition).
x_value	Digitized x-axis value as read from the source figure, in its original unit.
x_unit	Unit of x_value as given in the source figure (K or °C for wall superheat / ΔT).
y_value	Digitized y-axis value as read from the source figure, in its original unit.
y_unit	Unit of y_value as given in the source figure (before normalization).
source_type	Always “digitized_figure” in this dataset — every row comes from a figure, not a printed table.
extraction_method	Always “manual_pixel_digitization_screening” — identifies the method as hand pixel-grid calibration, not automated vectorization.

Column	Description
figure_id	Filename of the source figure crop (e.g. Figure_5.pdf) within the paper's extracted_output folder.
table_id	Filename of the source table, when a point came from a printed table rather than a figure (blank for all rows in this dataset).
notes	Free-text notes: what the curve represents, any simplification applied (e.g. multiple near-overlapping series combined), and known caveats.
wall_superheat_K	Derived: wall superheat normalized to K (numerically identical to a ΔT in °C).
heat_flux_W_m2	Derived: heat flux normalized to W/m² from whatever unit the source figure used.

References

1. Inada, S., Shinagawa, K., Illias, S.B., Sumiya, H., Jalaludin, H.A. (2016). Micro-bubble emission boiling with the cavitation bubble blow pit. *Scientific Reports*, 6, Article 33454. doi:10.1038/srep33454.

2. Kobayashi, H., Kurose, K., Ueno, I. (2022). On homogeneity of vapor bubbles' oscillation and corresponding heat transfer characteristics and boiling sound in microbubble emission boiling (MEB). *International Journal of Heat and Mass Transfer*, 188, 122564. doi:10.1016/j.ijheatmasstransfer.2022.122564.

3. Otake, A., Kobayashi, H., Kurose, K., Ueno, I. (2025). High-frequency oscillation of coalesced vapor bubbles and resultant ambient liquid motion in microbubble emission boiling in subcooled pool. *International Journal of Heat and Mass Transfer*, 242, 126832. doi:10.1016/j.ijheatmasstransfer.2025.126832.

4. Sinha, K.N.R., Ranjan, D., Kumar, N., Raza, M.Q. and Raj, R., 2020. Simultaneous audio-visual-thermal characterization of transition boiling regime. Experimental Thermal and Fluid Science, 118, p.110162.

5. Tang, J., Mo, Z., Sun, L. and Yan, C., 2017. An experimental study on microbubble emission boiling in a subcooled pool: heat transfer characteristics and visualized presentation. Experimental Thermal and Fluid Science, 80, pp.40-52.

6. Unno, N., Noma, R., Yuki, K., Satake, S.I. and Suzuki, K., 2022. Effects of surface properties on wall superheat at the onset of microbubble emission boiling. International Journal of Multiphase Flow, 155, p.104196.

7. Wojtasik, K., 2021. Boiling of water at low pressure: the role of subcooling and thermophysical properties on the bubble dynamics and heat transfer (Doctoral dissertation, Université de Lyon; Wrocław University of Science and Technology).

8. Zhu, G., Sun, L., Tang, J., Mo, Z. and Liu, H., 2014. A visualized study of micro-bubble emission boiling. International Communications in Heat and Mass Transfer, 59, pp.148-157.

9. Litvintsova, Y.E., Laouar, S., Delov, M.I., Kuzmenkov, D.M., Lavrukhin, A.A. and Kutsenko, K.V., 2020, November. Diagnostics of coolant boiling onset based on the analysis of fluctuations of thermohydraulic parameters. In Journal of Physics: Conference Series (Vol. 1689, No. 1, p. 012042). IOP Publishing.

10. Liu, B., Yu, L., Zhang, Y., Di Marco, P. and Wei, J., 2020. Enhanced nucleate pool boiling by coupling the pinning act and cluster bubble nucleation of micro-nano composited surfaces. International Journal of Heat and Mass Transfer, 157, p.119979.

11. Ono, J., Aoki, Y., Unno, N., Yuki, K., Suzuki, K., Ueki, Y. and Satake, S.I., 2023. Acoustic state detection of microbubble emission boiling using a deep neural network based on cepstrum analysis. International Journal of Multiphase Flow, 166, p.104512.

12. Sinha, K.N.R., Kumar, V., Kumar, N., Thakur, A. and Raj, R., 2021. Deep learning the sound of boiling for advance prediction of boiling crisis. Cell Reports Physical Science, 2(3).

13. Horiuchi, K., Kobayashi, H., Miyashita, S., Hori, T., Ueno, I. (2021). Spatial–temporal thermal-fluid behaviors of microbubble emission boiling (MEB). *AIChE Journal*, 67(8), e17193. doi:10.1002/aic.17193.

14. Ueki, Y. et al. (2024). Acoustic state sensing of subcooled boiling heat transfer on a CuCrZr surface using a deep neural network for divertor application. *Fusion Science and Technology*. doi:10.1080/15361055.2024.2435193