EFFECT OF HEIGHT OF SINK LOCATION ON DRAWDOWN FROM A TWO LAYERED FLUID BODY THROUGH ROUND HOLE.

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Abstract This paper represents an experimental study on drawdown from a two layered fluid body through a round hole at different sink heights. Mean interface heights are measured on the basis of drawdown fraction and results are analyzed for different extensions or sink height conditions. Although drawdown behaviour has already characterized by Froude number , but non-dimensional extension height indicates a distinctive drawdown history from those of sink located at the bottom of tank.

Keywords: Drawdown, Two Layered Fluid Body.

INTRODUCTION

Numerous theoretical and experimental studies for withdrawal from a two layered fluid body have been reported in the literatures. It is experimentally established fact that Fruode numbers are primary governing parameter for characterizing the flow of interest. The Froude number F_r is defined as $F_r=Q/sqrt(g'L^5)$; where Q is the withdrawal flowrate, L is the characteristic length and g' is the buoyant acceleration and is equal to $g(\rho_1-\rho_2)/\rho_1$. Here, ρ_1 and ρ_2 are densities of the lower and upper layers respectively. For point sink at bottom, Craya (1949) and Gariel (1949) found that there exists a critical Froude number, F_{rc} above which both layers flow into the sink and thus drawdown occurs. Razzaque (1994) worked on similar field with plain intake at bottom and obtained a relationship between the percentage of drawdown Λ and logarithmic normalized densimetric Froude number $[\log(F_r/F_{rc})]$; where F_{rc} is the critical densimetric Froude number at some selected drawdown such as, 5%, 10%, 15%. He formulated the different equations for different drawdown conditions. The equations are:

i. For F_{rc} at $\Lambda=5\%$

$$\Lambda=48.0[\log(F_r/F_{rc})]^2+22.4[\log(F_r/F_{rc})]+4.56 \quad (1)$$

ii. For F_{rc} at $\Lambda=10\%$

$$\Lambda=67.9[\log(F_r/F_{rc})]^2+44.7[\log(F_r/F_{rc})]+9.98 \quad (2)$$

iii. For F_{rc} at $\Lambda=15\%$

$$\Lambda=80.9[\log(F_r/F_{rc})]^2+60.2[\log(F_r/F_{rc})]+15.1 \quad (3)$$

Jirka and Katavola (1979) also worked on this field. They observed that a small degree of withdrawal ($\Lambda<3\%$) consistently occurred even at values of F_r well below the incipient condition. This phenomena is also harmonious with the slowly over the cold layer, until a desired total height of water level is reached.

EXPERIMENTAL SET-UP AND PROCEDURE

Experiments were conducted in a square tank of dimension 1210 mm x 1210 mm x 530 mm (Figs. 1 and 2). The sides of the tank were made of Perspex sheet and details of it are in Anwar (1995). For convenience of formation of a two layered system an extra feeder tank of dimension 1115 mm x 28 mm x 64 mm was placed at suitable height adjacent to a vertical wall. Initially , the tank was filled up with cold water up to the top edge of the feeder tank. Then warm water of uniform temperature was delivered into a layer of small glass balls in the feeder tank and was allowed to overflow slowly over the cold layer, until a desired total height of the water level was reached. In this way a two-layer fluid body was formed with an interface thickness of about 33-60 mm. The intakes were set-up at the middle of the bottom of the tank.

RESULTS AND DISCUSSIONS

In the present study, twenty four experimental runs were made with eight different intake heights (EX=0, 13, 19, 42, 54, 76, 100 &120mm); in each case three different flow rates were played. The Froude number range were $17.75<F_d<82.00$ and $1.50<F_l<11.43$. From the recorded instantaneous temperature of the withdrawn water, the percentage of drawdown was calculated as:

$$\Lambda=(T_m - T_1)/(T_2 - T_1)*100\% \qquad (4)$$

where T 's are the temperatures and m,1 and 2 refer to the mixed withdrawn water, lower and upper layers respectively. Figure:3 shows a typical temperature(density) profile just before onset of withdrawal which indicates the construction of two layer fluid body. The drawdown of warm layer begins when the interface falls to a particular height . As the interface falls further, the drawdown increases in nonlinear way. The mean instantaneous heights in determining F_r are calculated far away from the sink when the isotherm corresponding to ($\phi=(T_m - T_1)/(T_2 - T_1)$ =0.5) pulled down to the level (Harlemn et al (1959); Goldring(1981)).

