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EFFECT OF STABILIZING PLATE PLACED IN ENTRANCE BEND OF AN AXIAL PUMP

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ABSTRACT

For the axial pumps, the inlet bend of 90° affect widely the prerotation, losses and the pump performance as well. A stabilzing plate has been placed in the entrance bend, in the plane of curvature, to minimize these effects. Experimental investigations have been carried out for the pumping head, power and cavitation characteristics. It has been found that the stabilizing plate improves the pump performance at normal and higher flow rates. At partial discharges, the results showed that the pump performance is lower due to supplementary losses due to plate. The cavitation ability has been found to be improved at normal and higher flow rates.

INTRODUCTION

The pump impeller is the active part, that transforms the mechanical energy supplied by the working shaft to fluid energy carried out by the flowing fluid. The overall pump performance depends widely on the inlet and outlet flow conditions. Piping to the suction of the pump must be carefully worked out to provide a reasonable uniform velocity and straight line flow, to avoid impeller disturbances, [1,5].This suggests the need of straight part of the suction pipe prior to the pump suction. In some engineering applications, specially for vertical pump uses, inlet bends are required. Herein, the effect of a stabilizing plate placed in the suction bend and in the same plane of the bend, has been investigated experimentally. Analysis of the flow prewhirl and the shock losses have been assumed to explain the experimental results.

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EXPERIMENTAL INVESTIGATION

The effect of the stabilizing plate placed in the inlet bend of an axial pump has been investigated experimentally for an axial flow pump having the following parameteres ,[2],

- outer radius R_o = 0.12 m ,
- hub radius R_h = 0.07 m ,
- number of vanes = 4 ,
- speed n = 700 rpm.

The shape and dimensions of the inlet bend, and the stabilizing plate are given in Fig.(1).

The pumping head, power, effeciency and characteristics have been measured for the pump with and without the stabilizing plate. The pump performance are evaluated by measuring :

- the volumetric flow rates, by an orifice meter fitted to the pump outlet pipe. The pressure difference on the the meter is measured by a differential water manometer.

- the manometric head, by using a U-tube mercury manometer,

- the input mechanical power, by means of an electric dynamometer,

- the pump speed, by an electric tachometer,

- the suction pressure, by a mercury manometer.

The variation of the net positive suction head NPSH, of the pump has been carried out by means of an evacuation pump connected to the suction tank. The critical NPSH is estimated to that results in reduction of the working head, for certain flow rate, by 3 %, Fig. (2),[2].

Fig. (2 to 5), show the effect of the stabilizing plate on the pumping head, power, effeciency and critical NPSH. At normal and higher flow rates, the pump performance are improved, while at partial flow rates the pump shows lower values in using the stabilizing plate.

ANALYSIS OF RESULTS

The effect of the stabilizing plate, may be explained by analysing the prerotation in the pump suction space and the vortex flow in the suction bend.

The principle of least resistanc implies that the

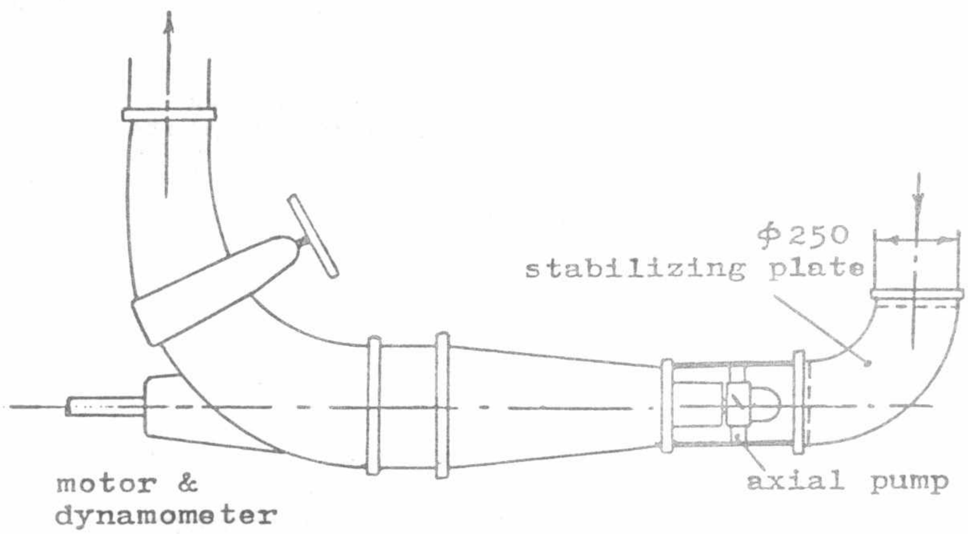

Fig. (1), Inlet bend and the stabilizing plate

fluid acquires prerotation to enter the impeller passages without disturbances. The resistance of the flow is a minimum if the fluid enters the impeller channels at an angle approaching the vane angle β_1, [3]. The fluid preroation direction is opposite to the impeller rotation, at higher capacities, or in the same direction at low flow rates, Fig. (6).

