

Nozzle Test : Measurement of Water Jet Movement

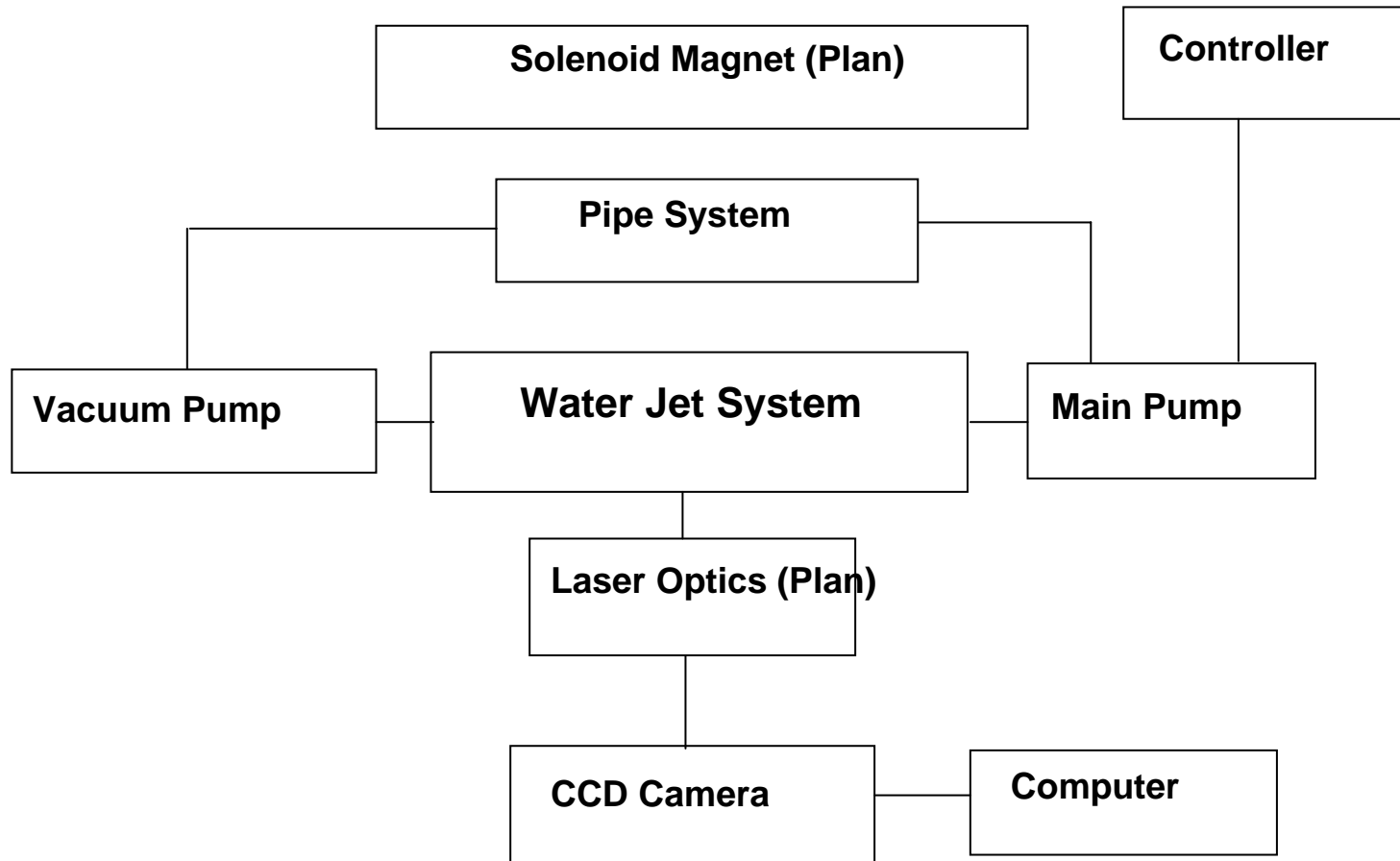
12/12/2005 by HeeJin, Park

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

Plan

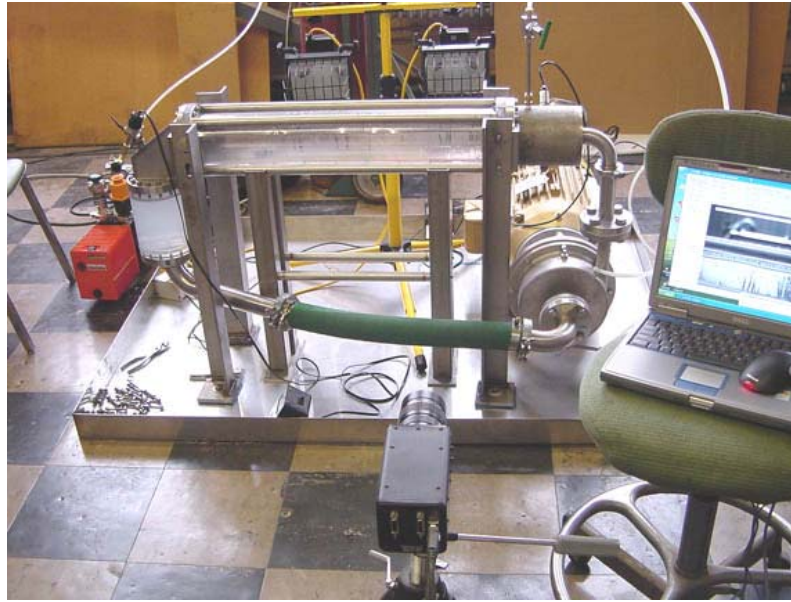
No.	Condition	Atmospheric	Vacuum
1	Orifice Nozzle (Steel)	Done	
2	Tapered Nozzle (Steel)	Done	
3	Straight Nozzle (Steel)	Done	Done
4	Tapered Nozzle with Straight (Bronze)	Done	Done
