Nozzle Test : Measurement of Water Jet Movement

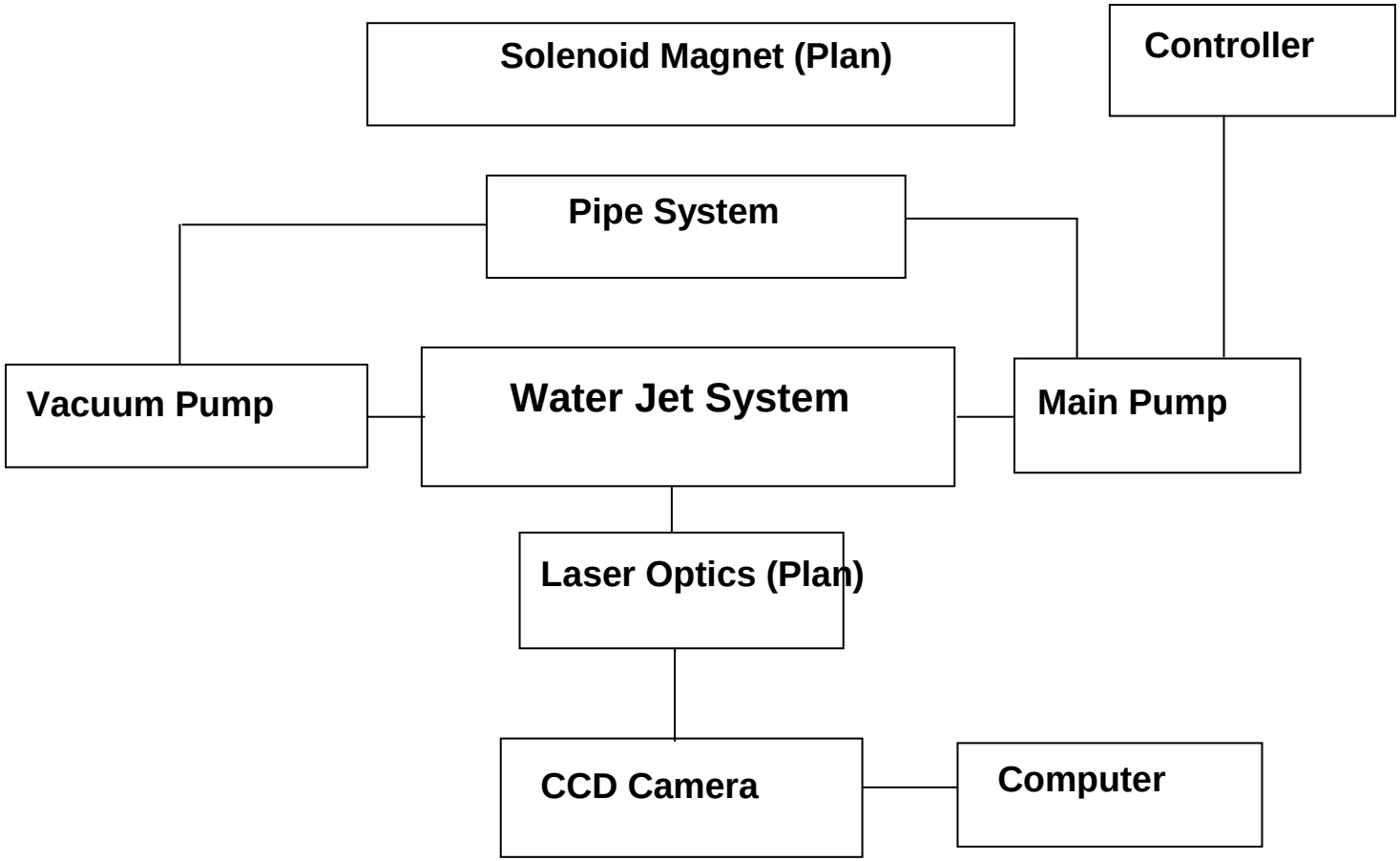
12/12/2005 by HeeJin, Park

Goal : To measure velocity and distortion of water jet with different nozzle and Evaluate.

