Documentation for 3D, two-phase jet instability tool (2PJIT) in cylindrical coordinates

The solver consists of 3 main matlab scripts:

The main script for the user is ‘**twoPJIT.m**’ which contains the properties of the two-phase jet. This script then calls the function ‘**Cylindrical_3D_solution**’ to solve the eigenvalue differential equations and then calls the ‘**perturbation**’ function to extract the perturbation quantities at the most unstable point.

Read the following instructions to run the solver:

- Open *‘twoPJIT.m’*
- Under the section Properties of the jet, enter the properties of the liquid jet, the surrounding gas, the shear layer thicknesses in both the phases and the surface tension coefficient. (Remember to make sure that the gas domain length is more than the shear layer thickness in gas, delta_G, in order to eliminate the effect of gas domain length on the solution). A snippet of the code where properties are entered is given below:

```
%% %%%%%%%%%%%%%%%%%%%%%%%%%%%%%% %%
%%%%% Properties of the jet %%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% The properties of the jet are entered here
% The following values are default values which can be changed by the user

Ujet = 200;
R = 45e-6;
H = 5*R;

rho_L = 666.7;
rho_G = 50;

nu_L = 6.947e-7;
nu_G = 3.76e-7;

delta_L = R/5;
delta_G = R;

gamma = 0.02;
```

- Run the code *‘twoPJIT.m’*

- A prompt will be asked for the mode of disturbance. Press *'0'* for axisymmetric and *'1'* for asymmetric disturbance and hit return:

```
Enter the mode of disturbance:
 0 - Axisymmetric mode
 1 - Asymmetric mode
1
```

- A prompt will be asked to *'Input an array of non-dimensional frequency values'.* Usually *linspace* or *logspace* can be used. Enter the input array and hit return. Default values with *linspace(0,15,40)* will be used if no value is entered. An example is shown below:

```
Input an array of non-dimensional frequency values
Hit return to use a default value (linspace(0,15,40) will be
used as default value)
Otherwise enter the values (usually linspace or logspace can
be used)
linspace(0,15,40)
```

- A prompt will be asked to enter the number of Gauss-Lobatto (G-L) points in the liquid domain. Enter the number of divisions and hit return. A default value of 40 will be used if no value is entered:

```
Enter the number of Gauss-Lobatto points in liquid domain:
Hit return to use a default value (40 number of G-L points in
liquid will be used as default value)
Otherwise enter the value
50
```

- A prompt will be asked to enter the number of G-L points in the gas domain. Enter the number of divisions and hit return. A default value of 70 will be used if no value is entered:

```
Enter the number of Gauss-Lobatto points in gas domain:
Hit return to use a default value (70 number of G-L points in
gas will be used as default value)
Otherwise enter the value
80
```

- For the given input frequency values, the equations will be solved by calling the function *'Cylindrical_3D_solution'*. For each frequency value, the corresponding growth rate and wavenumber obtained as the solutions will be displayed. The Residual error for the solution will also be displayed. The low values of residual error confirm the correctness of the solution. The outputs displayed with one of the input frequencies is shown below:

```
Input frequency = 1.5385
Growth rate = 0.039517
Wavenumber = 1.5763
Residual Error = 1.0165e-11
```

- After solving for all the input frequencies, a prompt will be asked to display the dispersion plot in non-dimensional or dimensional form. Press *'0'* for non-dimensional form or *'1'* for dimensional form and hit return. (The non-dimensionalization is done using the jet velocity and the jet radius)

```
Select whether to plot non-dimensional or dimensional
dispersion plot:
0 - Non-dimensional
1 - Dimensional
1
```

- Figure 1 gives the dispersion plot of growth rate versus the frequency and figure 2 gives the dispersion plot of growth rate versus the wavenumber.
- The characteristics of the most unstable mode will be displayed on the screen as follows:

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Frequency of the most unstable mode=18803418.8034 rad/s
Wavenumber of the most unstable mode=95742.7828 m^{-1}
Growth rate of the most unstable mode=1231.6791 m^{-1}
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
```

- The perturbation quantities will be solved for the most unstable mode by calling the function *'perturbation.m'*. The figures 3, 4, 5 and 6 will display the radial velocity perturbation, azimuthal velocity perturbation, axial velocity perturbation and the pressure perturbation along the radial direction respectively.
- Finally, a figure with 3D cylindrical jet with the most unstable mode of disturbance is generated in figure 7.