Swirl Flow Around a Rotating Disk

1)Important Info's: -

➔*This example models a rotating disk in a tank.*

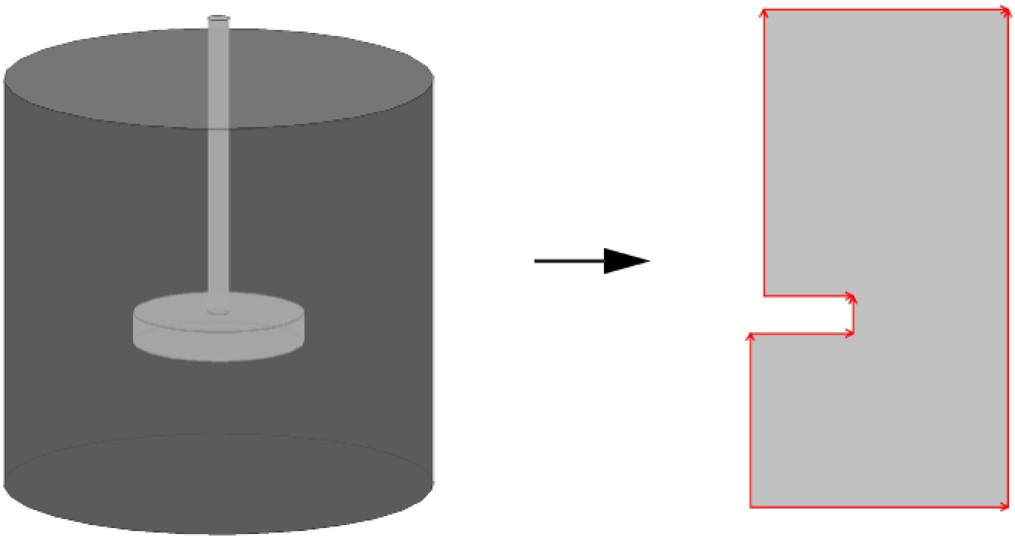


Figure 1: The original 3D geometry can be reduced to 2D because the geometry is rotationally symmetric.

➔*the velocities in the angular direction differ from zero, so the model must include all three velocity components, even though the geometry is in 2D.*

2)Physics and Equations: -

➔*The flow is described by the Navier-Stokes equations:*

$$\rho\frac{\partial \mathbf{u}}{\partial t} - \nabla\cdot\eta(\nabla\mathbf{u} + (\nabla\mathbf{u})^T) + \rho\mathbf{u}\cdot\nabla\mathbf{u} + \nabla p = \mathbf{F}$$

$$\nabla\cdot\mathbf{u} = 0$$

- *u denotes the velocity (SI unit: m/s),*
- *ρ the density (SI unit: kg/m³),*
- *μ the dynamic viscosity (SI unit: Pa·s),*
- *p the pressure (SI unit: Pa).*

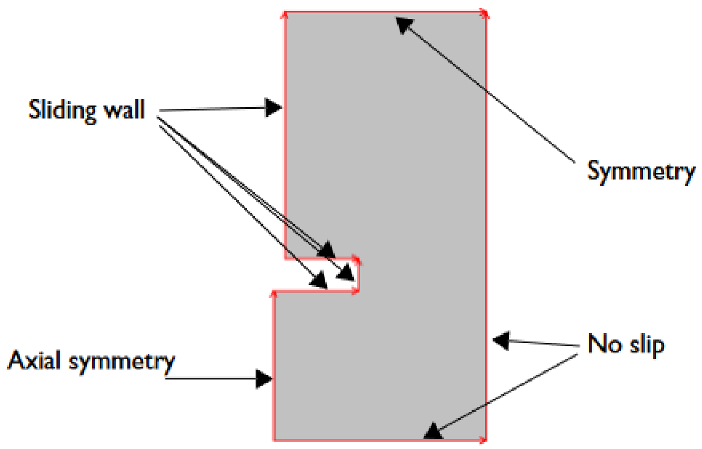
$$\rho\left(u\frac{\partial u}{\partial r} - \frac{v^2}{r} + w\frac{\partial u}{\partial z}\right) + \frac{\partial p}{\partial r} = \mu\left[\frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial u}{\partial r}\right) - \frac{u}{r^2} + \frac{\partial^2 u}{\partial z^2}\right] + F_r$$

