ME224 Lab 4

Characteristics of a submerged jet

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Roll Number- 200100094 $\Rightarrow$ $X_1 = 4, X_2 = 9$

Part 1 (Using Sr No = 4)

Given: $z/d = 6$

$h = 287$ mm

$$U = \sqrt{\frac{2\Delta P}{\rho_a}} = \sqrt{\frac{2 \times \rho_w g h}{\rho_a}} = \sqrt{\frac{2 \times 1000 \times 9.81 \times 0.287}{1.2}} = \boxed{68.5 \text{ m/s}}$$

$1/(z/d) = 1/6 = 0.166 = x$

$$U/U_0 = \frac{68.5}{90.866} = 0.7538 = \cancel{x}\, y$$

$xy = 0.125645$

$x^2 = 0.027778$

Part 2

$$X_3 = (10 \times 9 + 4) \bmod 5 = \boxed{4}$$

For 8d:

Given: $r = 3$mm

$h = 109$ mm

$$U = \sqrt{\frac{2 \times 1000 \times 9.81 \times 0.109}{1.2}} = \boxed{49.52272 \text{ m/s}}$$

$U^2 = 2452.5 \text{ m}^2/\text{s}^2$

$r^2 = \cancel{10}\ 9 \times 10^{-6} \text{ m}^2$

For 14d

Given $r = 3\,mm$

$h = 68\,mm$

$$U = \sqrt{\frac{2 S_w g h}{S_a}} = \sqrt{\frac{2 \times 1000 \times 9.81 \times 63 \times 10^{-3}}{1.2}} = 32.094\,m/s$$

$U^2 = 1030.5\,m^2/s^2$

$r^2 = 9 \times 10^{-6}\,m^2$

Calculation of Momentum and Discharge:

For 8d

Q (discharge) $= \pi \times$ (Area under U vs r^2 curve)

$= \pi \times (980.0129149) \times 10^{-6}$

$= \cancel{3078}$ $\boxed{3.0788 \times 10^{-3}\ m^3/s}$

M (momentum) $= \pi \times S_a \times$ (Area under U^2 and r^2 curve)

$= \pi \times 1.2 \times 40507.13 \times 10^{-6}$

$= \boxed{0.1527\ \cancel{Kg/ms}\ Kg\,m/s}$

For 14d

Q (discharge) $= \pi \times$ (Area under ~~U_2 are~~ U vs r^2 curve)

$= \cancel{2362}$ $\boxed{2.362 \times 10^{-3}\ m^3/s}$

M (momentum) $= \pi \times S \times$ Area under U^2 vs r^2 curve

$= \pi \times 1.2 \times 22979.93 \times 10^{-6}$

$=$ ~~[illegible]~~ $\boxed{0.0866\ Kg\,m/s}$

* Sources of error

a) The flow of air may not be perfectly uniform leading to fluctuations.

b) Parallax error while taking readings

c) Ambient atmosphere may affect the flow of the air jet due to disturbances

d) The pitot tube may not be perfectly placed during measurements

* Conclusions

a) As mentioned, the velocity does not degrade much in the core region as we increase the axial direction initially. With larger axial distances, the external fluid is entrained into the flow. This reduces the velocity as mass increases. Momentum is constant which can be observed in the graph U vs Z/d

b) Since we cannot consider the whole velocity profile, we measure a greater momentum at 8d and at 14d for the same cross section. The profile widens with distance and external fluid is also entrained with distance. So discharge should be greater at 14d than at 8d, but again since we consider a constant cross section and not the full profile, we get opposite results.

