MODELLING OF PRESSURE-DROP INSTABILITY IN SINGLE AND MULTI MICROCHANNELS

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Abstract: In the paper the model of pressure-drop oscillations has been proposed. The model was based on the iterative solution to equations. The dynamics of pressure-drop oscillations in a single channel and in two neighbouring channels have been analyzed. There has been assumed that the pressure-drop oscillations in the system are caused by interactions between the heat supply system and liquid supply system. These interactions influence the heat and mass transfer inside the microchannel. Obtained results indicate that the shape of pressure drop curve has a significant influence on the system stability. When the slope of curve $\Delta p = f(G)$ in the region between function extremes increases then the pressure oscillations become chaotic. In case of multichannel system the thermal interactions (occurring through the channel walls) and hydrodynamic interactions (occurring inside the common channels outlet) have been considered. Four types of two-phase flow behaviours in parallel channels have been observed depending on the intensity of interactions: alternate oscillations, consistent oscillations, periodic oscillations and completely synchronized oscillations. Obtained qualitative results have been compared with conclusions of experimental results reported by other researches. The good qualitative agreement with experimental results has been obtained.

Key words: Two-Phase Flow Instabilities, Microchannels, Pressure Drop, Flow Oscillations

1. INTRODUCTION

During two-phase flow in microchannel system different types of instabilities may occur. The classification of two-phase flow instabilities was discussed in papers (Kakac and Bon, 2008; Boure et al., 1973). In general they identify two types of instabilities: static and dynamic. The process when the existing state of equilibrium after some disturbance tends to a new different state is called the static instability. The following static instabilities are identified in two-phase flow in microchannels: Ledinegg instability, boiling crisis, flow pattern transition instability, bumping, geysering or chugging. The Ledinegg instability occurs when channel pressure-drop curve versus flow rate has a negative slope and its slope is greater than the slope of liquid supply system curve. When two-phase flow in microchannel cannot absorb the heat supplied to the system then boiling crisis appears. Flow pattern transition instability is connected with oscillations between the bubbly and annular flow regimes (Boure et al., 1973). Bumping, Geysering and Chugging are also considered as static instability and are associated with the process of violent liquid evaporation (Kakac and Bon, 2008).

Dynamic instabilities occur when the disturbed flow cannot reach a new equilibrium point because of complex mechanism of multiple feedbacks occurring in the system. Generally, four types of dynamic instabilities can be distinguished (Kakac and Bon, 2008):

- density-wave oscillations;
- pressure-drop oscillations;
- acoustic oscillations;
- thermal oscillations.

Multiple feedbacks between the mass flow rate, steam generation and pressure drop in the channel are responsible for density-wave oscillations. Density-wave oscillations have low frequency and large amplitudes. The pressure-drop oscillations are connected with existence of compressible volume in the system. The compressible volume amplifies the interaction between microchannel and liquid supply system. Pressure-drop instability causes long period oscillations. The formation of acoustic oscillations is related to the speed of the pressure waves in the system which causes high frequency oscillations. The thermal oscillations of heating surface temperature are connected with transitions between different boiling regimes.

In multi microchannels the channel walls are very thin and the channels interact through the conduction. Other interactions occur in common liquid inlet and outlet. The spatial non-uniform distribution of heat flux density supplied to the multi channel system appears for example in computer systems where the single heat exchanger is installed on the many processors. Dynamics of work of microprocessors causes the changes of spatial distribution of heat flux supplied to the heat exchanger. Such changes finally influence the structure of two-phase flow in neighbouring channels.

In the paper the iterative solution to equations have been used to model the pressure-drop oscillations. The dynamics of pressure-drop oscillations in a single channel and in two neighbouring channels have been analyzed. The thermal and hydrodynamic interactions between channels have been considered. There has been considered the thermal interactions occurring through the channel walls and the hydrodynamic interactions occurring inside the common outlet of channels. The obtained qualitative results have been compared with conclusions of experimental results reported by other researches.

2. MECHANISM OF PRESSURE-DROP OSCILLATIONS

Mechanism of pressure-drop instability was discussed in papers (Liu et al.,1995, Kakac, Bon, 2008). The two conditions must be fulfilled so that this type of oscillations occur: the curve of channel pressure drop versus mass flow rate must have negative slope region and the compressible volume must be in the system. Existence of compressible volume in the system amplifies the interaction between microchannel and liquid supply system. Pressure-drop instability causes long period oscillations (period oscillations is equal about 20 sec, Kakac, Bon, 2008) with high amplitude of pressure, temperature and mass flow rate fluctuations.

