CHAPTER IV

EXPERIMENTAL RESULTS

4.1 Experimental Results on the Effect of Important Parameters

4.1.1 Length to Diameter Ratio (L/D), Reynolds number (Re_d) and Tank Diameter to Inlet Diameter Ratio (D/d)

Experimental data were taken for five different tank sizes with L/D = 0.60, 4.28, 5.00, 7.50, and 10.00. D/d = 4.75, 6.34, 9.53, 11.13, and 15.88. For each tank run, the flow rates were varied from 2.30-8.82 l./min.. Various temperature readings correspond to the times were recorded in Table 9, 10, 11, 12, and 13 of App. I. The experimental values of dimensionless time and dimensionless temperature were calculated and tabulated in Table 16, 17, 18, 19, and 20 of App. II. The extraction effeciency values for ε_{90} and ε_{50} were computed directly from Figs. 17, 18, 19, 20, and 21, and summarized in Table 3 and 4. The effect of L/D on the extraction efficiency (ε_{90} and ε_{50}) is shown in Figs. 6 and 7, the effect of the Reynolds number is shown in Figs. 8 and 9, and the effect of D/d is shown in Fig. 10.

4.1.2 Experimental Results on the Effect of Inlet-Exit Water Temperature Difference (Gr_D)

In this experiment, the tank size (L/D) = 7.50 and Re_d = 4,916 were arbitrary chosen. The inlet-exit water temperature differences

Table 3

Effect of L/D Ratio on Extraction Efficiency at Various Reynolds number

$\frac{L}{D}$	ε_{90} (%)				ε_{50} (%)			
	Re_d 3215	Re_d 6221	Re_d 8993	Re_d 12325	Re_d 3215	Re_d 6221	Re_d 8993	Re_d 12325
0.60	40.50	38.80	37.50	35.38	50.42	49.70	42.37	45.72
4.28	76.85	75.17	70.30	66.78	80.27	80.44	73.25	69.77
5.00	85.70	82.38	78.40	74.53	88.17	86.14	82.38	79.00
7.50	93.56	91.68	81.92	76.40	97.70	95.50	86.20	81.50
10.00	100.09	95.54	90.37	82.90	103.38	97.97	92.06	87.23

Table 4

Effect of D/d Ratio on Extraction Efficiency at Various Reynolds number

$\frac{D}{d}$	ε_{90} (%)				ε_{50} (%)			
	Re_d 3215	Re_d 6221	Re_d 8993	Re_d 12325	Re_d 3215	Re_d 6221	Re_d 8993	Re_d 12325
4.75	100.09	95.54	90.37	82.90	103.38	97.97	92.06	87.23
6.34	93.56	91.68	81.92	76.40	97.70	95.50	86.20	81.50
9.53	85.70	82.38	78.40	74.53	88.17	86.14	82.38	79.00
11.13	76.85	75.17	70.30	66.78	80.27	80.44	73.25	69.77
15.88	40.50	38.80	37.50	35.38	50.42	49.70	48.37	45.72

