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# The Influence of Concentration on the Suction Performance of Dredging Pumps.

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# THE INFLUENCE OF CONCENTRATION ON THE SUCTION PERFORMANCE OF DREDGING PUMPS

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## ABSTRACT:

An experimental investigation of the influence of solid materials concentration on the suction performance of dredging pumps is presented in this paper. The experimental data, carfully collected from the field were put together in dimensionless form to present an overall picture of the suction performance of the pump at different operating conditions. The effect of the use of a booster pump was considered and the influence of speed was shown.

The objective of this experimental investigation is to present the relation between the concentration and the suction performance of dredging pumps which is an important factor in determining the optimum operating efficiency.


## INTRODUCTION:

Recently the use of centrifugal pumps handling solid materials has been considerably increased. Generally and more particularly for dredge pumps there is a lack in the available literature. The development of the dredge happend through random trial and error rather than by plan [1] Despite the endless of literature treating the cavitation in monophase flow the literature in the field of polyphase flow at high concentration remains very poor. In fact the lack of knowldge about the mechanism of flow in polyphase flow is the major obstacle ,besides at high concentration the flow becomes no longer newtonian . The classical model of cavitation in monophase flow is based on the formation of nuclei and consequently, the develo-pment of the cavity, in polyphase flow,the forgoing model became question-able ,where the tensile strength of the interface between liquid and vapour will be altered by the presence of solid particles, also adding to this

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complexity that for the time being, even for monophase flow the mechanism of turbulence is not fully understood, not to speaking about polyphase flow.

A general performance characteristics of dredging pumps is given in refere -nce [1] ,it follows from reference [2] , that the manometric head is decreased by increasing concentration, this depends to a certain degree on the solid size.

In the presente investigation the influence of increasing concentration on the net positive suction head NPSH was evaluated at variable dredging depth s and speeds.

FORMULATION OF THE PROBLEM:

Generally the supply of nuclei is almost due to the following potential sources:

- The presence of air bubles in the flow.
- The hydrophobic partcles,as defined in [3] ;A very small gas bubble lodging in a crevice of a hydrophobic particle will be on the convex side of the liquid gas interface.
- Air bubbles attached to solid surfaces. In dredge pumps ,due to the water pressure acting on the solid particle the particles could be considered as completly wet.

The nonuniformity of the flow inside the impeller due to the creation of low pressure and high pressure regions will facilitate the creation of the nuclei in the low pressure side [4] . The nonuniformity is influenced to a certain degree by the velocity of flow at the entrance to the leading edge of the blade.

Remain the direct influence of the solid particles in decreasing the tensile strength of the liquid acting as a nuclei . Also a small particle may attain a rotational mouvement due to the nature of turbulent flow forming a small eddies which increases due to the centrifugal forces [5] increasing the turbulence level and reducing the liquid tensile strength.

From the forgoing analysis the available NPSH should decrease with increasing concentration , the influence of particle size on the concentration is not considered.

The considered parameters in this investigation are the NPSH,Thoma cavit ation factor, the cavitation specific speed, at four different speeds of rotation and dredge depths.

DATA COLLECTION AND REDUCTION:

More than hundred point were carfully collected from a dredger Tarek . The dredger is equiped with an impeller of the following specification,outer diameter= 2.01 m, inlet diameter= 1.0 m ,has four blades curved backward at an angle of 145° at exit and 154° at inlet , the impeller height is 550 mm, weighs 4795 kg.
Runs with pure water has been conducted perior to the operation of dredger. The pressure measuring devices are the pressure guages, Bourdon type, the calibration of those guages was achieved in the shipyard, the expected error is ± 1 % , the magnitic flow meter is used to measure the flow, the accuracy of the instrument is ± 2 % ,The concentration is measured by a magnitic meter , all the above mentioned instruments were calibrated perior to operation in the shipyard. An error analysis was conducted according to the standard procedure, the relative error in the net positive suction head is ± 1 %.
The NPSH was calculated after the expression $NPSH= P_a/w - H_{ss} - H_f - H_v$ the term( $P_a/w - H_{ss} - H_f$) is directly measured by the pressure gage the specific weight of the mixture is used to calculate the head. The manometric head is the simple difference between the readings of the pressure gages on the delivery and suction.
The cavitation factor $\sigma = NPSH/ H_m$, and the cavitation specific speed $S = N\sqrt{Q} / NPSH^{.75}$ .

