3rd AIAA CFD High-Lift Prediction Workshop

Embraer´s Participant Grids of the HL-CRM Gapped Geometry Model

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SUMMARY

A family of three unstructured grids of the HL-CRM gapped configuration model (Case 1a) was created according to the HiLift-PW3 meshing guidelines.

All meshing guideline requirements are met in all grid levels, coarse, medium and fine.

All grids were generated with ANSA pre-processing software v17.1.1.

The purpose of this document is to summarize the grid characteristics, including grid sizes and any issues encountered/corrected when creating them.

All grids are provided in inches and in CFD++ format. For more informartion or different format request, please contact: maximiliano.souza@embraer.com.br

Grid Characteristics

The wing, slat and flap surface mesh elements are made of quad cells mostly, and the fuselage are made of triangles. Therefore, the viscous layers are made of hexa and prismatic cells.

The volume mesh are made of tetrahedral cells with pyramid elements for the hexa-tetra transition.

In summary this is a Hexa(60%)-Prism(10%)-Tetra(28%)-Pyra(2%) unstructured mesh built for a cell-centered solver.

Grid Characteristics

	COARSE	MEDIUM	FINE
Surface Mesh Size [million cells]	0.8	1.9	4.0
Volume Mesh Size [million cells]	39	127	400
Layers First Height [inches]	0.00174	0.00117	0.00077
Layers Growth Ratio	1.23	1.15	1.10
Wing No. of Layers	33	49	72
Fuselage No. of Layers	43	64	94
No. of Constant Spacing Layers	3	5	7
Tetra Growth Ratio	1.23	1.15	1.10
Max Tetra Size [wing span]	4.8	3.2	2

Grid Characteristics

The surface mesh of the wing, slat and flaps are essentially a structured mesh built up from quad elements. Therefore the mesh resolution is defined by how many points are in each direction and how they are distributed along it.

Due to the high degree of freedom and control of the surface mesh cell size and distribution a structured mesh can offer, it was possible to fulfill the HiLift-PW3 meshing guidelines to its full extent.

Grid Characteristics

COARSE - SURFACE MESH	WING	SLAT	FLAP
Chordwise No. of Cells	294	138	203
Spanwise No. of Cells	741	1480	818
LE Chordwise Spacing [% local chord]	0.15%	0.15%	0.15%
TE Chordwise Spacing [% local chord]	0.15%	0.15%	0.15%
Chordwise Growth Factor	1.10	1.10	1.10
Chordwise Max Spacing [% local chord]	0.90%	3.50%	1.70%
Root Spanwise Spacing [% wing span]	0.15%	0.012%	0.03%
Tip Spanwise Spacing [% wing span]	0.03%	0.008%	0.03%
Spanwise Growth Factor	1.01	1.01	1.01
Spanwise Max Spacing [% wing span]	0.22%	0.09%	0.14%
TE No. of Cells	4	2	4

Grid Characteristics

MEDIUM - SURFACE MESH	WING	SLAT	FLAP
Chordwise No. of Cells	457	246	316
Spanwise No. of Cells	1064	2215	1245
LE Chordwise Spacing [% local chord]	0.10%	0.10%	0.10%
TE Chordwise Spacing [% local chord]	0.10%	0.10%	0.10%
Chordwise Growth Factor	1.05	1.05	1.05
Chordwise Max Spacing [% local chord]	0.60%	2.50%	1.10%
Root Spanwise Spacing [% wing span]	0.10%	0.008%	0.02%
Tip Spanwise Spacing [% wing span]	0.02%	0.008%	0.02%
Spanwise Growth Factor	1.01	1.01	1.01
Spanwise Max Spacing [% wing span]	0.15%	0.06%	0.09%
TE No. of Cells	8	4	8

Grid Characteristics

FINE - SURFACE MESH	WING	SLAT	FLAP
Chordwise No. of Cells	686	384	496
Spanwise No. of Cells	1574	3266	1731
LE Chordwise Spacing [% local chord]	0.07%	0.07%	0.07%
TE Chordwise Spacing [% local chord]	0.07%	0.07%	0.07%
Chordwise Growth Factor	1.03	1.03	1.03
Chordwise Max Spacing [% local chord]	0.40%	1.50%	0.70%
Root Spanwise Spacing [% wing span]	0.08%	0.008%	0.01%
Tip Spanwise Spacing [% wing span]	0.01%	0.008%	0.01%
Spanwise Growth Factor	1.01	1.01	1.01
Spanwise Max Spacing [% wing span]	0.10%	0.04%	0.06%
TE No. of Cells	12	6	12

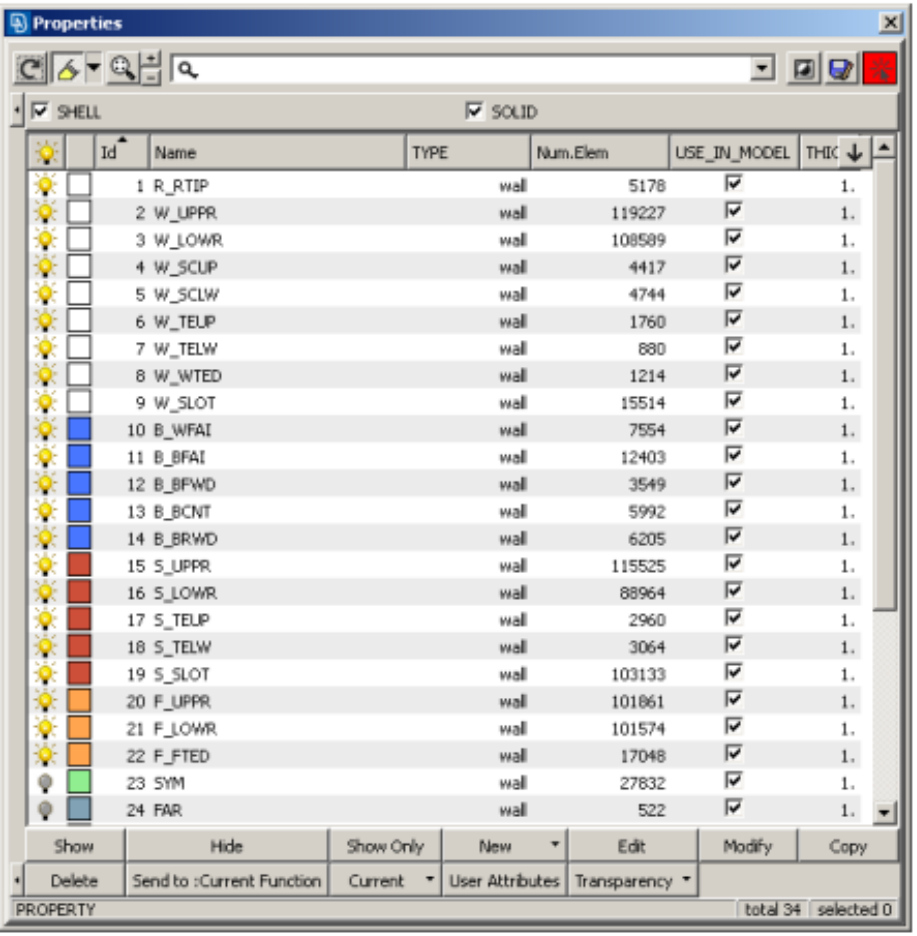
Grid Characteristics

The fuselage surface mesh is made of triangular type element with variable size based on local curvature.

FUSELAGE	COARSE	MEDIUM	FINE
Curvature Refinement [1-90]	10	10	10
Cell Size Nose/Tail	1.5% C_{ref}	1.0% C_{ref}	0.6% C_{ref}
Maximum Cell Size	6.0% C_{ref}	4.0% C_{ref}	0.8% C_{ref}
Growth Factor	1.10	1.10	1.10

C_{ref}: Wing Reference Chord

GEOMETRY



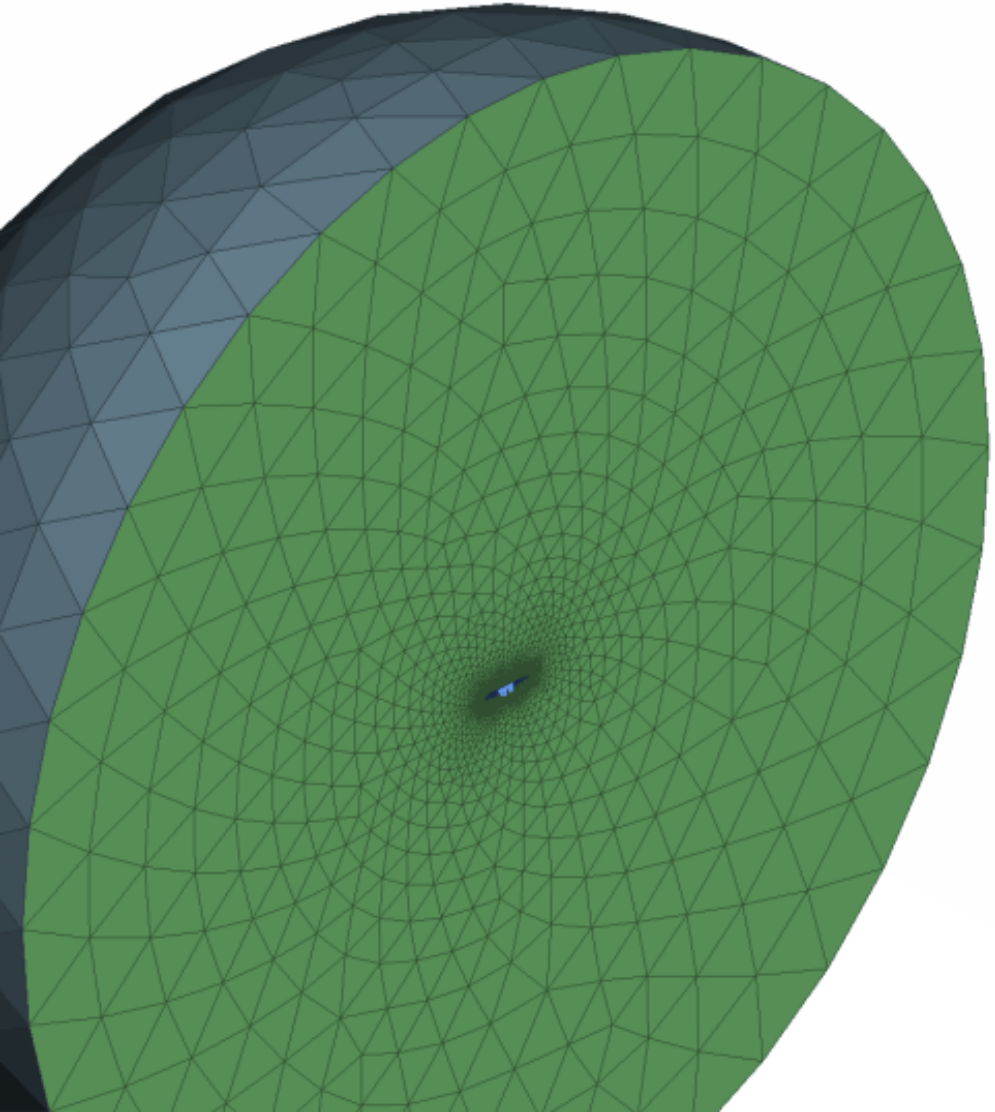
Id	Name	TYPE	Num.Elem	USE_IN_MODEL	THIC
1	R_RTIP	wal	5178	✓	1.
2	W_UPPR	wal	119227	✓	1.
3	W_LOWR	wal	108589	✓	1.
4	W_SCUP	wal	4417	✓	1.
5	W_SCLW	wal	4744	✓	1.
6	W_TEUP	wal	1760	✓	1.
7	W_TELW	wal	880	✓	1.
8	W_WTED	wal	1214	✓	1.
9	W_SLOT	wal	15514	✓	1.
10	B_WFAI	wal	7554	✓	1.
11	B_BFAI	wal	12403	✓	1.
12	B_BFWD	wal	3549	✓	1.
13	B_BCNT	wal	5992	✓	1.
14	B_BRWD	wal	6205	✓	1.
15	S_UPPR	wal	115525	✓	1.
16	S_LOWR	wal	88964	✓	1.
17	S_TEUP	wal	2960	✓	1.
18	S_TELW	wal	3064	✓	1.
19	S_SLOT	wal	103133	✓	1.
20	F_UPPR	wal	101861	✓	1.
21	F_LOWR	wal	101574	✓	1.
22	F_FTED	wal	17048	✓	1.
23	SYM	wal	27832	✓	1.
24	FAR	wal	522	✓	1.

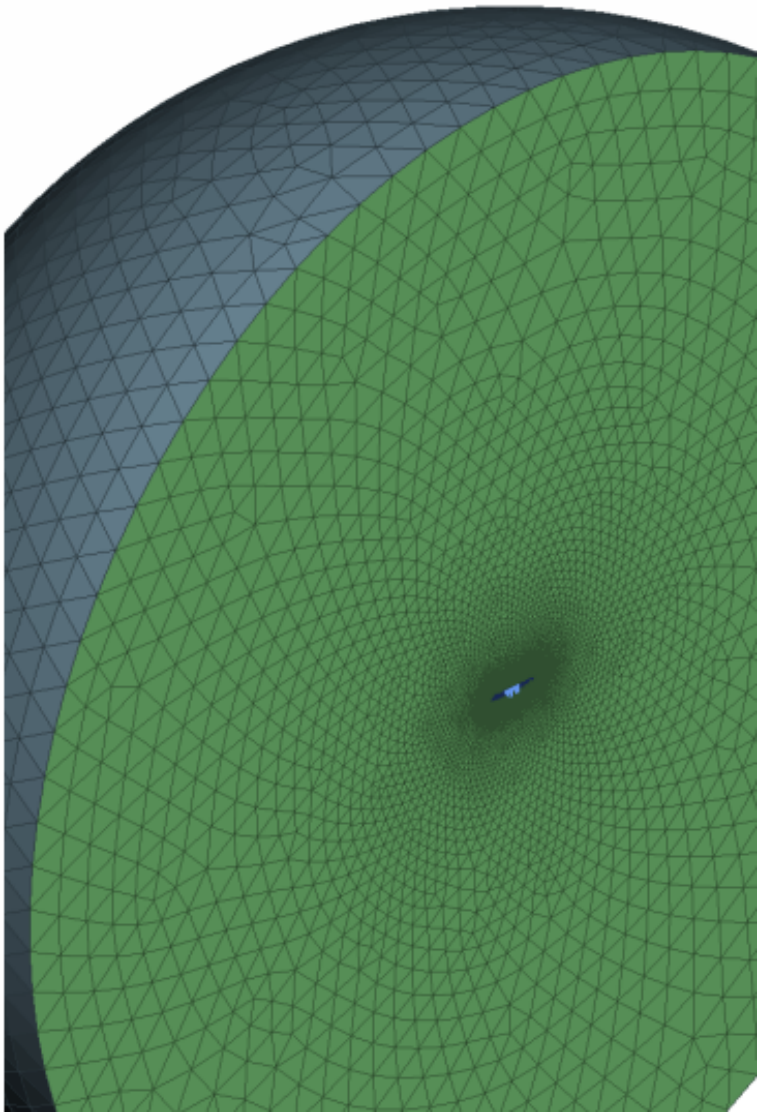
Boundary Condition Surfaces Type:
Surfaces 1-22 WALL
Surface 23 SYMMETRY
Surface 24 FREESTREAM

GEOMETRY

Farfield is located at 100 C_{ref} for all grid levels.

Surface Mesh





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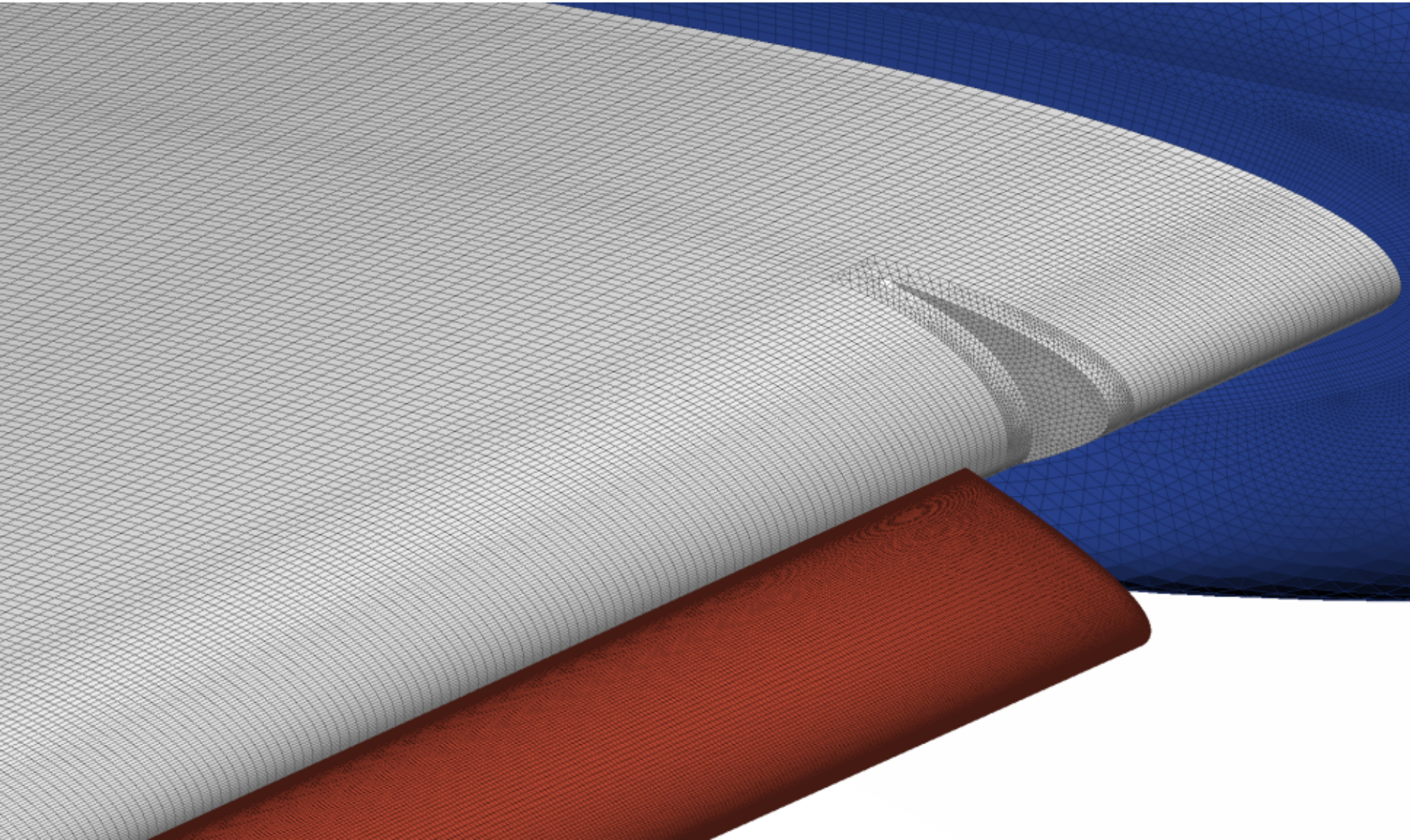