For a stabilizing plate placed in the suction space of the pump, the fluid prerotation is inhibited. For complete inhibitance of fluid prerotation, the velocity triangle at inlet is modified as shown in Fig. (6).

The hydraulic losses at entrance of the pump may be assumed to be :

- the energy required to prerotate the fluid at the pump entrance space,

- the shock losses caused by sudden expansion after seperation, if the fluid appraoches the vanes edges at incidence angle, [3].

In case of pumping without a stabilizing plate, the shock losses may be neglected, while the prerotation losses may be assumed to be proportional to the prewhirl component Δc_{u1}. From the velocity triangle at inlet, it is clear that for the same change of flow rates (increase or decrease), the same change of Δc_{u1} is obtained. That results to a symmetrical prerotation losses variation arround the shockless flow rate (axial absolute velocity at inlet).

In case of absence of prerotation, the shock losses

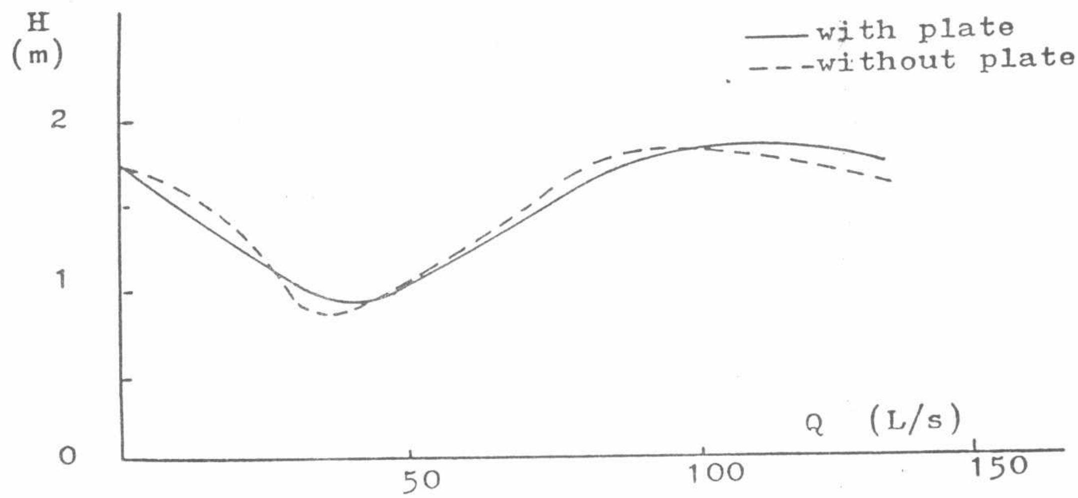

Fig. (2), Head-Discharge Curves

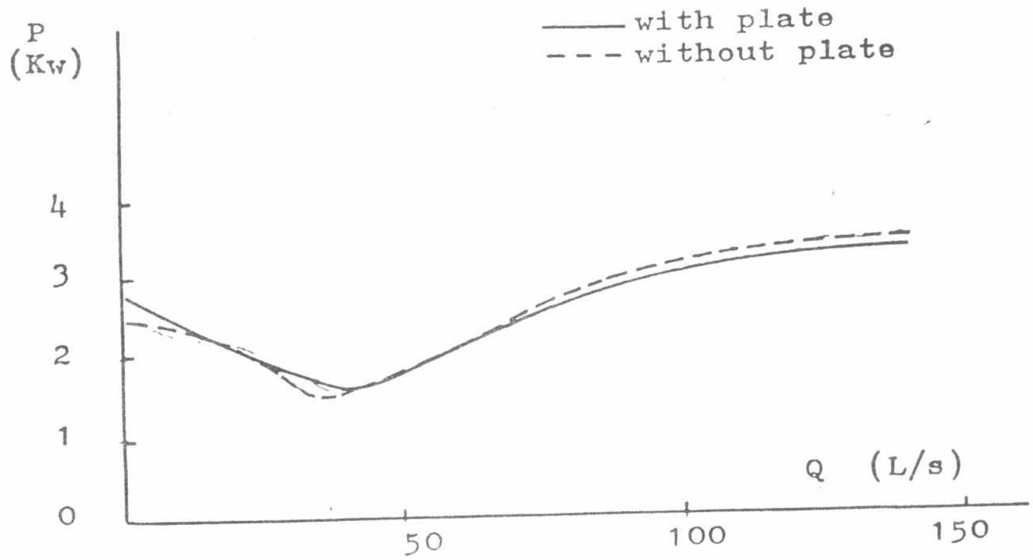

Fig. (3), Power-Discharge Curves

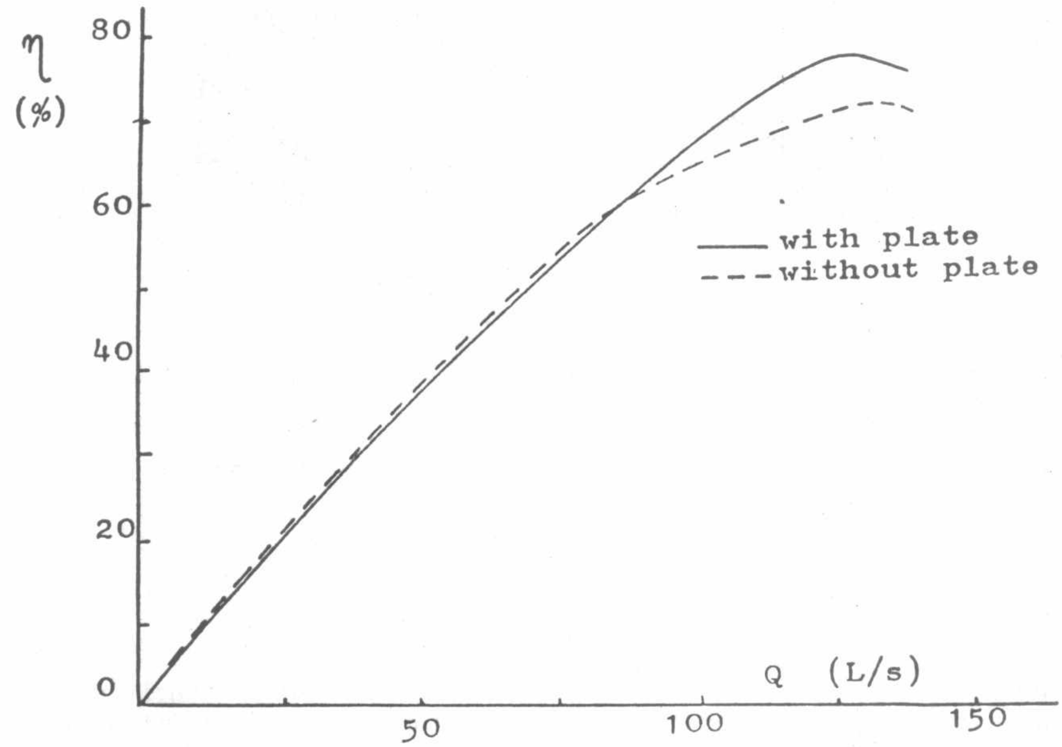

Fig. (4), Effeciency-Discharge Curves

