International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 3 Issue 6, June - 2014

CFD Analysis of Water Flow Through Gradual Contraction Joint

Mr. Amol V Narayane[1]
M-TECH Scholar, Datta Meghe Institute of Engineering Technology & Research Sawangi, Wardha-442001[1]

Mr. Vivek C Pathade[2]
Assistant Professor, Datta Meghe Institute of Engineering Technology & Research Sawangi, Wardha-442001[2]

Mr. Rupesh G Telrandhe[3]
Assistant Professor, Datta Meghe Institute of Engineering Technology & Research Sawangi,Wardha-442001[3]

***Abstract*: The aim of this research paper is to understand the flow behavior of water through gradual contraction joint. In order to find out optimum angle at which head loss will be minimum different angle has been consider for the gradual contraction ratio 2. The experimentation was carried out to measure discharge (Q) at different pressure, from which inlet and outlet velocity was calculated. With the help of inlet and outlet velocity head loss has been calculated.Fluent software was used to plot the characteristics of the flow & GAMBIT was used design the model.**

Keywords: Fluent Software, GAMBIT, Gradual Contraction Ratio, optimum angle, discharge.

1. INTRODUCTION

In hydraulic engineering practice, it is frequently necessary to estimate the head loss incurred by a fluid as it flows along a pipeline. For example, it may be desired to predict the rate of flow along a proposed pipe connecting two reservoirs at different levels, or it may be necessary to calculate what additional head would be required to double the rate of flow along an existing pipeline.

Pipes are the important media for transporting fluids (liquid or gases) from one place to another under pressure. The efficiency depends on minimize the losses in fluid flow is important. Pipes consist of elbows, T-junctions, bends, contractions, expansions and many other components. When a fluid flows through a pipe due to friction between walls and to the layers of fluids, the energy is converted into thermal energy. Hence energy losses are developed in terms of the fluid height known as the head losses. These losses are classified into major losses or linear head present throughout the length of the pipe and minor losses or singular head occurring due to minor appurtenance and accessories present in a pipe network. The major loss can actually be smaller than the minor loss for a pipe system containing short pipes and many bends and valves.

In case of gradual contraction there is the energy loss due to change in diameter of pipe, this energy loss is depend upon the angle between the larger and smaller pipe known as cone angle.

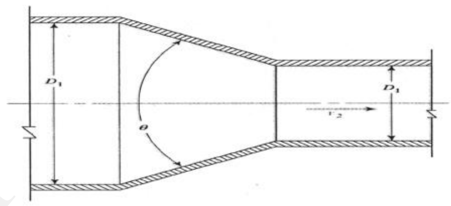


Fig.1 Gradual contraction joint

In this paper the analysis was done on very small area and common components of pipe network i.e. gradual contraction of pipes. The main aim behind the project is to find out optimum angle to minimize head losses.

2. EXPERIMENTAL ANALYSIS

2.1) Experimental detail

In order to get exact relationship between cone angle and head loss, the experiment has been set & the details are as follows.

a) 0.5 Hp Motor (b) PVC Pipe
(c) Gradual contraction joint
d) Fluid (Water-γ = (1000 kg/m^3))

2.2) Experimental Procedure

Measure the discharge rate (Q) for the different inlet pressure i.e.; 10 Kg/cm^2, 15 Kg/cm^2, 20 Kg/cm^2, 25 Kg/cm^2. With the help of various parameters has been calculated i.e.; inlet & outlet velocity, head loss etc.

3. GEOMETRY DETAILS

The geometry was done in the GAMBIT with measurements, larger pipe diameter and length as 25mm and 40mm, smaller pipe diameter and length as 12.5mm and 60mm in case of gradual contraction. Defining required boundaries like inlet, outlet and wall of the geometry and mesh under triangular. The figure shows the mesh geometry of the fluid flow.

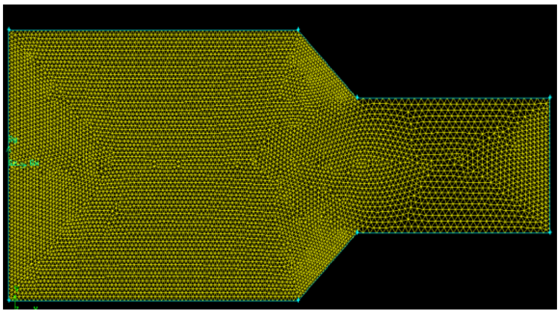


Fig.2 Mesh Geometry of GradualContraction Ratio 2.

