Chapter VI

Discussion

Referring to the obtained results as analysed in the previous chapter, it is found that many factors affect the overall coefficient of oxygen transfer.

It would be advantageous to discuss them separately as following:-

Elevation head of diffuser (H)

As shown in Figure 6 and 7, it is observed that, for a certain range of H for each diffuser the overall transfer coefficient at 20°C ($K_{La(20)}$) increases as the increase in H. This is due to the fact that greater value of H results in higher suction pressure or more air supply.

For the further range of H, (Figure 7, Diffuser No.8) after the maximum $K_{La(20)}$ is reached, the value of $K_{La(20)}$ gradually decreases as the increase in H. This can be explained that at the range, an excess of air is obtained and very large air bubbles are observed thus almost approaches the maximum air absorbing capacity of the liquid. Therefore the increase rate of $K_{La(20)}$ by the mentioned cause is less than the decrease rate of $K_{La(20)}$ due to the decrease in the flow rate of discharge which will be discussed later.

Also in Figure 6 & 7 by Diffuser No. 4, 7 and 8, as a result of using another piece of longer pipe instead of the original shorter one, at H of 250 cm., the value of $K_{La(20)}$ obtained seems to be smaller than it should. The reason for the case is that, it offers more loss of head and causes the more decrease in flow rate of discharge hence decreases the value of $K_{La(20)}$. Though it can not be taken as an reference to this comparative study, it still shows more or less the effect of flow rate of discharge on $K_{La(20)}$.

With other three diffusers, the experiment was not carried on until the maximum value of $K_{La(20)}$ is obtained because of the same reason discussed above. However it almost reached the maximum value as explained by the observation of very large air bubbles when Diffuser No. 2, 5 and 9 are used.

The different reason with Diffuser No. 1, 3 and 6 will be discussed later in Characteristics of orifice.

Immersion depth of effluence or exit discharge (s)

According to Figure 8, the effect of immersion depth (s) on $K_{La(20)}$ seems to be small because more aeration action occurs firstly in the pipe and finally occurs partly in the ditch. This can be explained by prolonging the curve to the immersion depth of zero, the approximate value of $K_{La(20)}$ taken at the intercept point is resulted from the aeration action in the pipe only.

However, for an economic consideration on power consumption, the $K_{La(20)}$ per unit power consumed is plotted against immersion depth (s) as shown in Figure 11. It is found that $K_{La(20)}$ / Power gradually increases as the increase in S for the whole range of the curve, therefore it is most economic to locate the exit discharge at the bottom of the ditch. It would be advantageous also to apply this system of aeration with a tank containing deeper liquid, because the gas-liquid mixture can still go down to the required depth as long as the velocity of flow is greater than the uplift velocity of air bubbles. It is independent of uplift pressure at exit discharge but depend on the increase in energy to overcome friction loss of head due to increase in length of the down pipe as shown in Equation 1 of Chapter II.