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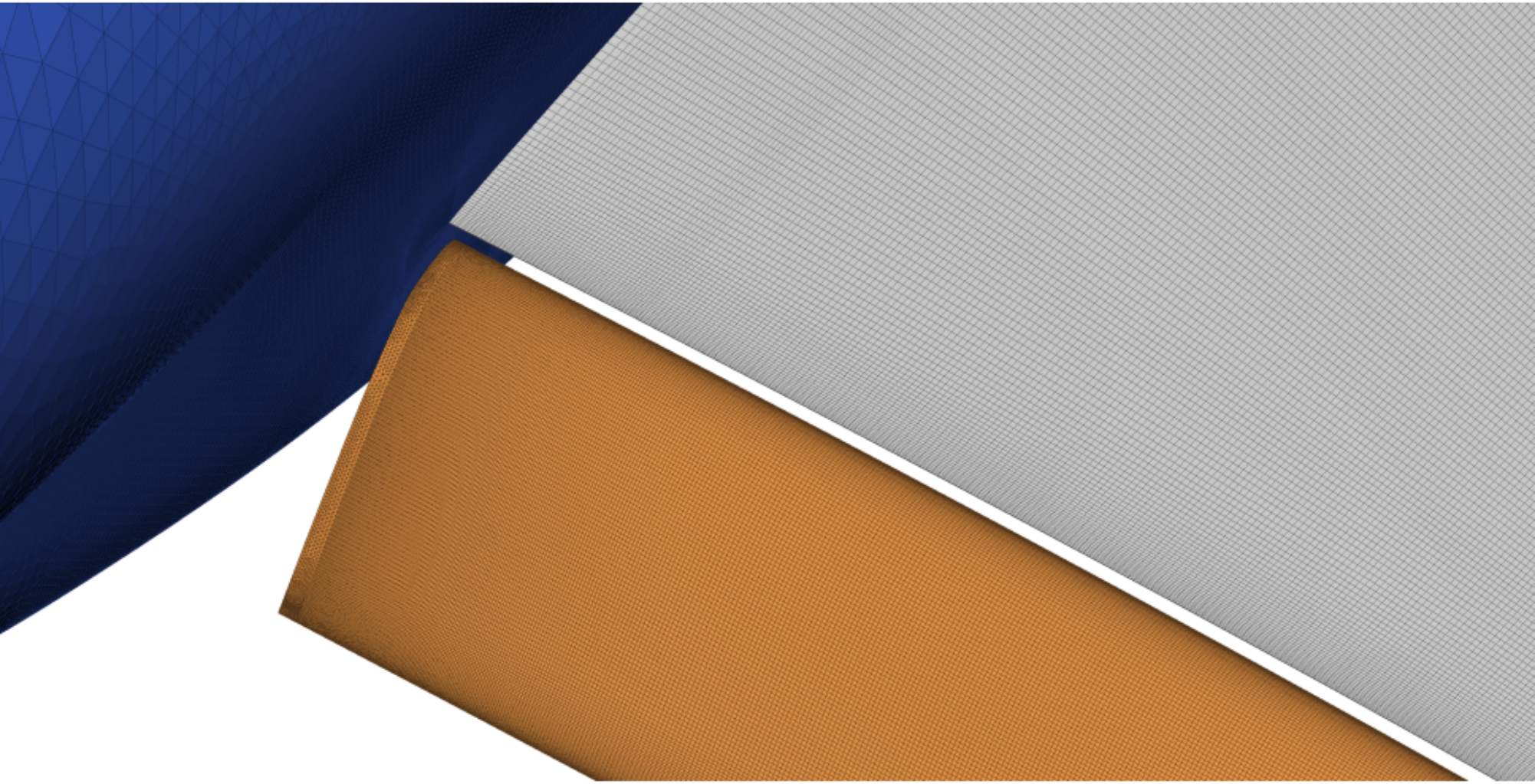

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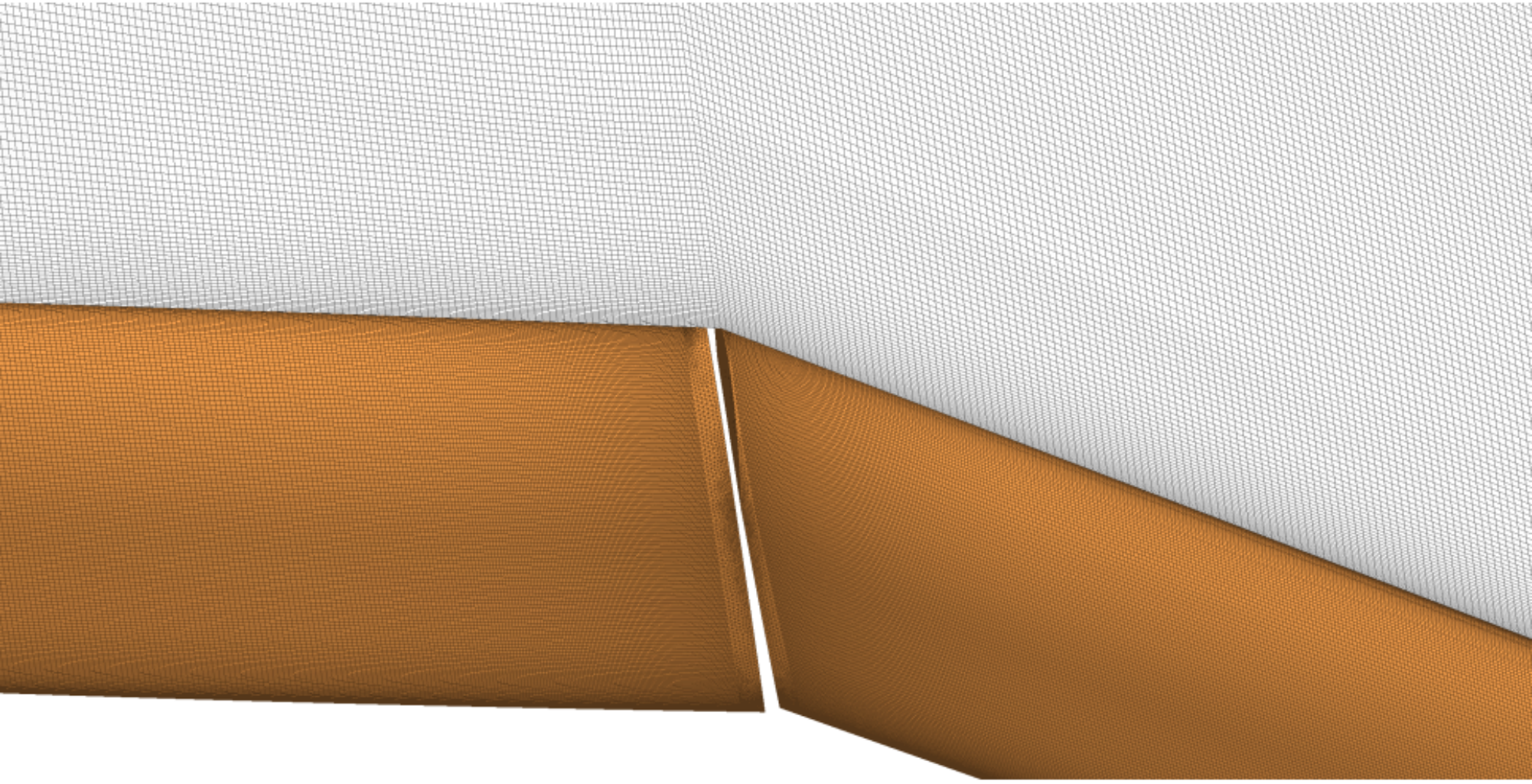

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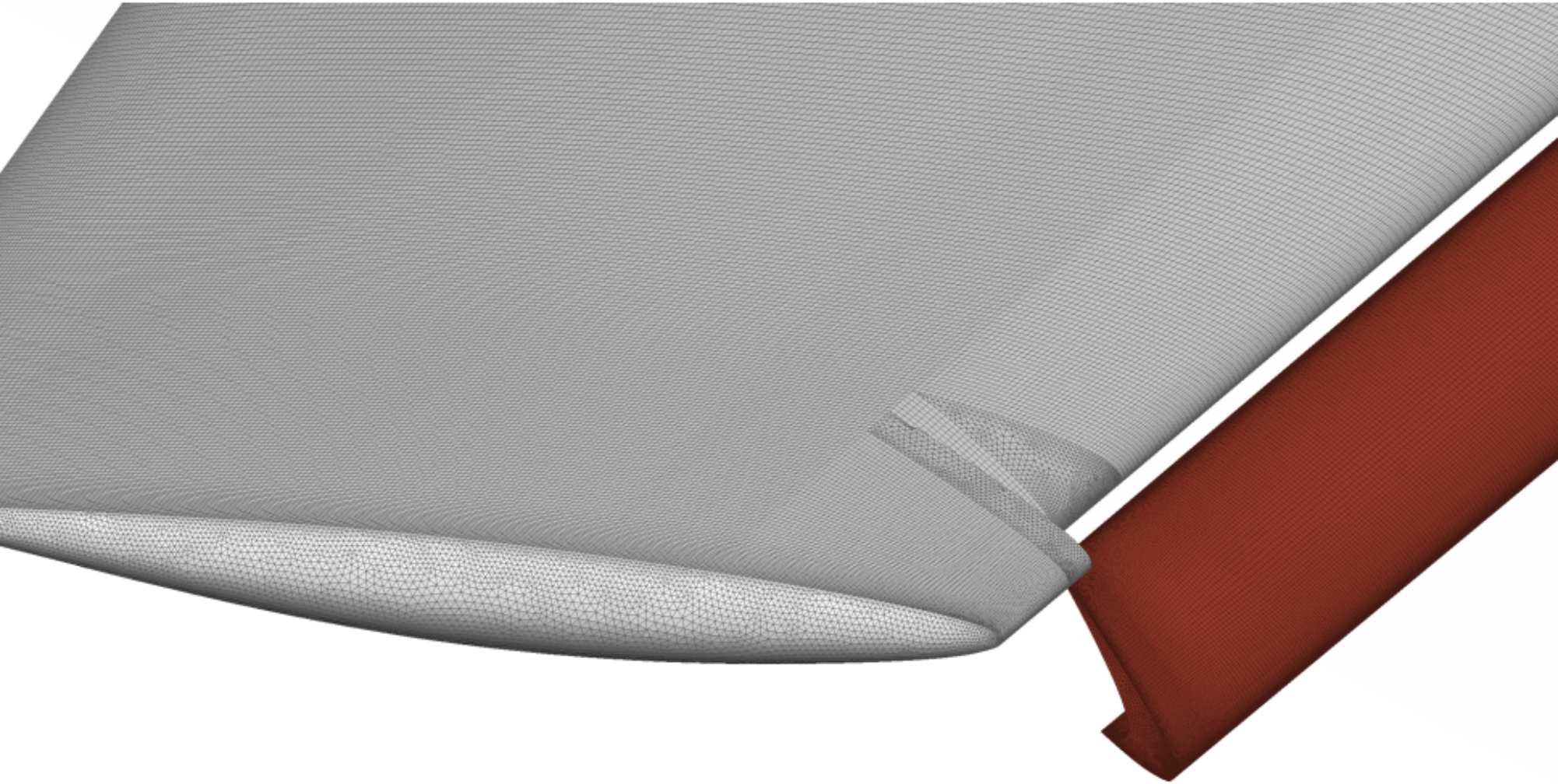

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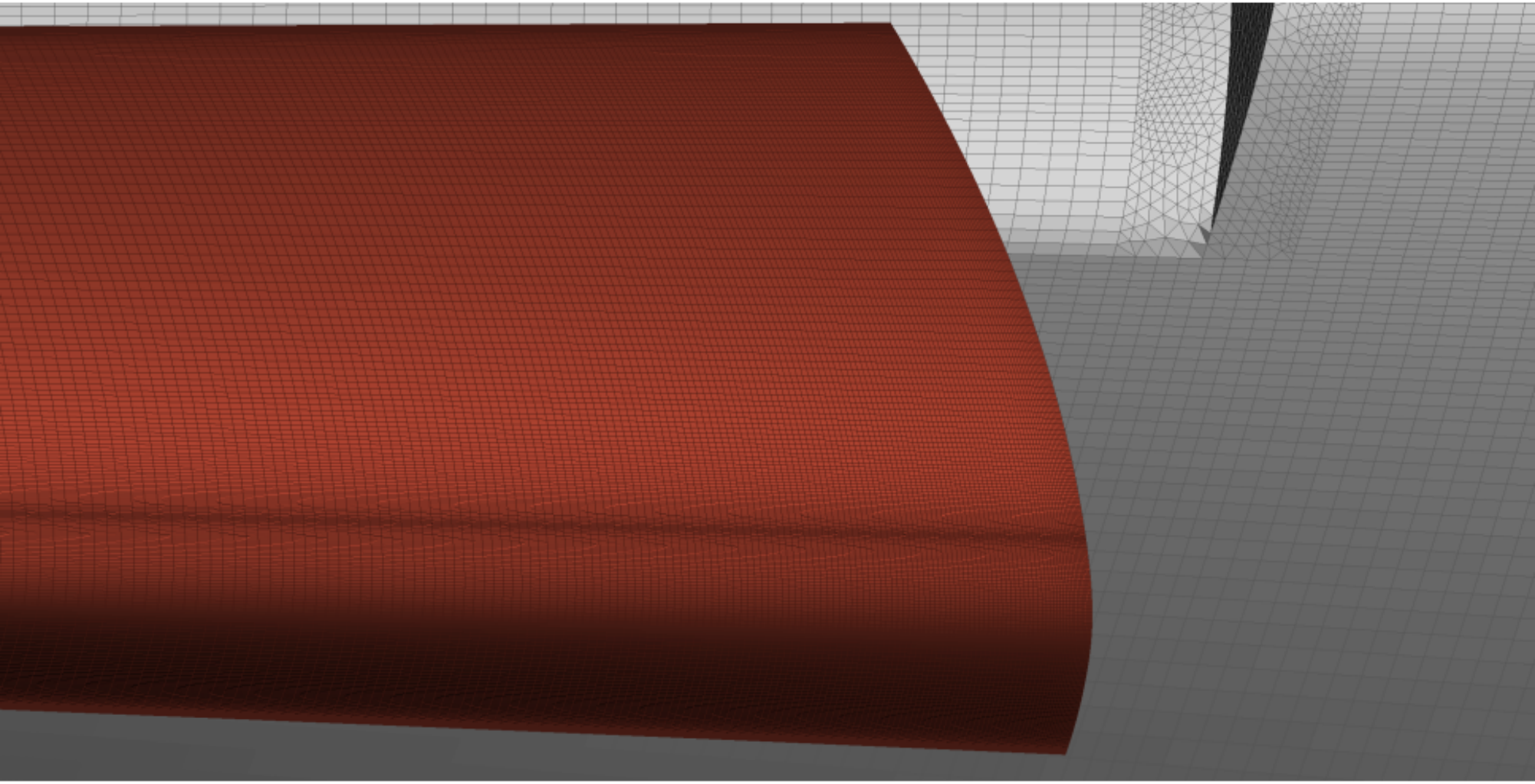

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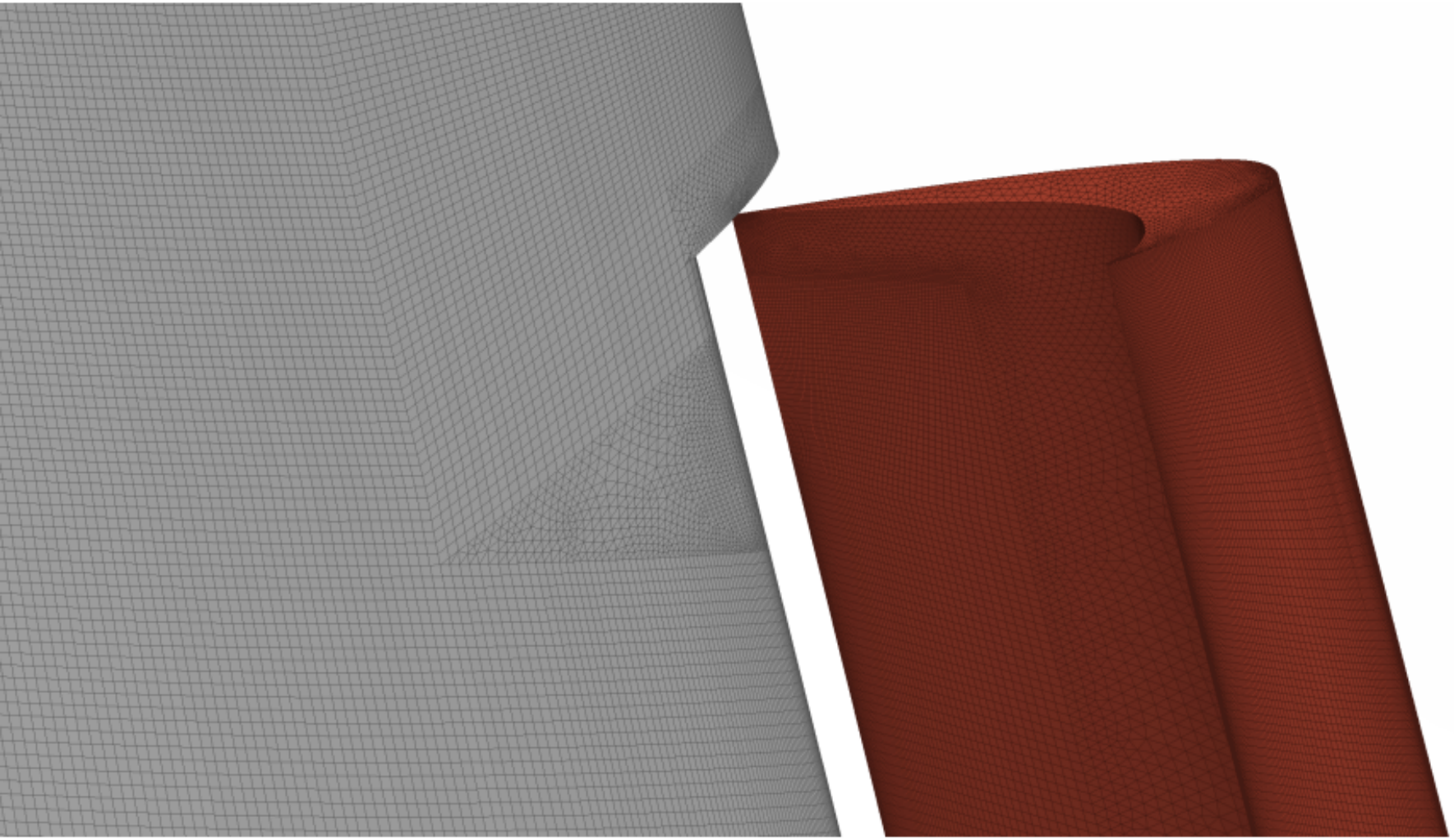

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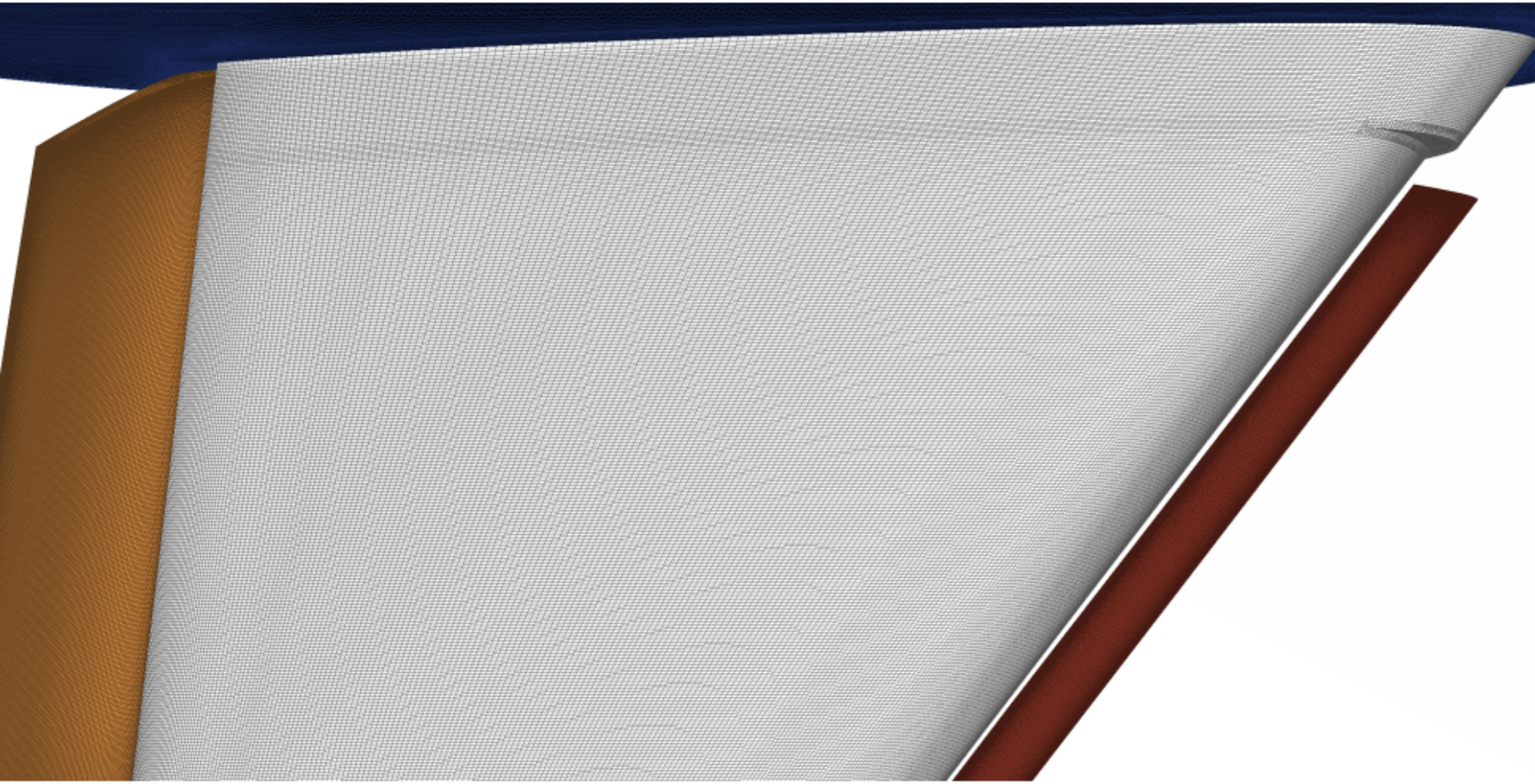