Plan

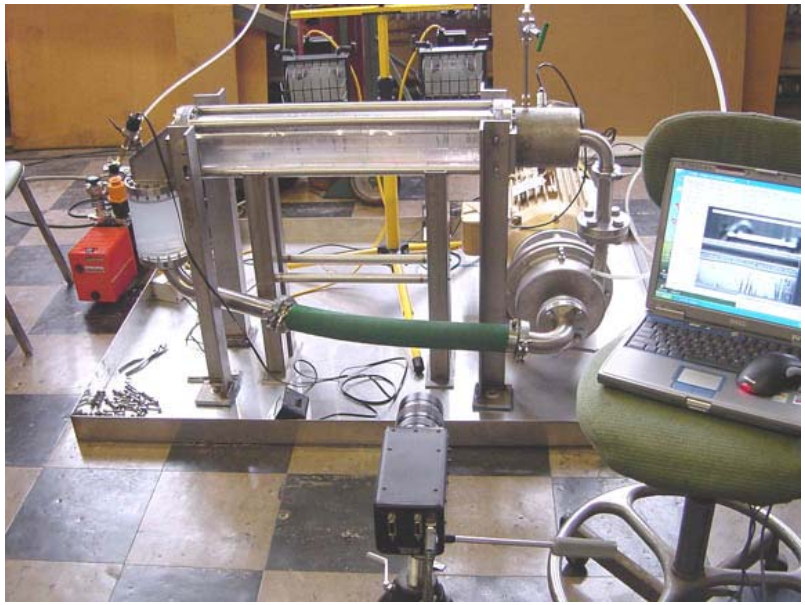
No.	Condition	Atmospheric	Vacuum
1	Orifice Nozzle (Steel)	Done	
2	Tapered Nozzle (Steel)	Done	
3	Straight Nozzle (Steel)	Done	Done
4	Tapered Nozzle with Straight (Bronze)	Done	Done
5	Tapered Nozzle with Straight (Steel)	Done	

Experimental Sketch (11/16/05 version)



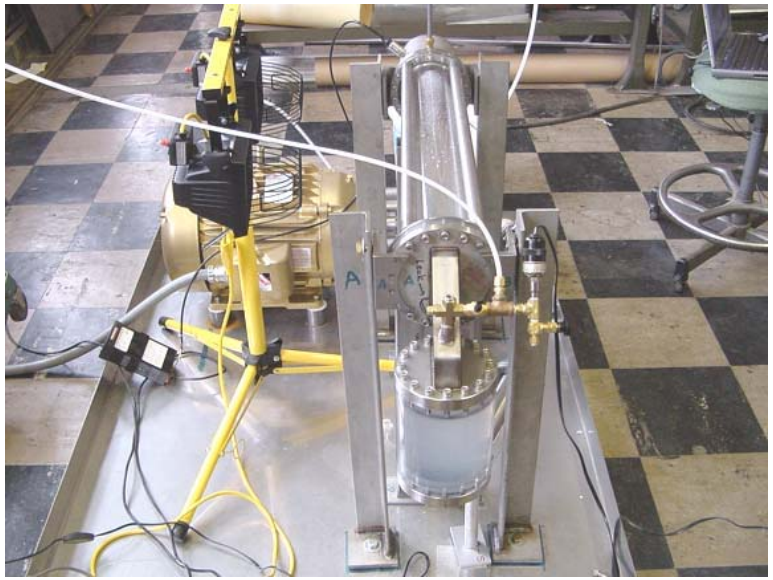
Experimental Setup (11/16/05 version)

