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SOME RESULTS OF THE EXPERIMENTAL RESEARCH FOR THE STUDY OF THE FLOW IN AN ADIABATIC REGIME THROUGH CAPILLARY TUBES

BY

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Abstract. The flow in adiabatic regime through capillary tubes was researched with the help of an original experimental installation presented in the paper "Experimental installation for the study of the flow in an adiabatic regime through capillary tubes". The processing of the experimental data, the analysis of the variation of the parameters and the conclusions that resulted are presented as follows.

Key words: adiabatic flow, capillary tubes.

1. Introduction

The flow of the liquids in an adiabatic regime through long pipes is a complex phenomenon with an interesting evolution and it is often met in practice. Having an adequate experimental installation were developed experimental researches for different working regimes with the purpose to practically check the results of the theoretical research that was obtained through mathematical modelling (Vartolomei, 2001; Giurcă & Vartolomei, 2002). The paper presents the results and the interpretations of this experimental research.

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2. The Brief Presentation of the Variation of Different Sizes Calculated on the Length of the Pipe According to the Value of the Total Pressure from the Entry to the Exit from the Capillary

The results of experimental research presented in the paper "An experimental installation for the study of the flow in an adiabatic regime through capillary tubes" allow keeping track of the variation of different sizes calculated for partial lengths of the working capillary, according to the value of the total pressure from the entry and from the exit from the capillary, taking into account the measured pressures at precise distances on the length of the capillary. From all of these the most representative are presented next and are briefly analyzed.

The next set of graphic representations present the variation curves of the calculated sizes for values of x/D 75, 225, 375 and 450.

Fig. 1 presents the variation of p^* on the length of the capillary for different sizes of x/D, in the case of the flow in experimental conditions. The values of p^* are decreasing and the variation is almost linear. In the end all the curves go through the corresponding pressure point from the recipient bunker which is situated at the end of the capillary.

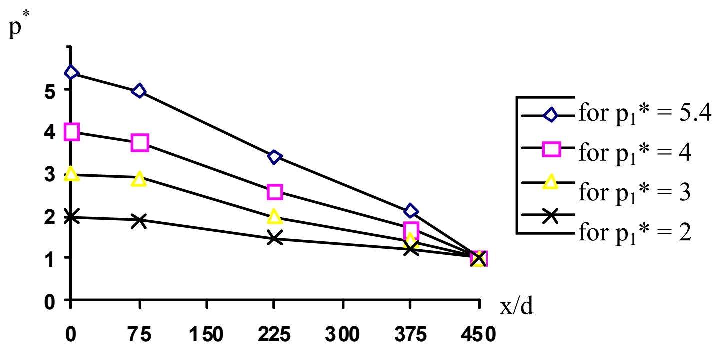

Fig. 1 − Variation graphic of p_2 on the length of the capillary.

In Fig. 2 is presented the variation of the report M_2/M_1 on the length of the capillary for different sizes of x/D, the adiabatic flow that is based on the established variation of entry pressures of the air in the capillary with the length of 450 mm. If for p_1^* = 2 bar the ascending variation is almost linear, as long as the total initial pressure of braking rises, the variation of the consecutive values of the report, especially those from the last section, is bigger and the inclination of the curve is accentuating on that particular section. Therefore it is shown for p_1^*= 5.4 bar the value of the report of 5.26 and for p_1^*= 4 bar. The value for the ratio of 3.9, for p_1^* = 3 and 2 bar, respectively, the differences are even smaller.

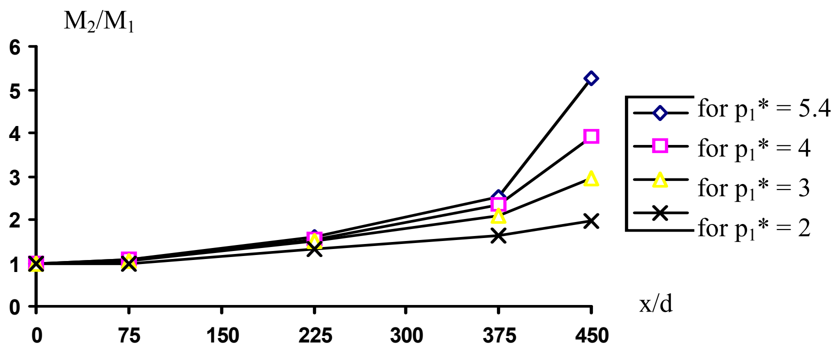

Fig. 2 – Variation graphic of the M_2/M_1 report on the length of the capillary.