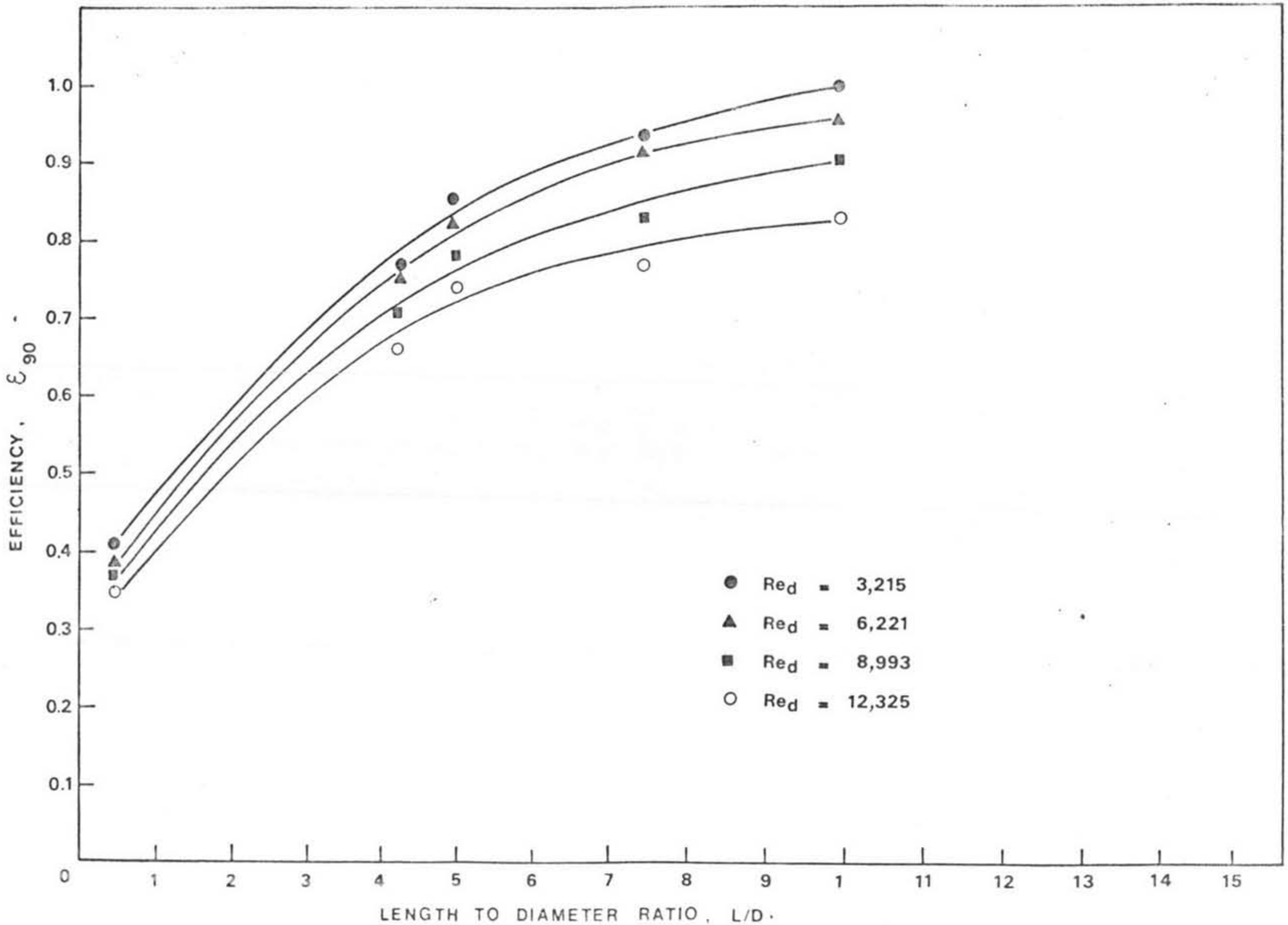

Figure 6 Effect of length to diameter ratio on extraction efficiency

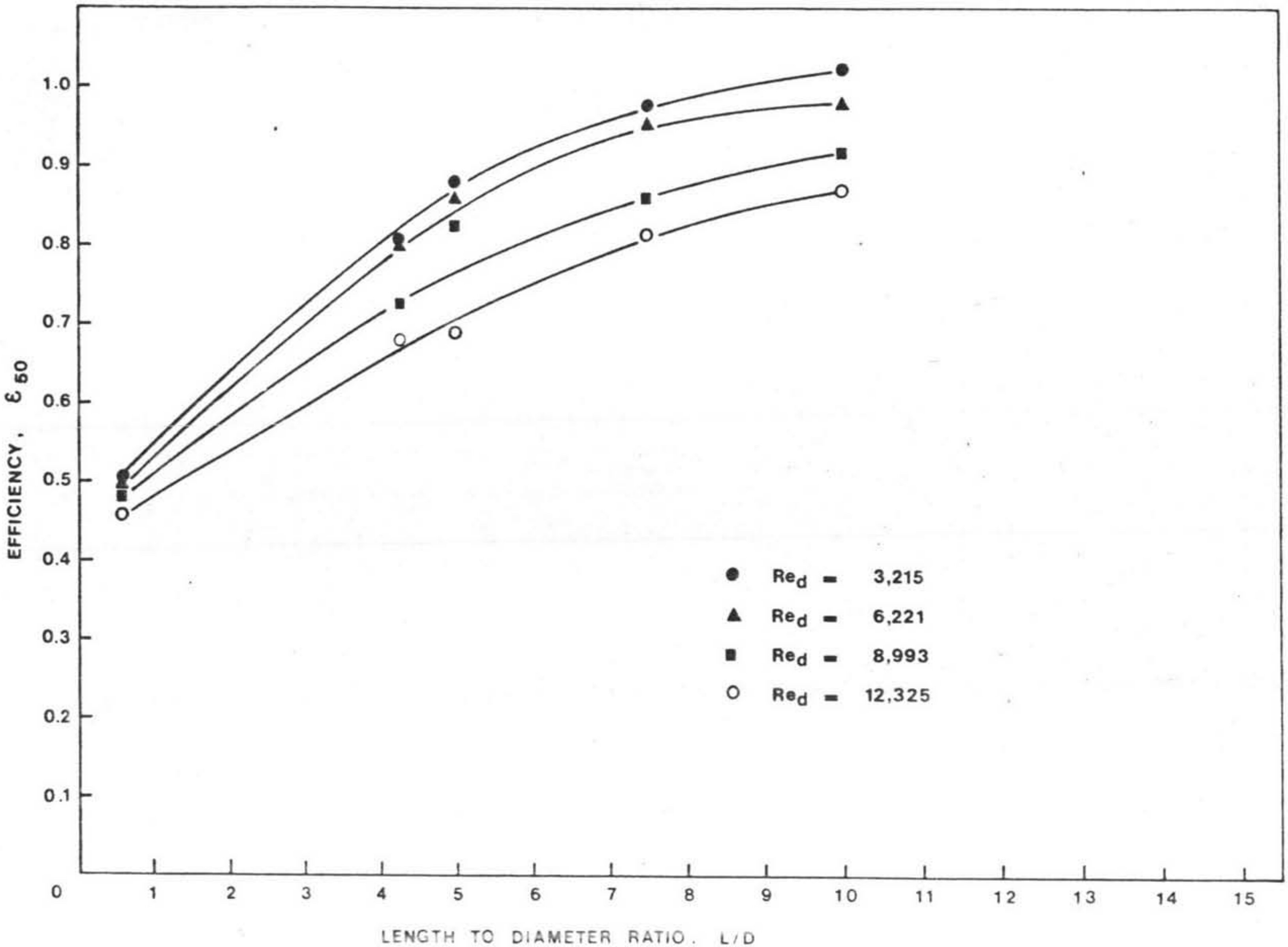

Figure 7 Effect of length to diameter ratio on extraction efficiency

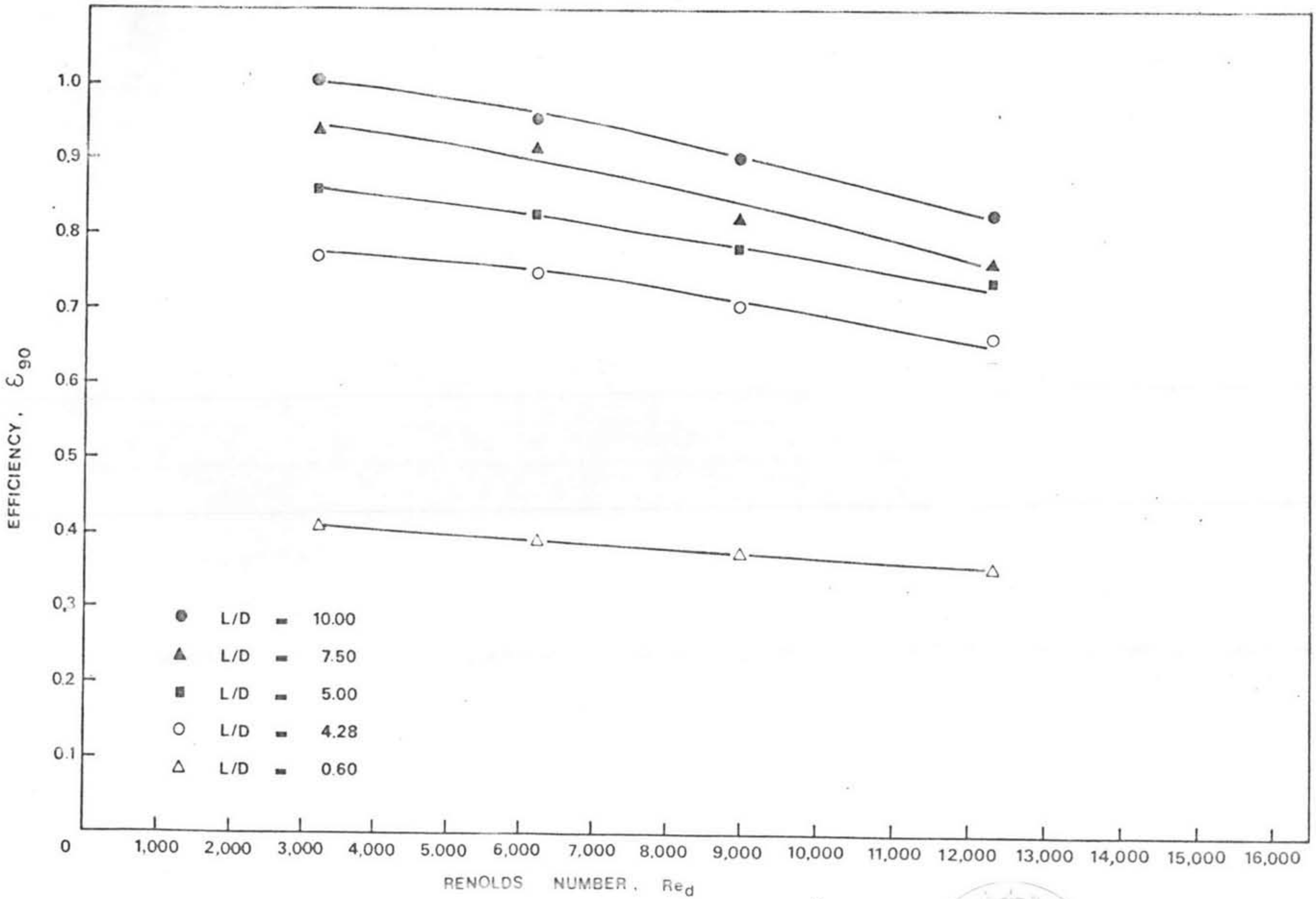

Figure 8 Effect of Reynolds number on extraction efficiency

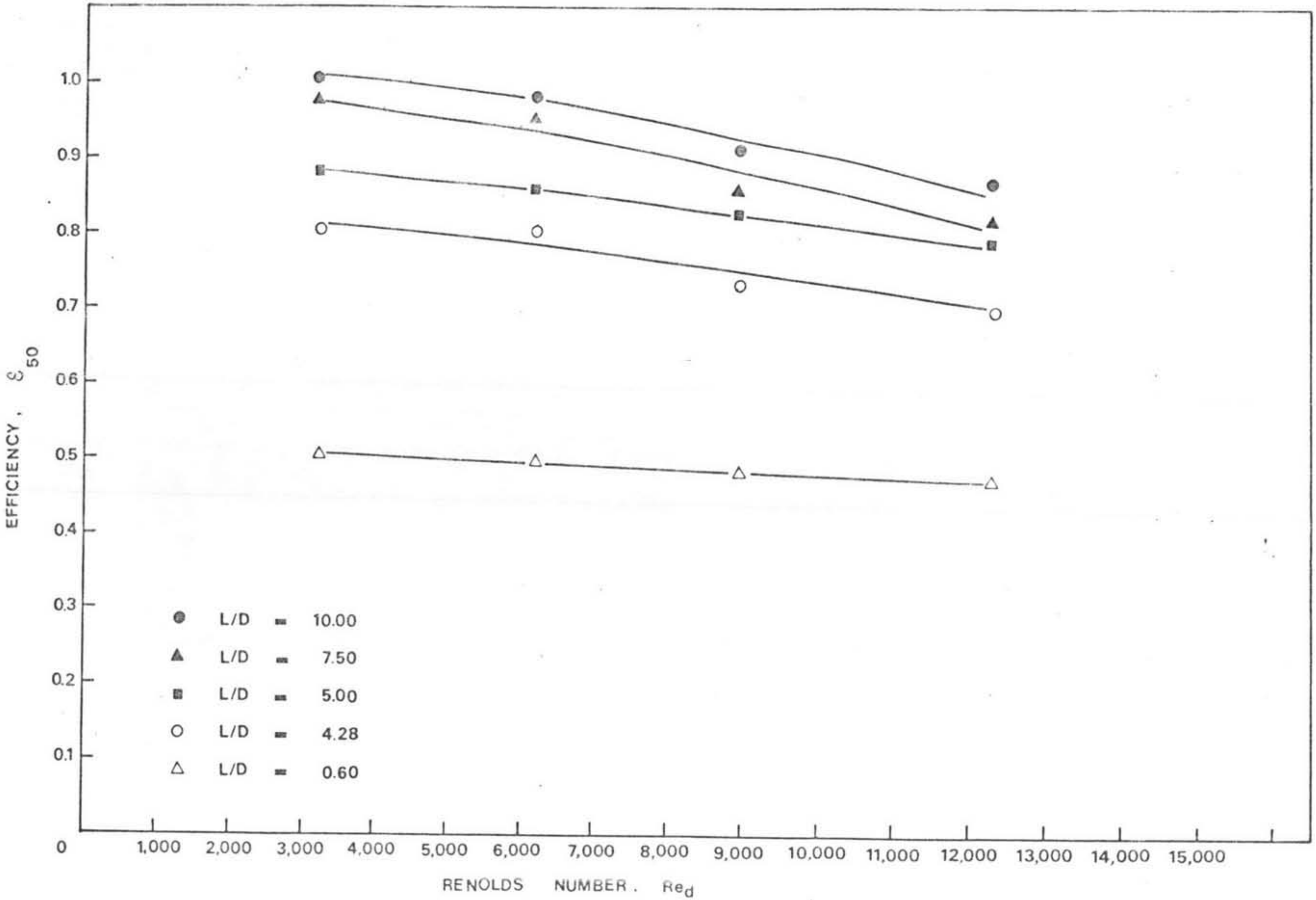

Figure 9 Effect of Reynolds number on extraction efficiency

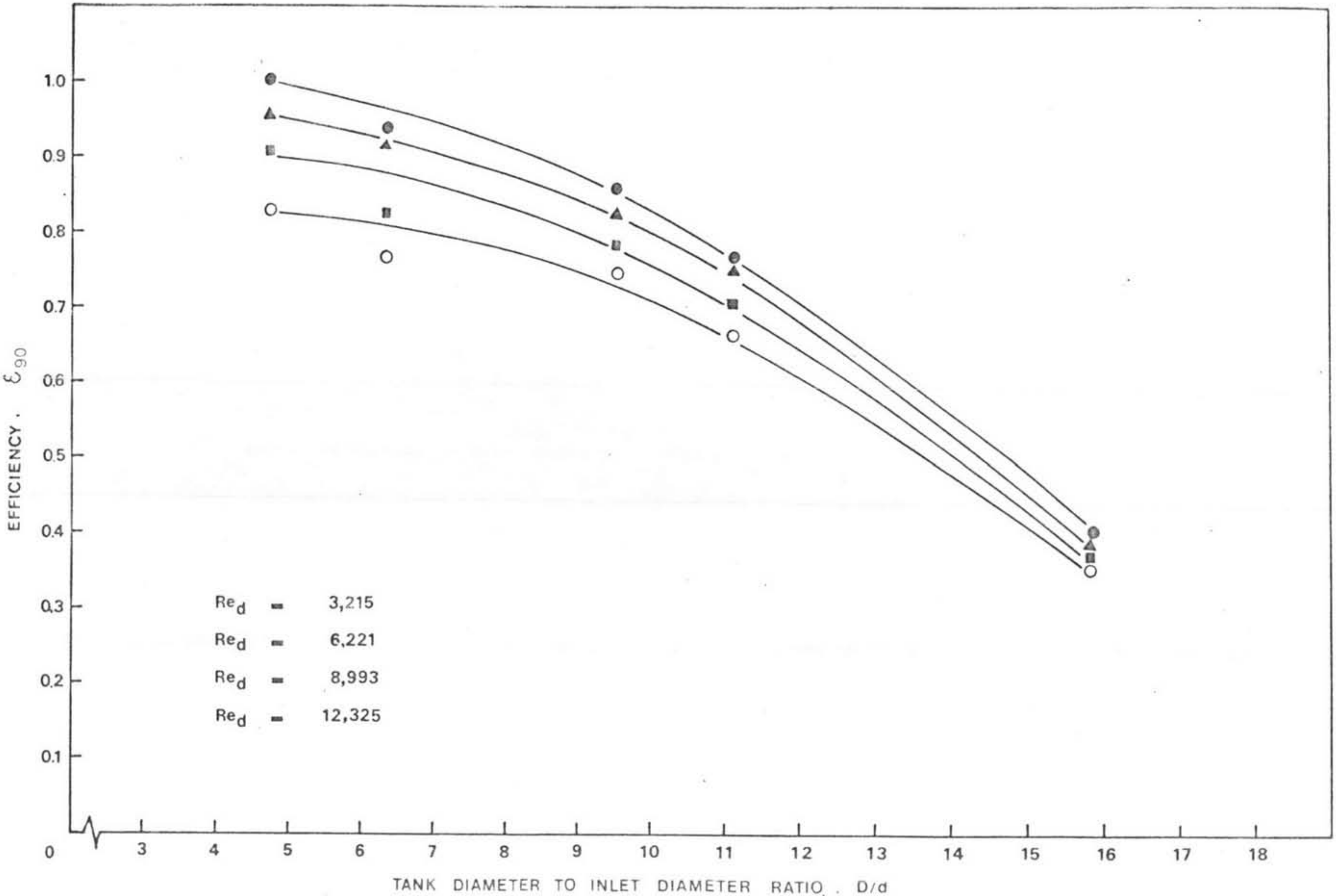

Figure 10 Effect of tank diameter to inlet diameter ratio on extraction efficiency

were taken to be 26, 33, 45, and 59 °C. The experimental data were recorded in Table 14 of App. I. The experimental results are shown in Tables 21, and graphically shown in Fig. 22. App. II. The efficiency at various ΔT was integrated directly from Fig. 22 