

Paper 21.4

LDA: An Experimental Whole Field Investigation on Confined Rotating Flow with and without Vortex Breakdown

by

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ABSTRACT

Rich complicated flow problems present in rotating flow inside cylindrical container, secondary flows, vortex breakdown, to name a few. The experimental research on vortex breakdown in rotating flows has been limited to visualizations up to now, and there are few quantitative measurement results. For the rotating flow with vortex breakdown, there are sharp changes of velocity distribution, especially direction of the fluid motion. Therefore, large number of measurement points is necessary to make clear the flow. With high measurement precision and broad dynamics band, LDA is suitable for whole field investigation on complicated recirculating flow with and without breakdown. However, it is unfortunately a point-by-point method, which makes duration of experimental whole field investigation much long. Constant working condition is necessary and important for whole field measurements for the reason of two factors, or the obvious variation of room temperature during long time measurement and the friction between the rotating boundary and the working fluid. The popular method to keep working condition constant in most experimental apparatuses is to place a high-precision constant temperature water tank outside of the flow field. But it makes the measurement system complicated and the cost is high. For the confined rotating flow inside cylindrical container with a rotating top lid, the method of adjusting the rotating rate dependent on measured temperature to keep Reynolds number is presented here, as a solution to the appreciable viscosity dependence of the working fluid on temperature. It is experimentally testified that the method is convenient to be used, and can keep the flow pattern at the same Reynolds number with high precision for long time. An experimental whole field investigation on confined rotating flow inside cylindrical container via LDA is presented in the paper. For $H/R=1.51$, $Re=330, 520, 610, 790, 990, 1290$ and 2180 , the whole field velocity distribution in the meridional plane is obtained. The flow patterns with existence and disappearance of vortex breakdown are made clear.

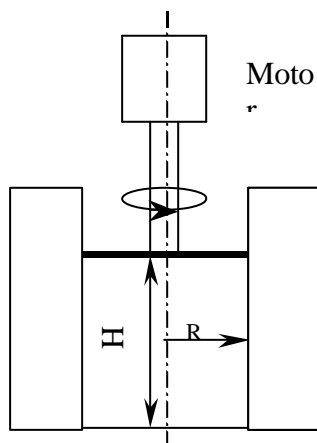


Fig.1. Schematic diagram of experimental apparatus: confined rotating flow inside cylindrical container with a rotating top lid. The rotating rate of the motor is under control of a frequency converter with precision of 0.01Hz.