* Questions and Answers

Q1) Zone 1 (Convergent Zone):

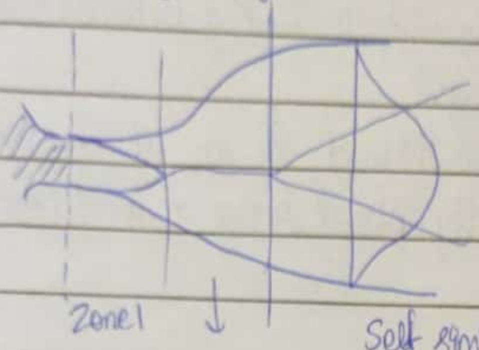
Potential core of the jet where the centerline velocity is equal to the nozzle exit velocity

Zone 2 (Transition Zone):

Region where the centerline velocity starts to decay. The velocity decay can be approximated as proportional to $x^{-0.5}$

Zone 3 (Self similar zone):

In this region, transverse velocity profiles are similar at different values of x and the centerline velocity decay is approximately proportional to x^{-1}



Q2) The standard half angle for submerged jet is 11.8°

Q3) Greater momentum is calculated at 8d as compared to 14d because we have considered only a particular cross section in which 8d profile has a greater velocity. It is only when we consider the full profile of the jet at 8d and 14d that we can measure the momentum to be equal.

Q4) We should get a greater discharge at 14d ~~and at~~ than at 8d as more external fluid is entrained as the jet travels larger distances. But as we don't take the full profile and only a certain, discharge at 8d is larger than at 14d. ~~as~~ This is due to velocity at 8d being greater than 14d for a small radial area.

Scanned with CamScanner

Part 1

Sr. no.	Z/d	h (mm of water)	U (m/s)	1/(Z/d) [X]	U/U0 [Y]	[XY]	[X^2]
1	0	505	90.86666				
2	2	482	88.77331	0.5	0.976962	0.488481	0.25
3	4	393	80.15953	0.25	0.882167	0.220542	0.0625
4	6	287	68.50146	0.166667	0.753868	0.125645	0.027778
5	8	214	59.1515	0.125	0.65097	0.081371	0.015625
6	10	158	50.82617	0.1	0.559349	0.055935	0.01
7	12	109	42.21552	0.083333	0.464588	0.038716	0.006944
8	14	80	36.16628	0.071429	0.398015	0.02843	0.005102
9	16	62	31.83866	0.0625	0.350389	0.021899	0.003906
10	18	49	28.30459	0.055556	0.311496	0.017305	0.003086
11	20	39	25.25173	0.05	0.277899	0.013895	0.0025
Sum				1.464484	5.625702	1.092218	0.387442

Area Calculation

	U vs r^2		U^2 vs r^2	
	57.29668	35.59207	3286.35	1267.125
	157.4469	103.9923	8289.45	3605.175
	229.3456	166.0119	10586.625	5518.125
	261.8538	211.3964	9957.15	6409.2
	274.07	235.0185	8387.55	6180.3
Sum	**980.0129**	**752.0112**	**40507.125**	**22979.925**