and tabulated in Table 5. Fig. 11 shows how the inlet-exit water temperature difference will affect the efficiency of the storage tank.

4.2 Experimental Results on the Effect of Water Inlet Location

The tank size (L/D) = 5.00 was arbitrary selected for this experiment. Various flow rates of the water inlet were set at 2.30, 4.45, 6.43, and 8.82 l./min.. The experimental data were recorded in Table 15. App. I. Dimensionless time and dimensionless temperatures were calculated and tabulated in Table 22. Fig 12 shows the result of these tabulated values. The extraction efficiency in the experiment is calculated to be only 11 % and is independent of the flow rates. Velocity of fluid particles when buoyancy effects are assumed to be predominant are calculated according to Eq. 34. for various temperature differences and are tabulated in Table 6.

4.3 Experimental Results on the Effect of Heat Conduction through the Tank Wall

The tank size (L/D) = 7.50 was used for this experiment with a sheet of copper 1.5 mm. thickness lining inside. The inlet water flow rate was varied from 2.3 - 8.82 l./min.. The temperature of the water and the tank wall at η = 0.5 and η = 1.0 were recorded according to time in Tables 23, 24, 25, 26 of App. I. The experimental calculation of dimensionless time and dimensionless temperature were also

Table 5

Effect of Grashof number Gr_D on Extraction Efficiency

ΔT °C	D m.	$\frac{g \beta \rho^2}{\mu^2}$ $(1/m^3.°C)$	Gr_D	$\mathcal{E}_{90}$
26	0.667	370×10^6	8.65×10^9	61.70
33	0.667	370×10^6	1.00×10^{10}	72.10
45	0.667	370×10^6	1.24×10^{10}	72.52
59	0.667	370×10^6	1.52×10^{10}	92.26

