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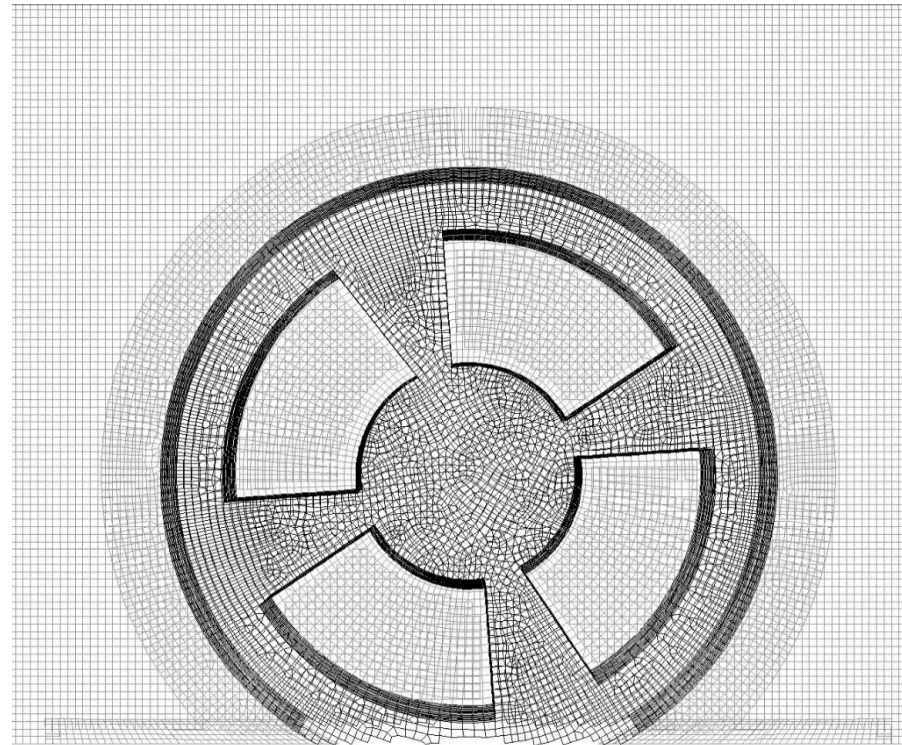
# ANSYS Fluent重叠网格介绍

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ANSYS

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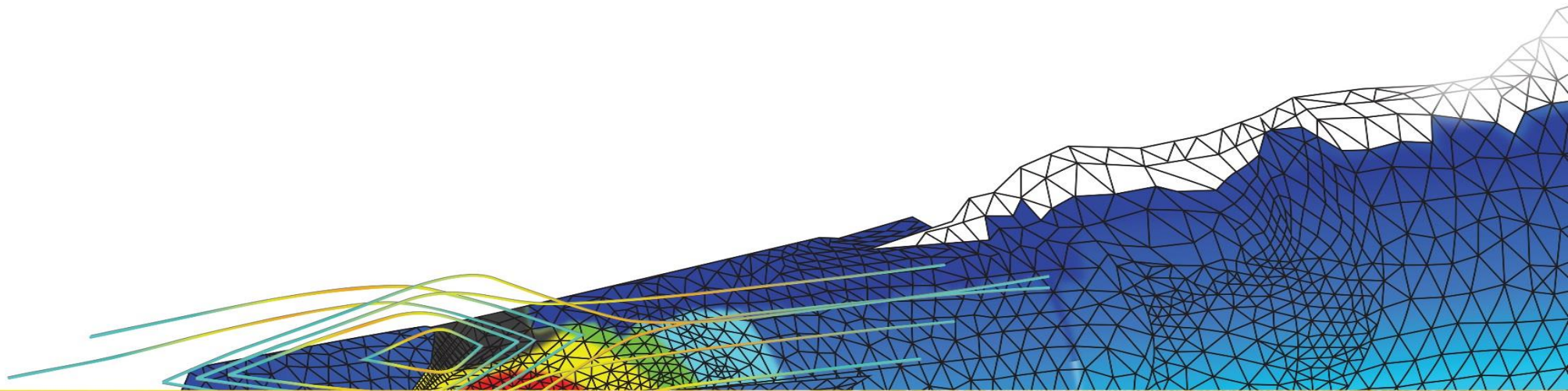
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- **案例展示**





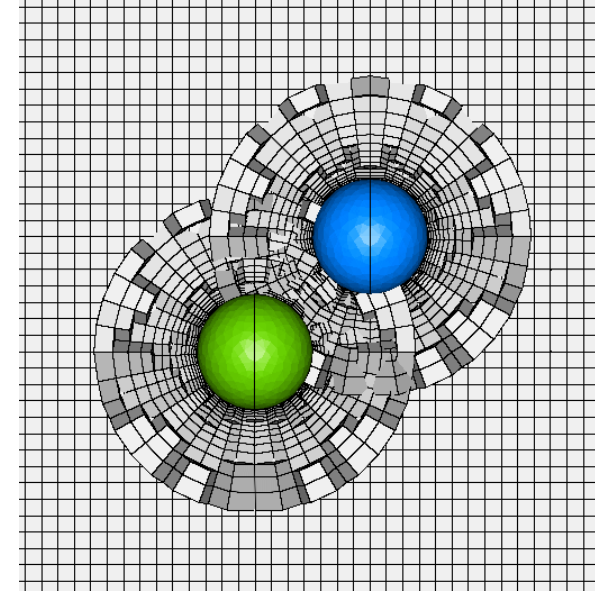


# 理论介绍



# 重叠网格介绍

- **Connect cell zones by interpolating cell data in overlapping regions**
  - ✓ Different from standard non-conformal (face zone) interfaces
- **Sufficient mesh overlap is important**
- **Enables:**
  - ✓ Structured mesh around individual parts
  - ✓ Part swapping
  - ✓ Moving cell zones without having to use re-meshing or smoothing  $\beta$
- **Note:**
  - ✓ Poorly designed meshes can lead to an invalid overset interface
  - ✓ The data interpolation between cell zones is not conservative and can lead to decreased accuracy compared to a similar conformal grid
  - ✓ Well designed meshes should however give good results

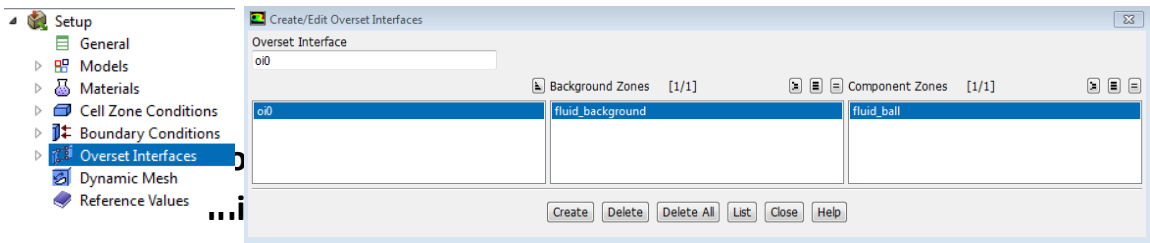


Independently generated prism grids around spheres overlap each other and the Cartesian background grid.

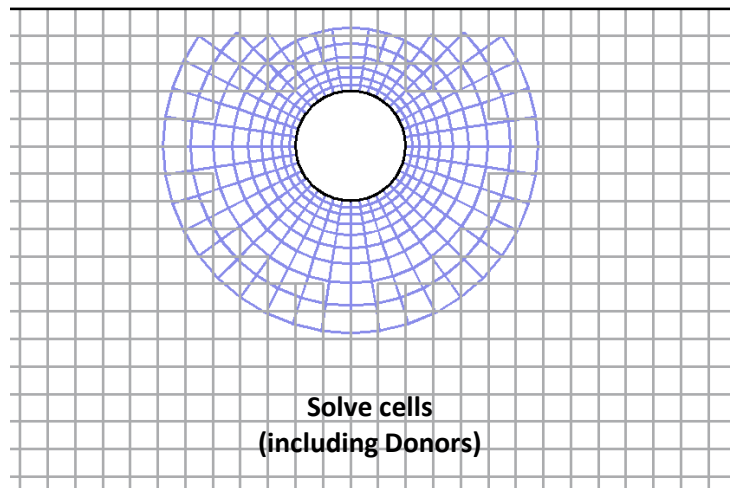
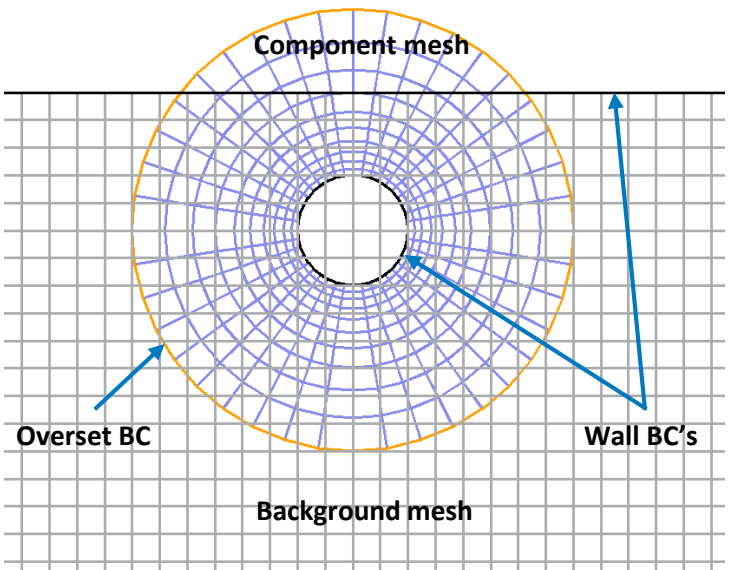
*Picture courtesy of POINTWISE*

# 重叠网格, 基础

- **An overset interface needs to have:**
  - ✓ At least one background & one component mesh
  - ✓ Each component mesh needs to have an overset BC
- **The interface can be setup in the UI**

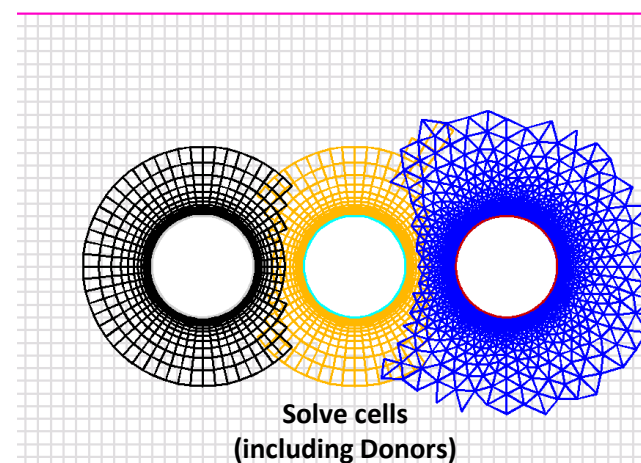
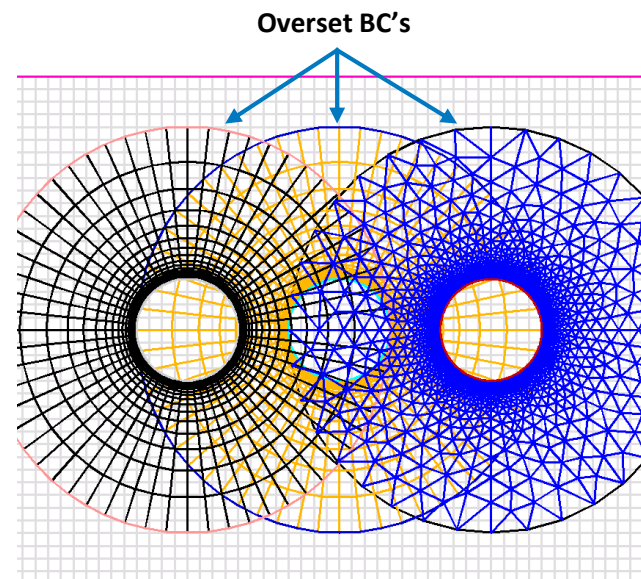


- ✓ *“Dead cells”*: cells that fall outside of the domain
- ✓ *“Solve cells”*: where flow equations are solved
  - *“Donor cells”*: subset of solve cells, sending data to:
- ✓ *“Receptor cells”*: cells receiving interpolated data



# 重叠网格的拓扑

- **There is no limit to the number of cell zones that can participate in an overset interface**
  - ✓ Regarding the participating cell zones:
    - Background zones:
      - Cannot have an overset BC
      - Must be conformal to other background zones
      - Can have non-conformal interfaces to zones that are not included in the overset interface
    - Component zones:
      - Must overlay background zones
      - Need an overset BC near where they connect to other zones
      - Cannot be part of a non-conformal interface
- **All cell types supported by Fluent are supported with Overset meshing**  
(including poly)
- **Compatible with mesh adaption**

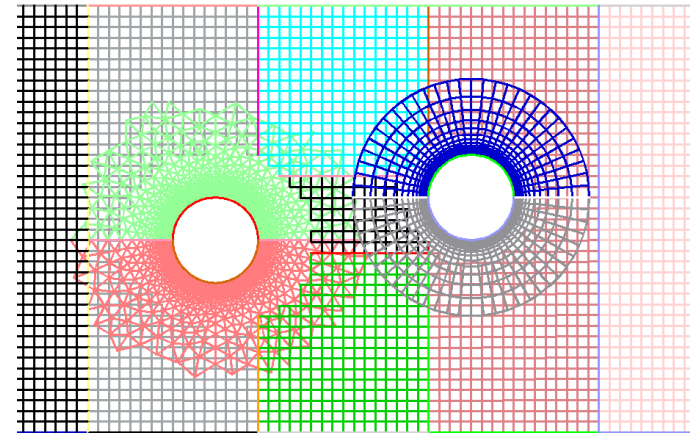
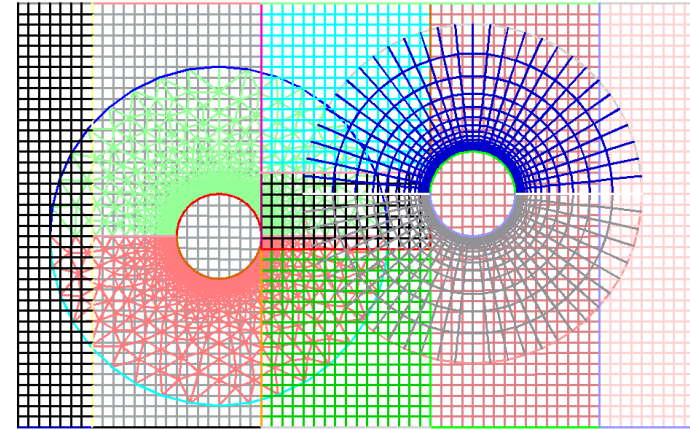




# 重叠网格的拓扑

- **A case can have multiple overset interfaces**
  - ✓ But, a cell zone can only participate in one interface
  - ✓ Defining multiple interfaces rather than one large interface can improve efficiency (if topology allows)
- **Remember that non-conformal interfaces aren't supported**
  - ✓ Except for connecting a background mesh to a cell zone that are not included in the overset interface
  - ✓ Conformal background and component meshes are used in the example to the right

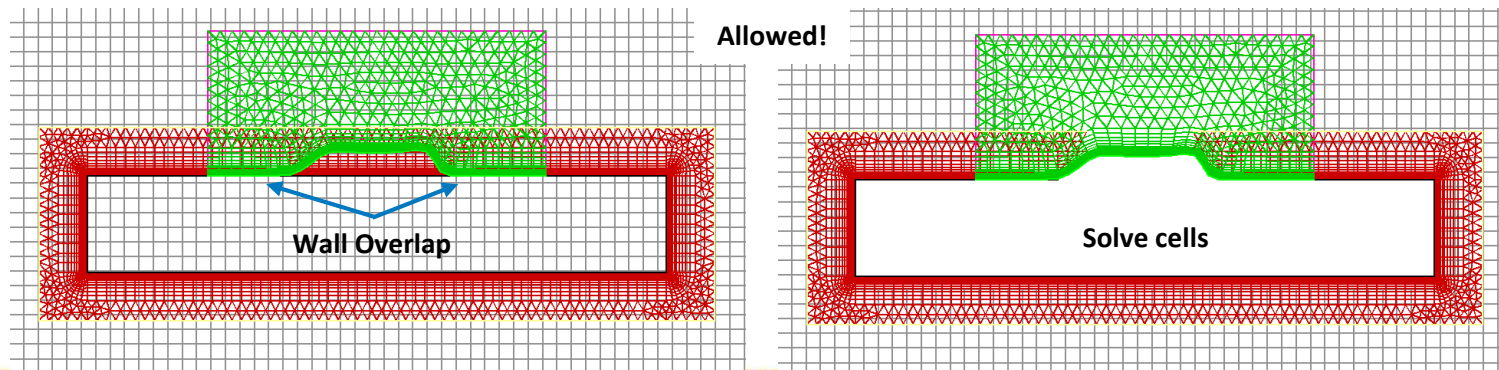
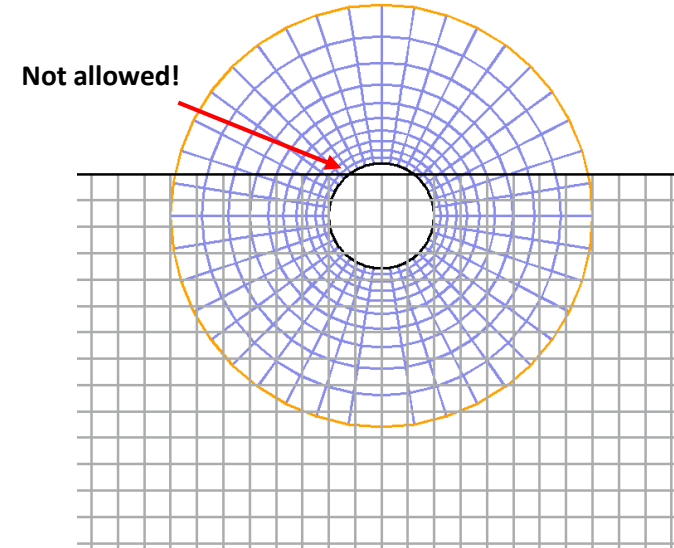
Multiple background and component meshes