5	Tapered Nozzle with Straight (Steel)	Done	

Experimental Sketch (11/16/05 version)

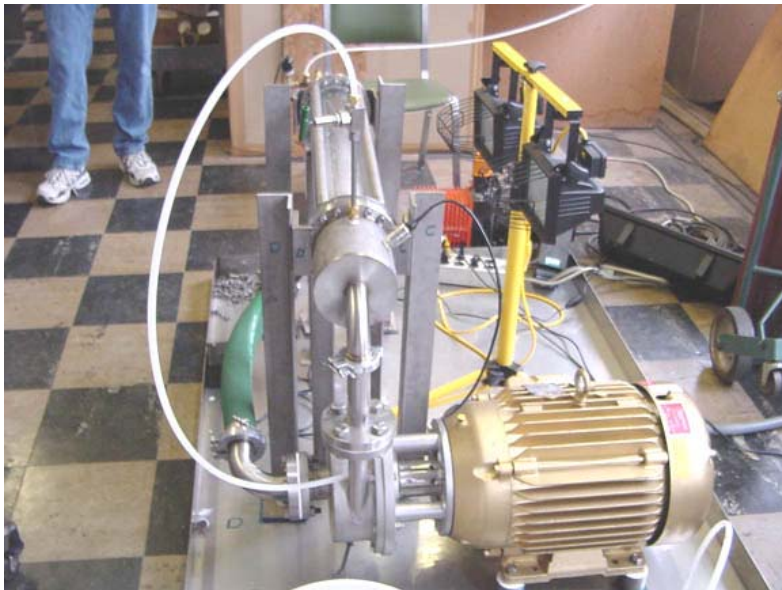


Experimental Setup (11/16/05 version)

Front view



Right view

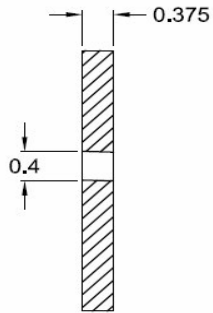


Left view

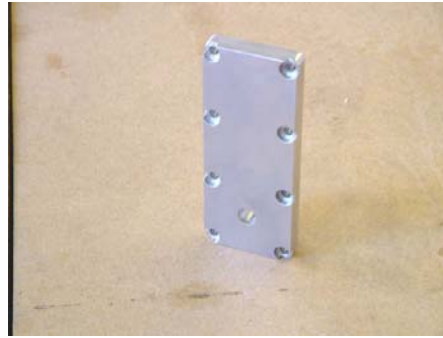


Nozzle Configuration

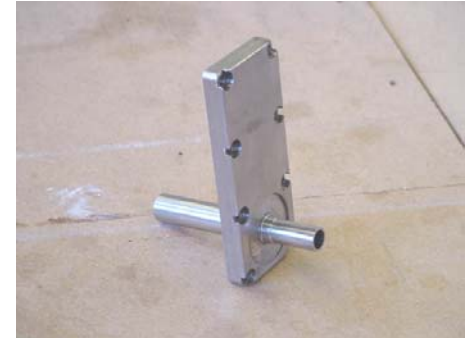
1) nozzle is orifice in flat plate at ~1.5 deg.



