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Grid generation for screw machines with large helix angle

How to Choose an Effective Grid Generation Methods for CFD Meshing of Screw Machine?

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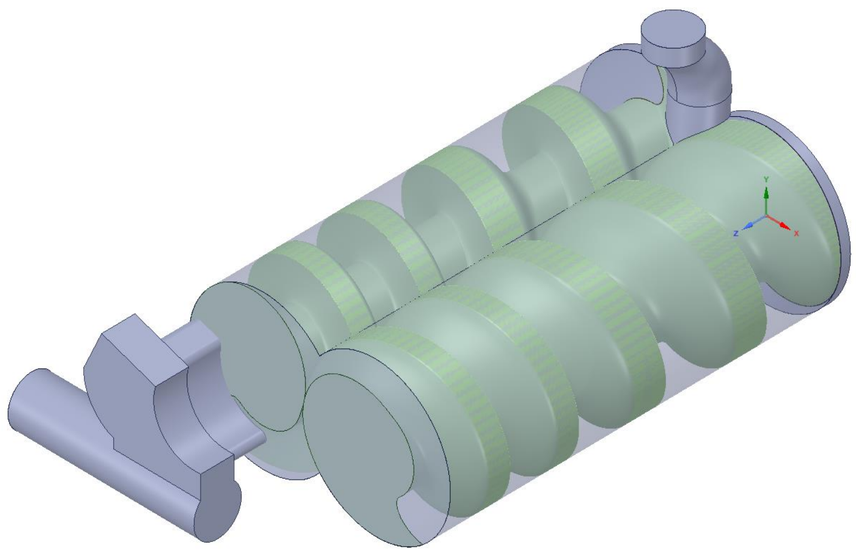
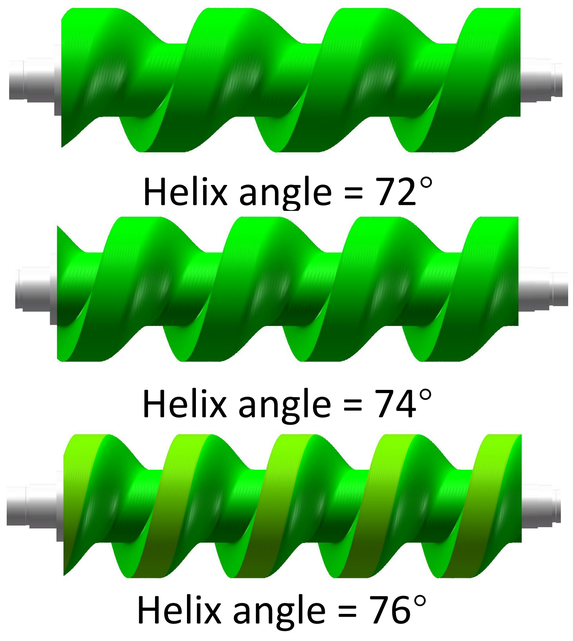
Aim Develop a robust grid generation method for screw machines with large helix angle .