Solve cells

# 重叠网格的拓扑

- **The Overset technique has an important topological constrain**
  - ✓ Physical boundaries (e.g. walls, inlets, outlets symmetries etc.) are not allowed to intersect with each other
- **Physical boundaries are allowed to overlap**
  - ✓ A wall boundary can be coincident with an other wall boundary
  - ✓ The coincident boundaries cannot cross or penetrate
  - ✓ This is a powerful feature that allows you to build a continuous body from overlapping meshes

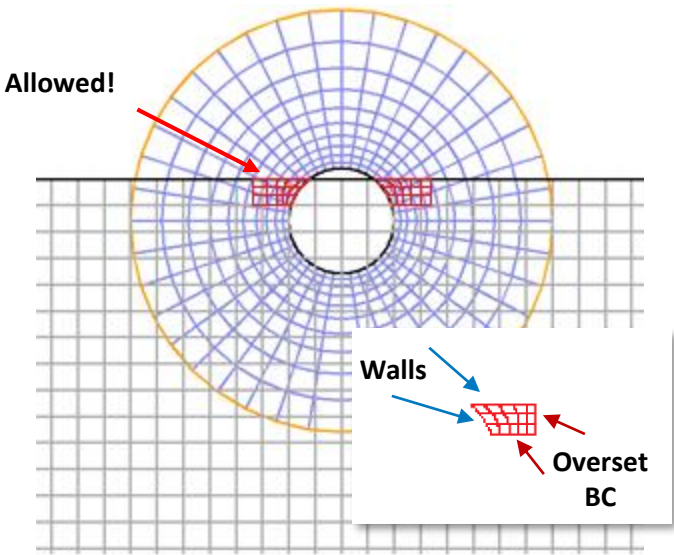




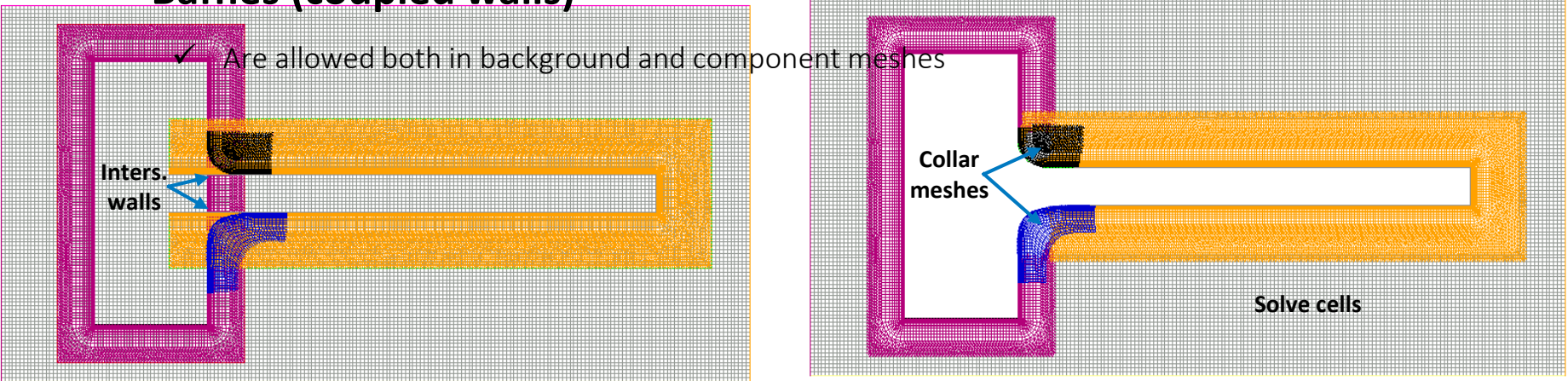
# 重叠网格的拓扑

- Collar mesh

- ✓ For cases where intersecting physical boundaries cannot be avoided (not allowed)
- ✓ An additional component mesh that “bridges” the intersecting physical boundaries
- ✓ Creates a case with overlapping boundaries (allowed)



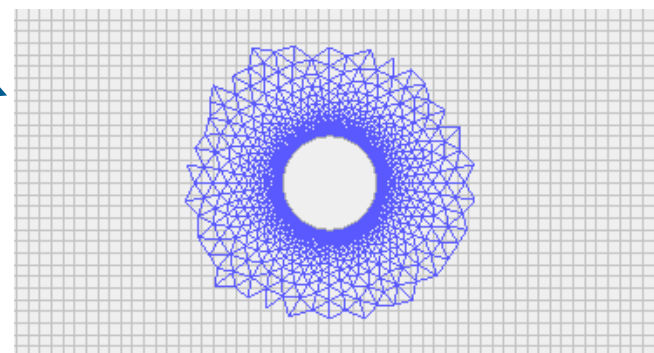
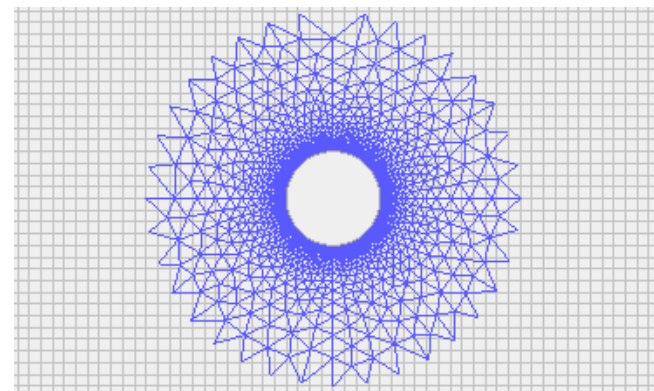
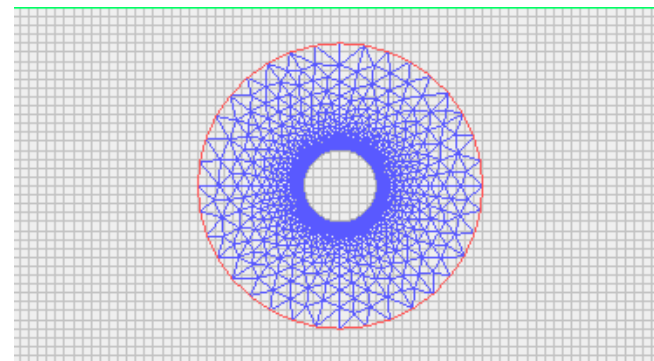
- Baffles (coupled walls)



# 重叠网格的连接性

- **Interface initialization includes:**

- ✓ Hole cutting
  - Cells outside of the computational domain marked as dead cells
- ✓ Overlap minimization
  - Minimize the “active” mesh overlap
- ✓ Donor search
  - Finding valid solve cell donors for each receptor



# 重叠网格的连接性

- **Hole Cutting**
  - ✓ Seed cells are identified in regions that are cut by physical boundaries (wall, inlet, outlet, etc.) and that are determined to lie outside of the flow domain
  - ✓ All dead cells are then identified by “flood filling” from the seed cells to physical boundaries
  - ✓ The result of this hole cutting is a valid overset mesh with maximum mesh overlap
- **Overlap Minimization**
  - ✓ The maximum overlap can be minimized by changing cell status:  
solve cells changed to receptors and unnecessary receptors changed to dead
  - ✓ The interface position seek a an area where the meshes are comparable in size
  - ✓ Works best if the component mesh is fine near the walls and increases away from the walls
  - ✓ No minimization will occur if the meshes have uniform and almost identical mesh size
  - ✓ Can be disabled in the TUI  
*define/overset-interfaces/options/minimize-overlap?*



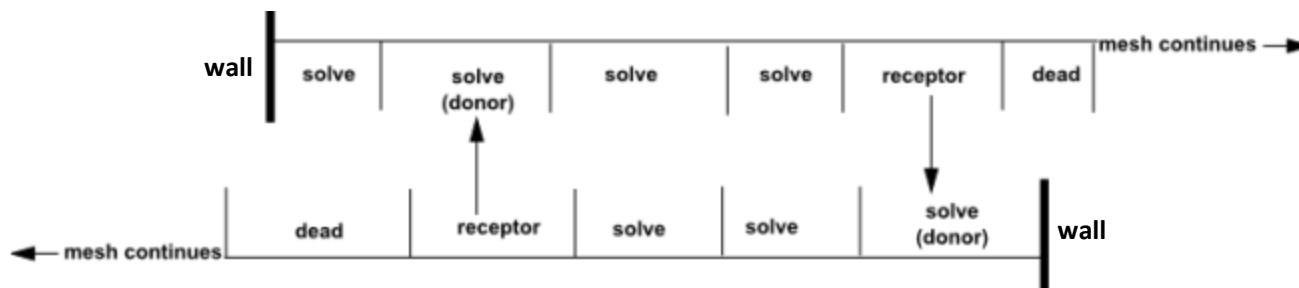
# 重叠网格的连接性

- **Grid Priorities**

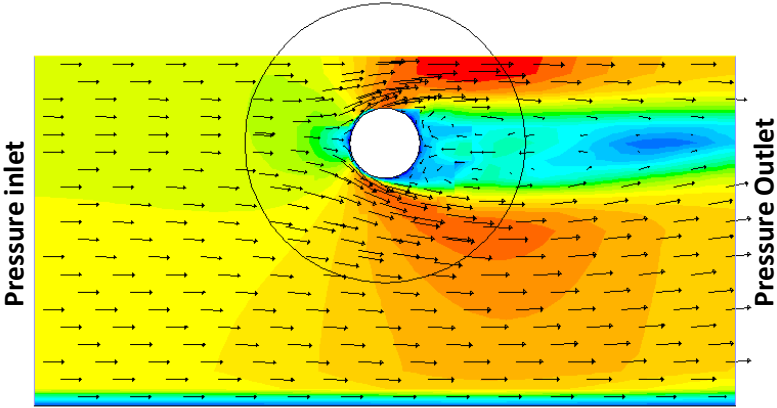
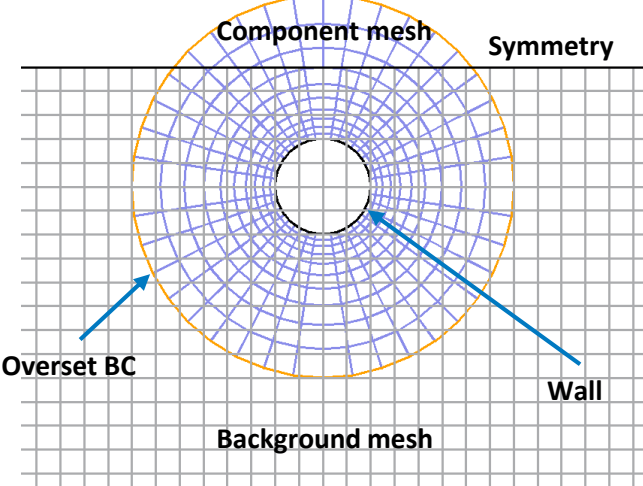
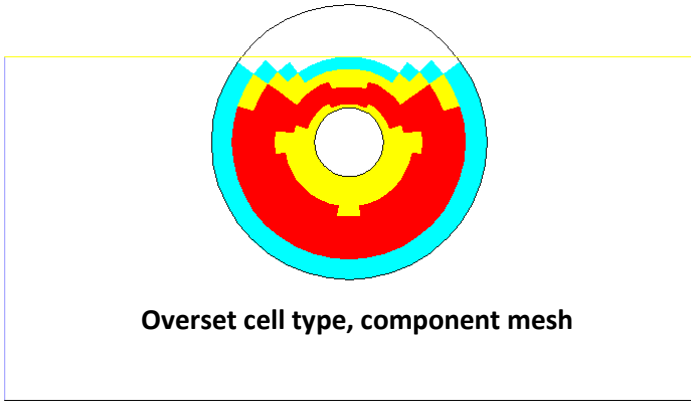
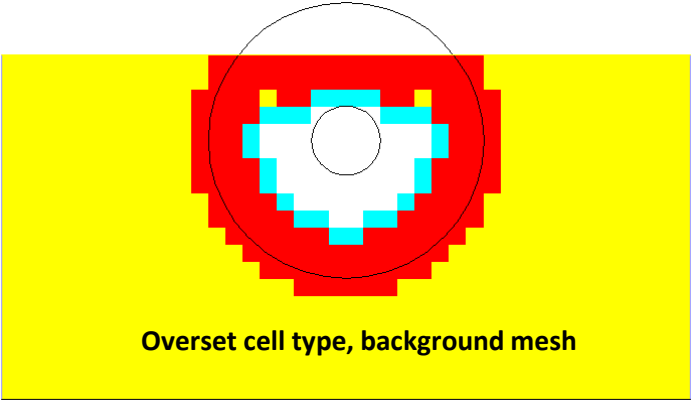
- ✓ Grid priorities gives some control over the overlap minimization
- ✓ Meshes with higher grid priority are favored during the minimization

- **Donor Search**

- ✓ The final step of the overset mesh connectivity is to search for valid solve cells (donors) to each receptor cell
- ✓ There must be four or more cells in the overlap for both meshes to ensure successful donor search



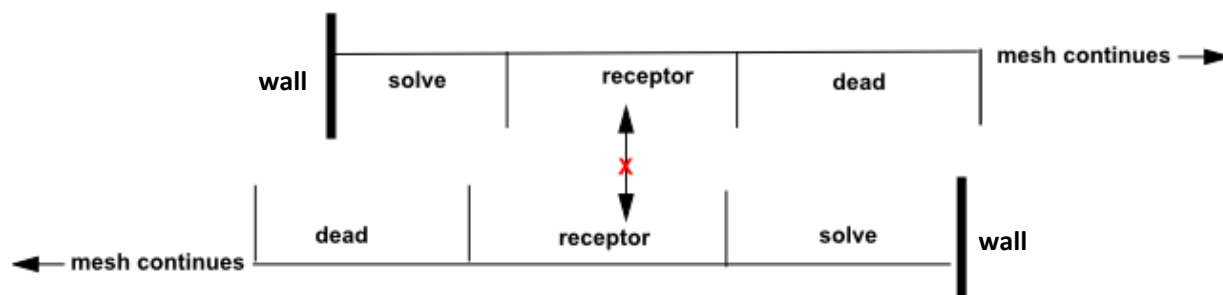
# 重叠网格的连接性



Mass imbalance < 1%

# 重叠网格的诊断

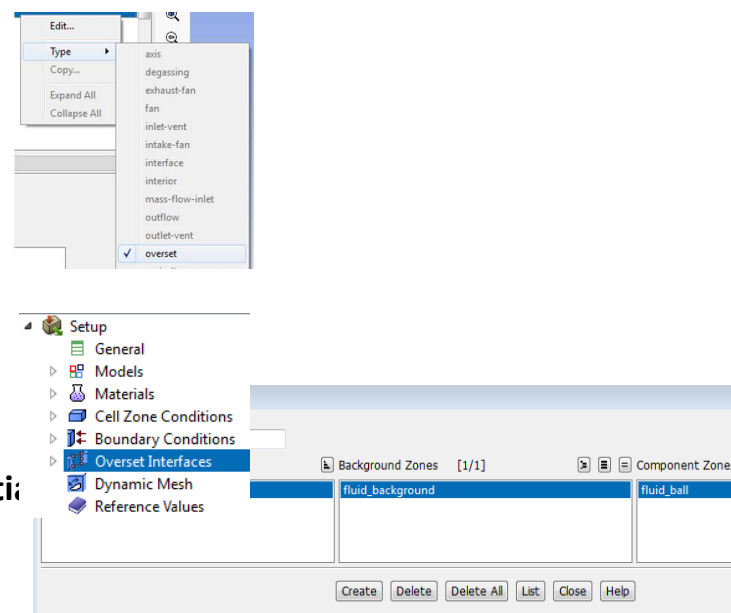
- ✓ It is not always easy to generate meshes that avoids problems during overset initialization
- ✓ When problems occur, it's often required to generate new meshes after analyzing the failure
- ✓ Always list the interface information with increased verbosity to get a good report of the interface
- Debug hole cutting failure (entire cell zones are filled with dead cells):
  - **Incorrect seed cells? Turn on expert tools and use *define/overset-interfaces/debug-hole-cut* (with *flood filling disabled*) to identify problematic seed cells. Seed cells should NOT be in the fluid region.**
  - **Leakage at overlapping physical boundaries? Use *define/overset-interfaces/debug-hole-cut* (with *flood filling*) to mark the flood filled dead cells**
- Debug donor search failure (Orphan cells being reported during initialization)
  - **Mark the orphan cells with *define/overset-interfaces/mark-cells***
  - **The reason for orphans cells are often insufficient mesh overlap or large difference in mesh sizes**





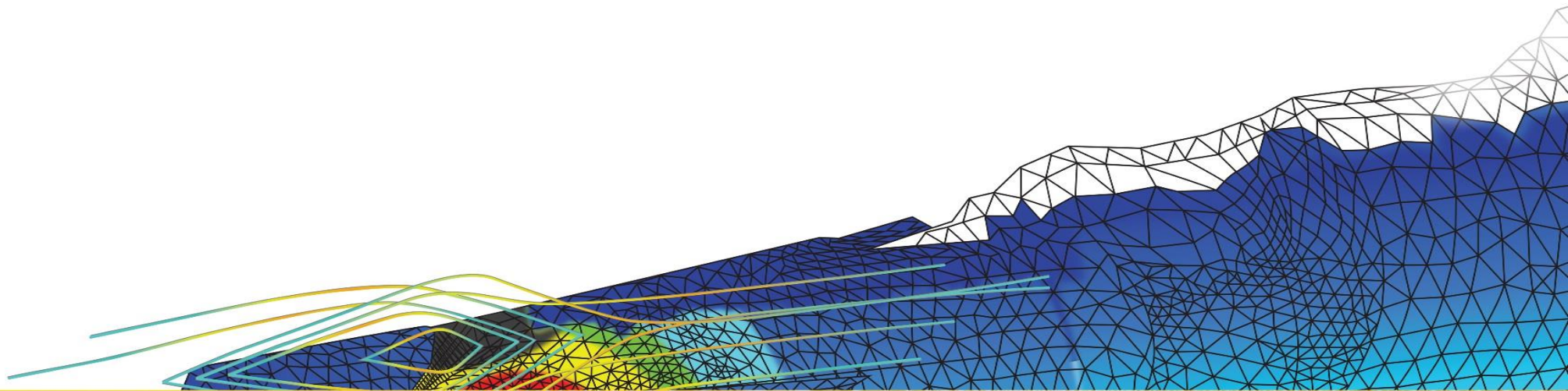
# 重叠网格的设置

- Read all related meshes into fluent
- Set the overset boundary condition
- Create the interface
  - ✓ Select background and component meshes
- Define grid priorities if needed
  - ✓ *define/overset-interfaces/grid-priorities*
- Initialize to intersect the interface
  - ✓ Or use TUI command to intersect the interface without initializing the flow field (activate expert options first)  
*define/overset-interfaces/intersect*
- An overset interface will automatically be created during initialization