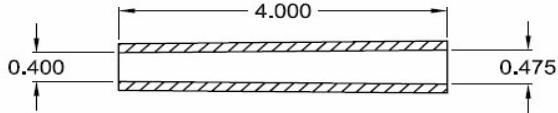
1)



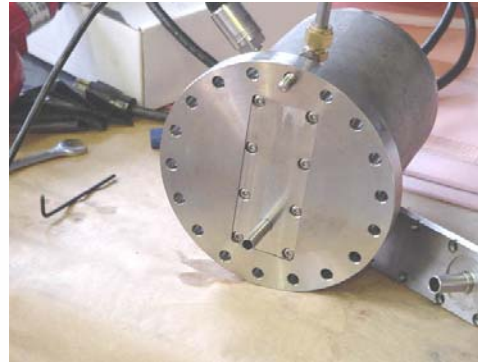
2)



2) converging nozzle at 1.5 deg.



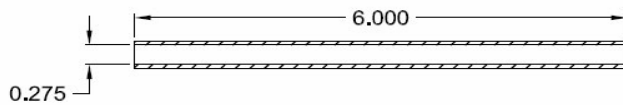
3)



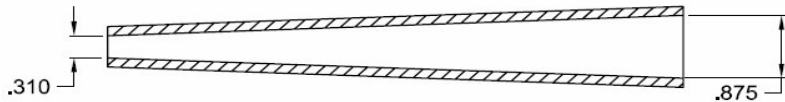
4)



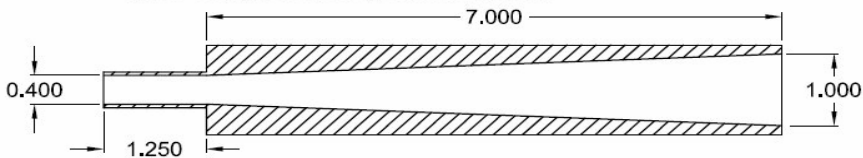
3) straight nozzle at 1.5 deg



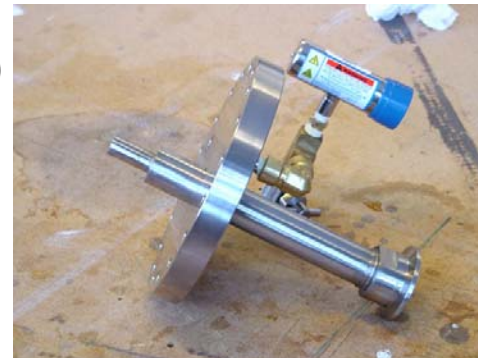
4) bronze converging nozzle with 1" straight at 1.5 deg



5) stainless steel converging nozzle with 2" straight at 1.5 deg. without plenum.



5)



Measuring Environments

High Speed Camera Setting

Frame Rate(fps)	2500
Exposure Time(μs)	200
Resolution	1280x200

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

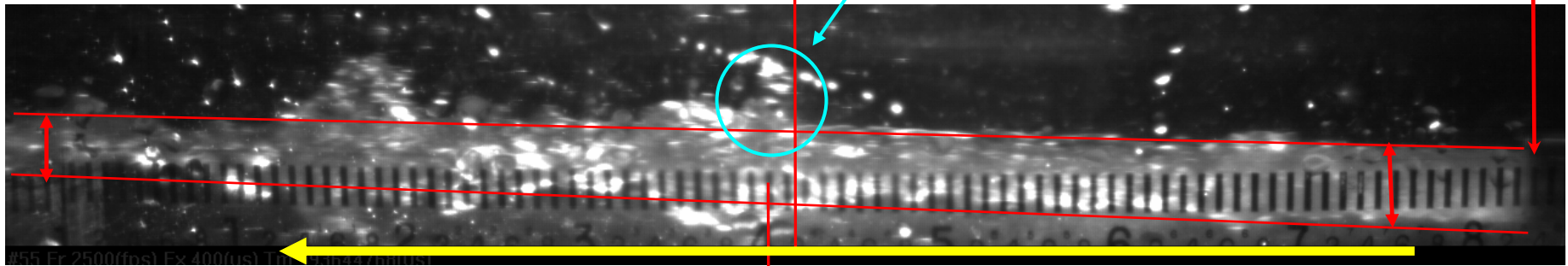
Measuring Technique

Example : Tapered Nozzle with Straight (atmospheric)

