# EFFECT OF PROPELLER DISTANCE ON DILUTION OF SINGLE PORT SUBMERGED DIFFUSER

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**ABSTRACT**

Thermal pollution raises the water source temperature and thus cause a change in physical, chemical and biochemical properties of water. It has a major impact on the aquatic life and disturb the environment. A model with 18m long and 2m was constructed to study Effect of The distance between the propeller and diffuser outlet on dilution. Experimental test was carried on for three different Reynolds number Ratios Rer (0.38, 0.2, and 0.13). It was found that increasing propeller distance from (L= 0.1) to (L= 0.5), the plume center temperature ratios were changed by 3.1%, 2.74%, 0%, temperature ratios at the end of measurements were increased by 43.4%, 73.33%, 61.11%. Temperature difference distribution through the model was increased. Increasing distance of propeller clogging single port submerged diffuser reduce dilution of temperature.

**Keywords:** thermal pollution, propeller, dilution, clogging, single port submerged diffuser, temperature distribution.

## 1. INTRODUCTION

Many industries use a cooling systems, which use water as a cooling fluid, like thermal power stations, textile manufacturing. Most of these industries use once through cooling system, which cause thermal pollution. Thermal pollution raises the water source temperature and thus cause a change in physical, chemical and biochemical properties of water. It affect the aquatic life and disturb the environment, there are some limitations for designing cooling system (amount of water, temperature difference between inlet and outlet) Which increase cost of cooling system.

Single port submerged diffuser is in between the surface discharge and the multi-port submerged diffuser In comparison with cost and dilution. George and Panayotis [6], studied dilution of water discharged from round vertical jet blocked by a thin concentric disc in salted water, the results showed that blocking the outlet of round single port submerged diffuser with a disc increase dilution rate in the region behind the disc compared to the unblocked one. Lilun and Lee [8], studied mixing process of jet blocked with pierced disc, the results showed that using jet obstructed by pierced disc increase dilution rate of injected fluid. Wen-xin, *et al.* [12, 13], studied behaviour of flow field the buoyant jet from a square diffuser blocked with a square disc discharge in static ambient.

Dilution of single port submerged diffuser was found to be increased when free rotating propeller clogging outlet of diffuser discharging hot water in cold ambient. The purpose of this study was to investigate the effect of changing the distance of free rotating propeller clogging outlet of single port submerged diffuser discharging hot water in cold ambient on dilution of thermal plume experimentally.

## 2. EXPERIMENTAL MODEL

Experimental model was built in hydraulic research institute in order to study the effect of changing the distance between free rotating propeller and outlet of diffuser discharging hot water in cold ambient.

Experimental model consist of three parts entrance, main body and exit. Model entrance consists of a receiving tank (3 m long, 0.5 m wide, 1.5m height), to dissipate energy of water, a weir with high of (0.4 m) and with wide (2 m), and screen box field with large stones, all of these components are used to make sure to dissipate energy at the inlet, excessive turbulence and to avoid any disturbance in the flow. Main body; model bed made from concrete and it is (18 m) long and (2 m) wide, model exit; model exit consists of a revolving tail gate used to control water level in model manually by adjusting the height of the gate.

In order to perform test, two pumps were used to deliver water to the model; main pump used to deliver cold water to the model, it has the flowing specification (Discharge (Q) = 0.07 m3/s, Head (h) =10 m.), electromagnetic flow meter was used to measure cold water flow rate. Second pump used to deliver cold water to the electric water heater and then pumped to the model, it has the flowing specification (Discharge (Q) = 0.012 m3/s, Head (h) = 12 m). Ultrasonic flow meter was used to measure hot water flow rate, it is inserted on two-inch pipe, which deliver hot water to the model. Electric water heater was used as source for hot water. Temperature of water is controlled by electric switches and thermostat. Figure-1 shows single port submerged diffuser clogged with propeller.

Flow similarity [5], Reynolds number (Re) model ≥ 2000, and this mean that internal friction force can be neglected so that the gravity force is the dominant, and that can be expressed by Froude number, for the flow in model Fr<1. Thus similarity between open channel flow and rigid boundaries model is attained.