During these oscillations the sudden flow changes between subcooled and superheated operating conditions are observed (Liu et al., 1995). In Fig. 1 the example of cycle of pressure-drop oscillations has been presented. The chart has been prepared basing on data presented in (Zhang et al., 2010). Sudden flow change is shown by two line segments: D-A and B-C. The mechanism of pressure-drop oscillations is as follows. When boiling is initiated in microchannel, then more vapour appears in two-phase flow. It causes the increase in pressure drop. Compressible volume (surge tank) starts to accumulate the liquid because the channel exit is blocked by vapour. The system pressure drop increases until it reaches the peak (point D, Fig. 1). Accumulated liquid in surge tank is now released - vapour is being pushed out from the channel and system moves to point A (Fig. 1). At this point the amount of liquid leaving the surge tank is greater than the entering liquid. Pressure in the surge tank is decreasing until the point B is reached. In this stage the pressure in the surge tank is too low to prevent the boiling in microchannel and system moves to point C (Fig. 1). Now the channel exit is being blocked by vapour which causes that the liquid is accumulated in the surge tank and the system pressure drop is increasing until it reaches the point D. Now the cycle repeats again. Between points A-B and C-D the stable flows in microchannel are observed.

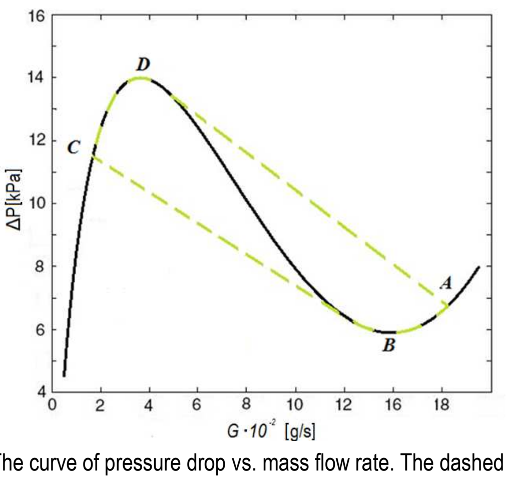

Fig. 1. The curve of pressure drop vs. mass flow rate. The dashed line shows the cycle of pressure-drop oscillations. The chart has been prepared based on data presented in Zhang et al., (2010)

The process of the sudden changes between two operating conditions very often has periodic character but the chaotic changes are also reported in papers (Hardt et al.,2007).

3. MODELLING OF HEAT AND MASS TRANSFER IN MICROCHANNEL

To describe the heat and mass transfer in microchannel the mass, momentum and energy balance equations inside the micro channel should be considered. This set of equations should be supplemented by relationships describing the mechanism of phase change, interactions between phases and equations describing the behaviours of liquid and heat supply systems.

In modelling of heat and mass transfer in microchannel system the many assumptions are usually considered. Different types of models are used to describe the behaviour of two-phase flow in microchannel. The most commonly used models are: homogeneous flow, separated flow and drift flux (Kakac and Bon, 2008; Awad and Muzychka, 2008; Kocamustafaogullari, 1971; Ishii, 1977).

In pressure-drop oscillations the system state oscillates between two kinds of stable two-phase flows. Because the duration of stable two-phase flow regimes is relatively long (e.g. 20 s) therefore, such two-phase flows can be treated in the paper as quasi-steady states. Thus, we can assume that the pressure-drop oscillations occur between two quasi-steady states. This allows us to model the dynamics of such oscillations using the iterative equations, which determines the successive values of the parameters characterizing the quasi-steady states. Such model has a qualitative character, but due to its low mathematical complexity it allows us in easy way to estimate the complexity of the system dynamics. It also allows for the identification of processes responsible for the stability loss.

3.1. Model of a single channel system

In Fig. 2a it has been shown the schema of microchannel system with two systems supplying heat and liquid to the microchannel. The heat supply system consists of the heat source (generating the constant heat flux (q_d)) and the heating surface whose temperature varies in time. The liquid supply system consists of compressible volume (surge tank) which may accumulate the liquid when the channel exit is blocked by vapour. The surge tank is supplied by constant liquid mass flux (G_d). It has been assumed that each steady state of heat and mass transfer in microchannel can be clearly identified by the following parameters: heating surface temperature (T_w), thermodynamic vapour quality (X), liquid mass flux (G), pressure drop (Δp) and heat flux absorbed by boiling liquid (q_b).

