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Asymmetric Diverging Flow on a 90° Tee Junction

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The flow in pipe network systems is of great engineering importance due to its widespread industrial application, such as in fluid transport and heating and cooling systems. Therefore, its proper design requires the knowledge of pressure losses in pipes, as well as fittings and accessories. There is a wide range of information available in the literature for those losses, but the accuracy of the results is unsatisfactory for a number of reasons: (1) most of the data were obtained in the early half of the century, (2) there is lack of data for some flow configurations and, (3) frequently the energy loss coefficients are not defined consistently.

One of the more complex accessories is the bifurcation and the present work investigates the flow in a 90° tee junction, having in mind that the project of more energy efficient systems requires the optimisation in the design of fluid transport networks. The paper investigates the effect of geometrical changes on the energetic performance of a 90° flow bifurcation operating with Newtonian fluids. A full understanding of the reasons behind the observed pressure variations can only be gained through a thorough investigation of the relationship between flow geometry, pressure field and flow kinematics.

In this work the pressure, as well as the mean and turbulent velocity fields are fully characterised for non-symmetric diverging flow configurations in two sharp edged tees ($r/D = 0$), one with a branch to straight pipe area ratio (A_b/A_s) of 1 and the other of 0.7. The two sets of data can be compared to draw conclusions on the effects of branch to straight pipe area ratio. Comparison of these effects with the ones correspondent to edge radius of curvature will be also emphasised.

The experimental set-up has been used previously and is described in Maia et al (1998). Figure 1 shows the acrylic transparent test section and the fibre optic based LDA system employed to carry out the velocity measurements. At the inlet of the tee-junction the flow was fully developed and downstream of the test section there were sufficiently long pipes to enable flow redevelopment in both the straight and branch pipes.

Figure 2 shows the local loss coefficients between the side branch and the inlet pipe (K_{31}) as a function of the flow ratio partition (between the inlet and branch pipes) for the two different studied geometries, at a constant Reynolds number of 30000. The correspondent curve for a studied round edged tee ($A_b/A_s=1$, $r/D=0.1$) is also shown, for comparison. The plot clearly shows the effect of the geometric differences and the final paper will also include results that quantify the effect of the inlet pipe Reynolds number on the loss coefficients.

Detailed measurements of the longitudinal and the two cross-stream mean and turbulent velocities have been carried out for the two 90° tee junctions for inlet Reynolds number of 36000 and for a flow ratio partition of 0.5, on different planes. Figure 3 shows the vector plot of the longitudinal and transverse velocity components in the diametrical horizontal plane for the sharp-edge $A_b/A_s=0.7$ tee. A complete local flow characterisation of the turbulent flow field, including turbulence intensities, will be presented in the full manuscript.

The complex, three-dimensional shape of the recirculation region in the branch pipe was also studied, which involved a detailed characterisation of its mean and turbulent velocities inside and outside the horizontal diametrical centre plane. This study will be presented for different inlet pipe Reynolds numbers and different flow ratio partitions. In spite of the complex 3-D flow, the main features of the turbulent flow fields are expected to be explained on the basis of a simpler identification of the most important terms of the transport equations of the Reynolds stresses.

References

Maia, R., Pinho, F., Proença, M. F., Schulte, A. 1998. Energy Losses on a 90° Tee Junction, Ninth International Symposium on Applications of Laser Techniques to Fluid Mechanics, Lisbon, Portugal, July 1998, pp 137-144.