## 3. EXPERIMENTAL PROCEDURE

Experimental work was accomplished in order to investigate the effect of changing the distance of free

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rotating propeller clogging outlet of single port submerged diffuser discharging hot water in cold ambient.

Free rotating propeller was placed at the outlet of diffuser. diffuser consists of two parts; first part was a horizontal pipe with (0.25 m long and 0.05m diameter ), the second part was (0.25 m long and 0.05m diameter ) and inclined with angle of ($30^{\circ}$) with horizontal direction and ($20^{\circ}$) with vertical direction.

Distance between the Propeller and Diffuser outlet was changed from ($L = \frac{l}{d_{pipe}}$) (0.1 to 0.5). Water depth above diffuser was one time pipe diameter, difference between the cold water and hot water discharged was ($\Delta T = 10$ ℃). Three Reynolds number ratios ($Re_r$) between cold water flow and hot water flow were considered (0.38, 0.2, and 0.13).

Temperature distribution at the Surface was measured across the model using thermistors after steady state conditions had been reached. Hot water temperature and cold water temperature were continuously measured, and adjusted as necessary. Temperature distribution was measured upstream and downstream from single port submerged. Temperature readings were taken at the selected positions for each experiment. At each run, data acquisition was set to measure temperature three times at each position, each time scanned in two minutes. Figure-2 shows model schematic diagram.

**Figure-1.** Single port submerged diffuser clogged with propeller.

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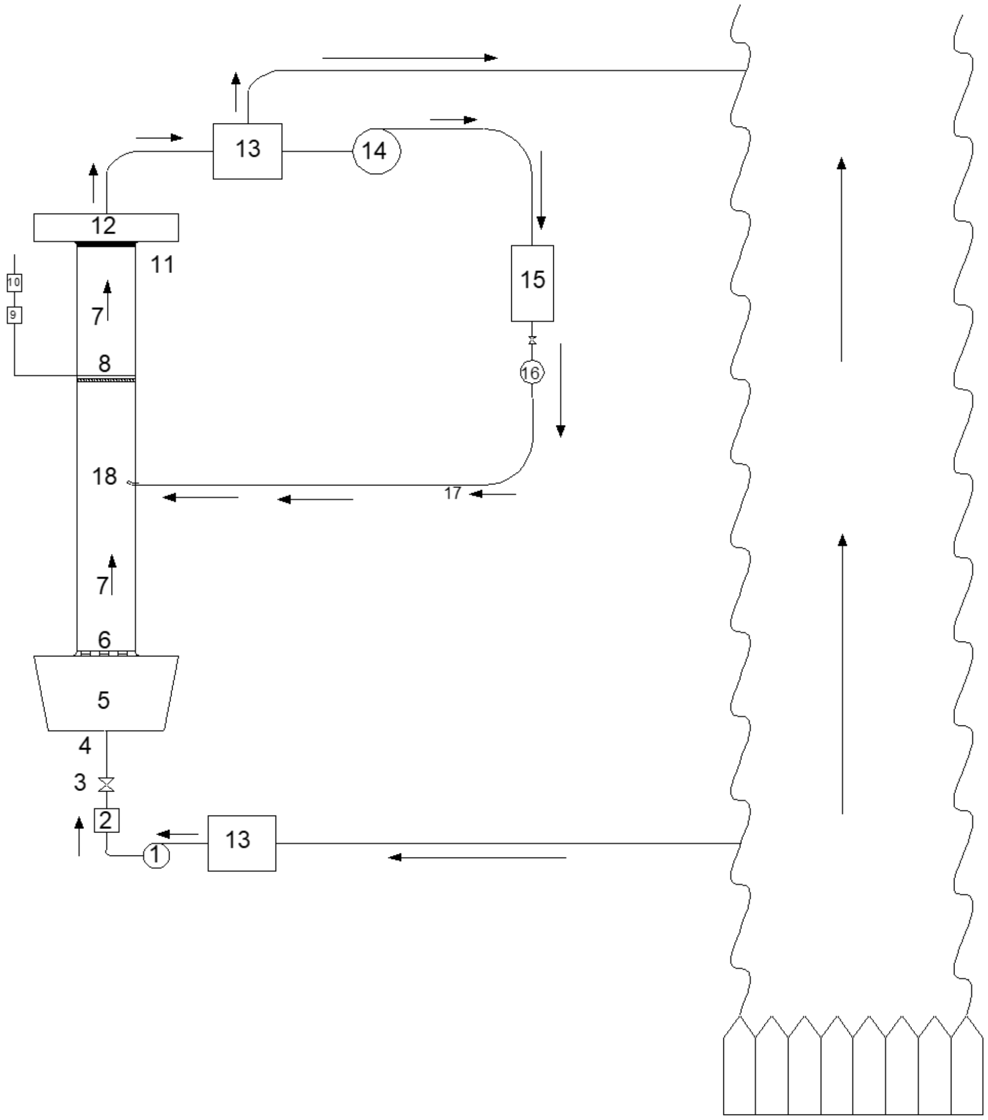

