2D Jet Simulation Updates

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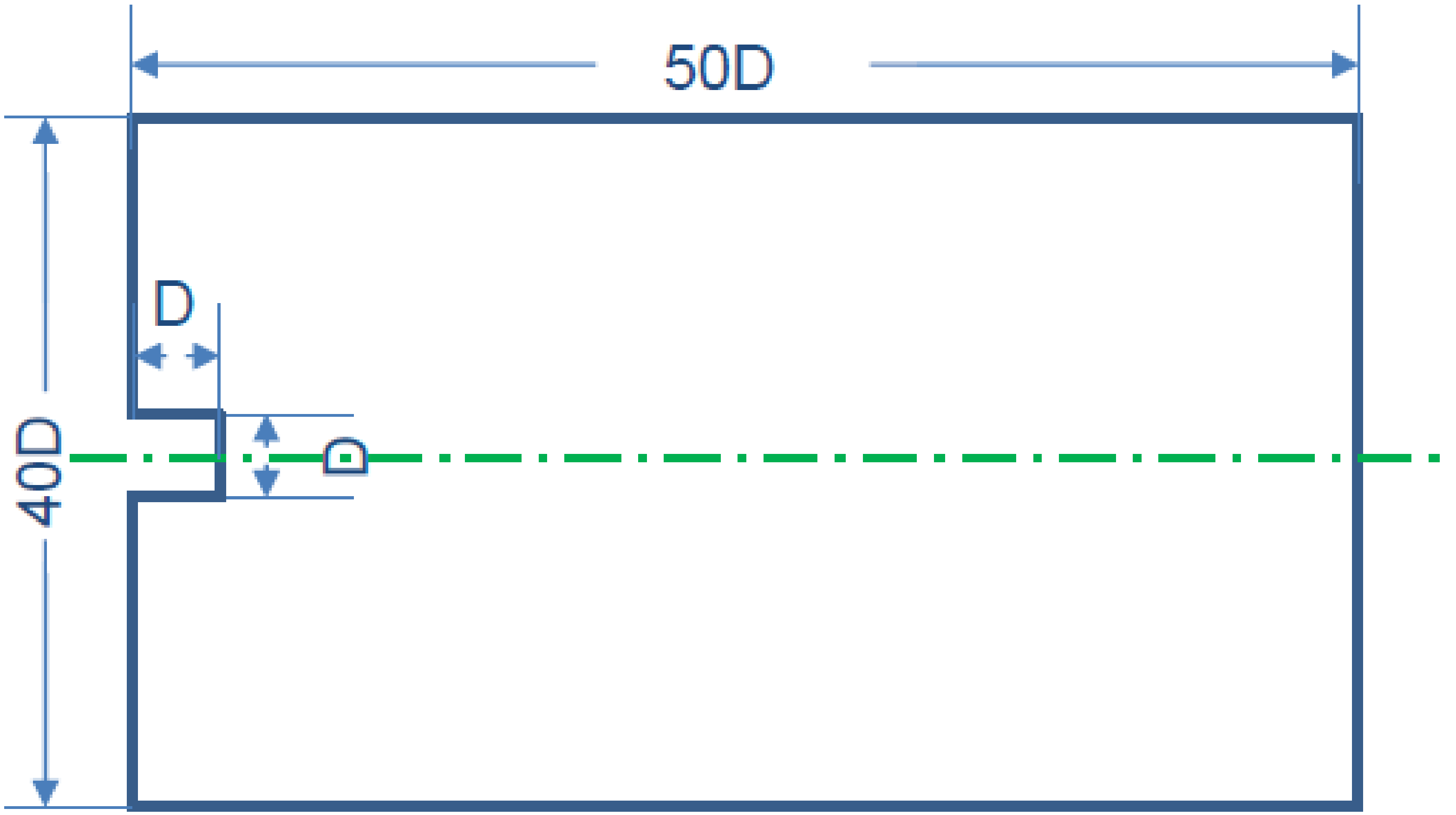
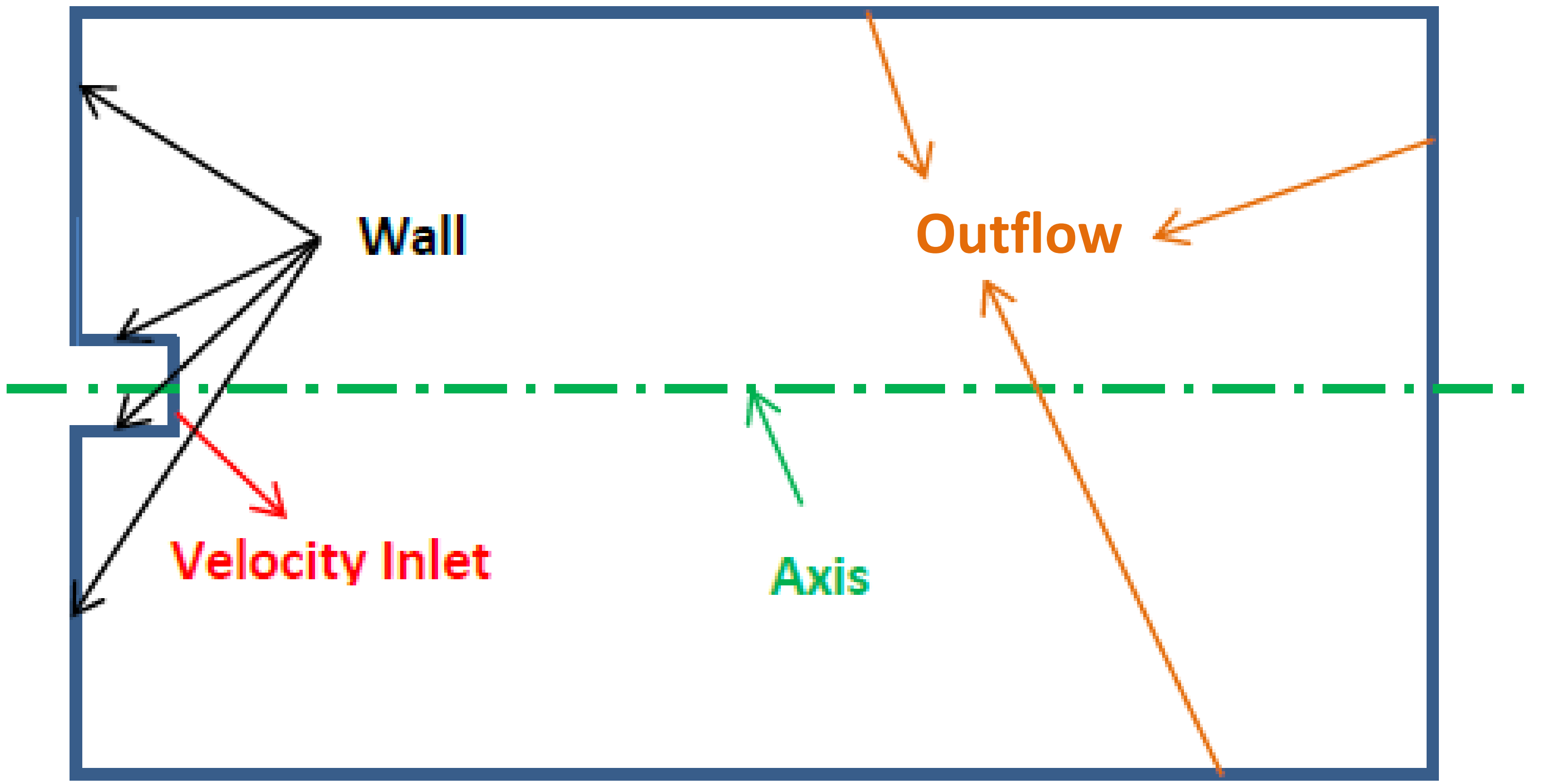
Problem 1: **Water-Air Jet**



An axis-symmetric **water** jet into still **air** with a mean bulk velocity of **4.5455** m/s (D = 0.01m, and Re = **50,000**).