Velocity = Distance × FPS

Observing Point

Nozzle Exit



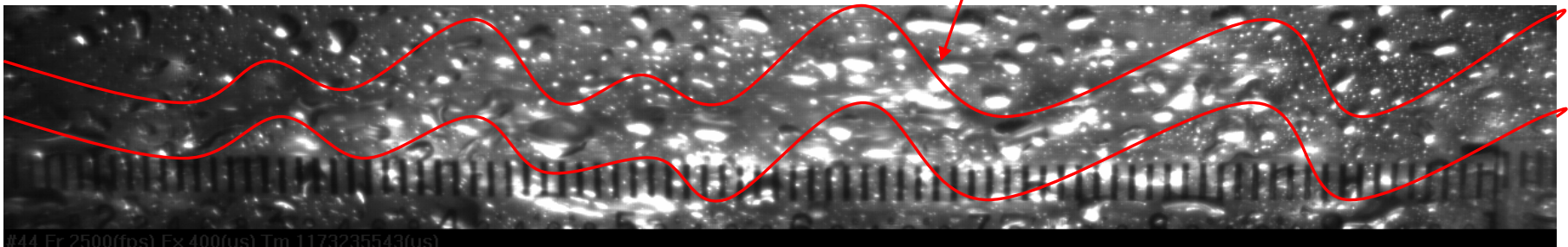
Overall View

Example : Tapered Steel Nozzle with Straight

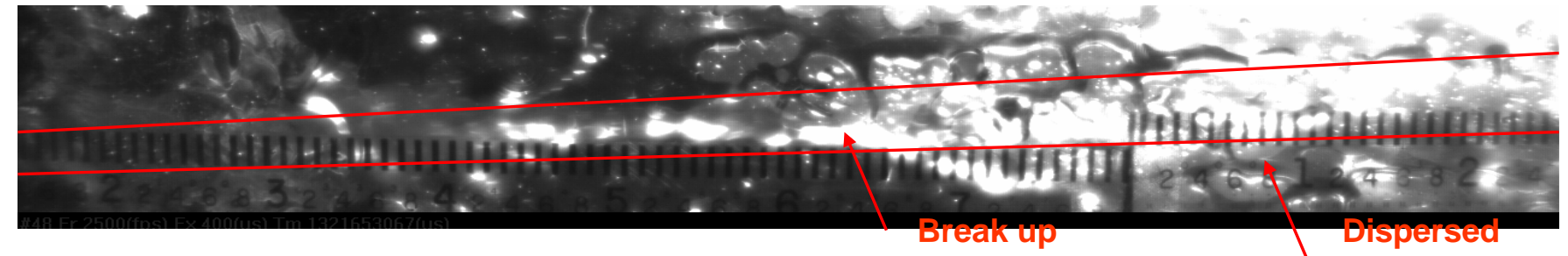
Front



Middle

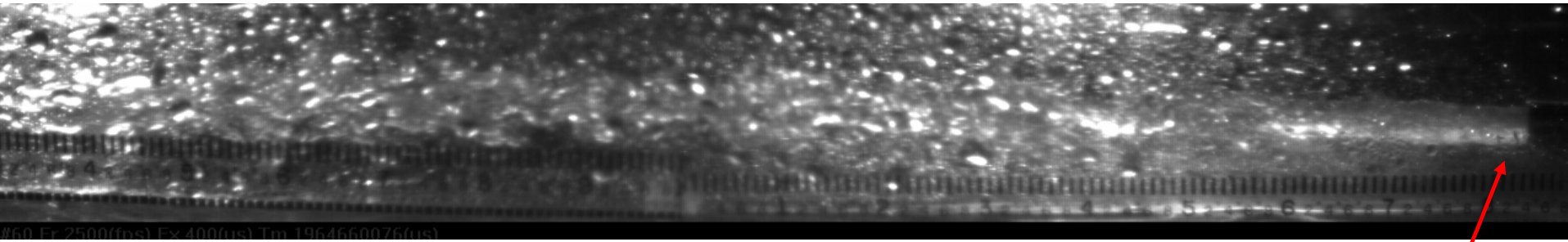