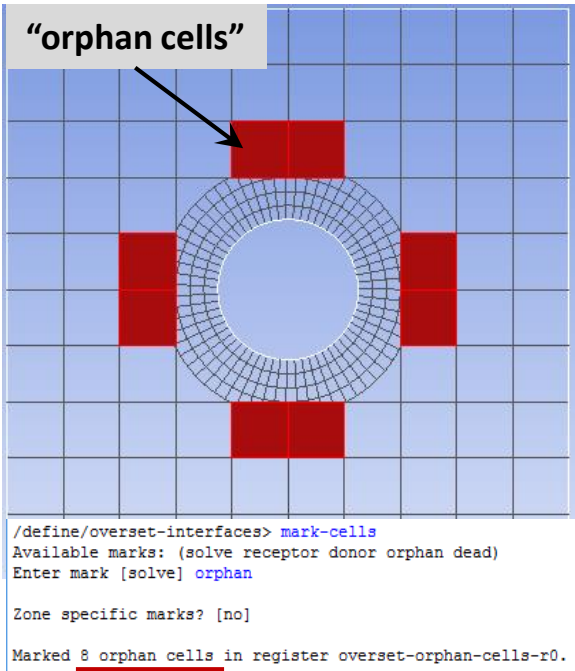
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**设置推荐**

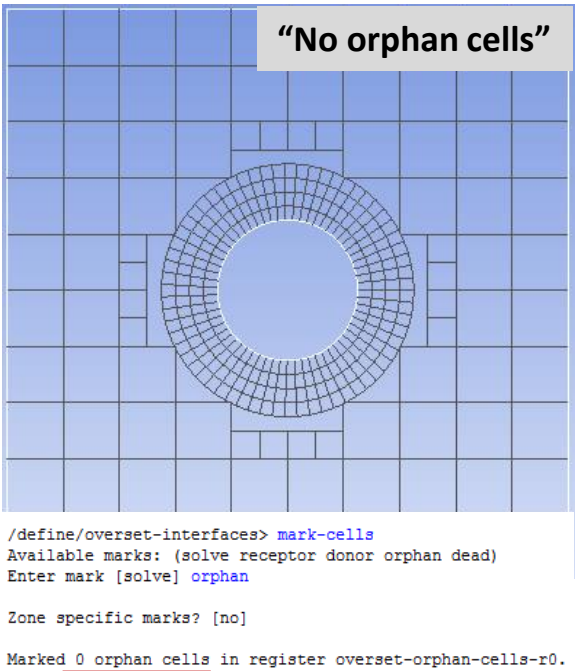


# 重叠网格设置推荐

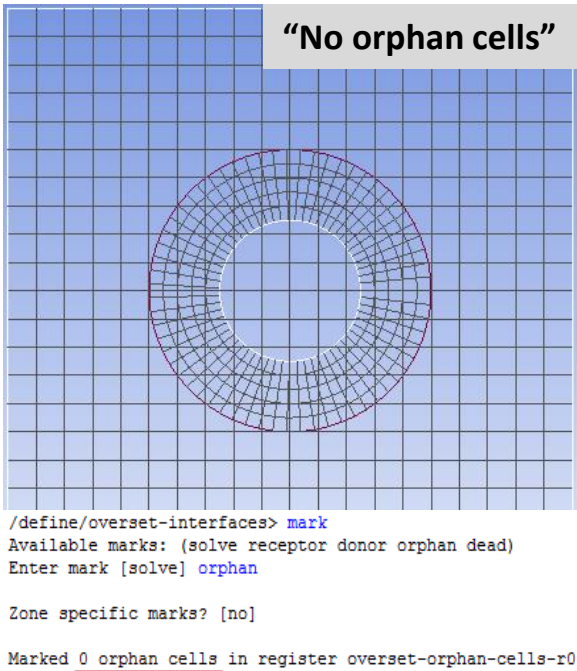
- Receptor and Donor cell sizes should be comparable to minimize interpolation error and to create a valid overset interface
  - Disparate cell sizes may create orphan cells
  - Use manual mesh adaption or refinement to reduce the mesh mismatch



8 mm / 2 mm



Marked orphan cell adapted manually

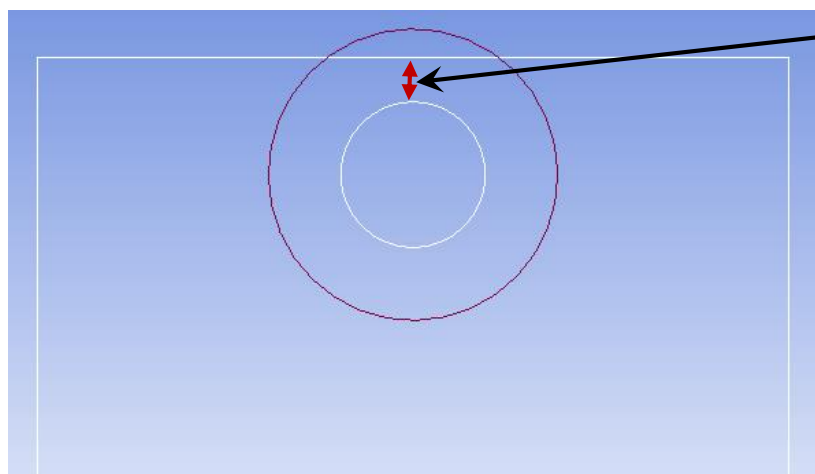


4 mm / 2 mm

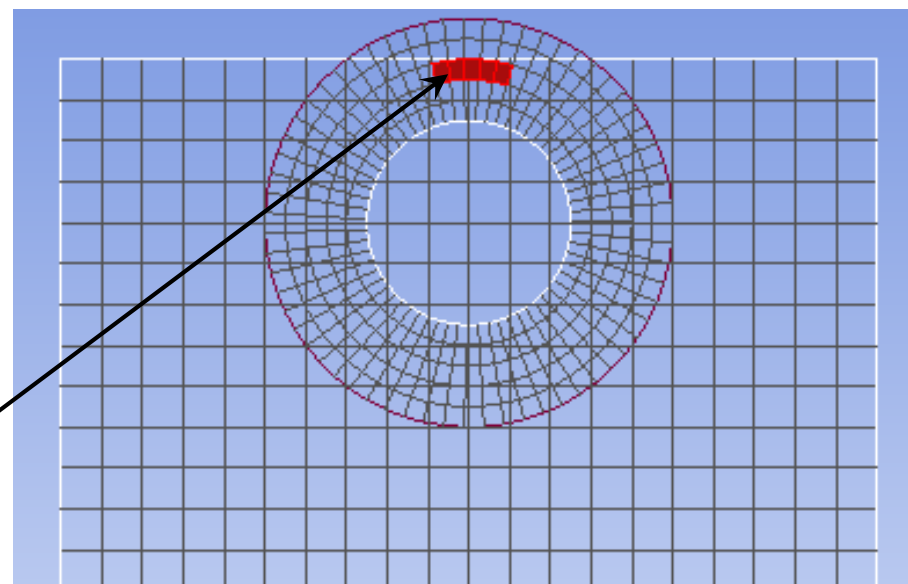


# 重叠网格设置推荐

- Must have minimum of four cells in the gap to create valid overset mesh interface
  - Higher number of cells in the gap is recommended to ensure robust coupling between meshes



Must have minimum **4 cells** in each mesh in this gap



Less than 4 cells in each mesh  
can result in creation of  
**Orphan cells**

## 重叠网格设置推荐

- It is recommended to start transient simulations from a converged steady-state solution
- In case of start up issue with steady-state cases, it is recommended to ramp-up to the final boundary conditions
- While using automatic time-step calculation for the pseudo-transient method, it is recommended to use the user-defined length scale option

***Note:***

***Principal Axes*** is the default partitioning method for overset meshing

# 重叠网格设置推荐

- When using moving meshes  $\beta$ , select time step size  $\sim$  moving the smallest cell (in the overset interface) one cell length per time step

✓ If the time step is too large, dead cells will directly turn into solve cells without first being a receptor. This information is printed in the TUI:

```
Updating solution at time level N... done.
```

```
Updating overset interface o-if.
```

```
WARNING: 951 overset dead->solve cells in interface o-if.
```

iter	continuity	x-velocity	y-velocity	z-velocity	k	epsilon	surf-mon-1	surf-mon-2	time/iter
240	4.6721e-03	3.6292e-05	5.0243e-05	3.3826e-05	8.3157e-04	6.9187e-04	1.1554e+01	1.2119e+01	0:00:39 10
241	1.9478e-01	1.3629e-03	1.4206e-03	1.3155e-03	1.2627e+00	3.7917e+00	1.2844e+01	1.3364e+01	0:00:32 9
242	9.1586e-02	8.3932e-04	9.6232e-04	7.8482e-04	6.7096e-02	5.7639e-02	1.2908e+01	1.3428e+01	0:00:27 8
243	4.4753e-02	4.0263e-04	4.3435e-04	3.8380e-04	3.9938e-03	2.1586e-03	1.2532e+01	1.3072e+01	0:00:25 7
244	2.4027e-02	2.7077e-04	2.8110e-04	2.5905e-04	1.0110e-03	1.6787e-03	1.2196e+01	1.2749e+01	0:00:22 6
245	1.7354e-02	1.9456e-04	2.0549e-04	1.7716e-04	8.8818e-04	1.4884e-03	1.2000e+01	1.2561e+01	0:00:18 5

✓ The transient moving mesh simulation won't stop due to orphans. Make sure that the solution looks reasonable for that time step

```
Updating solution at time level N... done.
```

```
Updating overset interface o-if.
```

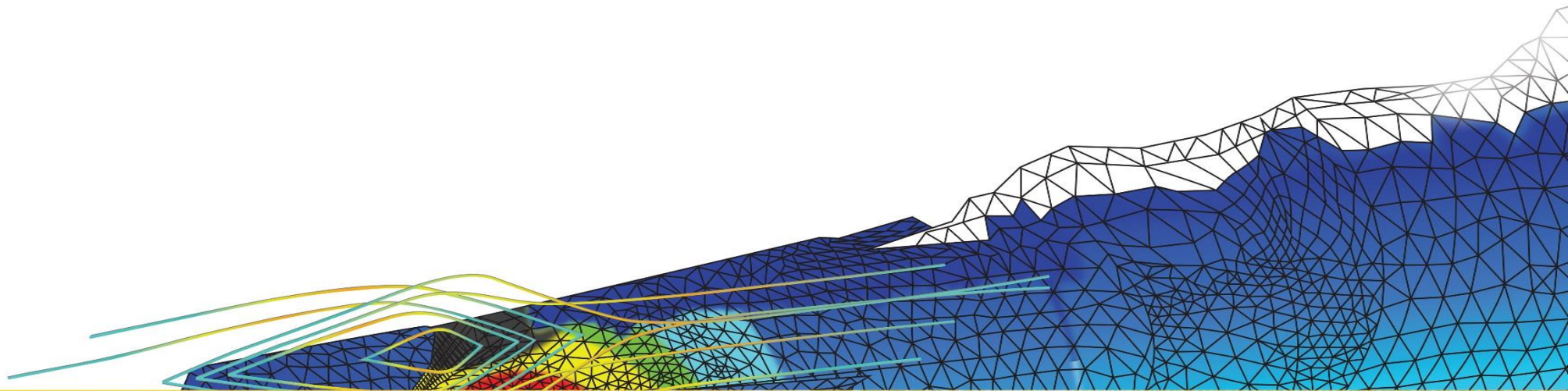
```
WARNING: 1 overset orphan cells in interface o-if.
```

```
WARNING: 863 overset dead->solve cells in interface o-if.
```

iter	continuity	x-velocity	y-velocity	z-velocity	k	epsilon	surf-mon-1	surf-mon-2	time/iter
960	2.0771e-04	1.9173e-06	4.9007e-06	2.1088e-06	1.9535e-04	1.3638e-04	1.1476e+01	1.2025e+01	0:00:32 10



# 功能支持与限制





## R17 重叠网格功能限制

- **Overset interfaces cannot contain solid cell zones**
- **Component meshes cannot be connected to a non-conformal interface**
- **Background meshes cannot have non-conformal interfaces between them if they are part of the same overset interface**
- **Component zones cannot have periodic boundary conditions**
- **Background zones cannot have overset boundaries**
- **Component mesh boundaries cannot overlap with coupled walls**
- **Overset meshing is not compatible with remeshing or layering (dynamic mesh)**

# R17 重叠网格支持的选项与模型

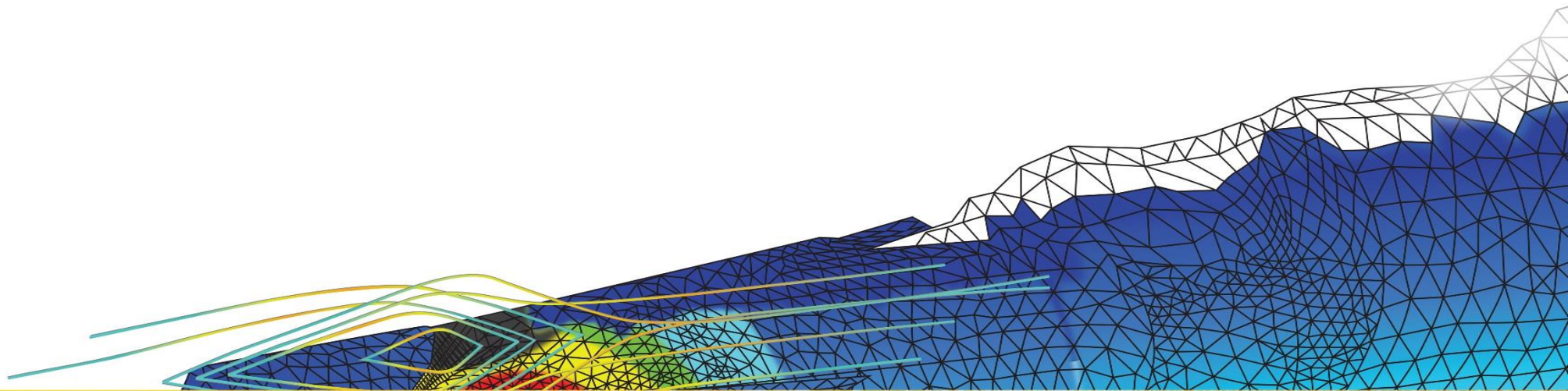
- Transient & Steady State Solvers with heat transfer
- Coupled solver (including pseudo transient method)
- Laminar, standard k-epsilon & standard k-omega
- Volume of Fluid (VOF)
- Standard initialization
- Moving Mesh is supported as  $\beta$  Feature

*Refer Documentation Section for More Details :*

***5.5.6. Overset Meshing Limitations and Compatibilities***

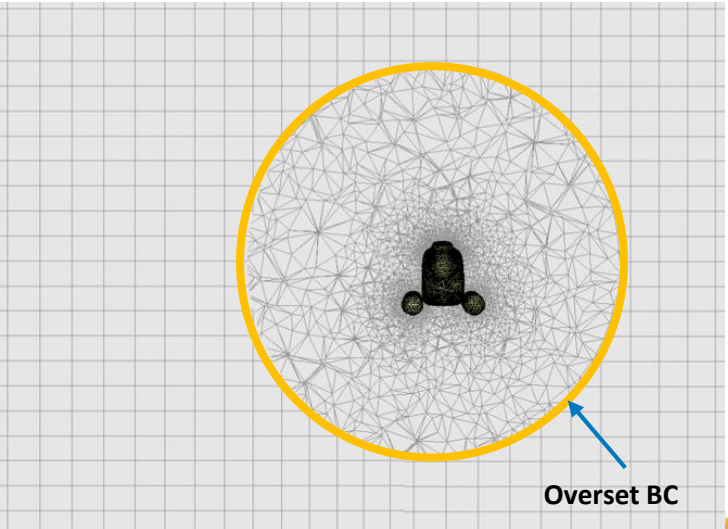
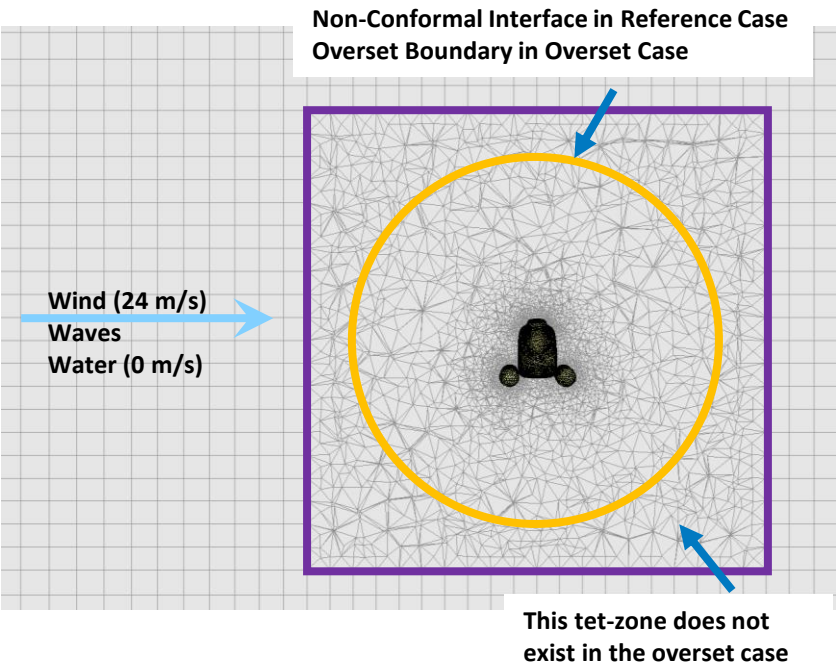
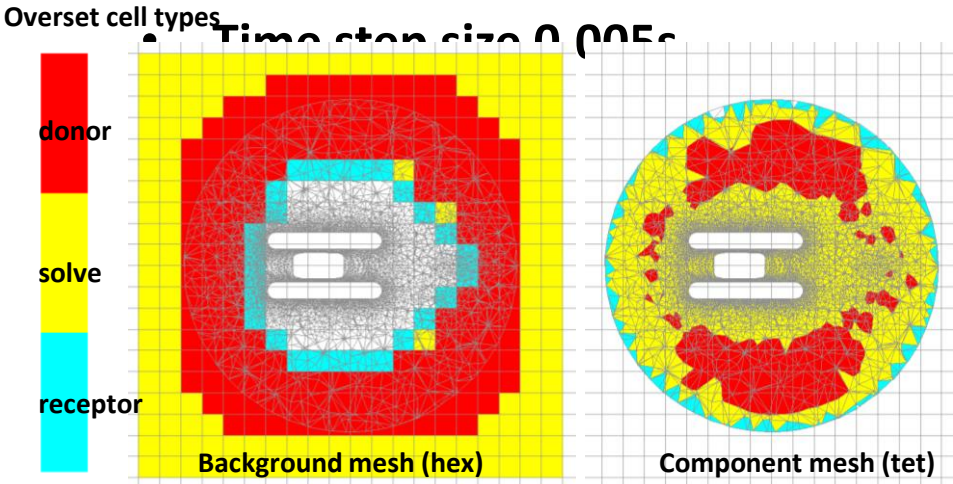
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# 案例展示