Front view

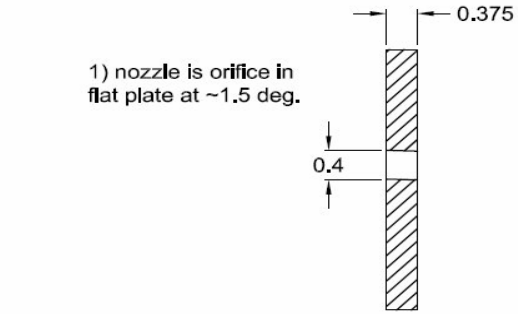


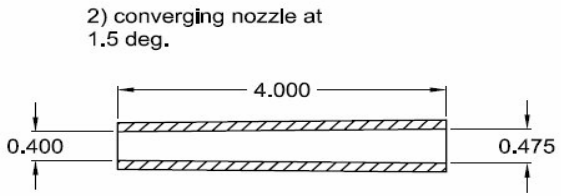
Right view

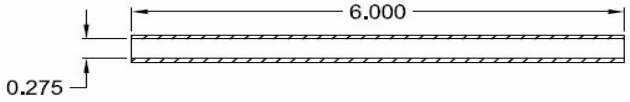
Left view

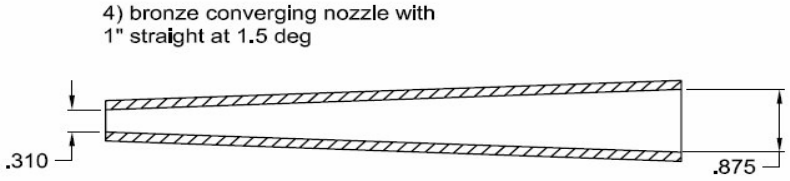


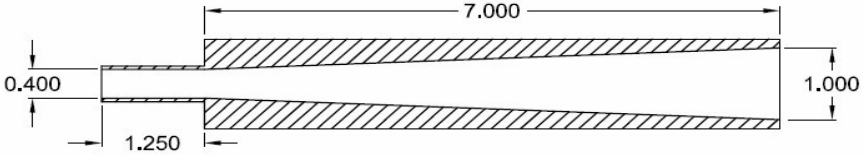
Nozzle Configuration



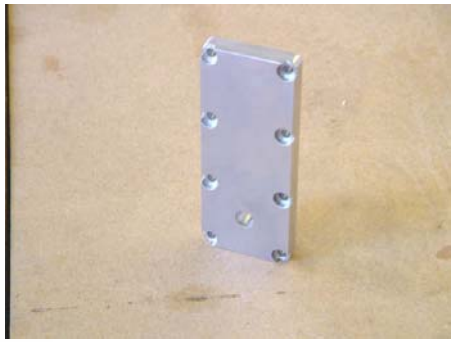








1)



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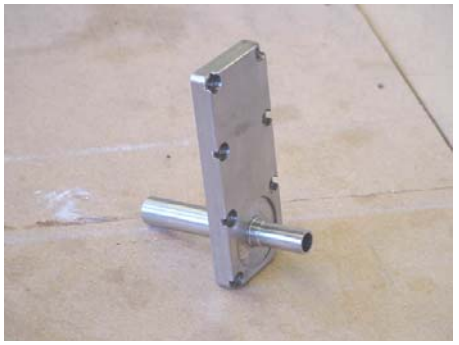

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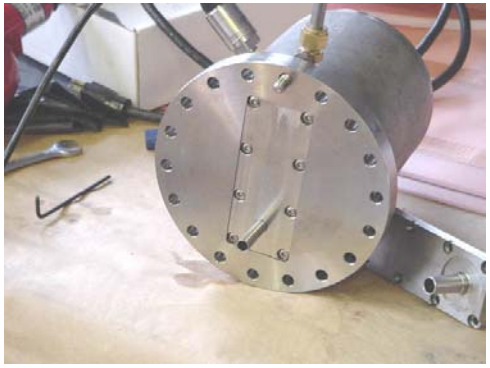