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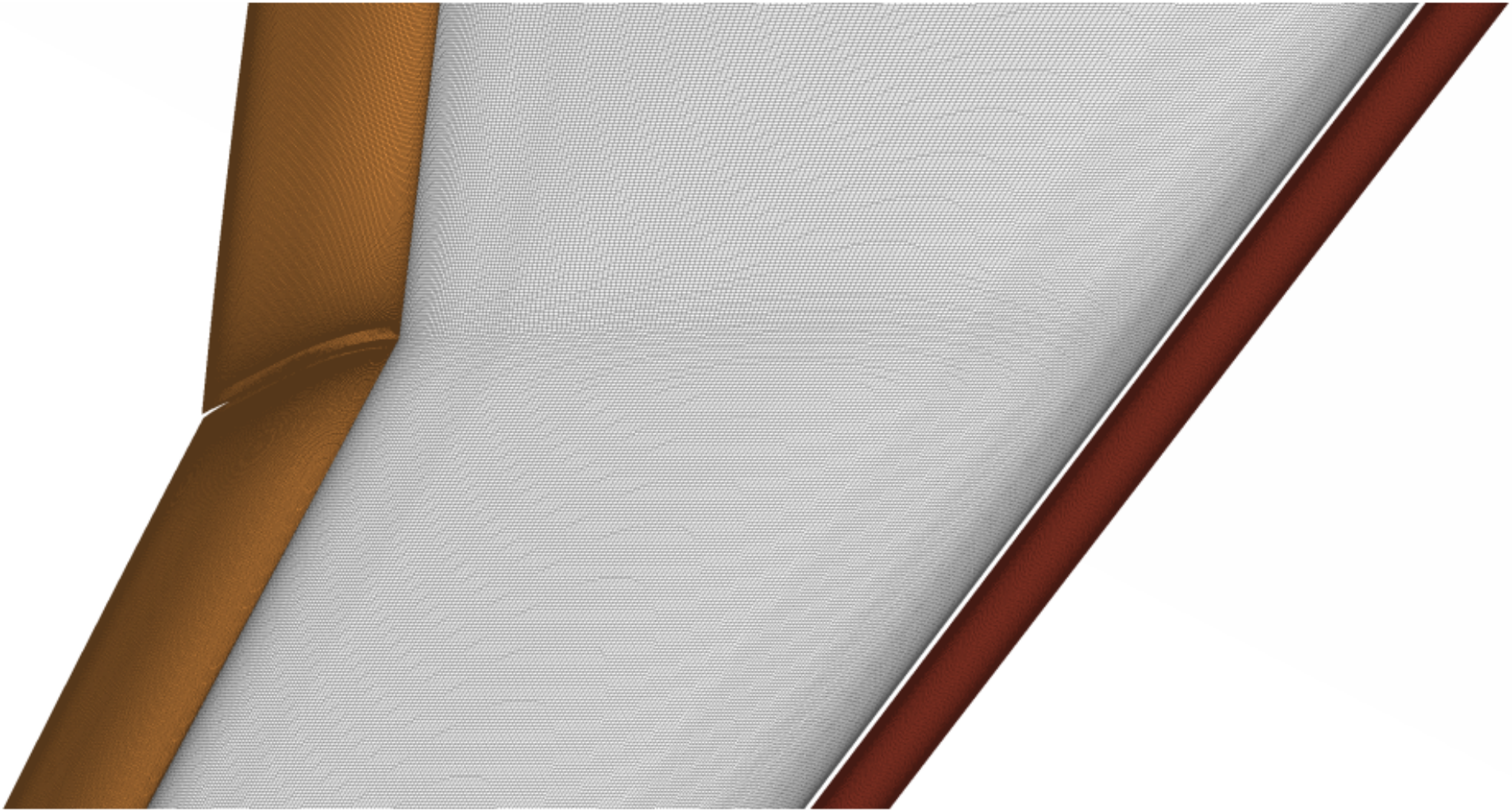

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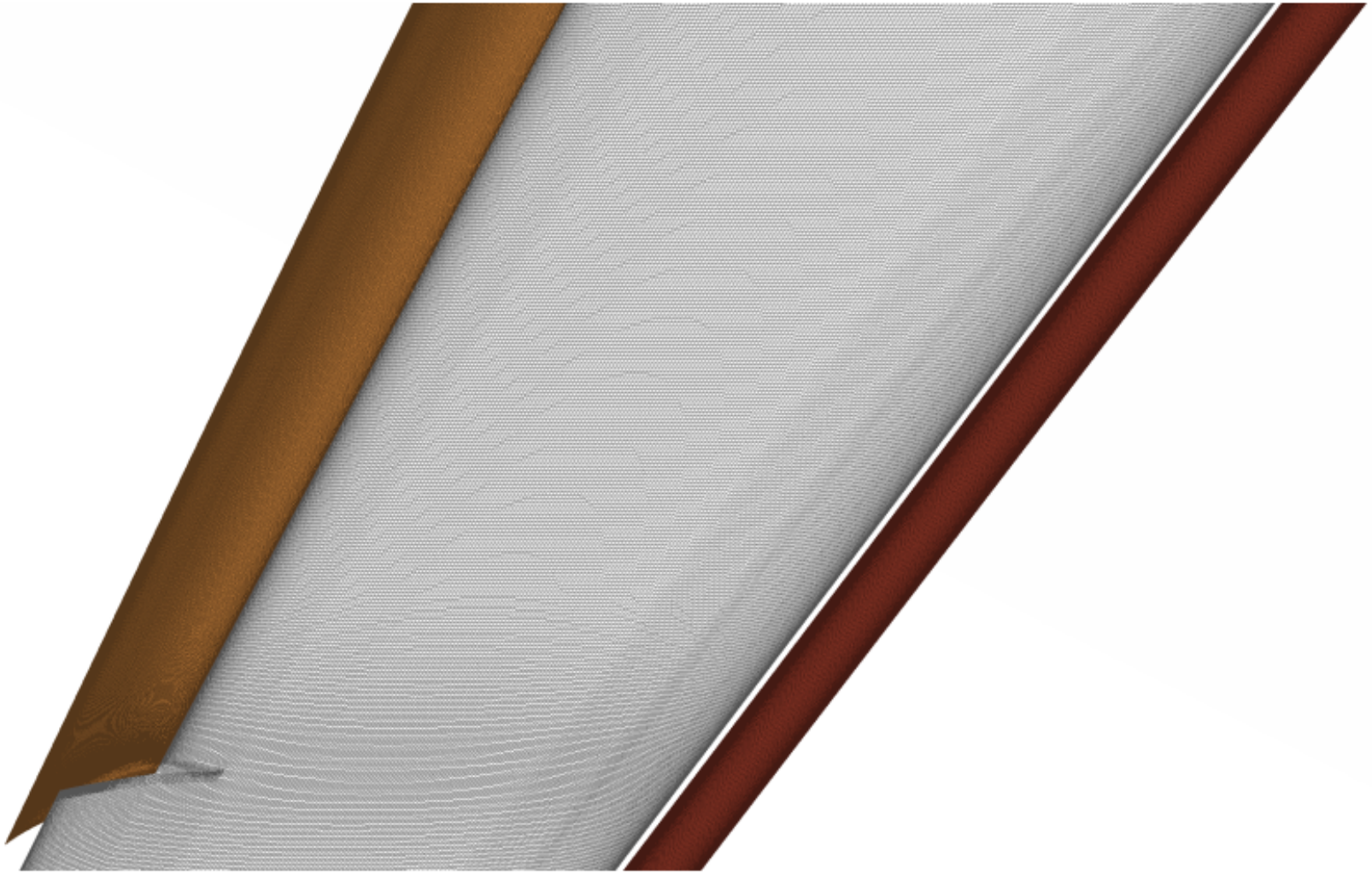

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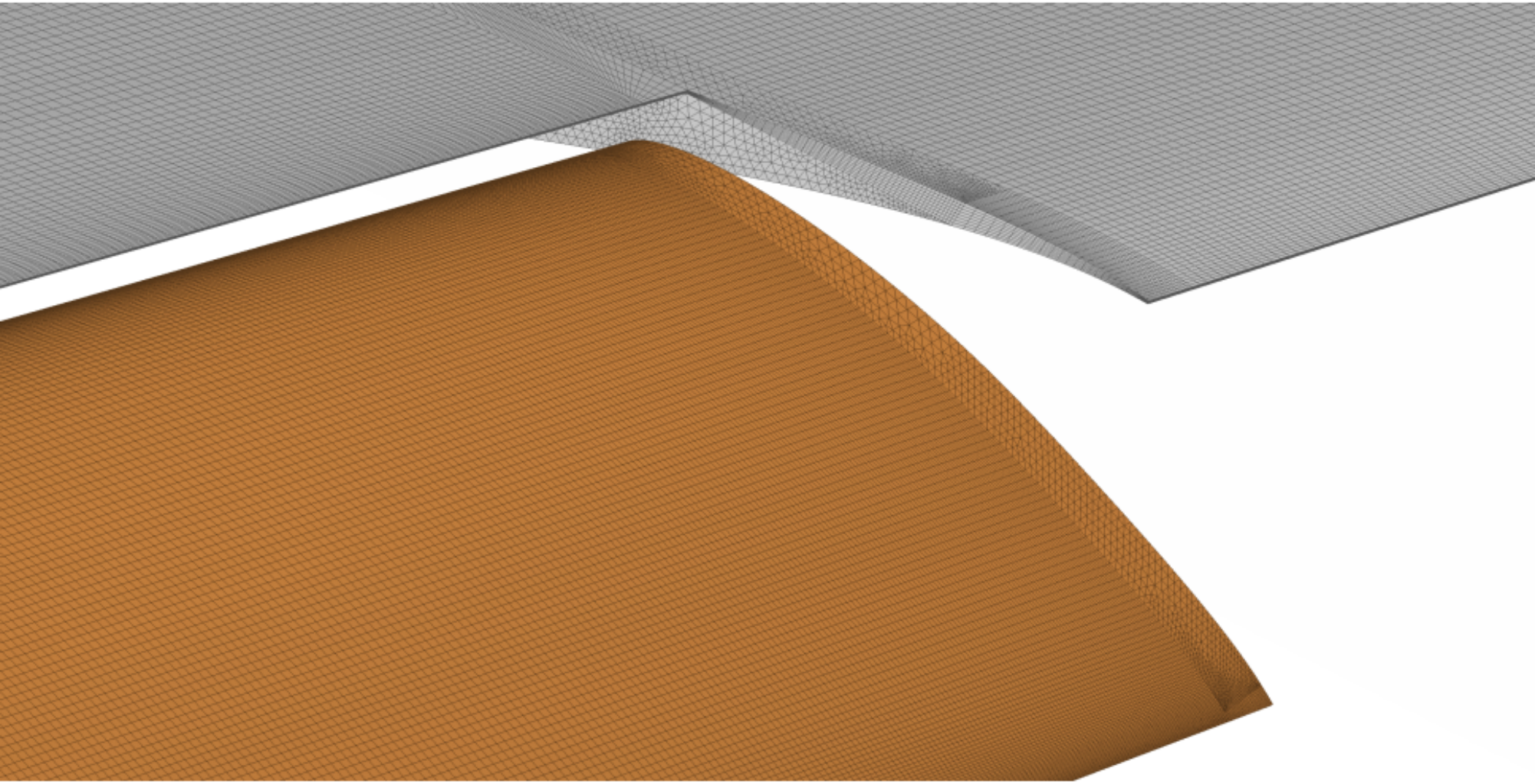

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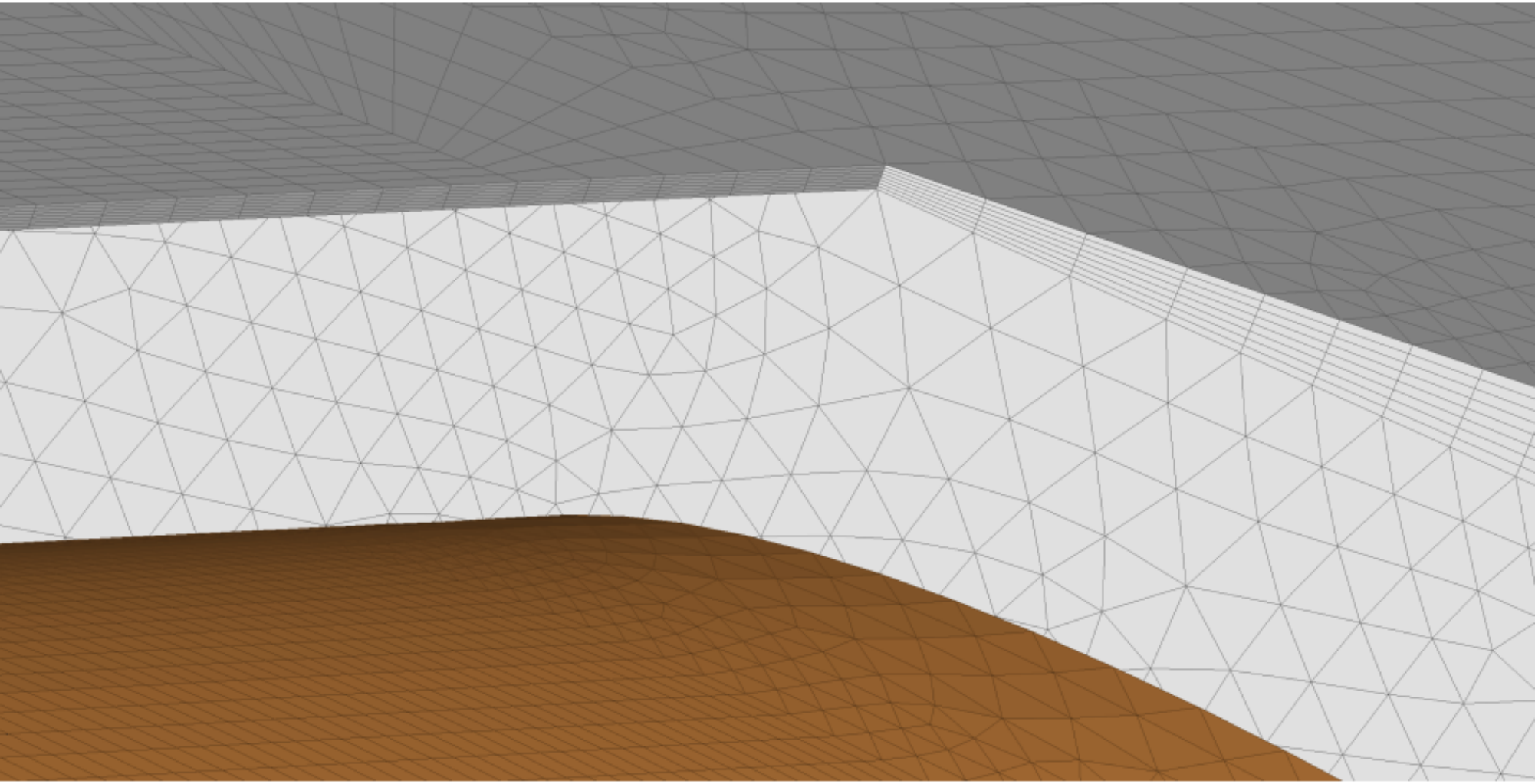

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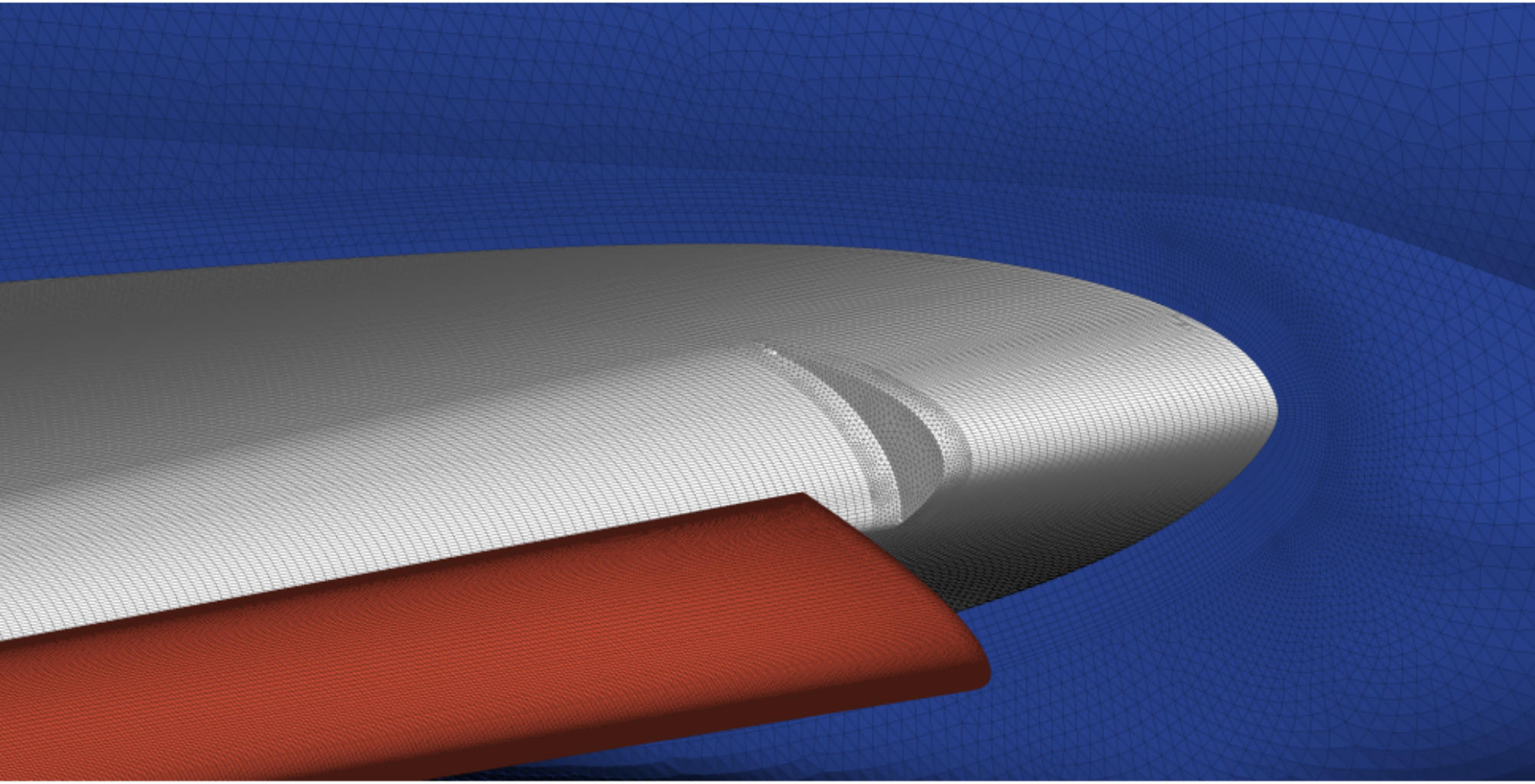