It has been assumed that the pressure-drop oscillations in the system are caused by interactions between the heat supply system and liquid supply system. These interactions influence the heat and mass transfer inside the microchannel. In Fig. 2b it has been shown the schema of mutual relationships between two supply systems and heat and mass transfer inside the microchannel. Changes of the value of heat absorbed by boiling liquid in the microchannel cause the changes of heating surface temperature (*I*, Fig. 2b). Such changes (in our model will be described by function f_1) influence the heat and mass transfer inside the microchannel (1, Fig. 2b) and reduce the boiling intensity. Finally, the vapour quality (*II*, Fig. 2b) decreases. In our model these changes will be described by function f_2. The changes influence the liquid supply system (2, Fig. 2b) and modify the pressure drop and mass flux (*III*, Fig. 2b). In our model such changes will be described by functions f_3 and f_4. Such new conditions influence the heat and mass transfer inside the microchannel (3, Fig. 2b). The new liquid flow inside the microchannel modifies the value of heat flux absorbed by boiling liquid (*IV*, Fig. 2b). In our model such changes will be described by function f_5. This new value of heat flux absorbed by boiling liquid influence on the heat supply system (4, Fig. 2b) and the new cycle start again (new quasi-steady state appears inside the microchannel system). The time of one cycle, *Δt*, corresponds with the duration of quasi-steady state. For example in the paper (Zhang et al., 2010) such time is about 20 s. In our model this time period is constant. To complete the model knowledge about five functions, *f*, shown in the Fig. 2b is required.

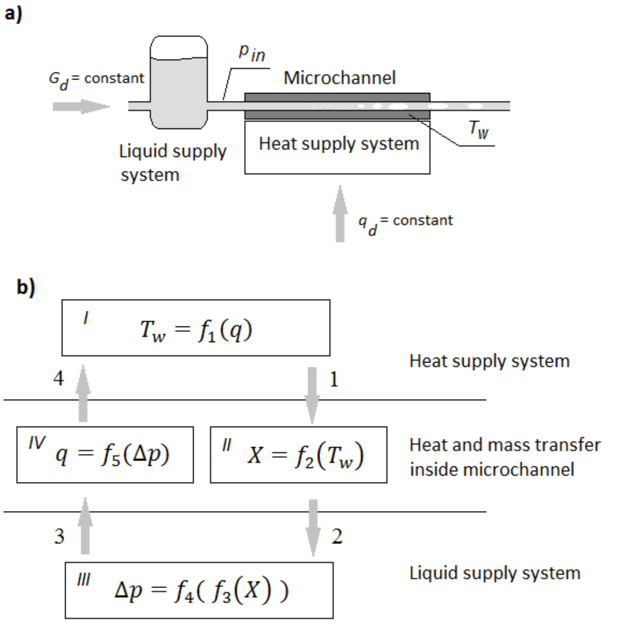

Fig. 2. Model of heat and mass transfer during the pressure-drop oscillations: a) schema of microchannel system. b) schema of algorithm of calculations of the quasi-steady states parameters. 1. Influence of heat supply system on the two phase flow in microchannel, 2. Influence of two phase flow in microchannel on the liquid supply system. 3. Influence of liquid supply system on the two phase flow in microchannel. 4. Influence of two phase flow in microchannel on the heat supply system.

In the paper (Wang et al., 2008) it has been noted that flow instabilities cause oscillates between two quasi-steady states which correspond with minimal and maximal values of wall temperature or pressure drop in microchannel. In the present model it has been used normalized values of parameters describing the heat and mass transfer inside the microchannel. For example the heating surface temperature has been described as follows:

$$T_w = \hat{T}_w(T_{w,max} - T_{w,min}) + T_{w,min} \quad (1)$$

where $\hat{T}_w$ is normalized value of heating surface temperature.

According to Warrier's for the narrow rectangular channel the heat transfer coefficient can be expressed by the following correlation (Warrier et al.2002):

$$\alpha_{tp} = \frac{Nu_3}{Nu_4}(E\alpha_{sp}) \quad (2)$$

where: $\alpha_{sp} = Nu_4 \frac{k_f}{d_h}$

$E = 1.0 + 6Bo^{\frac{1}{16}} - 5.3(1 - 855Bo)X^{0.65}$; $Nu_3 = 8.235(1 - 1.883\beta + 3.767\beta^2 - 5.814\beta^3 + 5.361\beta^4 - 2.0\beta^5)$; $Nu_4 = 8.235(1 - 2.042\beta + 3.085\beta^2 - 2.477\beta^3 + 1.058\beta^4 - 0.186\beta^5)$; $Bo = q/G \cdot h_{lv}$ – boiling number, α_{sp} – heat transfer coefficient ($_{sp}$ – single-phase, $_{tp}$ – two-phase), Nu – Nusselt Number, X – thermodynamic vapour quality, β – aspect ratio, k_f – thermal conductivity, h_{lv} – latent heat of vaporization, d_h – hydraulic diameter.

Considering that:

$$\alpha_{tp} = \frac{q}{(T_w - T_{sat})} \quad (3)$$

The equation (2) allows us to calculate the value of function $X(T_w)$. In Fig. 3 the function $X(T_w)$ obtained for constant q and G is presented.