1 Cold water Centrifugal pump
2 Electromagnetic flow meter
3 Gate Valve
4 Inlet ambient cold water pipe
5 Model entrance
6 Screen Box
7 Model
8 Measuring thermistors carriage
9 Scaling units
10 Data logger
11 Revolving tail gate
12 Model exit
13 pumps intake well
14 Hot water centrifugal pump
15 Electric water heater
16 Ultra sonic flow metere
17 Diffuser feed line(5cm diameter)
18 Single port Submerged Diffuser

**Figure-2.** Model schematic diagram.

## 4. RESULT AND DISCUSSIONS

Placing propeller at (L = 0.1), Temperature distribution was measured at water surface for $Re_r$ (0.38, 0.2, and 0.13). Temperature difference was plotted in upstream and downstream of diffuser as ($\Delta T_f/\Delta T$), in longitudinal direction and transverse direction. Figure-3 Shows Temperature distribution at surface for different $Re_r$ (A at $Re_r$ = 0.38, B at $Re_r$ = 0.2, C at $Re_r$ = 0.13).

When adding propeller at (L=0.1), the plume center temperature ratios were 0.65, 0.73 and 0.81 respectively corresponding to Reynolds number ratios. Average temperature ratios at the end of measurements

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were 0.106, 0.15, and 0.18. Table-1 shows the Plume center Temperature ratio, average temperature ratio at the end of measurements.

**Table-1.** Plume center temperature ratio, average temperature ratio at the end of measurements.

| Reynolds number ratios | Plume center Temperature ratio | average temperature ratio at the end of measurements |
|---|---|---|
| 0.38 | 0.65 | 0.106 |
| 0.2 | 0.73 | 0.15 |
| 0.13 | 0.81 | 0.18 |

Placing propeller at (L = 0.5), Temperature distribution was measured at water surface for $Re_r$ (0.38, 0.2, and 0.13). Temperature difference was plotted in upstream and downstream of single port submerged diffuser as ($\Delta T_f / \Delta T$), in longitudinal direction and transverse direction. Figure-4 Shows Temperature distribution at surface for $Re_r$ (A at $Re_r$ = 0.38, B at $Re_r$ = 0.2, C at $Re_r$ = 0.13).

Adding propeller at (L=0.5) the plume center Temperature ratios were 0.67, 0.75 and 0.81 respectively with flow discharge ratio, increase the distance of propeller reduce Plume center Temperature. Table-2 Shows the Plume center Temperature ratio, average temperature ratio at the end of measurements for (L= 0.5). Figure-5 Shows Plume center temperature dilution (L=0.1). Figure-6 Shows Plume center Temperature dilution (L=0.5). Figure-7 Shows a comparison of Plume center Temperature for (L= 0.1, 0.5).

**Table-2.** Plume center temperature ratio, average temperature ratio at the end of measurements for (L= 0.5).

| Reynolds number ratios | Plume center Temperature ratio | average temperature ratio at the end of measurements |
|---|---|---|
| 0.38 | 0.67 | 0.152 |
| 0.2 | 0.75 | 0.26 |
| 0.13 | 0.81 | 0.29 |