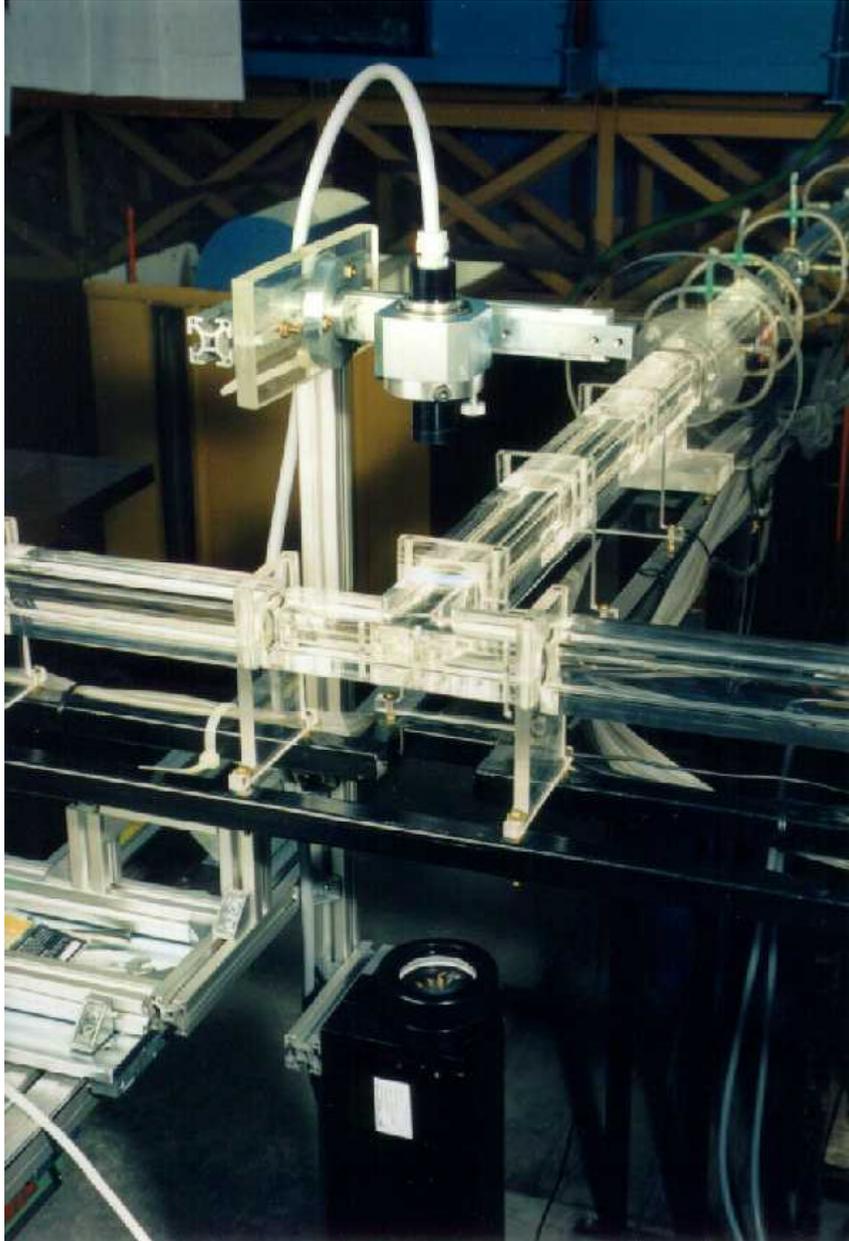


Figure1- 90 ° Tee test section

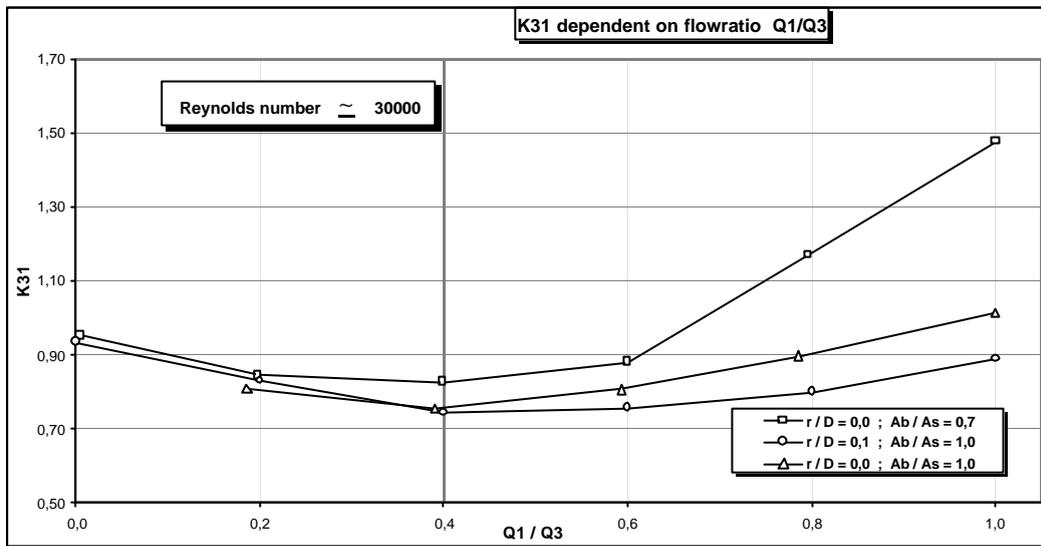
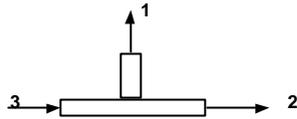


Figure 2 - 90° Tee junction. Diverging flow configuration. K_{31} as a