In Fig. 3 it has been also shown the example of chart of function $\hat{X}(\hat{T}_w)$ prepared for the exemplary oscillations occurring in the rectangular area. For simplifying the future consideration it has been assumed that function $\hat{X}(\hat{T}_w)$ is linear and its values change as it has been shown in Fig. 3.

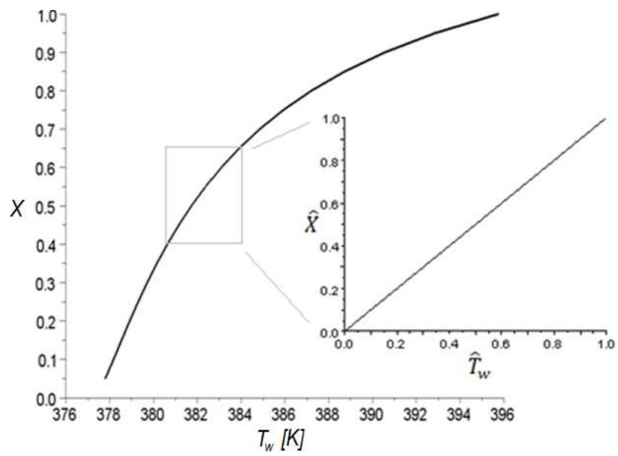

Fig. 3. Vapour quality vs. heating surface temperature. q = 8.5 W/cm^2, G = 200 kgm^{-2}s^{-1}, d_h = 100 μm

The thermodynamic vapour quality is defined as follows (Wang et al., 2008):

$$X = \frac{h_{in} - h_{l,sat}}{h_{lv}} + \frac{A_w Bo}{A_c} \quad (4)$$

where: Bo – Boiling Number, h_{in} – inlet enthalpy, $h_{l,sat}$ – enthalpy of saturated liquid, h_{lv} – latent heat of evaporation, A_w – cross-sectional flow area of each microchannel, A_c – area of microchannel bottom wall and side walls.

In Fig. 4 it has been shown the function $G(X)$ based on equation (4).

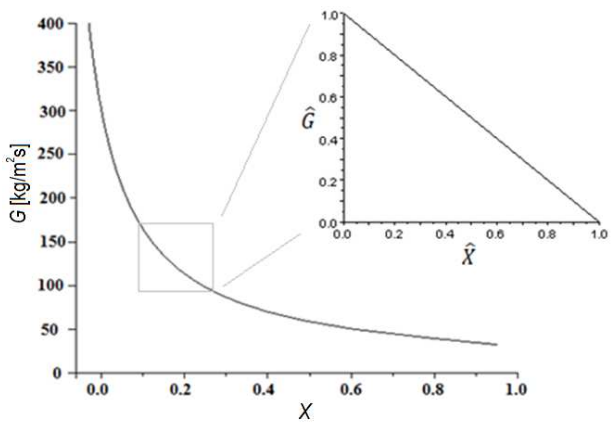

Fig. 4. Function $G(X)$ according to the Eq.4 for d_h = 100 μm, q = 8.5 W/cm^2

Fig. 4 presents the example of chart of function $\hat{G}\,(\hat{X})$ prepared for the exemplary oscillations occurring in the rectangular area. For simplifying the future consideration it has been assumed that function $\hat{G}\,(\hat{X})$ is linear and its values change as it has been shown in Fig. 4.

Pressure drop vs. heat flux is presented in Fig. 5. The chart has been prepared based on data presented in (Weilin, Issam, 2004).

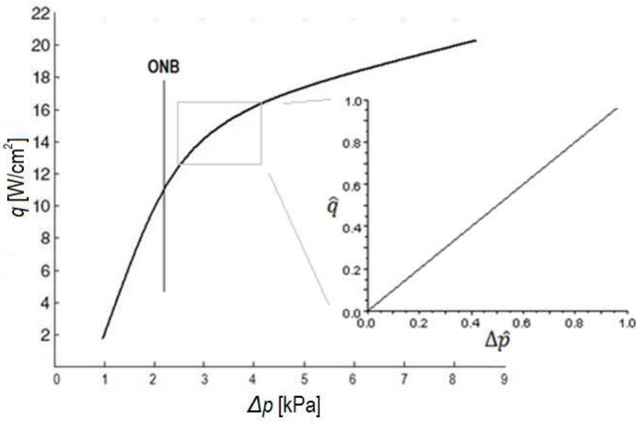

Fig. 5. Heat flux vs. pressure drop. The chart has been prepared based on data presented in (Weilin and Issam, 2004)

In Fig. 5 it has been also shown the example of chart of function $\hat{q}\,(\Delta\hat{p})$ prepared for the exemplary oscillations occurring in the rectangular area. For simplifying the future consideration it has been assumed that function $\hat{q}\,(\Delta\hat{p})$ is linear and its values change as it has been shown in Fig. 5.

