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TVD

Archive of SID

[ ]

[ ]

$k-\varepsilon$

$k-\varepsilon$

[ ]

[ ] [ ]

$$G_v = y \begin{bmatrix} 0 \\ \mu u_y \\ \frac{4}{3} \mu v_y \\ u\tau_{xy} + v\tau_{yy} + \mu \text{Pr}^{-1}(\gamma-1)^{-1} \partial_y a^2 \end{bmatrix} \quad [ ] [ ]$$

( )

$$p = \rho RT, \quad \gamma = \frac{C_p}{C_v}, \quad a = \sqrt{\gamma RT}$$

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$$p = (\gamma - 1) \left[ e - \frac{1}{2} \rho (u^2 + v^2) \right]$$

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$\mu$

$\mu$

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$k-\varepsilon$

[ ]

$$\frac{\partial \bar{Q}}{\partial t} + \frac{\partial \bar{F}}{\partial x} + \frac{\partial \bar{G}}{\partial y} + \bar{S} = \text{Re}^{-1} \frac{\partial \bar{G}_v}{\partial y} \quad ( )$$

[ ]

$$S : \bar{G}_v \quad \bar{Q} \quad \bar{G} \quad \bar{F}$$

TVD

$$\bar{Q} = y[\rho, \rho u, \rho v, \rho e]^T \quad ( )$$

$$\bar{F} = y[\rho u, \rho u^2 + p, \rho uv, (e+p)u]^T \quad ( )$$

$$\bar{G} = y[\rho v, \rho uv, \rho v^2 + p, (e+p)v]^T \quad ( )$$

[ ]

$$\bar{S} = y[0, 0, -p, 0]^T \quad ( )$$

[ ]

ADI

$$\frac{\partial}{\partial t} \int_{\Omega(t)} U d\Omega + \oint_{\Gamma(t)} F d\Gamma = 0 \quad (1)$$

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MUSCL [ ] MCD

$$F = \begin{bmatrix} \rho(u - \dot{x}) \\ \rho(u - \dot{x}) + p \\ \rho E(u - \dot{x}) + pu \end{bmatrix} \quad (2)$$

$$\hat{F}_{j+1/2} = F_{j+1/2}^R + \frac{\Delta t}{2} \left( \frac{\partial F}{\partial t} \right)_{j+1/2}^n \quad (3)$$

$$\Omega_i^{n+1} \bar{U}_i^{n+1} = \Omega_i^n \bar{U}_i^n - \Delta t [\hat{F}_{j+1/2} - \hat{F}_{j-1/2}] \quad (4)$$

$$\hat{F}_{j+1/2} = \int_{t^n}^{t^{n+1}} F[U(x_{j+1/2}, \dot{x}_{j+1/2}, t)] dt \quad (5)$$

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$$L_y^{\Delta t} \quad L_x^{\Delta t} \quad L_{yv}^{\Delta t} \quad y \quad x \quad t^n$$

$$U^n(x, t^n) = \bar{U}_j^n + \frac{x - x_j}{2} S_j^n \quad (6)$$

$x \in [x_{j-1/2}, x_{j+1/2}]$

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$$\bar{U}_{j,k}^{n+1} = L_{yv}^{\Delta t/2} L_y^{\Delta t/2} L_x^{\Delta t} L_y^{\Delta t/2} L_{yv}^{\Delta t/2} \bar{U}_{j,k}^n \quad ( )$$

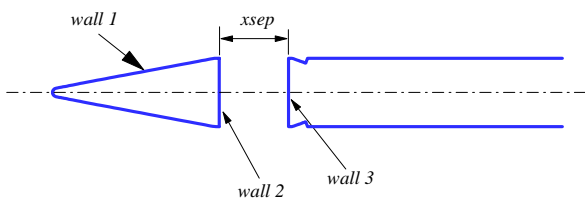
$$: L_x^{\Delta t} \bar{U}_{j,k}^n$$

$$L_x^{\Delta t} \bar{U}_{j,k}^n = \bar{U}_{j,k}^n - \frac{\Delta t}{\Delta x} [\hat{F}_{j+1/2,k} - \hat{F}_{j-1/2,k}] \quad ( )$$

