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EFFECT OF OUTLET FLOW CONDITIONS ON AXIAL PUMP PERFORMANCE

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ABSTRACT

The outlet shape and conditions affect widely the axial pump performance. The space axial distance between the pump impeller and stator plays an important roll in determining the outlet conditions. An experimental investigation has been carried to study the pump performance without stator, and with stator at different distances from the impeller. The results have shown that the best performance is obtained for a stator distance of half the vanes mean chord. The cavitation characteristics have been found to be sensible for the existance of stator, and the risk of cavitation is decreased by using the pump stator.

INTRODUCTION

Stator stage is usually used in axial pumps to convert the high kinetic energy of the fluid, leaving the impeller, to pressure energy. This is accomplished by straightning the flow as it leaves the impeller and by reducing the fluid velocity, [1,4].The overall pump performance is affected by many factors at inlet and outlet of the impeller. One of these factors is the axial space distance between the impeller and stator stages. Practically, this distance is taken to be about 0.05 of the outer impeller diameter,[2] . Herein, different distances have been used to find the most favourable distance as related to the impeller vanes mean chord. Also, the pump has been tested without using a stator stage. The cavitation test was done to find the stator bearing on the cavitation critical conditions.

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EXPERIMENTAL INVESTIGATION

The effect of the axial space distance, between the impeller and stator stage, has been investigated experimentally for an axial pump having the following parameters ,[3],

- outer radius R_o = 0.12 m
- hub radius R_h = 0.07 m
- number of vanes, rotor z_v = 4
- number of vanes, stator = 3
- rotor's vanes mean chord = 0.10 m
- pump speed n = 700 rpm.

To limit the study of the effect of outlet conditions the parameters at inlet were fixed during the test. For different space distances of 3, 5 (half mean chord), and 1 cm. the pump performance has been measured as the relations between the head, power, effeciency and flow rate. Cavitation test has been carried for the cases of using a stator stage at half mean chord distance from the impeller, and for pump without the stator stage.

The pump performance has been evaluated by measuring:

- the volumetric flow rates, by an orifice meter fitted to the pump outlet pipe. The pressure difference across 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 done by means of an evacuation pump connected to the suction tank. The NPSH may be defined as,[1];

$$NPSH = (p_i - p_{vp}) / \rho g ,$$

where p_i is the inlet absolute pressure at vane tip, p_{vp} is the vapour pressure of fluid at given temperature, ρ is the fluid mass density and g is the gravitional acceleration. The critical NPSH is estimated as that results in reduction of the working head, for certain flow rate, by 3 %, Fig.(4), [3].

The measurements have been crried out for four cases:

- stator axial space distance of 1, 5, 8 cms.,
- pumping without using a stator stage.

Fig. (1 to 4) show the axial pump characteristics for different cases of stator space distances, and the cavitation characteristics for the case of not using a stator stage at pump outlet. Different behaviours have been distinguished for partial, normal and higher flow rates. For partial flow rates, there are small differences of pump behaviour. For higher flow rates, placing the stator at half mean chord distance from the impeller results in improving the overall pump characteristics.

The cavitation characteristics and the critical NPSH are given in Fig. (4). Defining the cavitation factor,

$$\sigma = NPSH / H \quad ,$$

where H is the pumping head, it was found that the pump is more sensitive to cavitation if the stator stage is not used, (lower cavitation factor σ).

ANALYSIS OF RESULTS

The performance of pump for different cases of using the stator stage at the impeller outlet may be affected by the stator entrance shock losses as well as the inter-rotation losses between the pump impeller and stator. Approaching the stator stage to the pump impeller, results in decreasing the energy losses due to fluid rotation in the space between the impeller and stator, while the shock losses increase. The fluid has insufficient space to approach the stator vanes without shock. Increasing the impeller-stator space distance has an opposite effect. These two opposite effects dictate that there is an optimum distance which results to minimum losses between the pump stages. An extreme case of large space distance is the case of not using a stator stage, which results, also to pumping without kinetic energy recuperation. That may explain the reasons of obtaining low pumping head and effeciency, when stator stage is not used.