Energy balance in time Δt, in a small element of the heating surface with linear dimension δ, leads to the following equation:

$$q_d - q_b = \frac{\delta \cdot \rho \cdot c \cdot (T_{w_{t+\Delta t}} - T_{w_t})}{\Delta t} \quad (5)$$

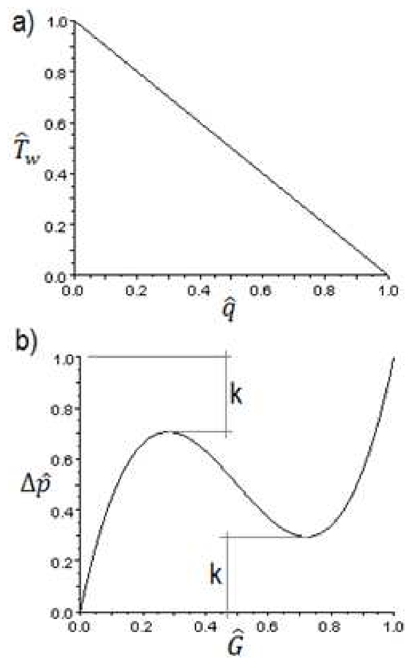

Fig. 6. The functions: f_1 and f_2. a) $\hat{T}_w = f_1(\hat{q}_b)$, b) $\hat{q}_b = f_5(\Delta\hat{p})$

Increase of q_b with constant q_d leads to decrease of T_w. Therefore, the function $\hat{T}_w = f_1(\hat{q})$ has been described by the linear function (with negative slope). The function $\Delta\hat{p} = f_4(\hat{G})$ has a minimum and maximum. It has been considered normalized function where both function values and function arguments are in the range (0, 1). The simulations were carried out for different values of negative slop of function $\Delta\hat{p} = f_4(\hat{G})$. The function has been modified by changing the function values for $G = 0.25$ and $G = 0.75$. It has been assumed that $f_4(0.25) = 1 - k$ and $f_4(0.75) = k$. The modification of value of coefficient k modifies the value of negative slope of function $\Delta\hat{p} = f_4(\hat{G})$. In Fig. 6 there has been shown functions: $\hat{T}_w = f_1(\hat{q})$ and $\Delta\hat{p} = f_4(\hat{G})$.

Finally, the system behaviours (Fig. 2a) have been described by the following five functions:

$$\begin{aligned} &\hat{T}_w = f_1(\hat{q}) \\ &\hat{X} = f_2(\hat{T}_w) \\ &\hat{G} = f_3(\hat{X}) \\ &\Delta\hat{p} = f_4(\hat{G}) \\ &\hat{q} = f_5(\Delta\hat{p}) \end{aligned} \quad (6)$$

where: $\hat{T}_w$ – normalized heating surface temperature, $\hat{X}$ – normalized vapour quality, $\hat{G}$ – normalized liquid mass flux, $\Delta\hat{p}$ – normalized pressure drop in microchannels, $\hat{q}$ – normalized heat flux absorbed by boiling liquid.

Zhang et al., (2010) studied pressure-drop oscillations in parallel-channel system with compressible volumes. They reported oscillations in range from 4 to 14 kPa. Obtained from the model pressure changes were rescaled to values obtained during the experiment. In Fig. 7 there has been shown the examples of function $\Delta p = f_4(G)$ obtained for different values of coefficient k. For $k = 0.38$ the subsequent iterations of set of equations (5) lead to reaching the single stable state in the system. The parameters of such state are shown in Fig. 7a by black dot. For $k = 0.2$, when the value of negative slope increases, the subsequent iterations of set of equations (6) create the periodic cycle between two quasi-steady states marked with black dots in Fig. 7b. The line segment which connects these points is the trajectory of the system. Further increase of the value of negative slope of function $\Delta p = f_4(G)$ (for $k = 0.097$) causes that the subsequent iterations of set of equations (6) create the chaotic time series. Finally, oscillations appear between two sets of quasi-steady states characteristic for subcooled and superheated operating conditions (Fig. 7c). In the right side of the charts (Fig. 7) the schematic picture of flow patterns appearing in the microchannel has been presented.

In Fig. 8 it has been shown the bifurcation diagram of iterations of set of equations (6) for different values of coefficient k. The pressure-drop oscillations starts for the critical value of $k = 0.35$. The chaotic pressure-drop oscillations starts for $k = 0.15$. In the right side of bifurcation diagram the schematic pictures of flow patterns in microchannel characteristic for different value of Δp have been presented.