$$\rho\left(u\frac{\partial v}{\partial r} + \frac{uv}{r} + w\frac{\partial v}{\partial z}\right) = \mu\left[\frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial v}{\partial r}\right) - \frac{v}{r^2} + \frac{\partial^2 v}{\partial z^2}\right] + F_\varphi$$

$$\rho\left(u\frac{\partial w}{\partial r} + w\frac{\partial w}{\partial z}\right) + \frac{\partial p}{\partial z} = \mu\left[\frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial w}{\partial r}\right) + \frac{\partial^2 w}{\partial z^2}\right] + F_z$$

- *u is the radial velocity, v the rotational velocity,*
- *w the axial velocity (SI unit: m/s).*
- *In the model we set the volumetric force components F_r, Fφ, and Fz to zero.*

3)Boundary Conditions: -



➔*The velocity components in the plane are zero, and that in the angular direction is equal to the angular velocity, ω, times the radius, r:*

$$u_w = r\omega;$$

➔*At the boundaries representing the cylinder surface a no slip condition applies, stating that all velocity components equal zero:*

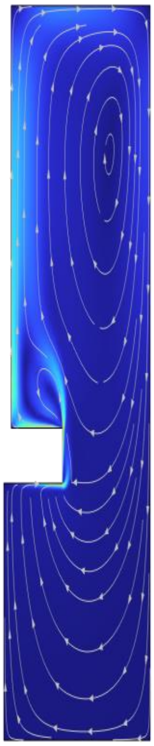
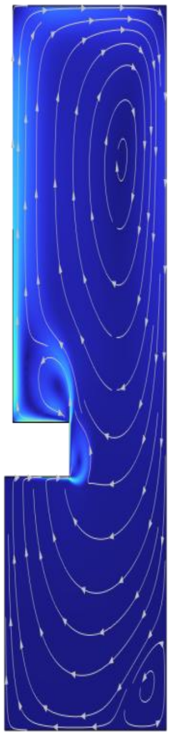
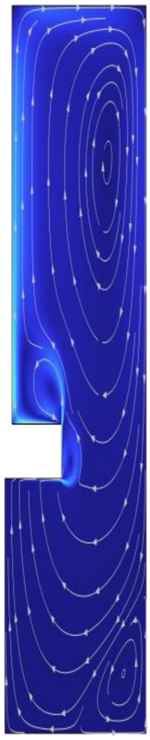
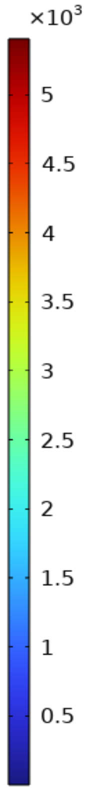
$$u = (0,0,0);$$

➔*At the boundary corresponding to the rotation axis, use the axial symmetry boundary condition allowing flow in the tangential direction of the boundary but not in the normal direction.*