The locations of sink play a vital role in determining Λ. In this work the sink was elevated gradually within the lower layer of the fluid, the data are plotted in Fig: 4a and Fig4b. In Fig 4a Λ is plotted with instantaneous densimetric Froude umber F_r for different sink locations. The figures show that varies for the same F_r for different sink location. The value of Λ decreases at higher sink location for the same F_r. Again, a symmetrical curve as described by Zirka & Katavola [1979] is not observed till the sink reaches a certain elevation. From Fig:4a and Fig: 4b a conclusion may be made that the pattern of the flow changes with location of the sink. When the sink is very near to the bottom surface it behaves much like plain intake. But as the height of the sink gradually increases the flow behaviour changes and after a certain height the nature of the flow becomes as those described by Zirka & Katavola.

Densimetric Froude number becomes a dominating tool for determining the value of Λ and the effect of F_d & F_l becomes less important. Best fit curves are drawn considering all the data obtained from the drawdown history, for EX/H >0.2. The maximum deviation of the curve is ±6.5%. The best fit equations are summarized below;

$$\Lambda=4.60[\log(F_r)]^3+11.5[\log(F_r)]^2+7.71[\log(F_r)]+2.31 \qquad (5)$$

for $-0.75 < \log(F_r) < 0.75$

$$\Lambda=1.44[\log(F_r)]^3-14.8[\log(F_r)]^2+53.2[\log(F_r)]-16.5 \qquad (6)$$

for $0.75 < \log(F_r) < 4.00$

CONCLUSIONS

The following conclusions can be drawn for the present work:

1. Sink location plays an important role in determining the drawdown history. For Ex/H >0.2. The value of F_d and F_l has less significant effect on the drawdown history of fluid, rather in such state the effect of densimetric Froude Number becomes notable.
2. A generalized relationship between densimetric Froude number and percentage of drawdown for a sharp round sink located at EX/H>0.2 is established.

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Fig. 1: Schematic diagram of experimental setup

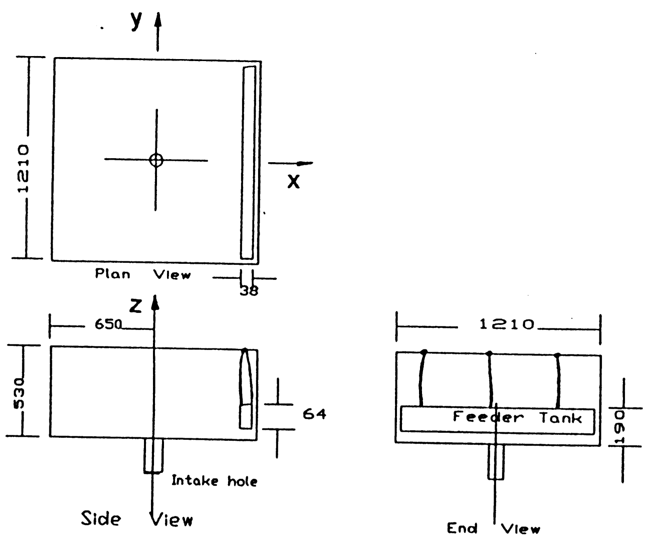

Fig:2 Experimental tank (dim: mm)