Obtained results (Fig. 7) indicate that the shape of pressure drop curve has a significant influence on the system stability. When the slope of curve $\Delta p = f_4(G)$ in the region between function extremes increases the pressure oscillations become chaotic. Kakac (Kakac, Bon, 2008) noted that the higher heat flux supplied to the system moves the maximum of pressure drop curve to higher value which causes the increase of the slope of curve $\Delta p = f_4(G)$ in the region between function extremes. Therefore, we can assume that the value of coefficient k corresponds to the amount of heat supplied to the system. Kakac noted also that the increase of the slope of curve $\Delta p = f_4(G)$ in the region between function extremes causes the bigger instability and oscillations become chaotic.

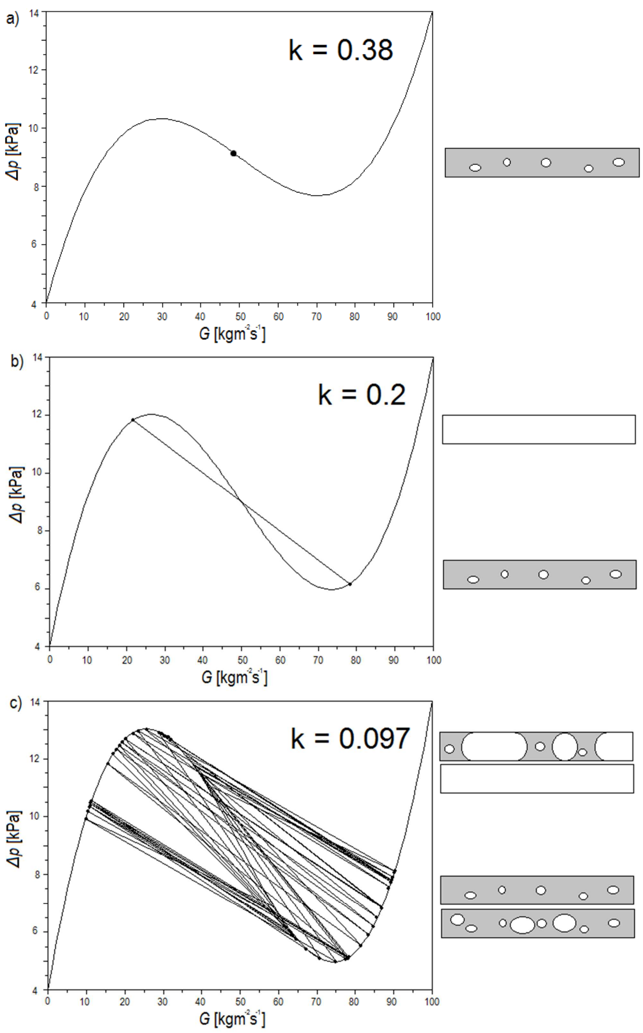

Fig. 7. The examples of subsequent iterations of function $\Delta p = f_4(G)$ for different values of coefficient k. a) k = 0.38, b) k = 0.2, c) k = 0.097

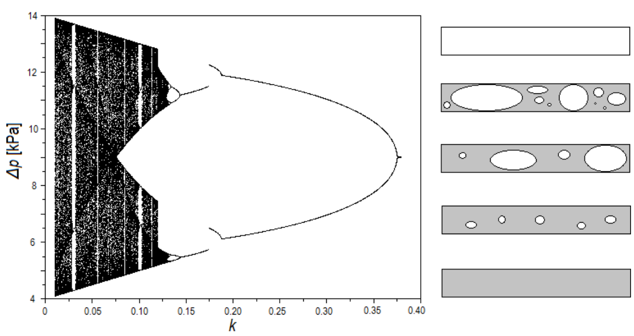

Fig. 8. The bifurcation diagram of iteration of set of equations (5) for different values of coefficient k

From this point of view the qualitative model properties are consistent with experimental results presented in the paper (Kakac, Bon, 2008).

3.2. Two neighbouring parallel microchannels

In case of multi channels system the channel-to-channel interactions may cause the synchronization of heat and mass transfer in neighbouring channels (Chen, 2004).

It the present paper it has been considered two neighbouring microchannels. The two kinds of interactions between channels have been considered:

- thermal (heat transfer between channels q^T);
- hydrodynamic (flow disturbance because of common channels outlet).