RESULTS AND DISCUSSION:

The involved parameters are the net positive suction head NPSH, cavitation factor and cavitaion specific speed granulometric study was under taken . The sand in the dredging area has mean diameter $d_p$= 0.08mm .
Since the most important parameter in dredging is the concentration , all the above mentioned parameters are presented as a function of concentration . Figure (1) presentes the NPSH at different dredging depth s varying from 15.5 meters to 22 meters for the main pump operating without booster the initiation of cavitation is manifested by the high noise level followed by the openning of the surge valve of the injection of pure water in the suction line. It is enteresting to note that many of the normal operation points of the dredger were arround the cavitation limit as a try to reach the maximum excavated materials per unit time, figure (2) shows the NPSH when a booster pump is used, the characteristics of booster pump connected in series with the main pump is sensible to the variation of the speed

since the depth has no signif icance. The booster is used to supply the necessary additional dynamic head to conv y the dredged materials to the canal banks, certainly the danger of cavitation is not presente for the booster pump.

The cavitation factors at different dredging depthes in function of concentration is shown in figure (3) for the main pump and in figure (4) for the booster. The cavitation specific speed is presented at different depths for the main pump in figure (5) and at different speeds for the booster in figure (6).

In fact to deduce the relation between concentration and the NPSH other parameters should be involved as the grain size, the depth, the speed, the manometeric head , it is convenient to present the relation in a dimension -less form as $\sigma$, S .

From figure (1) it is clear that increasing depth decreases the maximum dredging concentration, one should notice that despite the change in the depth the static suction left remains constant since the dredger still floating on the water surface, but increasing the depth increases the suct -ion line lenth and consequently the hydraulic losses, an increase in the dredging depthby 45% resulted in a reduction in the concentration of 50 %, in fact the calculation of the hydraulic losses in the suction line still needs more researchs to be done, in the suction side two factors affecting the losses should be considered , the length and the angle of inclination of the pipe, from figure (1) it is clear that the hydraulic losses in the suction line is the predominant factor in determining the maximum dredging concentration, this will reduce the problem to the classical problem of polyphase flow in inclined pipes.

Figure (5) shows the relation between the concentration and the cavitation specific speed in dimensionless form, the advantage of this presentation is the cavitation specific speed includes the speed and the NPSH ,because despite the importance effect of the hydraulic losses in the suction line on the cavitation the speed of rotation still responsible of creation of low pressure regions and consequently the formation of nucleis.

The set of curves (2, 4,5) shows clearly the effect of speed since the speed is the only predominate factor of the suction performance of the booster pump , certainly the booster pump is safe of cavitation. From those figures the dredging concentration increases with decreasing speed to a certain limit because this is achieved on the despense of the manometeric head.

Since the pump is operating arround it's cavitation limit to reach maximum dredging per unit time the effect of wear should not be omitted, in the present investigation it was not possible to consider the wear because the dredger is new, certainly the determination of the pump performance on time bases will show the propagation of wear and the deterioration of the performance. It will be of great use to dredger users to give the relation between the pump effiency, dredging effiency and wear in mathematical form.

CONCLUSION:

Based on this investigation the following conclusion and recomendations are offered:

- The concentration is function of dredging depth, a detailed investigation is obviously important to put this relation in mathematical form including the hydraulic losses.

-The intiation of cavitation in dredging pumps is mainly dependant on the concentration. A chart presenting the relation between the NPSH , $\sigma$ , and concen -tration at different depths and constant speeds will be of a great use to users in predicting the cavitation limit and hence the safe operating range.

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NOMENCLATURE:

C Transport concentration $Q_s/Q_d$.

H Pressure head in meters.

Q Discharge in cu m/hr.

P Pressure in Kg/sq cm.

N Speed of rotation in R.P.M.

NPSH Net Positve Suction Head in meters.

S Cavitation specific speed.

w Specific weight of the mixture in Kg/ cu m.

Greek Letters:

$\sigma$ Thoma cavitation factor.

Subscripts:

a Atmospheric.

d Mixture.

f Friction losses head.

M.6. El-Mansoura Bulletin, Vol. 6, No. 1, June 1981.

m Manometric head.

s Solid materials.

ss Static suction head.