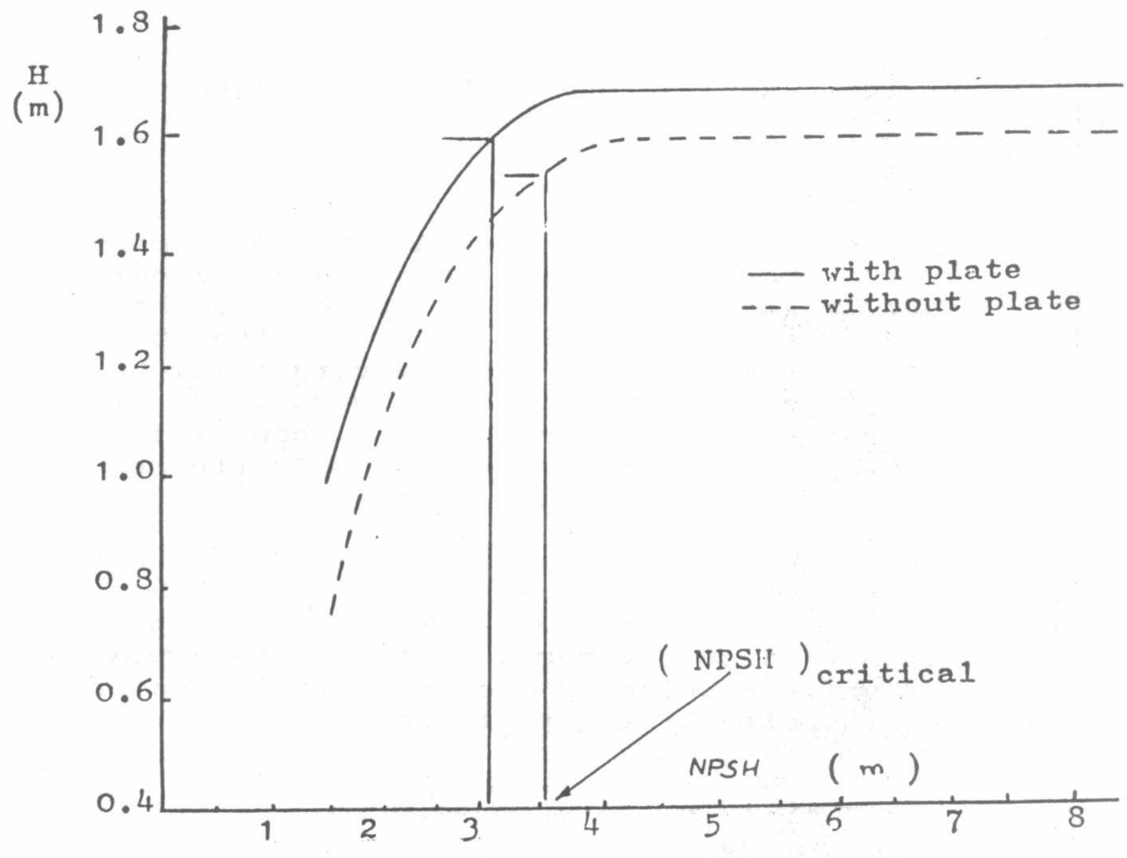

Fig. (5), Head-NPSH Curves

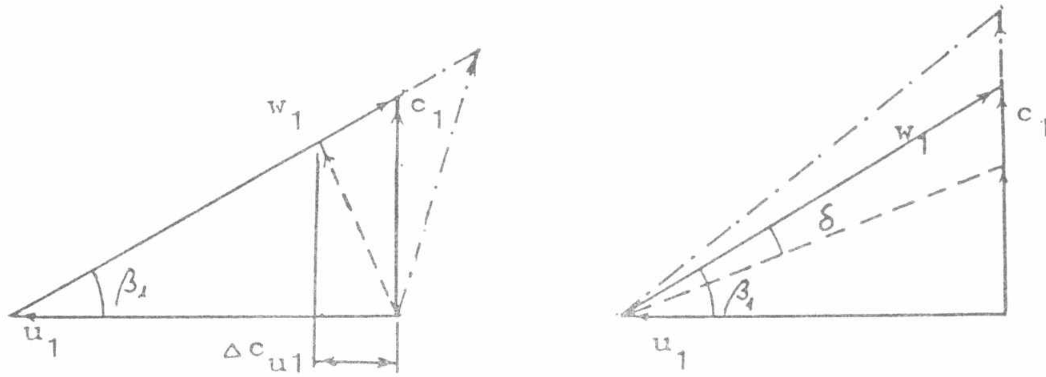

Fig. (6), Velocity Triangles at Inlet

may be assumed to be proportional to the incidence angle δ, Fig. (6). As shown in figure, the incidence angle is higher for partial flow rates than that for high rates of flow. S ock losses have usually a symmetrical relation for positive or negative incidence angles, δ .

The effect of the stabilizing plate inhibits the fluid prerotation. That results in higher incidence angles and shock losses at partial flow rates than that for higher rates. That explains why the pump attains favourable performance at higher flow rates.

In curved pipes there exists a secondary flow because the particles near the flow axis, which have higher velocities are acted upon by a larger centrifugal force than the slower particles near the walls,[4]. The effect of the stabilizing plate placed in the plane of bend curvature may be explained by dividing the flow area into two parts. The size of the secondary flow vortex is reduced, which results to more uniform velocity distribution as well as reduction of the energy required to produce the flow circulation.

The cavitation characteristics and the critical net positive suction head, at which the cavitation starts, have favourable values due to the stabilizing effect of the plate placed in the suction bend of the pump. That may be explained by the effect of uniform velocity distribution in suction space obtained when the stabilizing plate is used.

CONCLUSIONS

The effect of a stabilizing plate placed in the suc-

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ally. The plate has been found to improve the pump performance at normal and high flow rates. The cavitation appearance is retarded by using the stabilizing plate. At partial flow rates the stabilizing plate has found to have a maleffect on the pump performance. The plate effect may be explained by analysing the prerotation and vortex flow in the suction space. The plate affects the fluid prerotation, incidence angle and shock losses as well as the secondary flow and circulation in the suction bend. From that it is recommended to use the stabilizing plates in the suction space if the flow prerotation is important and if the pump normally operates at normal and higher flow rates.

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