Archive of SID

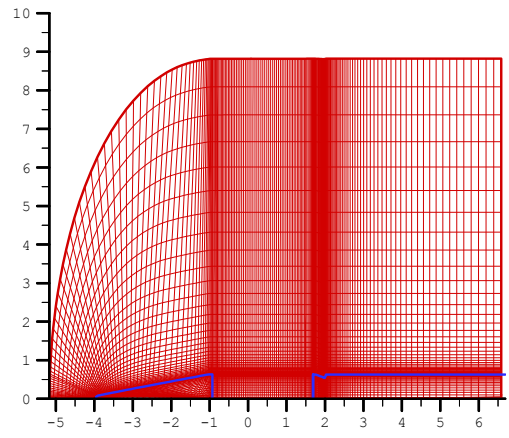
$M_\infty =$

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K kPa

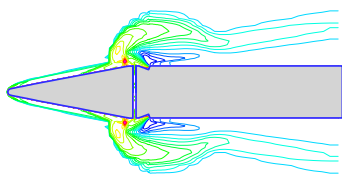
$$M_{jet} = \quad P_0 = \quad kPa \quad \rho = 1 \quad kg/m^2$$

$$T = \quad / \quad K$$

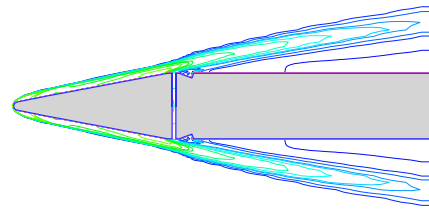
( )

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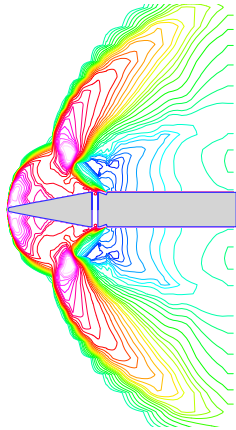
( )