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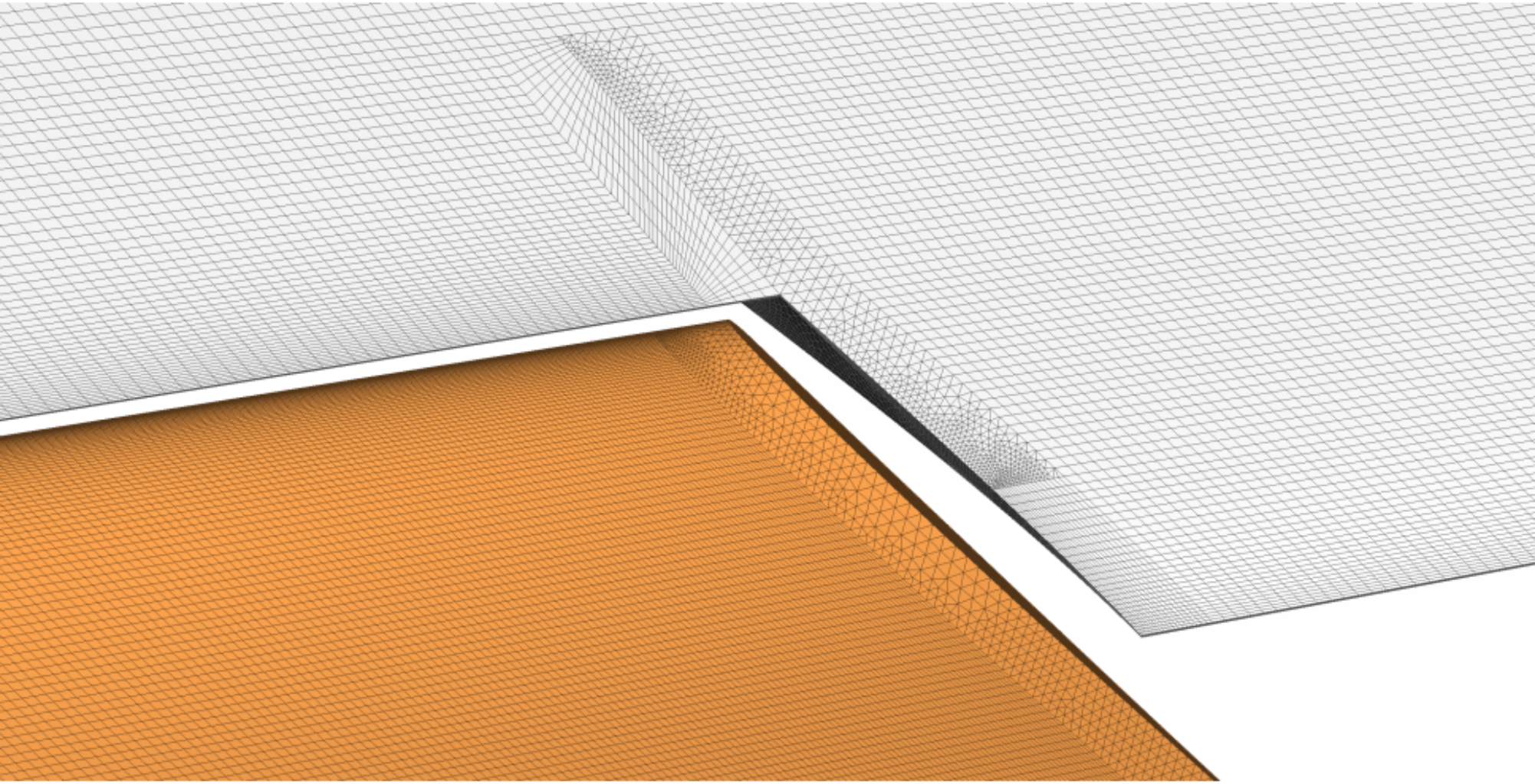

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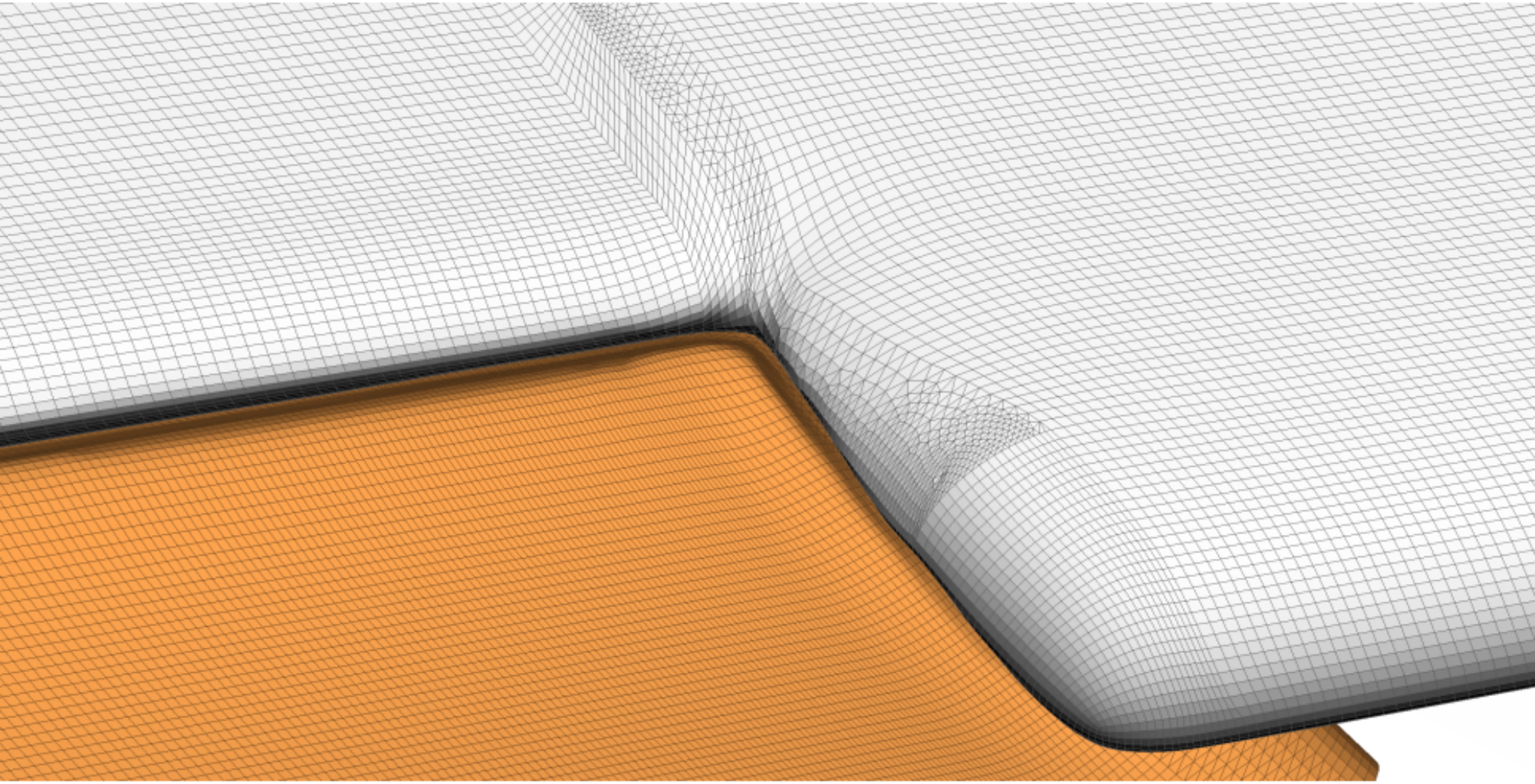

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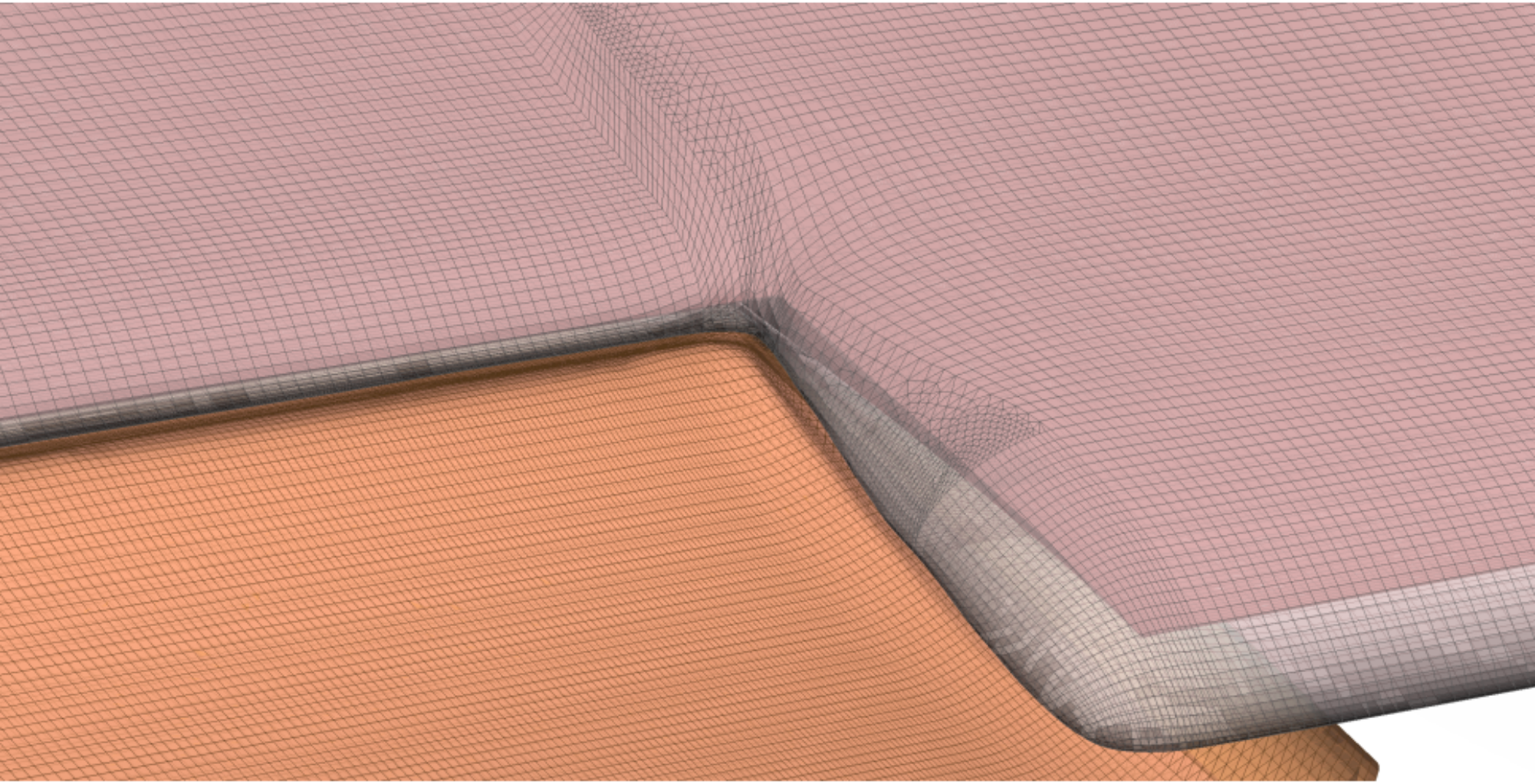

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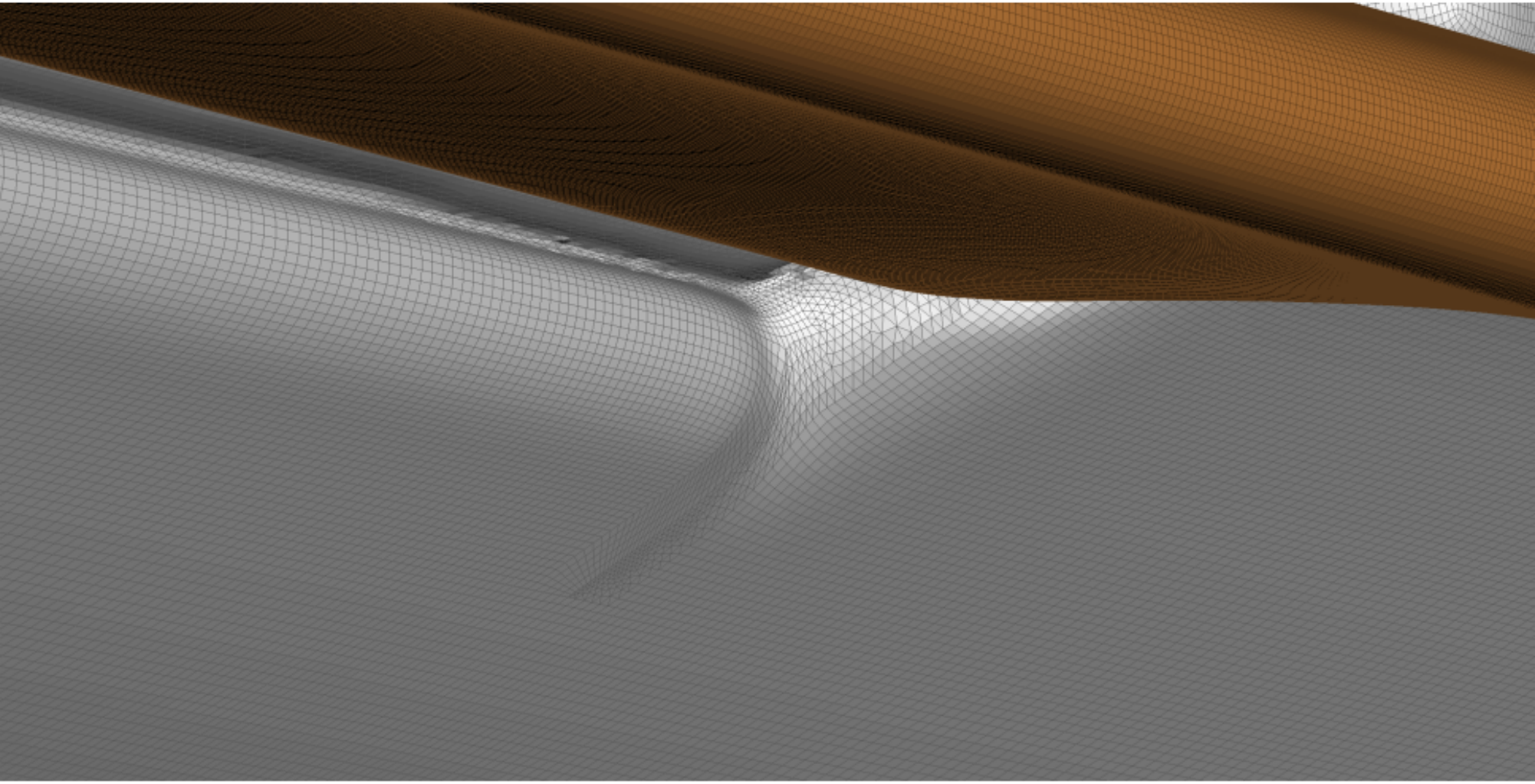

Layers TopCap

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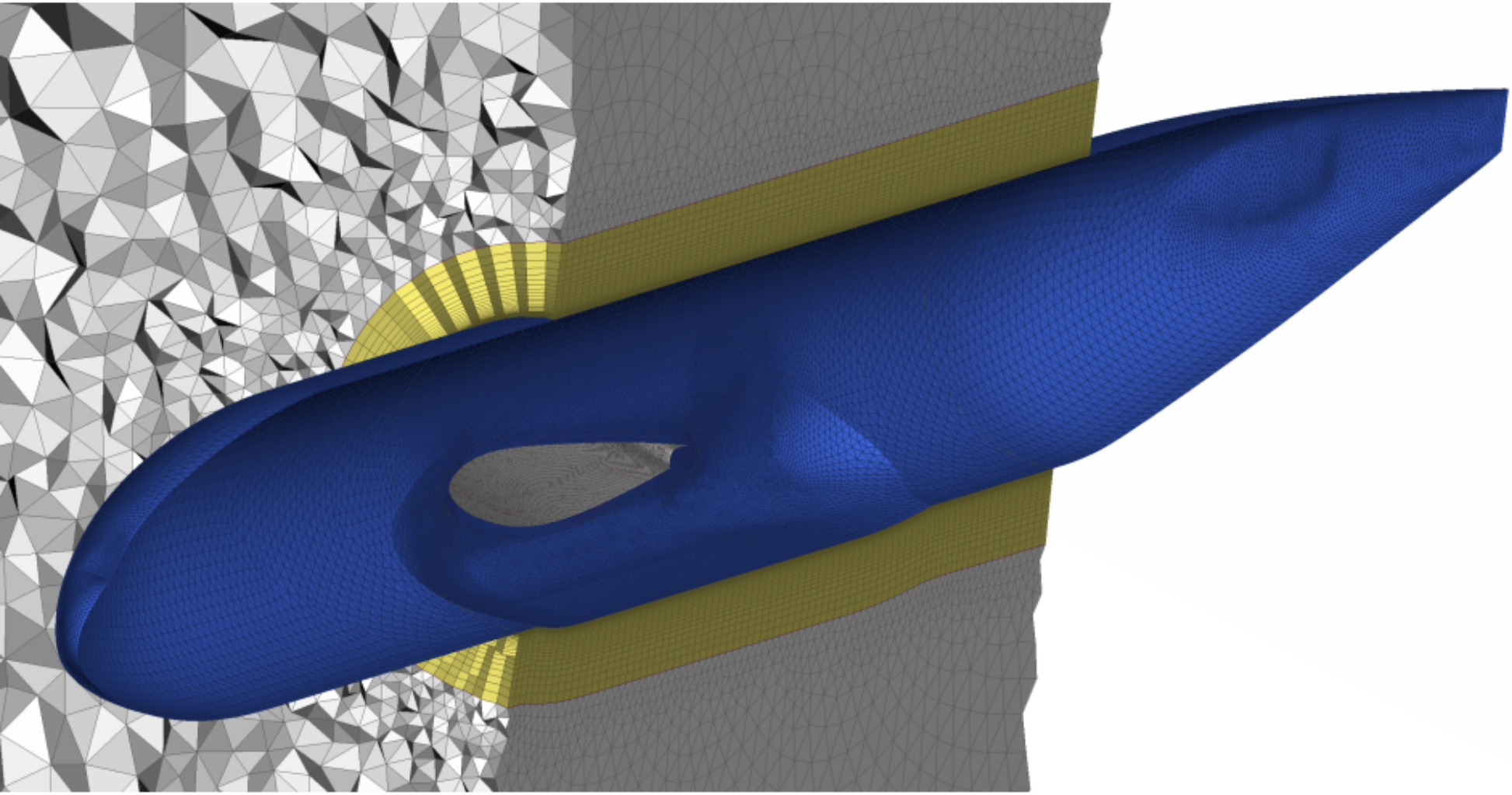

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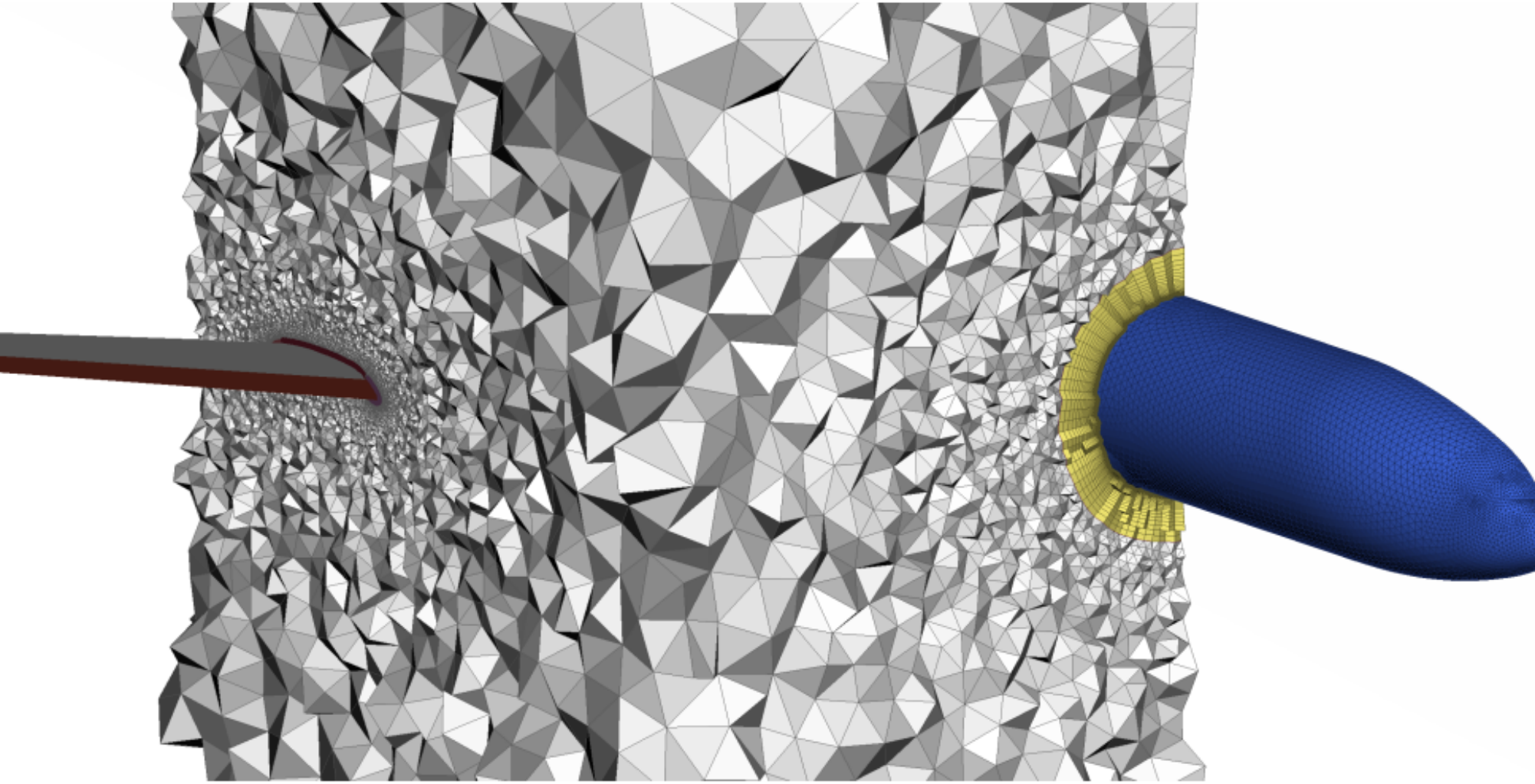

