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Solution 2043021
Influence of polyhedral mesh on gradient calculation

Index

Description (1)

ANSYS Fluent has the capability to convert *globally* or *locally* the cells of a pre-existing grid into polyhedral cells.

The generation of polyhedral grids is now natively possible in ANSYS Fluent Meshing and is a valuable solution compared to *a posteriori* conversion (see next slide).

Polyhedral are known to show some numerial properties due to lower cell count compared to tetraedral grid:

- Less memory required
- Faster time to obtain solution

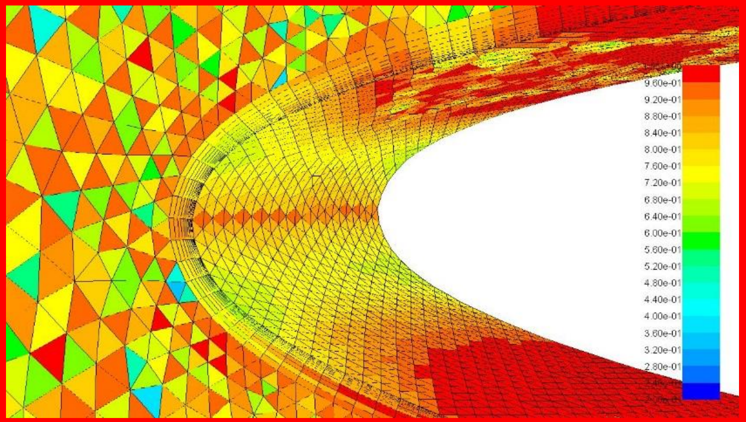
→ Nevertheless, what is the impact of polyhedra on the calculation of gradients?

Description (2)

- NACA0012
- Grids with < 500k cells

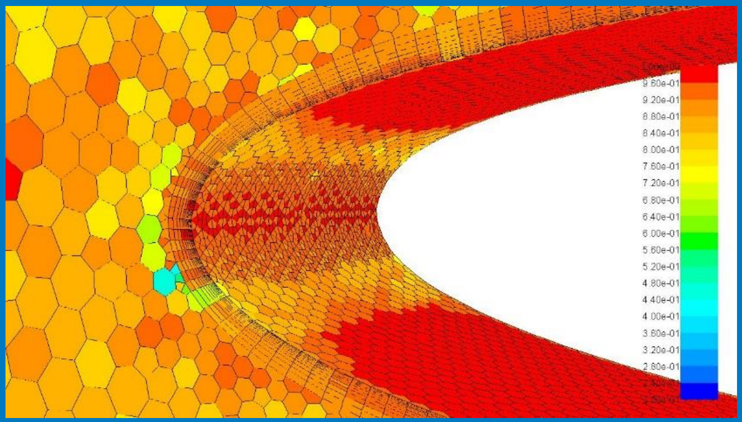
Contours of Orthogonal quality

Tetrahedra + 12 Prisms

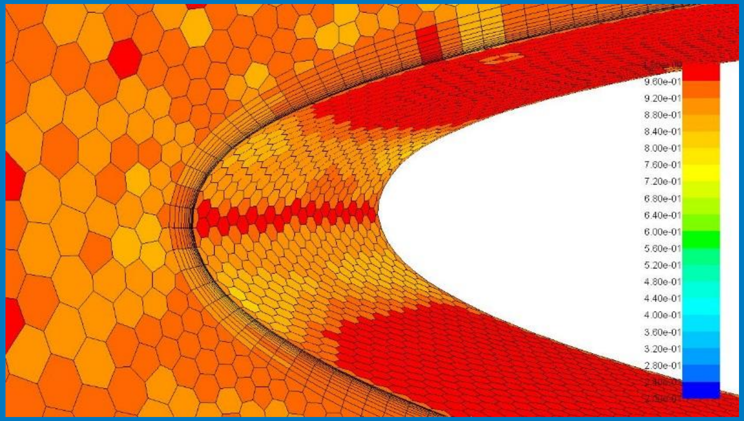


Tetra + Prisms in Fluent Meshing

Polyhedra + 12 « Prisms »