Fig. 3 presents the variation of $\zeta_{\text{experimental}}$ on the length of the capillary for different sizes of x/D, in the case of the adiabatic flow that is based on the established variety of air entry pressure in the capillary $\zeta_{\text{experimental}}$ values are descending for the same total braking pressure. As the entry pressure is smaller than the values corresponding to $\zeta_{\text{experimental}}$ are bigger.

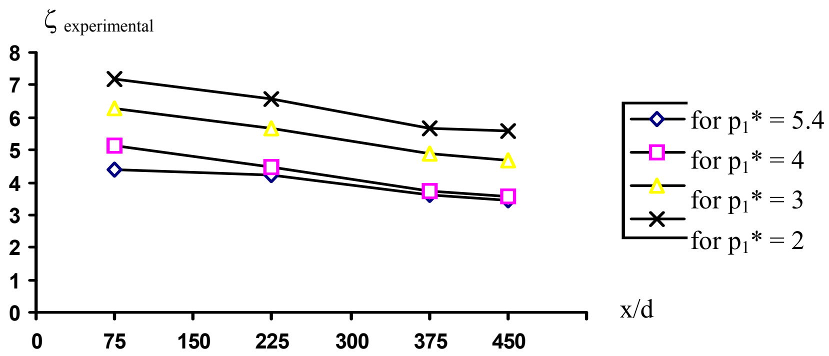

Fig. 3 – Variation graphic of $\zeta_{\text{experimental}}$ on the length of the capillary.

In Fig. 4 presented the variation of the loss coefficient of total pressure on the length of the capillary σ for different values of x/D, in the case of the adiabatic flow that is based on different air entry pressures in the capillary. In order to determine the values of σ was used in the calculus program the definition equation. The inclination of the variation curves is more accentuated than the one for other experiments. The smaller the p_1^* is the smaller the inclination of the graphic is and the corresponding values for the same x/D are bigger, being placed on superior curves.

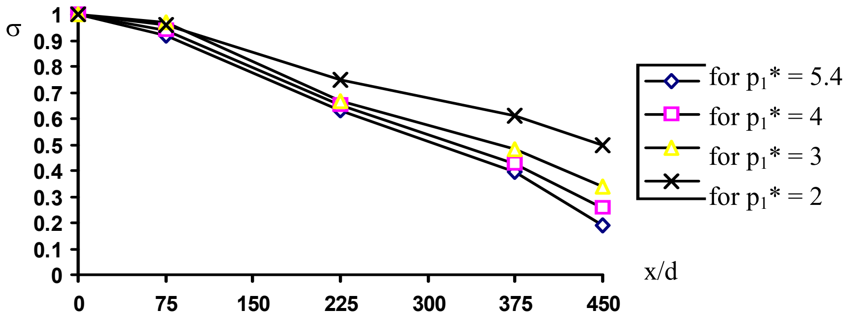

Fig. 4 − Variation graphic of σ on the length of the capillary.

Fig. 5 presents the variation of Δs on the length of the capillary crossed by the air in adiabatic flow for different values of x/D and for the variety of entry pressures that was established. The general inclination of the variation curves is identical to the one of the corresponding graphics made for other experiments. The final values of Δs are close to the ones that were calculated for other experiments. The variation of the maximum values at the exit concerning other experiments is insignificant if we do not take into account the x/D.

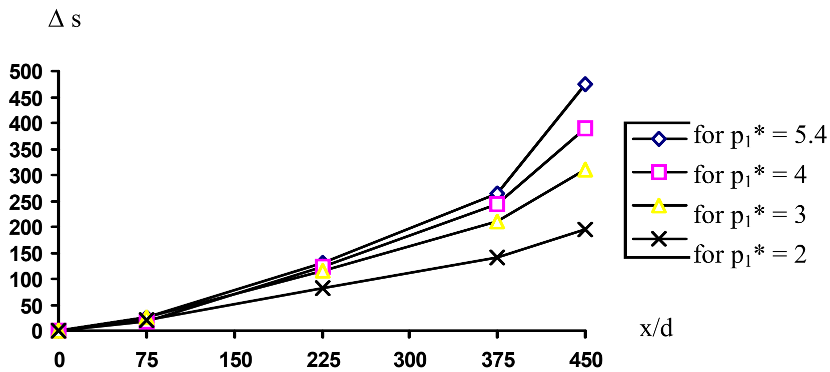

Fig. 5 − Variation graphic of Δs on the length of the capillary.

In Fig. 6 is presented the variation of w_2 on the length of the capillary crossed by the air in adiabatic flow for different sizes of x/D and for different entry pressures that were pre-established.

Fig. 7 presents the variation of the λ_2 / λ_1 report on the length of the capillary crossed by the air in adiabatic flow. Things change if the analysis of the values according to x/D, especially for the final sections.