$$Gr_D = \frac{g \beta \rho^2}{\mu^2} D^3 \Delta T$$

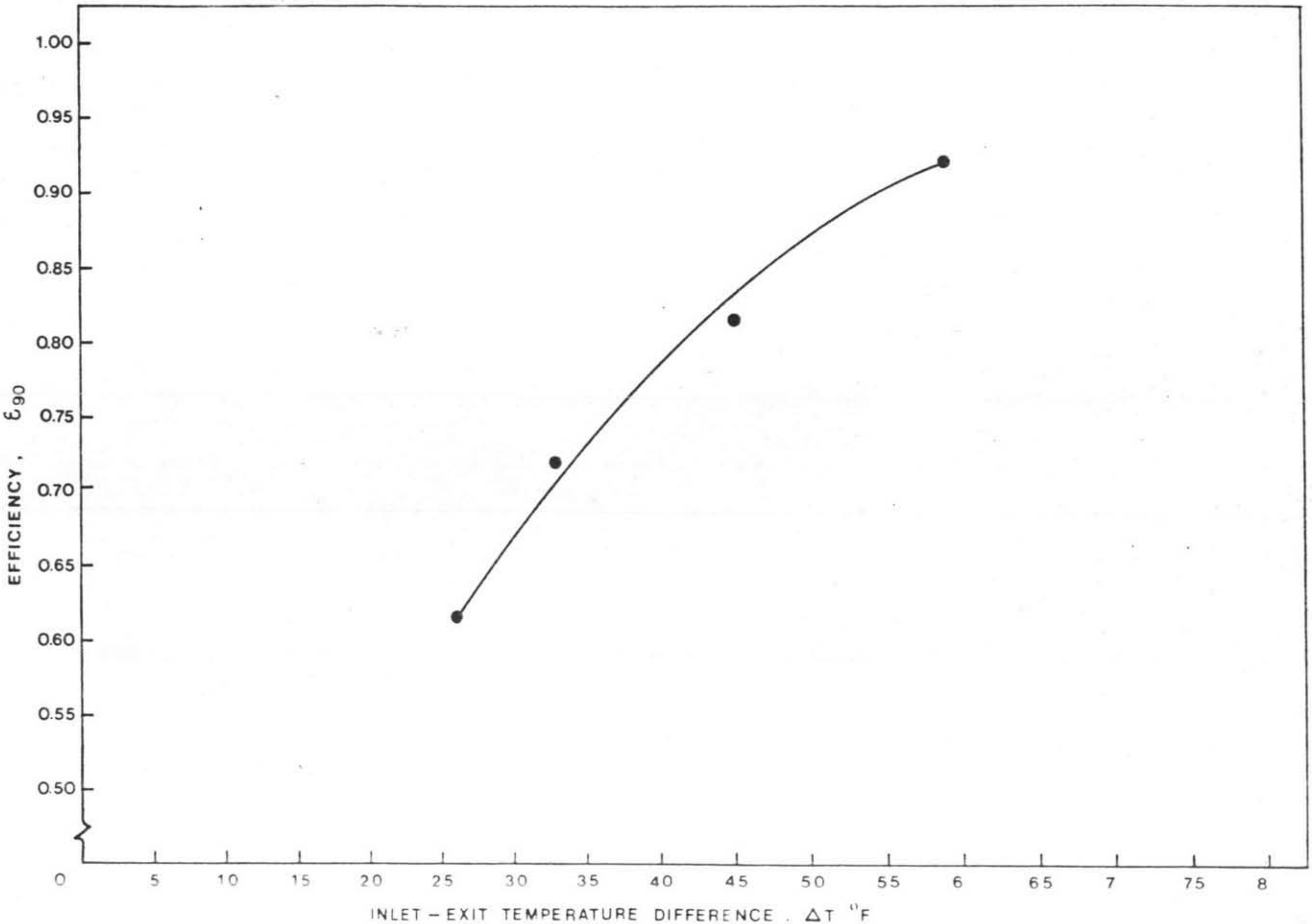

Figure 11 Effect of inlet-exit water temperature difference on extraction efficiency with Re_d = 4,916

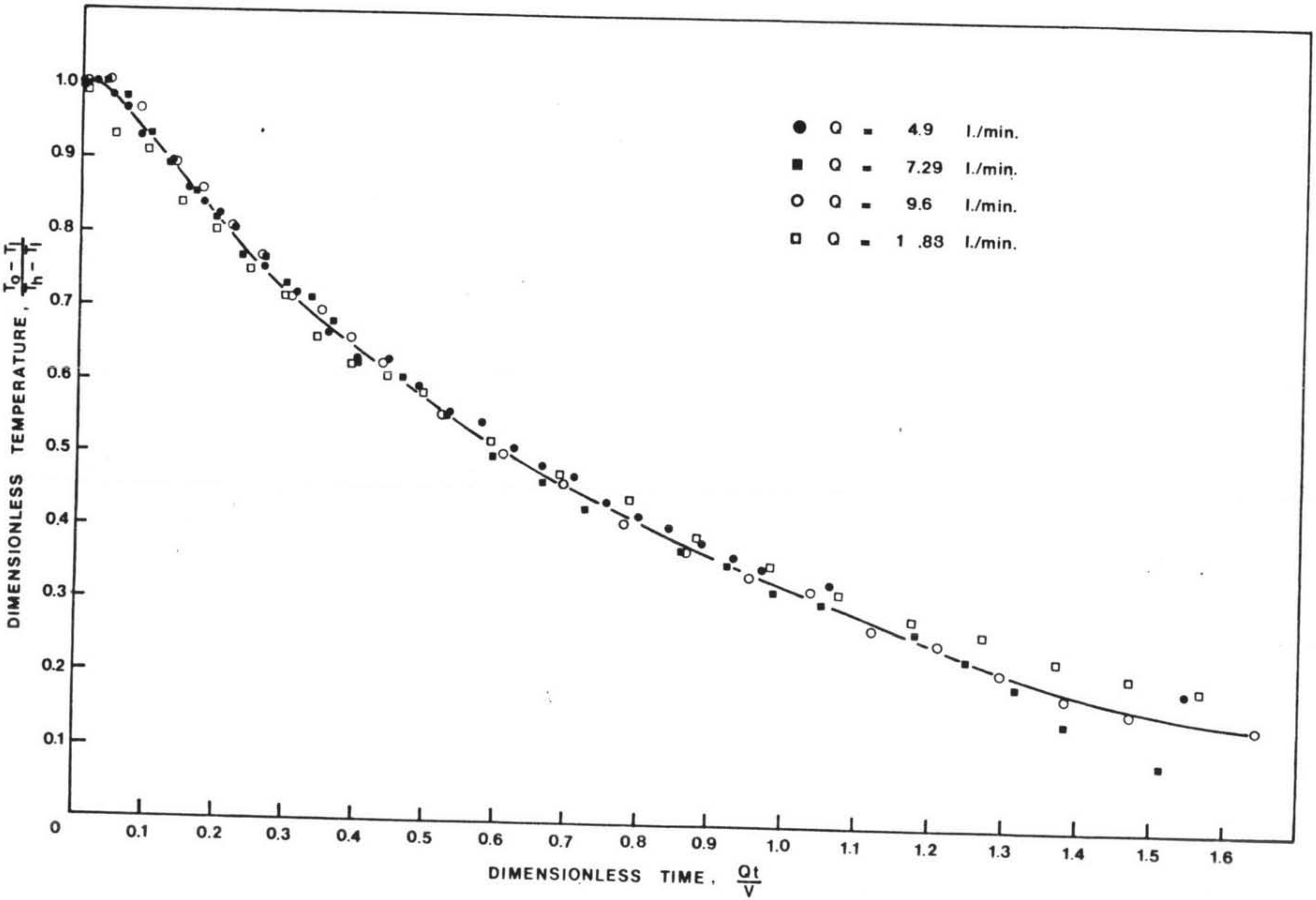

Figure 12 Dimensionless temperature, $\frac{T_o - T_l}{T_h - T_l}$ as a function of dimensionless time, $\frac{Qt}{V}$ at various flow rates entering at the top port with L = 1.524 m., D = 0.305 m.

Table 6

Velocity of Fluid Particles when Buoyancy Effects are Predominant for Various Temperature

T_o °C	T_1 °C	ΔT °C	ρ_o g/cm^3	ρ_1 g/cm^3	t sec	g m/sec^2	v_o m/hr	$v_{buoyancy}$ m/hr
63	37	26	0.9934	0.9816	5.12	9.8	8.31	2146
71	38	33	0.9930	0.9773	4.44			2477
80	36	45	0.9937	0.9718	3.75			2915
94	35	59	0.9941	0.9626	3.13			3499

tabulated in Tables 23, 24, 25, and 26. The theoretical calculations from Eq. 24 were tabulated in Tables 27, 28, 29, and 30, and Eq. 32 in Tables 31, 32, 33, and 34. The comparison of theoretical and experimental output responses are shown in Tables 7.1, 7.2, 7.3, and 7.4. The results were plotted in Figs. 13, 14, 15, and 16.