Background

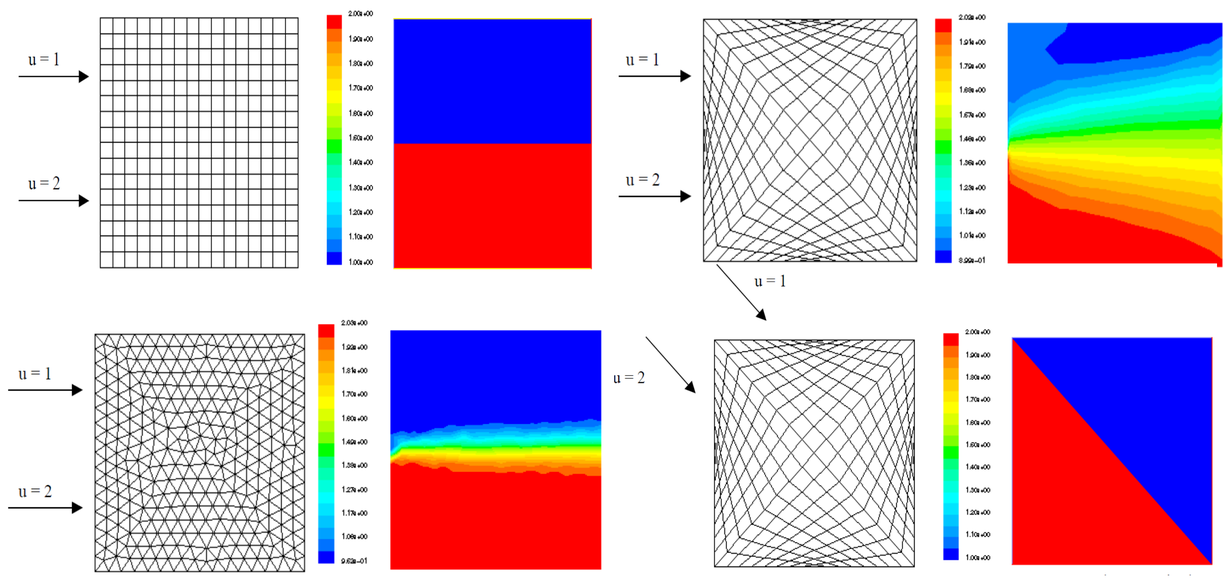
- Vacuum pumps has large helix angle and the grid generation for screw machines with large helix angle is difficult.
- The leakage flow directions are perpendicular to the helix of the leak flow path. The flow direction cannot aligned with the grid which will produce convection errors.



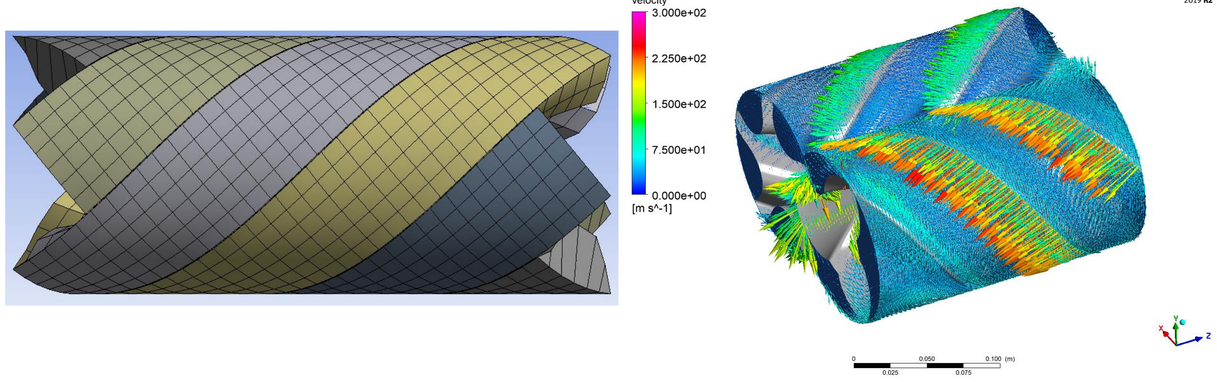


$$\underbrace{\frac{d}{dt}\int_{\Omega}\rho\phi d\Omega}_{transient} + \underbrace{\int_{S}\rho\phi(\boldsymbol{v}-\boldsymbol{v_b}).\boldsymbol{n}dS}_{convection} = \underbrace{\int_{S}\Gamma\ grad\ \phi.\boldsymbol{n}dS}_{diffusion} + \underbrace{\int_{\Omega}q_{\phi}d\Omega}_{source}$$ General conservation equation