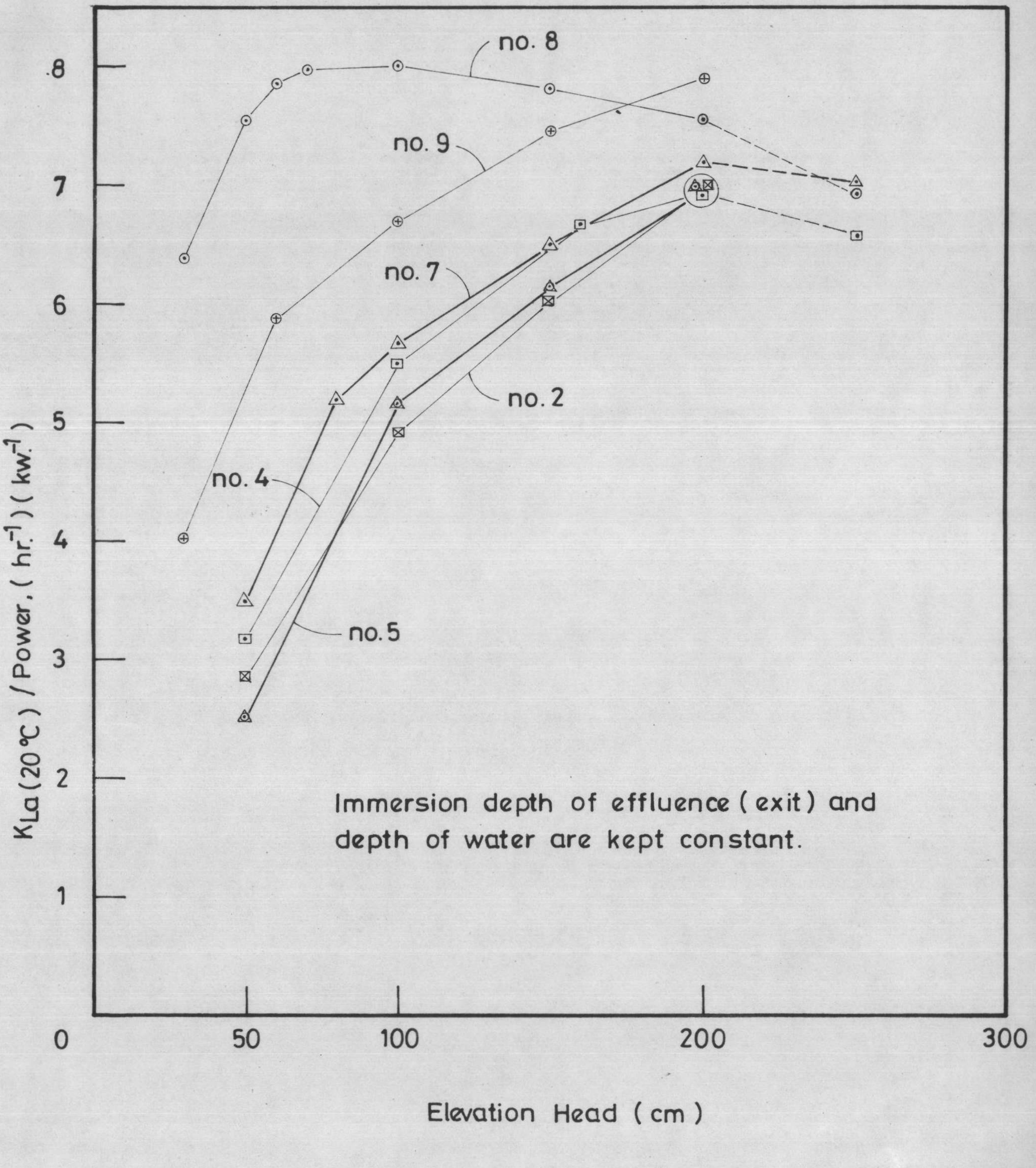

Fig. 10 Relationship between $K_{La}(20°C)$ / Power and Elevation-Head for indicated diffusers.