Boundary Conditions



Jet Characteristics

- Physical Characteristics

Diameter (D)	Velocity	Turbulent Intensity
0.0102108 m	4.5455 m/s	u'/U = 0.05

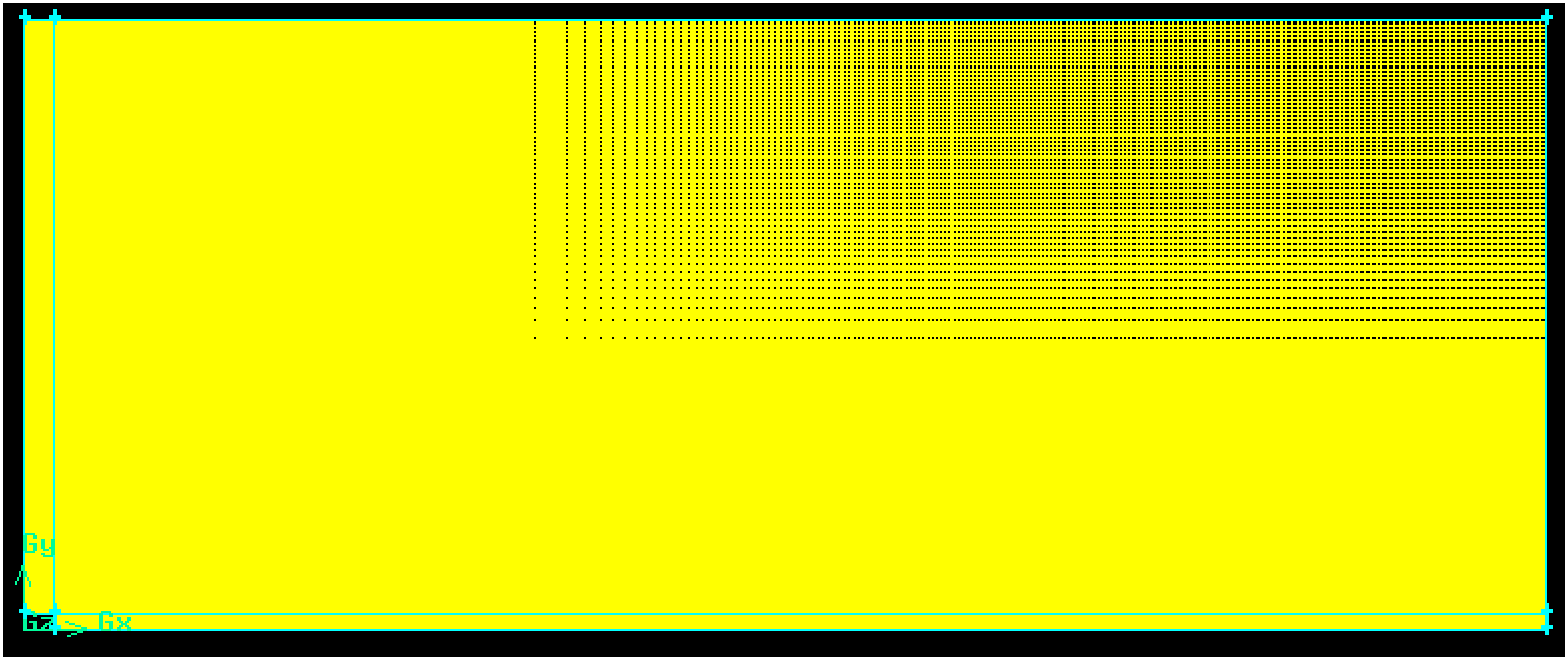
Phase	Density	Viscosity	Surface Tension
Air	1.225 kg/m^3	1.46×10^{-5} m^2/s	0.071 N/m
Water	998 kg/m^3	0.9×10^{-6} m^2/s	

- Numerical Characteristics
  - Determination of the mesh size:

Assume only primary breakup, the critical liquid Weber number is 10, then Δx_critical = 34.4µm

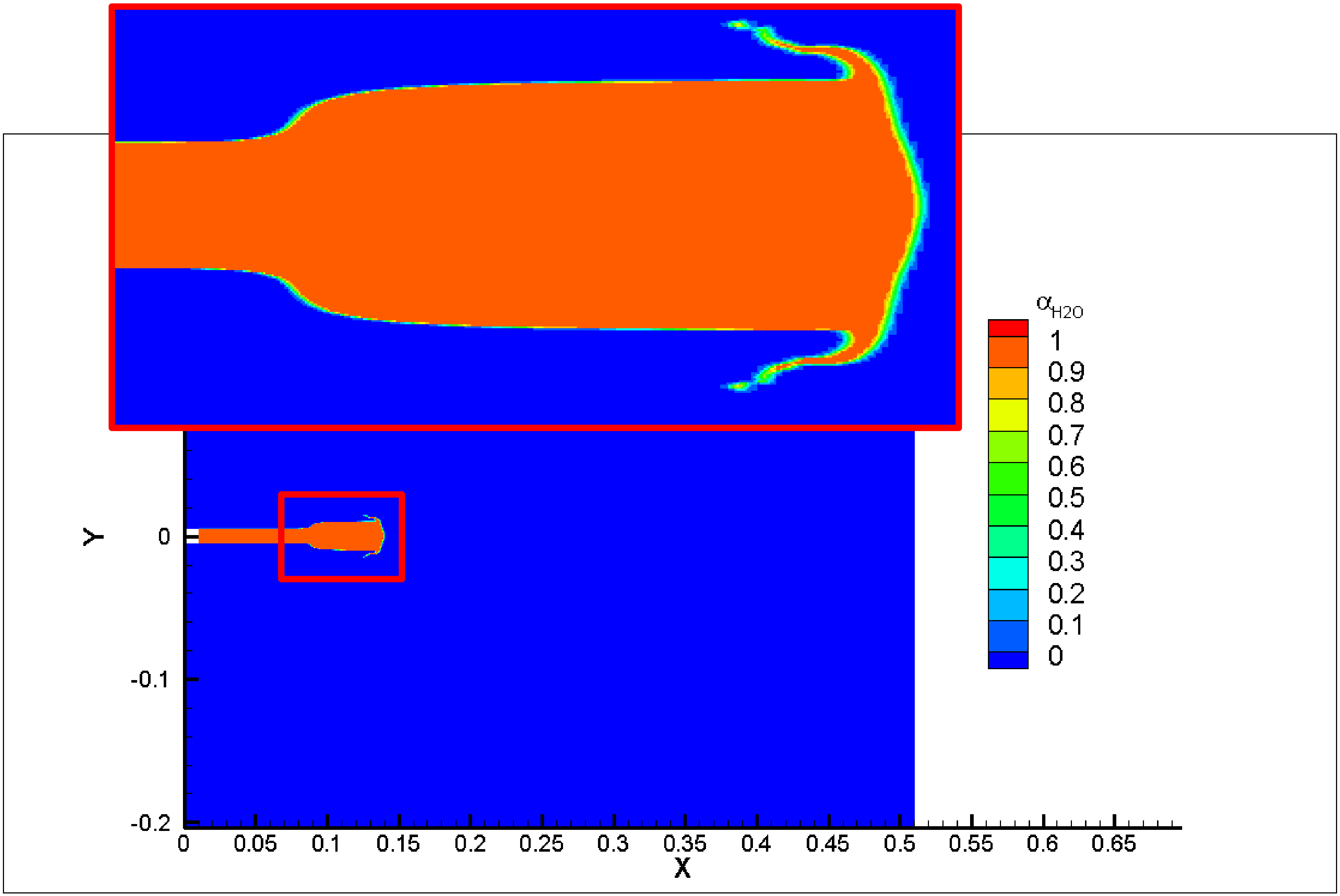
$$We \equiv \frac{\rho u^2 \Delta x}{\sigma} \rightarrow \Delta x = \frac{10*0.071}{998*4.5455*4.5455} = 3.44 * 10^{-5} \text{ m}$$