Rear

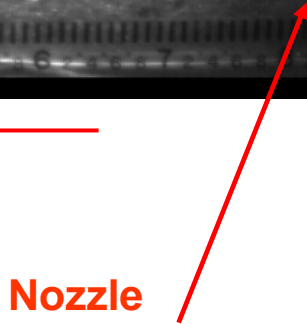


Overall View

Continuous Captured Frame Image Example : Tapered Steel Nozzle with Straight

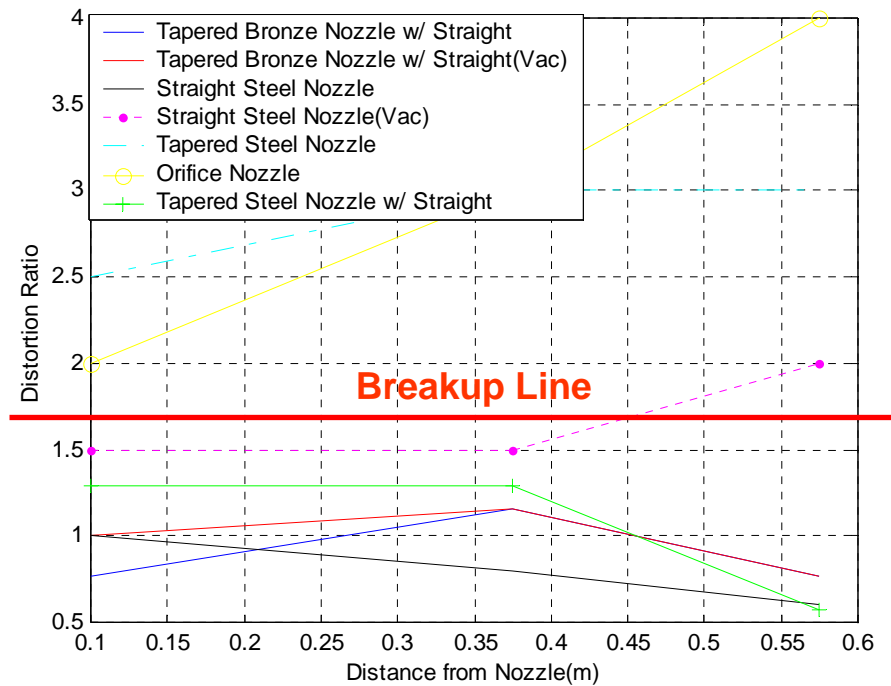
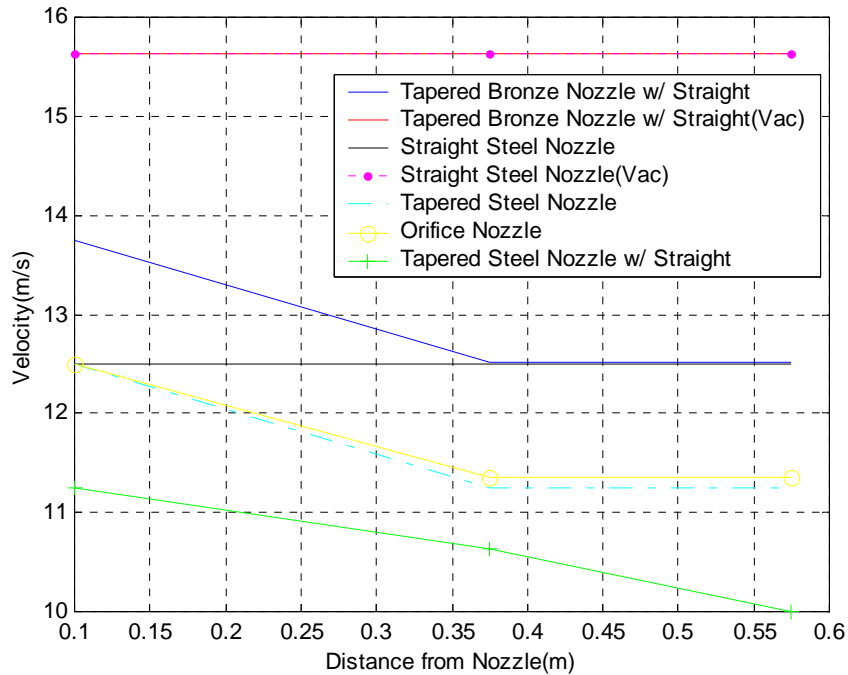