# 海面上的直升机

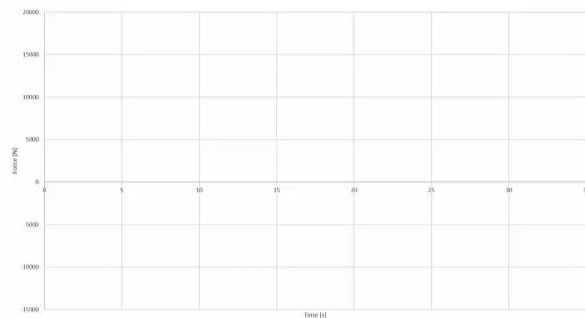
- **Comparison between:**
  - ✓ Stationary overset mesh case
  - ✓ Stationary MDM case with mesh interfaces
- **Almost the same mesh in the two cases**
  - ✓ Not an ideal mesh for overset



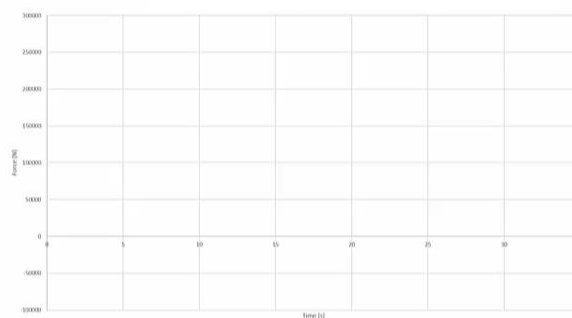


# 海面上的直升机

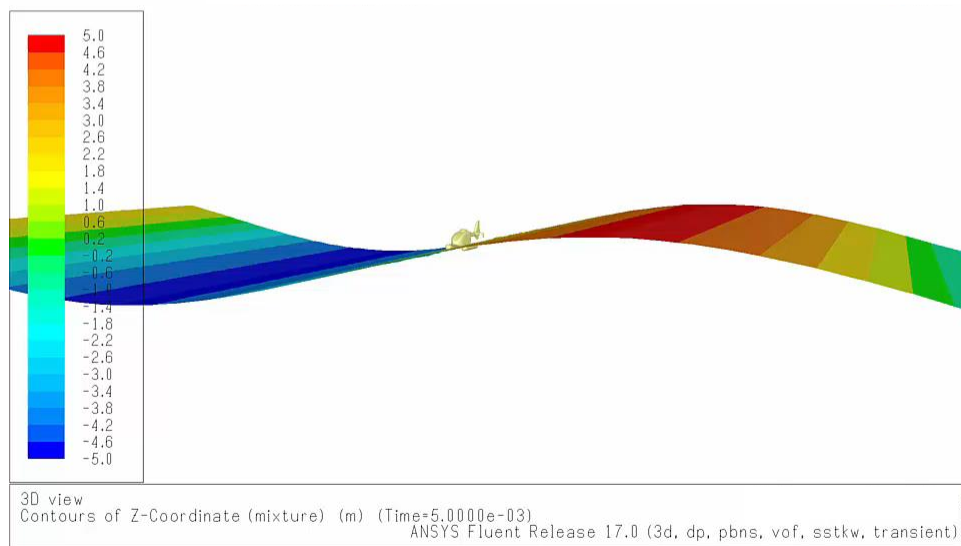
Forces in x-direction vs time



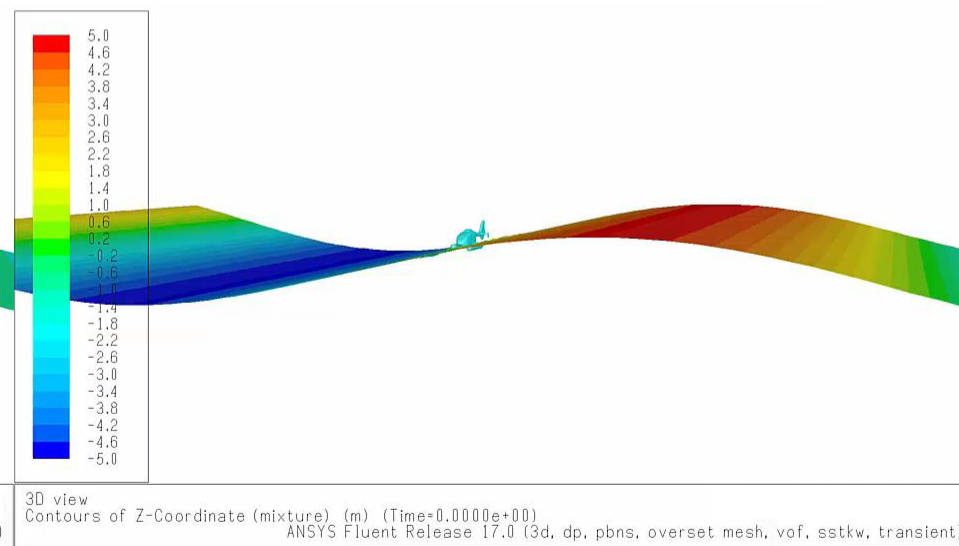
Forces in y-direction vs time



Forces in z-direction vs time

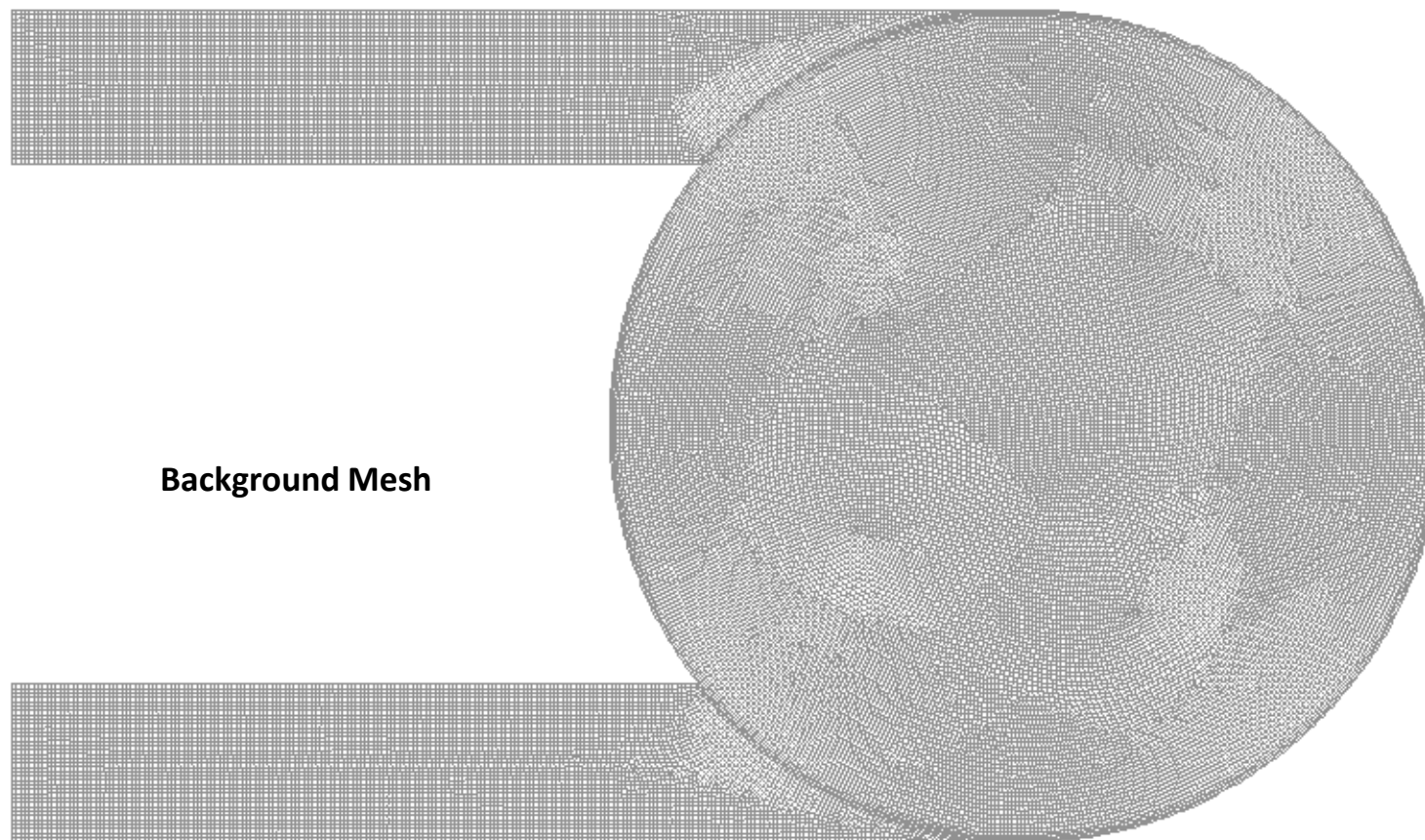


**Reference Simulation, non overset**  
*(blue force curves)*



**Overset Simulation**  
*(red force curves)*

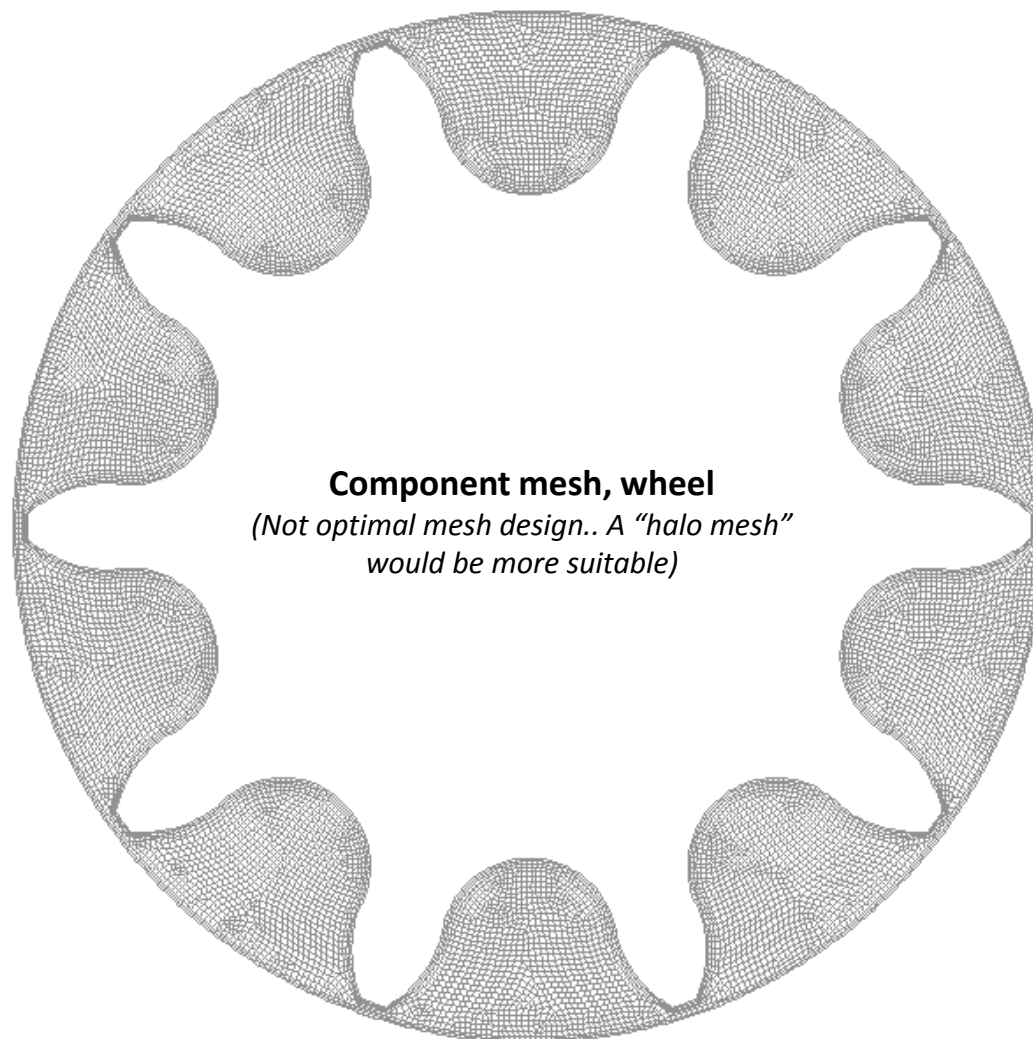
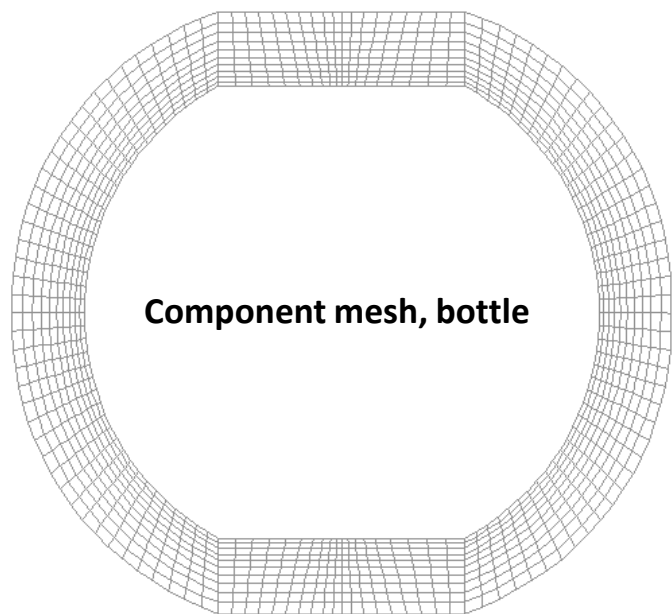
# 2D 传送装置



Background Mesh

0 0.5 (m)

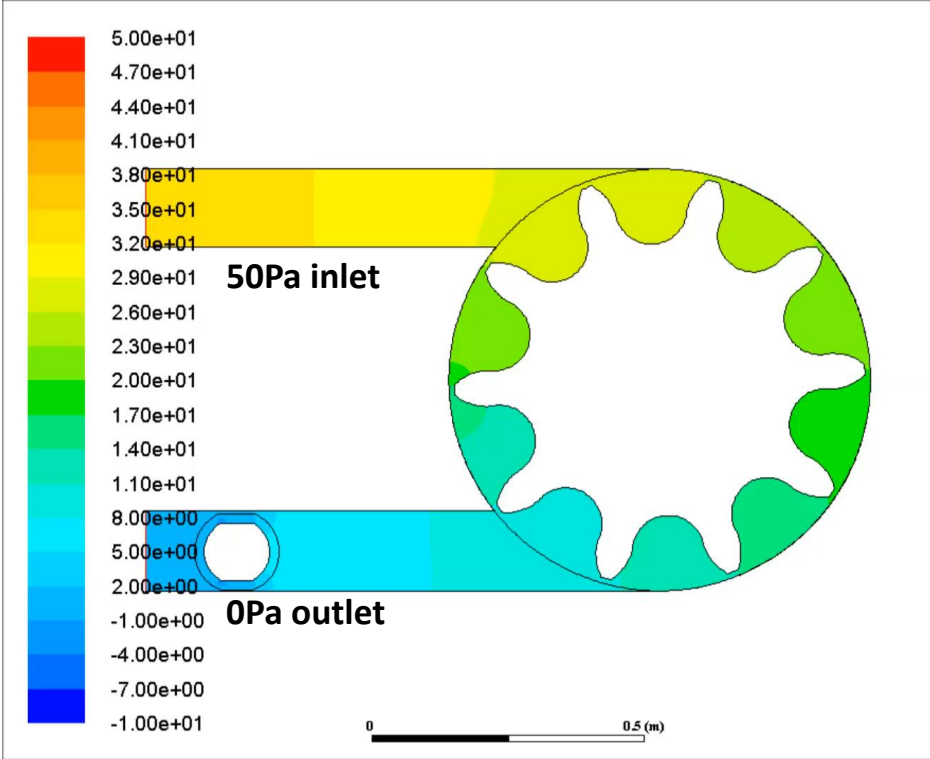
## 2D 传送装置



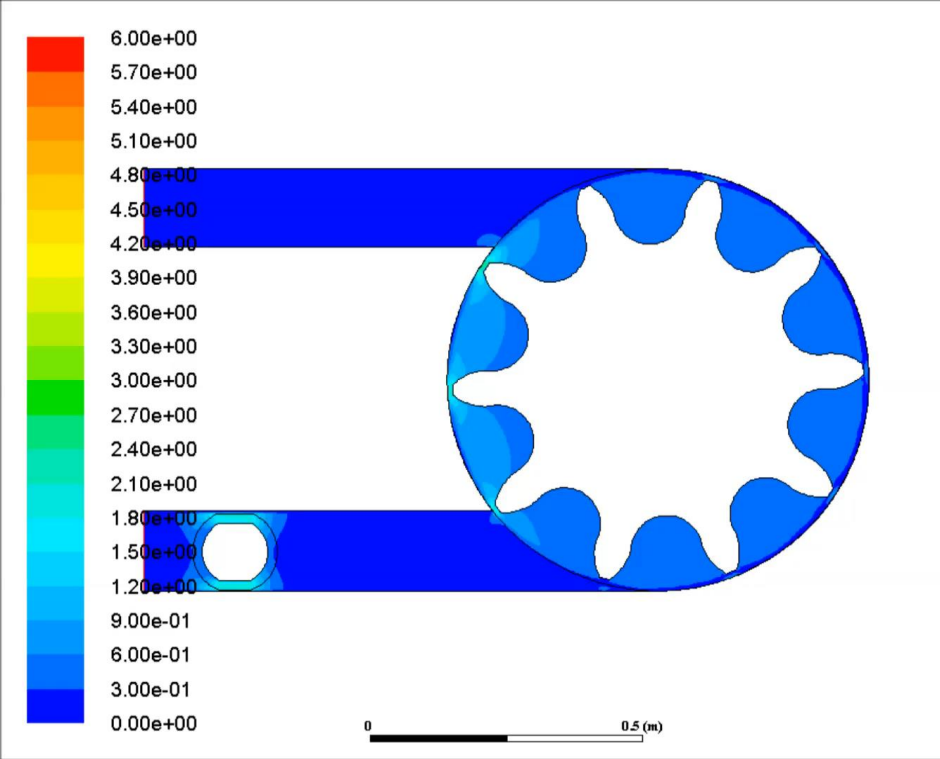
# 2D 传送装置

Coupled solver default settings, standard k-eps  
dt=0.005 (~moving 3 minimum cell sizes per dt)