The cavitation factor measures the sensitivity of the pump to cavitation. In spite of the fact of occurance of cavitation in the zone of least pressure at impeller vanes tips at inlet, the outlet conditions affect the cavitation characteristics by decreasing the cavitation factor σ due to decrease of pumping head H.

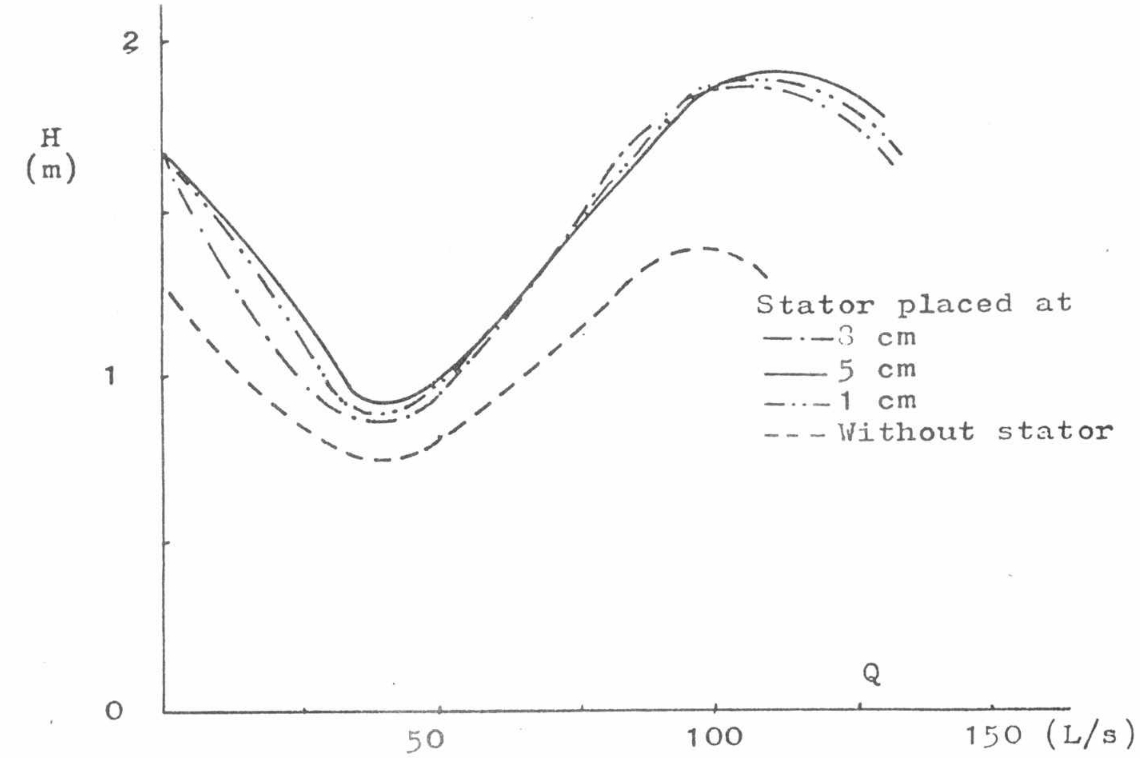

Fig. (1), Head-Discharge Curves

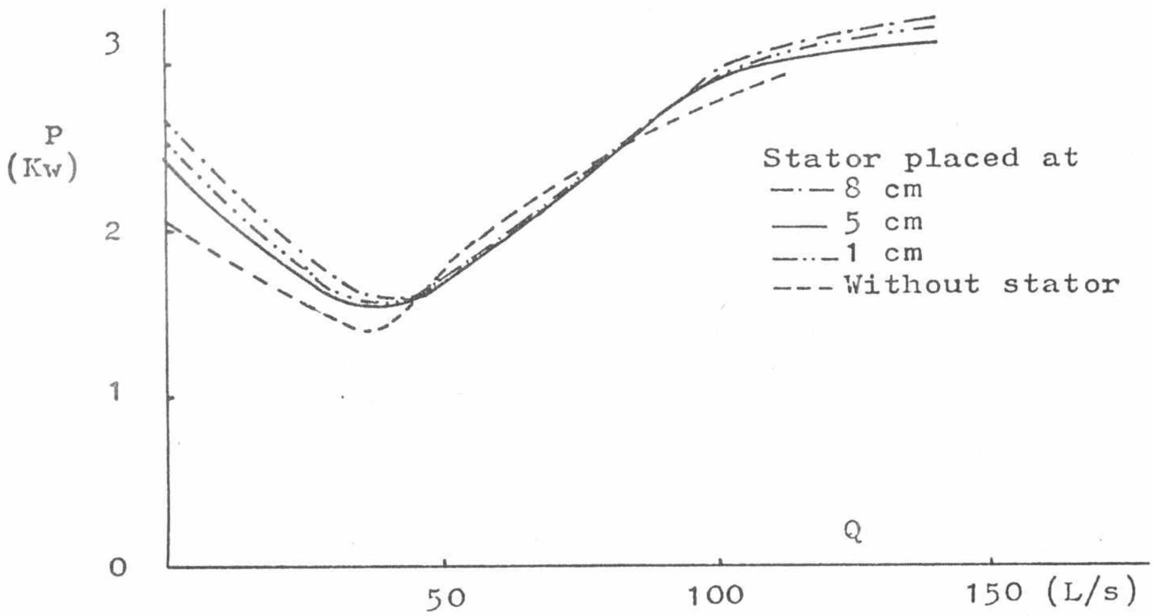

Fig. (2), Power-Discharge Curves