Conversion to polyhedral grid in Fluent



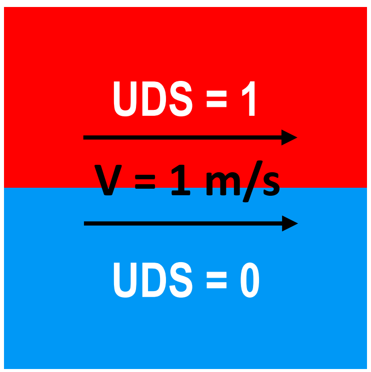
Native polyhedral grid in Fluent Meshing

The conversion of tetras into polyhedra directly in ANSYS Fluent allows to improve the orthogonal quality of cells. However, mesh orthogonal quality is still higher when generating directly polyhedral cells in Fluent Meshing.

→ All polyhedral grids are natively created in Fluent Meshing hereafter.

Solution (1)

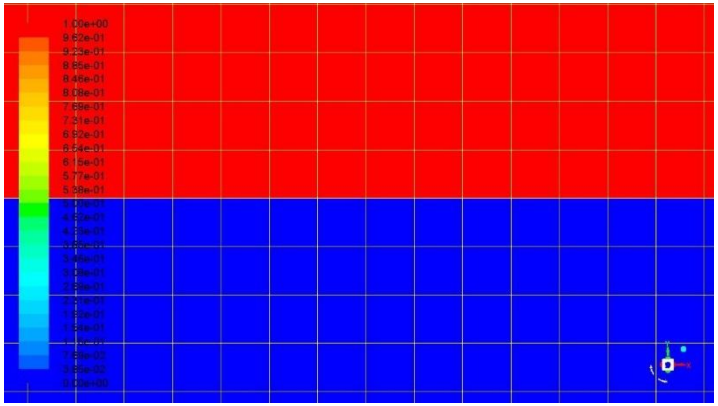
- Inviscid fluid (No laminar or turbulent viscosity)
- 2nd order upwind
- Green-Gauss Node-Based for gradient algorithm



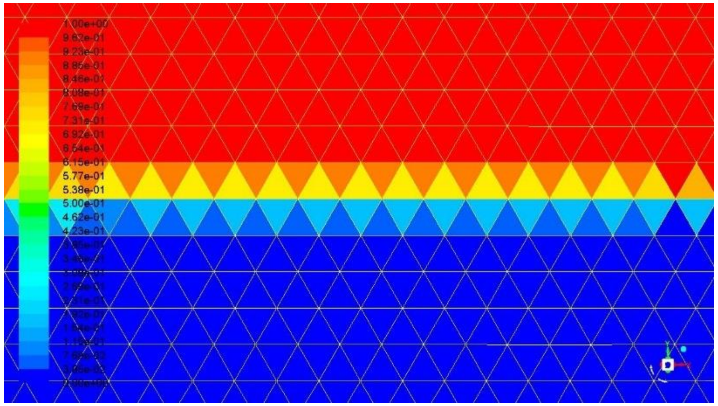
Numerical diffusion of gradient is obvious on unstructured meshes. Effect is even higher on polyhedral mesh.

Aligned hexahedral grid shows no diffusion of UDS gradient.

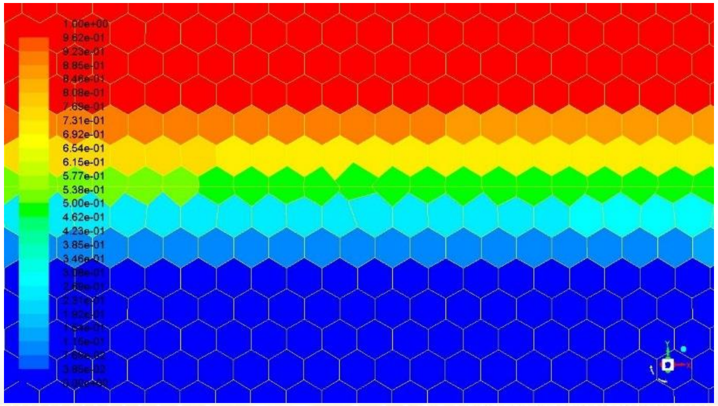
Contours of UDS



Hexaedral mesh 10K cells (Aligned)