Pressure



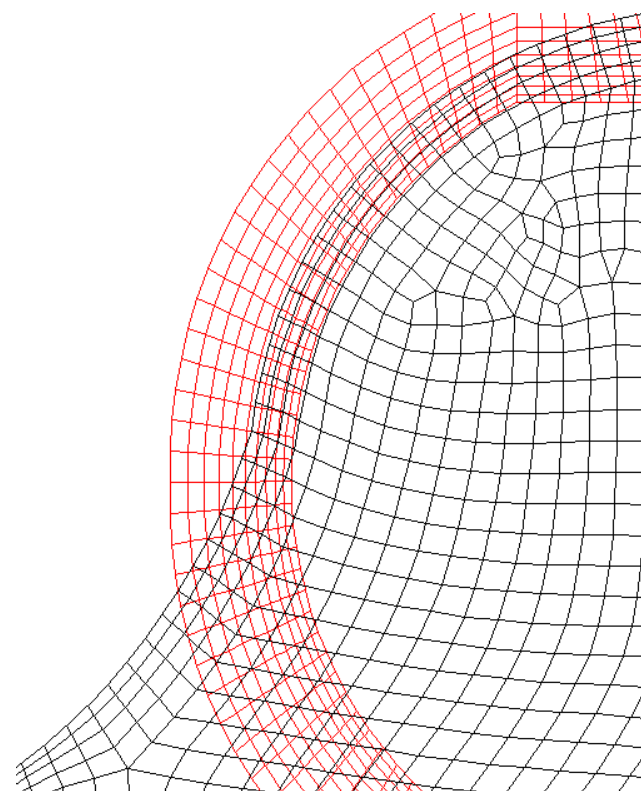
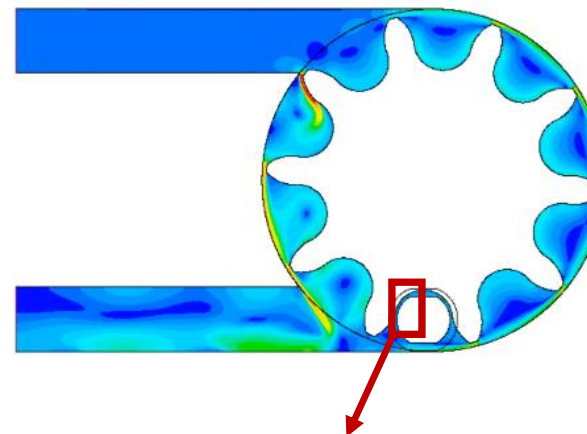
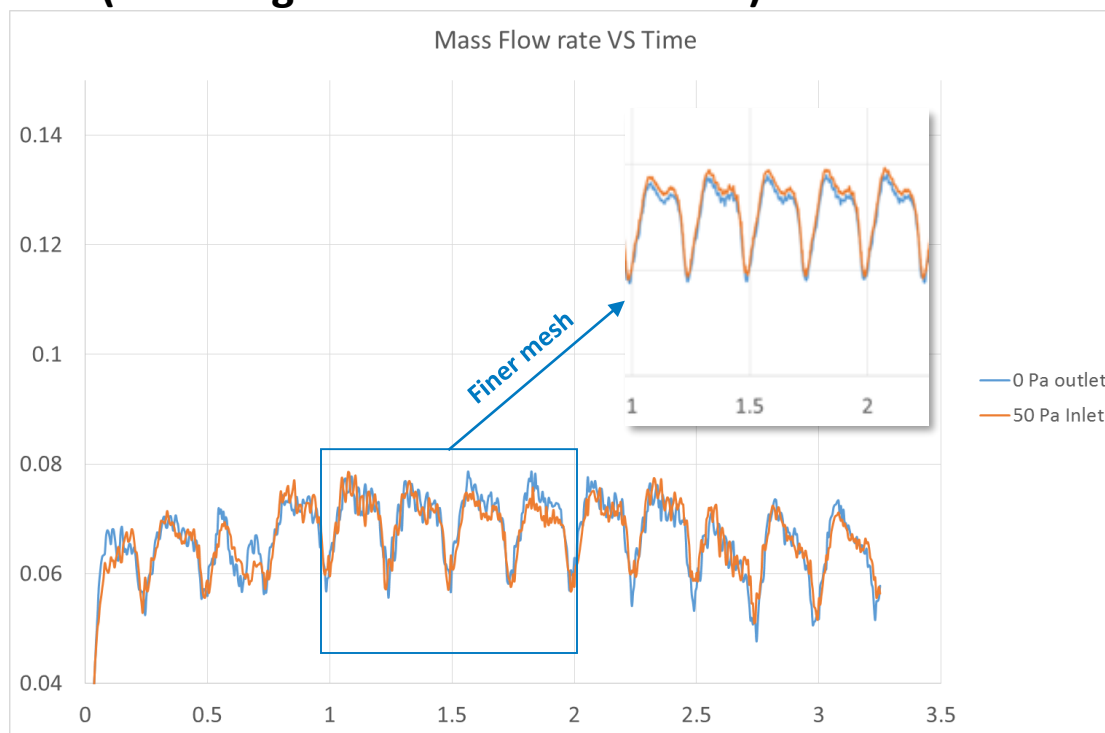
Velocity





## 2D 传送装置

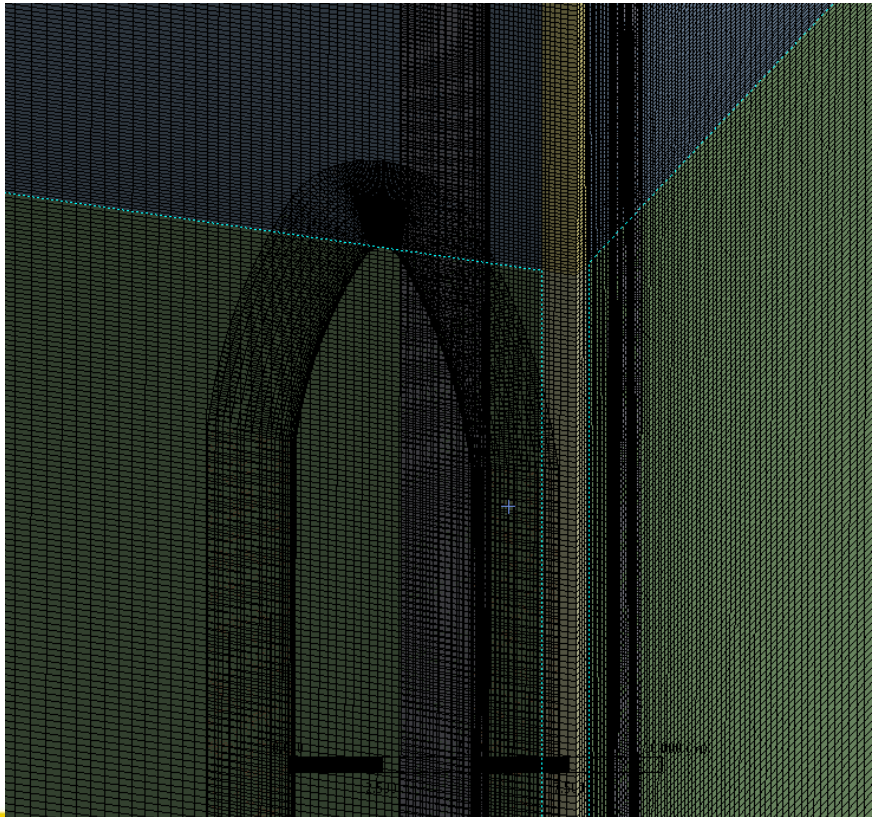
- 3 Meshes:
  - Background, bottle mesh & wheel ,mesh
- Reasonable mass conservation  
(for being a coarse overset mesh)



Free Stream Mach = 3.0 (Note: DBNS is not supported for Overset Mesh at R17.0)

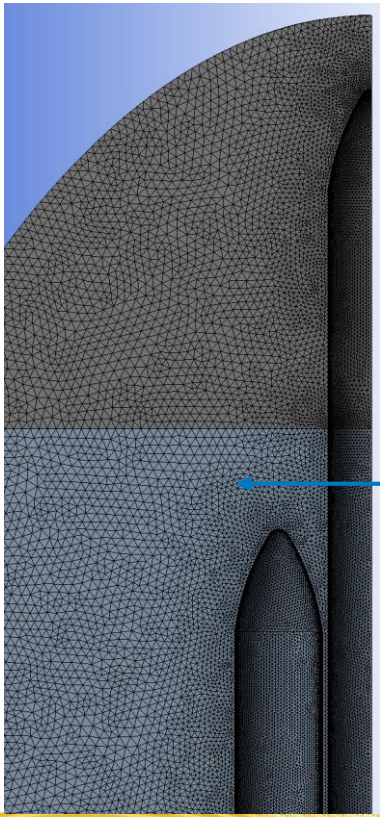
Overset Mesh

Quarter symmetry, hexahedral mesh with inflation, **1.67M cells**



MDM Mesh

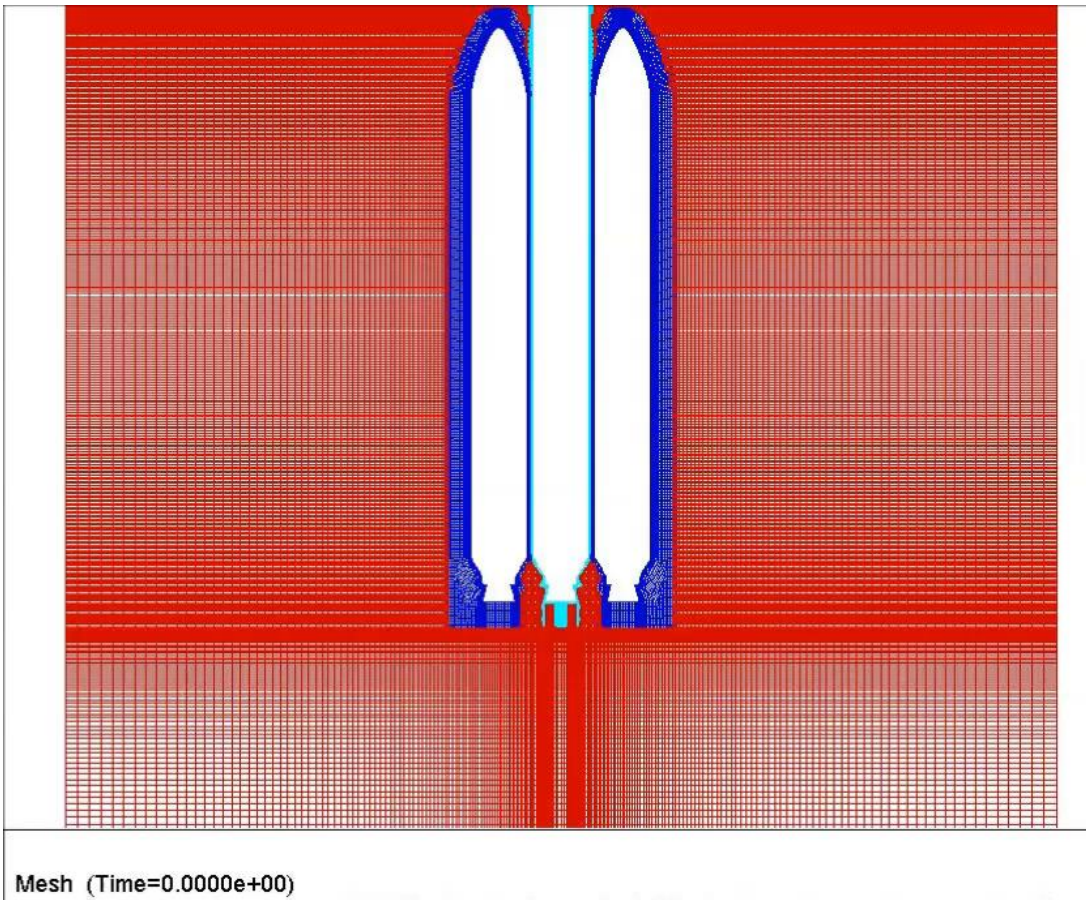
Quarter symmetry, hybrid mesh with inflation, **6M cells**



