FLOW VISUALIZATION EXPERIMENTS OF CELLULAR STOKES FLOWS INDUCED BY ROTATION OF A CYLINDER VARIOUSLY POSITIONED INSIDE CHANNELS

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Summary In this work, flow visualization experiments of cellular Stokes flows induced by rotation of a circular cylinder variously positioned inside channels of different shapes have been performed. Flow visualization experiments have been carried out inside wedge-shaped and rectangular channels. High quality visualization photographs have been presented. The inner cylinder is positioned at different locations inside these channels and many interesting flow patterns have been visualized. The shape of the separating streamline and recirculating eddies are clearly seen and compared for the channels.

INTRODUCTION

Many problems of physical interest involve the flow of fluids at low Reynolds numbers. This type of flow is encountered in many practical application, cited in [1]-[3]. The purpose of the present investigation is to perform flow visualization experiments of cellular Stokes flows induced by rotation of a circular cylinder variously positioned inside channels of different shapes. In the experiments wedge-shaped and rectangular channels are filled with silicon rhodorsil oil of different viscosities (Newtonian fluid) and carboximetilcellulose (CMC) (non-Newtonian fluid). The motion is generated by the uniform rotation of a circular cylinder positioned at different locations inside these channels. Flow visualization experiments are carried out using solid tracers of magnesium for the Newtonian fluid and Rilsan for CMC. They are illuminated by a thin sheet of light coming from a laser device and the visualization photographs are obtained by means of long time exposure photography. A series of experiments have been performed at different rotational speeds varying from 3 rpm to 80 rpm and using silicon rhodorsil oil of viscosities 10 cm^2/s and 300 cm^2/s. Thus the Reynolds number of the flow, defined by $Re=(\omega_0 R_1^2)/\nu$, ranged between 0.001 and 0.84, have been obtained and high quality visualization photographs have been presented at these low Reynolds numbers. The shape of the separating streamline and recirculating eddies are clearly seen on these photographs and some quantitative data (the center of the recirculating eddies, the location of the separating streamlines) are deduced from these pictures. The inner cylinder is positioned at different locations inside these channels and many interesting flow patterns have been visualized.

EXPERIMENTAL RESULTS

In Figure 1, the visualization photographs for the centered and upper position of the cylinder are presented. The exposure times are 15 minutes and 90 minutes, respectively.