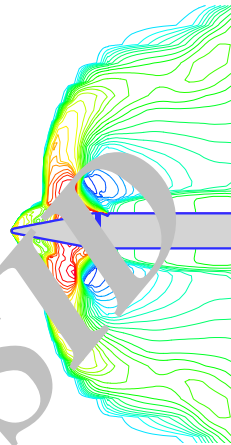
$t=0.00027 \text{ sec}$



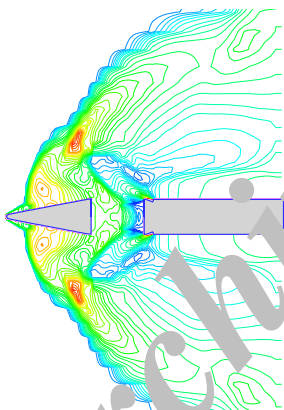
$t=0.0 \text{ sec}$



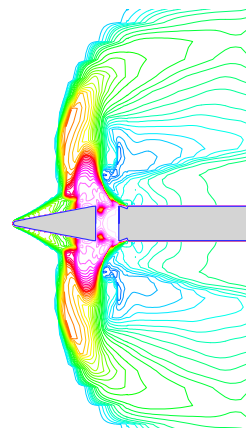
$t=0.0181 \text{ sec}$



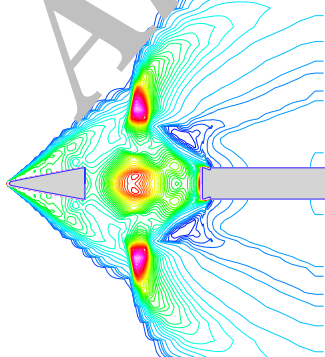
$t=0.00720 \text{ sec}$



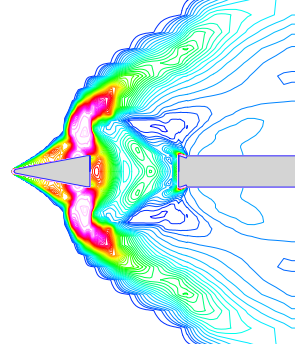
$t=0.01636 \text{ sec}$



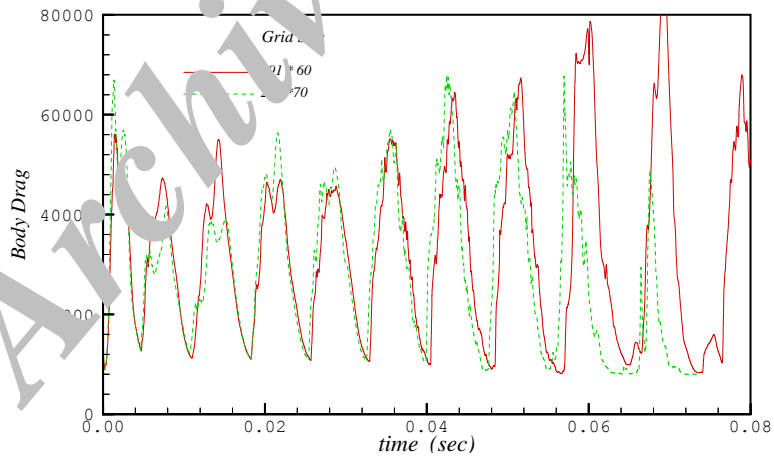
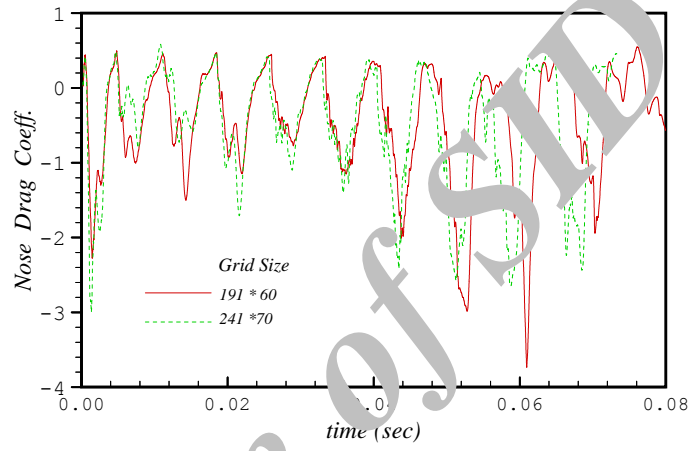
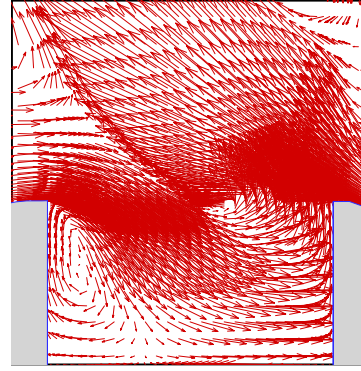
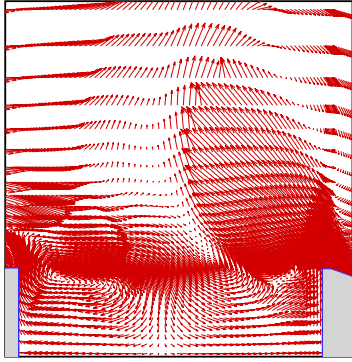
$t=0.0433 \text{ sec}$