4)

5)

Measuring Environments

High Speed Camera Setting

Frame Rate(fps)	2500
Exposure Time(μs)	200
Resolution	1280×200

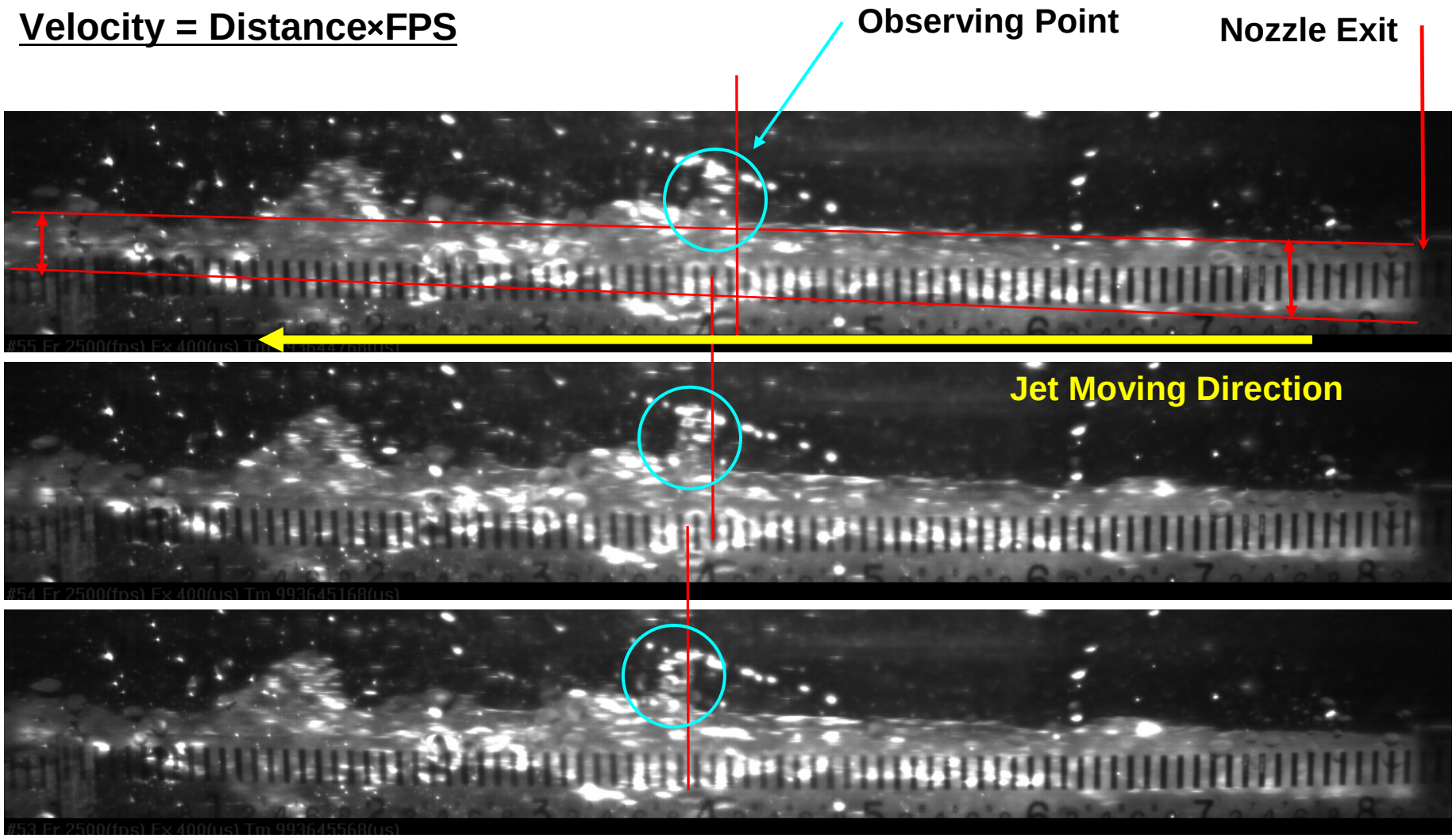
Measuring Position

	Distance from Nozzle	
	in	cm
Front	4	10
Middle	15	37.5
Rear	23	57.5
Total Travel of Jet	27	67.5