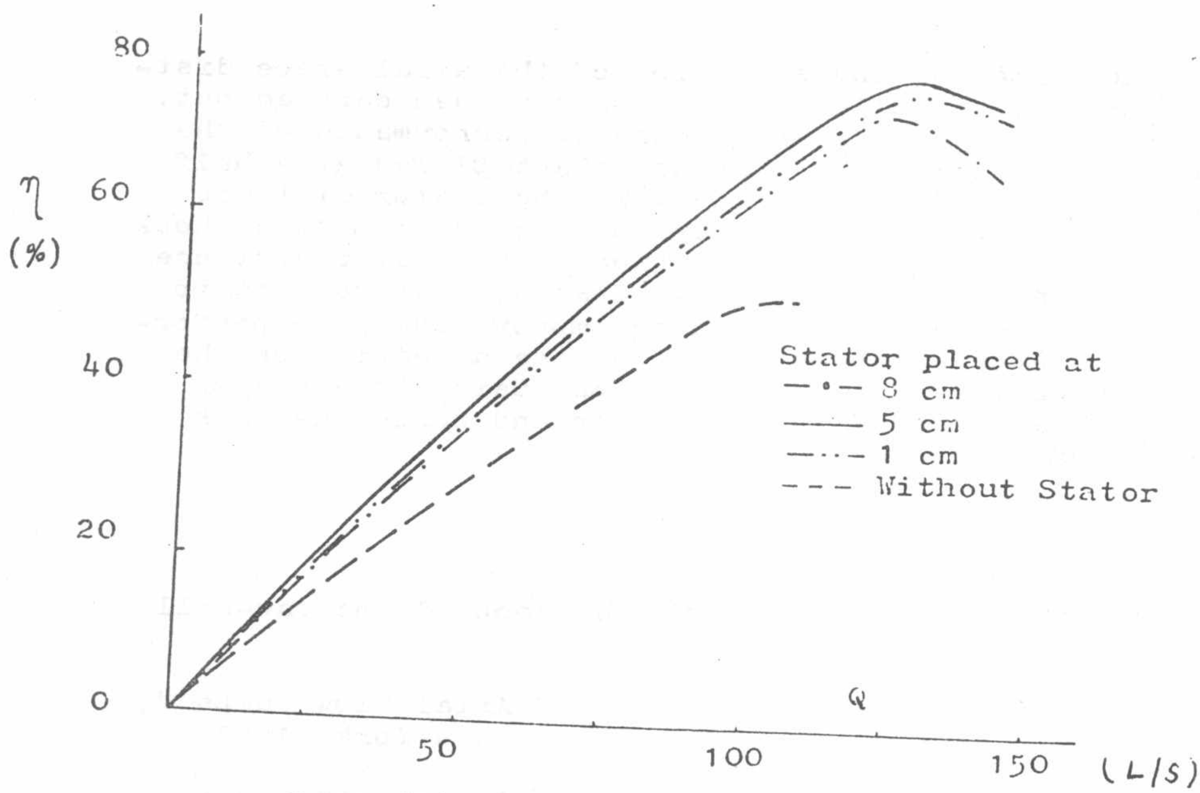

Fig. (3) Effeciency-Discharge Curves

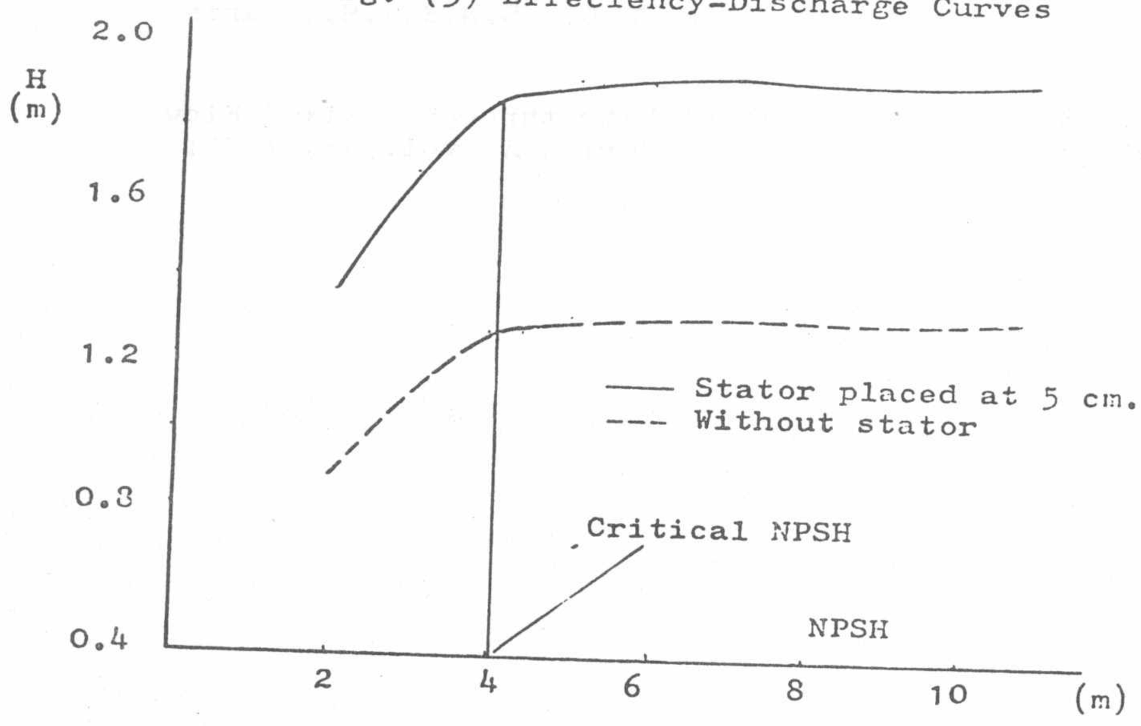

Fig. (4) Head-NPSH Curves

CONCLUSIONS

Experimental investigation of the axial space distance between the impeller and stator has been carried out. The results have shown that favourable performance of the pump is obtained by using a stator stage placed at a half mean chord length from the impeller. The stator distance effect may be explained by analysing the rotation and shock losses near the stator stage entrance. The stator distance has opposite effects on these two losses, that results to optimum distance has to be used to improve the pump performance. The stator has been found to have a bearing on the sensitivity of the pump to cavitation. Using of a stator stage decreases the cavitation factor and hence the risk of cavitation occurance.

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