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Article

Research On The Optimal Merging Angle of Flows In Channels

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Abstract: In the article, based on the experimental method, the dependence of the flushing process of the junction of two channels on the angle of the junction is established, the deformation process occurring at the junction of ground channels and the erosion problems caused by its influence during the use of channels are studied. The dependence of the hydraulic parameters in the area of the confluence of two streams on the confluence angle is shown

Keywords: Inlet Area, Leaching Process, Bedrock, Erosion Problems, Hydraulic Parameter, Inlet Angle, Flow, Angle Comparison

1. Introduction

Investigating the optimal merging angle of flows in channels is one of the important issues related to hydraulics and flow dynamics. The completion of these studies is crucial for understanding the deformation process in the region of flow merging and for the long-term efficient use of channels. At the same time, the complex hydrodynamic characteristics of channel merging lead to difficulties in analyzing the flow behavior. The swirling zone in channel merging [1], as shown in Figure 3, is dependent on the merging angle. The flow structures created by geometric and hydrological characteristics [2] result in the formation of a deformation process during flow merging due to the swirling zone and the interaction of secondary flows [3]. The deflection along the turning angle of the flows and the subsequent motion after the flow collision represent the boundary [4] of the swirling zone. The swirling motion, in turn, leads to deformation. In flow merging, the velocities and surfaces interact [5]. If the surfaces are designed similarly, we will examine the intensity of flow merging in relation to the merging angle [6]. To conduct this study, we will use the experimental setup from the laboratory of the Department of Hydraulics and Hydraulic Engineering at the Karshi Engineering-Economic Institute [11].

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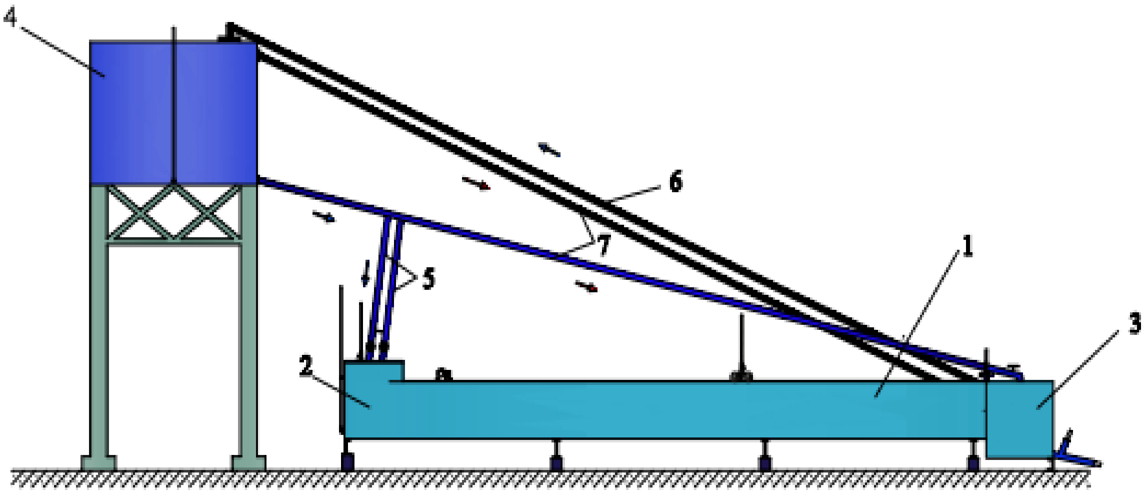


1-Figure. Hydraulic flow diagram

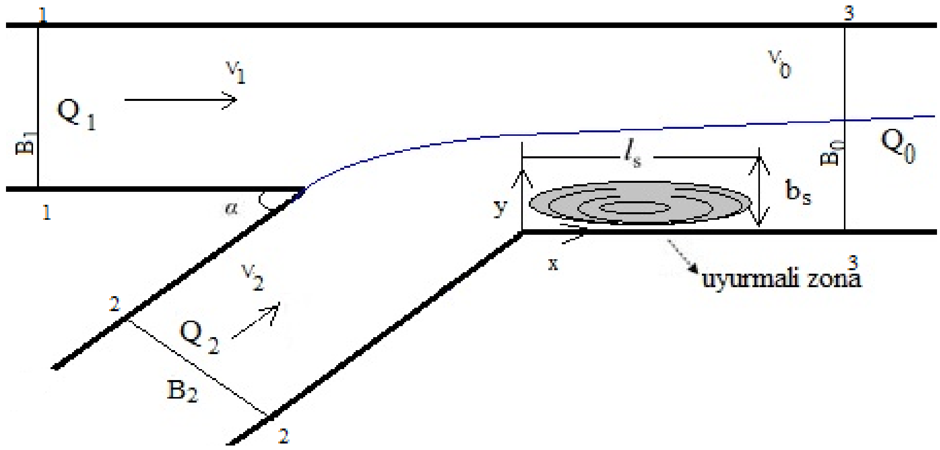
1- pipe; 2- pipe's starting section; 3- lower reservoir; 4- upper reservoir; 5- water supply pipe; 6- discharge pipe; 7- water discharge pipes.

