Numerical Analysis of Flow around Circular Cylinder

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1. Introduction

The laminar flow of around circular cylinder in the uniform flow was studied by numerical analysis. MAC method(1) and CIP method(2) were used. Two-dimensional flow and three- dimensional flow were examined. On the three dimensional flow, the height of the column was examined on finite case and the case in which it is infinite length. The Strouhal number of the column of three-dimensional infinite length agrees well with conventional experimental result.

2. Basic Equations and Numerical Method

Fundamental equations of the incompressible viscous fluid are as follows.

$$\frac{\partial v_i}{\partial x_i} = 0$$

$$\frac{\partial v_j}{\partial t} + v_i \frac{\partial v_j}{\partial x_i} = -\frac{\partial p}{\partial x_j} + \frac{1}{\mathrm{Re}} \frac{\partial^2 v_j}{\partial x_i \partial x_i} \qquad (i, j = 1,2,3)$$

The MAC method is used in order to obtain velocity field and pressure field. The staggerd grid is used. The CIP method is used for the calculation of the advective term.

3. Result and Discussion

3.1 The 2-D column and the 3-D finite length column

The calculating areas are shown in fig.1 and fig.2. The diameter of the column is made to be d. In the two dimensional flow, it was made to be L=20d length, W=80d width. In the three dimensional flow, it was made to be L=40d, W=10d, H=10d.

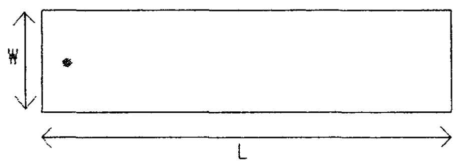

Fig.1 The calculating area of 2-D flow

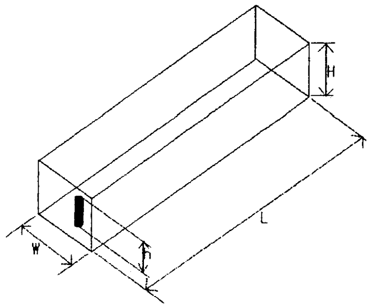

Fig.2 The calculating area of 3-D flow

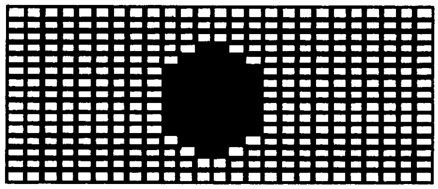

Fig.3 The outline of lattice and column is shown.

In the calculating area, the space is divided into regularly-interval orthogonal grid. In the two-dimensional flow field, numbers of partitions were made to be 800×200, and in the three dimensional flow fields, it was made to be 400×100×100.

The region was divided into solid cell and fluid cell. This be shown by fig. 3. The solid cell shows the column.

In fig. 4 and fig. 5, the pressure distribution of the back of the column of two-dimensional flow field in case of Re=280 and 1500 is respectively shown. There is a Karman vortex street in the flow of the back of the column. With the increase of the Reynolds number, the interval of the low pressure narrows.

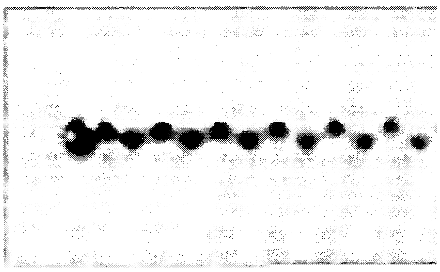

Fig.4 The pressure field of the two-dimensional flow (Re=280).

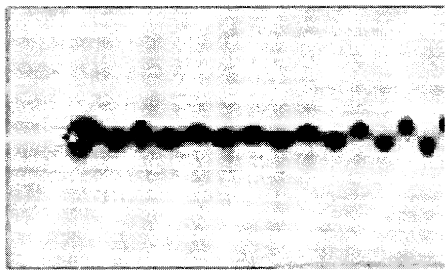

Fig.5 The pressure field of the two-dimensional flow (Re=1500).

In fig.6 and fig.7, the pressure distribution of the flow of the back of the limited height column is shown. They are flow patterns in the position of half height of the column height. The region of which the pressure is low for the rear flow of the finite length column spreads.

Fig.6 The pressure field of the three-dimensional flow around finite length cylinder (Re=280).

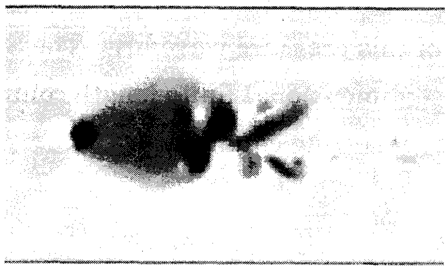

Fig.7 The pressure field of the three-dimensional flow around finite length cylinder (Re=1500).

Velocity vector distribution of the flow of the finite length column is shown in figures of 8. There is the downward flow from the column top in the column back.

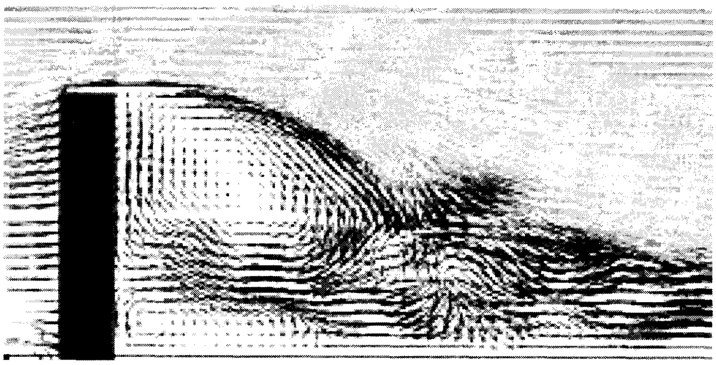

Fig.8 Velocity vector distribution of the flow of the finite length column.

