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FLOW OVER AN INFINITE-RECTANGULAR OBSTRUCTION IN A PARALLEL FLOW

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ABSTRACT

The streamlines of the flow of inviscid fluid over an immersed infinite rectangular obstruction are determined for different ratios. The results are highly acceptable.

INTRODUCTION

For long the study of the flow of different fluids over obstructions has been the subject of many papers. Nevertheless, this study has become more important due to its applications in blood flow in blood vessels and the different obstruction it faces [1], [2] and [3].

In the present work, use has been made of different technique, other than the grid-generation and the subsequent finite differenc approach, which we explain in the subsequent section.

1 The domain under consideration is shown in figure (1)

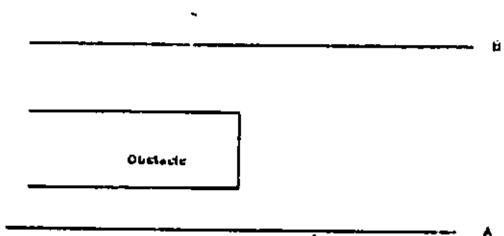

Fig (1)

which consists of two parallel plates A & B including flowing fluid in between, which encounters a rectangular obstacle as shown in figure (1). We start with a corresponding parallel flow with a width π. We use Schwartz Christoffel transform this flow to an upper-half plane.

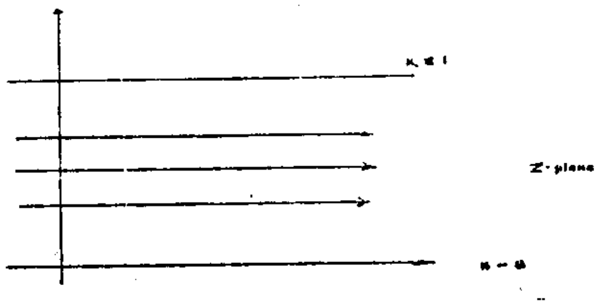

Fig (2)

The transformation that maps the domain between the parallel plates to the upper-half plane is given by,

$$\zeta = e^{z} \qquad (1)$$

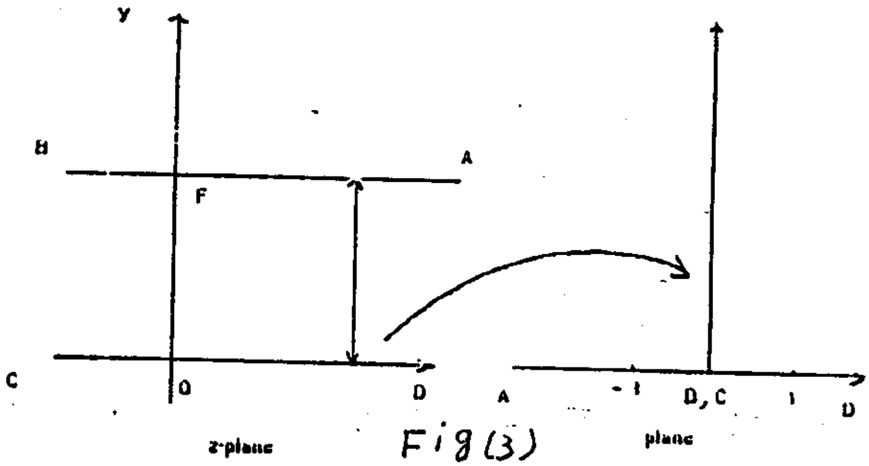

Fig (3)

Where the corresponding points are given as shown in figure (1). Meanwhile, the Schwartz- Christoffel transformation that transforms from a step or contraction flow to an upper-half plane could be derived as given in what follows :-

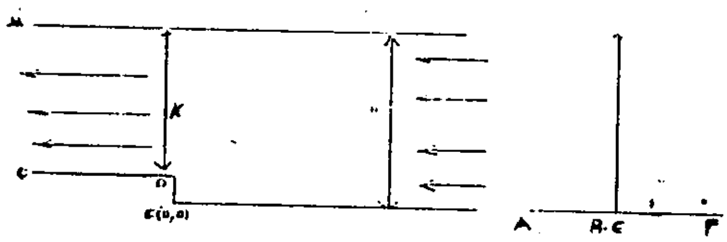

Fig (4)