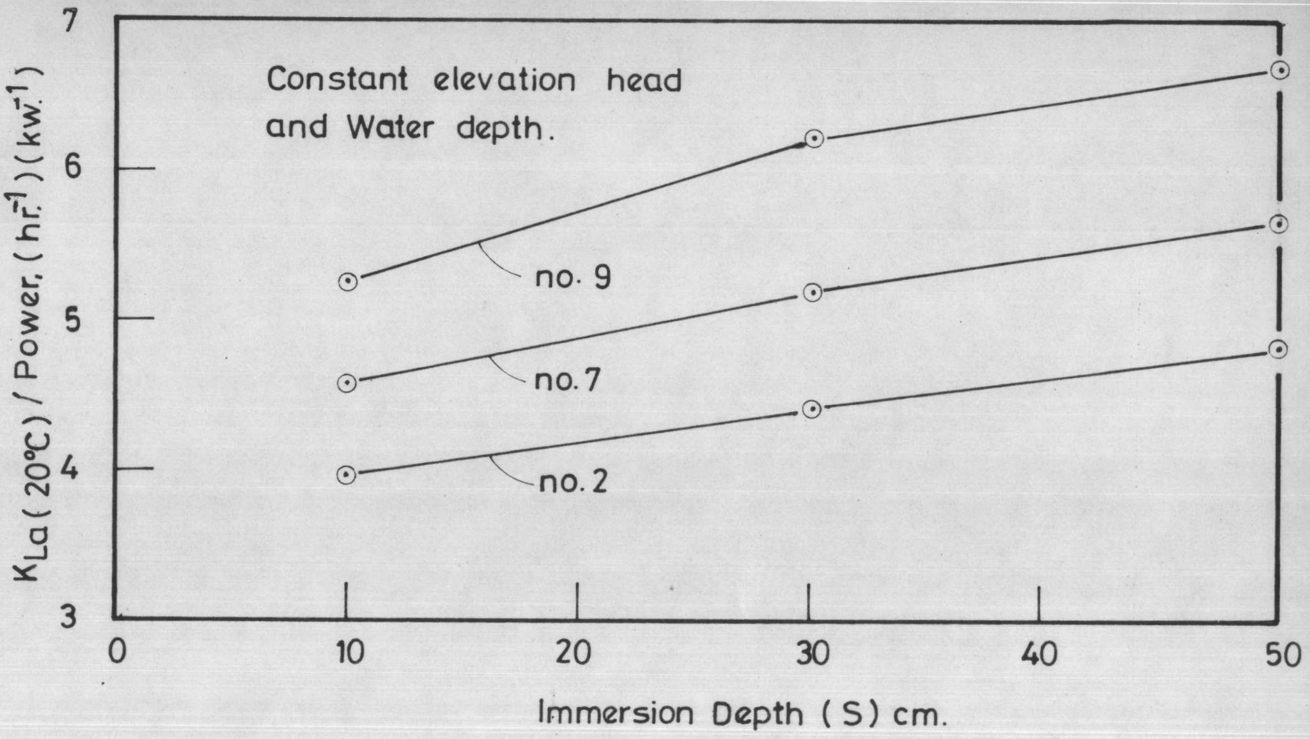

Fig. 11 Relationship between K_{La}(20°C) / Power and Immersion depth of effluence for indicated diffusers.