The pressure fluctuation in the flow of the two-dimensional column is shown in fig.10. The pressure fluctuation in the flow of three-dimensional column of finite length is shown in fig.11. The pressure was obtained in the place of the back of the column. The amplitude of the pressure fluctuation of the three-dimensional finite length column is smaller than that of the two-dimensional column.

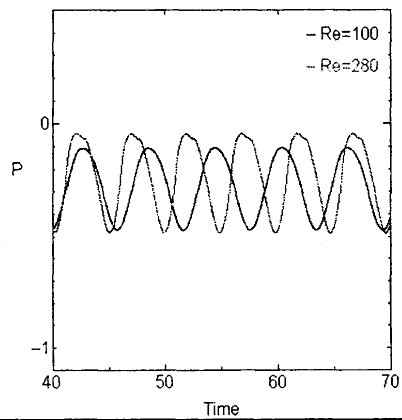

Fig.10 The pressure fluctuation (The two-dimensional column).

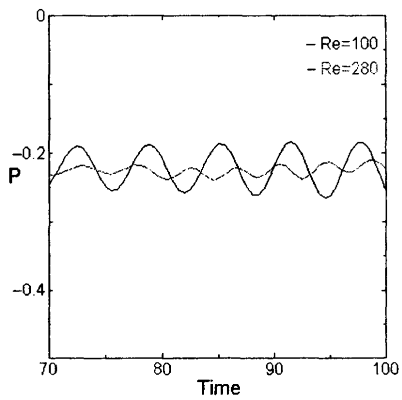

Fig.11 The pressure fluctuation (The three-dimensional column) .

The frequency which discharged the vortex by the FFT was calculated in respect of this pressure waveform. The Strouhal number of two-dimensional column and three-dimensional finite length column is shown in fig.12. The Strouhal number is shown by following equation.

$$St = \frac{N\,d}{V}$$

N is a frequency of the vortex emission. The diameter of the column is d. The inlet velocity is V. The Strouhal number of the two-dimensional column increases only a little than experimental value(3). The Strouhal number of the three-dimensional finite length column agrees with experimental value in case of Re=100. However, it decreases from the experimental value in Re=280. This is the effect of the downward flow from the column top.

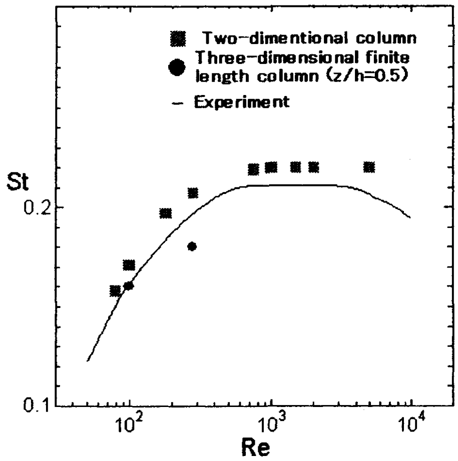

Fig.12 Strouhal number

3.2 The column of the three-dimensional infinite length.

The column of the three-dimensional infinite length was calculated. The low-pressure region of the back of the column spreads further than the two-dimensional column.

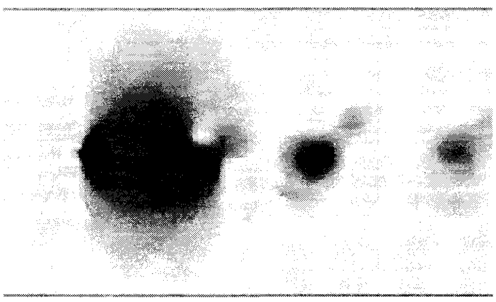

Fig.13 The pressure distribution of the column of three-dimensional infinite length (Re=280).

The Strouhal number of the three-dimensional infinite length column is shown in fig.14. The calculated value of Strouhal number agrees well with experimental value(3).

4. Conclusion

(1) The Strouhal number of the three-dimensional infinite length column agrees well with the experiment.

(2) There is the downward flow at the back of the three-dimensional finite length column.

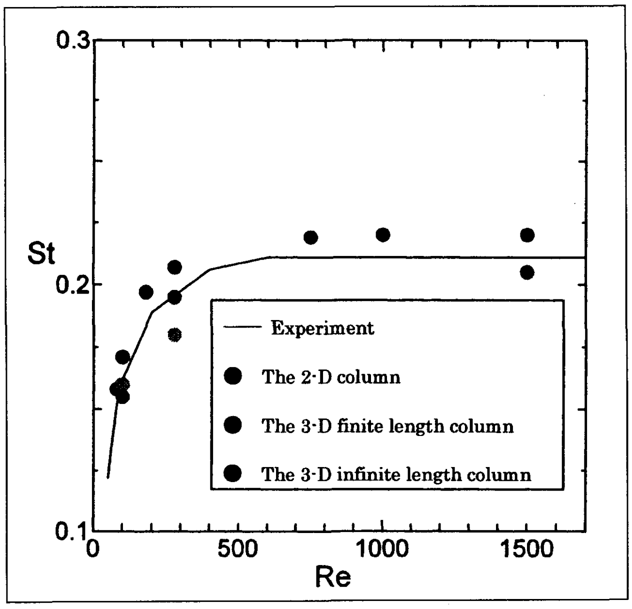

Fig.14 Strouhal number

Acknowledgement

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