Table 7.1

Efficiency Comparison between the Theoretical and Experimental Output Responses ($\Gamma = 0.3320$)

θ	Θ_{theo} Eq. 24	Θ_{theo} Eq. 32	Θ_{exp}	ε_{90} Eq. 24	ε_{90} Eq. 32	ε_{90} Exp.
0	1.000	1.000	1.000	79.00	99.68	91.83
0.20	0.994	0.999	1.000			
0.40	0.975	0.998	1.000			
0.60	0.944	0.997	0.990			
0.80	0.903	0.996	0.950			
1.00	0.851	0.995	0.525			
1.01	0.131	0	0.400			
1.03	0.127		0.275			
1.05	0.120		0.205			
1.10	0.107		0.105			
1.20	0.084		0.015			
1.40	0.046		0			
1.60	0.020					
1.80	0.004					
2.00	0					

Table 7.2

Efficiency Comparison between the Theoretical and Experimental Output Responses ($\Gamma = 0.2926$)

θ	Θ_{theo} Eq. 24	Θ_{theo} Eq. 32	Θ_{exp}	$\mathcal{E}_{90}$ Eq. 24	$\mathcal{E}_{90}$ Eq. 32	$\mathcal{E}_{90}$ Exp.
0	1.000	1.000	1.000	82.08	99.71	91.00
0.20	0.994	0.999	0.995			
0.40	0.978	0.998	0.985			
0.60	0.950	0.997	0.975			
0.80	0.913	0.996	0.965			
1.00	0.867	0.995	0.485			
1.01	0.118	0	0.405			
1.03	0.115		0.325			
1.05	0.108		0.275			
1.10	0.097		0.195			
1.20	0.078		0.110			
1.40	0.042		0.045			
1.60	0.018		0.005			
1.80	0.004		0			
2.00	0					

Table 7.3

Efficiency Comparison between the Theoretical and Experimental Output Responses ($\Gamma = 0.2720$)

θ	Θ_{theo} Eq. 24	Θ_{theo} Eq. 32	Θ_{exp}	$\mathcal{E}_{90}$ Eq. 24	$\mathcal{E}_{90}$ Eq. 32	$\mathcal{E}_{90}$ Exp
0	1.000	1.000	1.000	84.83	99.73	80.17
0.20	0.995	0.999	0.995			
0.40	0.979	0.998	0.990			
0.60	0.954	0.997	0.975			
0.80	0.919	0.996	0.930			
1.00	0.876	0.996	0.225			
1.01	0.111	0	0.210			
1.03	0.108		0.190			
1.05	0.102		0.165			
1.10	0.091		0.130			
1.20	0.071		0.080			
1.40	0.039		0.015			
1.60	0.017		0			
1.80	0.004					
2.00	0					

Table 7.4

Efficiency Comparison between the Theoretical and Experimental Output Responses ($\Gamma = 0.2543$)

θ	Θ_{theo} Eq. 24	Θ_{theo} Eq. 32	Θ_{exp}	ε_{90} Eq. 24	ε_{90} Eq. 32	ε_{90} exp.
0	1.000	1.000	1.000	88.85	99.74	66.42
0.20	0.995	0.999	1.000			
0.40	0.980	0.998	1.000			
0.60	0.957	0.997	1.000			
0.80	0.924	0.997	0.765			
1.00	0.883	0.996	0.095			
1.01	0.105	0	0.085			
1.03	0.102		0.075			
1.05	0.097		0.650			
1.10	0.086		0.045			
1.20	0.068		0.025			
1.40	0.037		0.015			
1.60	0.016		0.010			
1.80	0.004		0.010			
2.00	0		0.010			

