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IMPACT OF DRYNESS DEGREE X ON PARAMETERS OF TWO-PHASE FLOW OF WATER IN SLICK VERTICAL TUBE

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Abstract: *In this study will be treated the correlation of tube wall temperature and heat transfer coefficient of saturated vapour from the dryness degree for different levels. For analysis will be used specified mass of saturated vapour flowing in slick vertical tube with specified diameter and temperature that is heated with unalterable quantity of heat. Analysis is done with the help of mathematical model and computer program for different levels of the dryness degree. The results provide a clearer overview for functional correlation of technical and hydraulic parameters with dryness degree of saturated vapour.*
Key words: *tube, vapour, temperature, dryness degree*

1. INTRODUCTION

The motion of two phase flow during the heat transfer depends on a number of different characteristics. All characteristics are mainly related to the mutual hydrodynamic action of phases among themselves and to the frozen wall as well as to the changes that contribute to the hydrodynamic flow of phase transition (Sacadura, 1993). For theoretical analyses made in this study is used the overall linkage between variables and qualitative interdependences, respectively between unknown specific operands and those determined by different authors (Gorodecki, 1987), (Michael & Howard, 2004), and (Kutepov & Sterman, 1983). For this particular case the correlation of the tube wall temperature and heat transfer coefficient of saturated vapours is determined for different levels of dryness degree x. From the analysis of this correlation it will be observed that for greater values of dryness degree x, the heat transfer coefficient of saturated vapours and its temperature will be lower. The obtained results can be used for comparison with experimental ones.

2. MATHEMATICAL MODEL

During the motion of flow containing of vapour-water, the speed of vapour and water phase is different. In elevating tubes the speed of mixture of vapour phase is greater than the speed of liquid phase, whereas in release tubes it is smaller. Hence, to continue with a dimensional analysis, we avoid the flow speed at entrance and instead we rely on superficial mass flux, G, along the tube:

$$G = \frac{\dot{m}}{A_{pipe}} \left(\frac{kg}{m^2 s}\right) \tag{1}$$

This mass flow per surface unit is constant throughout the tube if the flow is stable. As a result, Reynold's number can be determined "only for fluid"

$$\mathrm{Re}_{l_o} = \frac{G\,D}{\mu_f} \tag{2}$$

Which would be Reynold's number if the entire mass flow was fluid.

Friction factor for slick tubes is provided in the equation

$$f = \frac{1}{\left(1.82\log_{10} R_{eD} - 1.64\right)^2} \tag{3}$$

Whereas Nuselt's number for tubes with slick walls according to Gnielinski (John, L.IV & John, L.V, 2005) can be calculated with equation:

$$N_{u_D} = \frac{(f/8)\left(R_{eD} - 1000\right)P_r}{1.07 + 12.7\sqrt{f/8}\left(P_r^{2/3} - 1\right)} \tag{4}$$

For $2300 \leq R_{eD} \leq 5 \circ 10^6$

Accordingly, the physical arguments suggest that the functional dimensional equation for heat transfer coefficient, should take the following shape for the flow of saturated vapour in vertical tubes:

$$h_{fb} = f_n\left(h_{lo}, G, x, h_{fg}, q_w, \rho_f, \rho_g, D\right) \tag{5}$$

It should be noted that other characteristics of fluids, such as viscosity and conductivity, are indirectly represented through hlo according to equation

$$h_{l_0} = \frac{k_f}{D} N_{U_D} \tag{6}$$

Functional equation (5) has eight dimensional variables (and one dimensional variable, x) per unit (m, kg, s, J, K).

These ways are obtained three times more dimensional groups under x, respectively:

$$\frac{h_{fb}}{h_{l_0}} = f_n\left(x, \frac{q_w}{G \circ h_{f_g}}, \frac{\rho_g}{\rho_f}\right) \tag{7}$$

In fact, the problem is simpler than this since the arguments related to the pressure gradient show that the quality and rapport of density can be joined in a single group, known as convection number:

$$C_0 = \left(\frac{1-x}{x}\right)^{0.8} \left(\frac{\rho_g}{\rho_f}\right)^{0.5} \tag{8}$$

Other group of dimensions in equation (7) is called boiling number:

$$B_0 \equiv \frac{q_w}{G\, h_{fg}} \qquad (9)$$

Therefore

$$\frac{h_{fb}}{h_{lo}} \equiv f_n\left(B_0, C_0\right) \qquad (10)$$

According to Kandlikar (John, L.IV & John, L.V, 2005) two correlations h_{fb} / h_{lo} can be calculated with sufficient accuracy, as follows:

$$h_{fb}\Big|_{nbd} = h_{lo}(1-x)^{0.8}\left[0.6683 C_0^{-0.2}\ f_0 + 1058 B_0^{0.7}\ F\right] \quad (11a)$$

$$h_{fb_{cbd}} = h_{lo}(1-x)^{0.8}\left[1.136 C_0^{-0.9}\ f_0 + 667.2\ B_0^{0.7}\ F\right] \quad (11b)$$

Where: "nbd"- means "nuclear boiling domination" and "cbd" means "convection boiling domination", f_0 -orientation factor, F - fluid dependent parameter for which is recommended F=1 for non corroded tubes for regimens with dryness degree $0 < x \le 0.8$. From above correlations h_{fb} / h_{l_0} the greater value is selected.

