JOURNAL OF APPLIED SCIENCE AND SOCIAL SCIENCE
eISSN 2229-3113 pISSN 2229-3205
Volume 15 Issue 10, October 2025
Impact factor: 2019: 4.679 2020: 5.015 2021: 5.436, 2022: 5.242, 2023: 6.995, 2024 7.75

PRESSURE LOSS IN THE BRANCH AND CHANGE IN LOCAL RESISTANCE OF THE CHANNEL

Yunusov Ganisher Gafirovich

Associate Professor, Asia International University

(Tel. (+9989 9) 7078297

E-mail: ganish2011@gmail.com)

Abstract: The article examines pressure losses in a branch and the variation of local resistance within a channel during fluid flow separation. It is shown that the pressure distribution in the branching zone is non-uniform and depends on both the geometric parameters of the channel and the flow velocity. Based on Bernoulli's equation and the momentum equation, relationships are derived for calculating pressure losses and the local resistance coefficient. An expression is obtained for the optimal branch flow velocity at which pressure losses are minimized. Analysis of experimental data confirms that as the flow velocity increases, pressure losses first decrease, reach a minimum value, and then increase again. It is established that the local resistance coefficient depends on the velocity and the geometry of the channel, which must be taken into account when designing hydraulic systems with branched channels.

Keywords: pressure loss, branch, local resistance, resistance coefficient, flow velocity, Bernoulli equation, hydrodynamics.

Pressure losses in the branch play a significant role in changing the local resistance of the channel. Figure 1 schematically shows the positions of the fluid flow streamlines EC in a divided section of the channel. Let the channel have a cross-sectional area at the initial section F, branch F_o, and extension F_{np}.

Let 's draw a section 1-1 before the branch and 2-2 after the branch. Let's write the Bernoulli equations

$$P+\frac{\rho V_1^2}{2}=P_0+\frac{\rho V_0^2}{2}+\Delta P_0, \qquad (1)$$

$$\Delta P_0=P-P_0+\frac{\rho\left(V_1^2-V_0^2\right)}{2}, \qquad (2)$$

the amount of motion for the allocated limited volume by the cross-sections, the channel walls and the flow line EC. The amount of motion in projections onto the branch axis will be equal to [1,2,3,9,10,11]

$$PF\cos\chi\pi+r_1\Phi_1\sin\chi\pi-r_2\Phi_2\sin\chi\pi-r_3\Phi_3\sin\chi\pi-P_0F_0=\rho_0F_0V_0\left(V_0-V_1\cos\chi\pi\right), \qquad (3)$$

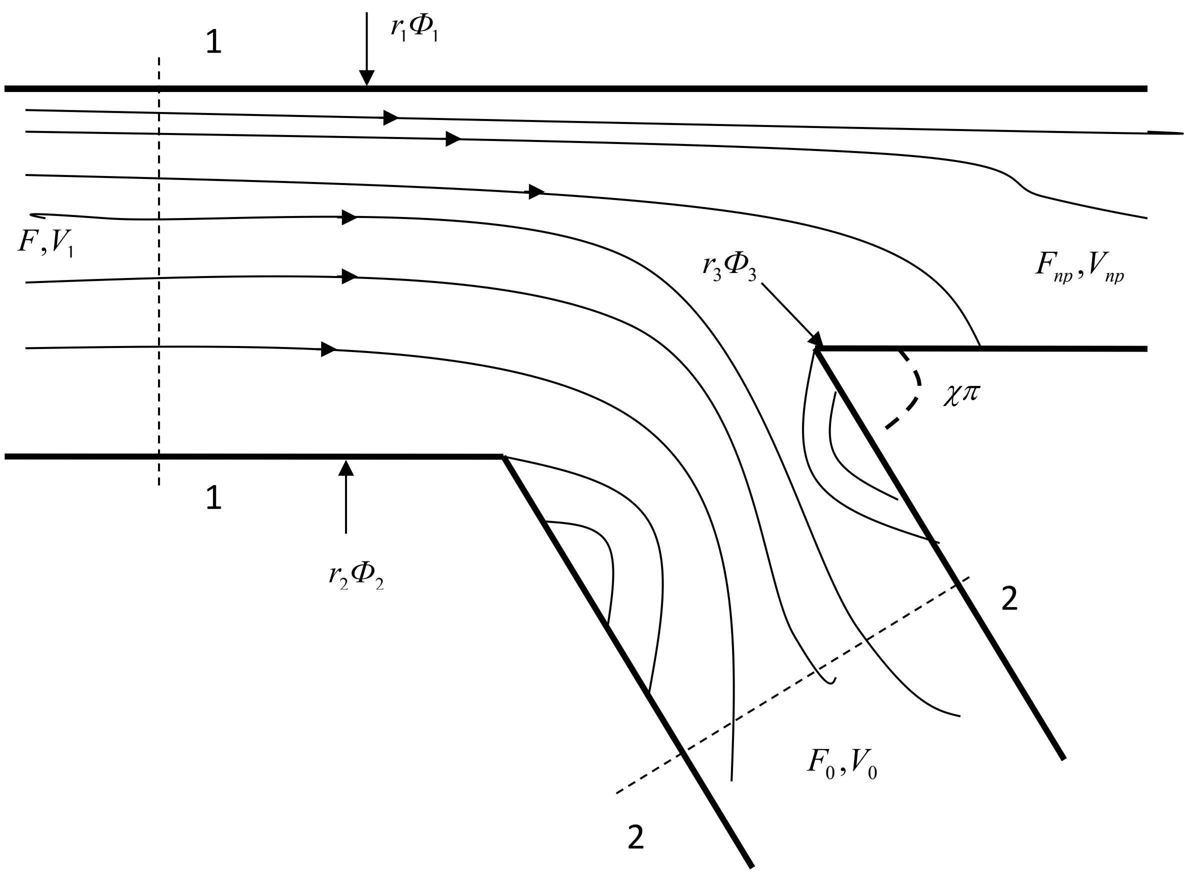
where r_1, r_2, r_3 are the reaction forces of the pressures from the areas $\Phi_1, \Phi_2\, u\, \Phi_3$. Experiments have shown that the fluid pressure near the surface is not uniform, since the excess static pressure, expressed as a fraction of the velocity pressure of the oncoming flow, is

