Composite Dilution of Merging Plumes
Technical Note

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Wastewater is often discharged as a “rosette” jet group from a riser mounted on a sea outfall. The buoyant jets mix with the ambient flow by shear and vortex entrainment as they are deflected. At some distance downstream adjacent plumes merge to form a surface or trapped layer. The geometry and dilution of the merging jets are needed for a definition of the mixing zone, and these can be obtained using VISJET2.0. We have recently performed a series of experiments to measure the composite dilution of merging plumes using laser-induced fluorescence techniques. When the jets are bent over, significant dilution has already taken place, and a good measure of the average dilution in any vertical downstream section can be obtained from the prediction of dilution and cross-sectional geometry by taking into account the degree of merging and overlap of the adjacent plumes.

In general, the merging jets in a downstream section consist of I) two symmetric group of side merging jets; and ii) a coflowing jet and highly diluted counter-flowing jet. This scenario is illustrated in Fig.1 for a 8 jet riser as observed in an experiment. Fig.2a) shows a top view of two horizontal jets (jet diameter D=3.1 mm; jet velocity Uj=0.76 m/s, at 60 and 120 degrees to the ambient current Ua=0.1 m/s) discharged at a jet densimtric Froude number of Fr=32 into a crossflow; the jet to ambient velocity ratio is 7.7. Fig.2b) shows the predicted jet merging as well as the observed LIF images. Fig.3 shows the comparison of observed and predicted concentrations at different distances downstream (x/D=20,40,60,80). It is shown that reasonable predictions can be obtained if the overlapped plume areas are considered in the dilution prediction.

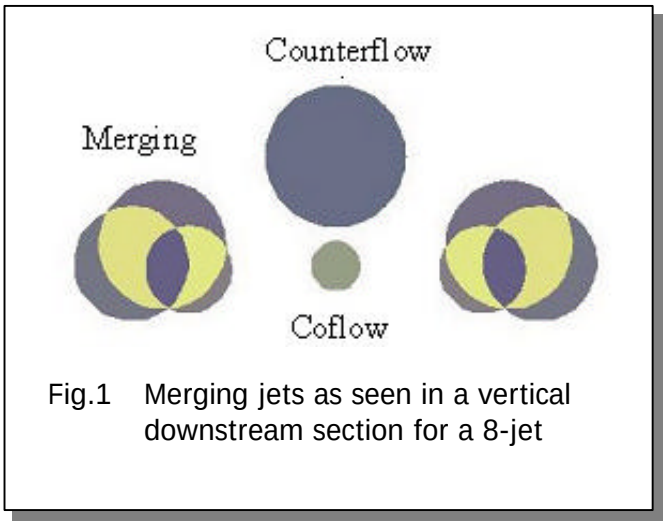

Fig.1 Merging jets as seen in a vertical downstream section for a 8-jet

Top view

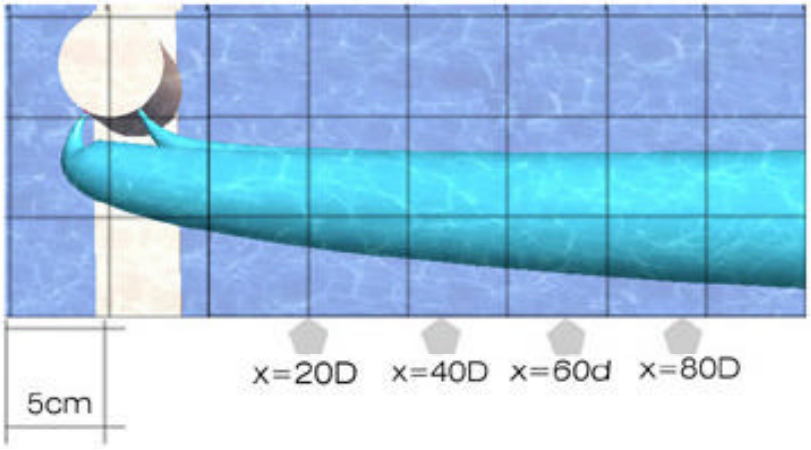

Fig.2a)
Top view of the merging of two jets discharged into a crossflow at 60 and 120 degrees

D=3.1mm; Uj=0.76 m/s;
Ua=0.1 m/s; Uj/Ua=7.7;
Jet densimetric Froude no.=32

Section view

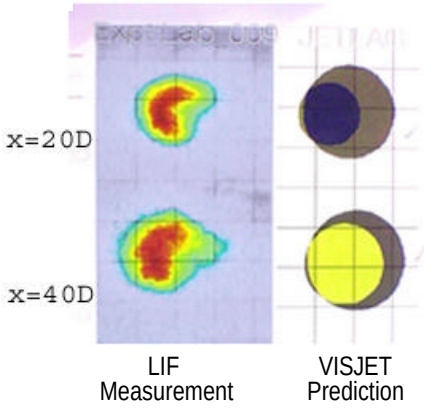

Fig.2b)
Predicted and observed LIF images of the cross-section concentration field at two downstream sections

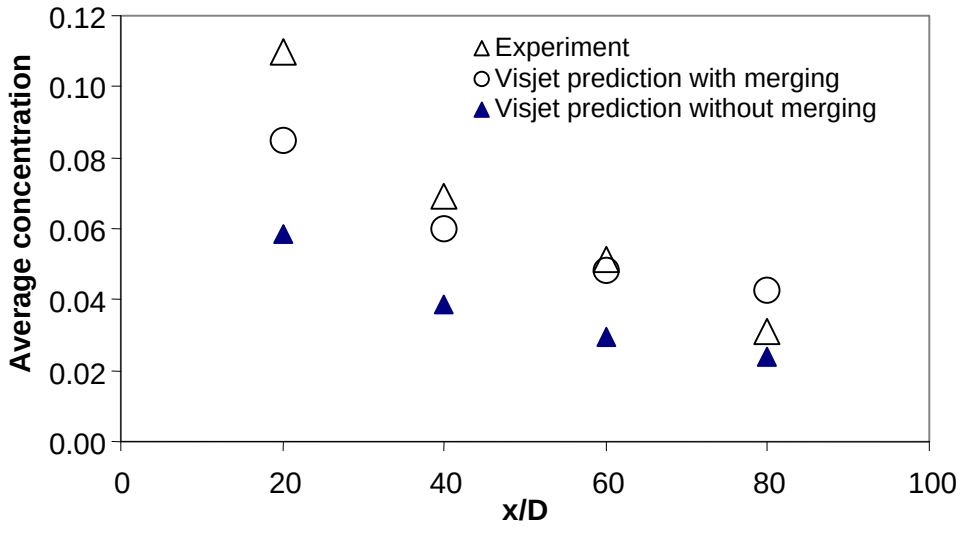

Fig.3 Comparison of predicted and observed average concentration for merging jet groups