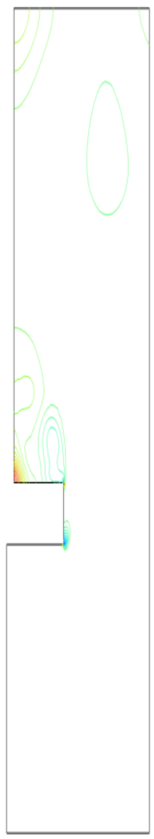
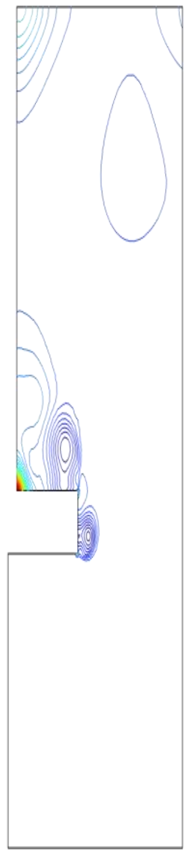
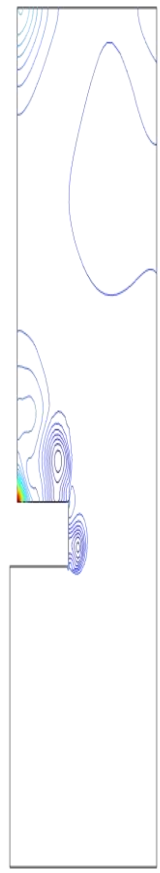
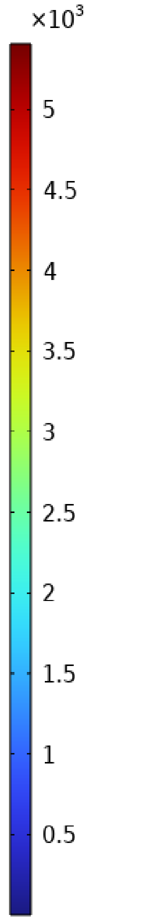
$$u = 0;\ v = 0;$$

4)Results: -

➔Velocity (Surface and Streamline) Plot: -

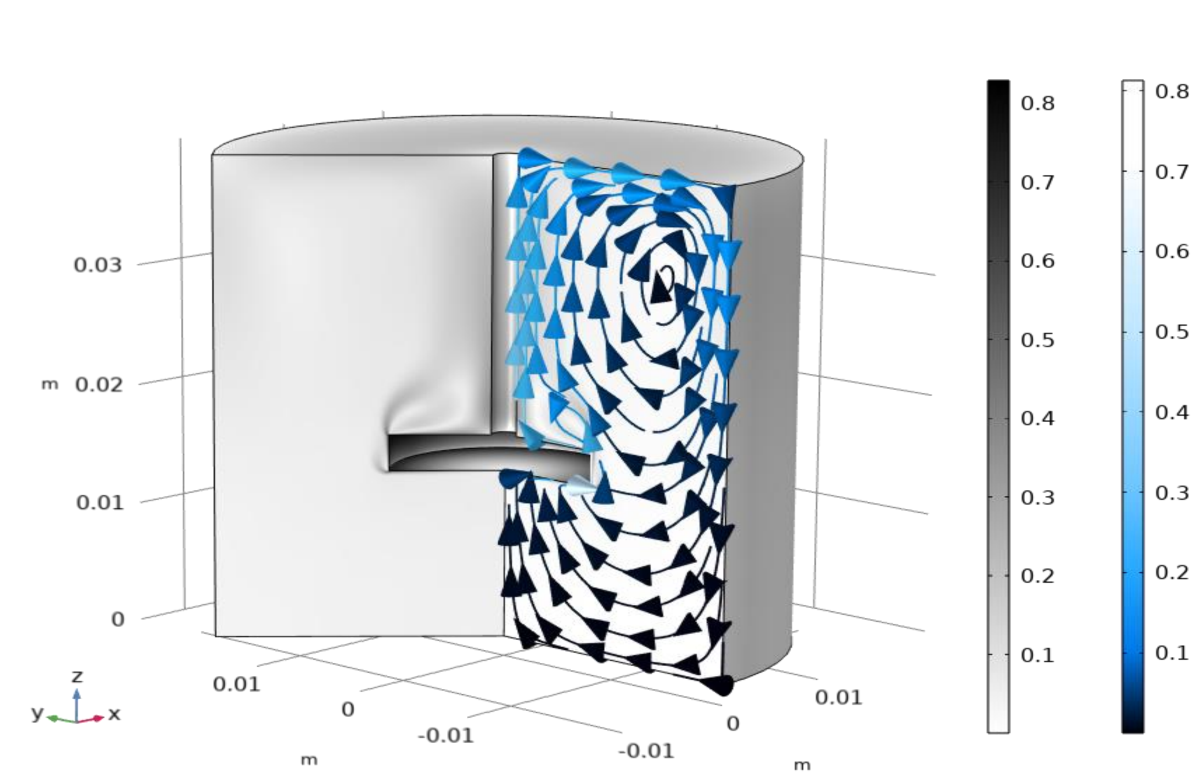
Omega=**314.16**	Omega=**942.48**	Omega=**1570.8**	Legend
			