Mesh

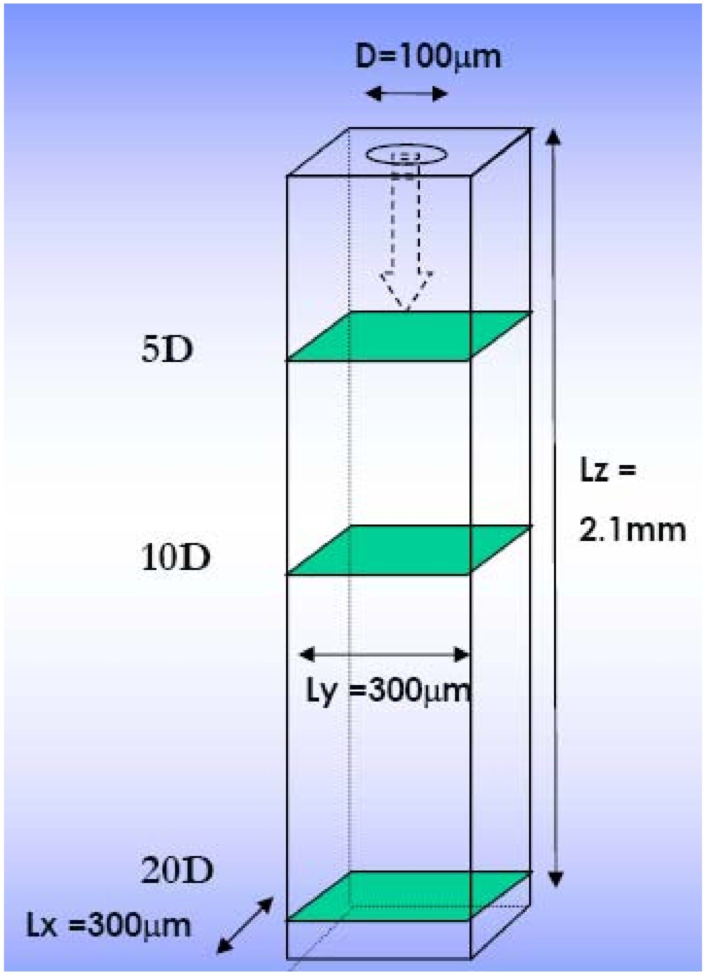


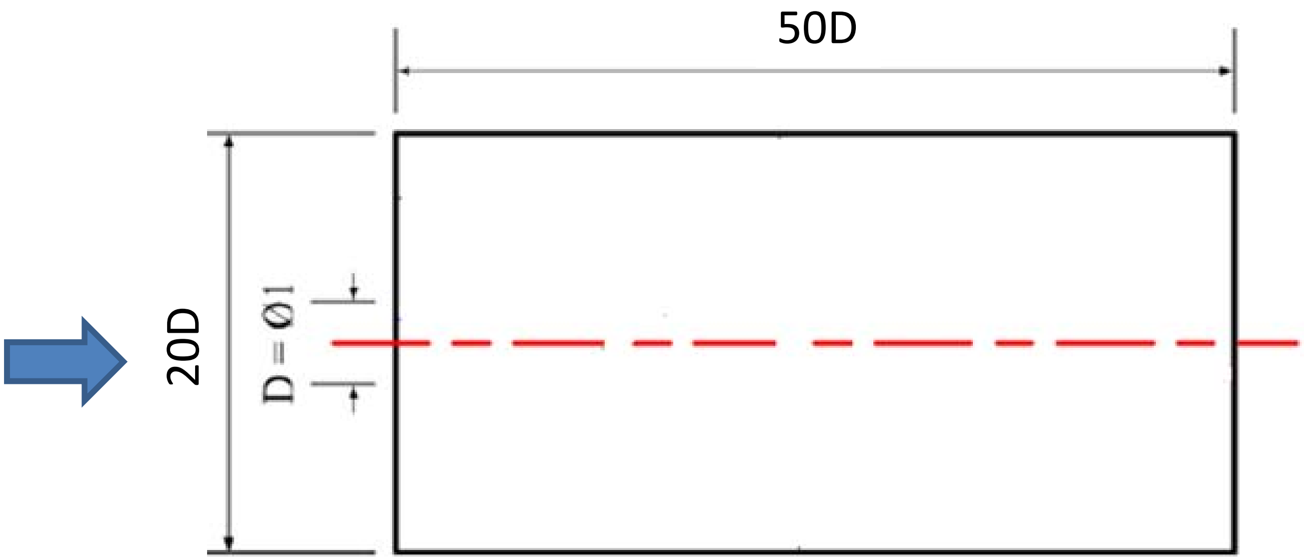
Halved (axis-symmetric) model with grid# of **822,000**

Results (t = 0.0307s)



Problem 2: Menard's Test[1]

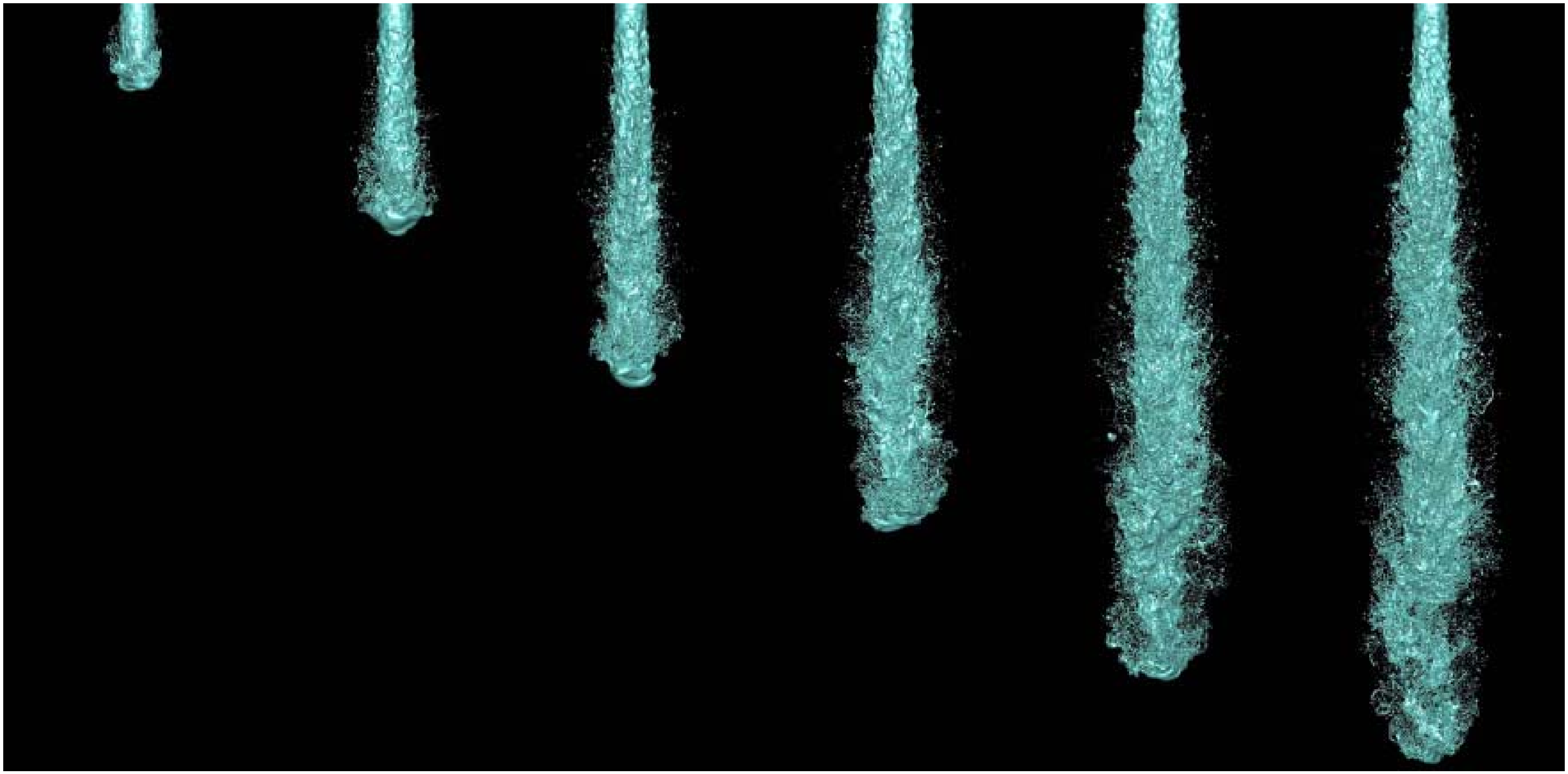




An axis-symmetric **liquid** jet into still **gas** with a mean bulk velocity of **100** m/s (D = 100 µm, and Re = **5,800**).

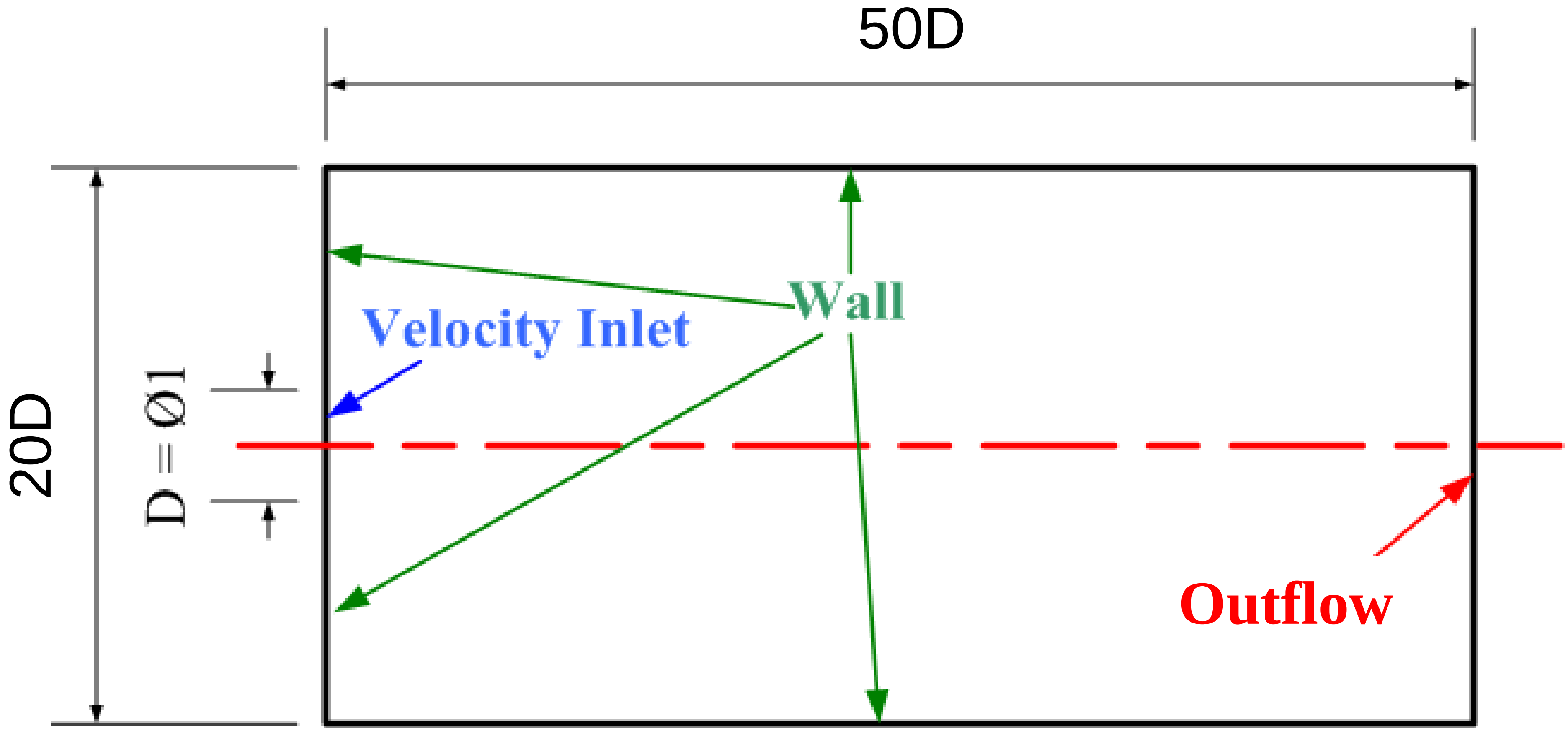
[1] T. Menard, etc., Coupling level set/VOF/ghost fluid methods: Validation and application to 3D simulation of the primary break-up of a liquid jet, International Journal of Multiphase Flow 33 (2007) 510–524