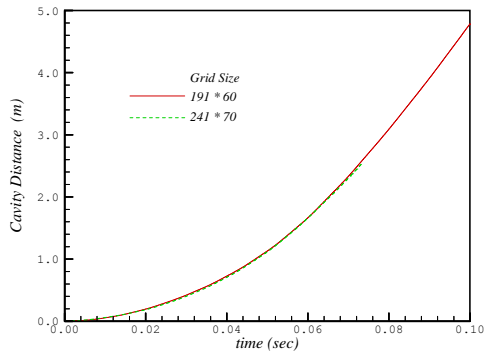


$t=0.1004 \text{ sec}$

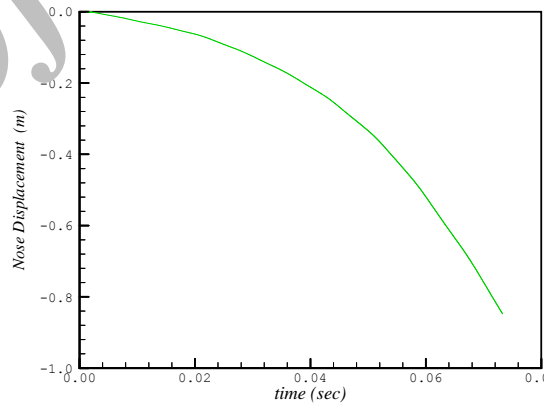


$t=0.0862 \text{ sec}$

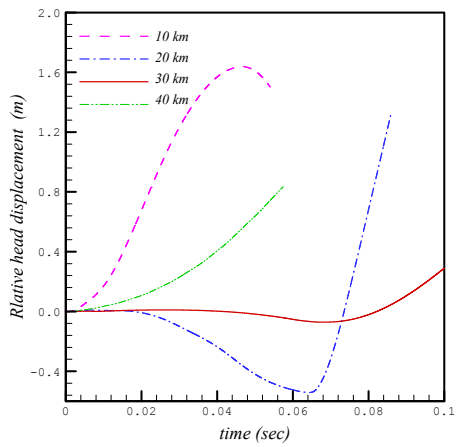
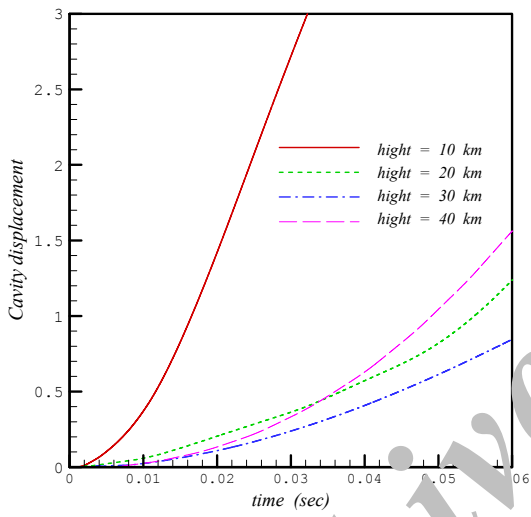
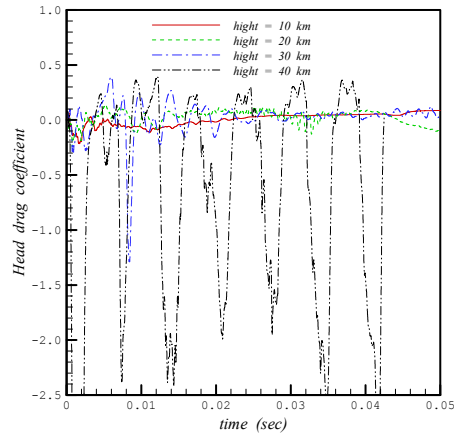




	<i>kPa</i>	<i>K</i>	<i>kg/m<sup>3</sup></i>
<i>km</i>	/	/	/
<i>km</i>	/	/	/
<i>km</i>	/	/	/
<i>km</i>	/	/	/







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:  $a$   
:  $c_p$   
:  $c_v$   
:  $e$   
:  $G$   $F$   
:  $G_v$   
:  $k$   
:  $M$   
:  $p$   
:  $Pr$   
:  $Q$   
:  $R$   
:  $Re$   
:  $S$   
:  $T$   
:  $t$   
:  $v$   $u$   
:  $y$   $x$   
:  $\Gamma$   
:  $\gamma$   
:  $\mu$   
:  $\rho$   
:  $\tau$   
:  $\Omega$

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- 1 - Hypersonic
- 2 - Under-Expanded Jet
- 3 - Cavity Flow
- 4 - Moving Boundary
- 5 - Separation Shock
- 6 - Body Bow Shock
- 7 - Jet Bow Shock