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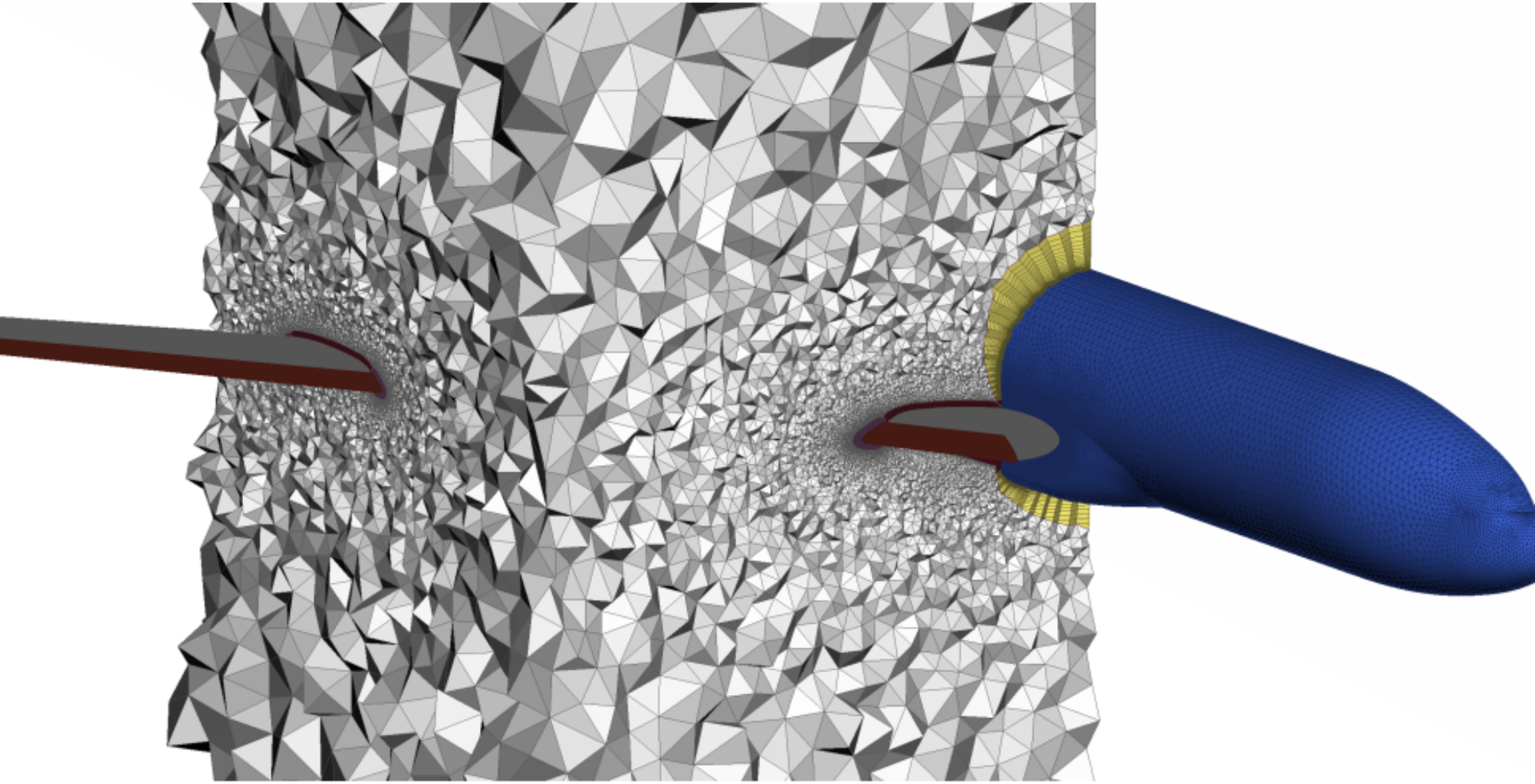

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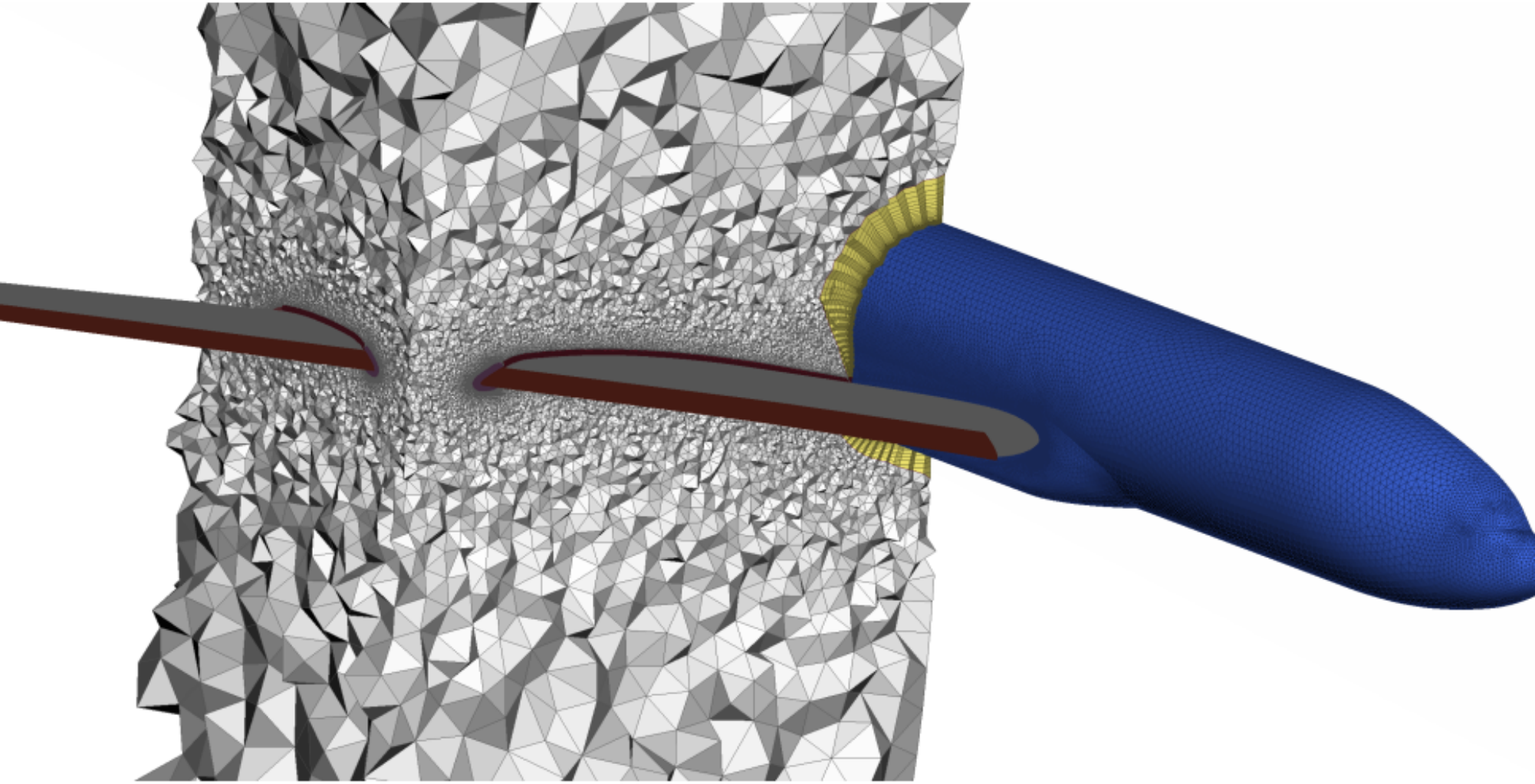

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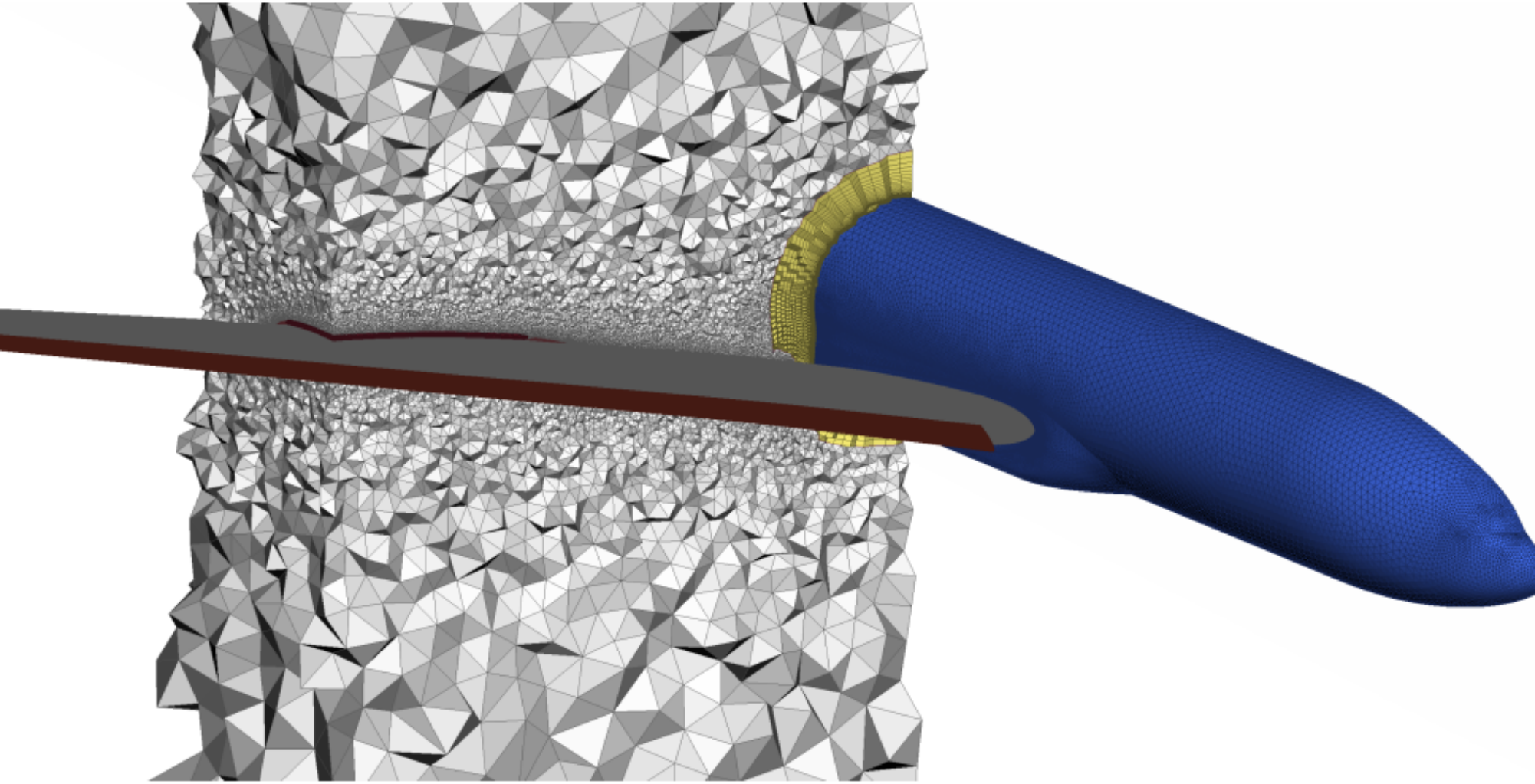

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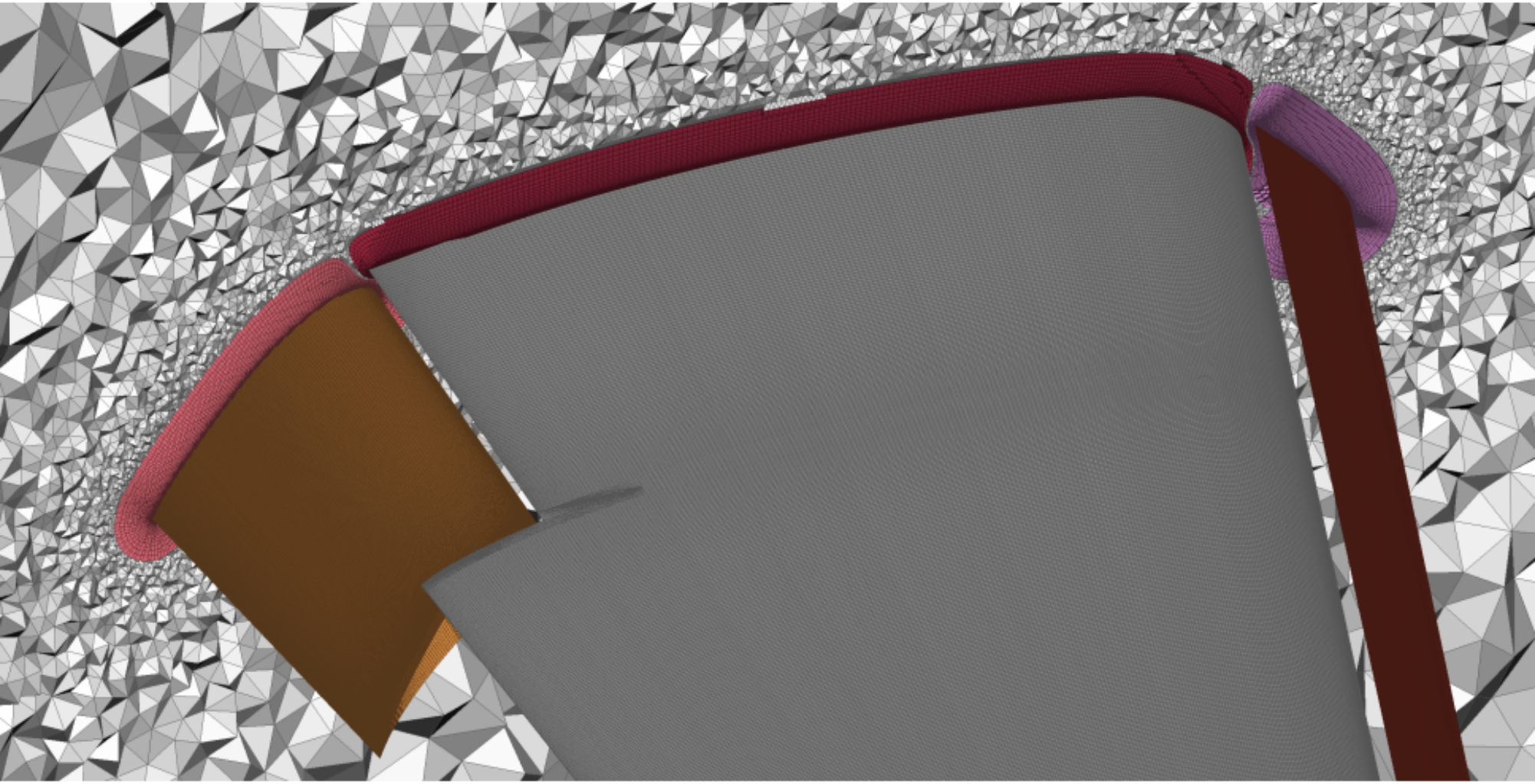

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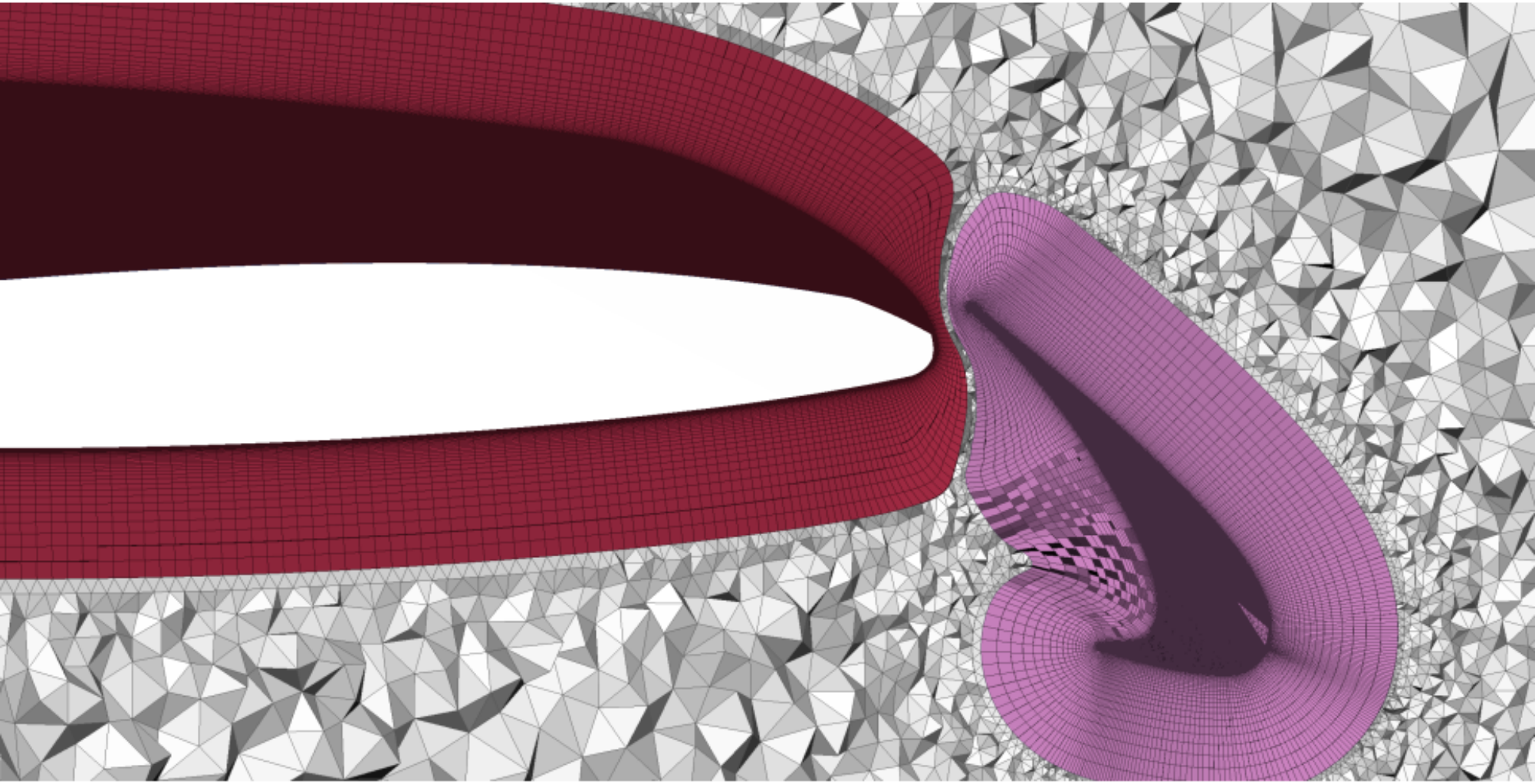

