CHAPTER- 3

EXPERIMENTAL SETUP, EQUIPMENTS AND METHODOLOGY

3.1 Experimental Test Rig

Hydraulic test rig consists of pump supply pipes, manifold, inlet pipe, control valve, pipe junctions, pressure gauges on the branch pipes, flow meters on each of the branch pipes, outlet pipes, collecting tank, stop watch, thermometer and MS frame support as shown in Fig. 3.1. The test rig consists of:

- Two centrifugal pumps (0.5 HP and 2 HP) for, low pressure and higher pipeline pressure.
- Dial type pressure gauges (accuracy achieving 0.10 kg/cm$^2$) are installed at inlet (upstream) and outlet (downstream) pipe of the junction to measure the line pressure under varying condition of discharge.
- Flow meters (accuracy achieving 100 ml) are installed at each of the pipe branches of bifurcation or trifurcation as the case may be to measure the discharge in branch pipes.
- Normal thermometer is used to note down the temperature of the recirculation water at beginning and end of the experimental run on each day.
- Control valves are provided at each of the pipe branches and at the inlet pipe to control the flow in respective pipe.
- Manifold is provided before (upstream) of the inlet pipe to regulate pipeline pressure.
- Frame support is provided to keep the test rig in horizontal position.

Following Table 3.1 gives the details of piping component parts of the test rig.

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Pipe</th>
<th>Material</th>
<th>Length (mm)</th>
<th>Diameter (d) mm</th>
<th>Area (mm$^2$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Inlet</td>
<td>GI</td>
<td>1370</td>
<td>25.40</td>
<td>506.77</td>
</tr>
<tr>
<td>2</td>
<td>Outlet</td>
<td>GI</td>
<td>760</td>
<td>19.60</td>
<td>301.75</td>
</tr>
<tr>
<td>3</td>
<td>Manifold</td>
<td>GI</td>
<td>1000</td>
<td>100.00</td>
<td>7855.00</td>
</tr>
<tr>
<td>4</td>
<td>Supply</td>
<td>PVC</td>
<td>2100</td>
<td>25.40</td>
<td>506.77</td>
</tr>
</tbody>
</table>
3.2 Pipe Junctions

Pipe bifurcation and trifurcation junctions are made up of GI pipe with inlet pipe diameter before the junction is 25.40 mm and branch pipes of 19.60 mm. The length of junction is 400 mm with the provision of pressure taps to install the pressure gauges to measure the pressure in branch and inlet pipe. Junction is used as symmetrical and unsymmetrical pipe bifurcation and trifurcation by closing the control valve at required branch pipes as explained in 3.2.1 and 3.2.2

Following Table 3.2 gives the details of pipe junction branch angles.

Table 3.2: Junction Branch Angles

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Junction type</th>
<th>Branch angle ($\theta_1^\circ$ - $\theta_2^\circ$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Symmetrical Branch</td>
<td>(10$^\circ$ - 10$^\circ$) (12.5$^\circ$ - 12.5$^\circ$) (15$^\circ$ - 15$^\circ$)</td>
</tr>
<tr>
<td>2</td>
<td>Unsymmetrical Branch</td>
<td>(35$^\circ$ - 20$^\circ$) (15$^\circ$ - 30$^\circ$) (15$^\circ$ - 45$^\circ$)</td>
</tr>
</tbody>
</table>
3.2.1 Symmetrical Pipe Trifurcation Junctions

(a) TSA (10°-10°): Symmetrical angle trifurcation is shown in Fig. 3.2 (a) with internal angle (10°-10°) the same is used as:

- Symmetrical bifurcation junction: BSA (20°) by closing center straight branch pipe.
- Unsymmetrical bifurcation junction: BUSA (10°) by closing left or right branch pipe
- Symmetrical trifurcation junction: TSA (10°-10°) by allowing the discharge in all the branch pipes.