In Fig. 9 it has been schematically shown the section of microchannels perpendicular to axis of channels. The heat flux, q_n^T, (where n is a moment of time) modifies the temperature of heating surfaces of microchannels, marked adequately with $T_{w_n}^{1}$ and $T_{w_n}^{2}$. The heat flux, q_n^T, is proportional to difference between heating surface temperatures of each channel $q_n^T \sim T_{w_n}^{2} - T_{w_n}^{1}$. The heating surface temperature changes in time period, Δt, are proportional to the heat flux, q_n^T. For channel 1 there is $T_{w_{n+1}}^{1} - T_{w_n}^{2} \sim q_n^T$. It allows us to estimate the heating surface temperature after time period Δt as follows:

$$\hat{T}_{w_{n+1}}^{1} = \hat{T}_{w_n}^{1} + A_T\left(\hat{T}_{w_n}^{2} - \hat{T}_{w_n}^{1}\right) \qquad (7)$$
$$\hat{T}_{w_{n+1}}^{2} = \hat{T}_{w_n}^{2} + A_T\left(\hat{T}_{w_n}^{1} - \hat{T}_{w_n}^{2}\right)$$

The coefficient A_T describes the intensity of heat transfer between the channels. Its value depends on the distance between channels, their geometry and material of heating surface.

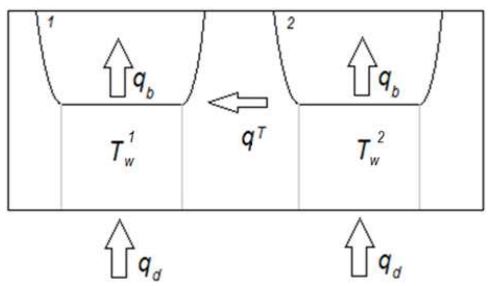

Fig. 9. Schema of heat transfer between two neighbouring channels

Common channels outlet has significant influence on the two-phase flow in neighbouring channels. Changes of kind of two-phase flow in one of microchannel cause the pressure changes in outlet of channels. Such process causes the appearance of pressure difference between neighbouring channel outlets. It causes the flow disturbance, ΔG_n, in each channel. The flow disturbance has been defined as follows: $\Delta G_n \sim G_n^2 - G_n^1$. The flow disturbance, ΔG_n, in each channel is proportional to difference between pressure drop in neighbouring microchannels ($\Delta G_n^1 \sim \Delta p_n^2 - \Delta p_n^1$). Finally, in time period of Δt the pressure drops in neighbouring microchannels vary. The pressure drops after time period of Δt can be estimated as follows:

$$\Delta\hat{p}_{n+1}^1 = \Delta\hat{p}_n^1 + A_p(\Delta\hat{p}_n^2 - \Delta\hat{p}_n^1) \qquad (8)$$
$$\Delta\hat{p}_{n+1}^2 = \Delta\hat{p}_n^2 + A_p(\Delta\hat{p}_n^1 - \Delta\hat{p}_n^2)$$

The coefficient A_p describes the intensity of influence of the pressure drop in neighbouring channels on the two-phase flow. Its value depends on the distance between channels and outlet geometry.

Finally, in subsequent time periods the parameters describing the quasi-steady states are described by the following set of equations.

$$\begin{aligned}
&\hat{T}^1_{w,n} = f_1(\hat{q}^1_n) + A_T \cdot [f_1(\hat{q}^1_n) - f_1(\hat{q}^2_n)]\\
&\hat{T}^2_{w,n} = f_1(\hat{q}^2_n) + A_T \cdot [f_1(\hat{q}^2_n) - f_1(\hat{q}^1_n)]\\
&\hat{X}^1_n = f_2(\hat{T}^1_{w,n}), \hat{X}^2_n = f_2(\hat{T}^2_{w,n})\\
&\hat{G}^1_n = f_3(\hat{X}^1_n), \hat{G}^2_n = f_3(\hat{X}^2_n) \qquad (9)\\
&\Delta\hat{p}^1_n = f_4(\hat{g}^1_n) + A_p \cdot [f_4(\hat{g}^1_n) - f_4(\hat{g}^2_n)]\\
&\Delta\hat{p}^2_n = f_4(\hat{g}^2_n) + A_p \cdot [f_4(\hat{g}^2_n) - f_4(\hat{g}^1_n)]\\
&\hat{q}^1_{n+1} = f_5(\Delta\hat{p}^1_n), \hat{G}^2_{n+1} = f_5(\Delta\hat{p}^2_n)
\end{aligned}$$