$$P_i - P_0 = \frac{k_i \rho V_0^2}{2},$$

where P_i is the static pressure at a point taken on the channel surface; P_0 is the static pressure of the incoming flow; k_i is the hydrodynamic coefficient [4-11]. The resultant forces of the reaction of the wall pressures on areas $\Phi_1, \Phi_2\, u\, \Phi_3$ in the liquid will be equal to

$$R_i = r_i \Phi_i = \; P_0 + k_i \frac{\rho V_0^2}{2} \; \Phi_i .$$

Flow diagram



JOURNAL OF APPLIED SCIENCE AND SOCIAL SCIENCE
eISSN 2229-3113 pISSN 2229-3205
Volume 15 Issue 10, October 2025
Impact factor: 2019: 4.679 2020: 5.015 2021: 5.436, 2022: 5.242, 2023: 6.995, 2024 7.75

Fig. 1

In our case

$$r_1 = P + k_1 \frac{\rho V_1^2}{2};\ r_2 = P + k_2 \frac{\rho V_1^2}{2};\ r_3 = P + k_3 \frac{\rho V_1^2}{2}.$$

Substituting these values into (3), we obtain

$$\begin{aligned} & P(F\cos\chi\pi + \Phi_1 \sin\chi\pi - \Phi_2 \sin\chi\pi - \Phi_3 \sin\chi\pi) - P_0 F_0 = \\ & = \rho F_0 V_0 (V_0 - V_1 \cos\chi\pi) - (k_1\Phi_1 - k_2\Phi_2 - k_3\Phi_3)\frac{\rho V_1^2}{2}\sin\chi\pi \end{aligned} \tag{4}$$

From the channel diagram we can obtain :

$$F\cos\theta + \Phi_1 \sin\theta - \Phi_2 \sin\theta - \Phi_3 \sin\theta = F_0.$$

Then (3.4) can be written in the form

$$P - P_0 = \rho V_0 (V_0 - V_1 \cos\chi\pi) - \frac{1}{F_0}(k_1\Phi_1 - k_2\Phi_2 - k_3\Phi_3)\frac{\rho V_1^2}{2}\sin\chi\pi\,, \tag{5}$$

Substituting (5) into (2) to express the pressure loss in the branch, we obtain

$$\Delta P_0 = \frac{\rho}{2}\left(V_0^2 - 2V_0V_1\cos\chi\pi + V_1^2\right) - \frac{1}{F_0}(k_1\Phi_1 - k_2\Phi_2 - k_3\Phi_3)V_1^2 \sin\chi\pi\ . \tag{6}$$

In formula (6), the last term on the right-hand side has unknown coefficients k_i. Replacing their influence with the correction coefficient η, we finally obtain

$$\Delta P_0 = \eta \frac{\rho}{2}\left(V_0^2 - 2V_0V_1\cos\chi\pi + V_1^2\right). \tag{7}$$

