UNIVERSITY OF SOUTHAMPTON

ABSTRACT

FACULTY OF ENGINEERING, SCIENCE & MATHEMATICS

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Doctor of Philosophy

JET IMPINGEMENT ON POROUS SURFACES

by Stephen David Webb

A series of experiments are described, documenting the flow resulting from the normal impingement of planar and axisymmetric jets onto a porous surface. Six different porous surfaces with open area ratios of 23, 26, 31, 37, 44 and 54% (β = 0.23, 0.26, 0.31, 0.37, 0.44 and 0.54) were placed in low speed (usually 40m/s exit velocity) air jets sufficiently far from the jet exit for the jet to be self similar. The β=0.23 and β=0.26 porosity surfaces were perforated steel plate, whereas the β=0.31, 0.37, 0.44 and 0.54 surfaces were woven wire mesh. Exit Reynolds number based on jet exit diameter is $3x10^4$ for the axisymmetric case and based on exit width from $0.5x10^4$ to $2.1x10^4$ for the planar case.

For β=0.44 and β=0.54 the impingement of the jet for both planar and axisymmetric geometries can be summarised as a widening of the jet as it passes through the mesh, followed by a region of reduced entrainment. For β=0.37 and below, there is evidence of wall jets on the upstream side of the surface. For the β=0.31 mesh and β=0.26 perforated plate, there are marked differences between the axisymmetric and planar cases. For the planar cases the flow is turned downstream of the porous surface away from the centreline such that on the centreline the axial velocity falls to zero, whilst a clear jet remains in the axisymmetric cases. Downstream of the β=0.23 porous surface there is a clear bounded jet in both planar and axisymmetric cases. The presence of a counter-flow at some distance from the centreline, downstream of the surface inhibits entrainment into the downstream jet; its growth rate and velocity decay rate are reduced.

Reducing the jet exit Reynolds number was observed to prevent flow turning in the planar β=0.26 and β=0.31 surfaces suggesting that there is a non-linear relationship between the flow mechanisms producing the centerline jet and those removing fluid from it. Direct experiments on the wall jet along a porous surface demonstrate that there is very little coupling between the parallel flows on the opposing sides. A rough estimate of the pressure gradients on the downstream side of the porous surface shows that any flow turning effect, as seen for the planar β=0.26 and β=0.31 surfaces is extremely unlikely to occur for axisymmetric jets in the velocity range tested.