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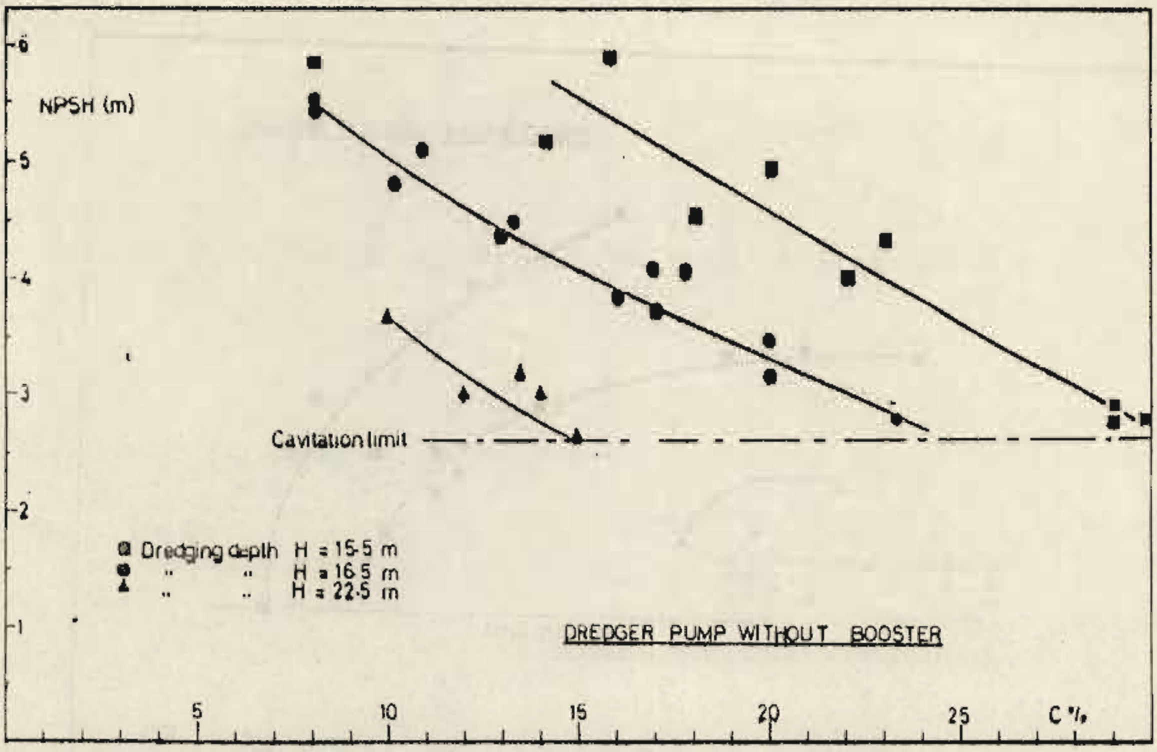
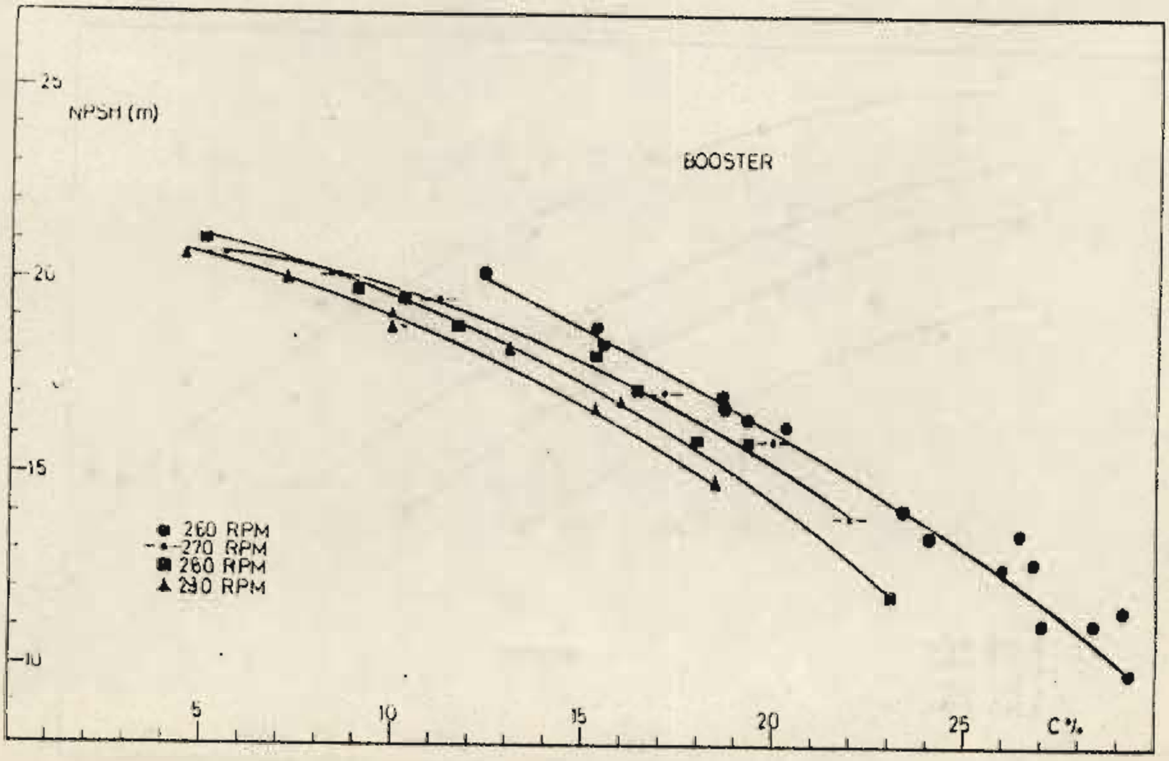