Water Jet Flow



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

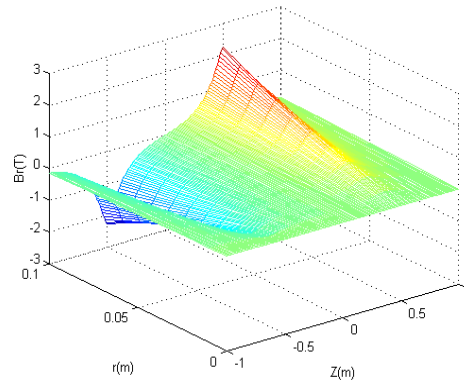
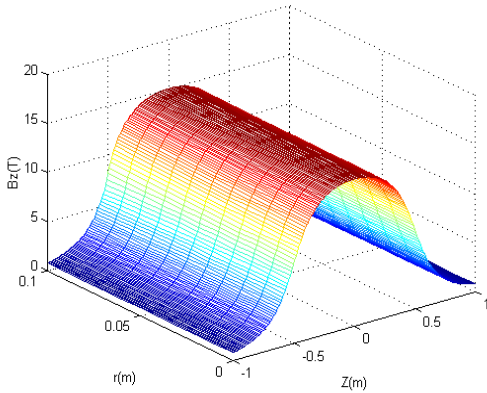
	Tapered Steel Nozzle w/ Straight (atmospheric)		
	Front	Center	Rear
Distance(in)/Frame	0.18	0.17	0.16
Distance(m)/Frame	0.0045	0.00425	0.004
Time(s)/Frame	0.0004	0.0004	0.0004
Velocity(m/s)	11.25	10.625	10
Distortion Ratio	1.286	1.286	0.571

	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

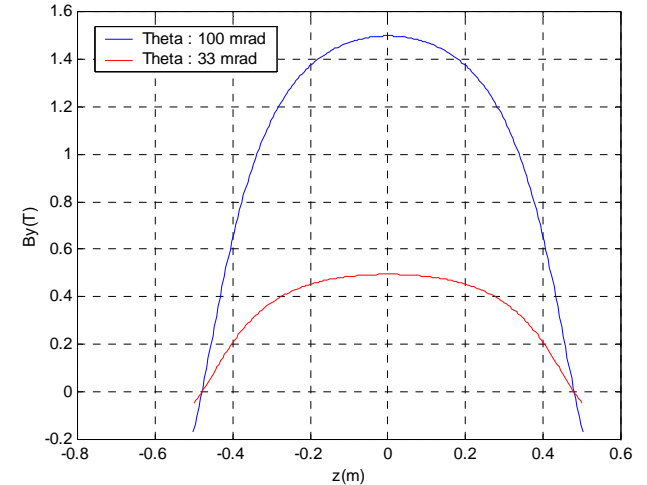
	Orifice Nozzle (atmospheric)		
	Front	Center	Rear
Distance(in)/Frame	0.2	0.18	0.18
Distance(m)/Frame	0.005	0.0045	0.0045
Time(s)/Frame	0.0004	0.0004	0.0004
Velocity(m/s)	12.5	11.25	11.25
Distortion Ratio	2.000	3.000	4.000

Further Study : Magnetic Field Effect with Jet Angle

Pulsed Solenoid Magnetic Field (15T)



Transverse Magnetic Field along Hg Jet Axis



Distortion ratio w/o Surface Tension

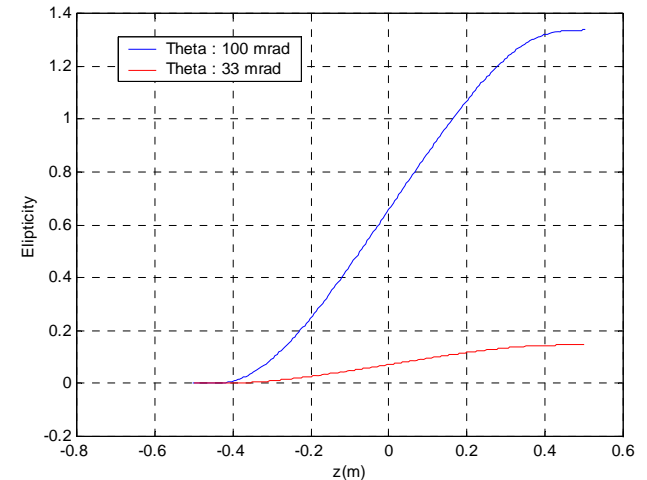
$$\varepsilon(z) = \frac{\kappa}{2\nu\rho} \iint B_y \frac{\partial B_y}{\partial z} dz dz$$

Distortion ratio w/ Surface Tension

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



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)