➔Pressure Plots: -

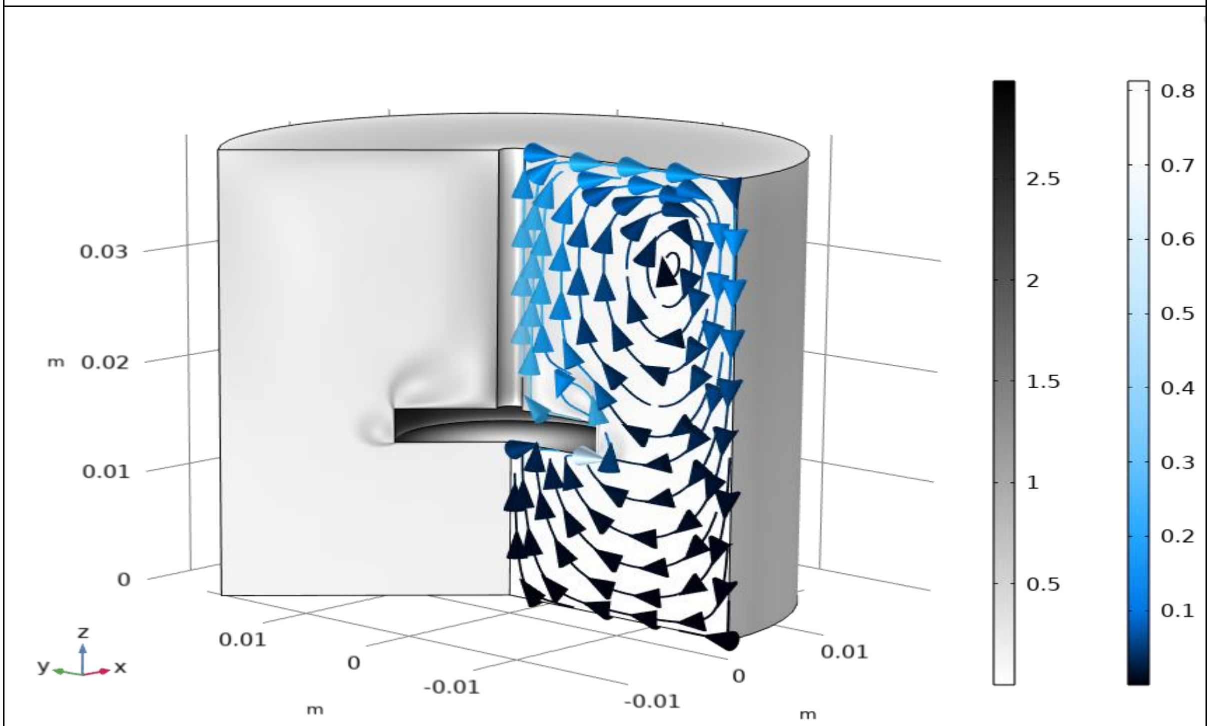
Omega=**314.16**	Omega=**942.48**	Omega=**1570.8**	Legend
			