Tetrahedral mesh 17K cells



Polyhedral mesh 6K cells

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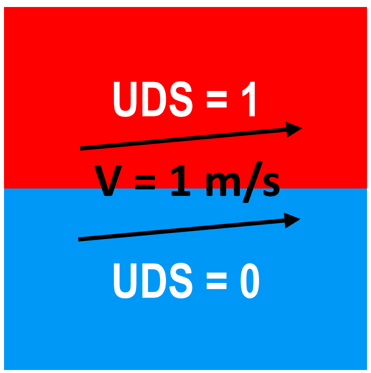
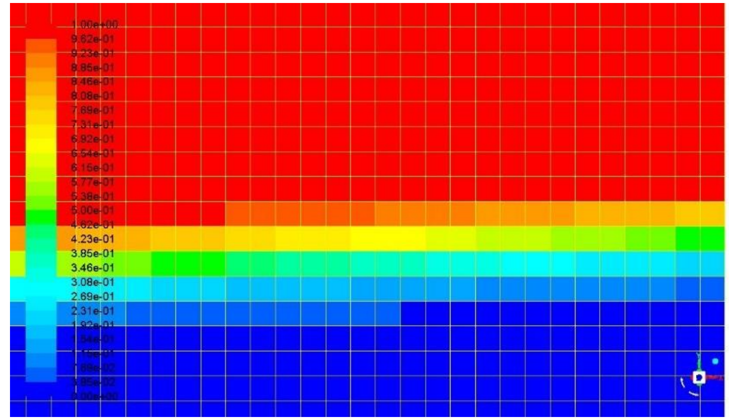
Solution (2)

- Inviscid fluid (No laminar or turbulent viscosity)
- 2^{nd} order upwind
- Green-Gauss Node-Based for gradient algorithm

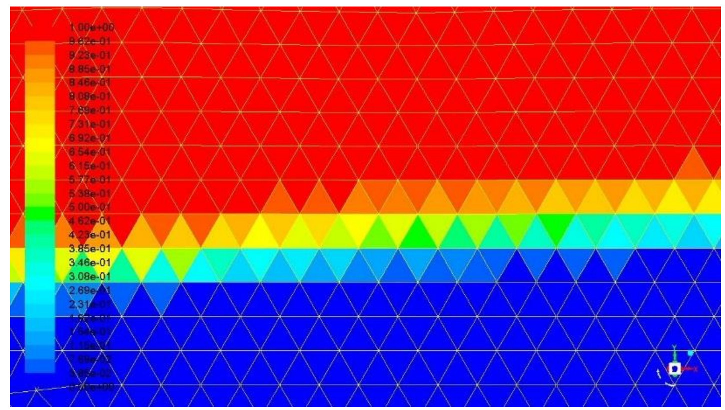


Numerical diffusion of gradient is obvious and comparable on all meshes. Such effect is visible even for light mis-alignment of flow with hexaedral cells.

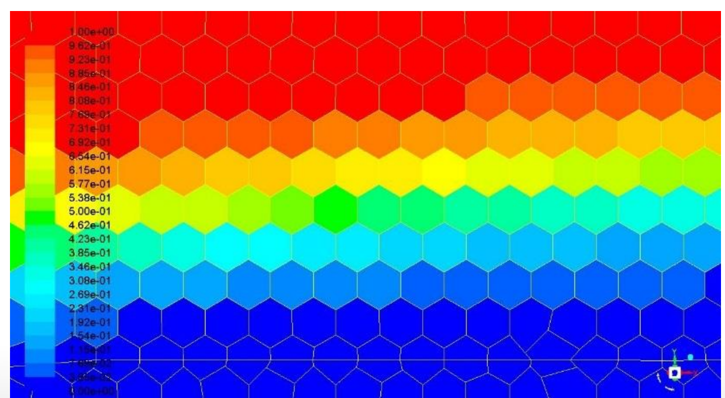
Contours of UDS



Hexaedral mesh 10K cells (Aligned)