Measuring Technique

Example : Tapered Nozzle with Straight (atmospheric)

Velocity = Distance×FPS

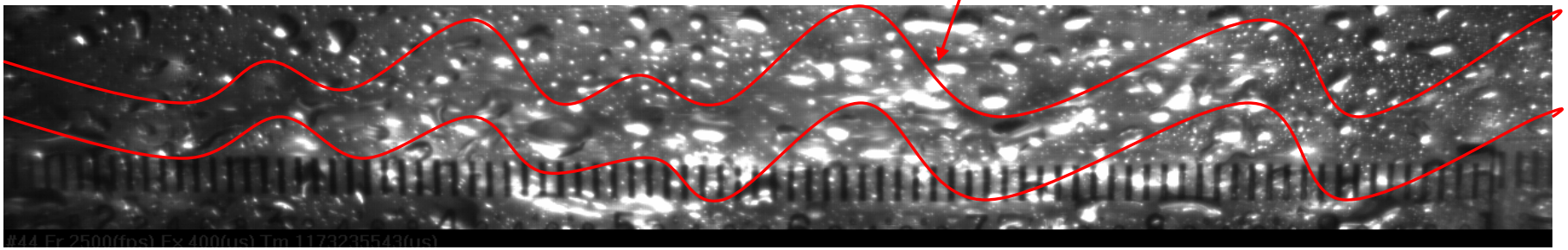


Overall View

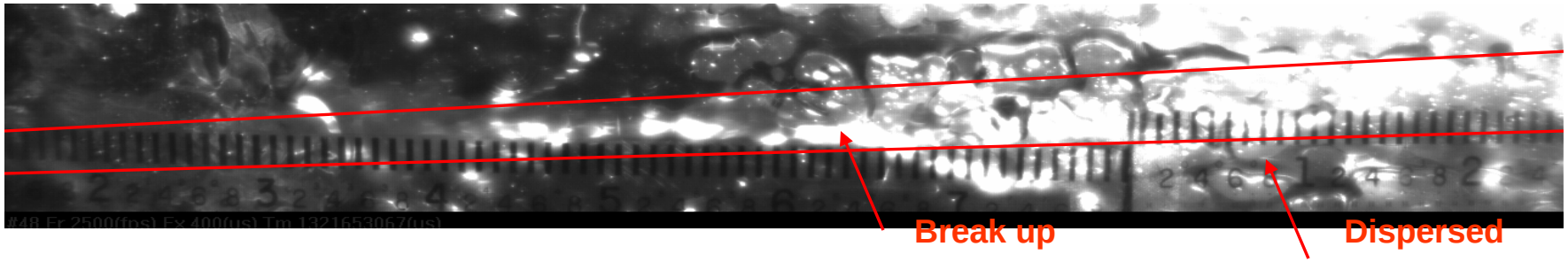
Example : Tapered Steel Nozzle with Straight