4. SOLUTION STRATEGY& CONVERGENCE

The simulation is done in the FLUENT based upon the governing equations. The steps followed in the fluent are define Model, define Material, define cell zone, boundary condition, solve, iterate, and analyze results. The governing equations used to solve this problem as below.

4.1) continuity equation

The continuity equation describes a discharge as constant and continuous over the period of time in consideration (Chow, 1959). The concept of continuity is shown in

$Q = v1A1 = v2A2$

Where:

$A1$ = cross-sectional area normal to the direction of flow at the downstream cross section (m^2);

$A2$ = cross-sectional area normal to the direction of flow at the upstream cross section (m^2);

Q = discharge (m^3/sec);

$v1$ = average velocity at the downstream cross section (m/s); and

$v2$ = average velocity at the upstream cross section (m/s).

Using the continuity equation, the average velocity is expressed in terms of discharge and

Cross-sectional area,

$v = Q/A$

Where:

A = cross-sectional area normal to the direction of flow (m^2);

Q = discharge (m^3/sec); and

v = average velocity (m/s).

4.2) Kappa-Epsilon Model

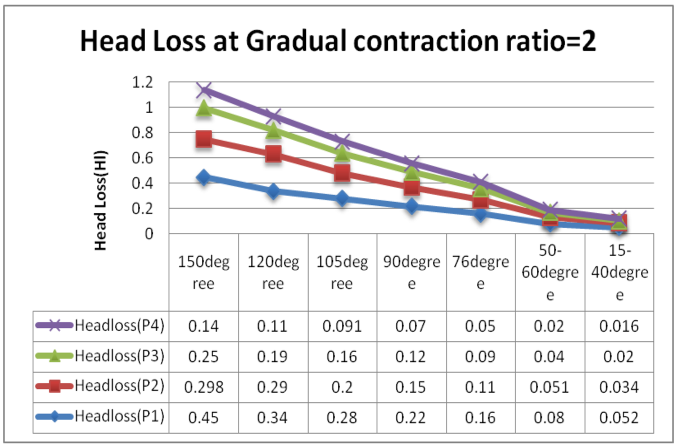
The K-epsilon model is most commonly used to describe the behavior of turbulent flows. It was proposed by A.N Kolmogrov in 1942, then modified by Harlow and Nakayama and produced K-Epsilon model for turbulence. No single turbulence model can be universally applied to all situations. Some consideration must be taken when choosing a turbulence model including; physics encompassed in the flow; level of accuracy; and computation resources available. The K-Epsilon model was tested in CFD.

5. RESULTS& DISCUSSION

5.1:Flow analysis in gradual contraction:

Gradual Contraction Ratio=2			
INLET P1	Q(ml/min)	V1 (m/s)	V2 (m/s)
10	120	0.004	0.016
15	100	0.0033	0.013
20	90	0.003	0.012
25	70	0.0023	0.009

Gradual Contraction Ratio=2						
$\{Hl=k(V2^2/2g)\}(10^{-5})$						
150^0	120^0	105^0	90^0	76^0	50^0-60^0	15^0-40^0
0.45	0.34	0.28	0.22	0.16	0.08	0.052
0.298	0.29	0.2	0.15	0.11	0.051	0.034
0.25	0.19	0.16	0.12	0.09	0.04	0.02
0.14	0.11	0.091	0.07	0.05	0.02	0.016



In the above graph it is found that, the head loss is minimizes by reducing the cone angle and we got optimum result at the angle of 15^0-40^0.