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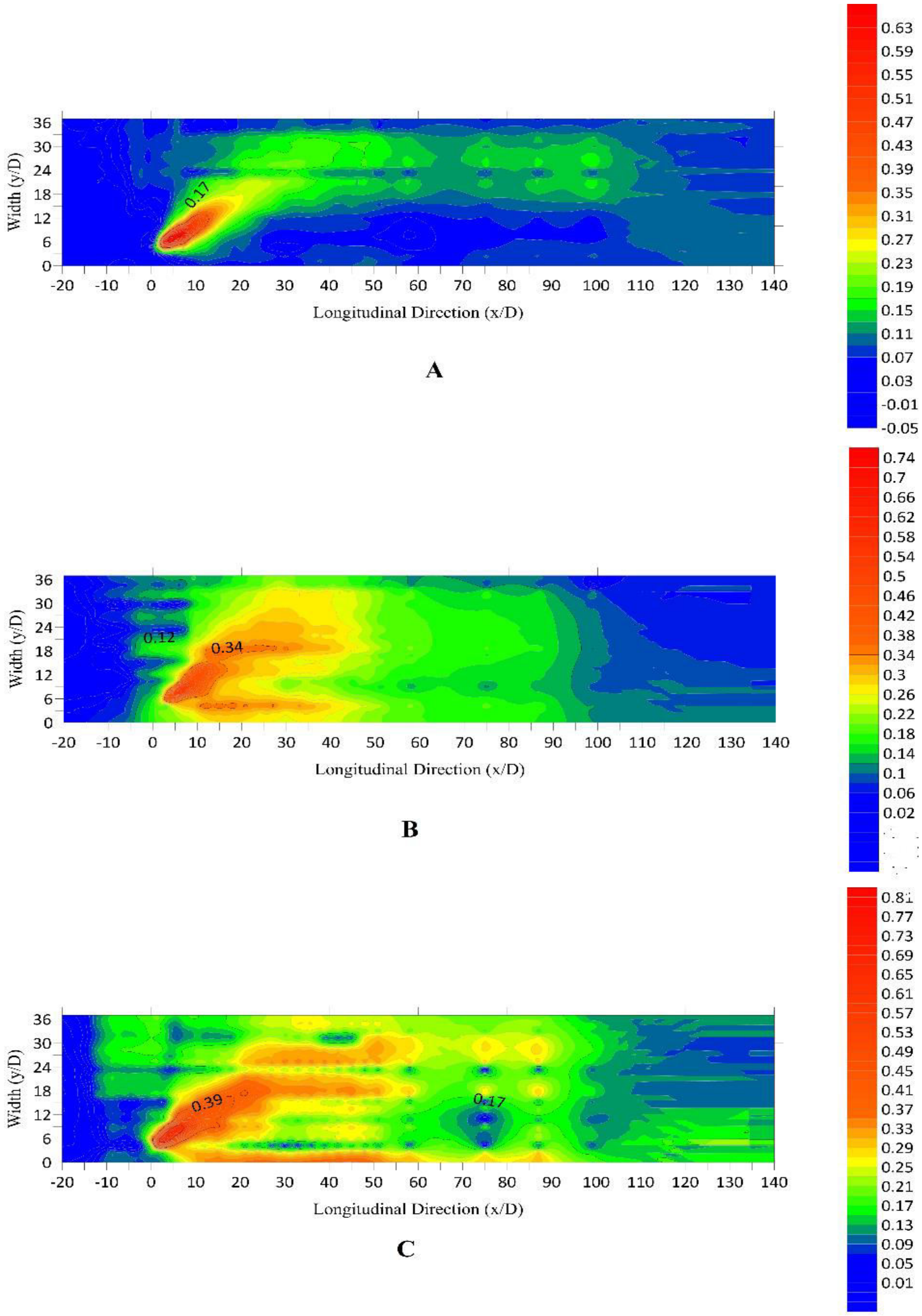


**Figure-3.** Temperature distribution at surface for at (L=0.1) for $Re_r$ (A at $Re_r = 0.38$, B at $Re_r = 0.2$, C at $Re_r = 0.13$).