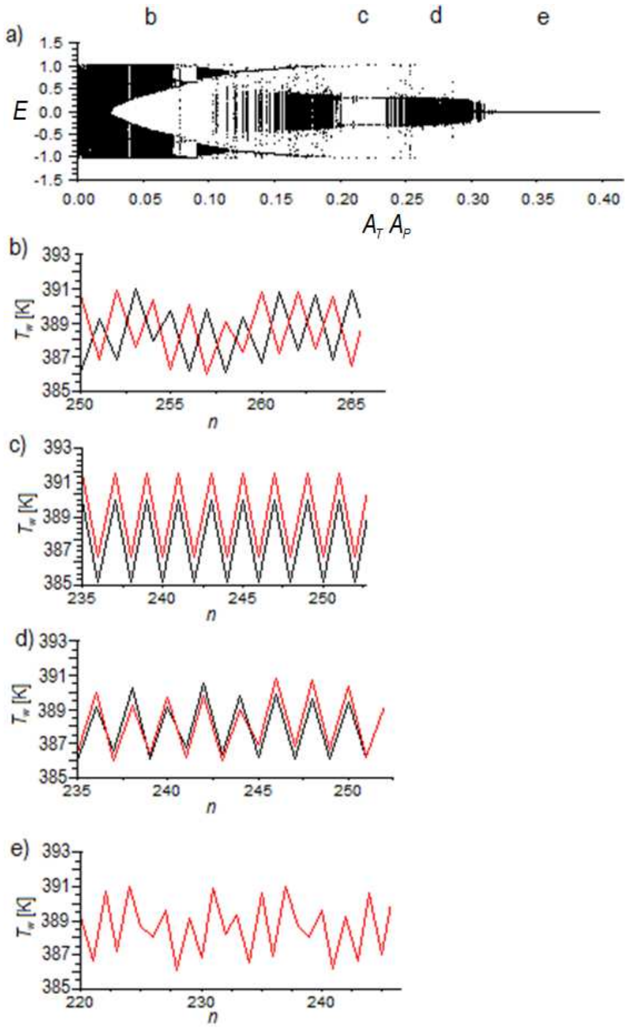

Fig. 10. Examples of simulations results for different values of coefficient A_T and A_P. a) changes of synchronization error for different values of coefficients A_T and A_P b) temperature changes for A_T, $A_P = 0.05$ c) temperature changes for A_T, $A_P = 0.22$ d) temperature changes for A_T, $A_P = 0.28$ e) temperature changes for A_T, $A_P = 0.35$

Synchronization error is a parameter which describes the level of synchronization. It is defined as difference between values of parameters characterising the synchronized systems. For example, for heating surface temperature the synchronization error is as follows:

$$E^T = T_{w_n}^{\ 1} - T_{w_n}^{\ 2} \qquad (10)$$

In Fig. 10 it has been shown the examples of simulation results obtained for different values of coefficient A_T and A_P. During the simulations the coefficient A_T was equal to A_P.

The changes of synchronization error for different A_T and A_P coefficients have been shown in Fig. 10a. Normalized values of $\hat{T}_{w_n}$ were converted to values observed in experimental results (Wang et al.,2007). Obtained results indicates that for $A_T > 0.32$ and $A_P > 0.32$ *the* synchronization between channels appears even when pressure-drop oscillations in both channels are chaotic (Fig. 10e). Hardt et al. also reported synchronization between parallel channels (Hardt et al, 2007). For A_T and $A_P < 0.32$ different scenarios of channel-to-channel interaction can appear. For A_T and A_P equal to 0.05 the temperature alternately oscillates in the neighbouring channels (Fig. 11b). Synchronization between channels is low and temperature oscillations are chaotic. Similar regime of working the system of microchannels was reported in paper (Hardt et al, 2007). For A_T and A_P equal to 0.22 periodic oscillations in microchannels are observed (Fig. 11c). Synchronization error has a constant value. Wang et al. reported similar instability regime in the paper (Wang et al., 2007). For A_T and A_P equal to 0.35 (Fig. 11d) temperature oscillations are chaotic but the synchronization error, E^T, is equal to zero – the heat and mass transfer in neighbouring microchannels are completely synchronized.

4. CONCLUSION

In the paper the dynamics of pressure-drop oscillations in a single channel and in two neighbouring channels have been analyzed. The thermal and hydrodynamic interactions between the channels have been considered.

Obtained results indicate that the shape of pressure drop curve has significant influence on the stability of the system. When the slope of curve $\Delta p = f_4(G)$ in the region between function extremes increases then the pressure oscillations become chaotic.

Four types of two-phase behaviours in parallel channels have been observed depending on the intensity of interactions.

- two-phase flow parameters oscillate alternately in the neighbouring channels but synchronization between channels is low and oscillations of two-phase flow parameters are chaotic;
- two-phase flow parameters oscillate consistently in the neighbouring channels but synchronization between channels is low and oscillations of two-phase flow parameters are chaotic;
- two-phase flow parameters oscillate periodically;
- oscillations of two-phase flow parameters in both channels are chaotic but the synchronization error is equal to zero – the heat and mass transfers in neighbouring microchannels are completely synchronized.

Obtained qualitative results have been compared with conclusions of experimental results reported by other researches (Kakac, Bon, 2008, Hardt et al, 2007, Wang et al., 2007). The qualitative model properties are consistent with experimental results.

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