Figure(1) The relation between the NPSH and the transport concentration at different depths.




Figure(2) The relation between the NPSH and the transport concentration , at different speeds.

M.8. El-Mansura Bulletin, Vo. 6, No. 1, June 1981.

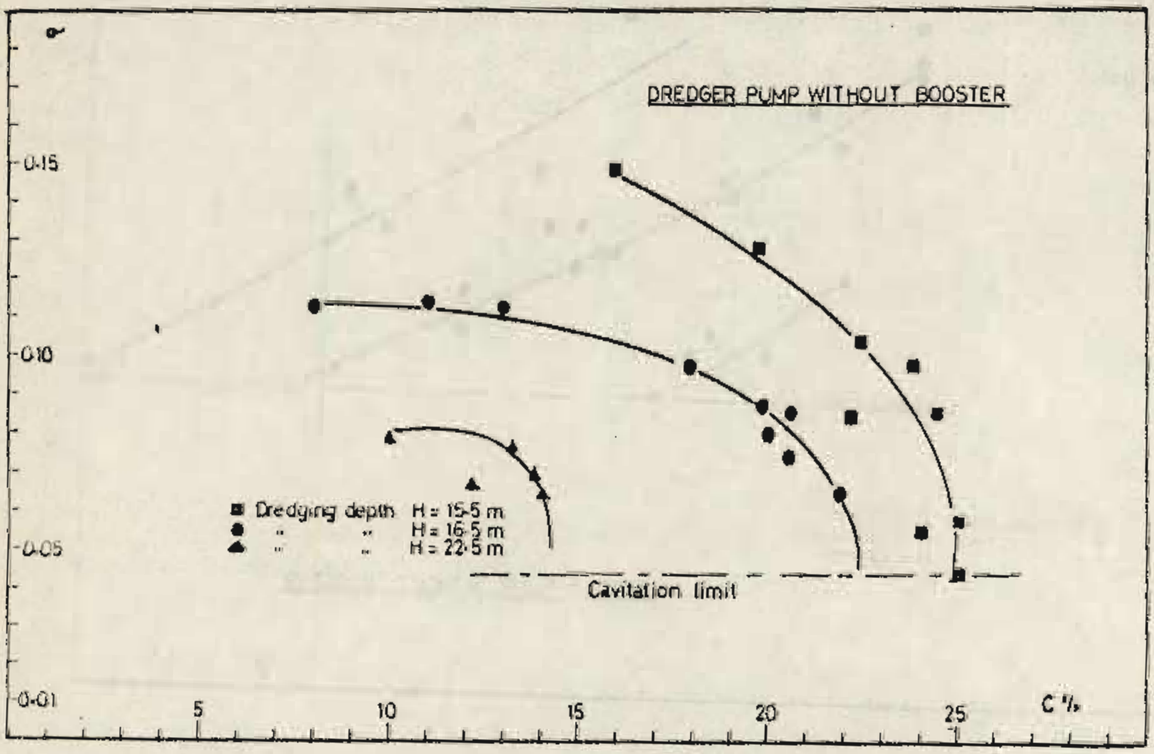
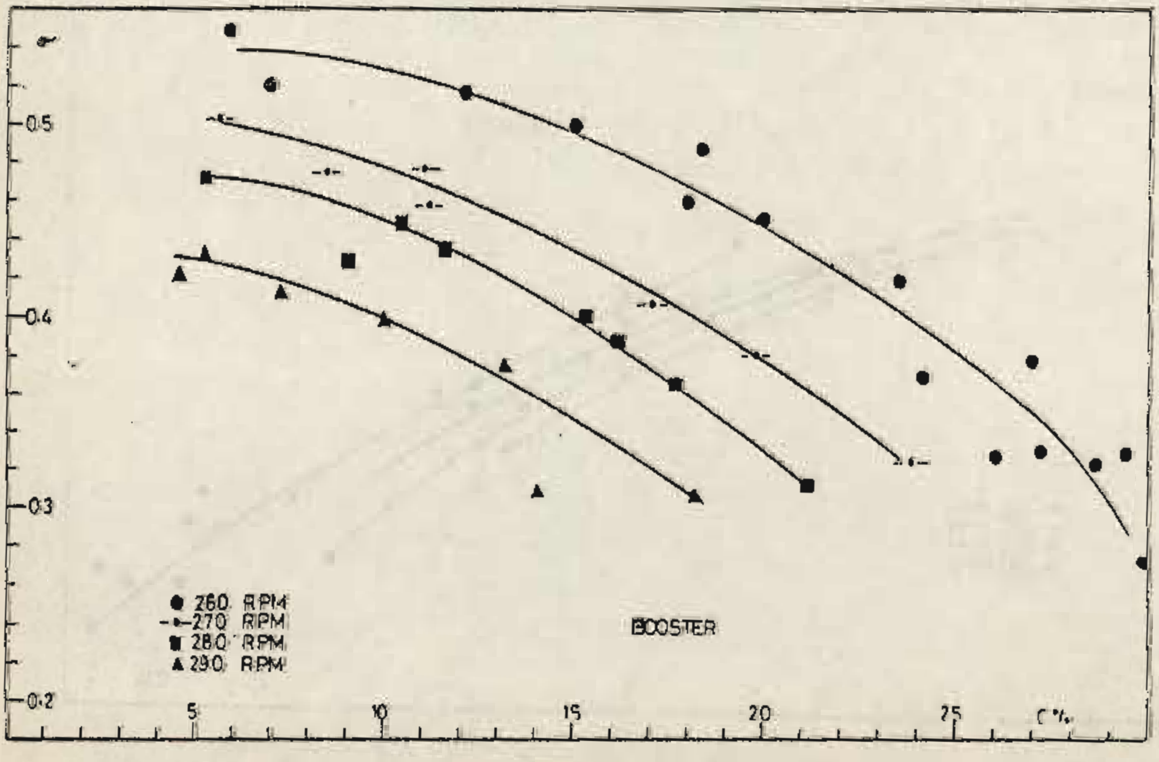
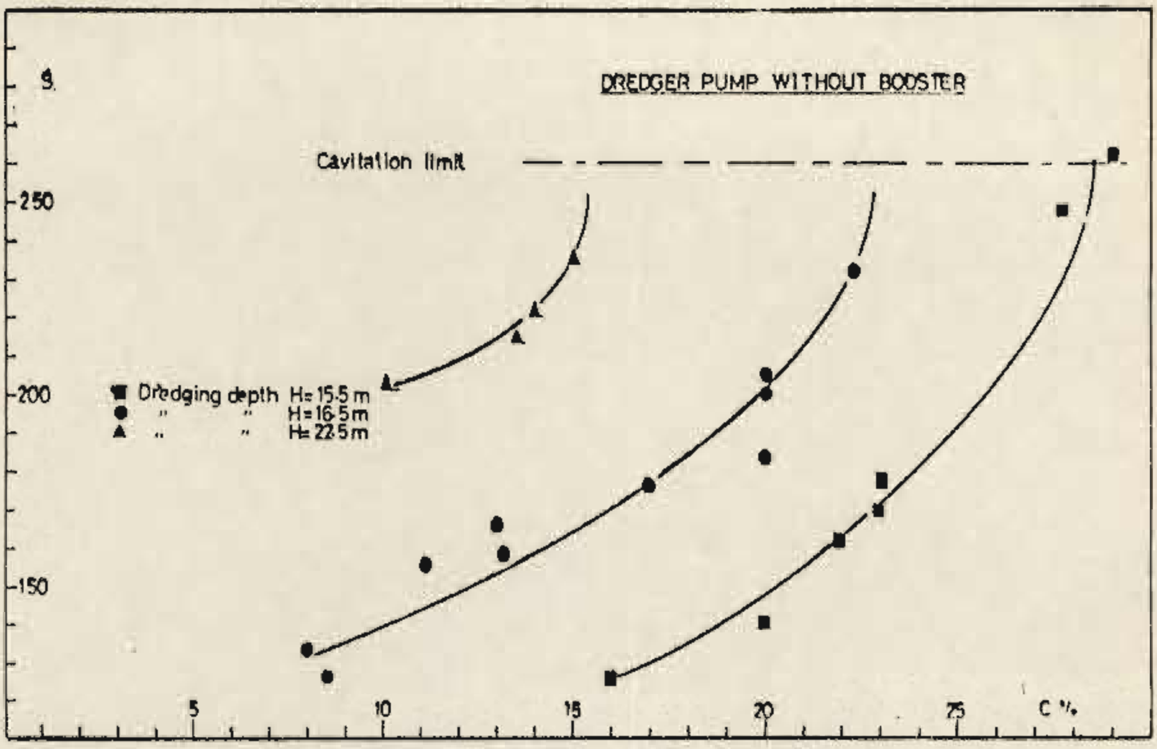


