Progress on the study of the flow through tube banks by turbulent cross flow

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Banks of tubes or rods are found in the nuclear and process industries. Tube banks are the usual simplification for fluid flow and heat transfer in the study of shell-and-tube heat exchangers. Geometric characterization of a tube bank is made by the tube arrangement and the P/D-ratio, being D the tube diameter and P, the pitch, which is the distance between the centerlines of adjacent cylinders.

In general, fluid flow loads can be classified in static, due to the mean pressure variation. In tube banks with large P/D-ratios, the dynamic loads are mainly associated with the vortex shedding, while for with small aspect ratios, the turbulent flow is usually characterized as broad band turbulence, without a defined shedding frequency.

This lecture shows a glimpse on the evolution of methods and results along 25 year research on tube bank flow based on the results from velocity and velocity fluctuation measurements with hot wire technique in tube banks with square and triangular arrangements.

Analysis of the results is made by means of statistical and spectral tools as well as continuous and discrete wavelets and flow visualizations. Finite mixture, Monte Carlo method, symbolic dynamics and Hilbert-Huang Transform are some of the tools employed. The presence of bistability is observed in some cases.

Some simple conclusions can be drawn from this study. The first one is that the reduction of the aspect ratio increases the energy of the smaller scales, increasing mixing and leading to a tendency of a uniform distribution of pressure fluctuation. Far field disturbances are amplified in the first rows, than annihilated. The flow is three dimensional and non-stationary, the velocity distribution can be non-uniform inside the bank and its behavior is chaotic.