TURBULENCE STRUCTURE OF RECTANGULAR SURFACE JETS

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Surface jets are relevant to many engineering applications, ranging from remote sensing of ship wakes to anticipating the environmental effects of the discharge of pollutants into large bodies of water. It is important to understand the structure of the jet because it governs the mixing and transport of scalars, such as temperature, oxygen and other chemical species. The near surface development of the jet is particularly important. From an environmental perspective, the surface layer plays a key role in determining the rate of atmospheric oxygen absorption and thus the sustainable levels of microflora. In northern climates, surface currents are also important in determining and controlling ice formation.

Comprehensive experimental studies on non-buoyant surface jets are sparse. This study aims to investigate and document the turbulence structure of a rectangular jet discharged horizontally at the free-surface of a deep body of water. In this configuration the concurrent development of the surface current and the jet can be studied within a reasonable distance from the outlet, as opposed to a free jet interacting with the free surface at a further distance downstream. Laser Induced Fluorescence (LIF) was used to visualize the flow in order to establish a framework for quantitative measurements. Mean flow filed and turbulence quantities were mapped using Laser Doppler Velocimetry (LDV). Particle Image Velocimetry (PIV) was deployed to study the instantaneous flow filed of the jet.

The results showed the development of a surface current, the prominent feature of free-surface flows, whose lateral spreading rate was twice that of the jet below. The turbulence data supported the previous studies, in which the anisotropy of the Reynolds stress field near the free surface boundary was speculated to be responsible for development of the surface current . The data was in good agreement with the semi-empirical model for the velocity distribution in the surface current, which had been previously proposed by the authors. The jet turbulence structure was compared to those of the free and wall jets, highlighting differences and similarities. Unlike the free jet, in the surface jet vertical velocity fluctuations diminished close to the jet centre (the free surface) and as a result mixing lengths decreased. Turbulence intensities near the surface boundary were smaller than those in the wall jet close to the wall boundary, which were induced by the wall shear stresses. Turbulent shear stresses were smaller close to the free surface comparing to those at the centre in the free jet and near the wall in the wall jet, indicating lower turbulent mixing in the surface current, as it was previously observed by flow visualization.

Keywords: turbulence, surface jets