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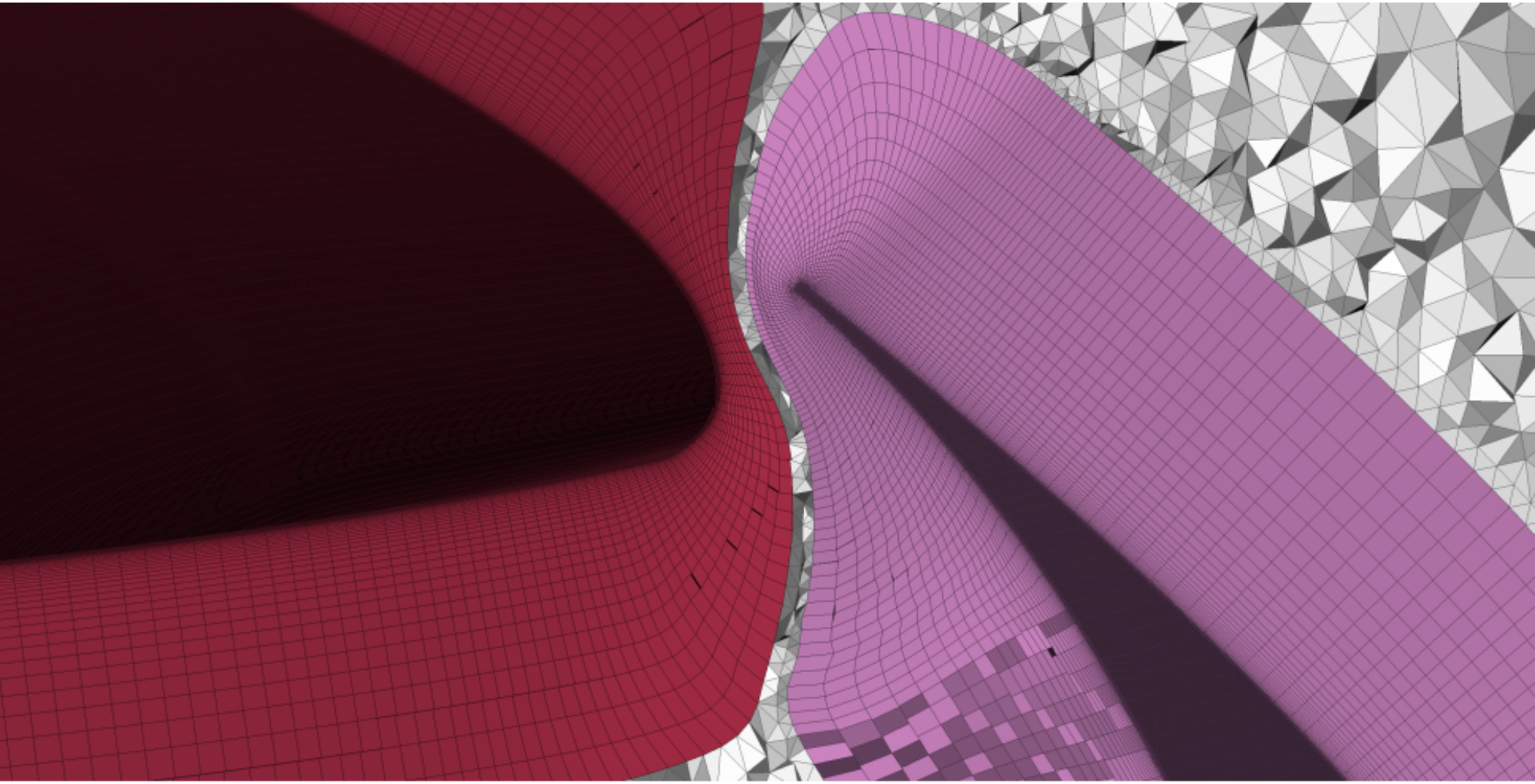

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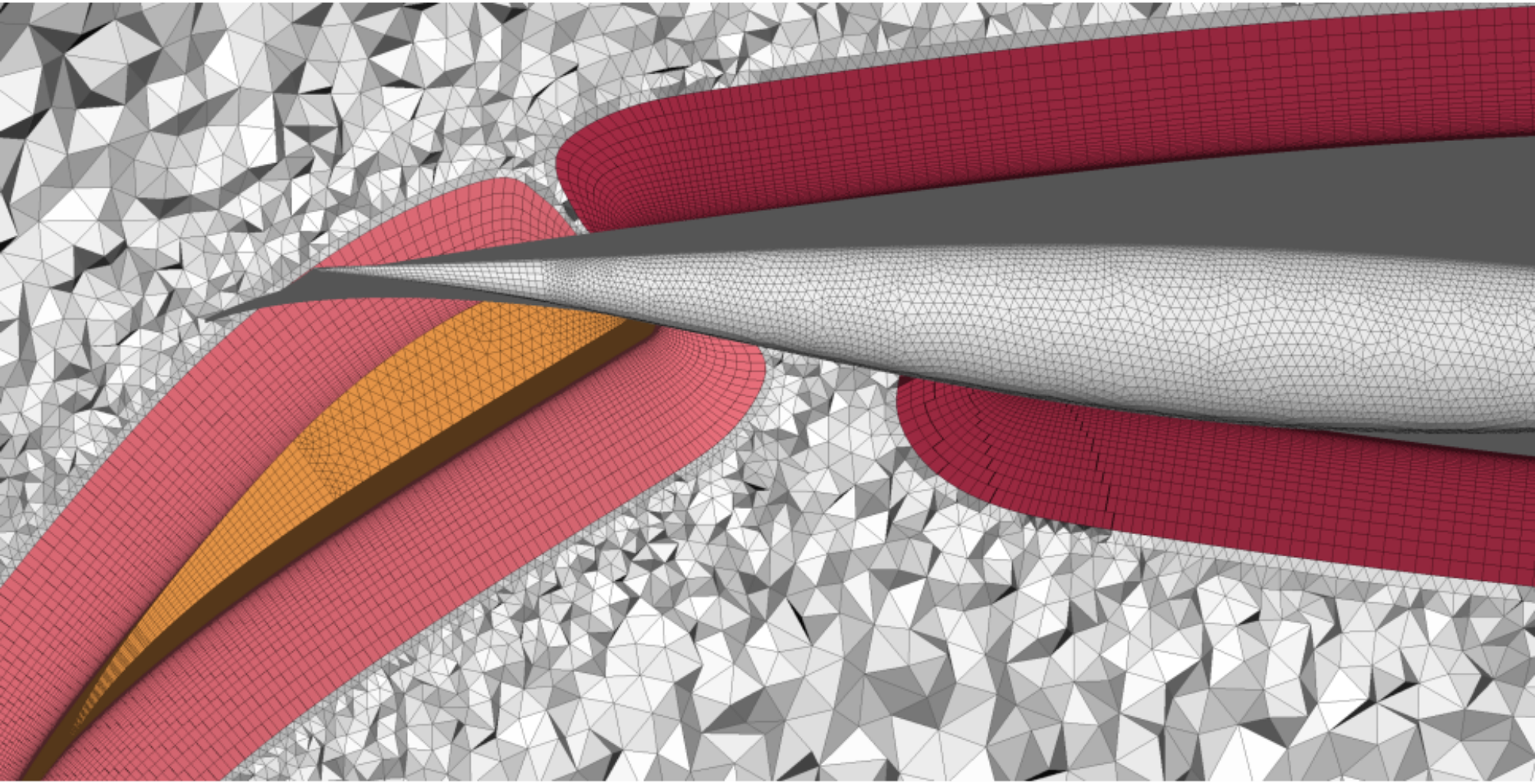

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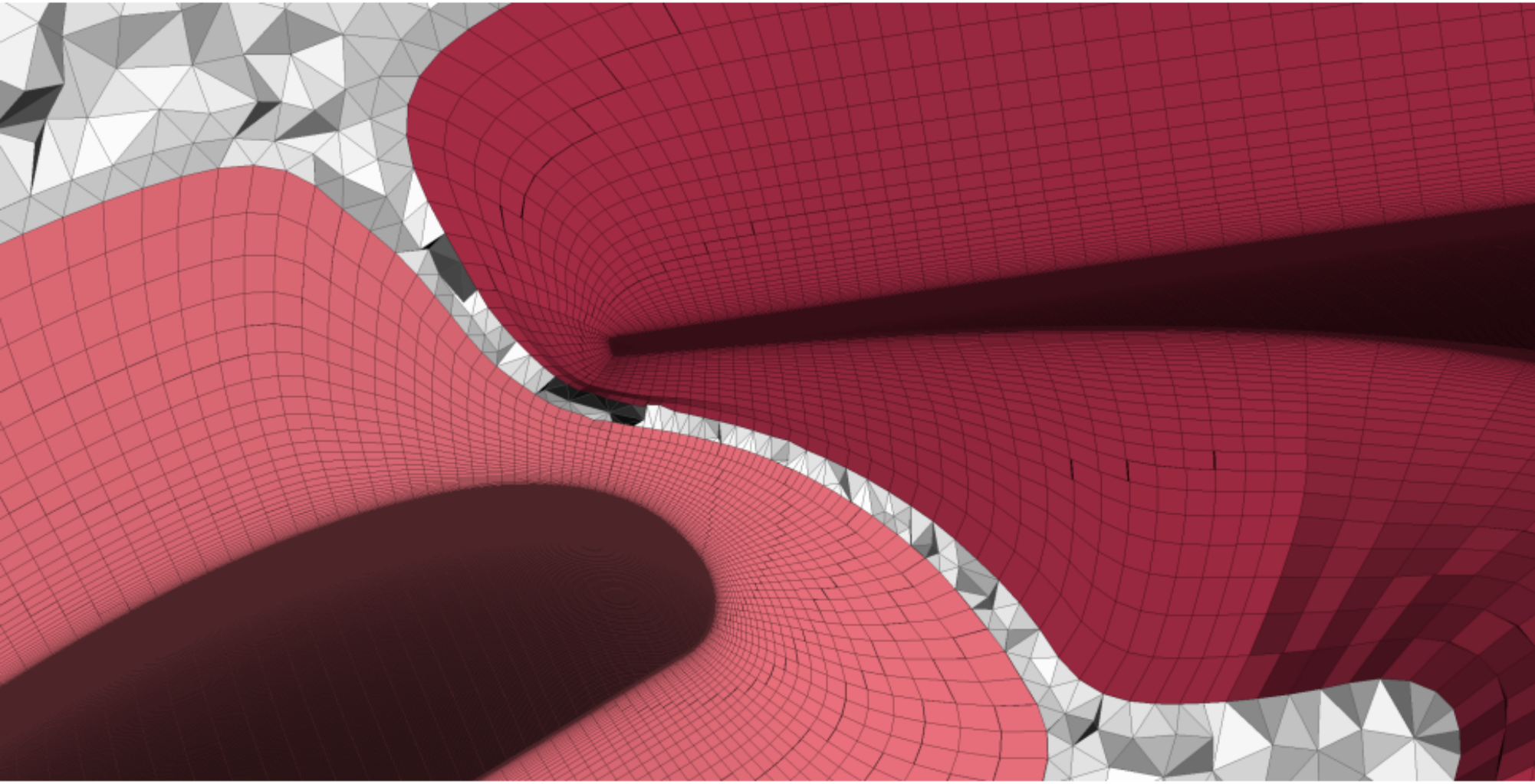

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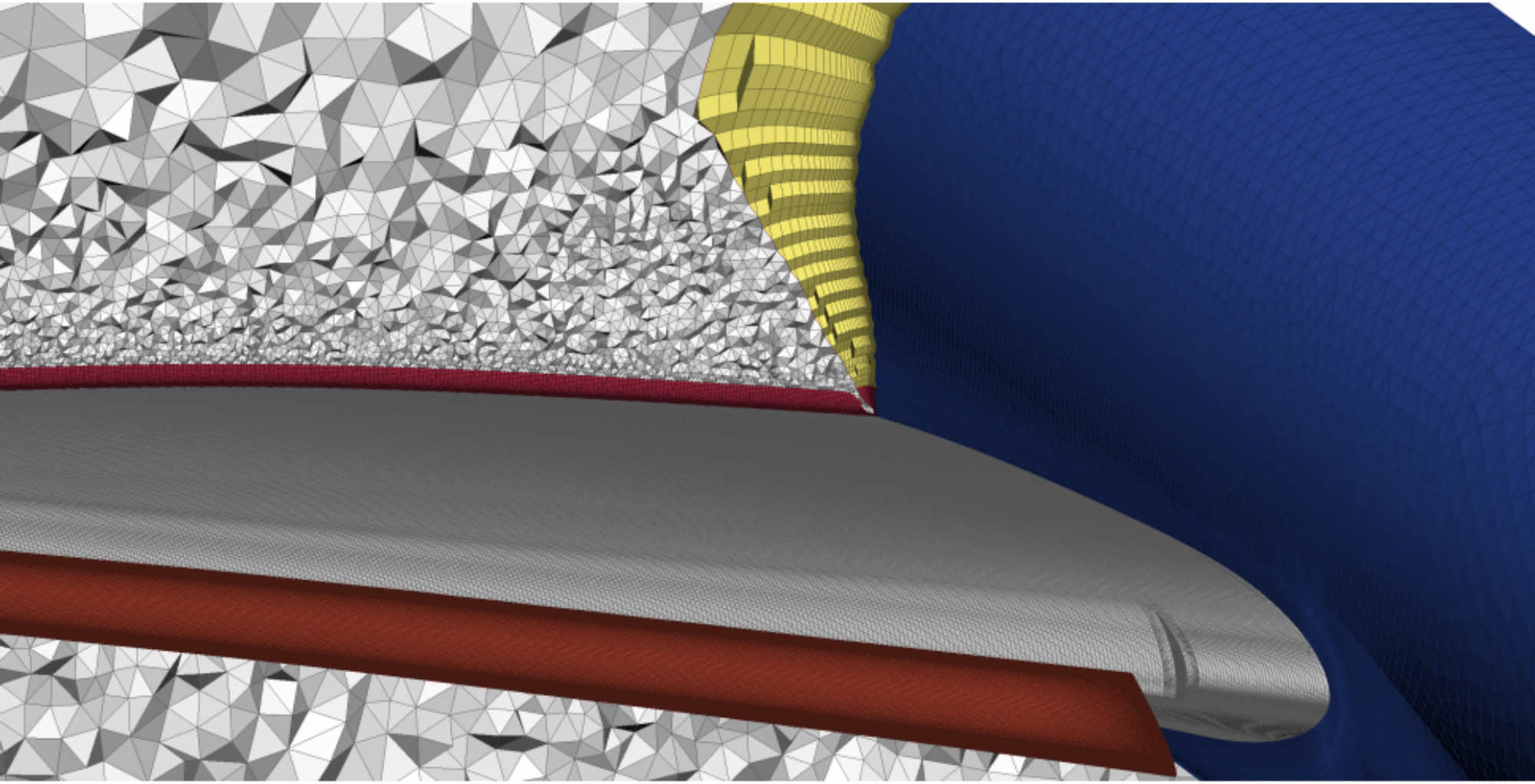

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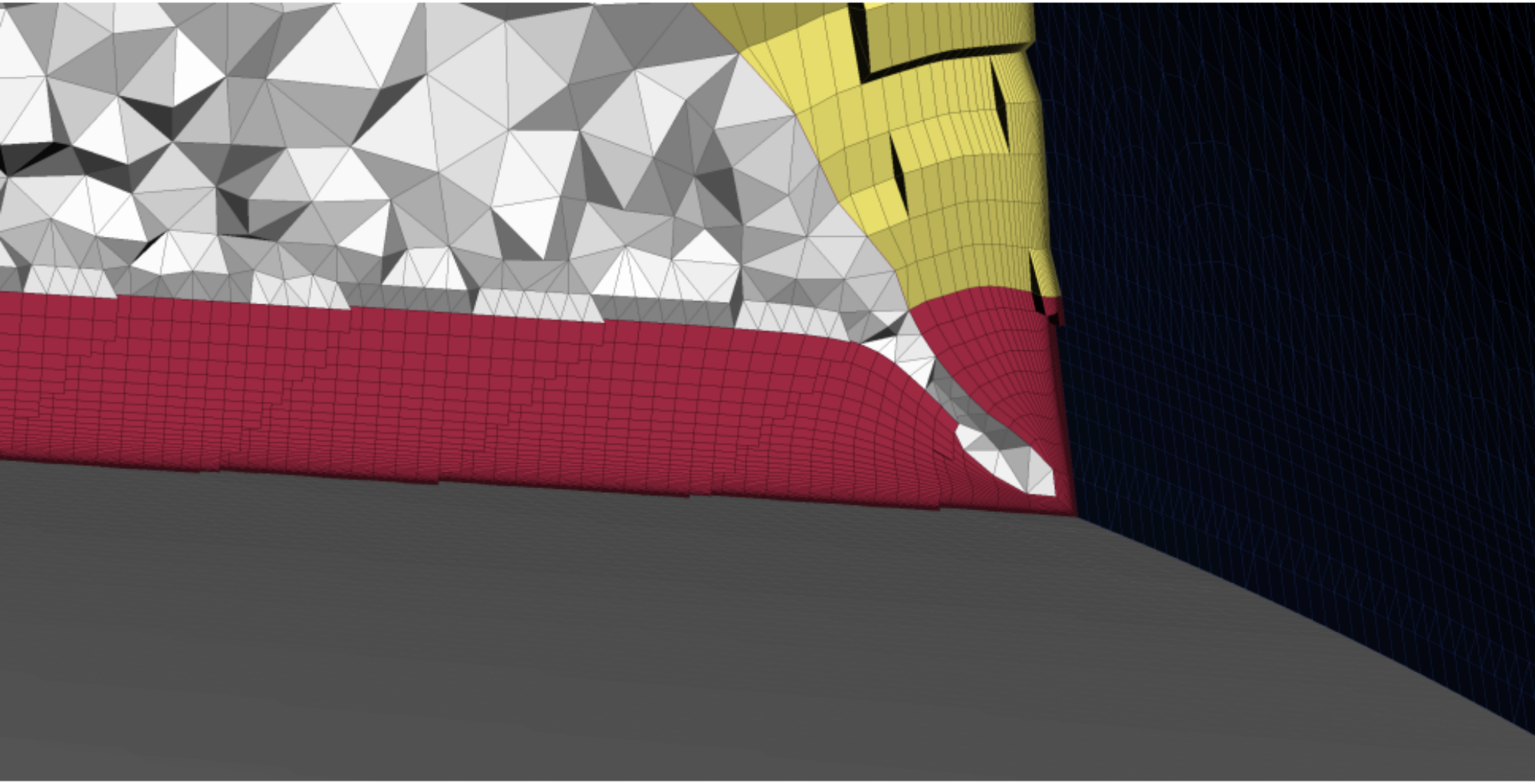

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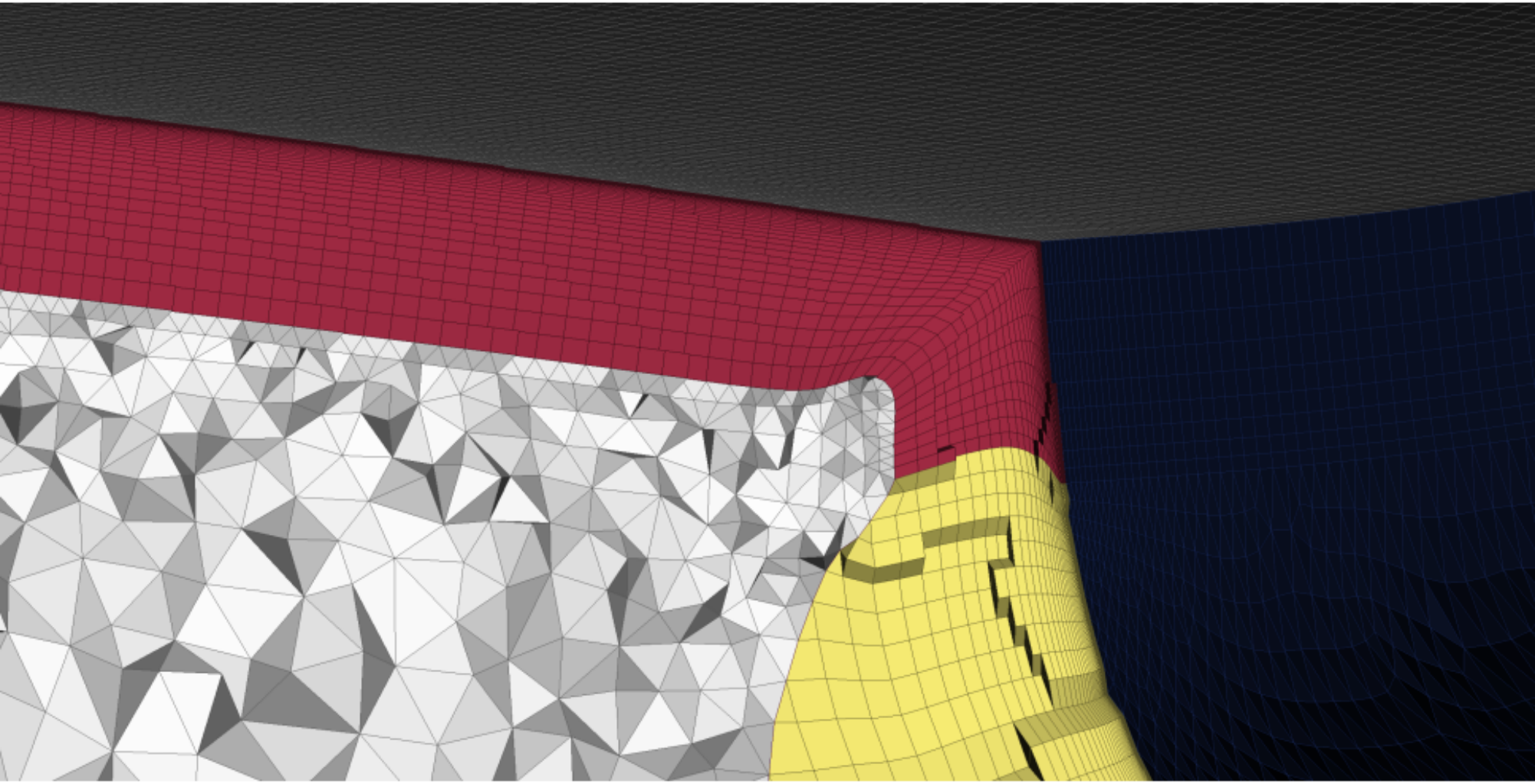