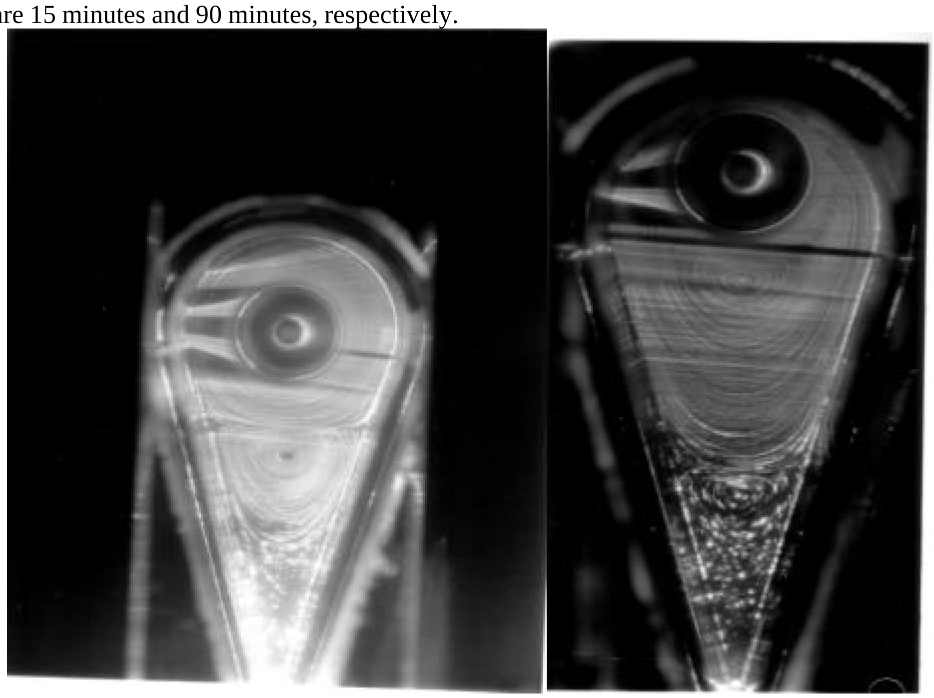

Figure 1- The visualization photographs for the exposure time of 15 (left) and 90 (right) minutes.

In Figure 2 (left) the cylinder is positioned 1 cm ahead along the axis towards the corner. At each side of the cylinder there is a cellular motion. On the right side of Figure 2 the cylinder is shifted 0.5 cm from the centered position towards the right wall.

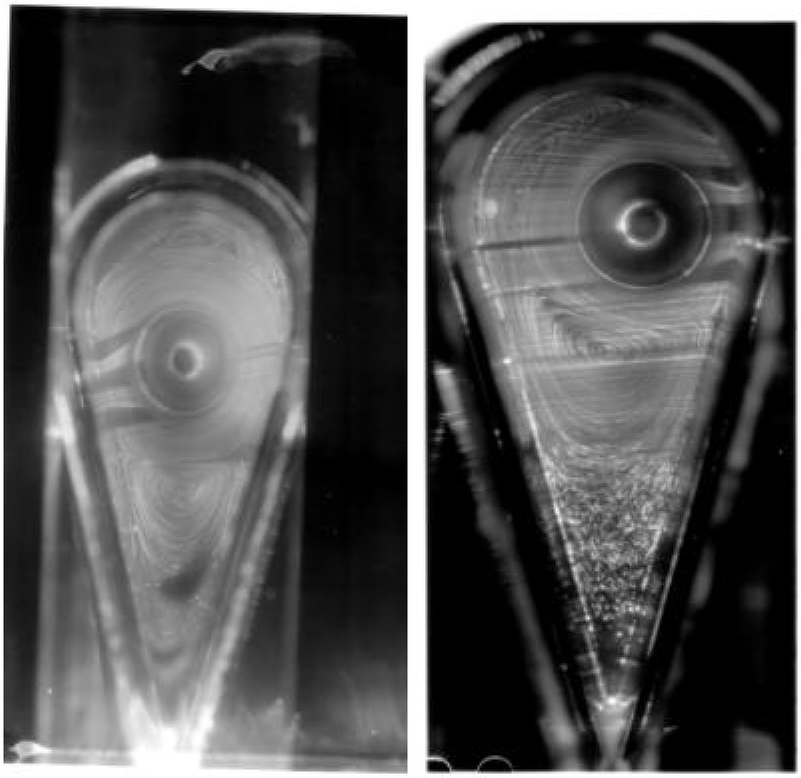

Figure 2- The visualization photographs for different positions of the cylinder.

The experiments are also performed in rectangular channels and compared with wedge-shaped channels. The shape of the separating streamline and recirculating eddies are clearly seen on these photographs and some quantitative data (the center of the recirculating eddies, the location of the separating streamlines, ect.) are deduced from these pictures. The experiments are also carried out with CMC fluid for comparison. The numerical solution of the problem is also obtained and compared with the corresponding visualization photographs. Excellent agreement is found between experimental and numerical results.

CONCLUSIONS

Flow visualization experiments of cellular Stokes flows induced by rotation of a circular cylinder variously positioned inside channels of different shapes have been performed. These experiments have been carried out inside wedge-shaped and rectangular channels and high quality visualization photographs have been presented. The inner cylinder is positioned at different locations inside these channels and many interesting flow patterns at low Reynolds numbers have been visualized. The shape of the separating streamline and recirculating eddies are clearly seen on these photographs and some quantitative data (the center of the recirculating eddies, the location of the separating streamlines) are deduced from these pictures and compared each other.

References

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