Menard's Results[1]



Jet development and penetration (dt = 2.5 µm)

Boundary Condition



Jet Characteristics

- Physical Characteristics

Diameter (D)	Velocity	Turbulent Intensity
100 µm	100 m/s	u'/U = 0.05

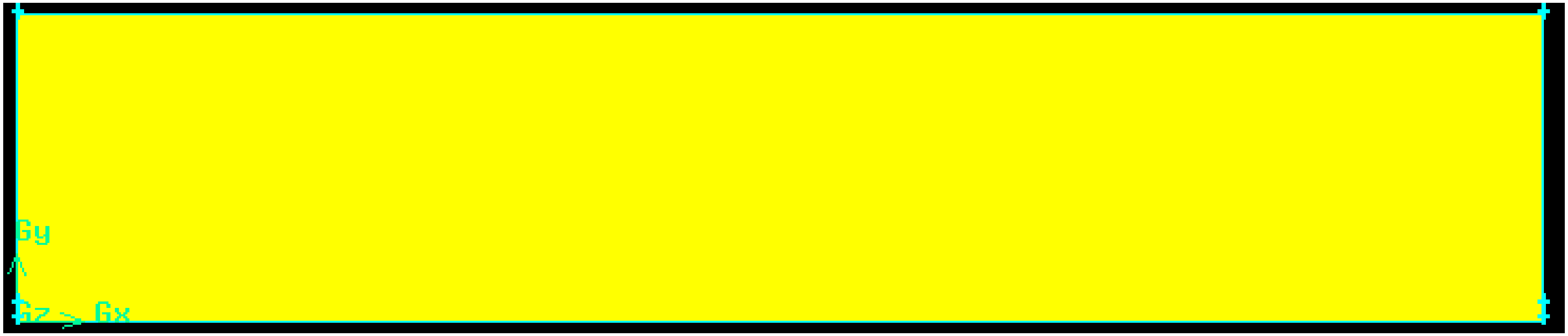
Phase	Density	Viscosity	Surface Tension
Gas	25 kg/m^3	4×10^{-7} m^2/s	0.06 N/m
Liquid	696 kg/m^3	1.724×10^{-6} m^2/s	

- Numerical Characteristics
  - Determination of the mesh size:

Assume only primary breakup, the critical liquid Weber number is 10, then Δx_critical = 2.36 µm

$$We \equiv \frac{\rho u^2 \Delta x}{\sigma} \rightarrow \Delta x = \frac{10*0.06}{696*100*100} = 2.36 * 10^{-6} \text{ m}$$