To determine the optimal flow rate in a branch, we take the first derivative of the pressure loss with respect to velocity V_0

$$\frac{\partial \Delta P_0}{\partial V_0} = \eta \frac{\rho}{2}(2V_0 - 2V_1\cos\chi\pi). \tag{8}$$

By equating the right side of this expression to zero, we obtain the value of the optimal fluid velocity in the branch

JOURNAL OF APPLIED SCIENCE AND SOCIAL SCIENCE
eISSN 2229-3113 pISSN 2229-3205
Volume 15 Issue 10, October 2025
Impact factor: 2019: 4.679 2020: 5.015 2021: 5.436, 2022: 5.242, 2023: 6.995, 2024 7.75

$$V_{onm} = V_1 \cos \chi\pi \,. \qquad (9)$$

To determine the minimum pressure loss on a branch of a flow, instead of formula (7), we substitute the expression for the optimal speed.

Then

$$\Delta P_{0_{наим}} = \eta \frac{\rho V_1^2}{2} \sin^2 \chi\pi \,. \qquad (10)$$

The results of the analysis of experimental data provide grounds to assert that pressure losses in a channel branch with an increase in flow velocity initially decrease and reach the lowest value, and then increase again.

The coefficient of local resistance, related to the velocity in the channel branch , is equal to

$$\xi = \frac{2\Delta P_0}{\rho V_0^2} = \eta \;\; 1 - 2\frac{V_1}{V_0}\cos \chi\pi + \frac{V_1^2}{V_2^2} \qquad (11)$$

or

$$\xi = \eta \;\; 1 - 2\frac{F}{F_0}\cos \chi\pi + \frac{F^2}{F_0^2} \;\; . \qquad (12)$$

Now let's consider the change in local resistance to fluid flow given the channel's extension. For this, we'll use the flow equation.

$$Q_1 = Q_0 + Q_{np}$$

or

$$V_1 F = V_0 F_0 + V_{np} F_{np} \,, \qquad (13)$$

where Q_1 is the fluid flow rate at the initial section of the channel; Q_0 is the flow rate in the branch section; Q_{np} is the flow rate in the continuation of the channel; V_{np} is the velocity of the continuation of the channel; F_{np} is the cross-sectional area of the continuous section of the channel.

Substituting expression (13) into (7), we obtain the following equation:

JOURNAL OF APPLIED SCIENCE AND SOCIAL SCIENCE
eISSN 2229-3113 pISSN 2229-3205
Volume 15 Issue 10, October 2025
Impact factor: 2019: 4.679 2020: 5.015 2021: 5.436, 2022: 5.242, 2023: 6.995, 2024 7.75

$$\Delta P_0 = \eta \frac{\rho}{2} \; V_0^2 - 2V_0 \frac{V_0 F_0 + V_{np} F_{np}}{F} \sin \chi\pi + \; \frac{V_0 F_0 + V_{np} F_{np}}{F} \;^2 \; =$$

$$= \; V_0^2 - 2V_0 \frac{V_0 F_0 + V_{np} F_{np}}{F} \sin \chi\pi + \frac{(V_0 F_0)^2}{F^2} + 2\frac{V_0 F_0 + V_{np} F_{np}}{F^2} + \frac{(V_{np} F_{np})^2}{F^2} \qquad (14)$$

In this case, the local resistance coefficient is

$$\xi = \frac{2\Delta P_0}{\rho V_0^2} = \eta \; 1 - 2 \; \frac{F_0}{F} + \frac{V_{np}}{V_0}\frac{F_{np}}{F} \; \sin \chi\pi + \frac{F_0^2}{F^2} + 2\frac{F_0 F_{np}}{F^2}\frac{V_{np}}{V_0} + \frac{V_{np}}{V_0^2}\frac{F_{np}^2}{F^2} \qquad (15)$$

strongly depends on the speed of channel extension and the change in the cross-sectional area in all sections of the channel.

Let us perform calculations using the Bernoulli formula to determine the pressure losses in the branch and the local resistance related to the velocity in the channel outlet using formulas (2) and (12).

The results are given in engineering units at $\rho = 102 \frac{\kappa\Gamma \;\; c^2}{\text{м}^4}$ and $\gamma = 1000 \frac{\kappa\Gamma}{\text{м}^3}$. Here V_1, V_0 are the velocities at the initial and outlet sections of the channel.