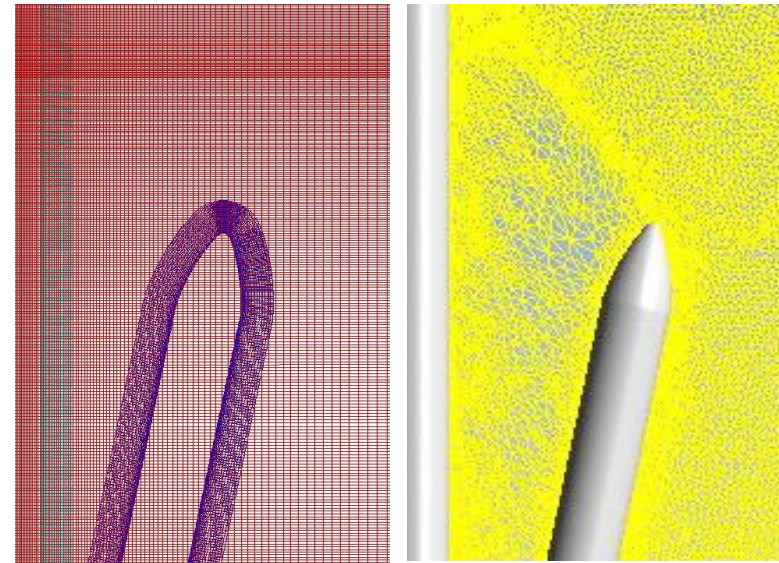
Remeshed zone



# 火箭分离

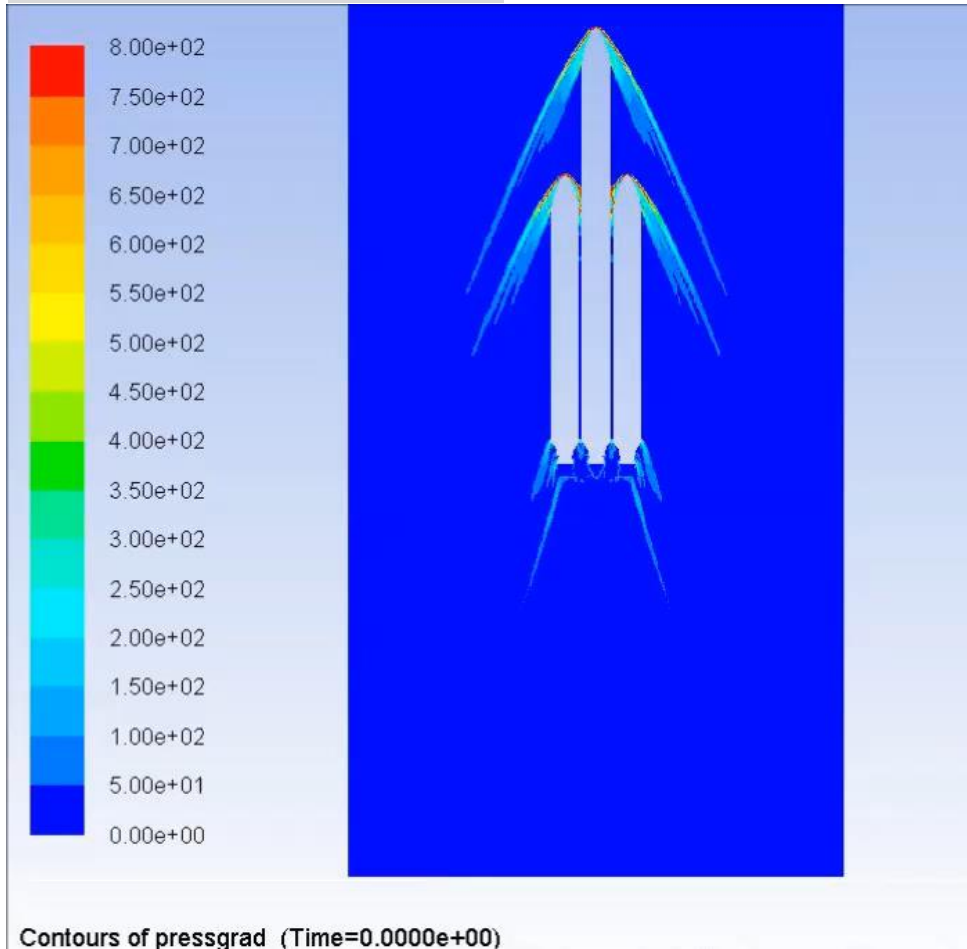


**Mesh at 1.0s:**  
Original mesh quality preserved in  
overset mesh

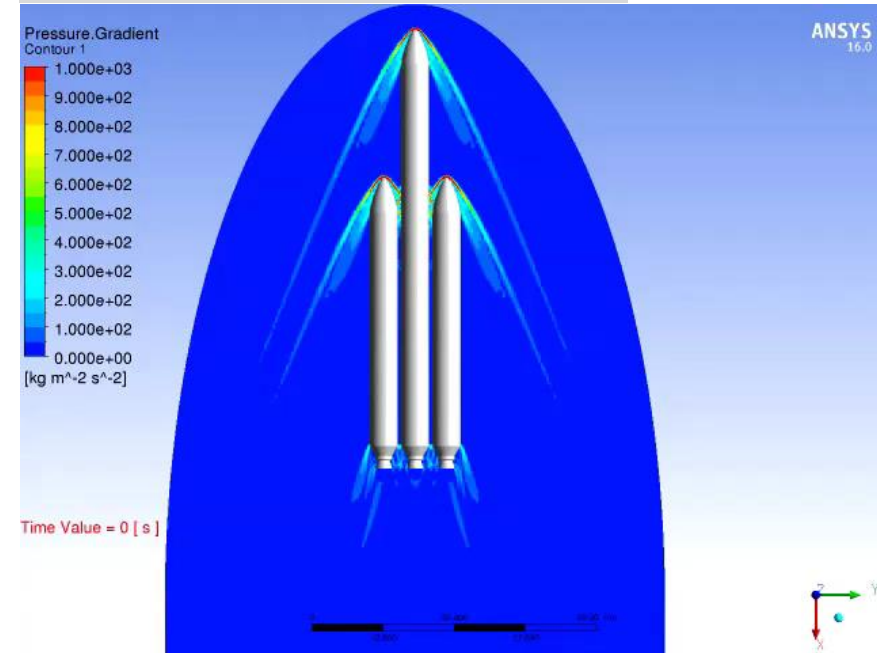


# AFT Test Case : ULA Stage Separation

## Overset Mesh Solution



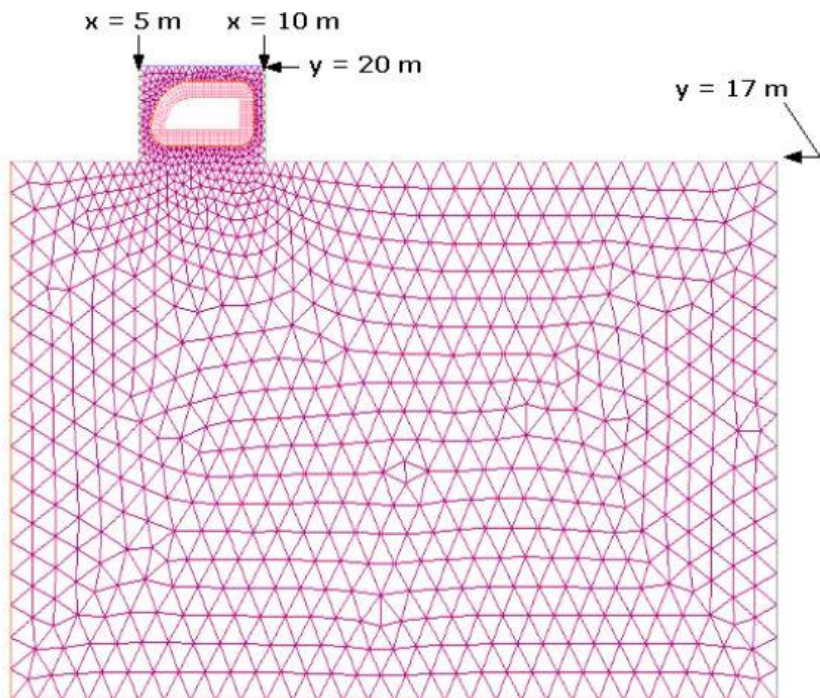
## MDM (Remeshing) Solution



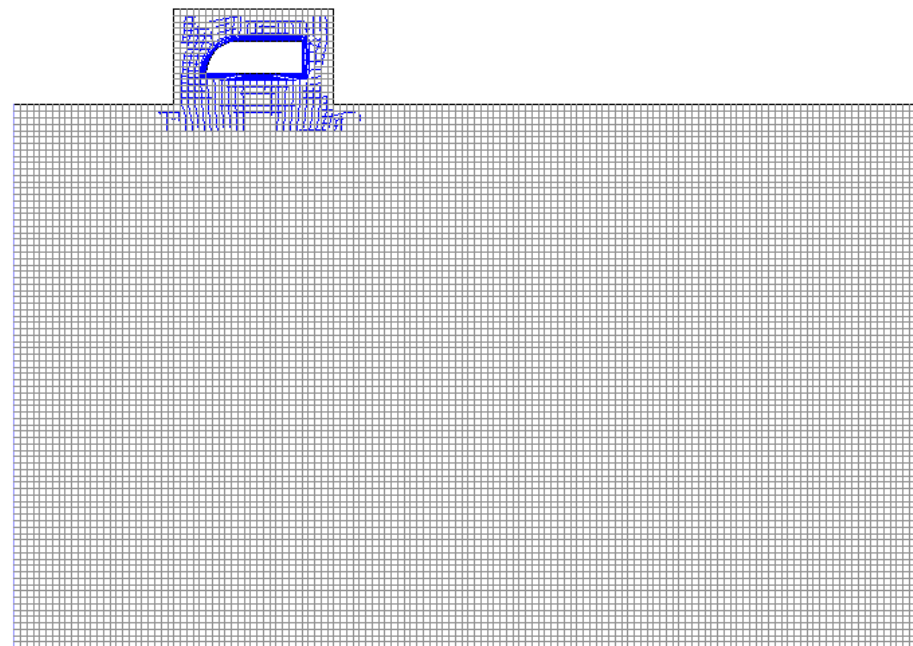
- No Mesh Degradation in Overset Mesh and it preserves quality of Shock Capture
- Overset not currently supported by DBNS Solver (limited to Mach < 3)
- Overset not currently supported by CFD-Post



# 弹仓分离2D

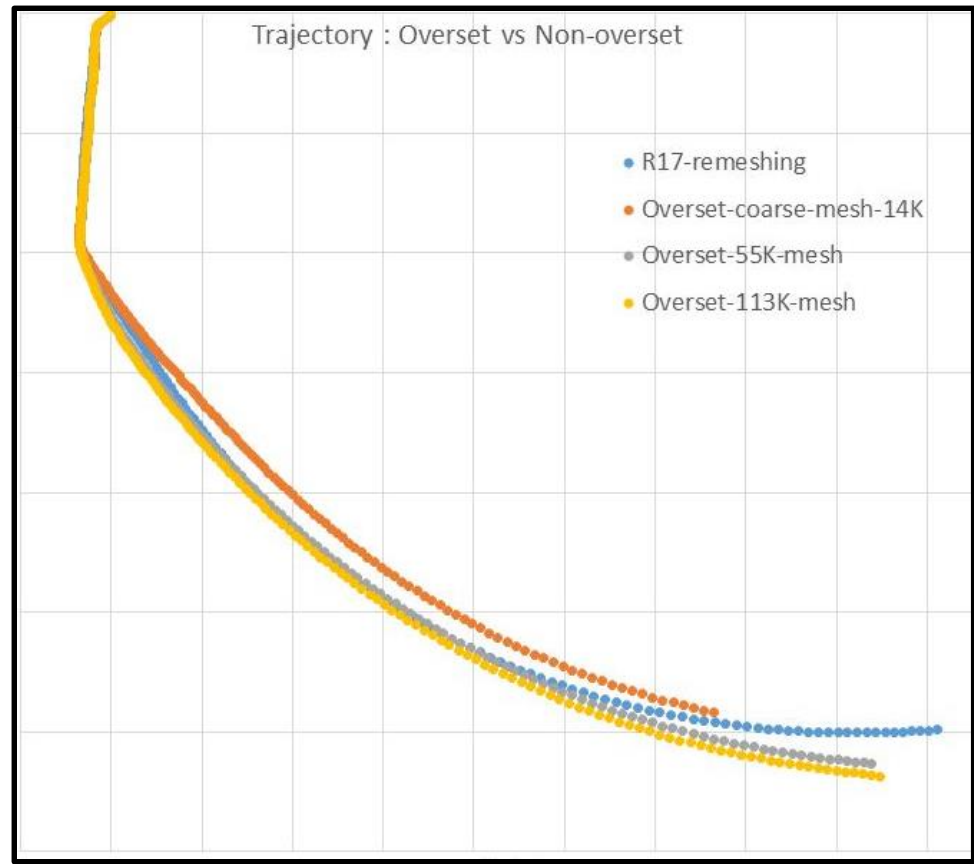


- 2D Tutorial on Store Separation
- Tri/prism mesh with Re-meshing & 6DOF
- 2k cells



- Overset Mesh Method
- 2D Quad Mesh with boundary layers
- Mesh Density Studied :
  - Coarse – 14K cells
  - Medium – 55K cells
  - Fine – 113K cells

# 弹仓分离2D

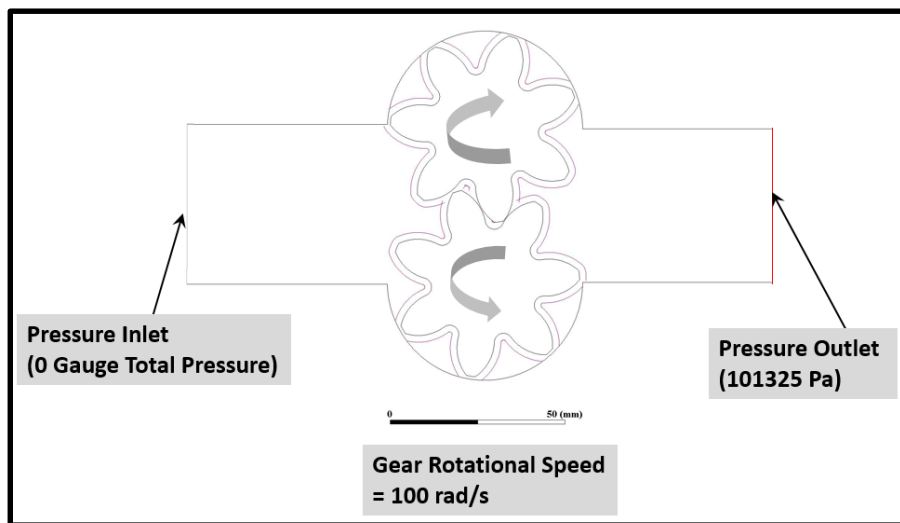


## Remeshing

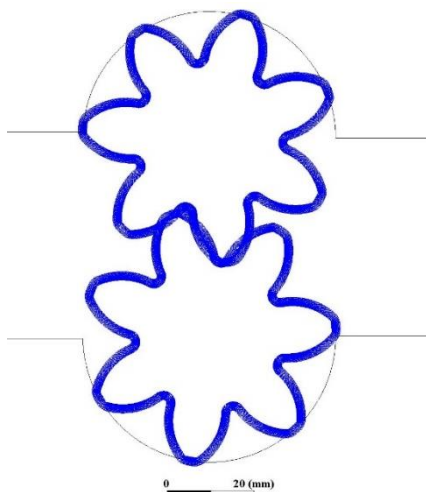


## Overset

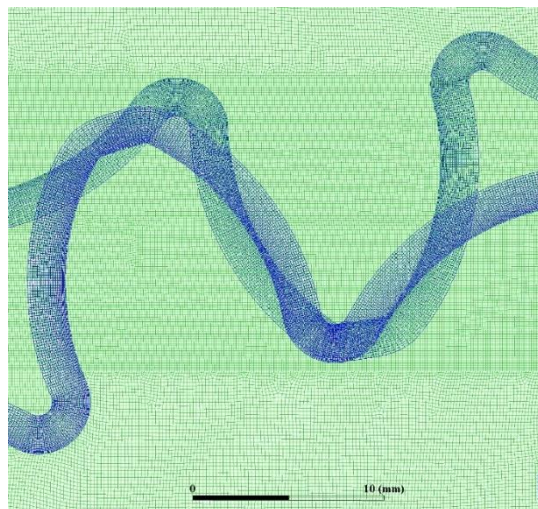
# 齿轮泵



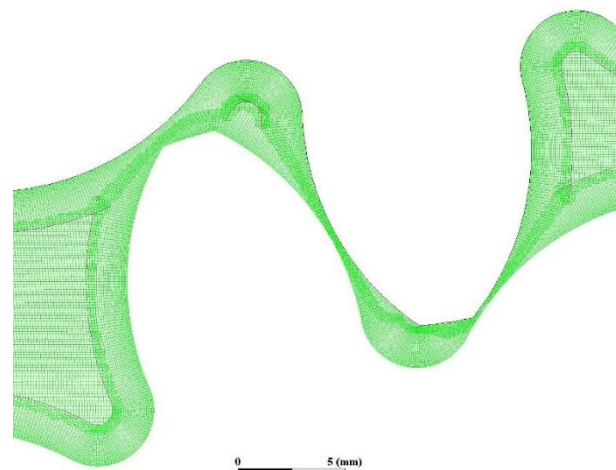
- Steady State Solution → Transient
- Material Properties :
  - Density = 830 kg/m<sup>3</sup>
  - Viscosity = 0.00332 kg/m-s



Component grid



Background grid

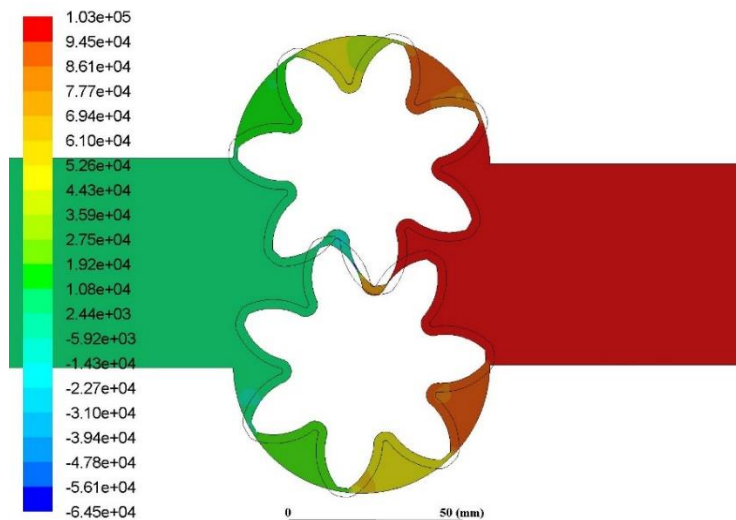
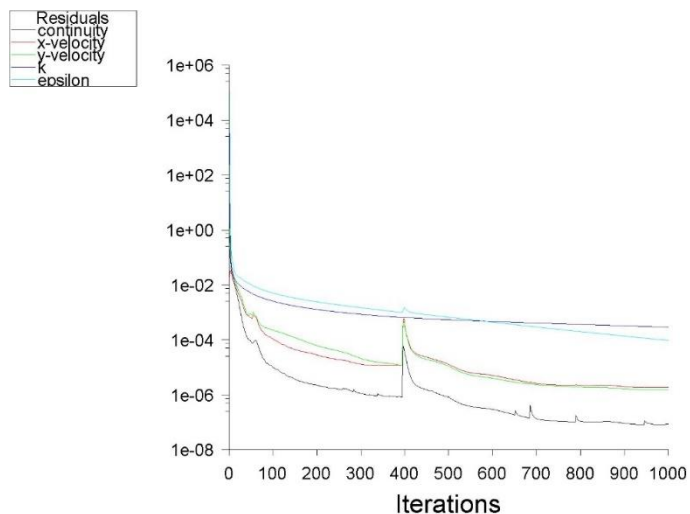


Overset Mesh

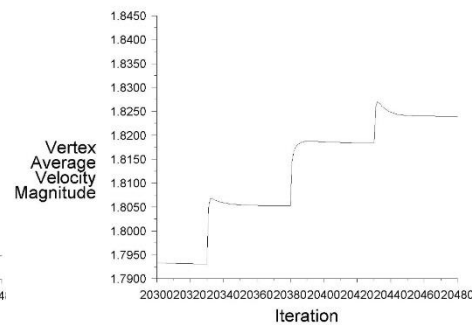
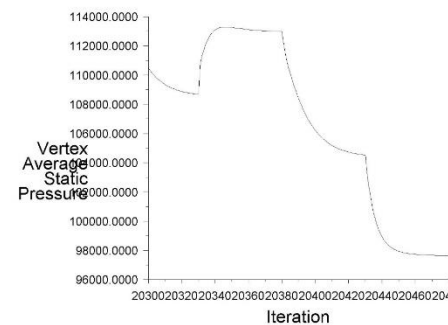
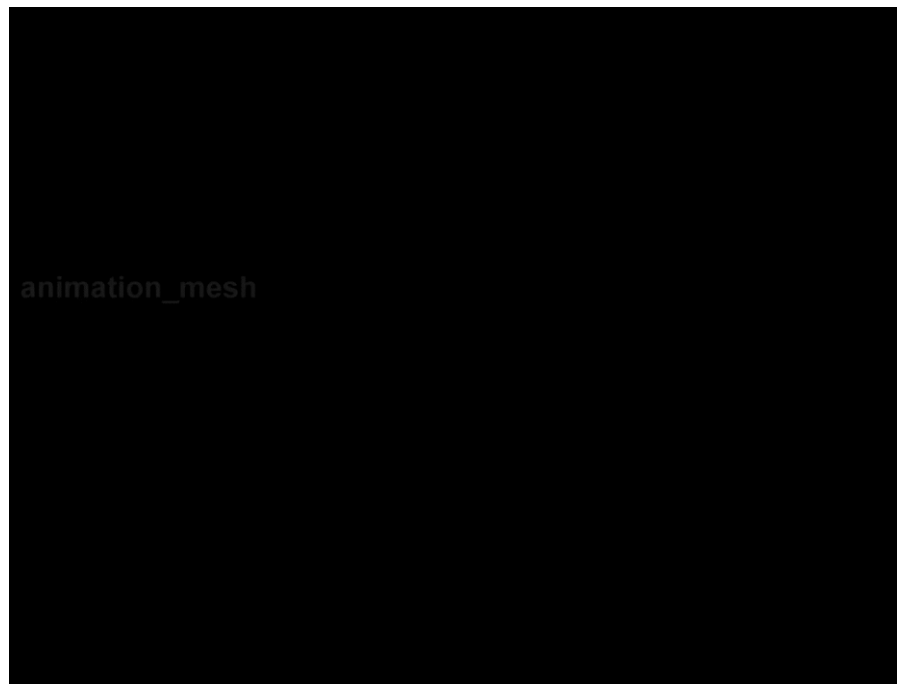