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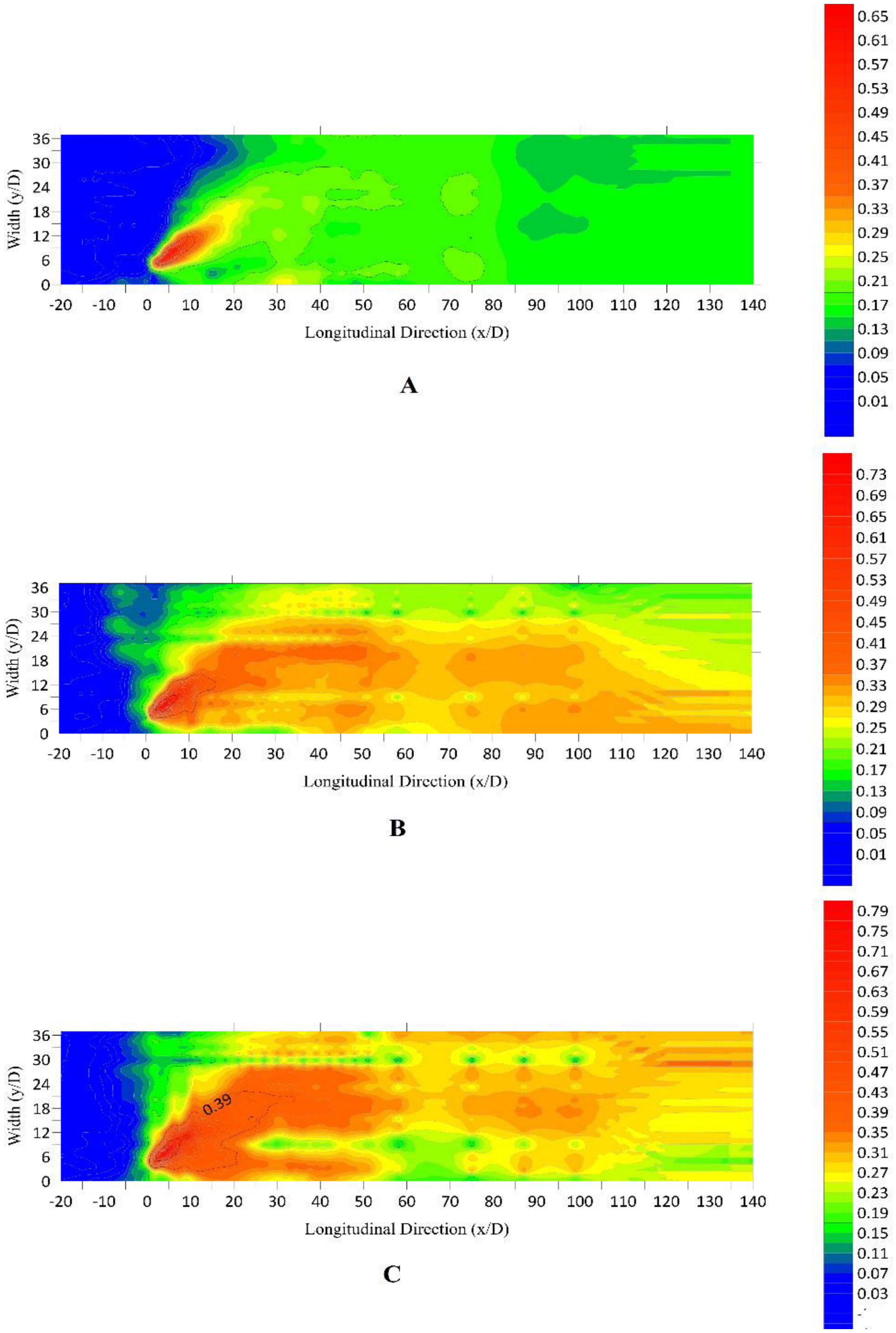


**Figure-4.** Temperature distribution at surface for different for $Re_r$ (A at $Re_r = 0.38$, B at $Re_r = 0.2$, C at $Re_r = 0.13$).

