ABSTRACT

The branching of pipes is common in water distribution system and penstock of hydroelectric power plants. It is necessary to design a good branching junction/division with desired flow distribution with a minimum hydraulic loss. A branching junction introduces extra energy losses because of changes in the flow direction, velocity and flow rate.

Flow separation at the sharp corners of the junction induces pressure losses. The flow predictions at pipe junctions/divisions are influenced by the angle of bifurcation/trifurcation, curvature, turbulence, pipeline pressure and split flow rates. It is required to know the split flow ratios $\frac{Q_2}{Q_i}$, $\frac{Q_3}{Q_i}$, and $\frac{Q_4}{Q_i}$ at the pipe trifurcation/bifurcation junction and calculate the overall pressure loss coefficients (K) at various line pressures and at different angles of pipe bifurcation/trifurcation. The research focuses in determination of pressure losses and flow distribution of pipe bifurcations and trifurcation at various flow rates and pressures using the experimental and numerical techniques. It is also aimed to optimize the pressure loss coefficient for a given angle of bifurcation/trifurcation to evaluate the corresponding split flow ratio in pipe branches.

The current research aimed to evaluate experimentally the pressure loss at pipe bifurcation and trifurcation with different angles of bifurcation and trifurcation by varying the line pressure between 50KPa to 400KPa. The experimental results are validated using CFD Code.

The symmetrical and unsymmetrical bifurcation/trifurcation junction setups used in the current study are as follows:

1. The branching angles for symmetrical bifurcation junctions are:
   - Pipe Symmetrical Bifurcation BSA (20°)
   - Pipe Symmetrical Bifurcation BSA (25°)
   - Pipe Symmetrical Bifurcation BSA (30°)
   (B-Bifurcation, S-Symmetrical A-angle i.e. BSA)
2. The branching angles for unsymmetrical bifurcation junctions are:
   - Pipe Unsymmetrical Bifurcation BUSA (10°)
   - Pipe Unsymmetrical Bifurcation BUSA (12.5°)
3. The branching angles for symmetrical trifurcation junctions are:
   - Pipe Symmetrical Trifurcation TSA (10°-10°)
   - Pipe Symmetrical Trifurcation TSA (12.5°-12.5°)
   - Pipe Symmetrical Trifurcation TSA (15°-15°)

   (T-Trifurcation, S-Symmetrical A-angle i.e. TSA)

4. The branching angles for unsymmetrical trifurcation angle are:
   - Pipe Unsymmetrical Trifurcation TUSA (15°-30°)
   - Pipe Unsymmetrical Trifurcation TUSA (20°-35°)
   - Pipe Unsymmetrical Trifurcation TUSA (15°-45°)

   (T-Trifurcation, U-Unsymmetrical A-angle i.e. TUSA)

The diameter of the GI inlet pipe is 25.40 mm and that of branch pipes are 19.60 mm. The
diameter ratio of the inlet pipe to branch pipe is considered as \( \frac{d}{D} = 0.75 \)

The flow parameters considered in this study are:

Split flow ratios \( \left( \frac{Q_2}{Q_1} \right), \left( \frac{Q_3}{Q_1} \right) \) & \( \left( \frac{Q_4}{Q_1} \right) \), Reynolds number \( R_e \), pressure loss coefficient \( K = \frac{H_i}{V^2} \). The combined loss coefficient \( K \) and branch loss coefficients \( K_{12}, K_{13}, \)
\( K_{14} \) for bifurcation and trifurcation have been correlated between split flow ratios
\( \left( \frac{Q_2}{Q_1} \right), \left( \frac{Q_3}{Q_1} \right) \) & \( \left( \frac{Q_4}{Q_1} \right) \) and flow energy ratio \( \left( \frac{E_{out}}{E_i} \right) \)
The geometry of pipe bifurcation and trifurcations are created using GAMBIT2.4 software with tetrahedral mesh of 4mm size. The model is imported to ANSYSFLUENT commercial software with the necessary boundary conditions as input. The standard K-ε turbulence model is used for numerical computations for validating the experimental results.

The model is run with ANSYS FLUENT to obtain the solution by performing number of iterations and residuals to converge. Pressure-velocity coupling is done using simplex algorithm for a segregated solver system. The output is taken in the graphical and tabular form.

The experimental results of flow velocity are compared with the CFD output results for validation.

The experimental findings for pipe bifurcation suggest that the head loss at the pipe junction is optimum when the flow distribution in each of the branch pipe is equal. Optimum loss coefficient (K) =1.20 for equal distribution of flow in each of the branch pipes. The value of combined loss coefficient (K), increases with the pipeline pressure for a given bifurcation angle.

In case of the trifurcation the minimum overall loss coefficient is (K) = 0.35 when straight pipe carry 40% of main flow and the remaining 60% flow is distributed amongst left and right branches of the trifurcation. As the trifurcation angles increases the value of loss coefficient (K) also increases.

The experiments conducted at different pipeline pressures also indicate that the overall trifurcation loss coefficient (K) is high for higher line pressures.