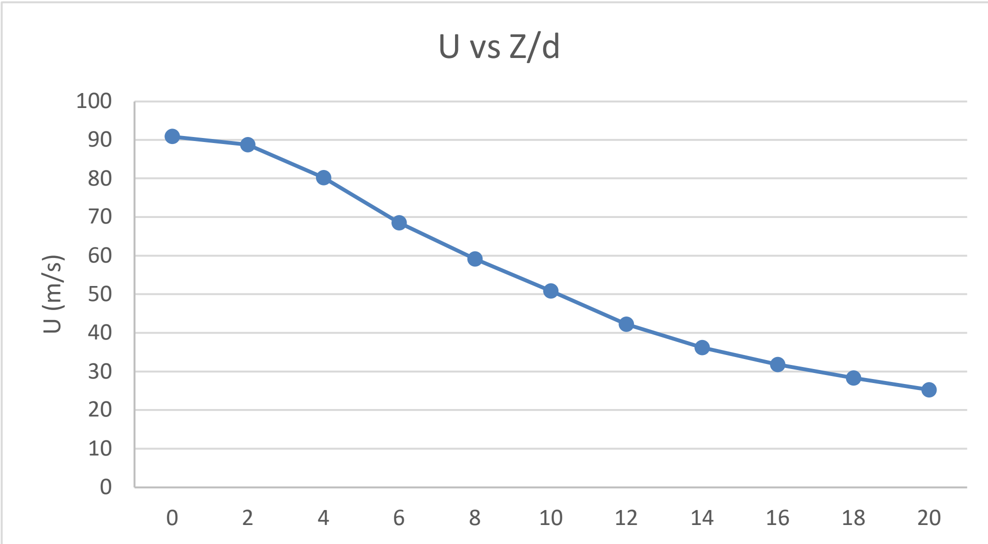
density of air =1.2 kg/m^3

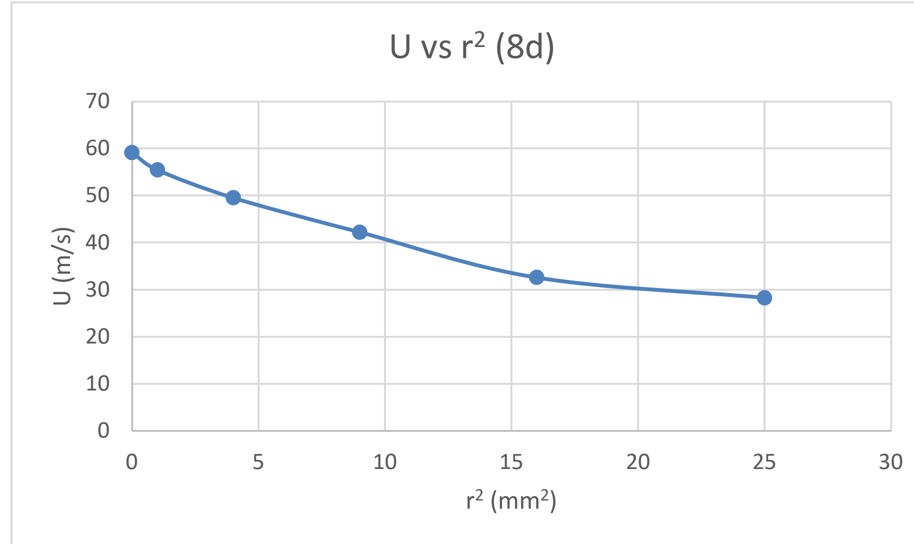
density of water =1000 kg/m^3

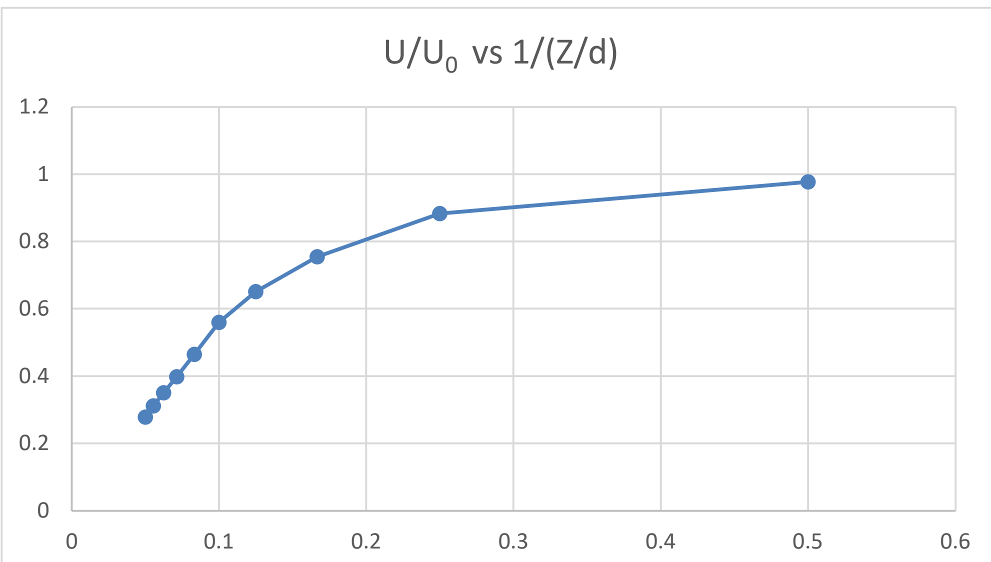
Part 2

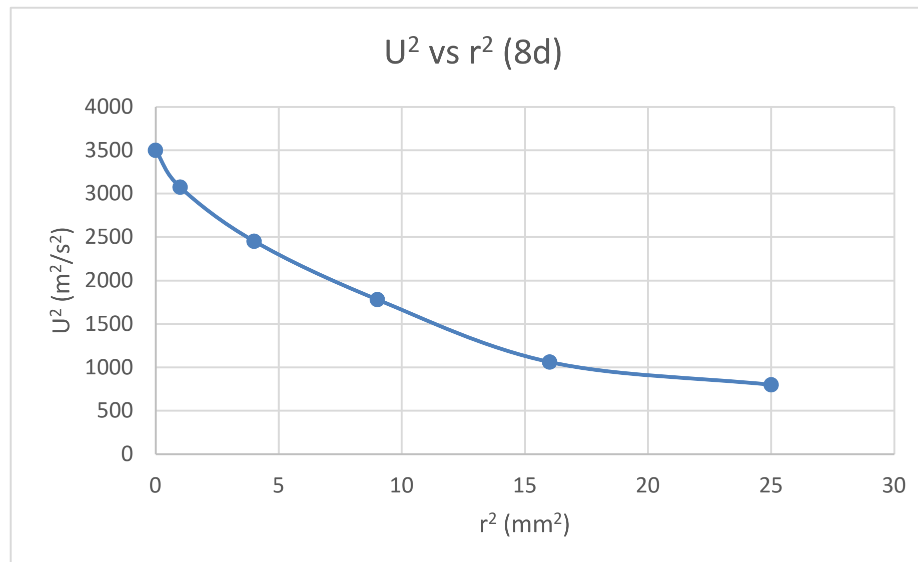
	At 8 d:					**At 14 d:**				
Sr. No.	r (mm)	h (mm of	U (m/s)	U^2	r^2	r(mm)	h (mm of	U (m/s)	U^2	r^2
1	0	214	59.1515	3498.9	0	0	80	36.16628	1308	0
