POLITECNICO
MILANO 1863

MSc. Music and Acoustic Engineering

Musical Acoustics - A.Y. 2020/2021

H6 - Design of a Recorder Flute

Authors' IDs:
10743504, 10751919,

December 26, 2020

1 Flue channel and mouth

1.1 Channel thickness

Given the pressure difference Δp between the player's mouth and the flue channel entrance, the flow velocity U_j in the flue channel can be easily recovered from the Bernoulli equation:

$$\frac{1}{2}\rho_0\left(v_2^2 - v_1^2\right) = p_2 - p_1 \quad \Rightarrow \quad U_j = \sqrt{\frac{2\Delta p}{\rho_0}}$$

where $v_2 = U_j$ is the jet velocity in the channel, $v_1 = 0$ is the air velocity in the player's mouth (assumed negligible) and p_1 and p_2 are the corresponding pressures.

Now, we know that the amplification of the jet perturbation is strongly dependent on the frequency of the acoustic field, and that it is strongest for frequencies around $0.3U_j/h$. This allows us to choose h according to the desired spectral characteristics of the instrument: we can "tune" the channel thickness to maximize the perturbation amplification at a target spectral centroid f_c, choosing $h = 0.3U_j/f_c$.

Our specific situation is:

$$\Delta p = 62\,\mathrm{Pa},\ f_c = 2\,\mathrm{kHz},\ \rho_0 = 1.2\,\mathrm{kg\,m^{-3}} \qquad \longrightarrow \quad h = 1.5\,\mathrm{mm}$$

The structure of the jet can be characterized computing the Reynolds number:

$$\mathrm{Re} = \frac{U_j h}{\nu} = 1033.3$$

where $\nu = 1.5 \cdot 10^{-5}\ \mathrm{m^2\,s^{-1}}$ is the kinematic viscosity of the air.