2. Materials and Methods

We design the merging state [1] of two channels in the hydraulic diagram at angles of α = 45°, 60°, and 90°. The designed channels will first be constructed at an angle of α = 45°, as shown in Figure 2. We will adjust the surfaces of the two channels accordingly to ensure they align, thereby generating the flow.

2nd Figure. Merging of two channels at an angle of α = 45°

In Experiment 1, the flow speed was $v_{o'rt}$ = 0.4 m/s; in Experiment 2, $v_{o'rt}$ = 0.6 m/s; in Experiment 3, $v_{o'rt}$ = 0.8 m/s; in Experiment 4, $v_{o'rt}$ = 1.0 m/s; and in Experiment 5, $v_{o'rt}$ = 1.2 m/s. The flow lasted from 08:00 to 16:00 for 8 hours. In Experiments 1, 2, and 3, the flow velocity was low, so no swirling process occurred. As the flow velocity increased over time, the average velocity reached $v_{o'rt}$ = 1.0 m/s, and as a result, the initial signs of the swirling state began to appear. At this point, the flow along its direction formed waves at an angle of α = 45°, and at the channel's side, a swirling zone was observed. The condition depicted in Figure 3 showed a spiral-like rotational motion.



3rd Figure. Swirling zone in the merging of two flows

In this, Q *- flow consumption* l/c, ϑ *- flow velocity* m/c, h *channel depth* cm, B *-channel width* cm.

In analyzing the results from our experiments, the merging angle and the hydraulic processes at each angle were studied in relation to the flow parameters. It was found that at an angle of α = 45°, the minimum velocity limit for the merging flows was $v_{o'rt}$ = 1.0 m/s. When the flow velocity exceeded $v_{o'rt}$ = 1.0 m/s, erosion started to be observed in the merged section of the channels. To analyze the hydraulic parameters along each channel and in the merged sections, we will include these values in a table [10, 12, 13].

3. Results

Hydraulic connection calculation results at points 1-1, 2-2, 3-3

Table 1.

α=45⁰ for the channel												
№ Exp.	Q_1 l/c	Q_2 l/c	Q_0 l/c	ϑ_1 m/c	ϑ_2 m/c	ϑ_0 m/c	h_1 cm	h_2 cm	h_0 cm	B_1 cm	B_2 cm	B_0 cm
1.	0,0015	0,0016	0,0031	0,52	0,542	0,434	3,5	3,7	4,2	17	16	38
2.	0,0016	0,0018	0,0034	0,63	0,69	0,624	3,7	4,2	4,4	19	17	39
3.	0,0018	0,0019	0,0037	0,8	0,86	0,868	3,8	4,3	4,5	21	18	40,5
4.	0,0021	0,0020	0,0041	1,024	1,088	1,098	4,0	4,5	4,7	24	22	42
5.	0,0023	0,0021	0,0044	1,162	1,184	1,26	4,2	4,6	4,8	25	24	43

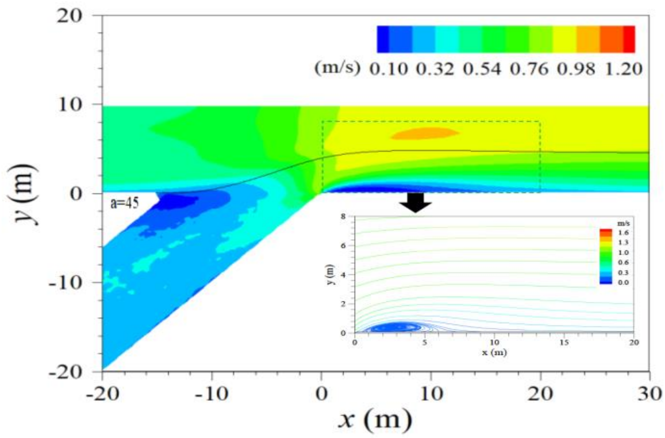
The hydraulic relationship calculation results at points 1-1, 2-2, and 3-3 are as follows:

- Point 1-1: This refers to the hydraulic parameters at the initial section of the first channel before merging. It includes values such as flow velocity, pressure, and channel depth at this stage.
- Point 2-2: This is the corresponding hydraulic data at the initial section of the second channel before merging. Similar to Point 1-1, the flow velocity, pressure, and channel characteristics at this point are calculated.

- Point 3-3: This represents the hydraulic parameters at the point where the two flows merge. Here, the flow conditions such as velocity, turbulence, and pressure are observed as the flows interact and combine.

These calculations provide insights into the behavior of the fluid flow at various points in the system, particularly at the merging region, helping to analyze how the flow dynamics change at each stage. The results would typically be presented in a table with parameters such as velocity, pressure, and depth for each point.

We will compare the obtained results with those obtained using the ANSYS Discovery software [1]. In the region where the channels with matching velocities merge, the swirling processes can be clearly observed. The comparison between the experimental results and the simulation results from ANSYS Discovery will help to verify the accuracy of the findings and provide a deeper understanding of the swirling dynamics in the flow merging region.



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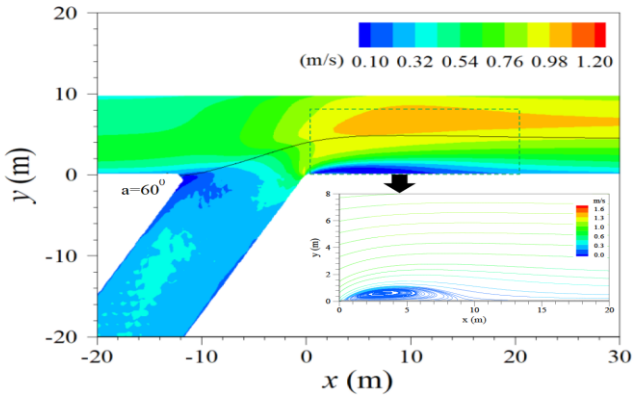

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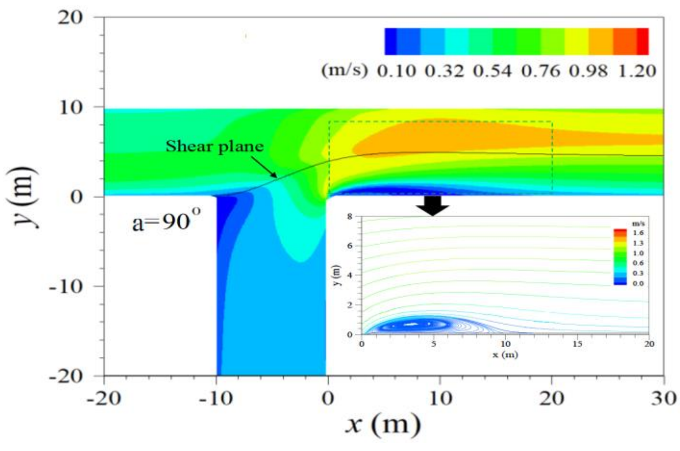

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4th Figure. a), b) and c) The dependence of the formation of a vorticity zone on the angle α at the junction of two flows in the ANSYS Discovery program.

4. Conclusion

As the flow moves from the entry point to the lower flow, the transverse flow deflection curves align. The dimensionless deflection curves through the cross-sections indicate the flow rate passing through. The process in Figure 4 is compared with the change in merging angle. The results show that the merging of the flow, with an increasing secondary flow rate, presents the primary flow rate lines as more aligned due to the increased transverse dispersion of the high-impulse flow. An increase in the merging angle, as shown in Figure 3, leads to an increase in transverse dispersion due to the sustained intersection of the strong transverse velocities.

Specifically, the reduction in the merging angle directly affects the behavior of the flow after merging. It is also important to note that as the merging angle approaches α = 90°, the flow's ability to streamline in the merging area decreases, and the flow's damping characteristics become more apparent in the experiment. Based on these observations, we recommend designing the optimal merging angle at α = 45° or a smaller angle.

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