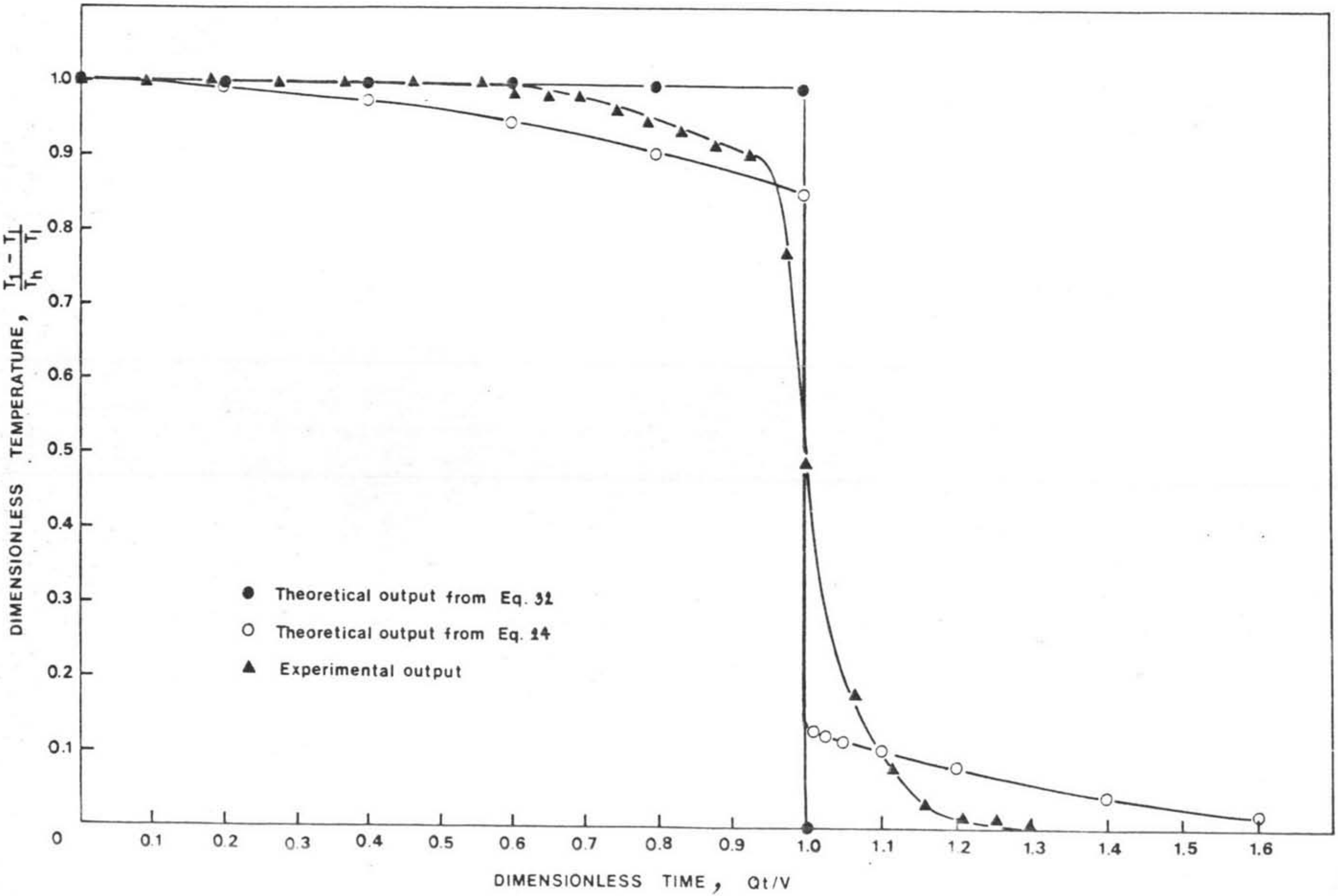

Figure 13 Comparison of theoretical and experimental outputs response (L/D = 7.50 , Re_d = 3.215 , Γ = 0.3320 , η = 1.0)

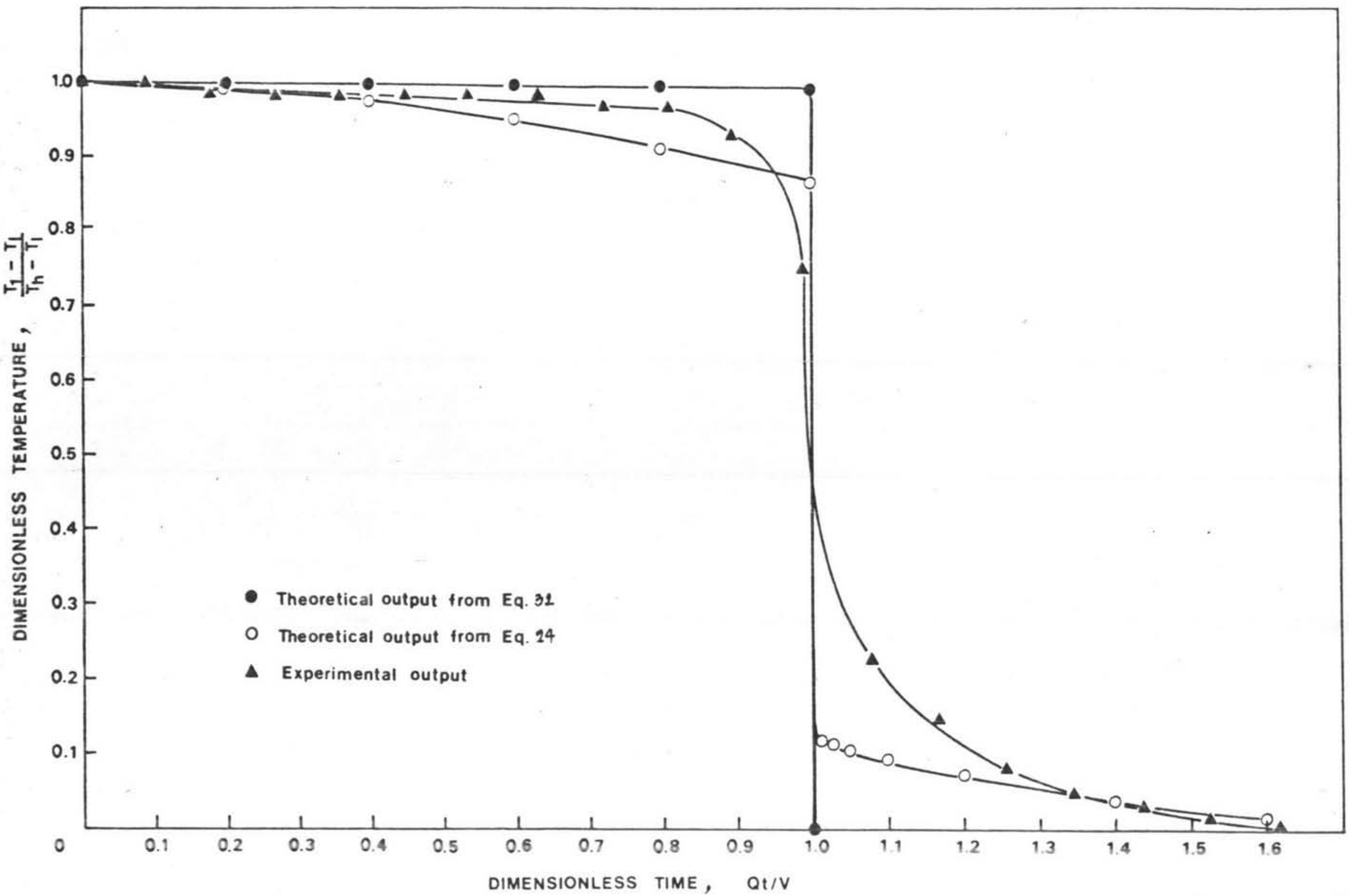

Figure 14 Comparison of theoretical and experimental outputs response ($L/D = 7.50$, $Re_d = 6{,}221$, $\Gamma = 0.2926$ $\eta = 1.0$)