# 齿轮泵

## Steady State Solution



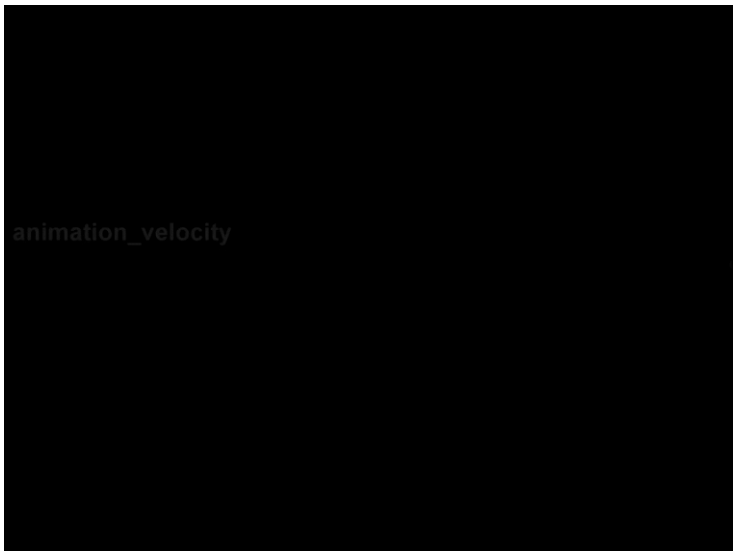
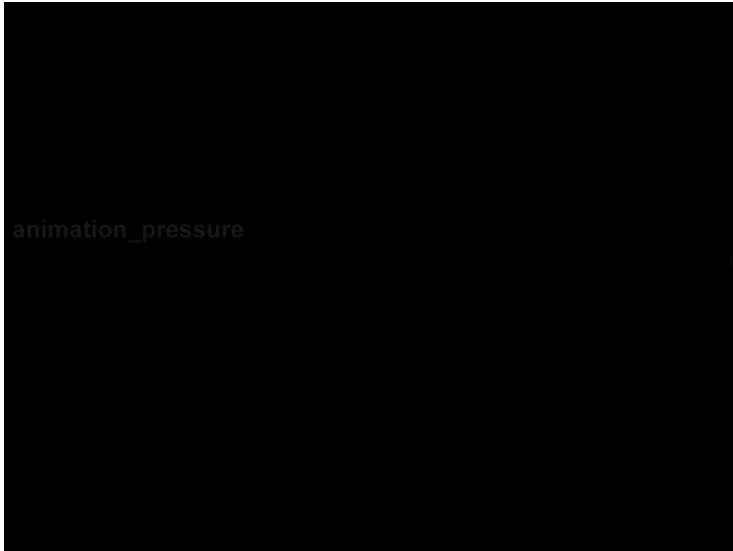
## Mesh Motion



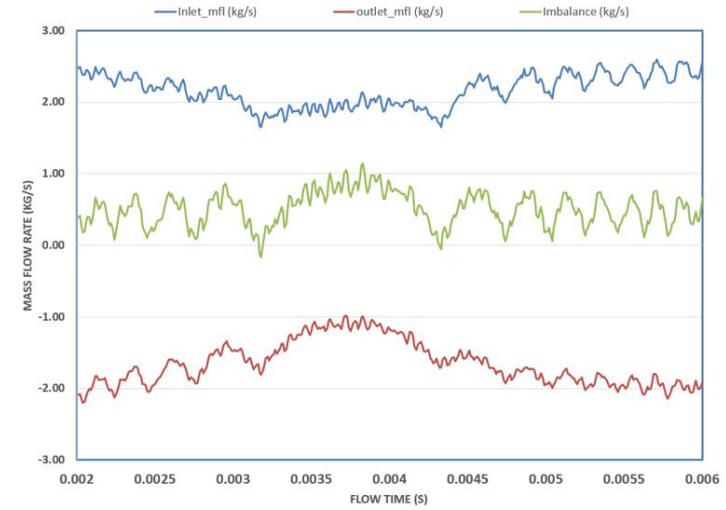
## Convergence within time step



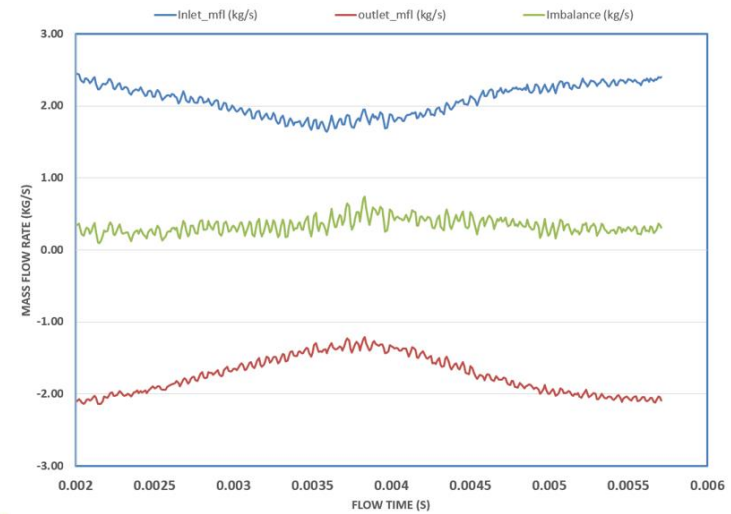
# 齿轮泵

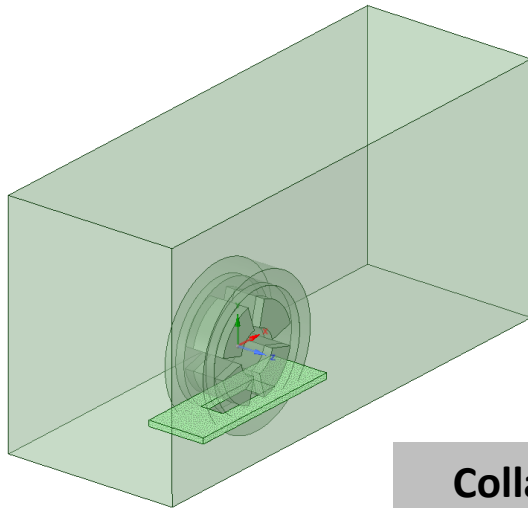


solve/set/overset/high-order-pressure? no



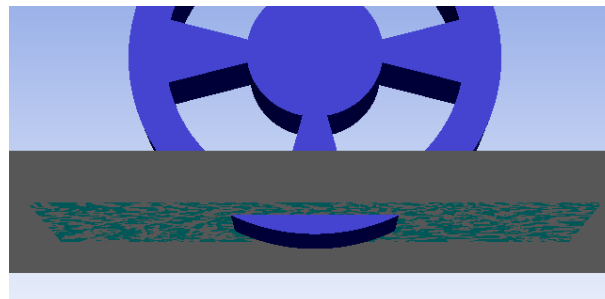
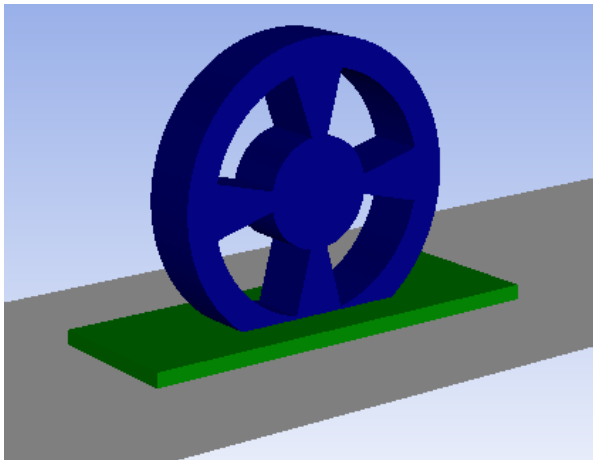
solve/set/overset/high-order-pressure? yes





Collar Grid

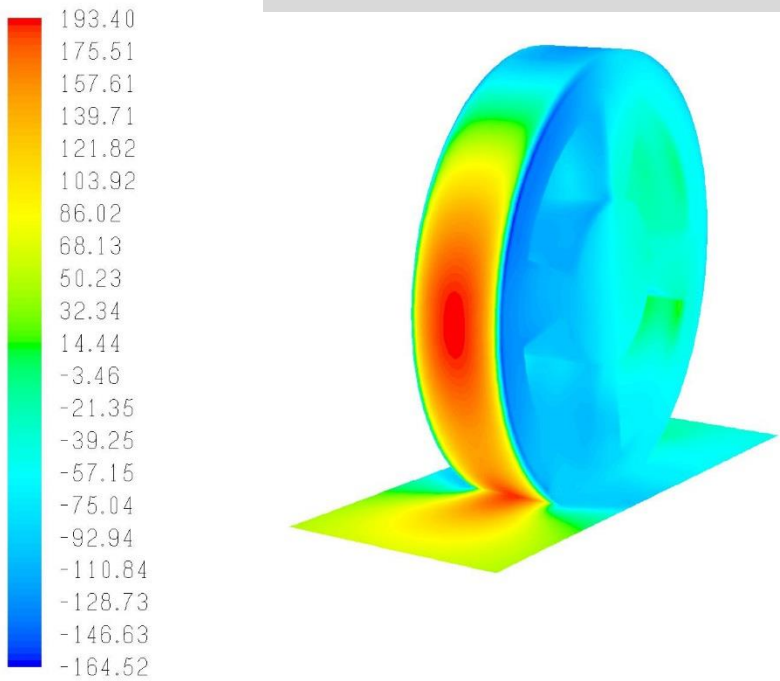
mesh motion



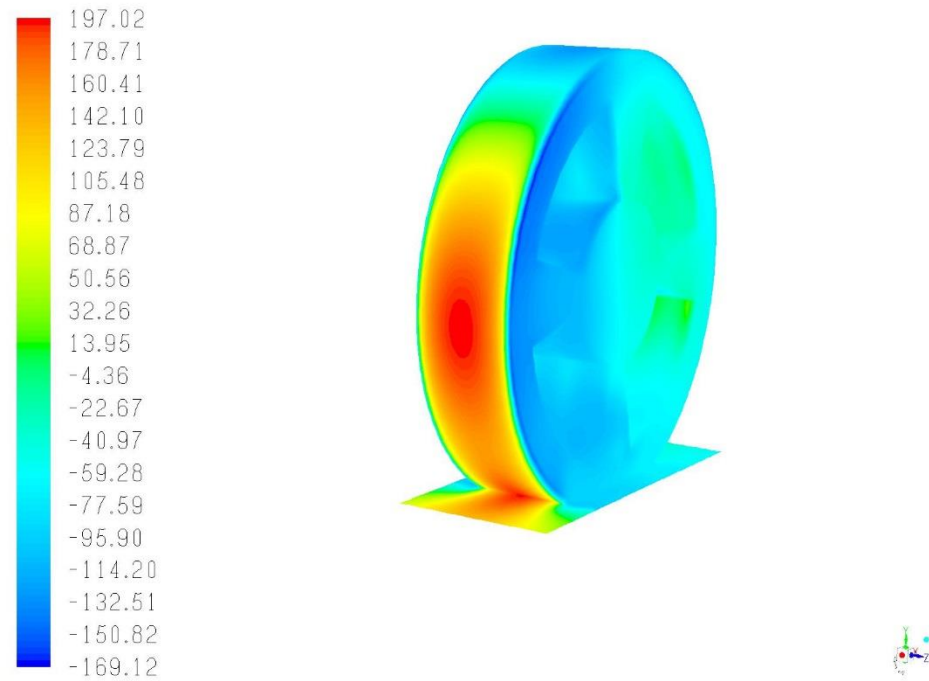
# 轮胎轧地面

## Steady state Results (Rotating Wall Boundary Condition)

Overset (Collar grid) Solution



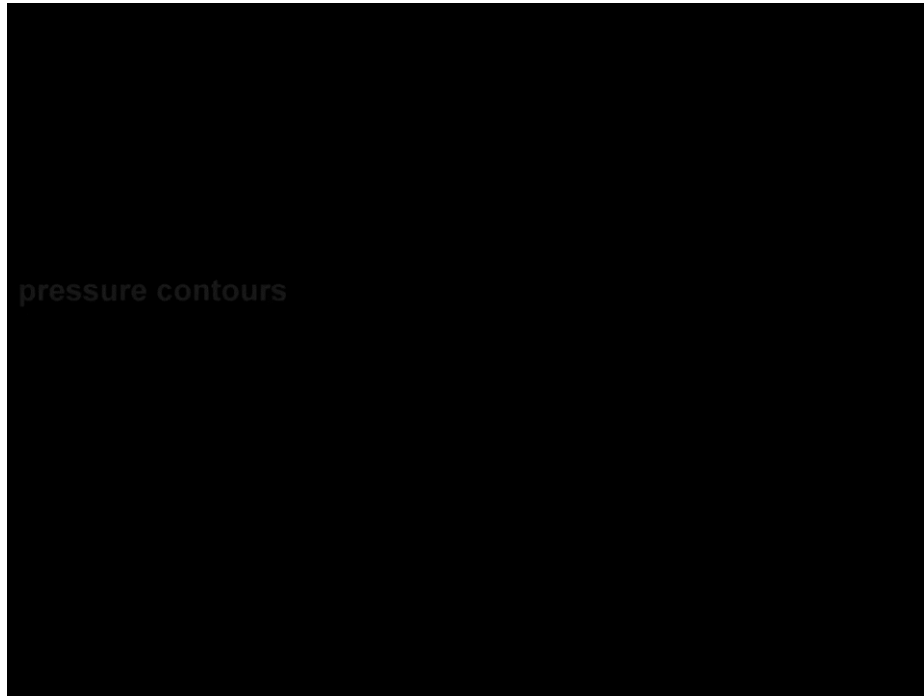
Conventional Grid Solution



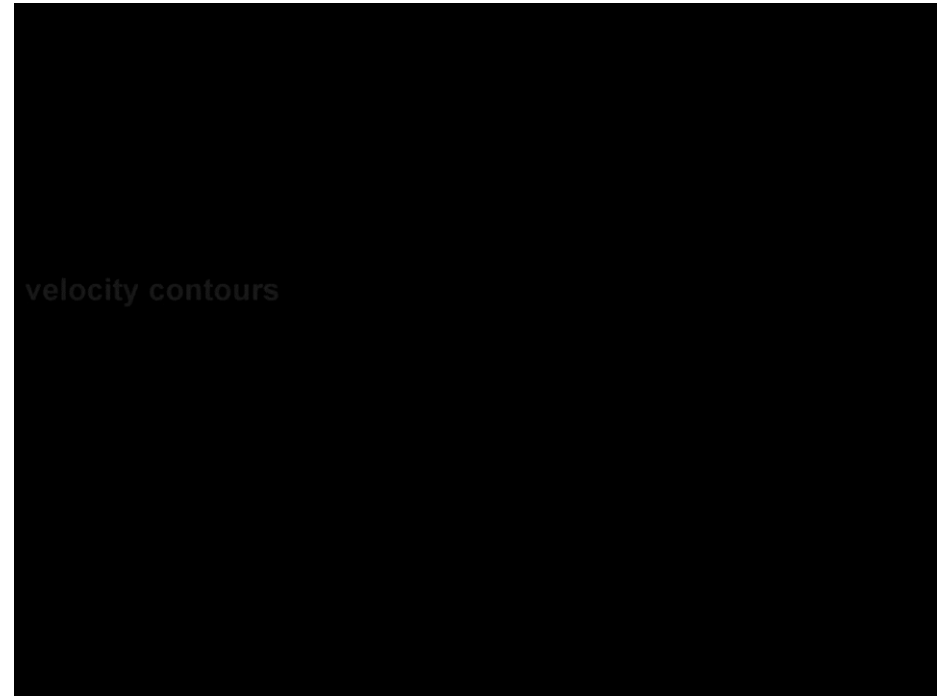
Static Pressure Contours on wall

# 轮胎轧地面

## Transient Moving Mesh Overset (Collar Grid) Solution



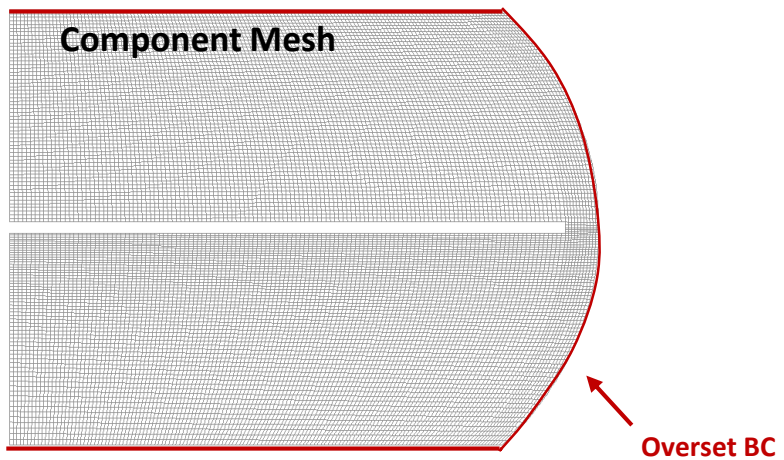
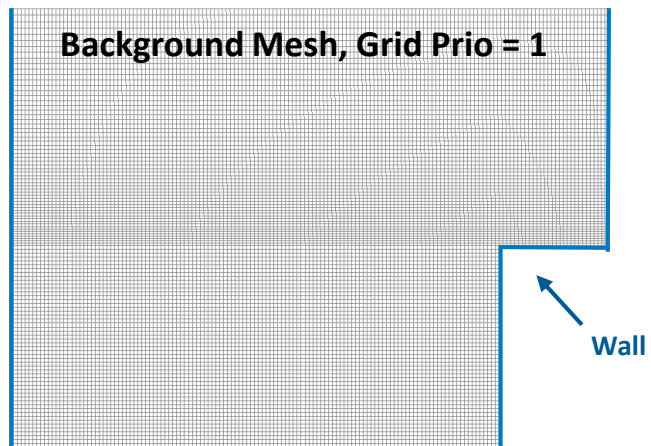
Static Pressure Contours