function of Q_1/Q_3 for different geometries .

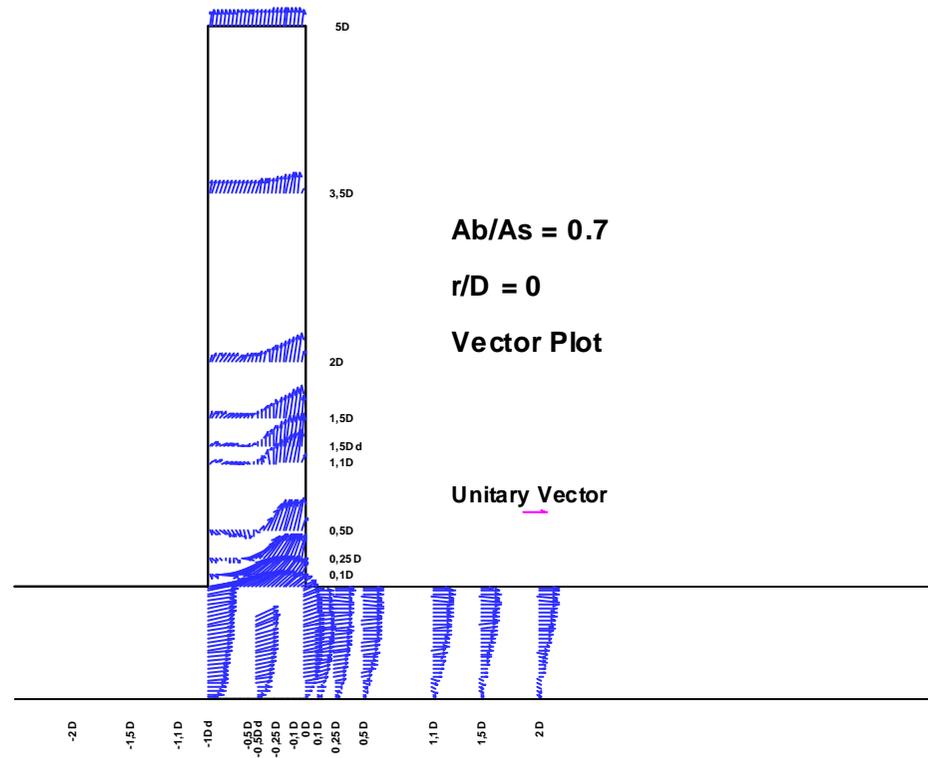


Figure 3 - Vector plot of u and v mean velocity components in the diametrical horizontal plane for the $Ab/As = 0.7$ sharp edge tee bifurcation.