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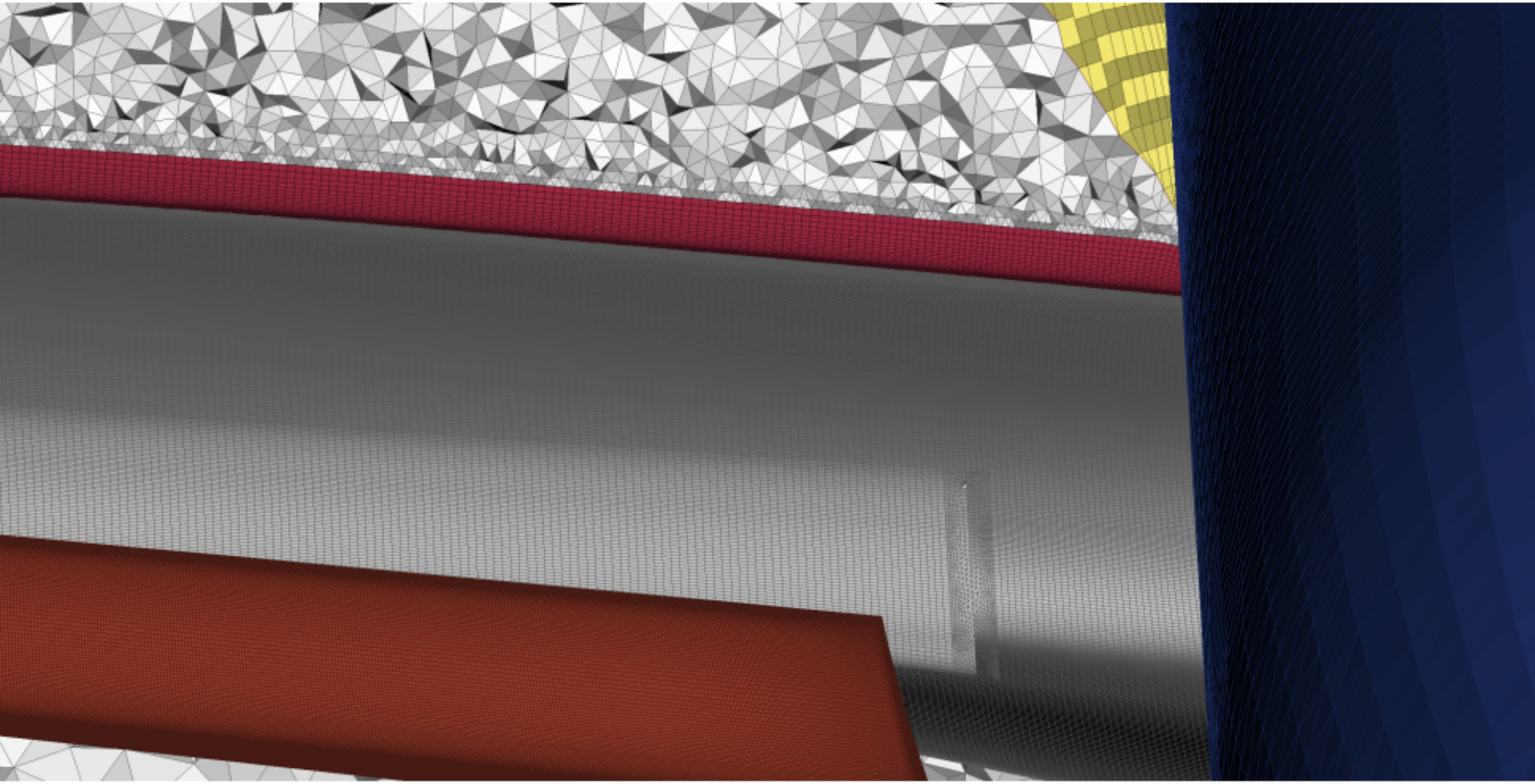

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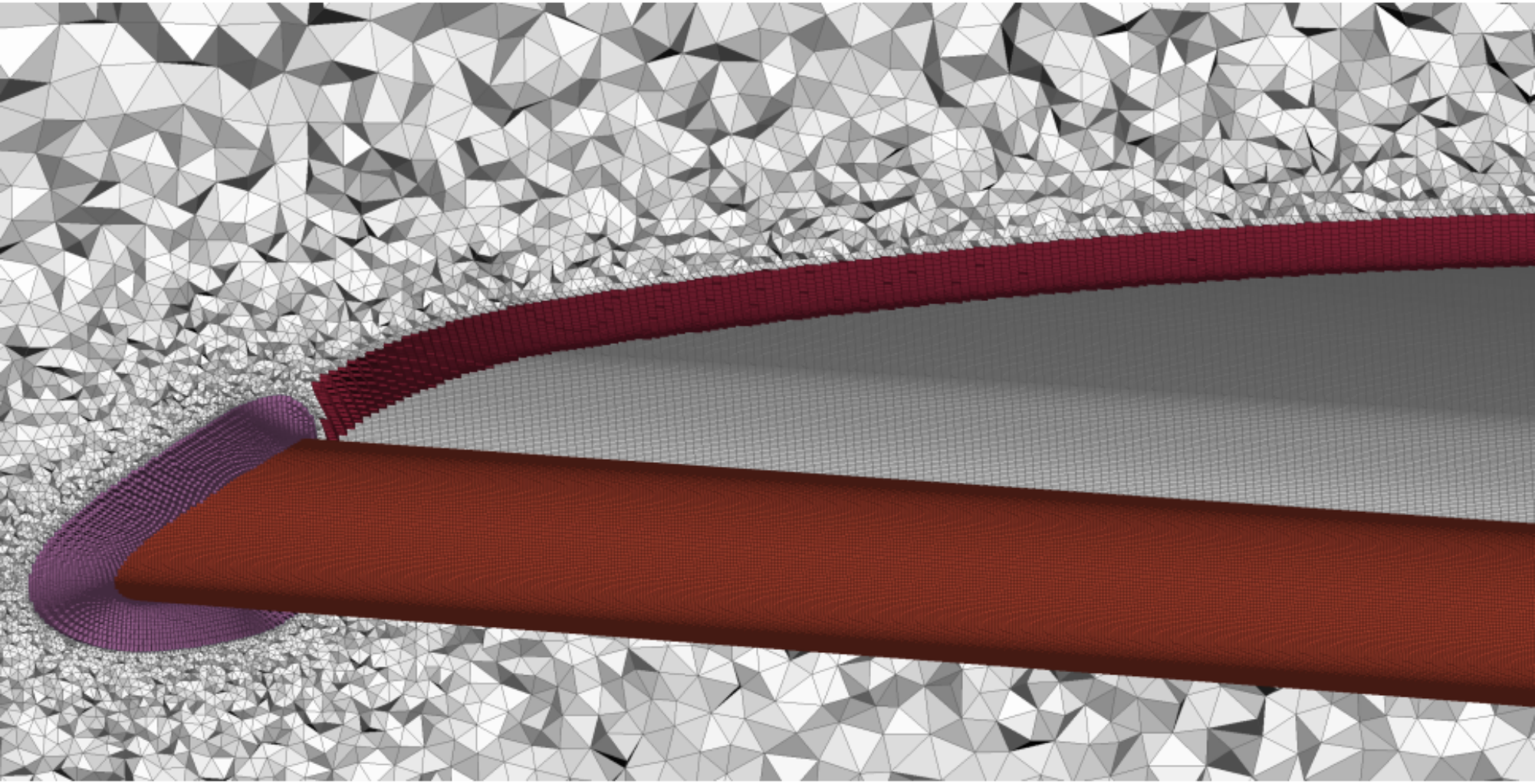

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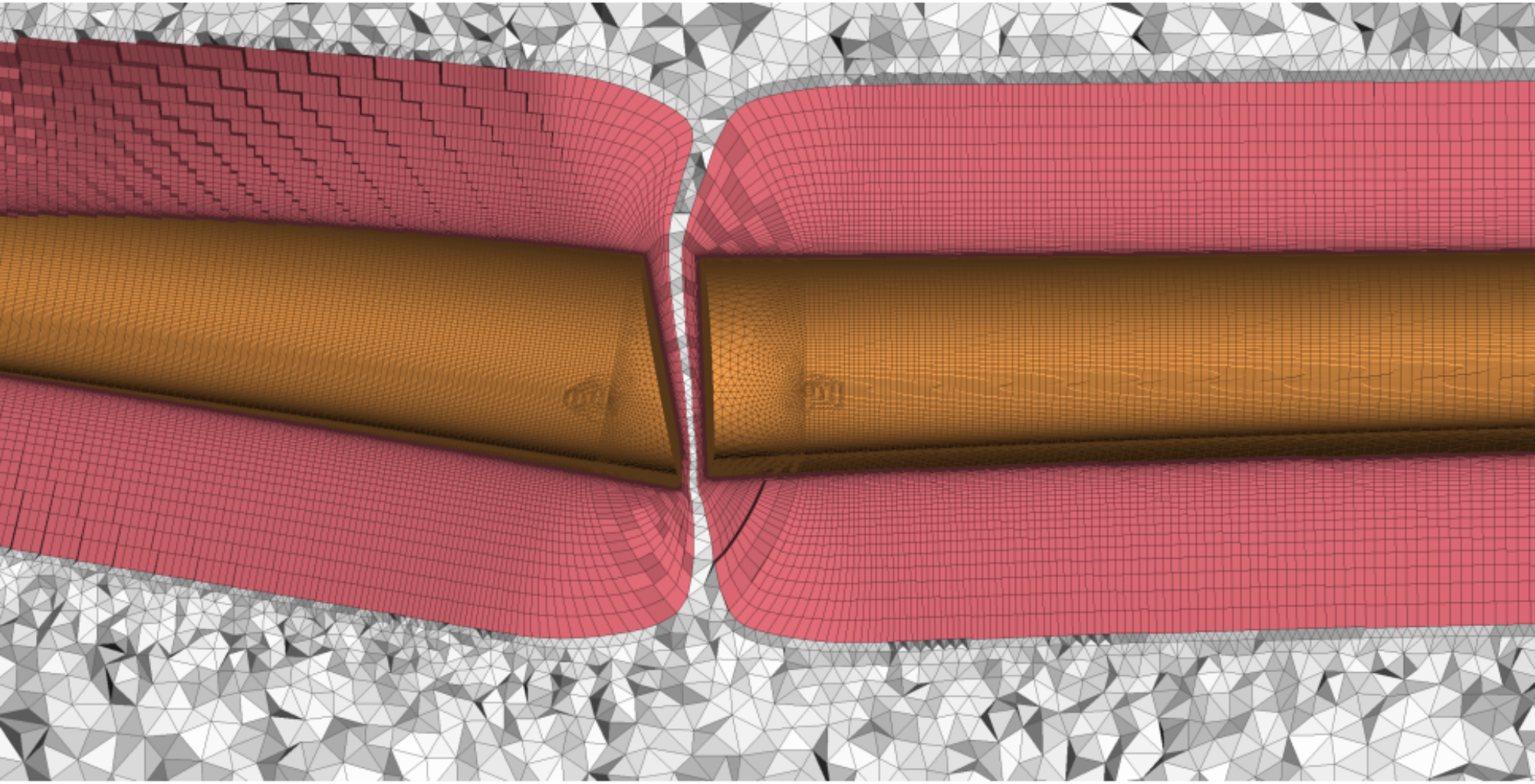

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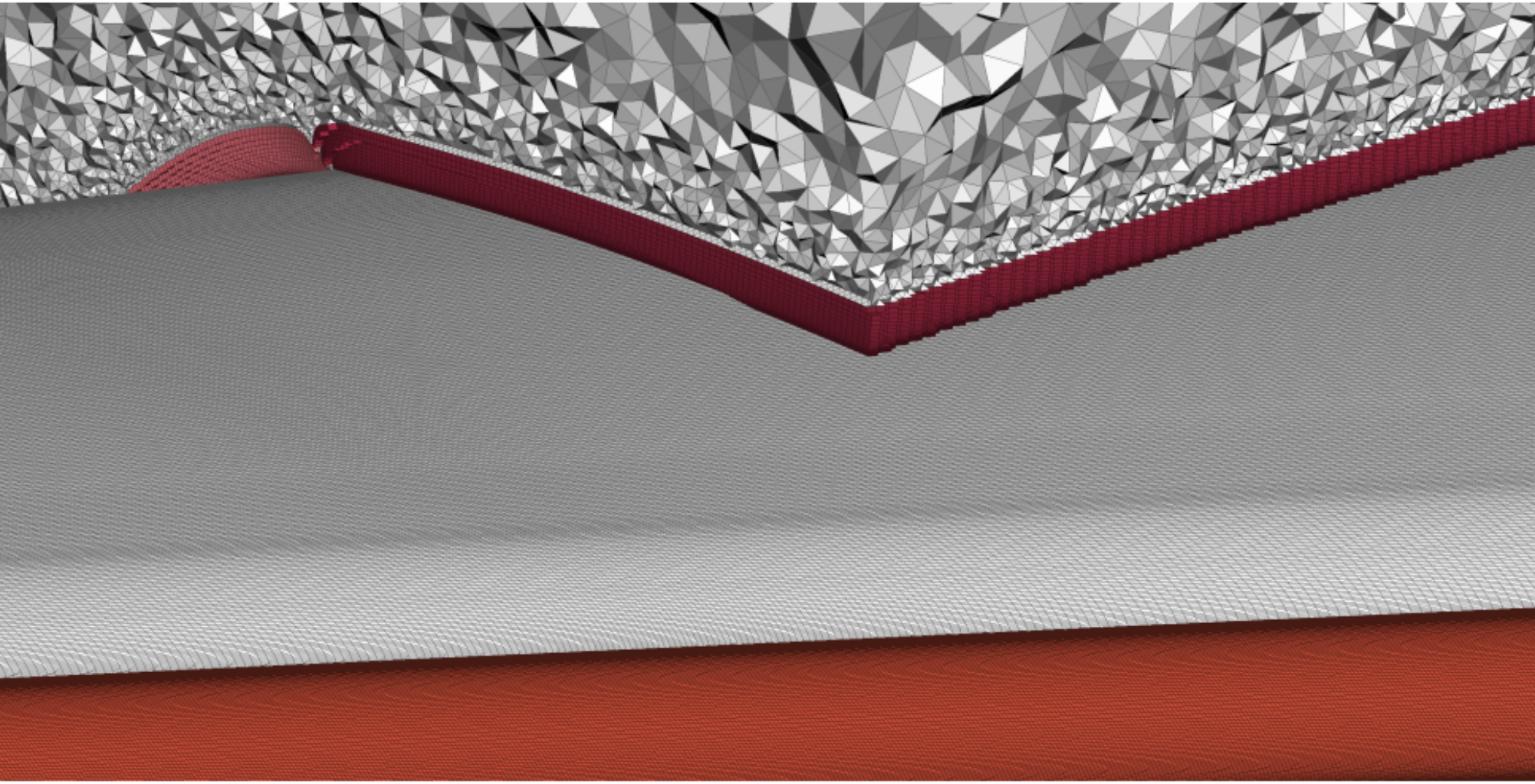

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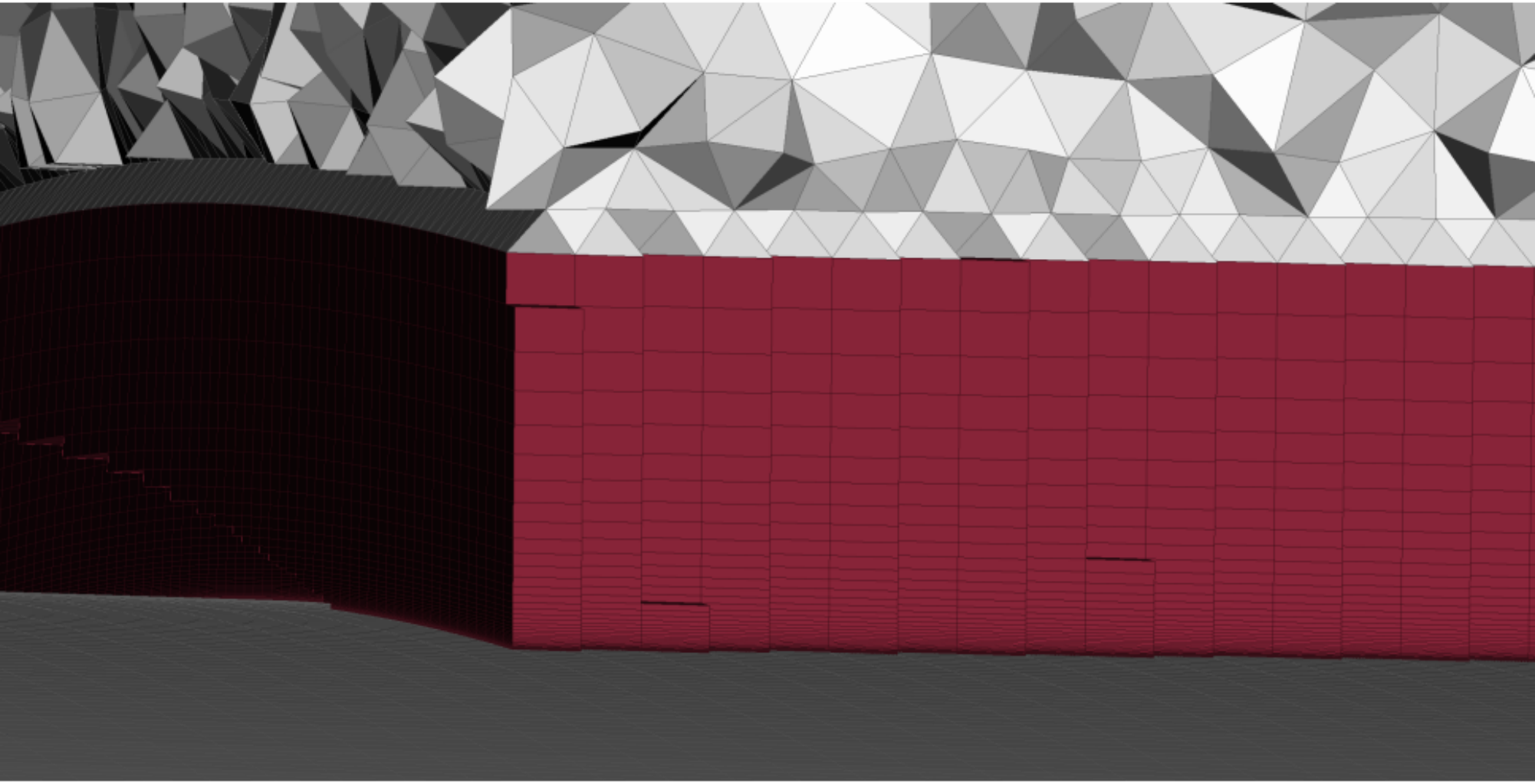