The Schwartz- Christoffel transformation from the plane of step- flow or the contraction flow to the upper- half plane as shown in the above figure is given by:

$$\frac{dw}{d\zeta}=C\zeta^{-1}(\zeta-1)^{\frac{1}{2}}(\zeta-\alpha)^{\frac{1}{2}} \tag{2}$$

Integrating expression (1) we get

$$w=\frac{h}{\pi}\left(\log\frac{1+t}{1-t}-\frac{1}{b}\log\frac{b+t}{b-t}\right)+const.$$

where

$$t^2=\frac{\zeta-b^2}{\zeta-1} \qquad and \qquad b=\frac{h}{k} \tag{3}$$

If we take z = O to correspond to $\zeta = \alpha$ where $\alpha = \dfrac{h^2}{k^2}$ we have t = O and therefore the constant = O, also taking h = π, then

$$w = \frac{h}{\pi}\left(\log \frac{1+t}{1-t} - \frac{1}{b} \log \frac{b+t}{b-t} \right)$$

Substituting for ζ from (1) into (3), we obtain the transformation that maps the points of the domain of the parallel flow to that of the contraction or the step flow,

$$t^2 = \frac{e^2 - b^2}{\zeta - 1} \qquad (4)$$

Next, if we rotate the domain of the w- plane about the central axis EF, we then obtain the figure given below

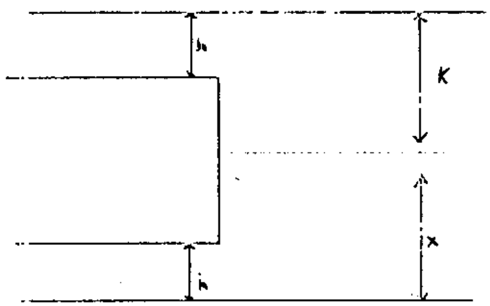

Fig (5)

which represents a flow past an infinite rectangular obstacle.

The Determination of The Flow

To study the flow over this obstacle due to some fluid with some given specifications, we start with a corresponding flow between the two parallel plates, determine the value of the streamline function where at each point and associate it with the corresponding coordinates of that point, then we transform this point using the above given transformation and the subsequently we get the streamline of the flow around the infinite rectangular obstacle due to the fluid under consideration.

Application :-

We have considered the case of an inviscid flow flowing around the obstacle with different ratios of $\alpha = \frac{k}{h}$. The results are shown in the figures below. Figure (3) gives the domain over which the flow is considered with some specified value of $\alpha = \frac{k}{h}$. Figure (4), (5) and (6) give the flow-streamlines for respectively. From the given figures it appears that they resemble the real flow to a very great extent. Nevertheless, work is being conducted for the same kind of geometry but, for viscous fluids.

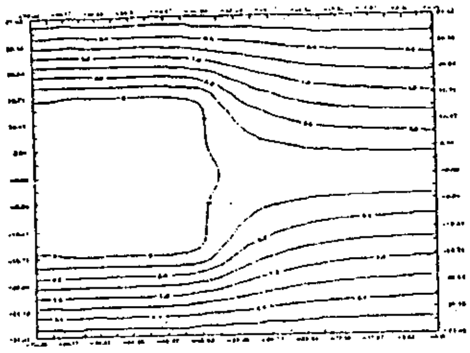

Figure (4)
Flow streamlines for $\alpha = 2$.

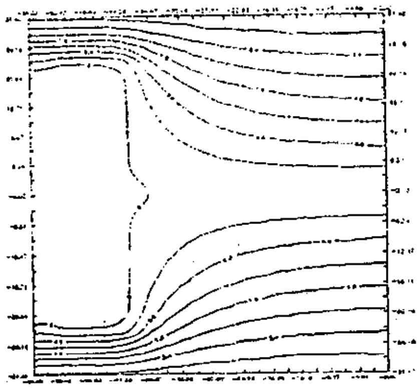

Figure (5)
Flow streamslines for $\alpha = 4$

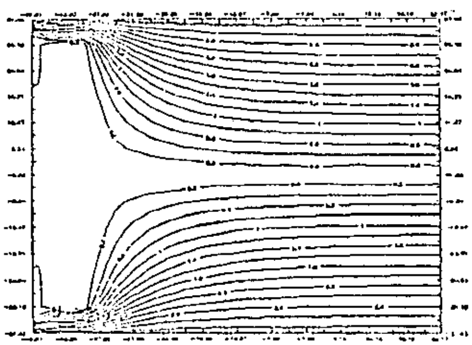

Figure (6)
Flow streamslines for $\alpha = 8$

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