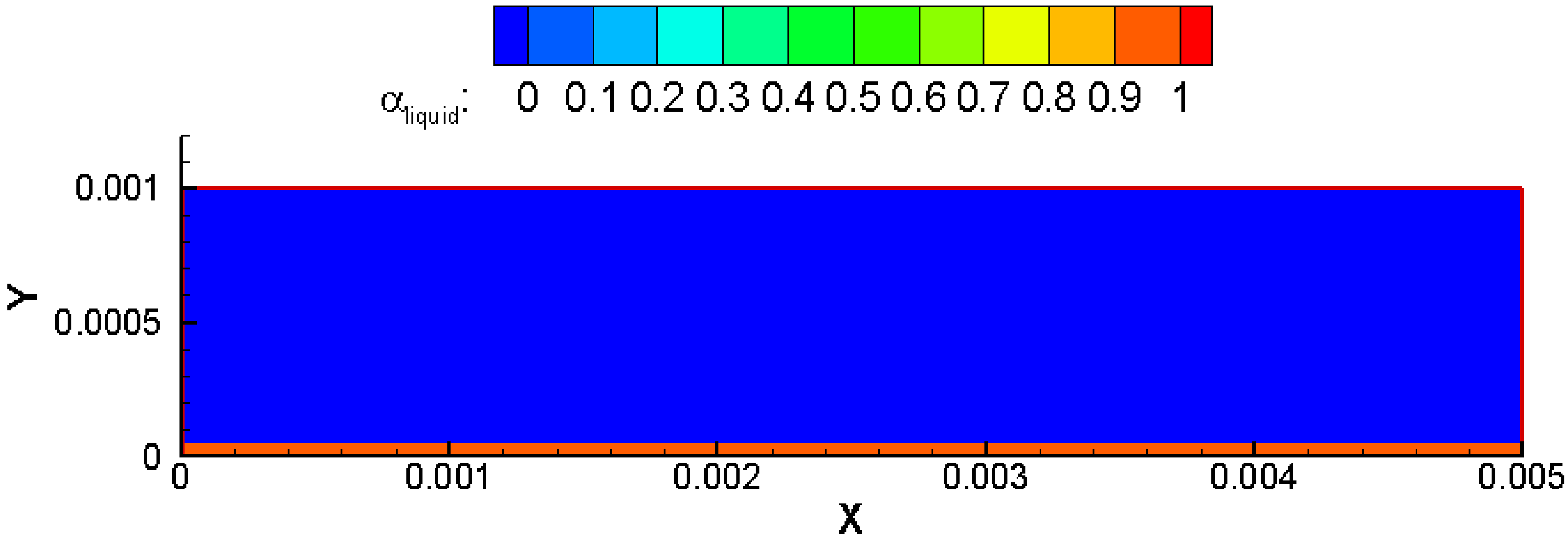
Mesh

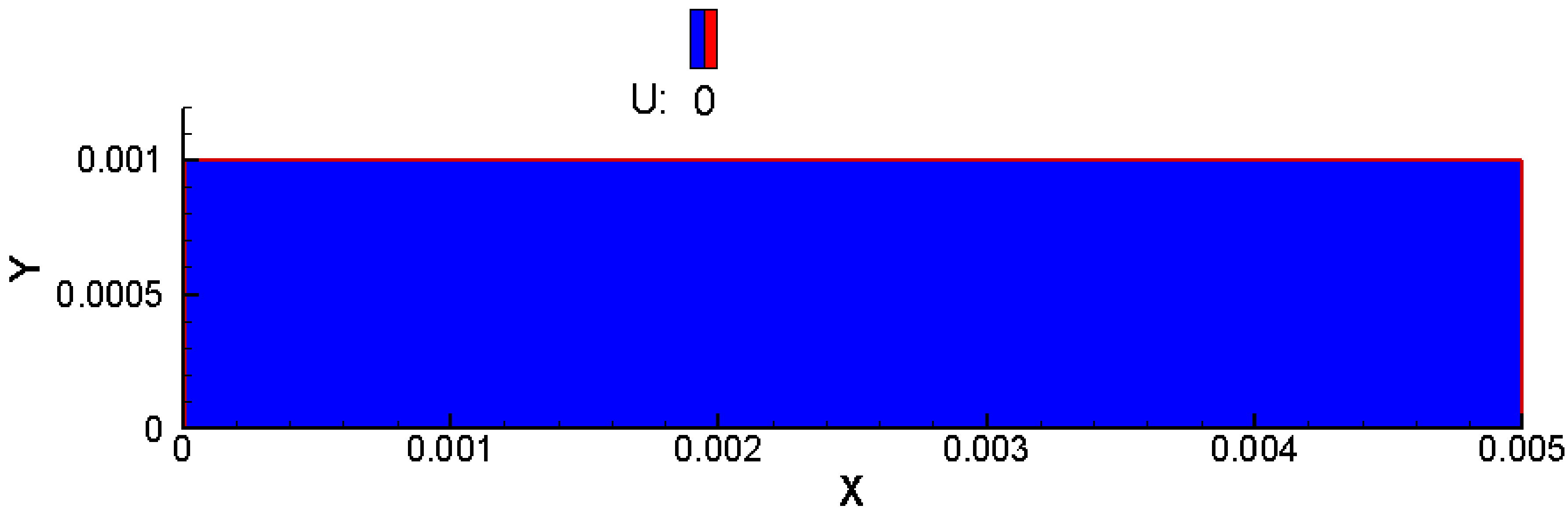


Halved (axis-symmetric) model with grid# of **1,146,880**

Results

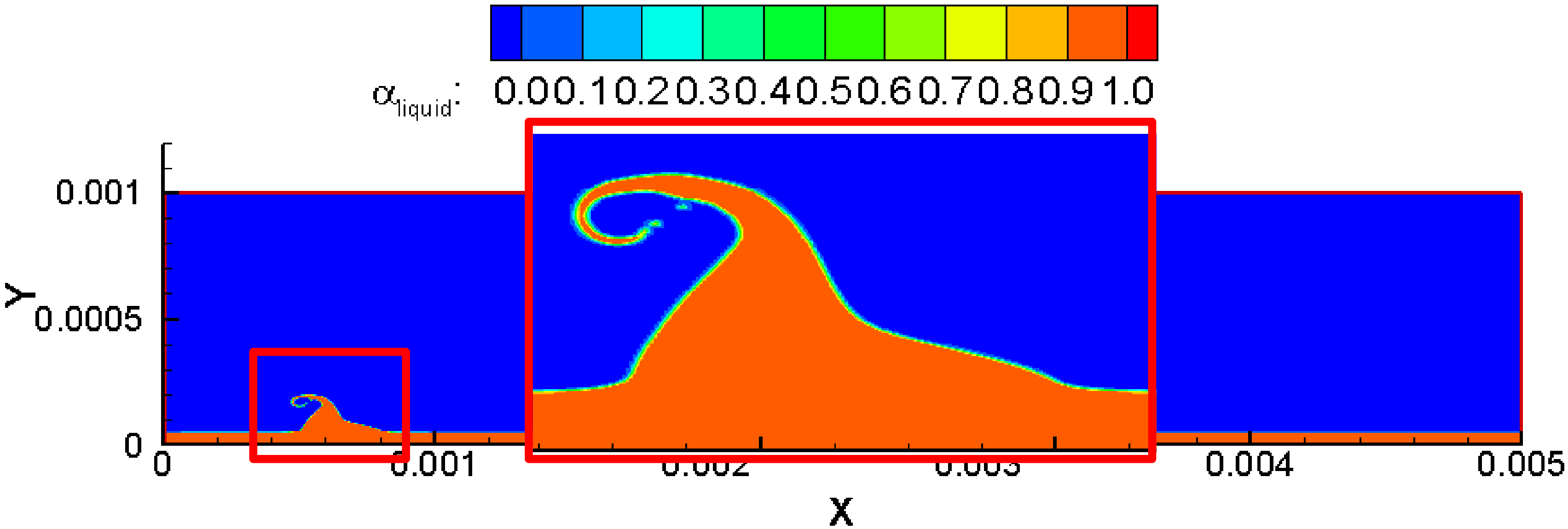
- Set Up 1 (t = **0** s):

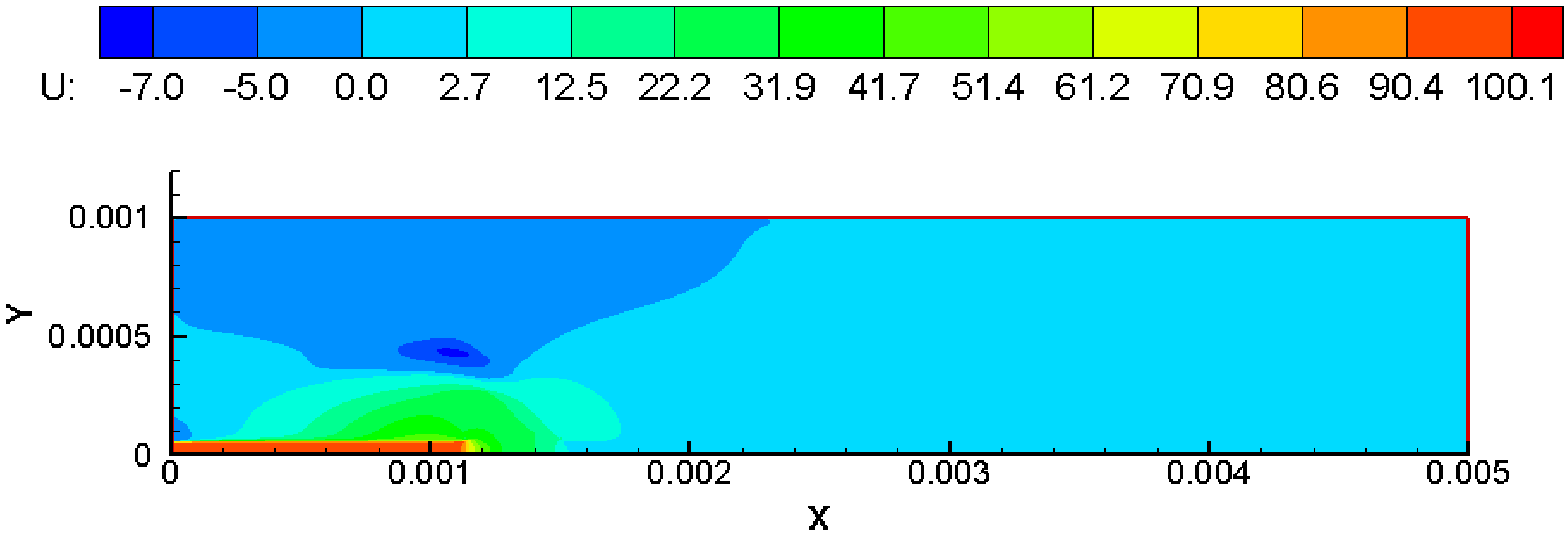




Results

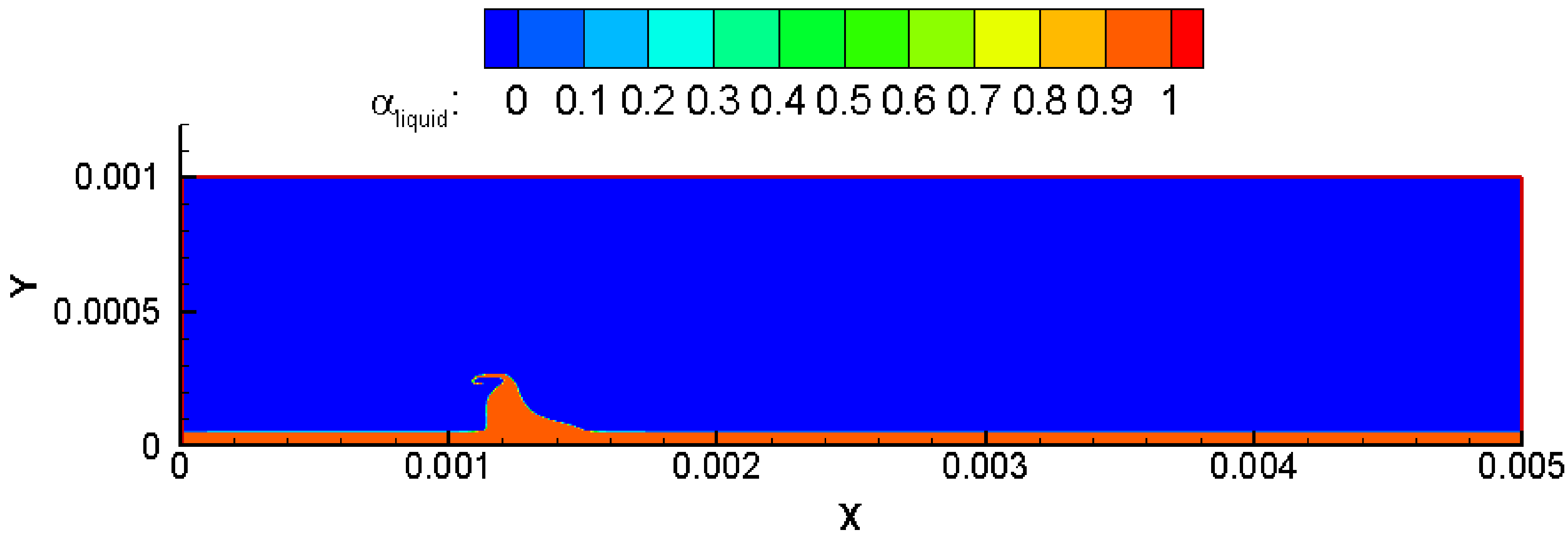
- Set Up 1 (t = **10** μs):