Front

Middle

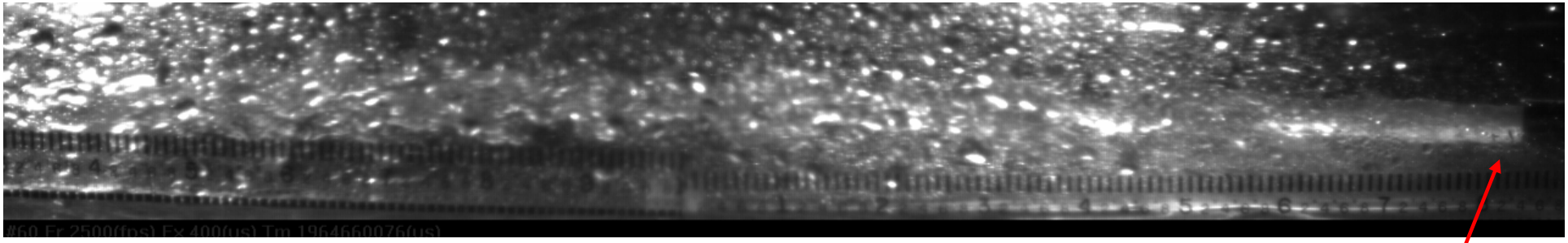


Rear



Overall View

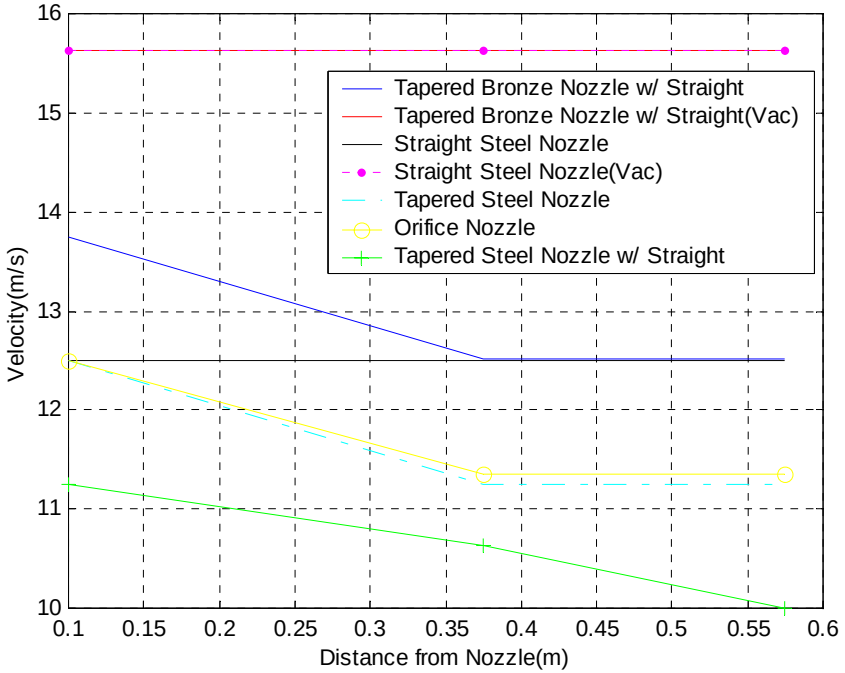
Continuous Captured Frame Image Example : Tapered Steel Nozzle with Straight