As can be seen from Table 1, ΔP_0 according to formula (10) has a more overestimated value than according to the calculation formula (14). This is due to the fact that the coefficient η in formula (14) depends on the channel outlet velocity. In the work [3] it is indicated that $\eta = 0{,}55$, meanwhile, actually η changes with the flow velocity. This is evidenced by the data in Table 2 on the change in the coefficient η.

Table 1

Changes in kinematic and dynamic quantities for different angles of departure

Calculation using formulas (2) and (12)	According to formula (14)
$B/B_0 = 1$ And $\chi\pi = 30^0$	

$\gamma(H_1 - H_2)$	$V_1, \frac{м}{c}$	$V_1^2, \frac{м^2}{c^2}$	$V_0, \frac{м}{c}$	$V_0^2, \frac{м^2}{c^2}$	$\frac{V_0^2}{V_1^2}$	$1-\frac{V_0^2}{V_1^2}$	ΔP_0	ξ	ΔP_0
7	0.507	0.257	0.205	0.042	0.163	0.837	17.97	8,384	5,862
4	0.397	0.158	0.131	0.017	0.108	0.892	11.16	12,751	3,645
2	0.294	0.086	0.093	0.0086	0.099	0.901	5.97	13,534	2,0075
2	0.214	0.045	0.099	0.009	0.214	0.786	3.84	7,682	1,052
$B/B_0 = 1$ And $\chi\pi = 60^0$									
9	0.486	0.236	0.168	0.028	0.119	0.881	19,604	13,728	5,115
6	0.394	0.155	0.132	0.017	0.109	0.891	13,043	15,044	3,366
2	0.294	0.086	0.112	0.012	0.139	0.861	5,776	9,434	1,825
2	0.214	0.046	0.079	0.0062	0.135	0.865	4,029	12.75	1,188
$B/B_0 = 1$ And $\chi\pi = 90^0$									
14	0.5	0.25	0.185	0.034	0.136	0.75	23.56	13,589	7.95
5	0.378	0.143	0.133	0.018	0.126	0.874	11.37	12,389	4.51
4	0.342	0.117	0.136	0.0185	0.158	0.842	9,024	9,564	3,815
4	0.336	0.113	0.141	0.0199	0.176	0.824	8,749	8,621	3,728

Note: B, B_0 - width of the channel at its beginning and branch.

Table 2

Changes in the coefficient η from the angle of the bend and

dimensionless flow velocity

JOURNAL OF APPLIED SCIENCE AND SOCIAL SCIENCE
eISSN 2229-3113 pISSN 2229-3205
Volume 15 Issue 10, October 2025
Impact factor: 2019: 4.679 2020: 5.015 2021: 5.436, 2022: 5.242, 2023: 6.995, 2024 7.75

$\gamma(H_1 - H_2)$	$\frac{V_1}{V_0}$	η	η_{cp}
$B/B_0 = 1$ And $\chi\pi = 30^0$			
7	2.73	3,066	3,188
4	3,031	3,062	
2	3,161	2,974	
2	2,162	3,650	
$B/B_0 = 1$ And $\chi\pi = 60^0$			
9	2,893	3,833	3,619
6	2,985	3,875	
2	2,625	3,165	
2	2,709	3,604	
$B/B_0 = 1$ And $\chi\pi = 90^0$			
14	2,703	1,424	2,164
5	2,842	2,519	
4	2,514	2,365	
4	2,383	2,342	

LIST OF USED LITERATURE

Y Ganisher, A Maqsud Theoretical study of he sida flow of he liquid from the channel Lambert Academic Publishing Beau bwssin **Volume 65 2018**

Г.Г Юнусов Гидродинамическая структура открытого потока на участках разветвления. Автореферат диссертации на соискание ученой степени к. Т. Н. Ташкент 2007

GG Yunusov INVESTIGATION OF THE PROBLEMS OF LATERAL OUTLOAD OF LIQUIDS Educational Research in Universal Science 5 (3), 110-122

ГГ Юнусов, ОИ Жураев ИССЛЕДОВАНИЕ ОСАЖДЕНИЯ ЧАСТИЦ ОТКРЫТОГО

МНОГОФАЗНОГО ПОТОКА В УЧАСТКЕ РАЗВЕТВЛЕНИЯ. Multidisciplinary Scientific Journal 1 (10), 218-226

G. Yunusov Hydrodynamic structure of the open flow in the branching areas. Dissertation for the degree of Candidate of Technical Sciences. Tashkent 2007.

Ganisher Yunusov Investigation of the problems of lateral outflow of liquids. Journal of Physics and Mathematics 1 (4) 2020