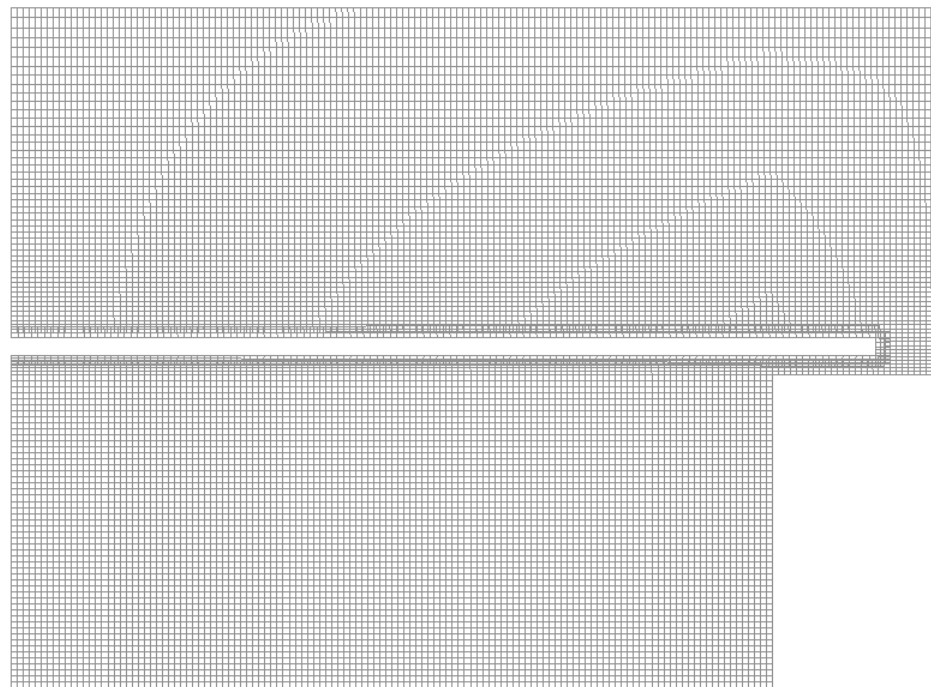
Velocity Contours



# FSI 仿真 高弹性簧片阀

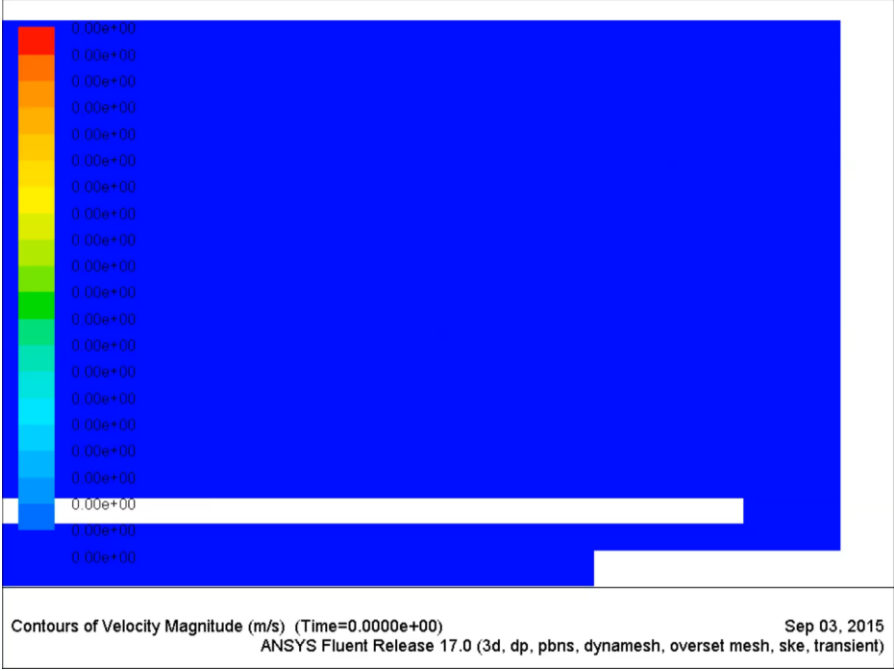
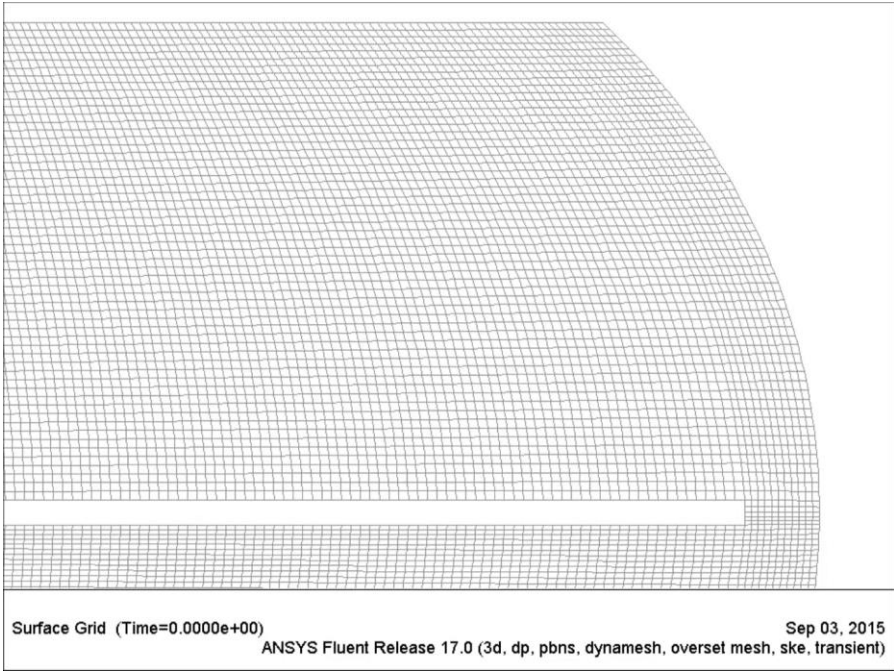


Intersected Overset interface

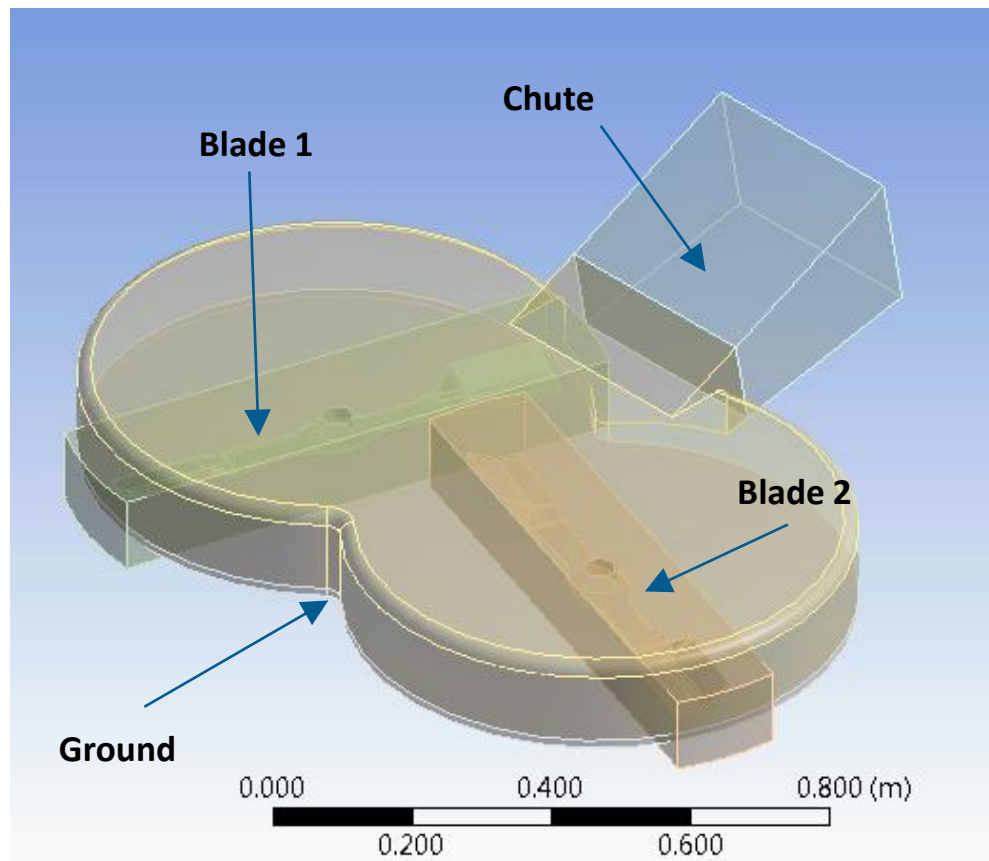


# FSI 仿真 高弹性簧片阀

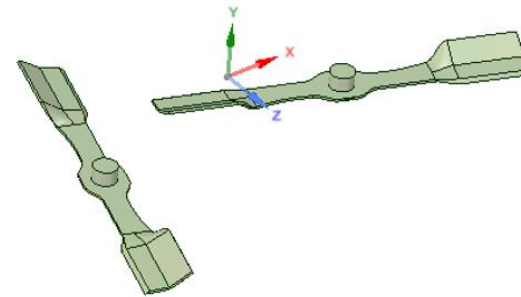
## Component Mesh, Smoothing



# 割草机



The Blades



Mesh Motion



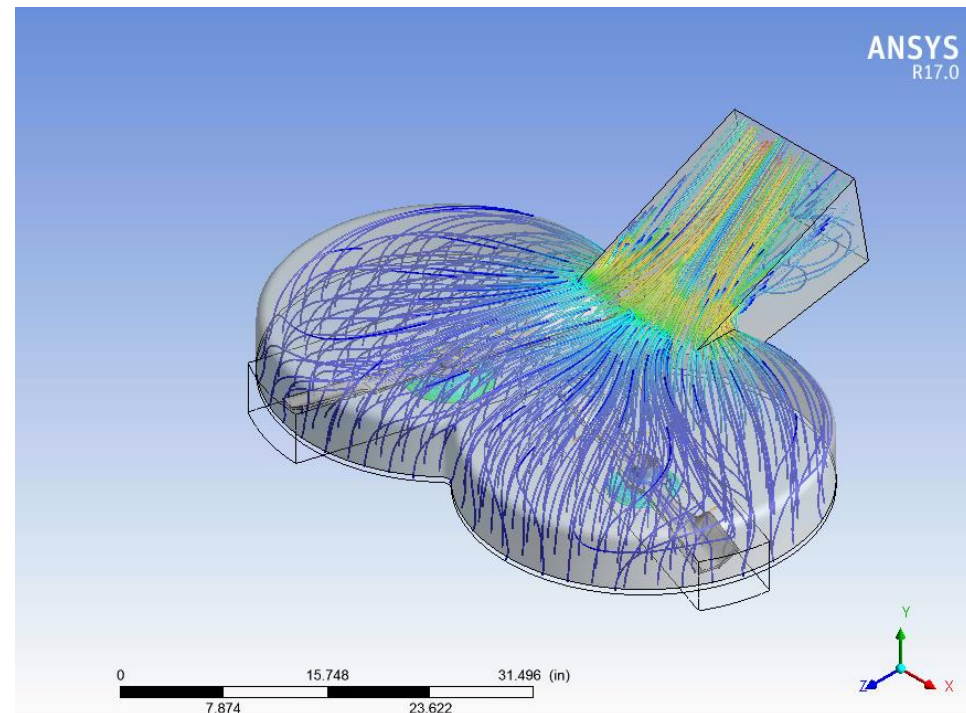
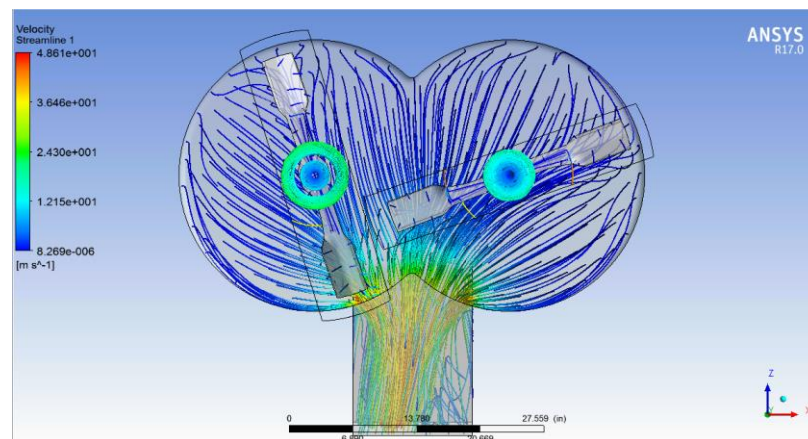
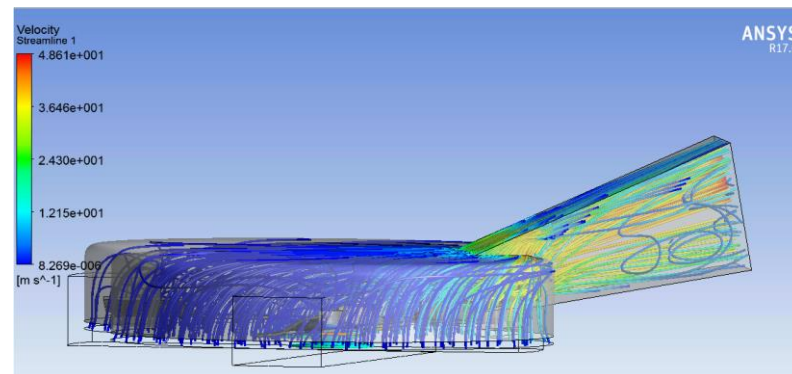
Grid (Time=1.6900e-03)

Aug 04, 2011  
ANSYS Fluent Release 17.0 (3d, dp, pbns, overset mesh, rke, transient)



# 割草机

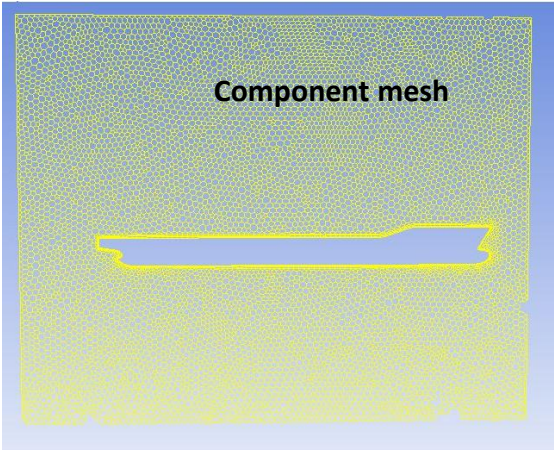
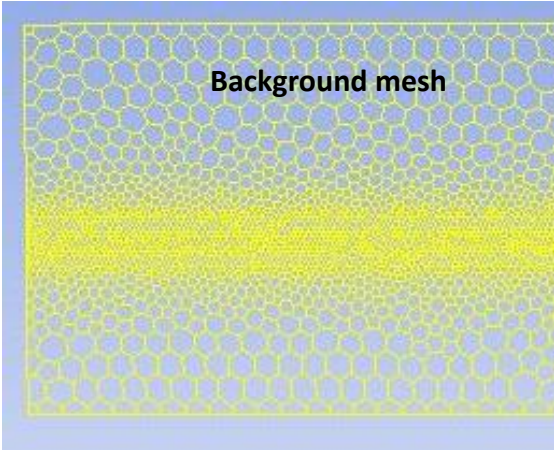
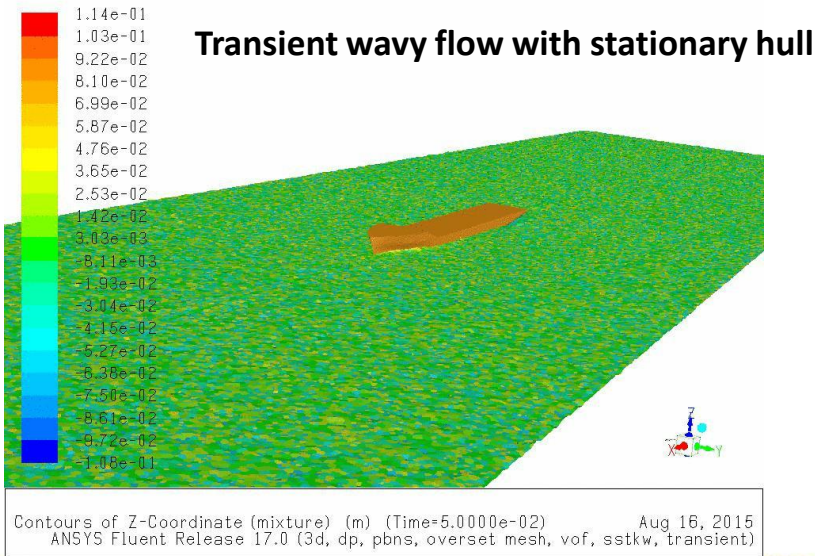
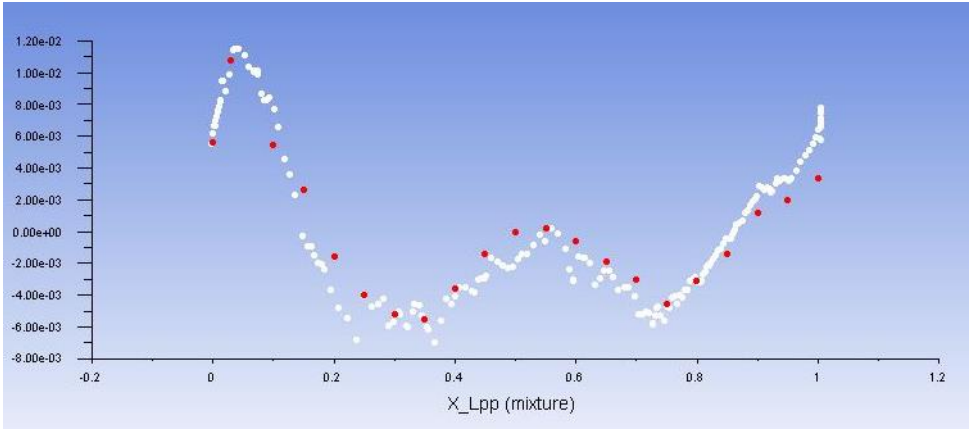
- Coupled solver default settings, standard k-eps
- Flow initialized from steady run
- Blade rotations 250rad/s
- $dt=1e-5s$  ( $\sim 0.15$  degrees/time step)





# 船体周围的流动

Water line for non-wavy flow, experimental data (red)  
Refined mesh would likely increase the accuracy



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感谢聆听