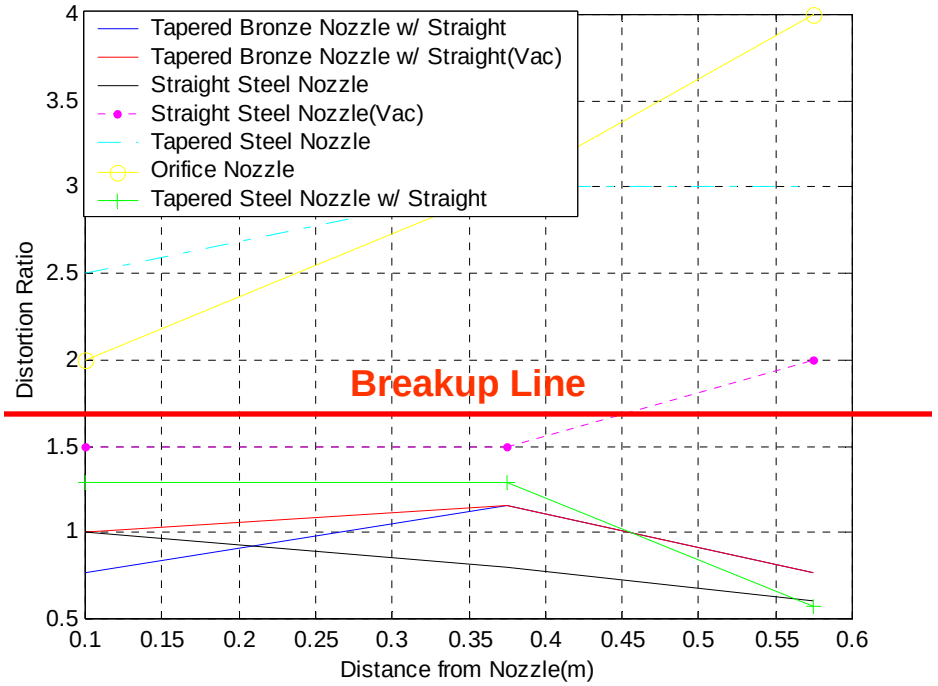


Water Jet Flow

Nozzle

Result





	Tapered Bronze Nozzle w/ Straight (atmospheric)			Tapered Bronze Nozzle w/ Straight (vacuum)		
	Front	Center	Rear	Front	Center	Rear
Distance(in)/Frame	0.22	0.2	0.2	0.25	0.25	0.25
Distance(m)/Frame	0.0055	0.005	0.005	0.00625	0.00625	0.00625
Time(s)/Frame	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004
Velocity(m/s)	13.75	12.5	12.5	15.625	15.625	15.625
Distortion Ratio	0.769	1.154	0.769	1.000	1.154	0.769

Result

	Straight Steel Nozzle (atmospheric)			Straight Steel Nozzle (vacuum)		
	Front	Center	Rear	Front	Center	Rear
Distance(in)/Frame	0.2	0.2	0.2	0.25	0.25	0.25
Distance(m)/Frame	0.005	0.005	0.005	0.00625	0.00625	0.00625
Time(s)/Frame	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004
Velocity(m/s)	12.5	12.5	12.5	15.625	15.625	15.625
Distortion Ratio	1.000	0.800	0.600	1.500	1.500	2.000

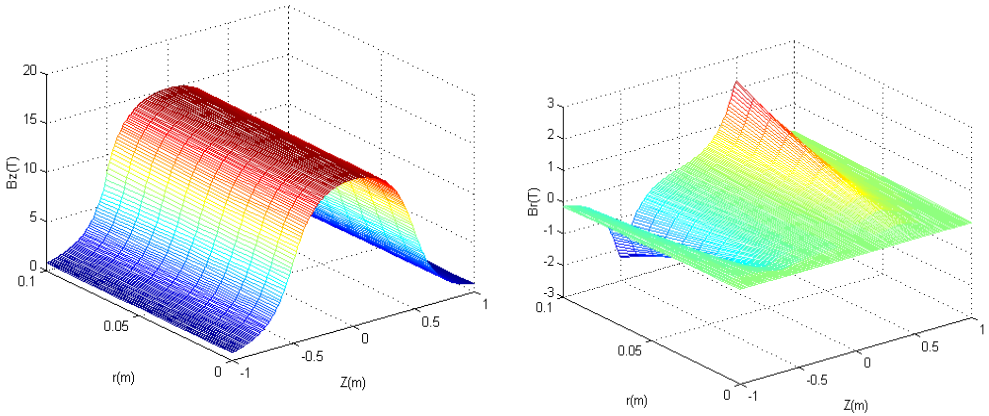
	Tapered Steel Nozzle w/ Straight (atmospheric)		
	Front	Center	Rear
Distance(in)/Frame	0.18	0.17	0.16
Distance(m)/Frame	0.0045	0.00425	0.004
Time(s)/Frame	0.0004	0.0004	0.0004
Velocity(m/s)	11.25	10.625	10
Distortion Ratio	1.286	1.286	0.571