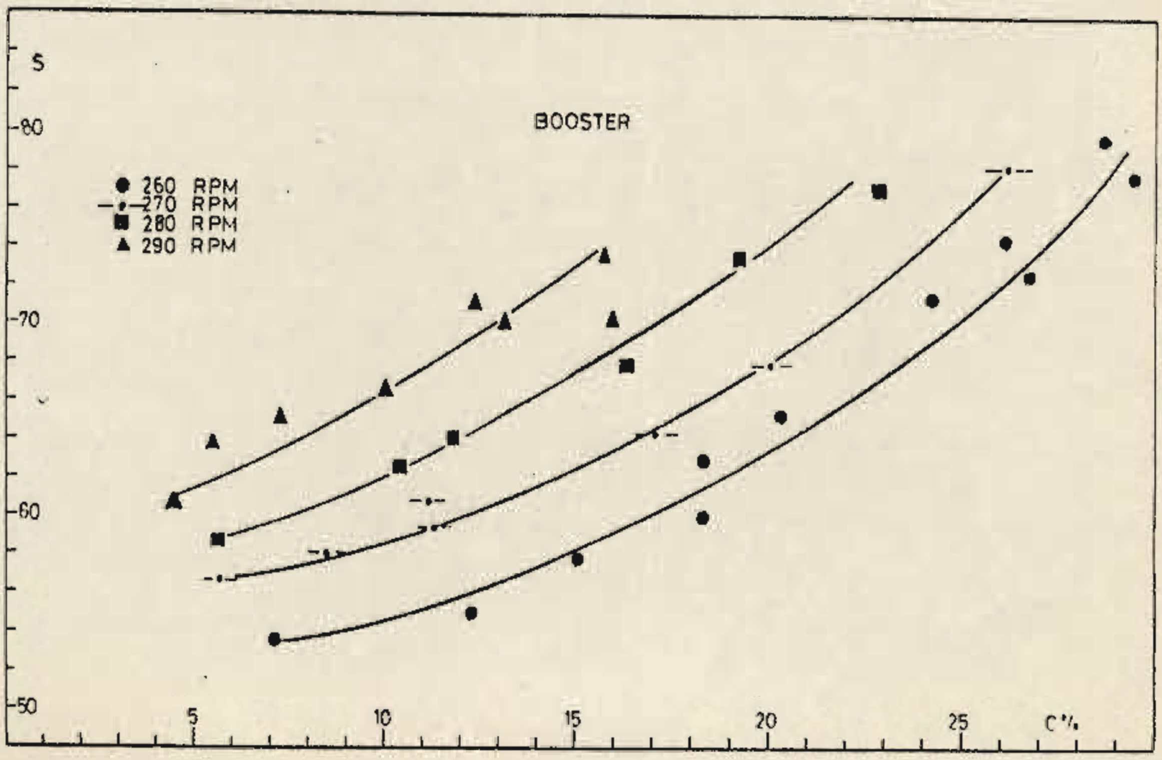

Figure (3) The relation between Thoma cavitation factor and the transport concentration at different depths.




Figure(4) The relation between the Thoma cavitation factor and the transport concentration at different speeds.




Figure(5) The relation between the cavitation specific speed and the transport concentration at different depths.




Figure(6) The relation between the cavitation specific speed and the transport concentration at different speeds.