2	1	188	55.44186	3073.8	1	1	75	35.01785	1226.25	1
3	2	150	49.52272	2452.5	4	2	72	34.31035	1177.2	4
4	3	109	42.21552	1782.15	9	3	63	32.09439	1030.05	9
5	4	65	32.59985	1062.75	16	4	49	28.30459	801.15	16
6	5	49	28.30459	801.15	25	5	35	23.92175	572.25	25

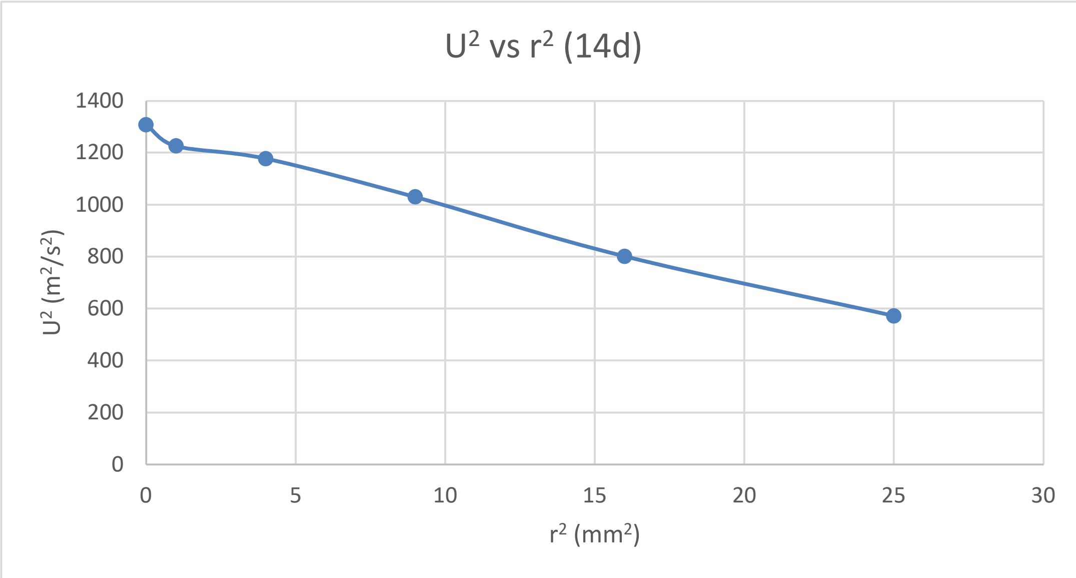
Area			
U vs r^2		U^2 vs r^2	
at 8d	**at 14d**	**at 8d**	**at 14d**
980.0129149	752.0112	40507.125	22979.93