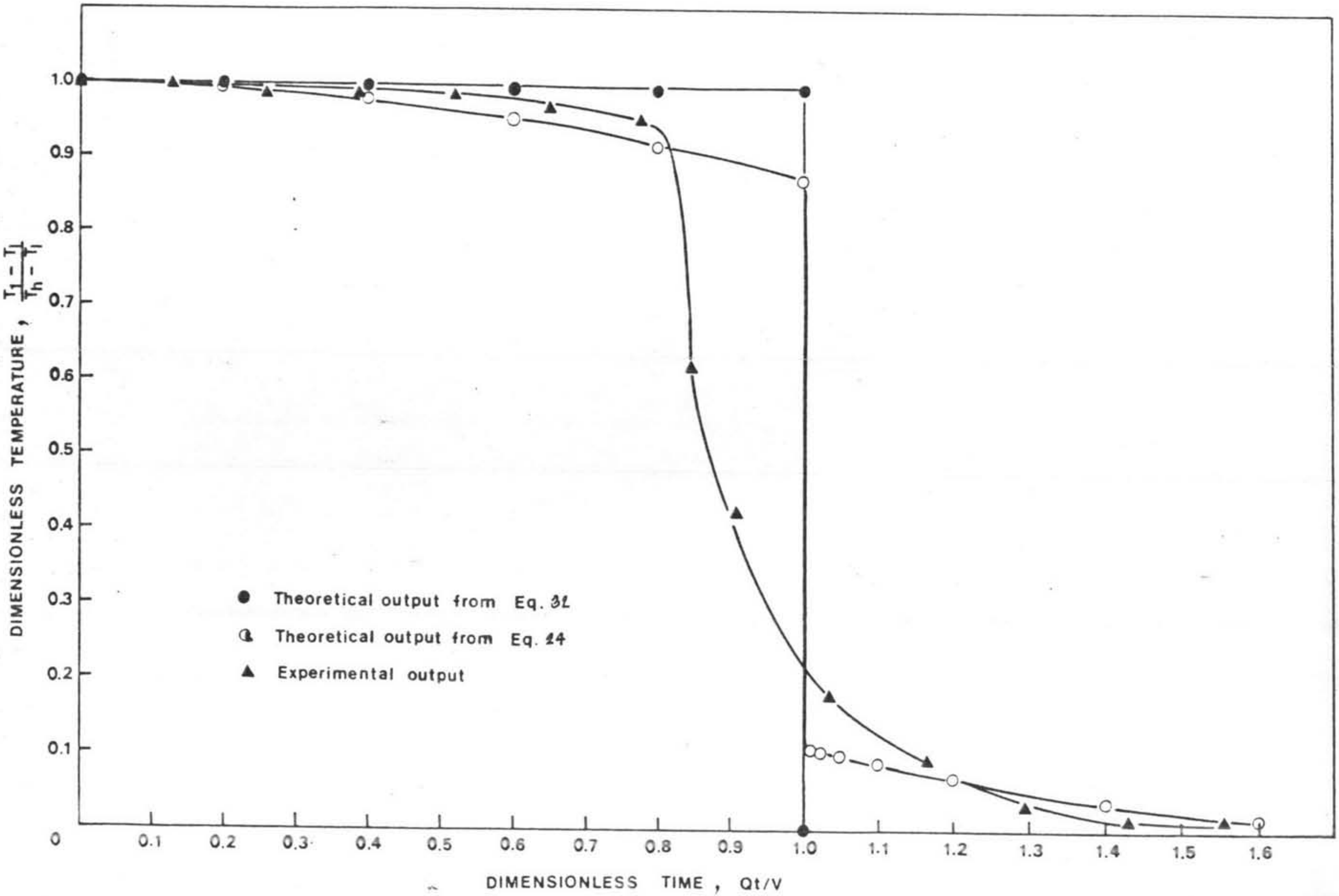

Figure 15 Comparison of theoretical and experimental outputs response ($L/D = 7.50$, $Re_d = 8,993$, $\Gamma = 0.2720$, $\eta = 1.0$)

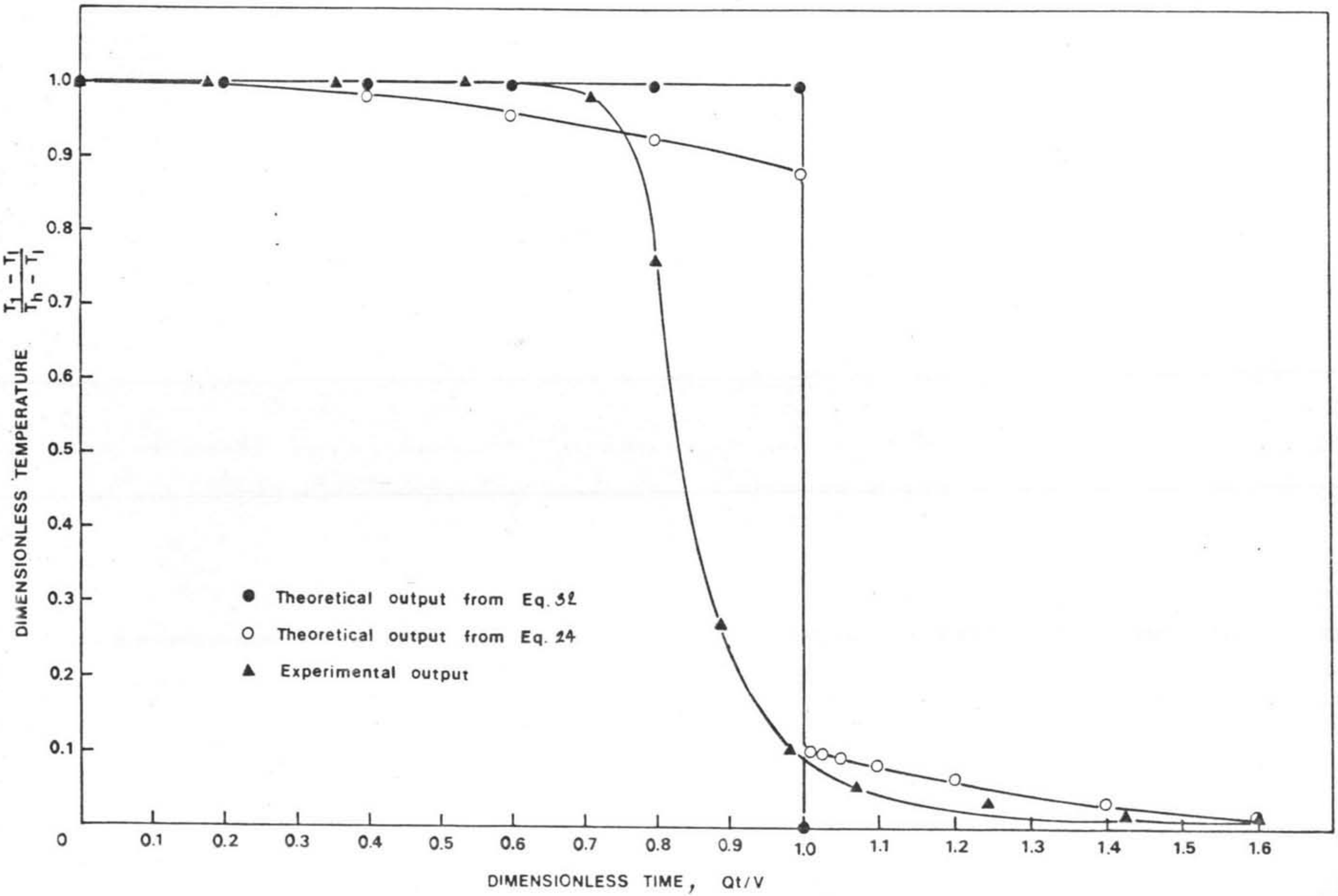

Figure 16 Comparison of theoretical and experimental outputs response ($L/D = 7.50$, $Re_d = 12.325$, $\Gamma = 0.2543$, $\eta = 10$)

Table 8

The Effect of Axial Dispersion for

Various Reynolds rumber

Re_d	3,215	6,221	8,993	12,325
$\frac{D}{v_m L}$	0.0617	0.0982	0.0990	0.1190