Tetrahedral mesh 17K cells



Polyhedral mesh 6K cells

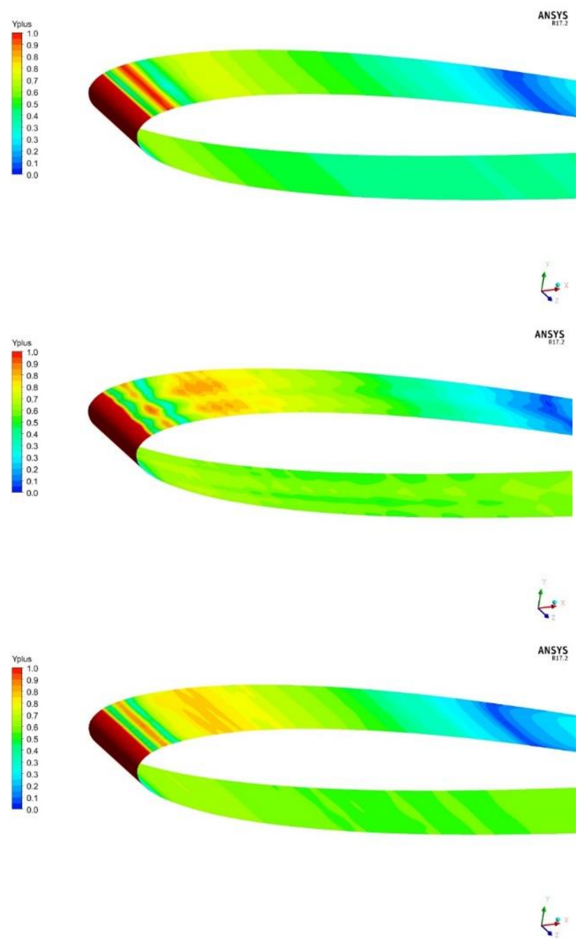
Solution (3)

- NACA0012
- All grids with < 500k cells
- 12 prism layers
- Roughly same wall resolution
- $Re_{chord} \sim 0.7\ 10^5$

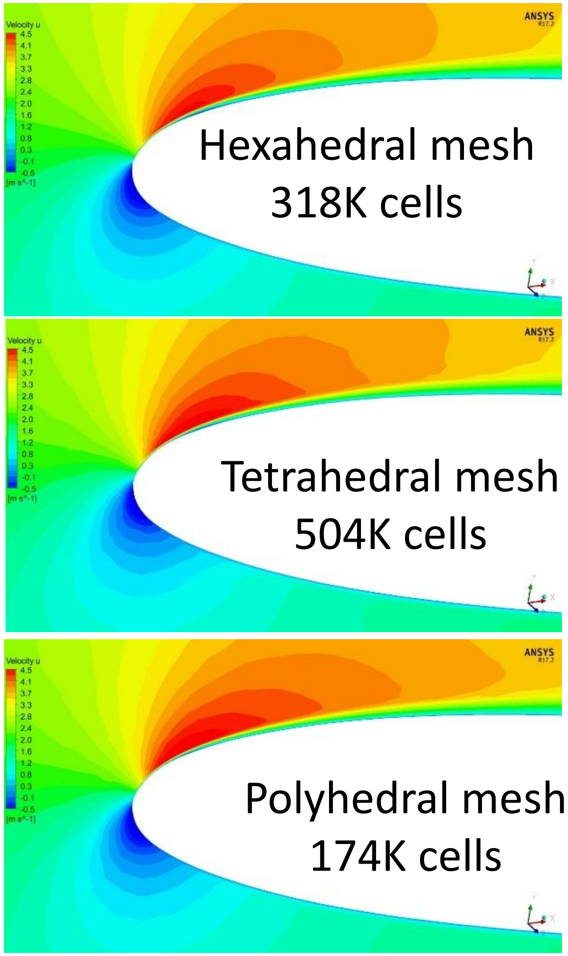
- RANS kw SST
- 2nd order upwind
- Green-Gauss Node-Based for gradient algorithm

All meshes show comparable velocity fields in the vicinity of the leading edge of airfoil.