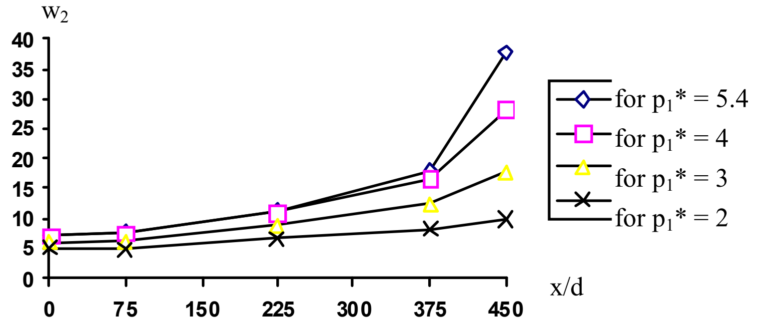

Fig. 6 – Variation graphic of w_2 on the length of the capillary.

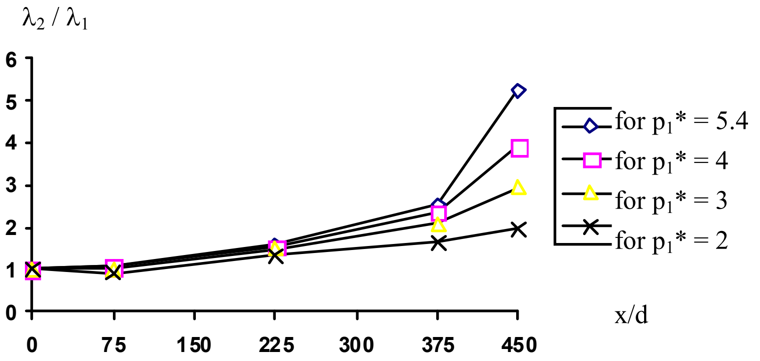

Fig. 7 – Variation graphic of the λ_2 / λ_1 report on the length of the capillary.

In Fig. 8 is presented the variation of ζ_c on the length of the capillary crossed by the air in adiabatic flow for different sizes of x/D and for different entry pressures that were pre-established.

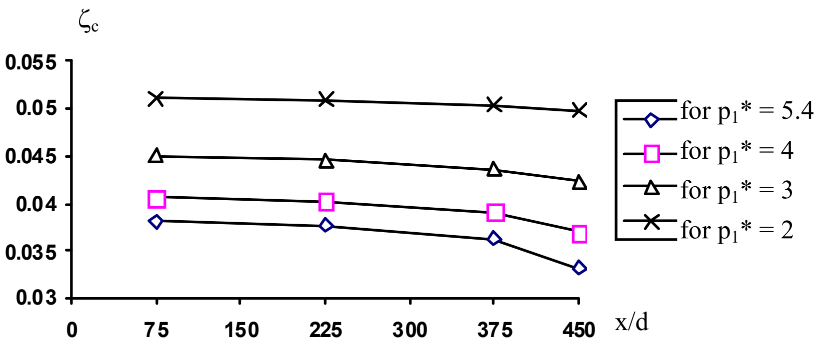

Fig. 8 – Variation graphic of ζ_c on the length of the capillary.

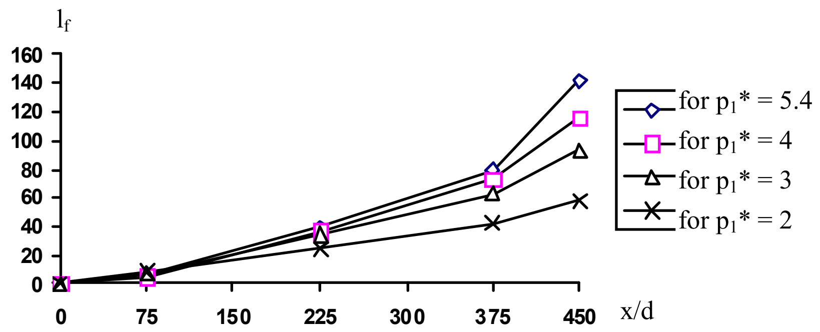

Fig. 9 – Variation graphic of l_f on the length of the capillary.

Fig. 9 presents the variation of the l_f report on the length of the capillary crossed by the air in adiabatic flow. Things change if the analysis of the values according to x/D, especially for the final sections.