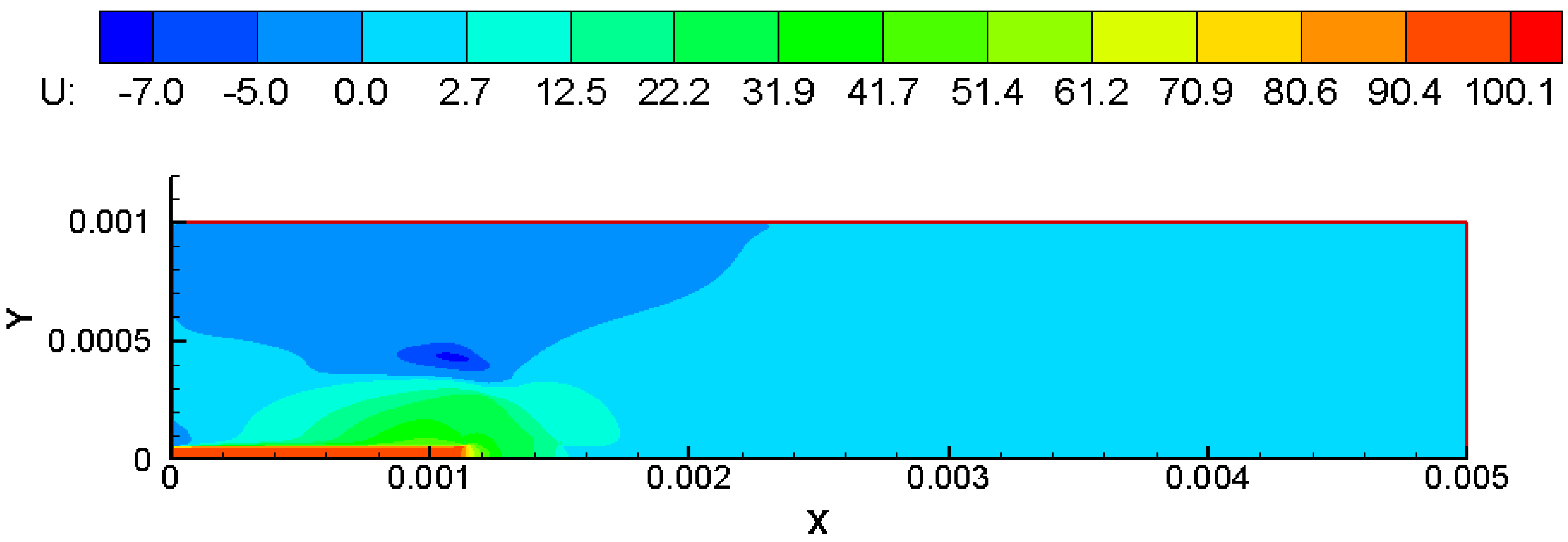




Results

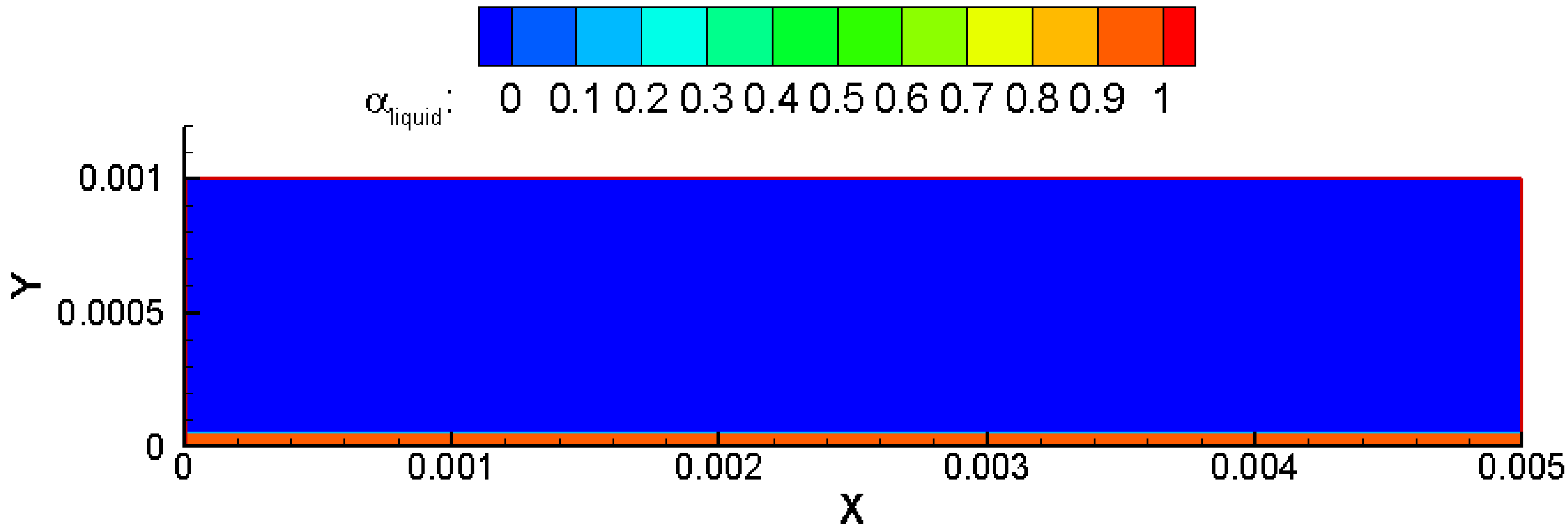
- Set Up 1 (t = **30** μs):

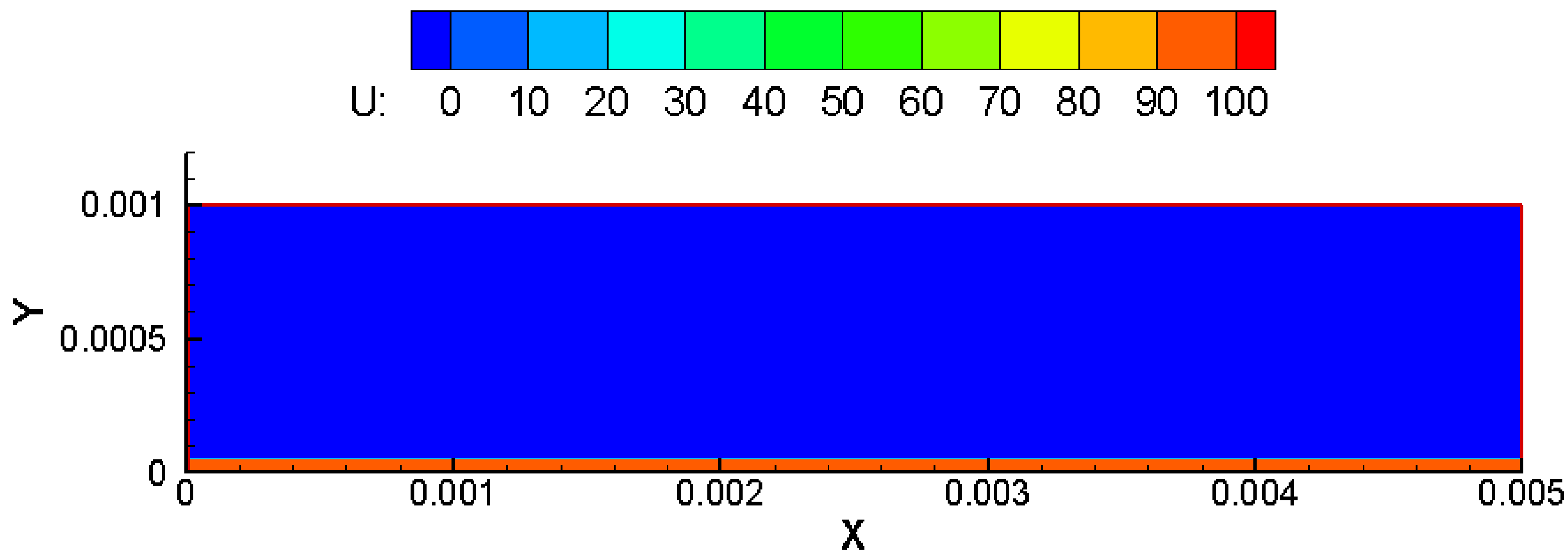




Results

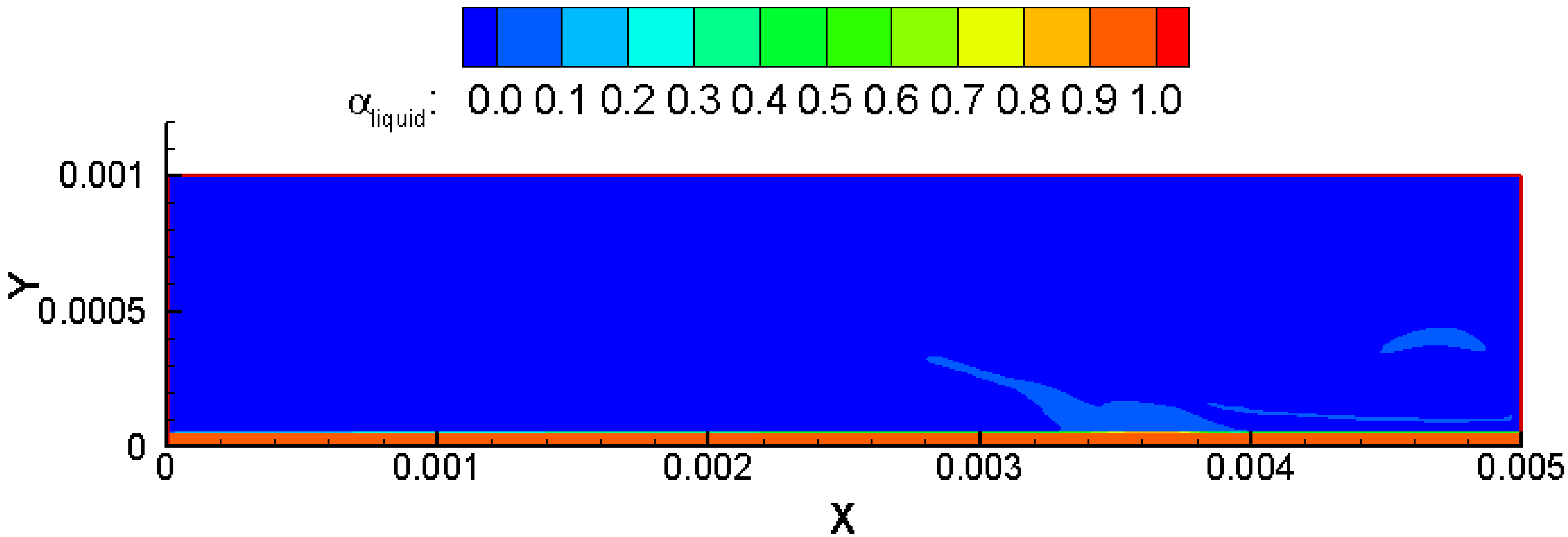
- Set Up 2 (iteration = **0**):

