CHAPTER -7

CONCLUSIONS

This chapter presents the summary of findings obtained from the present experimentation and numerical simulations for pressure losses in pipe bifurcation and trifurcation. The distributions of flow in branch pipes, for various configurations of bifurcation and trifurcations at different angles are estimated.

7.1 Head loss at Pipe Symmetrical Bifurcation (BSA) and Unsymmetrical Bifurcation (BUSA)

Determination of pressure loss for symmetrical bifurcation of BSA (20°), BSA (25°) and BSA (30°) and unsymmetrical bifurcation of BUSA (10°), BUSA (12.5°), BUSA (15°), BUSA (30°), BUSA (35°), BUSA (45°), BUSA (55°) and BUSA (60°) has been done by varying pipeline pressure ranging from to 0.50 kg/cm\(^2\) to 2.50 kg/cm\(^2\). The main findings are:

- The optimum value of loss coefficient(K) is obtained when each of the branch pipes carries 50% of the main flow (i.e., \(\frac{Q_2}{Q_1} = \frac{Q_3}{Q_1} = \frac{Q_4}{Q_1} = 0.50\)), and the value of K reduces from 2.50 to optimum value of 1.20. The above statement holds good for all the configurations of pipe bifurcation angles with symmetrical (BSA) and unsymmetrical (BUSA) combinations.
- The branch loss coefficient (K\(_{12}\)), (K\(_{13}\)) or (K\(_{14}\)) reaches maximum value of 2.50 when respective branch-2(Q\(_2\)) or branch-3(Q\(_3\)) branch-4 (Q\(_4\)) carries the full discharge for all the configurations of symmetrical bifurcation (BSA) and unsymmetrical bifurcation (BUSA).
- The value of loss coefficient (K) is more for higher pipe line- pressure (0.70 to 2.00 kg/cm\(^2\)) compared to low pipe line- pressure (< 0.70 kg/cm\(^2\)). However the loss coefficient optimizes at K= 1.20 for both high and low line pressures [(Fig.4.19 (a)] as the flow in the bifurcated pipes tend to equalize (i.e., \(\frac{Q_2}{Q_1} = \frac{Q_3}{Q_1} = \frac{Q_4}{Q_1} = 0.50\)).
• The value of pressure loss coefficient (K) at pipe junction is more for low flow ratios \( \left( \frac{Q_2}{Q_1}, \frac{Q_3}{Q_1} < 0.30 \right) \). The reason could be attributed to separation and mixing of flow, formation of vortex at downstream side of bifurcation junction as visualised in CFD images.

• The loss coefficient for both symmetrical bifurcation (BSA) and unsymmetrical bifurcation (BUSA) converges at Reynolds number \( (Re_1) = 10,000 \) and further increases in the value of \( Re_1 \) at the fully developed flow region the value of \( K \) tends asymptotically towards \( Re_1 \).

7.2 Head loss at Symmetrical Pipe Trifurcation (TSA) and Unsymmetrical Pipe Trifurcation (TUSA)

Determination of pressure loss coefficient for symmetrical angle trifurcation of TSA \( (10^\circ-10^\circ) \), TSA \( (12.5^\circ-12.5^\circ) \) and TSA \( (15^\circ-15^\circ) \) and unsymmetrical trifurcation of TUSA \( (20^\circ-35^\circ) \), TUSA \( (15^\circ-30^\circ) \) and TUSA \( (15^\circ-45^\circ) \) has been done by varying line-pressure ranging from to 0.50 kg/cm\(^2\) to 2.50 kg/cm\(^2\). The main findings from the present research are:

- The combined loss coefficient (K) decreases initially and increases as the flow in the straight branch increases and the loss coefficient curves meet at the common point when \( K = 0.65 \) at \( Q_3 = Q_1 \), optimum value of \( K = 0.35 \) when the straight branch pipe carries \( \left( \frac{Q_3}{Q_1} \right) = 0.40 \) i.e., for the optimum value of \( K \) the flow rate in the straight pipe is to be 40% of the main discharge \( (Q_3 = 0.4Q_1) \) and the remaining 60% is to be equally distributed among the left and right branches both in case of both symmetrical (TSA) and unsymmetrical trifurcation (TUSA) as observed in Fig. 5.12

- The minimum value of combined loss coefficient (K) is 0.31 for TSA \( (10^\circ-10^\circ) \), 0.40 for TSA \( (15^\circ-15^\circ) \) and 0.50 for TUSA \( (15^\circ-30^\circ) \), 0.58 for TUSA \( (15^\circ-45^\circ) \) which shows that as the angle of deviation increases consequently the loss coefficient also increases. For the optimum split flow of 40% in center pipe, the variation of \( K \) is due to the deviation of flow from inlet pipe to left and right branch pipes which leads to pressure gradient across the flow, along the direction of flow, formation of recirculation zones, pockets of vacuum pressure, mixing of
fluid particles by transfer of flow energy and the value of K is comparatively less in case of symmetrical trifurcation (TSA) due to streamlining of flow the same is observed in CFD output image.

- The value of K increases for higher discharges for both symmetrical (TSA) and unsymmetrical trifurcations (TUSA). It is noted that the values of \( K_{\text{unsymmetrical}} > K_{\text{symmetrical}} \) for the main discharge (\( Q_1 \)) in this study, as the trifurcation angle increases the value of loss coefficient also increases. The main reason could be whirling of flow, formation of vortex, complex flow phenomena in the extreme branch pipes of unsymmetrical trifurcation (TUSA).

- The combined loss coefficient (K) for all configurations symmetrical trifurcation (TSA) and unsymmetrical trifurcation (TUSA) converges to a common point at Reynolds number \( \text{Re}_1 = 10,000 \) and further increasing the Reynolds Number (\( \text{Re}_1 \)) in fully developed flow region the loss coefficient (K) tends asymptotically towards a constant value.

7.3 Numerical Simulations at Pipe Junction Using CFD

Simulated values are showing good coherence with experimental results, the correlation obtained in this study reflects the experimental results. The CFD simulations are validated with the experimental results. This extraction leads to show a good accuracy in predicting pre-defined physical condition.

As the angle of bifurcation increases the loss coefficient also increases for both symmetrical (BSA) and unsymmetrical bifurcation (BUSA) mainly due to formation of vortex and turbulent mixing.

Developments of pockets of formation of vacuum pressure, vortex, anisotropic and unstable condition of the flow is observed at the outer branches of the unsymmetrical trifurcation (TUSA) due to random movement of the fluid particle in unpredictable manner and momentum transfer which leads to energy losses at the downstream side of the pipe trifurcation junction. The pressure loss and flow fluctuations is comparatively less in case of symmetrical trifurcation (TSA) compared to unsymmetrical pipe trifurcation (TUSA).

In case of Trifurcation the discharge is more in center straight pipe with less oscillation and the discharge is less at outer branch pipes of unsymmetrical trifurcation (TUSA) due to bending of the pipe.