Tutorial 2 – Buoyant jet in stratified stagnant fluid/crossflow with a riser *(file Tut_2.vj3)*

The ambient receiving water often has a vertical variation of salinity and/or temperature, leading to density stratification. The jet may cause so much mixing that the mixed effluent stays trapped below the free surface. In this example we compute the mixing for a horizontal buoyant jet in a stratified fluid/crossflow.

Quite often the outfall is constructed deep under the seabed; in this case a riser is needed to bring the effluent from the underground outfall back to the sea. In this example we will also illustrate the use of a riser.

Basic Data:

Ambient Parameters:

Depth below surface (m)	Temperature (°C)	Salinity (ppt)
0	20	12.9
1	20	13.4
4	20	16.8
7	20	18.4
10	20	19.8
13	20	22.5
16	20	24.1
19	20	24.2
20	20	24.2

Current velocity   0.0 m/s (Current Angle = 90°)

Jet Parameters:
Diameter   0.125 m
Port height   30 m
Vertical angle   0°
Horizontal angle   0°

Outfall Parameters:
Depth (z)   50 m
Flow   0.0147 m³/s
Temperature   20 °C
Salinity   1 ppt
Concentration   1 relative units
Length   5 m
Width   2 m

Distance	2.5 m
Orientation	0º

Riser Parameters:

Distance	2.5 m
T. Radius	0.3 m
B. Radius	0.3 m
Height	30 m

(a) Vertical jet in stagnant ambient

General Notes:

1. Start up a new scenario in Port Shelter as instructed in Tutorial 1.

2. Enter ambient parameters: To add more layers of ambient parameters, click the button **"New"** just below the ambient parameters window. To delete extra ambient layer, click the button "**Delete**". Input the ambient parameters as given above.

3. Choose a location for the outfall as in Tutorial 1. Enter outfall parameters: Select **"Create an Outfall with Risers"**. Enter outfall parameters as given above.

4. Enter riser parameters: Enter the riser parameters as given above. Note that the riser height should be tall enough such that it can penetrate the seabed. Mathematically, Outfall depth – riser height ≤ Ambient depth, for example in this case outfall depth (50 m) – riser height (30 m) ≤ Ambient depth (20 m).

5. Enter jet parameters as given above by clicking **"New Jet"**. Note that port height again needs to satisfy outfall depth – port height ≤ Ambient depth. In addition the port height cannot be greater than the riser height.

6. Run the **"Start Near-field VISJET simulation"**.
The jet evolution can be seen. Note the major difference this time from the previous tutorial is that the plume is trapped under the water surface due to the effect of ambient stratification.

7. To obtain the computed result, instead of clicking each disk directly, we may open the SUSPEND file. To open the SUSPEND file, click **"View"** at the main menu, and select **"view SUSPEND file"**. The SUSPEND file shows key input parameters and length scales that govern the mechanics of buoyant jet mixing. For example, Total Q = 0.0147 (m³/s), jet densimetric Froude number Fd =8.22, Buoyancy flux Bj = 0.0026 m4/s², jet momentum length scale lM = 0.9482, and so on.   The

computed jet characteristics (co-ordinates of the jet trajectory, plume visual radius, velocity, concentration, dilution etc.) are tabulated. You will find some information about trap level. For this case, the neutral buoyancy level = 5.19 m, with a corresponding average dilution S=37.7 and visual radius = 1.61 m; jet centre maximum rise height = 7.34 m, corresponding average dilution S= 40.5 and visual radius = 2.55 m.

8. In the wet season, the receiving water is often stratified, and the sewage field may not reach the surface; the submergence of the sewage may be desirable for protection of nearby beaches.

(b) Horizontal jet in stagnant ambient

9. Jet angle does play a part in determining the dilution of the discharge. In this example, keep all the input parameters unchanged except change the vertical jet angle from 0° (horizontal) to 90° (vertical), and re-run the simulation.

10. Open the SUSPEND file and check the dilution. At the neutral buoyancy level (5.88 m), the dilution is S=27.4. At the maximum rise level (8.30 m), the dilution is S=31.2. Both dilution are less than that of a horizontal jet, this is due to the shorter entrainment path of the vertical jet.

(c) Horizontal jet in a stratified crossflow

11. We can similarly study the effect of a current as in Tutorial 1 in a stratified ambient condition.
(i) Keep the discharge parameters unchanged except changing the current speed of each ambient layer to 0.1 m/s as instructed in tutorial 1.
(ii) Run the simulation again by clicking **"Start Near-Field VISJET simulation"**.
(iii) Observe the evolution and spread of the jet. It can be seen that the jet oscillates and is trapped under the water surface due to the effect of the ambient stratification.
(iv) Open the **"SUSPEND FILE"** to study different mixing characteristics of the jet.
(v) It can be seen that the neutral buoyancy level is 5.1815 m above the discharge port with a dilution of S=125.42. Visual radius is 2.38 m at this level. The maximum rise of the jet is 6.04 m above the discharge port and the average dilution is S=226.14 at this level.