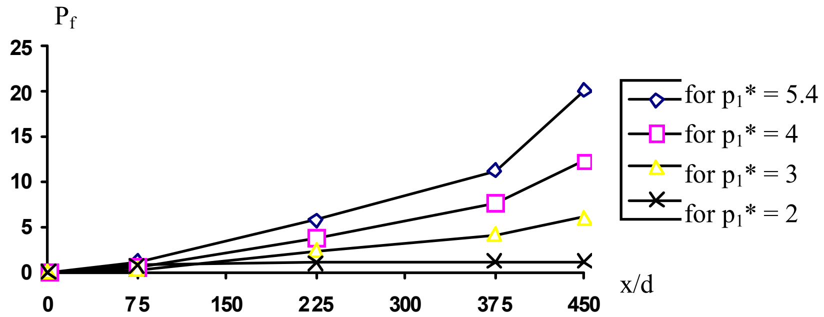

Fig. 10 – Variation graphic of P_f on the length of the capillary.

Fig. 10 presents the variation P_f on the length of the capillary crossed by the air in adiabatic flow for different values of x/D and for the variety of entry pressures that was established. The inclinations of the curves that resulted are accentuated. The exit values are 20.11, 12.31, 6.12 and 1.22. The improvements are even more important if we analyze the corresponding values from the perspective of x/D.

3. The Comparative Analysis Concerning the Results that were Obtained by Experiments and the ones Obtained by Numerical Simulation

If through the numerical simulation programs are checked the calculus relations that are met during the bibliographical research it is followed by arranging and structuring them in calculus programs after the indications from the suggested models by different authors, by processing the resulted data from the experimental part of the paper, were verified most of the theoretical affirmations as well as the practical availability of the calculus relations.

With the help of both research methods can be imagined different working regimes and the comments from the bibliography were verified, extended and thoroughly researched.

According to a quantity aspect, between the results that were obtained through simulations and the ones obtained through experiment there are some significant discrepancies concerning the actual values of the loss coefficient obtained through friction. Therefore, results that the experimental values are higher than the analytic ones. The differences may be explained by the fact that the actual relations for calculating the coefficient concerns only pipes with reduced roughness and turbulent flowing regimes, but they technically act as smooth pipes. In reality, at capillary tubes and pipes with small diameters (under 10 mm), the flow regimes are relatively different and their gasodynamic resistances is much bigger than the one of the usual pipe when it comes to the transportation of liquids, for which the correlation with a resistance factor was established.

The measurement error within the experiment is excluded (even the systematic ones), because the experiments were reproducible and the possible mistakes that will lead to different results with two size orders must have been some very big mistakes.

4. Conclusion Concerning the Obtained Results Through the Experimental Research of Adiabatic Lamination

The experimental installation and the possibilities of which it disposes allowed the development of a various measurement program, in adiabatic conditions and concerning relatively various permanent flowing regimes.

The model and the calculus programs for processing the experimental data based on the usage of the gaso-dynamic functions and the consideration of the real thermo-physical properties of the working program have permitted the determination of all the characteristics of the fluid flux, including their evolution along the flow. The resolution of the numeric procedure is superior to the experimental one. The connection of the two "visualization" means of the evolution of the flow, meaning through the experimental procedure – analytical, as well as through the monitoring of the flow by introducing some intermediary measuring sections, offers a more complete and adequate depiction for interpretations and correlations concerning various interactions and influences.

The experimental results confirm the validity of the theoretical models off simulation of the adiabatic lamination; The evolutions of the parameters of the gas along the capillary tubes or pipes of various dimensions and at different flowing regimes, imposed through total initial pressure, demonstrates that the established dependencies through numerical simulations are entirely confirmed.

From these are mentioned the following: a dropping of the static and total pressure, the acceleration of the flow and the diminution of the instantaneous temperature, raised report of pressure applied up to the current section or up to the exit, the intensification of the dissipation of energy along the flux and raising the mass entropy of the flux, the dropping of the resistance factor through friction once the speed of the flow raises and the number of the Reynolds increases.

The installation allows the calibration/sorting of the capillary tubes of the calibration of the pipes of relatively small diameters by blowing with air under pressure so that the length to correspond with an imposed gasodynamic/ hydrodynamic resistance.

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CÂTEVA REZULTATE ALE CERCETĂRII EXPERIMENTALE PENTRU STUDIEREA CURGERII ÎN REGIM ADIABATIC PRIN TUBURI CAPILARE

(Rezumat)

Curgerea în regim adiabatic prin tuburi capilare a fost cercetată cu ajutorul unei instalatii experimentale originale prezentată în lucrarea "Instalație experimentală pentru studierea curgerii în regim adiabatic prin tuburi capilare şi conducte lungi".

Interpretări rezultate în urma prelucrării datelor experimentale, analiza variației parametrilor şi concluziile care rezultă sunt prezentate în lucrare.