![Fig.3.2 (a) Symmetrical Pipe Trifurcation Junction TSA (10°-10°)](image)

(b) TSA (12.5°-12.5°): Symmetrical angle trifurcation is shown in Fig. 3.2 (b) with internal angle as (12.5°-12.5°) the same is used as:

- Symmetrical bifurcation junction: BSA (25°) by closing center straight branch pipe.
- Unsymmetrical bifurcation junction: BUSA (12.5°) by closing left or right branch pipe.
- Symmetrical trifurcation junction: TSA (12.5°-12.5°) by allowing the discharge in all the branch pipes.
3.2.2 Unsymmetrical Pipe Trifurcation Junctions (TUSA)

(a) TUSA (30°-15°): Unsymmetrical angle trifurcation is shown in Fig. 3.3 (a) with internal angle as (30°-15°). The same is used as:

- Unsymmetrical bifurcation junction: BUSA (30°) by closing right branch pipe.
- Unsymmetrical bifurcation junction: BUSA (15°) by closing left branch pipe.
- Unsymmetrical bifurcation junction: BUSA (45°) by closing center straight pipe.
• Unsymmetrical trifurcation setup: TSA (30°-15°) by allowing the discharge in all the branch pipes

![Unsymmetrical Pipe Trifurcation Junction (30°-15°)](image1)

Fig. 3.3 (a) Unsymmetrical Pipe Trifurcation Junction (30°-15°)

(b) TUSA (35°-20°): Unsymmetrical angle trifurcation is shown in Fig. 3.3 (b) with internal angle as (35°-20°) and is used as:
- Unsymmetrical bifurcation junction: BUSA (35°) by closing left branch pipe.
- Unsymmetrical bifurcation junction: BUSA (20°) by closing right branch pipe.
- Unsymmetrical bifurcation junction: BUSA (55°) by closing center straight branch pipe.
- Unsymmetrical trifurcation: TSA (35°-20°) by allowing the discharge in all the branch pipes.

![Unsymmetrical Pipe Trifurcation Junction TSA (35°-20°)](image2)

Fig. 3.3 (b) Unsymmetrical Pipe Trifurcation Junction TSA (35°-20°)

(c) TUSA (15°-45°): Unsymmetrical angle trifurcation is shown in Fig. 3.3 (c) with internal angle as (15°-45°) which is used as:
- Unsymmetrical bifurcation junction: BUSA (15°) by closing right branch
- Unsymmetrical bifurcation junction: BUSA (45°) by closing left branch
- Unsymmetrical bifurcation junction: BUSA (60°) by closing center straight branch
- Unsymmetrical trifurcation: TSA (15°- 45°) by allowing the discharge in all the branch pipes.

![Image of Unsymmetrical Pipe Trifurcation Junction TSA (15°-45°)](image)

**Fig. 3.3 (c) Unsymmetrical Pipe Trifurcation Junction TSA (15°-45°)**

### 3.3 Equipment

#### 3.3.1 Pressure Gauges (4 Nos.):
Dial type pressure gauges (Fig.3.4) are fitted at the inlet and branch pipes of the bifurcation or trifurcation junction to measure the line-pressure (accuracy of 0.1 and 0.05 kg/cm²). For each variation of discharge pressure gauge readings at inlet pipe (p₁) and branch pipes (p₂, p₃ and p₄) are noted.

![Image of Pressure Gauges (Dial type)](image)

**Inlet Pipe**  **Branch Pipe**

**Fig. 3.4 Pressure Gauges (Dial type)**
3.3.2 Flow Meters (3 Nos.): Flow meters (Fig.3.5) are installed at all the branch pipes (FM₂, FM₃ and FM₄) to measure the mass flow (liters) in each of the branch pipes (accuracy of 100 ml). The discharge (cm³/s) in each branch is calculated by dividing the volumetric flow (10 liters) with time taken. The discharge in inlet pipe is calculated by adding the discharges in all the branch pipes.

![Flow Meters](image)

Fig. 3.5 Flow Meters

3.3.3 Pump (2 Nos.): Mono block centrifugal pumps of capacity 0.5 HP (low pressure) and 2 HP (higher pressure) are separately used one after the other for pumping and recirculation of water from the sump tank (Fig.3.6). The entire experimentation is conducted for both the pumps separately for studying the effect of low and higher pressure on the pressure loss coefficient.

![Pump](image)

Fig. 3.6 Pump

3.3.4 Collecting Tank: MS collecting tank 2000 mm ×1000 mm ×1500 mm in size (Fig.3.7) is used for collecting discharge from all the branch pipes and creating the pool.
of water for recirculation by pumps provided at the side of the tank. Tank capacity is kept sufficiently large so as to maintain the constant temperature of recirculation water.

