TURBULENCE SPECTRA EVALUATION USING A SIMILARITY MODEL

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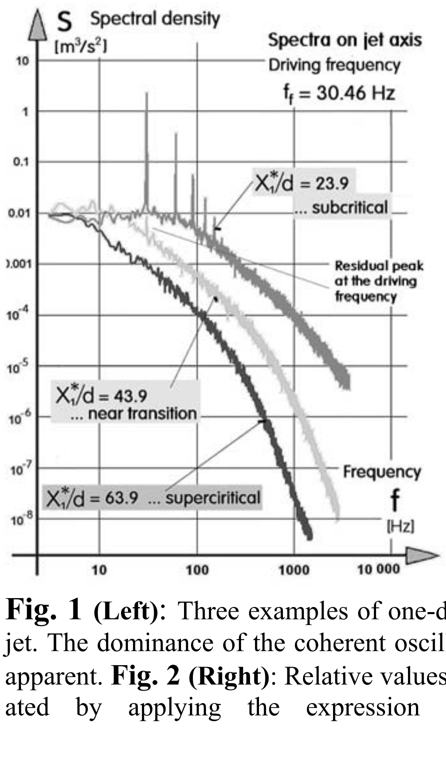
Spectra of turbulent shear flows – in particular of submerged jets - have been measured by many authors. In the present age of digital anemometric measurements, with acquisition of very large number of data values in each interrogation point of the investigated flowfield, obtaining the velocity spectral density is a relatively easy question of applying suitable library function (e.g. of MATLAB "Periodogram") on this set of instantaneous velocity values. However, extraction of further information from these spectra is a problem, since it requires a knowledge of some not obvious parameters.

Present authors performed such spectral analysis of the velocity data measured in the course of their evaluations of synthetic jets, refs. [1,2]. In these references the data were compared with quasi-similarity solution of turbulent jet with variable parameter $c_z/k_T s_{0.5}$ using one-equation model of turbulence [4]. The agreement was good – though unexpectedly in two different regimes, with a critical transition between them. The spectra examples in Fig. 1 show that the subcritical regime, nearer to the nozzle exit, is dominated by the organised motions, as seen from the spectral lines. This is replaced in the supercritical regime by the continuous spectrum typical for developed turbulence. The low-frequency ends of the spectra are distorted by aliasing. Of interest were therefore other parts: the dissipation range and the inertial range which, assuming isotropy, should follow the Kolmogorov law

$$S_{inertial\,1} = 18/55\, \alpha_K\, \epsilon^{2/3} k^{-5/3} \quad ...(1)$$

where α_K is expected to be a constant, usually in literature presented as $\alpha_K = 1.5$. Comparison of experimental data with this theory is mainly hampered by lack of knowledge