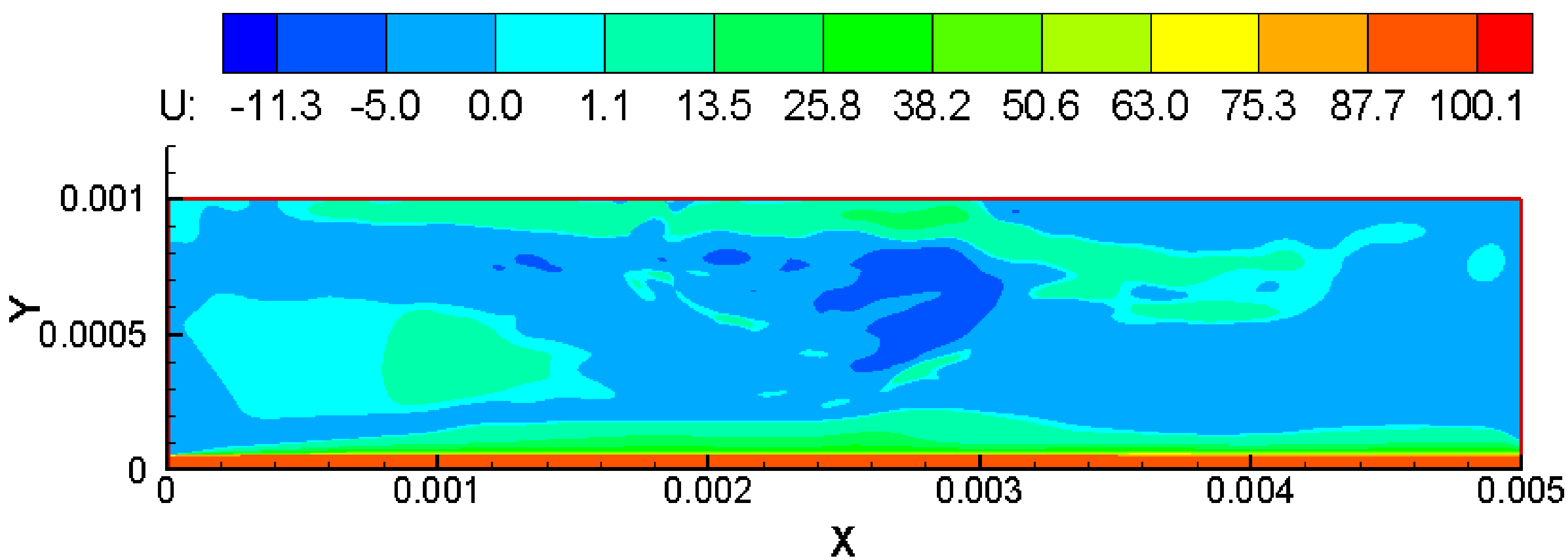




Results

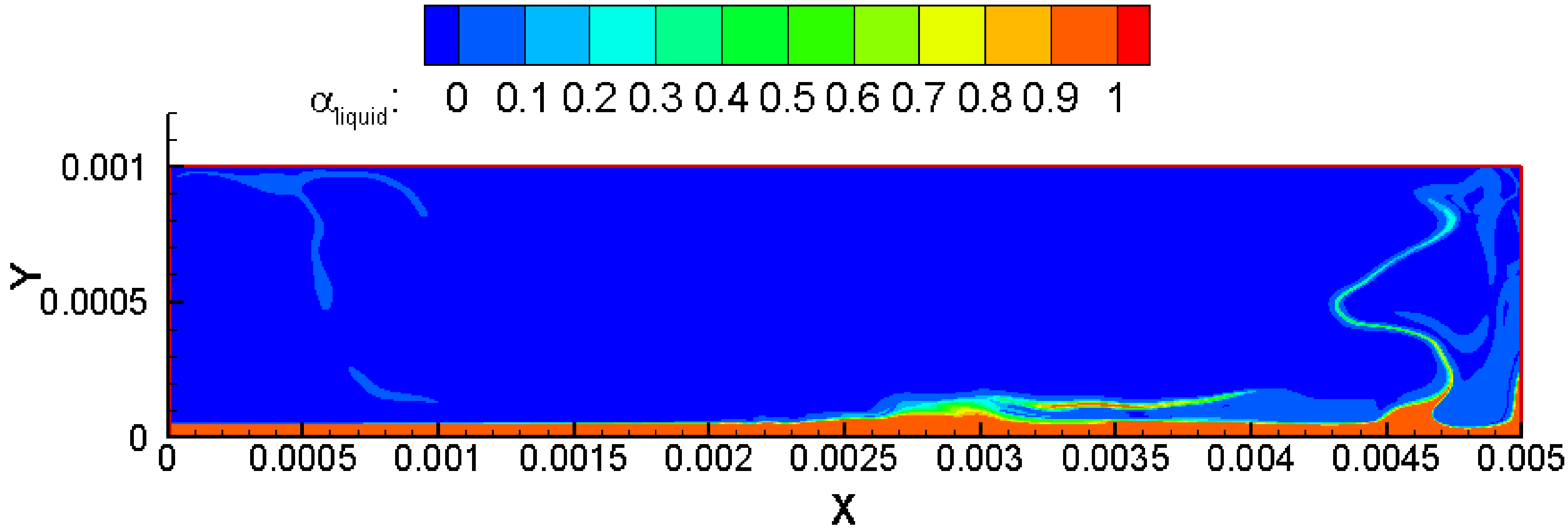
- Set Up 2 (iteration = **1500**): :

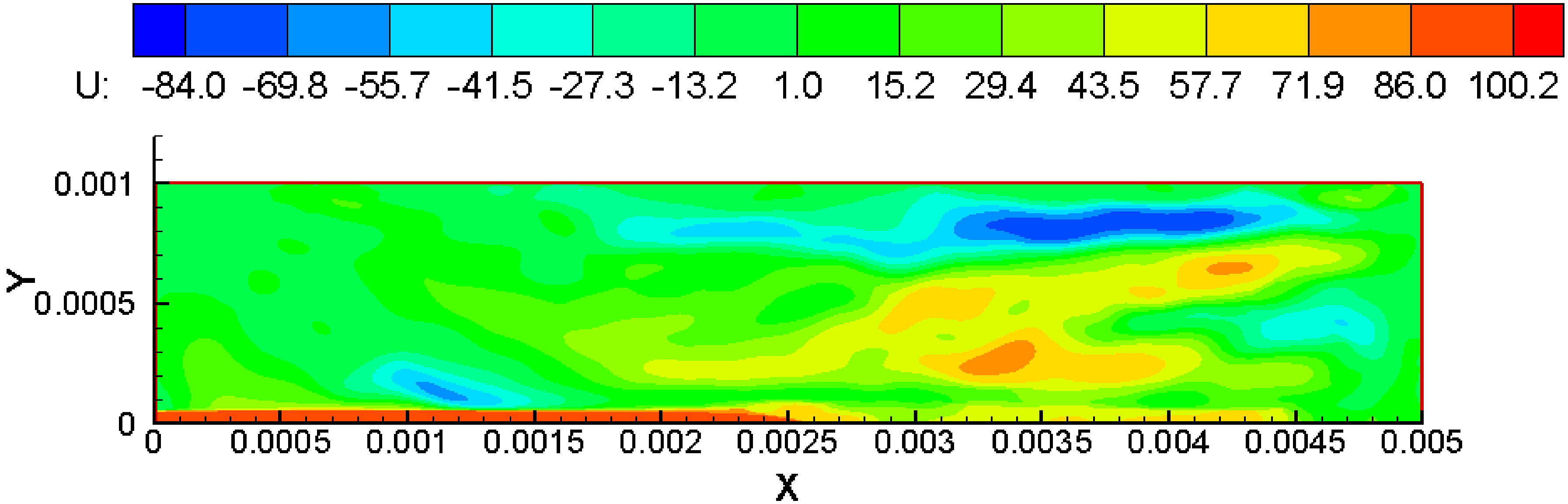




Results

- Set Up 2 (iteration = **3500**) :

