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Characterisation of the deflection of a liquid jet in an annular flow

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ABSTRACT

An experimental study of a water jet deflection in an annular flow, driven by a rotating cylinder, in a stationary casing is presented. The apparatus consists of a rotating cylinder (600 mm long and 60 mm in diameter) connected to a motor capable of generating speeds ranging from 0 to 3000 rpm. A stationary casing of 127 mm diameter, made of clear Perspex, surrounds the cylinder. The liquid (in this study water) is injected through the apparatus via a flexible pipe connected to a tank located at the top of the rig and is supplied as a continuous laminar jet into the casing so that it impinges on the cylinder and breaks-up into droplets with different sizes. These are then deflected by the effect of the rotating cylinder as discontinuous jets of droplets with different size towards the stationary casing. The injected water flow rates are varied up to 0.38 l/min and the cylinder speeds up to 3000 rpm.

Particle Imaging Velocimeter (PIV) is used to scrutinise the flow events. The equipment used to generate the pulsed light sheets consists of a twin pulsed Nd:YAG lasers, operating at 15 Hz. The laser system is Q-switched to provide 150 mJ of pulse maximum energy at 532 nm, and the pulse duration is 4 ns. The advantage of this system is that the pulse separation can be altered to the desired value for the particular flow properties under examination. This feature is crucial for the capture of the real structure of the flow phenomena under investigation. To image the flow field in the area of interest, a Megaplus Kodak camera model ES1.0 of 1008 x 1018 pixel resolution with a 50 mm Nikon imaging lens was placed perpendicular to the laser sheet. The laser and the camera were synchronised via a DANTEC PIV 2100 processor. A Personal Computer is used to collect, store and process the data.

This investigation is primarily concerned with the effect of a rotating annular flow on a freely falling water jet, which impinges on a rotating cylinder and then deflects within the gap between the cylinder and the stationary casing. The annular flow velocity profile of the gas phase (air) was obtained using PIV and LDV; it reveals that the airflow tangential velocity decreases along the distance across the gap from the cylinder to the casing and increases as the cylinder rotation speed increases.

The major findings of this study are:

- Increasing the jet flow rate causes an increase in droplet generation at the point of impingement. Moreover, higher flow rates affect the flow structure as a result of the enhanced water film breaking-up into droplets of different sizes, which are then deflected by the rotating surface of the cylinder.
- Increasing the cylinder speed appears to enhance the break-up of the water film around the rotating cylinder (due to increased Weber number). The breaking film forms droplets that are then deflected by the rotating surface of the cylinder/shaft.
- It is observed that the surrounding air entrains new droplets from the jet itself, as well as from the water film deposited on the internal surface of the stationary casing.
- The deflection of the liquid jet from vertical, at the rotating shaft surface, increases with increasing the cylinder rotational speed and decreases with increasing the liquid flow rate.
- The scattering/expansion angle of the deflection of the “secondary” jets is larger/wider at lower cylinder rotational speed.