**Fig. 3.7 MS Collecting Tank**

3.3.5 **Manifold:** GI manifold 100 mm diameter 1000 mm long (Fig.3.8) is provided at the end of the supply and before the inlet pipe so as to regulate the pressure variation at the inlet pipe of branching by providing sufficient space for accumulation of water.

**Fig.3.8 Manifold**

3.3.6 **Stop watch (3Nos.)** Digital stop watches (Fig.3.9) are used to note down the time required for 10 liters of volumetric discharge of water from the branch pipes.

Discharge, \( Q = \text{Volume of water / time taken} \) (\( \text{cm}^3/\text{s} \))
3.3.7 Thermometer: Thermometer (Fig. 3.10) is used for recording the temperature of water at the accuracy of 0.10°C. Temperature is noted before and after each of the experimental run to account for the variation of viscosity of the recirculation water. Due to large water pool in the collecting tank the temperature variation of recirculation water is less than 1°C which does not affect much on the viscosity of water.

3.3.8 Control Valve (4 Nos.): MS control valves (1 No) are provided at inlet of the pipe before junction and the remaining three control valves are provided at the end of the branch pipes so as to regulate the discharge in the respective inlet and branch pipes (Fig. 3.11). Control valves are operated as per the schedule of valve operation provided in the Table 4.2 for bifurcation and Table 5.1 for trifurcation experiments.
3.3.9 MS Support Frame: The assembly of test rig is supported by MS angular support frame to keep the test rig in horizontal and stable position. The datum head at inlet of pipe junction (Z1) and outlet at branch pipes (Z2=Z3=Z4) is equal.

Following Table 3.3 gives the calculation method for velocity of flow and discharge in each pipe.

**Table 3.3: Discharge Calculations at Inlet and Branch Pipes**

<table>
<thead>
<tr>
<th>Details</th>
<th>Unit</th>
<th>Branch 2</th>
<th>Branch 3</th>
<th>Branch 4</th>
<th>Inlet pipe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discharge</td>
<td>cm³/s</td>
<td>Q₂=10000/T₂</td>
<td>Q₃=10000/T₃</td>
<td>Q₄=10000/T₄</td>
<td>Q₁=Q₂+Q₃+Q₄</td>
</tr>
<tr>
<td>Velocity</td>
<td>cm/s</td>
<td>V₂=Q₂/A₂</td>
<td>V₃=Q₃/A₃</td>
<td>V₄=Q₄/A₄</td>
<td>V₁=Q₁/A₁</td>
</tr>
</tbody>
</table>

T₂, T₃ and T₄=Time required to collect 10 liters of water in branch 2, 3 and 4 respectively.

Following Table 3.4 gives the parameters considered in the present research.

**Table 3.4: Parameters Considered**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Branch 2</th>
<th>Branch 3</th>
<th>Branch 4</th>
<th>Combined</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure loss coefficient (K₁₂, K₁₃, K₁₄)</td>
<td>K₁₂</td>
<td>K₁₃</td>
<td>K₁₄</td>
<td>K</td>
</tr>
<tr>
<td>Split flow ratio (Q₂/Q₁, Q₃/Q₁, Q₄/Q₁)</td>
<td>Q₂/Q₁</td>
<td>Q₃/Q₁</td>
<td>Q₄/Q₁</td>
<td>Q₁</td>
</tr>
<tr>
<td>Energy ratio (E₂/E₁, E₃/E₁, E₄/E₁, Eₜ/E₁)</td>
<td>E₂/E₁</td>
<td>E₃/E₁</td>
<td>E₄/E₁</td>
<td>Eₜ/E₁</td>
</tr>
<tr>
<td>Reynolds number (Re)</td>
<td>Re₂</td>
<td>Re₃</td>
<td>Re₄</td>
<td>Re₁</td>
</tr>
<tr>
<td>Diameter ratio, (d₁=25.40 mm)</td>
<td>(d₂/d₁) = (d₃/d₁) = (d₄/d₁) = 0.75</td>
<td>--</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>