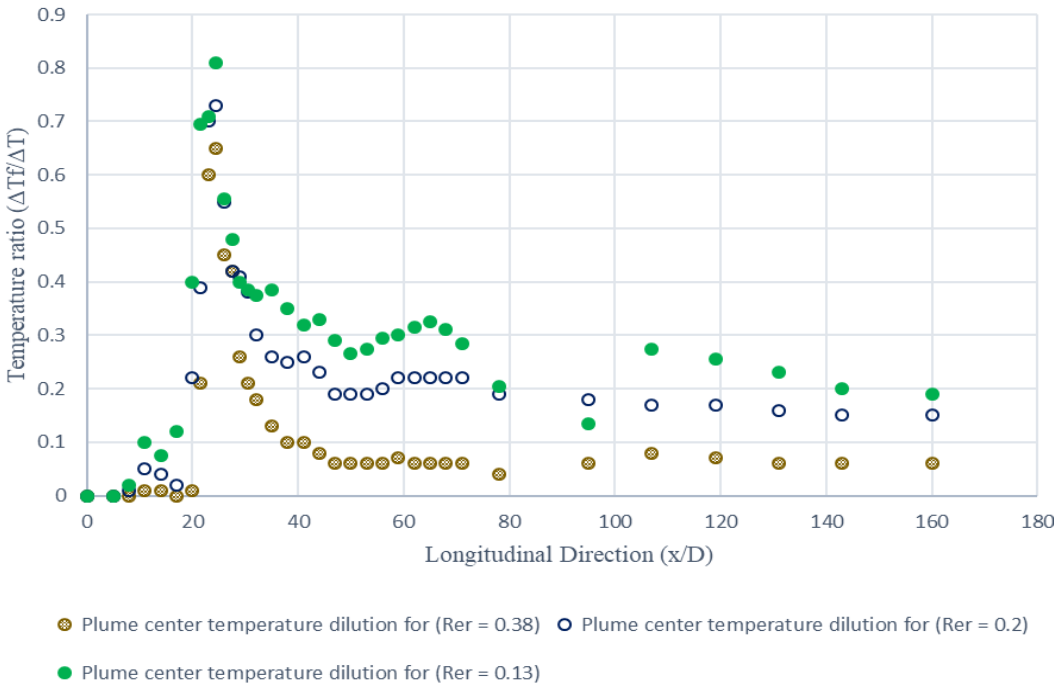


**Figure-5.** Plume center temperature dilution for (L=0.1).

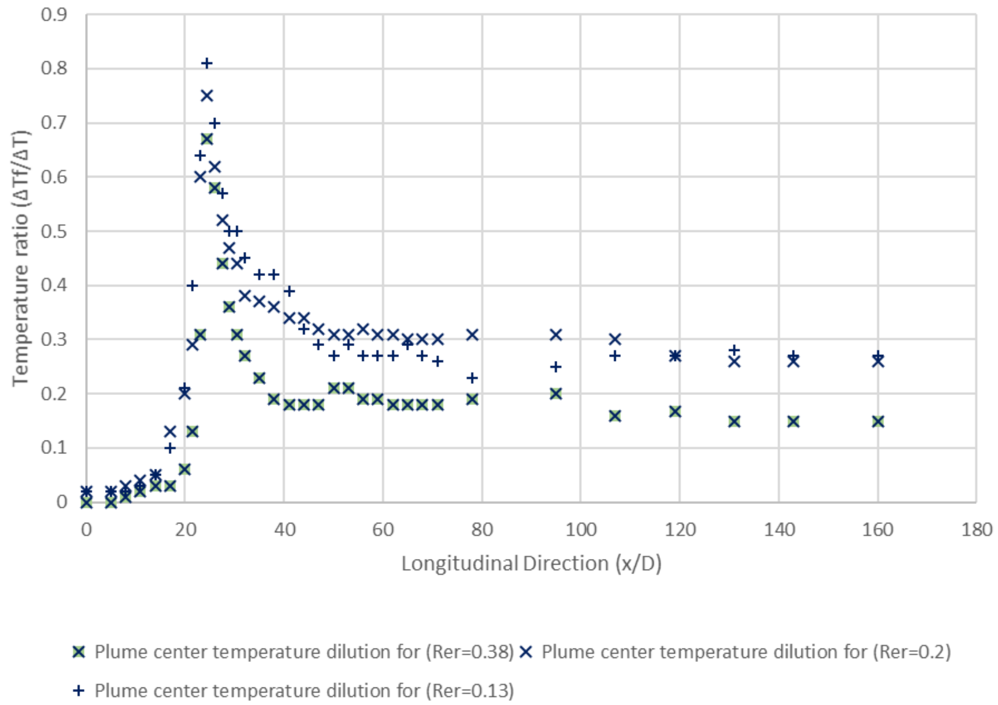


**Figure-6.** Plume center Temperature dilution (L=0.5).

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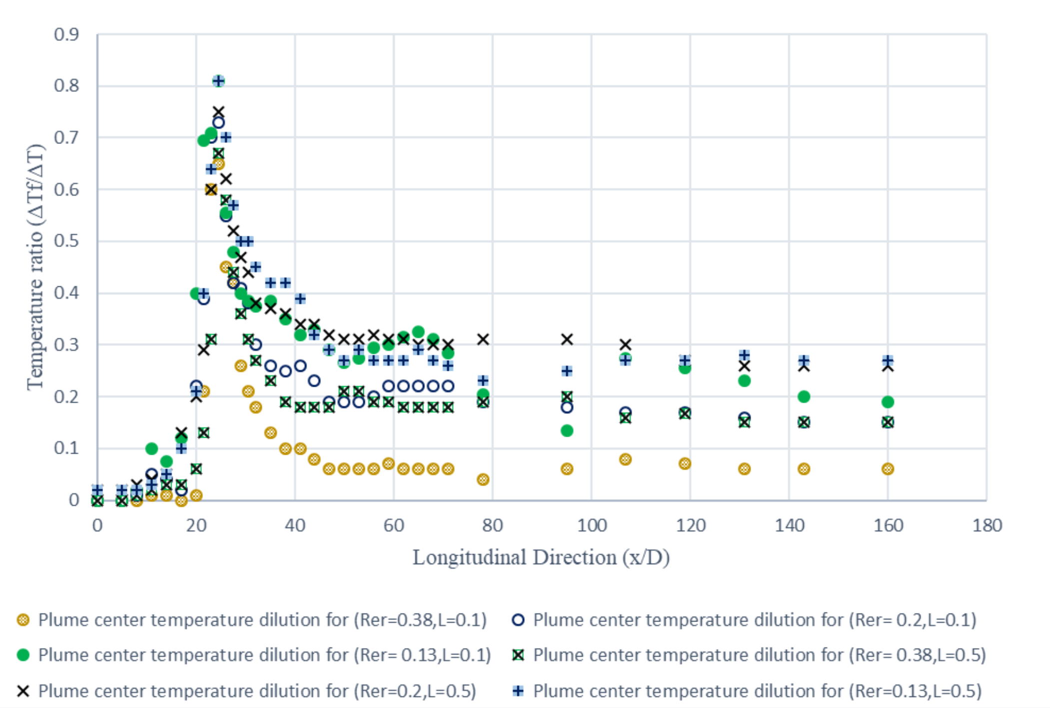


**Figure-7.** Comparison for plume center temperature dilution for (L= 0.1, 0.5).

When increasing propeller distance from (L= 0.1) to (L= 0.5), cause the plume center Temperature ratios to change by 3.1%, 2.74%, 0%, and temperature ratios at the end of measurements were increased by 43.4%, 73.33%, 61.11%. Increasing propeller distance from (L= 0.1) to (L= 0.5) cause Temperature distribution through the model to be increased. Increasing distance of propeller clogging single port submerged diffuser reduce temperature dilution.

## 5. CONCLUSIONS

Increasing propeller distance from (L= 0.1) to (L= 0.5) cause:

- Changed plume center Temperature ratios by 3.1%, 2.74%, 0%,
- Increased Temperature ratios at the end of measurements by 43.4%, 73.33%, 61.11%.
- Increased Temperature distribution through the model
- Reduced dilution of temperature.


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## ABBREVIATION:

$Re_c$: Reynolds number for cold water flow
$Re_h$: Reynolds number for hot water flow
$Re_r$: Ratio between Reynolds number for cold water and hot water flow
$\Delta T$: Difference between hot water temperature and cold water temperature
$\Delta T_f$: Difference between temperature at any point and cold water temperature
Fr: Froude number
l: distance between the exit of diffuser and propeller
L: Ratio between distance of propeller and diffuser diameter.
Plume center temperature: Maximum temperature of plume.
Average temperature ratio: sum of temperatures divided by the number of temperatures.

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