The wall temperature is determined according to the following equation:

$$T_w = T_b + \frac{q_w}{h_b} \qquad (12)$$

3. CALCULATIONS AND RESULTS

Model for analyzing the dependence of the tube wall temperature and enthalpy of saturated vapour for different levels of dryness degree x requires the following entry data: m=0.5 kg/s; T_b=227 ^{0}C; D=0.0445 m; q_w=176000 W/m^2; x=5 – 35 %; μ_f=0.0001177 kg/ms; P_r=0.853; k_f=0.6439 W/mK; F=1; ρ_g=13.2 kg/m^3; ρ_f=831.3 kg/m^3; h_{fg}=1828000 J/kg; f_0=1.

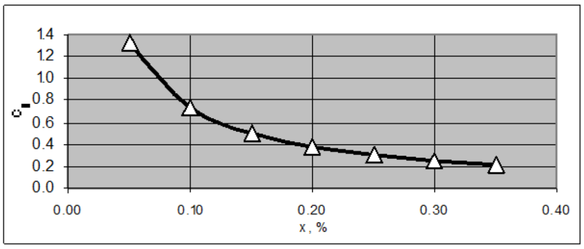

Fig. 1. Impact of x on factor Co as per Eq. (8)

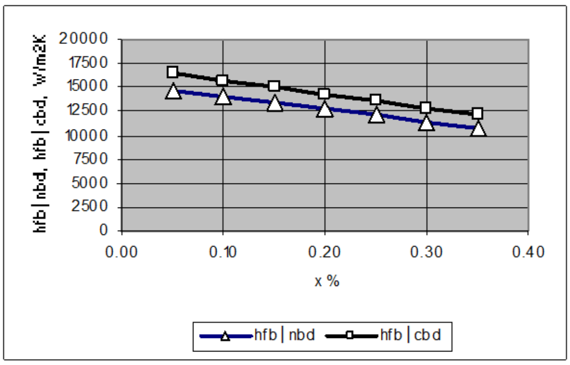

Fig. 2. Impact of x on $h_{fb}\big|_{nbd}$ and $h_{fb}\big|_{cbd}$ as per Eq. (11a) and Eq. (11b)

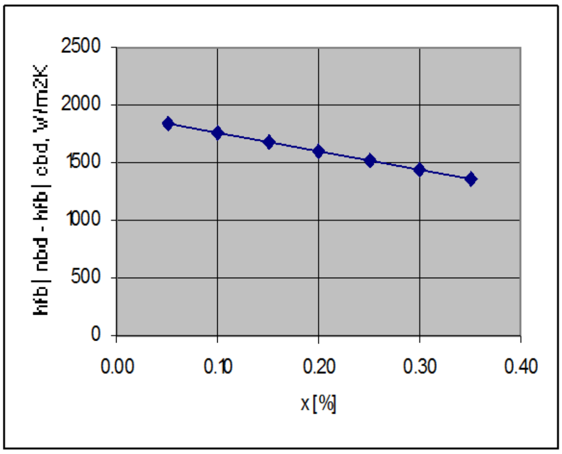

Fig. 3. Impact of x on difference $h_{fb}\big|_{nbd} - h_{fb}\big|_{cbd}$

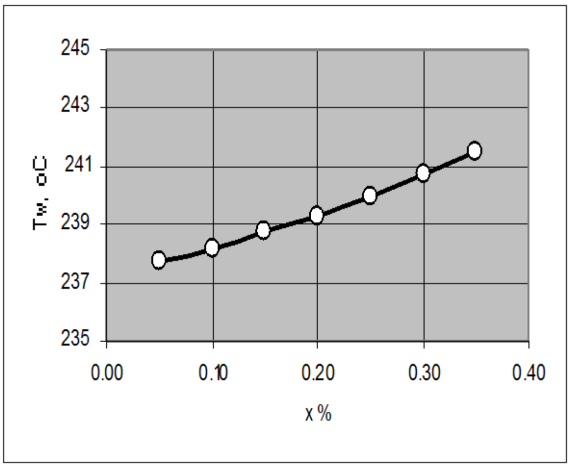

Fig. 4. Impact of x on T_w as per Eq. (12)

4. CONCLUSION

As provided in fig.1, convection number C_o is in exponential correlation with the dryness degree *x*. For lower values of dryness degree *x* convection number C_o has smaller values whereas for greater values of dryness degree *x* convection number C_o has greater values.

Whereas for greater values of *x* values $h_{fb}\big|_{nbd}$ and $h_{fb}\big|_{cbd}$ are lower. Whereas for greater values of x the difference $h_{fb}\big|_{nbd} - h_{fb}\big|_{cbd}$ is lower.

The internal temperature of tube wall is high for greater values of the dryness degree *x* and vice versa.

5. REFERENCES

John, L.IV & John, L.V (2005). A h*eat transfer textbook, third edition, Cambridge, Massachusetts, U.S.A*

Gorodecki, A., (1987). *Steam cooling of metallurgical aggregates*, Metallurgy, ISBN5-229-00711-7, Moskva

Michael, J. & Howard, N. (2004). *Fundamental of Engineering Thermodynamics*, John Wiley, ISBN 0-471-27471-2, Hoboken

Kutepov, M. & Sterman, S. (1983). *Hydrodynamics and heat transfer in the creation of steam*, BBK 31. 31 K95 YDK 621.1.7, Moskva

Sacadura, J. (1993). *Knowledge for thermal transfer*, TEC&DOC, ISBN 2-85206-618-1, Paris