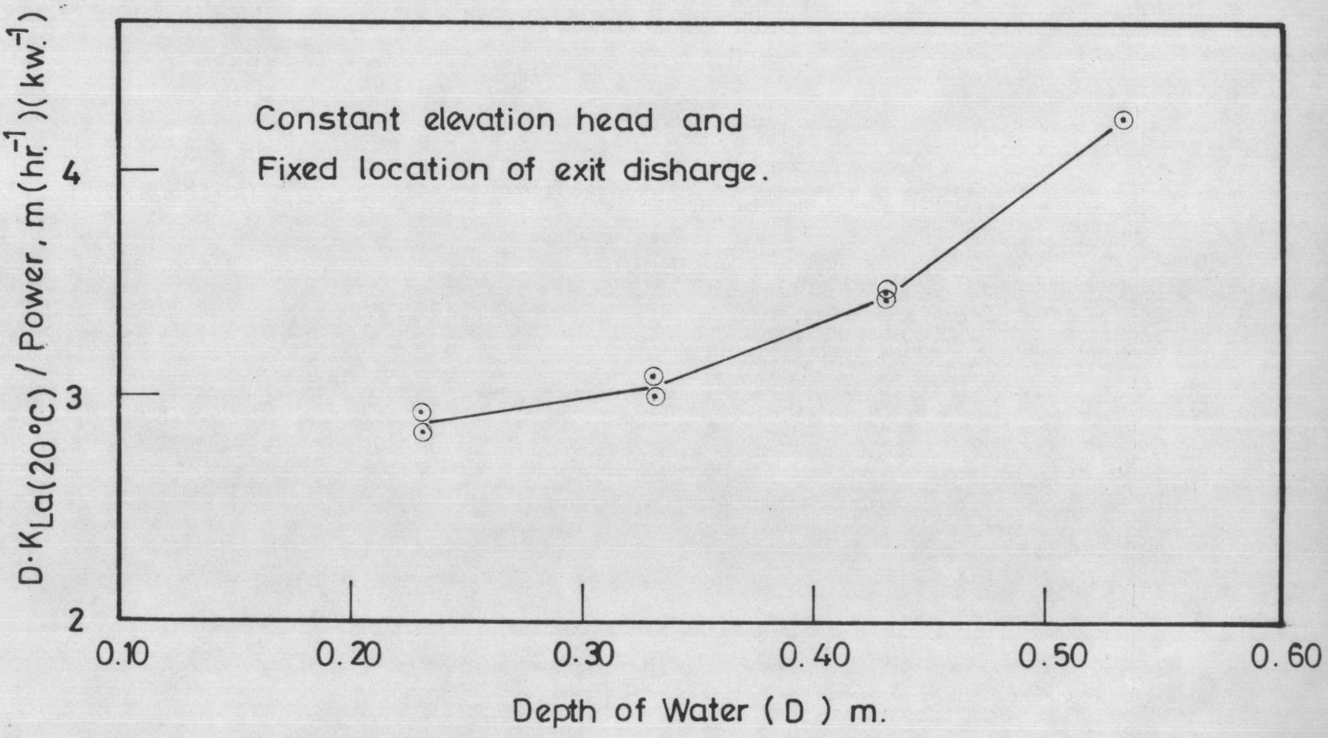

Fig. 12 Relationship between D•K_{La}(20 °C) / Power and Depth of Water (D)

Type of diffuser

As shown in Figure 6 and 7, it is found that at lower value of elevation head (H), the type of diffuser offers a greater effect on $K_{La(20)}$. At the same value of low elevation head, the Venturi type gives the highest $K_{La(20)}$, while the Pilot type gives the lower and the ordinary perforated pipe, the lowest. It can be simply explained by the equations in Chapter II which are satisfied by this study.

At higher H it has a lesser effect on $K_{La(20)}$, and at a certain H, when the maximum $K_{La(20)}$ is reached it has a least effect and offers a small difference in $K_{La(20)}$. However in practice, the Venturi type is most suitable while the ordinary type is less suitable but can be constructed at the lowest cost and most easily. The Pilot type is less suitable in practice and is also most difficult established.

Orifice Characteristics

Generally in most types of diffused aeration, the orifice diameter of diffuser has a great effect on $K_{La(20)}$ as a result of the size of air bubbles obtained. And the smaller the bubbles are, the greater is the interfacial area, thus gains a direct effect on the increase of $K_{La(20)}$.

In this type of aeration, the size of air bubbles is partly affected by the orifice diameter and partly by the redividing of air bubbles by the hydraulic shear force of flow in pipe.

As shown in Figure 6, it is found that for a certain range of elevation head (H), the orifice characteristics of the Diffuser type I (See Figure 2) have a small effect on $K_{La(20)}$. And for a further range of H, when excess air is obtained, they have a lesser effect.

It can be explained by firstly compare the difference in characteristics between Diffuser No. 2 and 4. The total orifice areas of both diffusers are approximately equal while the orifice diameter of Diffuser No. 2 is smaller than that of Diffuser No. 4. It is found that, under the same suction pressure, the amount of air induced by Diffuser No. 2 is less than that by Diffuser No. 4 because Diffuser No. 2 offers more friction loss of energy (Vennard, 1961), thus results in lesser amount of air obtained. To this study, Diffuser No. 2 still offers a lesser value of $K_{La(20)}$, even it consists of a smaller orifice diameter therefore indicates the effect of lesser total equivalent orifice area on $K_{La(20)}$.

Secondly compare the characteristics of Diffuser No. 4 and 5. Though Diffuser No. 5 consists of twice orifice area of the other, from Figure 6, it offers a lesser value of $K_{La(20)}$ as a result of its bigger orifice diameter thus indicates the effect of the size of orifice diameter on $K_{La(20)}$. Therefore, for a certain range of H, both orifice diameter and total orifice area have a small effect on $K_{La(20)}$.