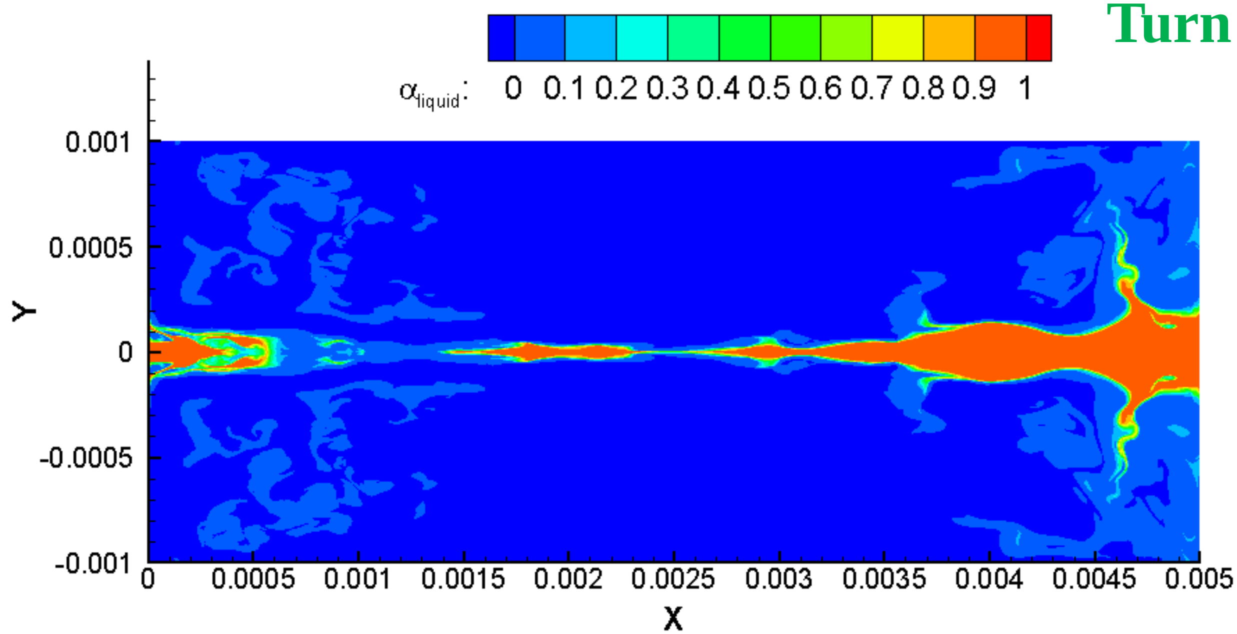


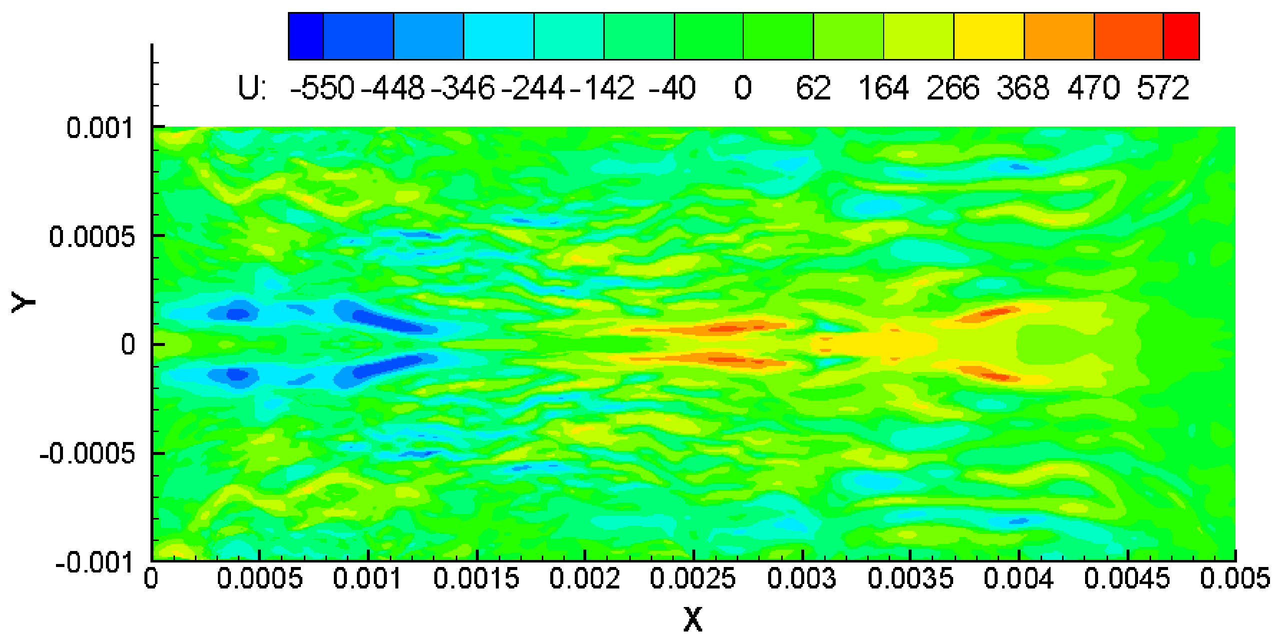


Results

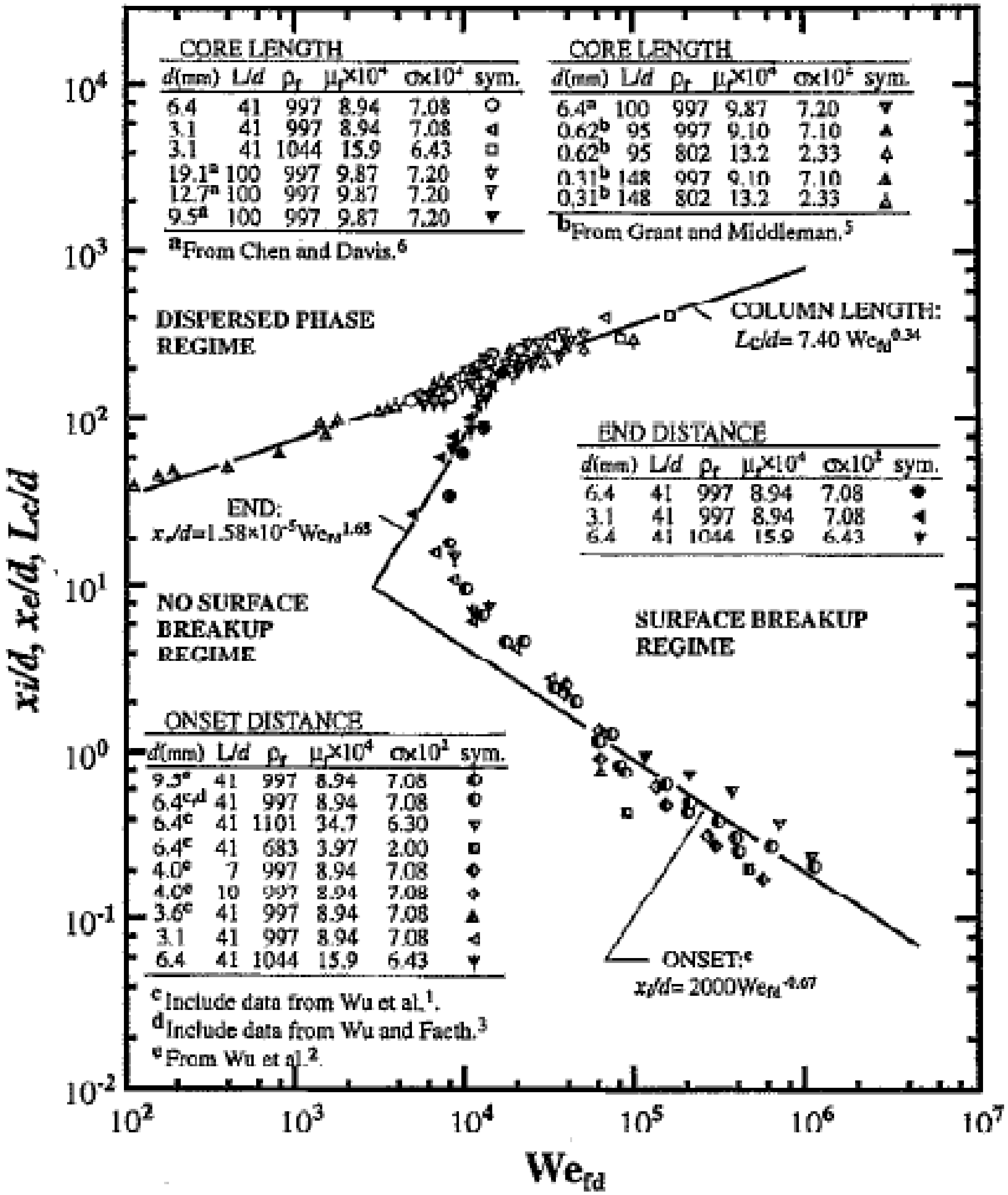
- Set Up 2 (iteration = **4500**) :

Next:
Turn to Unsteady Simulation





More Information



Surface breakup regime map for turbulent liquid jets in still gases when aerodynamic effects are small (liquid/gas density ratios are larger than 500)[2]

Considered Range:

Weber numbers ($We_{fd} = \rho d u_0{}^2/\sigma$) : 1.0X 10^2- 1.1X1 0^6;

Reynolds numbers ($Re_{fd} = \rho_f d u_0{}^2/\mu_f$) : 3.4X$10^3$-8.5X 10^5 ;

Ohnesorge numbers ($OH_d = \mu_f/\rho_f d\sigma$) : 0.001-0.017.

[2] P-K Wu and G M Faeth, Onset and end of drop formation along the surface of turbulent liquid jets in still gases, Phys. Fluids, Vol. 7, No. 11, November 1995

More Information

Problem #	We_{fd}	Re_{fd}	OH_d	$x_i = 2000{We_{fd}}^{-0.67}d$	$x_e = 1.58 \times 10^{-5}{We_{fd}}^{1.68}d$
Problem 1	2,904	50,000	0.001	9.568d	10.387d
Problem 2	11,600	5,800	0.01857	3.783d	106.4d

x_i: location of onset of turbulent breakup;
x_e: location of end of turbulent breakup.