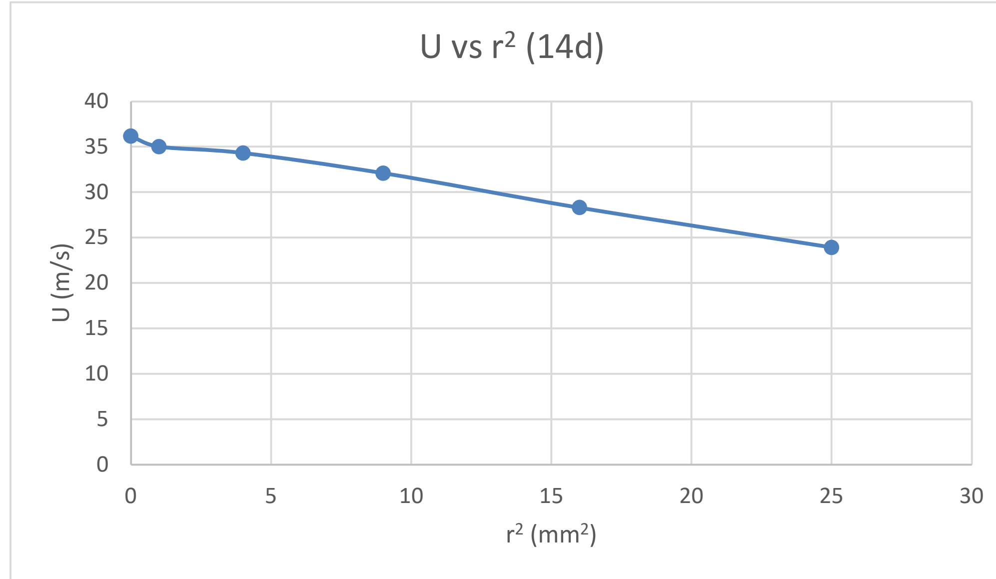

U vs Z/d
U (m/s)
100
90
80
70
60
50
40
30
20
10
0
0
2
4
6
8
10
12
14
16
18
20


U vs r2 (8d)
U (m/s)
70
60
50
40
30
20
10
0
0
5
10
15
20
25
30
r2 (mm2)


U/U0 vs 1/(Z/d)
1.2
1
0.8
0.6
0.4
0.2
0
0
0.1
0.2
0.3
0.4
0.5
0.6


U2 vs r2 (8d)
U2 (m2/s2)
4000
3500
3000
2500
2000
1500
1000
500
0
0
5
10
15
20
25
30
r2 (mm2)


U² vs r² (14d)
1400
1200
1000
800
600
400
200
0
U² (m²/s²)
0
5
10
15
20
25
30
r² (mm²)


U vs r² (14d)
40
35
30
25
20
15
10
5
0
U (m/s)
0
5
10
15
20
25
30
r² (mm²)