Again, for a further range of H they have a lesser effect, this is due to the fact that at the range, an excess of air is obtained and very large air bubbles are observed thus the amount of air supply exceeds the absorbing capacity of the liquid so the orifice characteristics have a lesser effect on $K_{La(20)}$ for the range.

Diffuser No. 1 and 3 differ from No. 2 and 4 by the changed direction of air induced. From Figure 6, compare Diffuser No. 1 and 2 or 3 and 4, it is found that the direction of air induced seems to has a least effect but by theoretically it have some as a result from affecting the ability of redividing air bubbles by hydraulic shear force.

Generally at an angle of 90° orificed, maximum shear force occurs so results in the highest value of $K_{La(20)}$.

The purpose of applying Diffuser No. 1 and 3 to this study is only to observe their ability in preventing any drop of water leaking out and they also serve well. It is also observed that if the direction of air induced is faced more or less upstream, the water will partly leak out.

As shown in Figure 7, only two experiments were carried out with Diffuser No. 6 because it has confirmed the effect of orifice area on $K_{La(20)}$ as already discussed. At higher value of H, more air has to be drawn in at higher velocity because of its small orifice area, thus offers more loss of energy and lesser value of $K_{La(20)}$.

<u>Liquid Depth</u>

The effect of liquid depth on $K_{La(20)}$ will depend in large measure on the method of operation. Eckenfelder (1966) stated that, for the most types of bubble diffusion system K_{La} will vary with depth (D) according to the relationship

$$\frac{K_{La(D_1)}}{K_{La(D_2)}} = \left(\frac{D_1}{D_2}\right)^n$$

where the exponent n has a value near 0.7 for most systems.

It means that $K_{La(20)}$ will increase as the increase in depth while the power consumption of air supply is increased in direct proportion to the liquid depth. (Eckenfelder and Ford, 1968)

According to this research as shown in Figure 9, $K_{La(20)}$ decreases as the increase in depth while the power consumption of water supply is more or less constant, however the decrease in rate of $K_{La(20)}$ decreases as the increase in depth.

Therefore, under economical operation it would be advantageous to apply this aeration unit in a deeper liquid as explained below.

When the volume of water is increased by the increase in depth dimension only, the variation in a quantity unit of Volume by $K_{La(20)}$ per power consumption (as the dimensional unit of Rate of discharge / Energy) can be represent by a unit of Depth by $K_{La(20)}$ per power (as a unit of Velocity / Energy) since the surface area is constant. As shown in Figure 12, it is found that the unit increases as the increase in depth, moreover the increasing rate of the unit increases as the increase in depth also.

Therefore this economical advantage agrees with the above suggestion.

According to Figure 9 and 12, another three sets of experiment were rerun in order to confirm results.

Rate of liquid discharge

To this study, the decrease in the rate of discharge will decrease $K_{La(20)}$ as a result of:-

a) Decreasing the degree of turbulent mixing.

b) Decreasing the rate of reoxygenating and

c) Decreasing the ability of redividing air bubbles by the hydraulic shear force.

The rate of discharge will decrease as the increase in elevation head as shwon in Figure B.

The causes of variation in the rate of discharge are already stated in Chapter III.

Power consumption

As shown in Apendix C, a little bit variation in power consumption is observed. It is resulted from thevariation in the voltage of electrical power supply and on the operational conditions of experiment.

Theoretically, increasing the voltage or the elevation head will increase the power consumption.

As shown in Figure 10, $K_{La(20)}$ per unit power plotted against elevation head, it is rather difficult to identify which diffuser that will offer the most economical operation because of incompleted data obtained as a result from an unexpected condition already discussed. However, by approximately determined on the figure, it seems to show that Diffuser type III offers the best and it is most suitable in practice.

Liquid Temperature

Liquid Temperature has an effect on K_{La} according to the equation shown in Chapter IV. Allthe results were already converted to the standard condition before comparison of the study.