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T h e R e v i e w

of Doctoral Thesis

Viktor Vajc : *Pool Boiling of Water-Glycerin Mixtures*, Czech Technical University in Prague, Faculty of Mechanical Engineering, Prague, 2022.

The submitted Doctoral Thesis contains 138 pages with title page, acknowledgements, Annotation Sheet, Table of Contents, List of Figures, List of Tables, Nomenclature, and text of Thesis, which consists of Introduction and Scope of This Thesis, Part I Theoretical Background, Part II Pool Boiling Experiments, Part III Conclusions, References, list of Author´s Publications, and Part IV Appendices.
The topic of the Doctoral Thesis is investigation of pool boiling of mixtures. Namely parameters of heat transfer at nucleate boiling are evaluated and analysed.
Theoretical approach is based on literature data. Chapter 1 deals with saturated and subcooled pool boiling. Modes of pool boiling are described. The most important parameters of boiling are introduced. From literature achieved correlations for heat transfer during nucleate boiling are presented. Chapter 2 summarizes important data on pool boiling of multicomponent mixtures. Namely, achieved correlations for heat transfer during boiling mixture are introduced In Chapter 3 boiling of water-glycerin mixtures is described. Thermodynamic data on properties of water-glycerin mixtures are briefly presented. In Chapter 4 research gaps in the literature are identified in eight issues. With respect to them, eleven aims of the Doctoral Thesis are introduced.
Experimental investigations of the nucleate pool boiling of water-glycerin mixtures performed by the author of the Doctoral Thesis are presented. Chapter 6 presents results of experiments performed on a smooth cooper horizontal square heating surface. In Chapter 7 the saturated and subcooled pool boiling experiments which were performed on five smooth nickel placed samples are discussed. Chapter 8 deals with the measurements performed with a smooth thin titanium foil when monitoring with infrared camera was used. Chapter 9 points out general experimental findings achieved by the author of the Doctoral Thesis. Chapter 10 recapitulates achieved results of the performed experiments.
In Conclusion twelve paragraphs summarize experimental results and evaluated data on pool nucleate boiling of investigated water-glycerin mixtures.
In References two hundred twenty seven literature items are cited. Among them six references are published by the author of the Doctoral Thesis as their co-author. Further eight publications are introduced as other author´s publications.
Four Appendices deals with details of investigations by means of infrared camera.

Assessment

Convection processes associated with phase changes of fluids are still topical problems in scientific and engineering investigations. Rational design and reliable operation of components in which phase changes occur dictate that relevant phase change processes be well understood. Regardless significant effort devoted to phase changes research from many workers and research institutions and by them achieved remarkable results, still concentrated investigations in scientific and engineering projects for new knowledge of phase change

processes continue go on. The author of the Doctoral Thesis turned his research activity to pool nucleate boiling of water-glycerin mixtures. He performed careful survey in available literature and chose goals for his research. Extensive theoretical analyses of nucleate pool boiling initiate his experimental investigations of nucleate pool boiling of water-glycerin mixtures on heating horizontal surfaces made of different materials. Heat transfer coefficient during saturated nucleate pool boiling of binary mixtures of water and glycerin at atmospheric pressure conditions is measured and investigated. The reviewer highly appreciates the author´s experimental investigation of nucleate boiling of fluid mixtures. The author´s experimental apparatus enabled him to perform experiments with three different materials of heating surfaces – with cooper, nickel, and titanium – mixtures were studied with water mass fraction from 100% down to 40%. Measured parameters and evaluated values of heat transfer coefficient were a basis for derivation of his empirical correlations for heat transfer coefficients. The empirical correlations are original and unique findings – they are dependences of heat transfer coefficient for nucleate boiling on heat flux and water mass fraction. The achieved data proves considerable influence of material of heating surface on heat process at nucleate boiling. Further influence of water concentration is proved and expressed by correlations. Special experiments were performed with thin titanium foil when infrared camera was used. Very interesting dependences of the footprint diameter of bubbles, nucleation frequencies and bubble growth rates on heat flux and water mass fraction are evaluated.

Achieved results by the author of the Doctoral Thesis are valuable for further research of nucleate boiling of water-glycerin mixtures. Namely evaluated correlations are significant contribution for design and operation of systems with nucleate boiling of binary mixtures. It is possible to state that the goals proposed by the author of the Doctoral Thesis were achieved.

The submitted Doctoral Thesis is topical contribution to investigation, design and operation of systems with water-glycerin mixtures at nucleate boiling. Undoubtedly, further research and technical projects with nucleate boiling of binary mixtures will follow this achieve experience and knowledge. The author proved his good knowledge in the field of heat and mass transfer and his experimental skills. Results of performed analysis of uncertainties of measurements and evaluations are interesting.

The reviewed Doctoral Thesis is understandable. The reviewer found misprints, inconsistencies in the Thesis. For example, empirical correlation for the measured growth rate of temperature footprints on page 112 is not in order (see Eq.(8.8)). The reviewer has to state that the author´s findings - "HTC decreased with increasing ω_w, the trend is accented for higher q and ω_w." - introduced on pages 110, 111, 112 are not correct in given regiones of water mass fractions and heat fluxes. Pool nucleate boiling does not occur at zero heat fluxes as it is introduced on pages 111 and 112. These notes do not affect outstanding achieved results.

The reviewer has following notes and questions :

1st Diagram on Figure 3.3 on page 61 is named "The phase diagram of water-glycerin mixtures near atmospheric pressure…" Diagram on Figure 3.3 is a detail of phase diagram of water-glycerin mixtures. It is a section in thermodynamic p-T-ω_w diagram. Has the author of the Doctoral Thesis data of p-T diagram of water-glycerin mixtures with ω_w = const.?

2nd Figure 1 is illustrative diagram q-ΔT for explanation occurrence of boiling regions. Can the author of the Doctoral Thesis derive his correlations into form q = f(ΔT, ω_w) and to draw them in diagram logq-ΔT? It would be very strong argument on influence of mass concentration ω_w on expression nucleate boiling regimes.

3rd Results obtained by the author of the Doctoral Thesis by means of infrared camera are undoubtedly very valuable. Table 8.2 on page 105 gives values of nucleation frequencies on border of audibility at infrasound. Have the author some experience

with acoustic effects at pool nucleate boiling at his experiments? Is it possible from his results obtain values of Strouhal number or other similarity criterions?

4th Let us return to findings "HTC decreased with increasing ω_w, the trend is accented for higher q and ω_w.". Of course, heat transfer coefficent deccreases with increasing high heat flux. Reviewer considers a start of heat transfer coefficient decrease to be onset of region of transition to film boiling. Has the author some experience with of the boiling crisis?

Conclusion

Submitted Doctoral Thesis is on very good level and contributes to research and design in the field of mechanical engineering. The author fulfilled proposed goals. The author performed theoretical analysis for initiation of experimental investigations of nucleate pool boiling of water-glycerin mixtures on heating horizontal surfaces made of different materials. The author designed and built test units and perform experiments with three different materials of heating surfaces – with cooper, nickel, and titanium. He achieved valuable results for evaluation his own correlations for nucleate pool boiling The author proved his creative capacities and his very good professional knowledge in the field heat and mass transfer and experimental thermomechanics. The reviewer

recommends Doctoral Thesis by Mr. Viktor Vajc for defence

before the Committee for Defence of his Doctoral Thesis in the study field Design and Process Engineering. After successful defence it is recommended to award a degree

Philosophiae Doctor (PhD.)

to Mr. Viktor Vajc.

Prague August 2nd, 2022