5.2 CFD ANALYSIS:

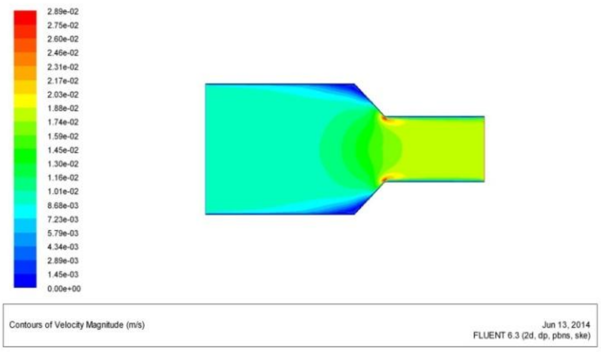


Fig. 5.21 CFD ANALYSIS AT ($10Kg/cm^2$)

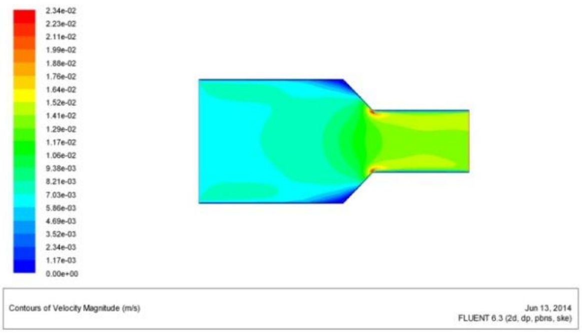


Fig. 5.22 CFD ANALYSIS AT ($15Kg/cm^2$)

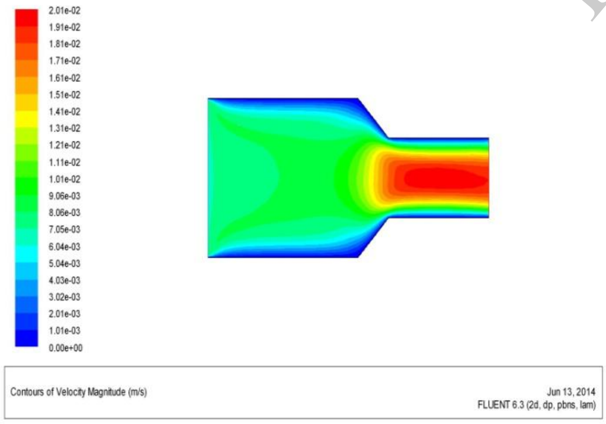


Fig.5.23 CFD ANALYSIS AT ($20Kg/cm^2$)

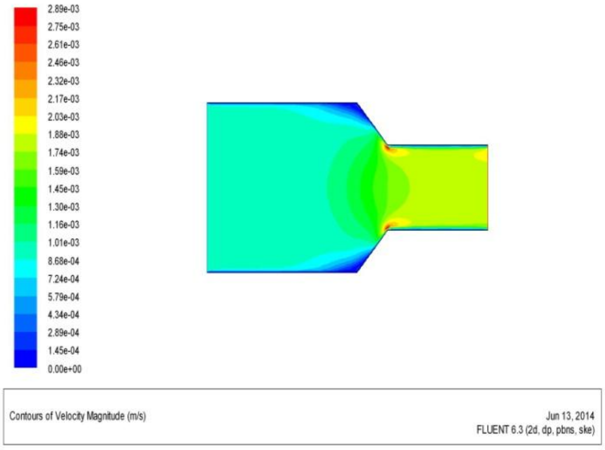


Fig. 5.24CFD ANALYSIS AT ($25Kg/cm^2$)

Discussion of CFD: In the entire above CFD diagram, it can be observed that there is a velocity loss at the gradual contraction; hence we can reduce it by finding optimum angle.

6. CONCLUSION

From the above analysis, it is found that head loss gets decreasing by decreasing the cone angle and the optimum angle for gradual contraction ratio could be in the range of 15^0-40^0.

7. FUTURE SCOPE:

Similar work can be done over gradual expansion joint of pipe with the different expansion ratio.

8. REFERENCES

[1] Hazen-Williams Formula http://www.pipeflow.com/pipe-pressure-drop-calculations/ Pipe-friction-loss.

[2] G.Satish, K. Ashok Kumar, V.Vara Prasad, Sk.M.Pasha Comparison of flow analysis of a sudden and gradual changeof pipe diameter using fluent software,IJRET Volume: 02 Issue: 12, Dec-2013.

[3] Casarsa L. and Giannattasio P., 2008.Three-dimensional features of the turbulent flow through a planar sudden expansion. *Physics of fluid*, 20, pp. 1-15.

[4] Vikram Roy, SnehamoyMajumder, Dipankar Sanyal, Analysis of the Turbulent Fluid Flow in an Axi-symmetric Sudden Expansion, International Journal of Engineering Science and Technology,Vol. 2(6), 2010, 1569-1574