Solution 1 - Flow aligned mesh

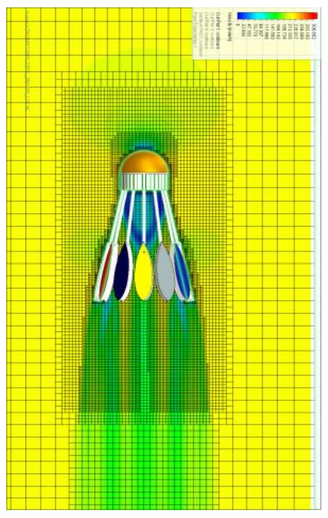


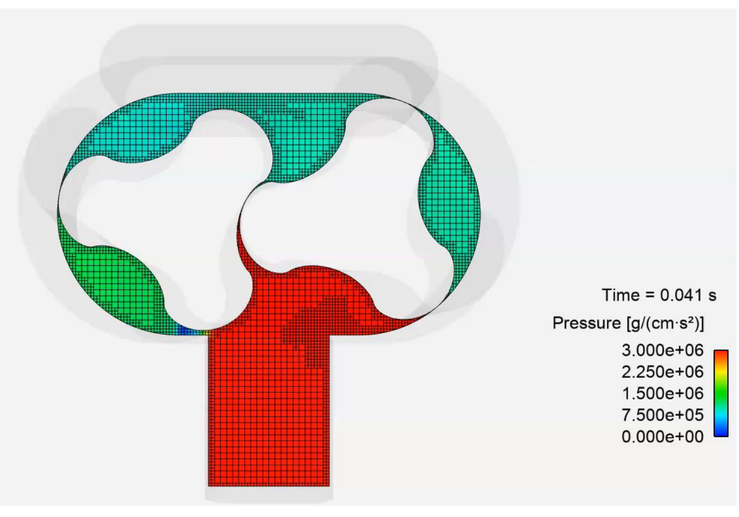
- Flow aligned method can reduce numerical diffusion for gap flow.



- Develop further with self-developed software.
- Algebraic grid generation method can provide explicit control of physical grid shape and spacing.
- Require relatively shorter calculation time.
- Can be used in most of CFD solver.

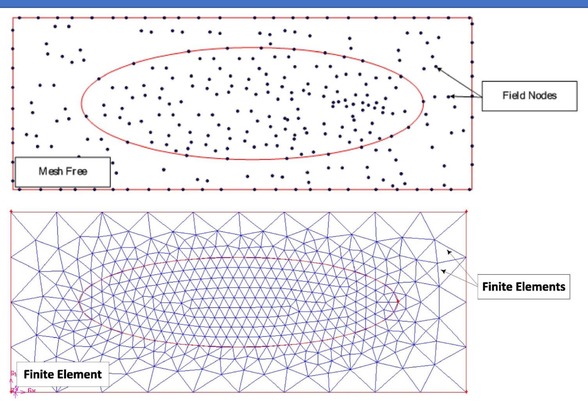
Solution 2 – Cut-cell mesh

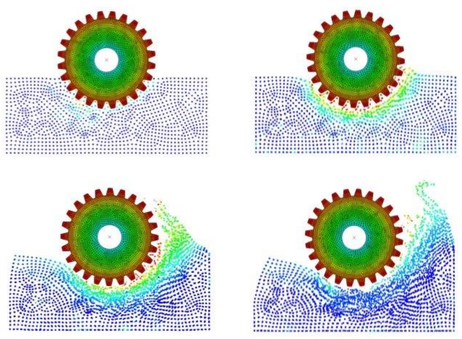




- The gap model is used to compensate for the under-resolved mesh in the gap region.
- High quality hexahedral elements adapted (refined/coarsened) very quickly based on a predefined criterion.

Solution 3 – Mesh free





- Do not rely on a traditional mesh and have low sensitivity to complex geometry, less effort on preparing models, generating meshes.
- Model particle flow are based on the analysis of the motion of individual particles.

Summary

- Algebraic grid generation algorithm can generate the grids aligning with the main and leakage flow direction for screw machines.
- Cut-cell method is used in ANSYS Forte and Converge for screw machines while Mesh free method is used in Xflow.
- Comparison of the simulation results of three different methods to give the guideline of the meshing of screw machines.

[1] J. Vierendeels, Ghent University, Introduction to CFD analysis in positive displacement machines.
[2] L. Yang, A. Kovacevic, N. Basha and M. Read, CFD analysis of twin screw vacuum pump. 9th International Conference on Compressors and Refrigeration, 2019.
[3] FloEFD image from Travis Mikjaniec's blog "CFD and the Olympics"

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