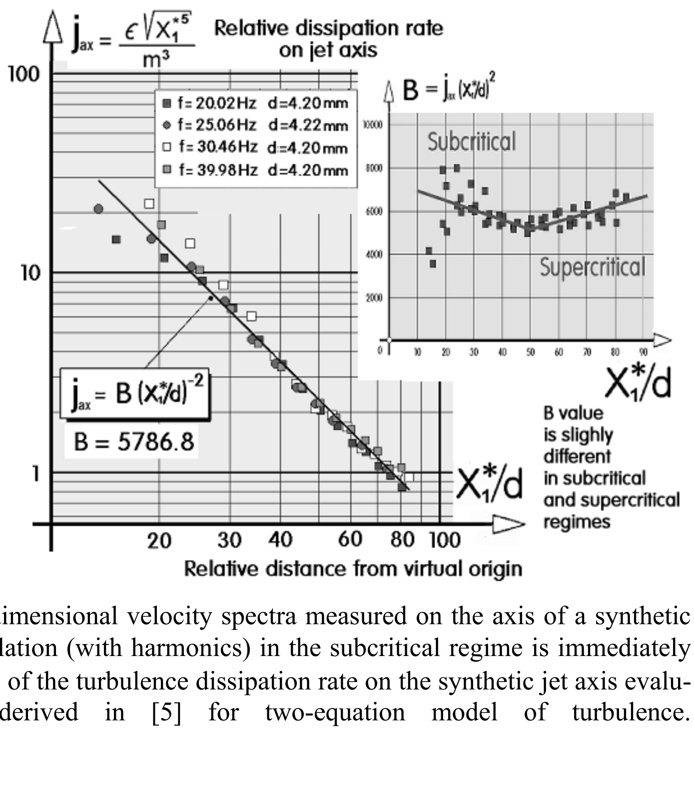


Fig. 1 (Left): Three examples of one-dimensional velocity spectra measured on the axis of a synthetic jet. The dominance of the coherent oscillation (with harmonics) in the subcritical regime is immediately apparent. **Fig. 2 (Right)**: Relative values of the turbulence dissipation rate on the synthetic jet axis evaluated by applying the expression derived in [5] for two-equation model of turbulence.

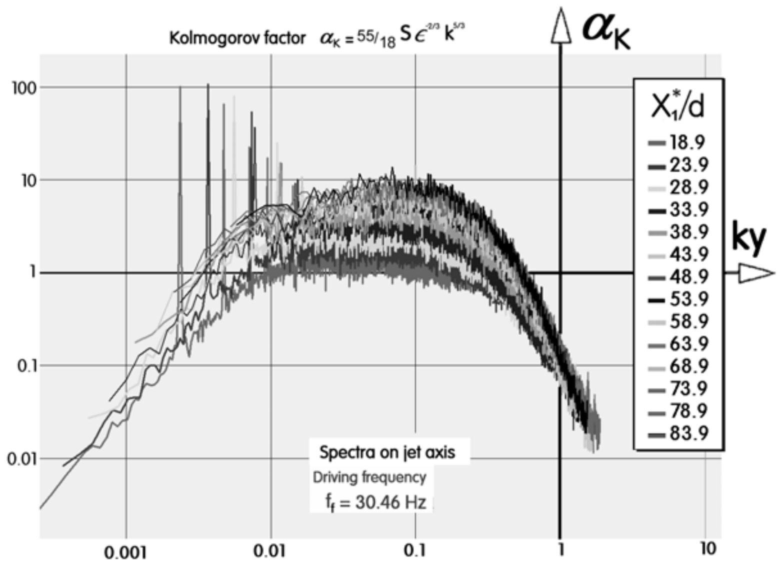
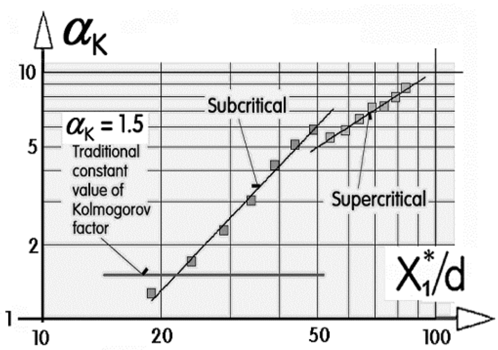


Fig. 3 Compensated presentation of the spectra measured on the synthetic jet axis. If the law eq.(1) were valid everywhere, the plotted values would be constant independent of the wavenumber k (here related to the microscale y, eq.(2)).

of the dissipation rate ϵ, needed also for evaluation of quantities like the microscale

$$y = \sqrt{\frac{\nu^3}{\epsilon}} \qquad \text{...(2)}$$



Fortunately, the present approach of evaluating the turbulence parameters by the fitting to the one-equation model solution – such as in Fig. 2 – makes the determination quite easy. The application to the synthetic jet in Fig.3 has shown, for example, the interesting variability of the Kolmogorov factor – again with different trends in the sub- and supercritical regimes.

Fig. 4 Horizontal line fits to the inertial range of the compensated spectra reveal streamwise growth of the factor α_K.

Acknowledgments

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