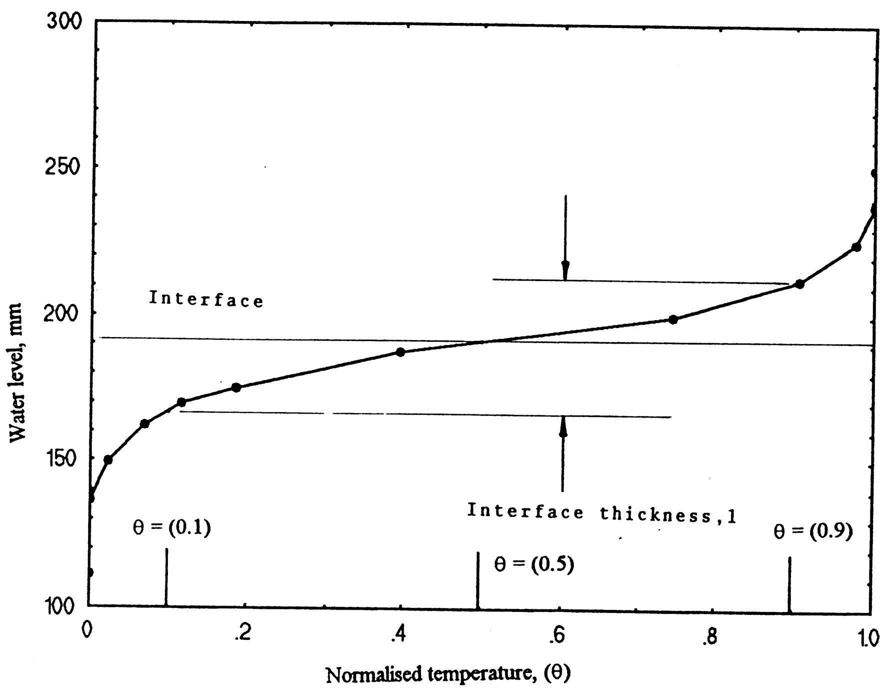

Fig:3 A typical temperature (density) profile

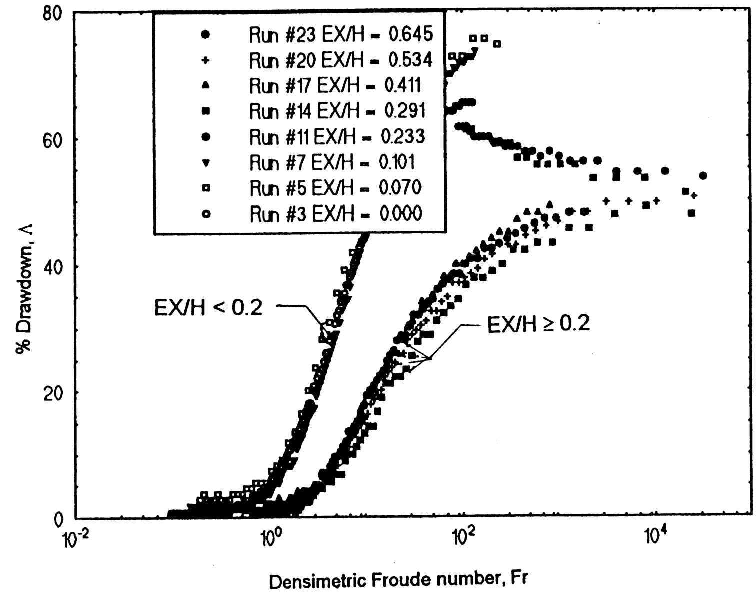

Fig:4 a Drawdown histoy at several location of sink

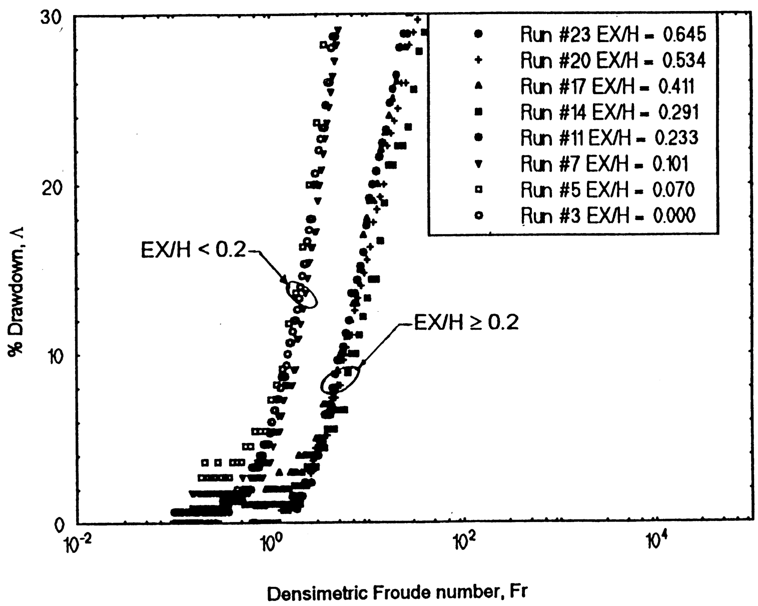

Fig:4 b Drawdown histoy at several location of sink