Numerical Study of Characteristics of 3D Flow in Square Duct 90° Elbow with Diamond Bodied Disturbance

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Abstract*—The use of elbow in the fluid mechanics system produces a larger pressure drop. The purpose of this research is to know the flow characteristic through square channel with elbow 90. The diamond-shaped body disturbance is placed at 10° inside the elbow inlet. This research was conducted in 3D simulation with standard k-3 turbulence model. The cross-sectional area uses a square with a side size of 125 mm, then the hydraulic diameter (Dh) is 125 mm as well. The elbow curvature ratio (R / D) is set to 3. A body disorder with diagonal (l / D) ratio at 0.064, 0.08 and 0.1 is placed at 10° in the elbow inlet. The results in this study indicate that body disorders with diamond shape can delay the separation of flow and increase the intensity of turbulence flow. Finally, the results also show that the pressure drop is reduced.

Keywords*—Square Duct Elbow 90°, Diamond Inlet Disturbance Body, Pressure Drop.

I. Introduction

The process of high-rise building cooling systems such as self-service is not possible if only using a blower or air conditioning system. The cooling process requires the use of central air conditioning to circulate between hot and cold air. Air distribution must follow the order of every room, so it requires installation of piping in accordance with the shape of the building. The airway system in which there is fluid flow across the 90 ° elbow will result in a greater pressure drop than crossing the straight airways at the same free flow rate, resulting in greater energy losses. Optimal airway construction is expected to reduce the pressure drop in the airway system of a building. The effect of adding guide vane to pressure drop at installation using elbow. The best pressure drop on Reynolds (Re) is low, whereas in (Re), the high pressure drop increases[1]. Comparison of simulation and experiment results[2]. This simulation uses a turbulent model RSM (Reynolds Stress Model) with three variations of mesh density Vk = 553.052; 1.766.079; and 1,034,775. There is a profile that approximates the experimental results in the mesh number of 1,034,775. The flow structure of the downstream channel is rectangular with variations in body disturbance in the form of diamonds and circular cylinders[3]. The study was conducted on the dimension of diamond disturbance of 20 mm x 20 mm and the diameter of circular cylinder (D) 20 mm. The experimental results show that diamond disturbances produce higher turbulence intensity than circular cylinders. The drop in pressure drop on the placement of the circular disturbance body in front of the circular cylinder in a rectangular channel[4]. The study was conducted on circular (D) diameter 25mm and 37.5mm. From the results of this study it can be concluded that the addition of circular disturbance body can decrease drag and pressure drop but only effective at angle 20° and 30° for D = 25mm, and 20°, 30°, and 40° for D = 37.5mm. The effect of curvature will decrease due to the higher Re value, flow separation will increase if the curvature ratio gets smaller[5]. Secondary flow occurs because of different distribution energy on outer wall and inner wall[6]. The aim of this research is to know the fluid flow characteristic with the addition of Inlet Disturbance Body (IDB) in the form of rectangular cylinder oriented in 90º elbow with Rc / Dh = 3 to know flow phenomenon ie speed profile and drop pressure at 90 square elbow and downstream channel area.

II. Literature Review

Numerical research is done by using Computational Fluid Dynamics (CFD) method. (Figure 1 and 2)

III. Results and Discussion

The comparison of pressure drop results in the inlet section and outlet of the 90º elbow is shown in Figure 3. The smaller pressure drop values were obtained using L / Dh = 0.064 at low Re values compared to with IDB or without IDB L / Dh = 0.08; 0.1 with other variations of Re values. The existence of a bully makes the pressure drop into a drop, this happens because with the disruption of the flow velocity in the elbow is increasing and the momentum in the flow is increasing which makes the flow separation decreases so that the pressure drop is reduced.

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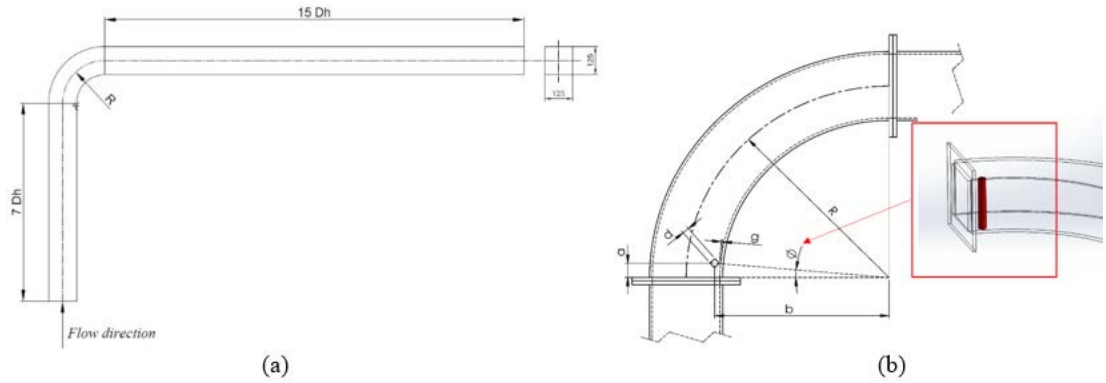