➔Velocity 3D Plots: -

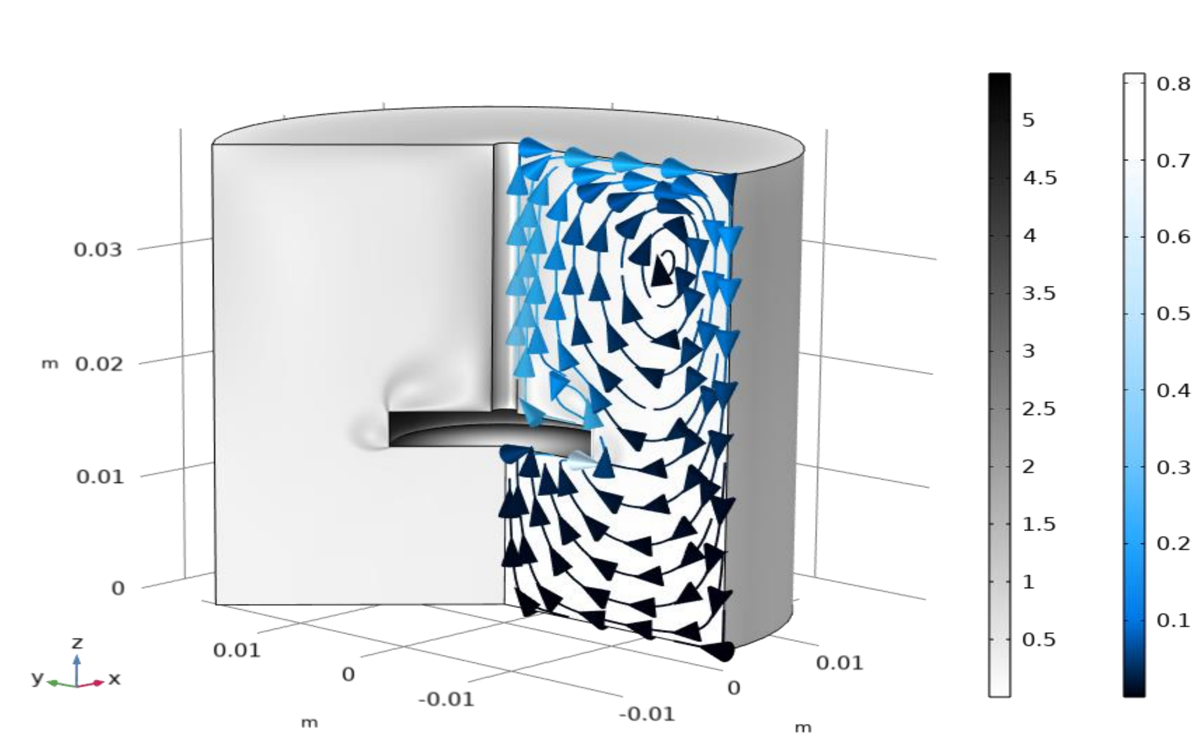
Omega =314.16 rad/sec



Omega=942.48 rad/sec



Omega=1570.8 rad/sec



➔ Azimuthal Velocity (Surface & Contour) Plot: -

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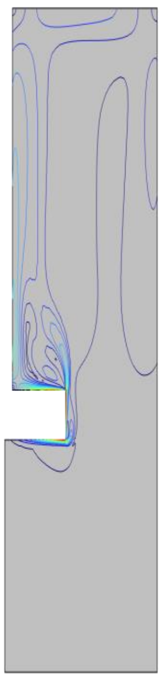	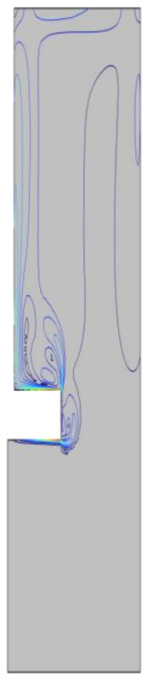	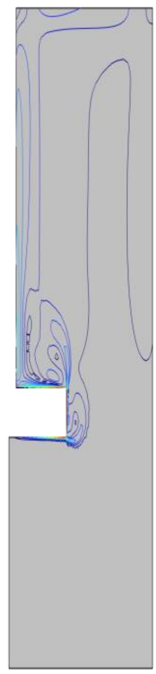	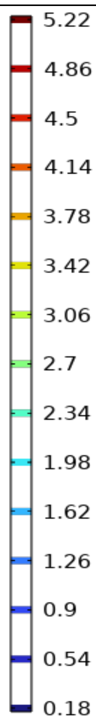

➔Turbulent Velocity (Surface & Streamline) Plot:

Omega=**314.16**	Omega=**942.48**	Omega=**1570.8**	Legend