

Jet rond subsonique turbulent

Turbulent velocity signals have been measured using x-hot-wire anemometer in a round subsonic jet. The signals have been recorded in data files, refer to Table 1, and collected in the zip file *hwa.zip* to download.

| $u_1 & u_2$ $x_2 = 0, x_3 = 0$ | $u_1 & u_2$ $x_2 = D/2, x_3 = 0$ | $u_1 & u_3$ $x_2 = 0, x_3 = 0$ | $u_1 & u_3$ $x_2 = 0, x_3 = D/2$ |
|-----------------------------------|-------------------------------------|-----------------------------------|-------------------------------------|
| data1.dat | data2.dat | data3.dat | data4.dat |

Matlab script
to read the data

$$\left\{ \begin{array}{l} \text{load data1.m} \\ t = \text{data1}(:,1); \\ u_1 = \text{data1}(:,2); \\ u_2 = \text{data1}(:,3); \end{array} \right.$$

TABLE 1 – Turbulent velocity signals for a free round jet of diameter $D = 50$ mm and exit velocity $U_j = 30 \text{ m.s}^{-1}$, corresponding to a Reynolds number value of $\text{Re}_D \simeq 10^5$. The Cartesian coordinates are denoted by (x_1, x_2, x_3) where x_1 is associated with the jet axis, and (u_1, u_2, u_3) are the velocity components. The hot-wire probe is located at $x_1 = 2D$.

You can conduct your study fairly freely, but the following points may be considered :

1. For a point located in the jet shear layer ($x_2 = D/2$ ou $x_3 = D/2$), extract the time signature of $u'_1(t)$, calculate $u'_{1\text{rms}} = (\overline{u_1'^2})^{1/2}$, the skewness S_1 and the flatness T_1 coefficients defined by

$$S_1 = \frac{\overline{u_1'^3}}{(\overline{u_1'^2})^{3/2}} \quad T_1 = \frac{\overline{u_1'^4}}{(\overline{u_1'^2})^2}$$

2. Compare your results with a Gaussian distribution for the longitudinal velocity u'_1 and comment.
3. What is the following quantity $(\overline{u_1'^2} - \overline{u_1'}^2)^{1/2}$? Compare this definition to the classical expression of the standard deviation.
4. Calculate the previous statistics for the time derivative of the longitudinal velocity component $\partial u'_1 / \partial t$.
5. Calculate the available Reynolds tensor components $\overline{u'_i u'_j}$ on the jet axis and in the shear layer. Comment your results, what is expected ?
6. Consider now the probability density function of $u'_i u'_j$ in the shear layer. Plot this function and comment your result.
7. By splitting the time signal $u'_1(t)$ into n segments, that are considered as n statistically independent realizations, verify that turbulence is stationary. What is the appropriate time length of each segment ?

8. Calculate the time correlation function $R(\tau)$ of the signal $u'_i(t)$ in the jet shear layer and the integral time Θ , defined as

$$R(\tau) = \frac{\overline{u'_1(t)u'_1(t+\tau)}}{\overline{u_1'^2}} \quad \text{and} \quad \Theta = \int_0^{+\infty} R(\tau) d\tau$$

9. How can you link the integral time scale Θ to the longitudinal integral length scale L , obtained from the space correlation of u'_1 in the x_1 direction.
10. Calculate and plot the power spectral density of u'_1 and u'_2 measured at $x_2 = D/2$ (hint : there is a short introduction to Matlab for signal processing on the website).