Figure 1. (a) Geometry Research, (b). Details of diamond inlet position disturbance body position

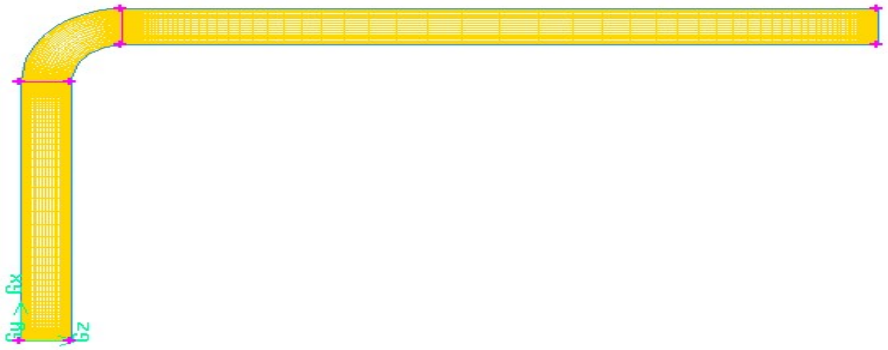

Figure 2. Meshing on channel with 90º elbow.

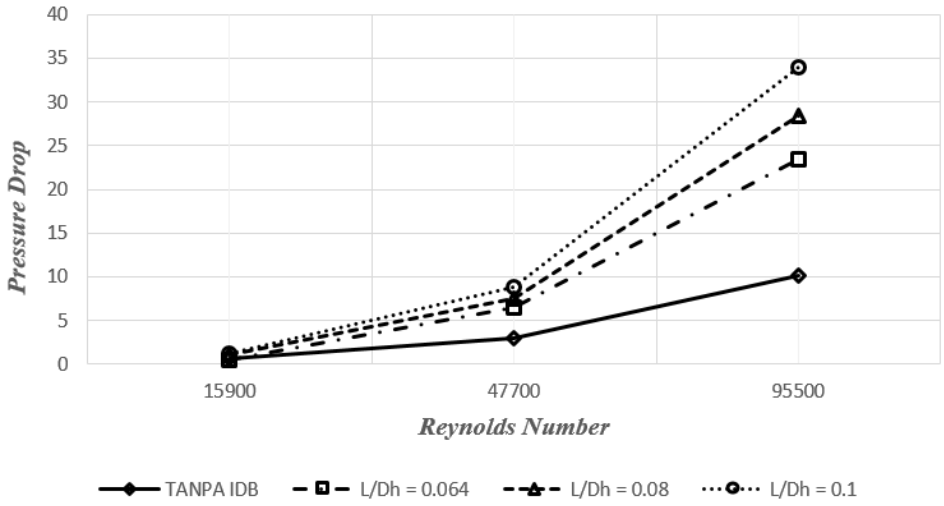

Figure 3. Pressure Drop at Elbow with Reynolds Number variation.

REFERENCES

[1] S. Sutardi, A. W. Wawan, I. Affan, I. Iswati, and M. D. Sutrisno, "Experimental study of the effect of guide vane insertion and reynolds numbers on the flow pressure drop in a 90° rectangular elbow," in *Regional Conference on Mechanical and Aerospace Technology*, 2010.

[2] K. Rup and P. Sarna, "Analysis of turbulent flow through a square-sectioned duct with installed 90-degree elbow," *Flow Meas. Instrum.*, vol. 22, no. 5, pp. 383–391, Oct. 2011.

[3] M. Ozgoren, "Flow structure in the downstream of square and circular cylinders," *Flow Meas. Instrum.*, vol. 17, no. 4, pp. 225–235, Aug. 2006.

[4] W. A. Widodo and R. P. Putra, "Reduction of Drag Force on a Circular Cylinder and Pressure Drop Using a Square Cylinder as Disturbance Body in a Narrow Channel," *Appl. Mech. Mater.*, vol. 493, pp. 192–197, Jan. 2014.

[5] P. Dutta and N. Nandi, "Effect of reynolds number and curvature ratio on single phase turbulent flow in pipe bends," *Mech. Mech. Eng.*, vol. Vol. 19, no. 1, pp. 6–16, 2015.

[6] D. S. Miller, *Internal flow systems*, 2nd ed. Cranfield Bedford: BHRA (Information Services), 1990.