	Tapered Steel Nozzle (atmospheric)		
	Front	Center	Rear
Distance(in)/Frame	0.2	0.18	0.18
Distance(m)/Frame	0.005	0.0045	0.0045
Time(s)/Frame	0.0004	0.0004	0.0004
Velocity(m/s)	12.5	11.25	11.25
Distortion Ratio	2.500	3.000	3.000

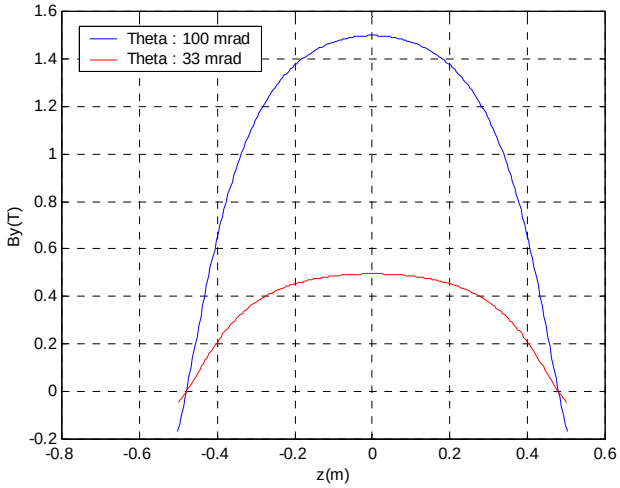
	Orifice Nozzle (atmospheric)		
	Front	Center	Rear
Distance(in)/Frame	0.2	0.18	0.18
Distance(m)/Frame	0.005	0.0045	0.0045
Time(s)/Frame	0.0004	0.0004	0.0004
Velocity(m/s)	12.5	11.25	11.25
Distortion Ratio	2.000	3.000	4.000

Further Study : Magnetic Field Effect with Jet Angle

Pulsed Solenoid Magnetic Field (15T)



Transverse Magnetic Field along Hg Jet Axis



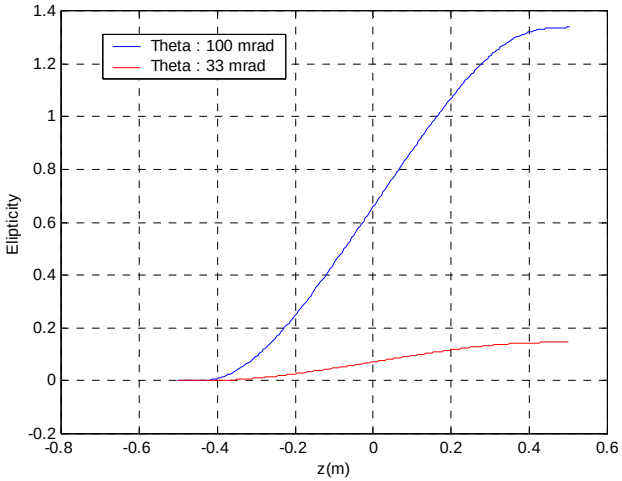
Distortion ration w/o Surface Tension

$$\varepsilon(z) = \frac{\kappa}{2\upsilon\rho}\iint B_y \frac{\partial B_y}{\partial z} dzdz$$

Distortion ration w/ Surface Tension

$$\varepsilon(z) = \iint\left(\frac{\kappa}{2\upsilon\rho} B_y \frac{\partial B_y}{\partial z} + \frac{2T\varepsilon}{\upsilon^2\rho r_o^3}\right) dzdz$$

Distortion Ratio along Hg Jet Axis



Further Study

Distortion Ratio of Hg Jet with Surface Tension

Require initial distortion ratio of Hg jet ?
Or Other way to approximate it ?

Mirror Mount Design for Optical Diagnostics

Component :
Window Clamper , Mirror Adjusting Mount

Requirement :
Focusing/Tilting of Reflecting Mirror (3 DOF)