Contours of y+



Contours of Axial velocity

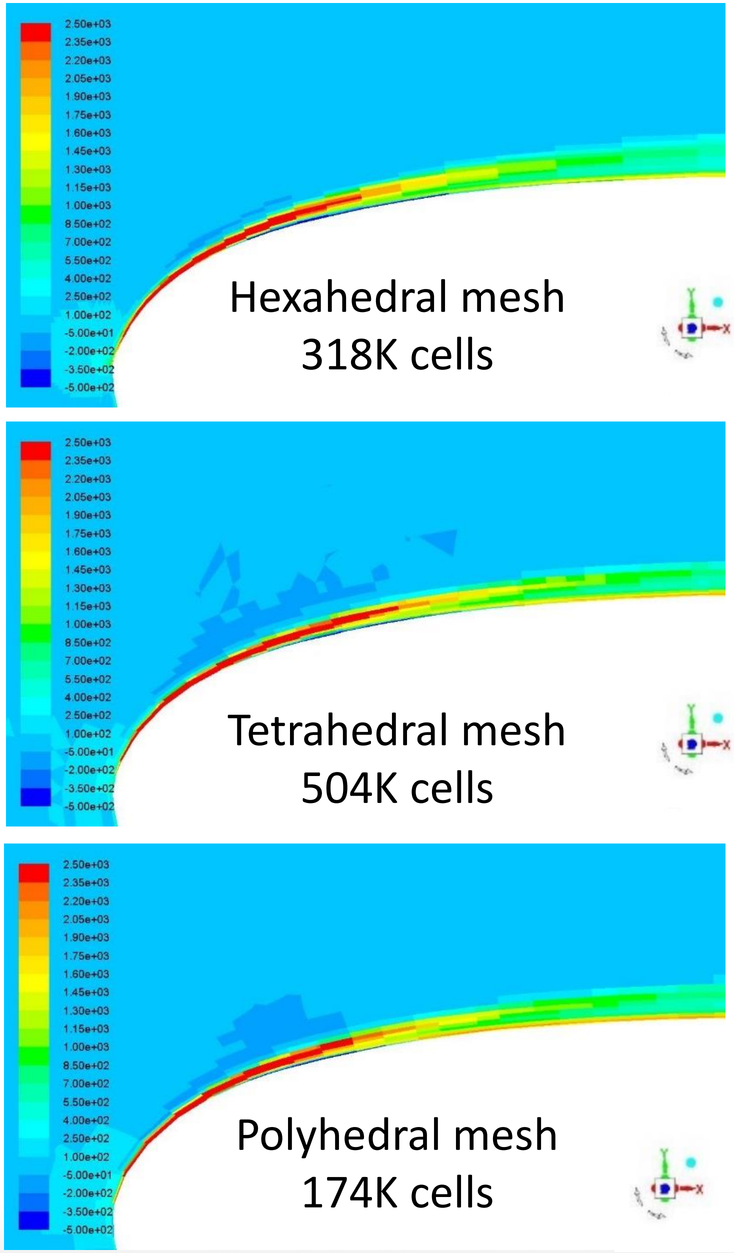


Solution (4)

- RANS kw SST
- 2nd order upwind
- Green-Gauss Node-Based for gradient algorithm

All meshes show similar velocity gradients in the vicinity of the leading edge of airfoil.

Contours of derivative dU/dY



Summary

Native generation of polyhedral is available in Fluent Meshing 17.x.

3 types of grids have been investigated to evaluate the influence of grid type on velocity gradient:

1. Structured grid with **hexahedra**
2. Unstructured grid with **tetrahedral** + **prisms**
3. Unstructured grid with **polyhedral**

Conclusions are the following:

- Polyhedral grids show much lower cell count and comparable accuracy compared to tetrahedral grids.
- Polyhedral mesh usually shows superior orthogonal quality compared to tetrahedral mesh when similar size functions are employed in Fluent Meshing.
- Hexaedral grids show superior numerical properties when flow is well aligned normal to cell faces.
- In other circumstances, gradients are very similar between the different grids.