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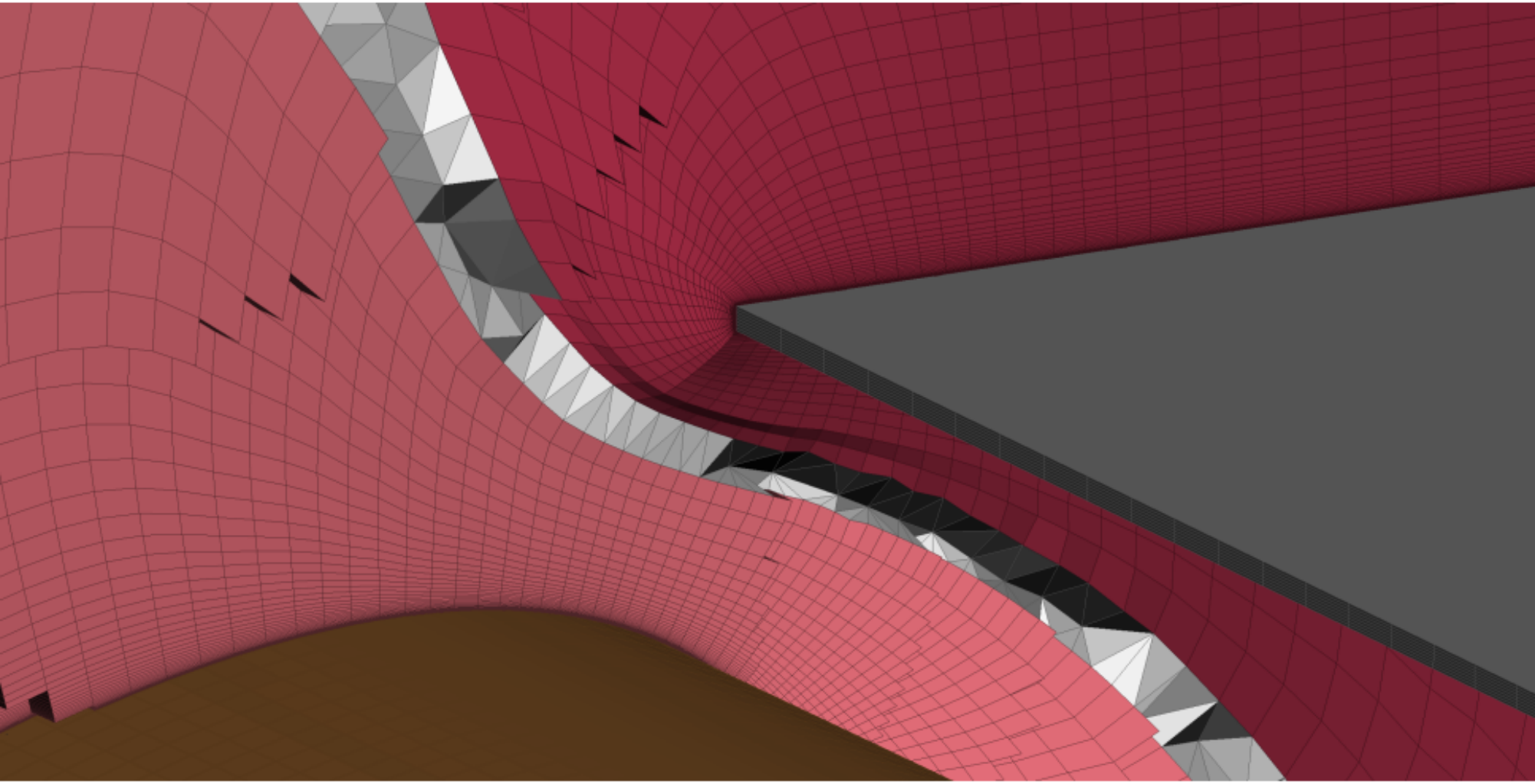

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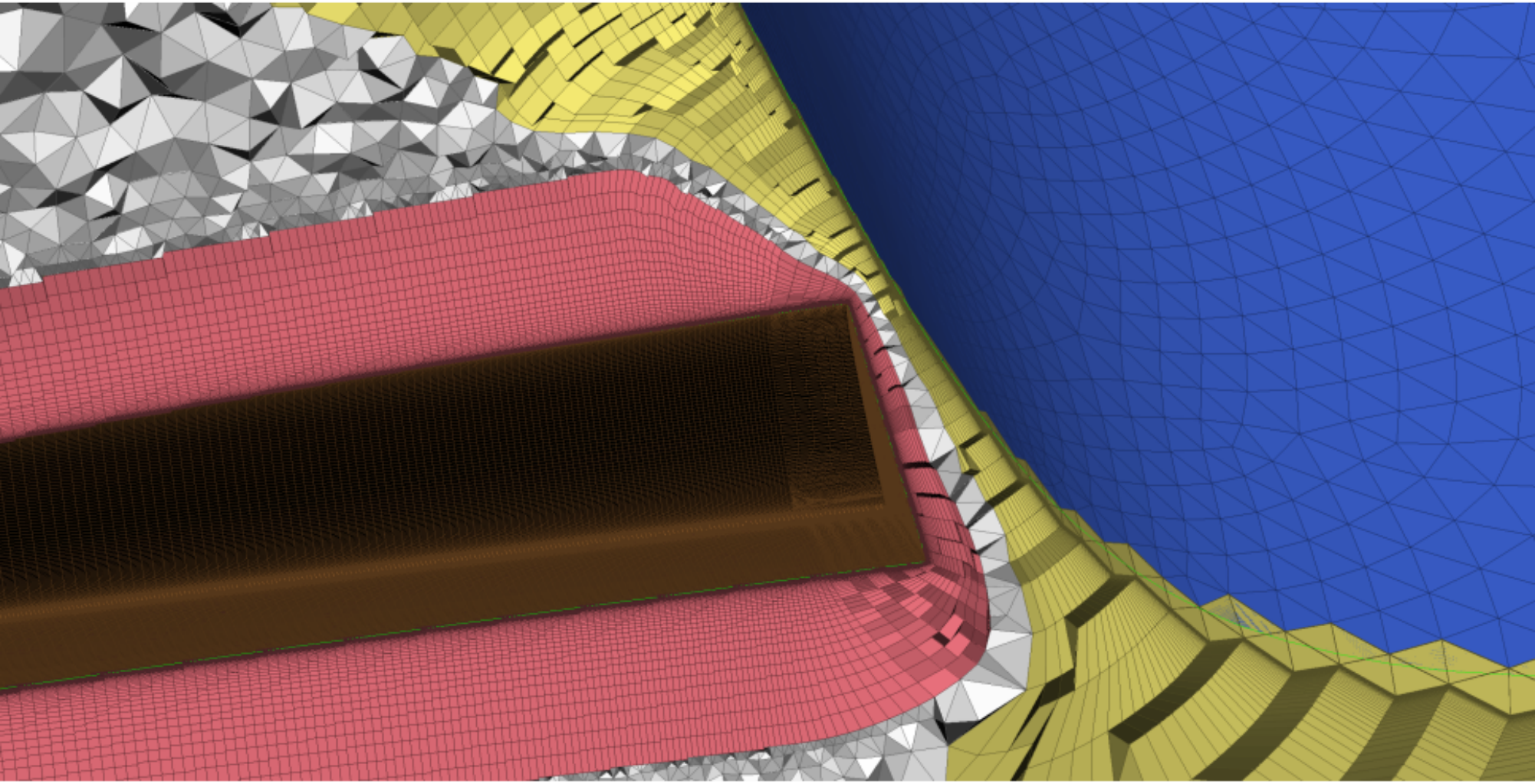

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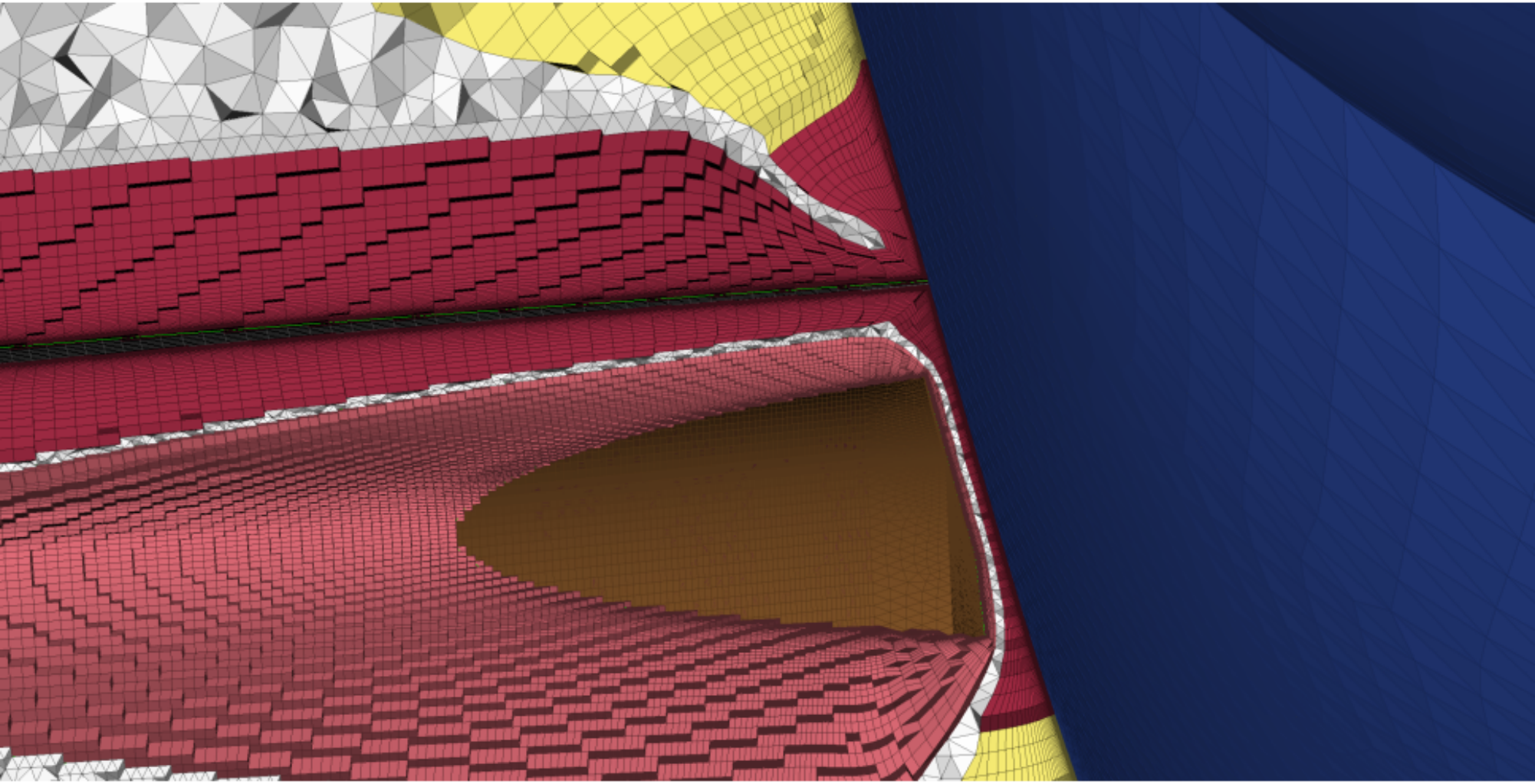
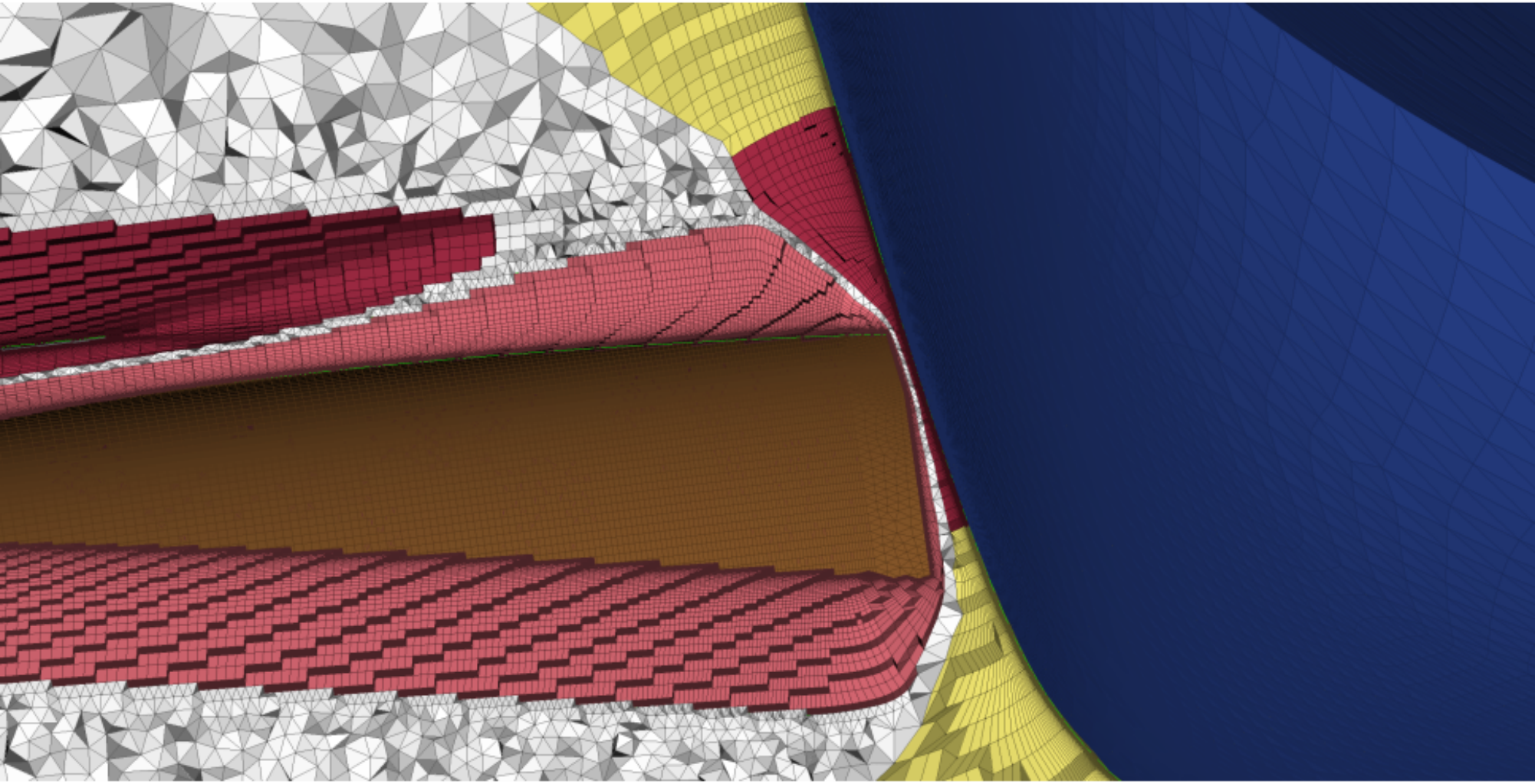


Volume Mesh



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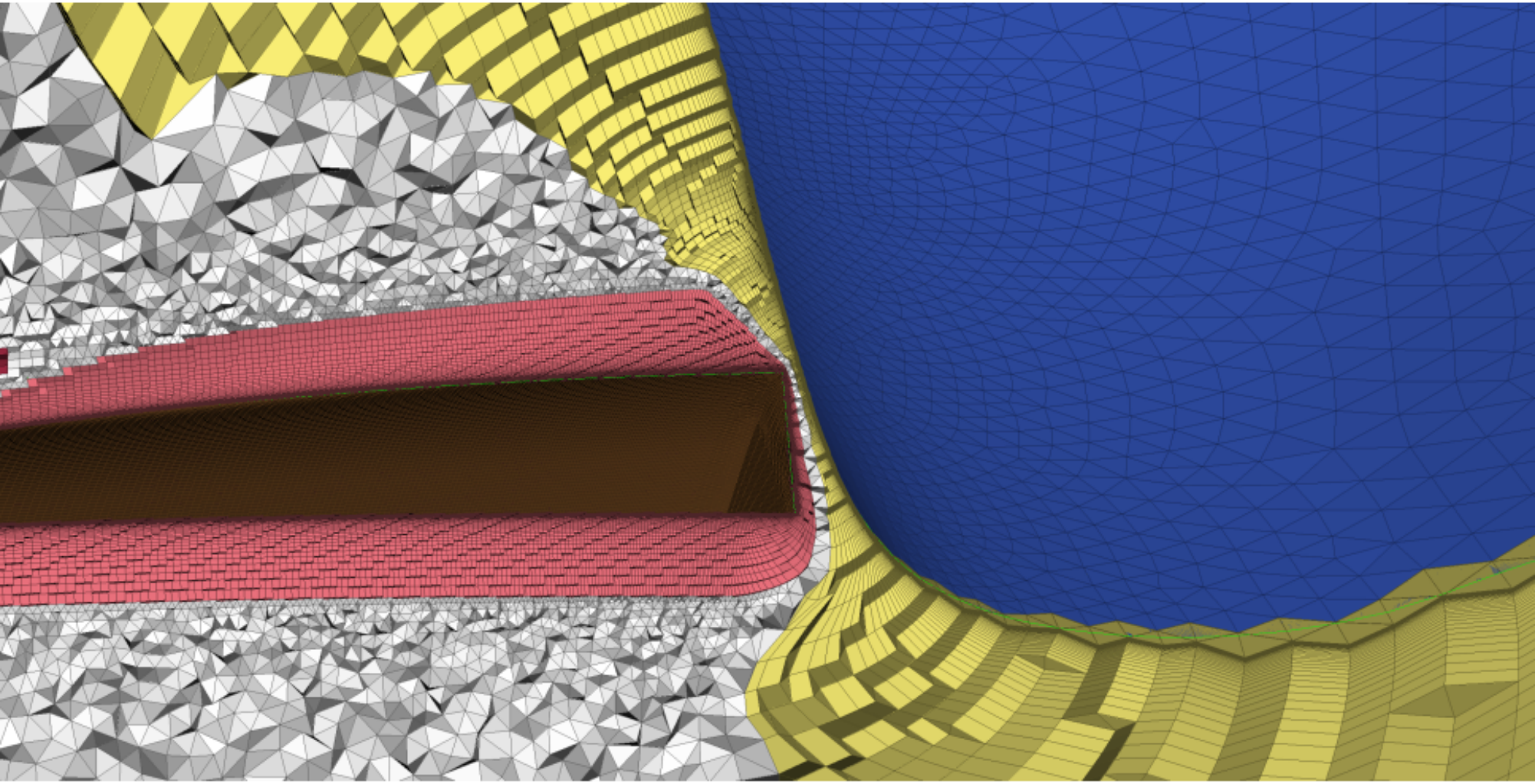

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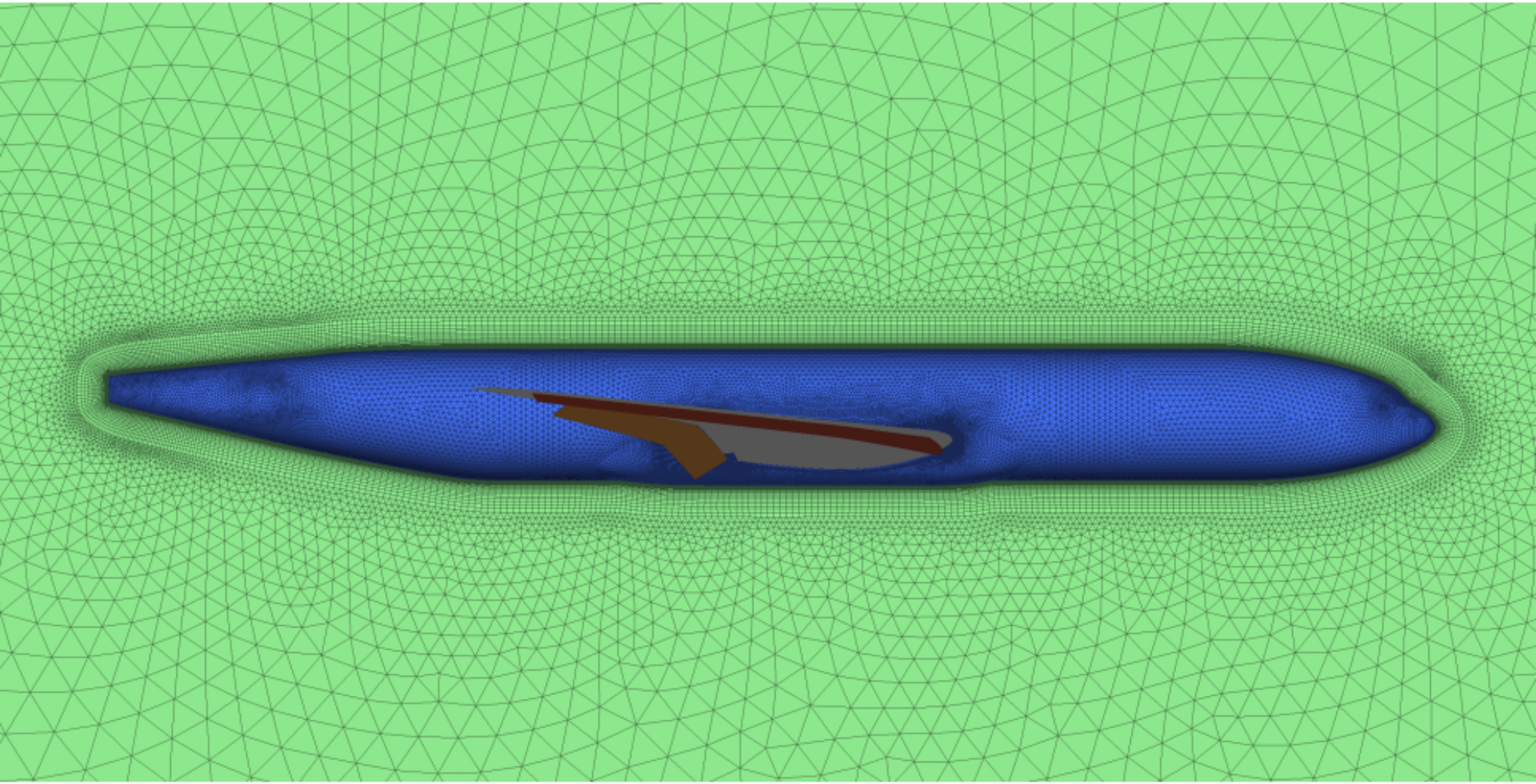

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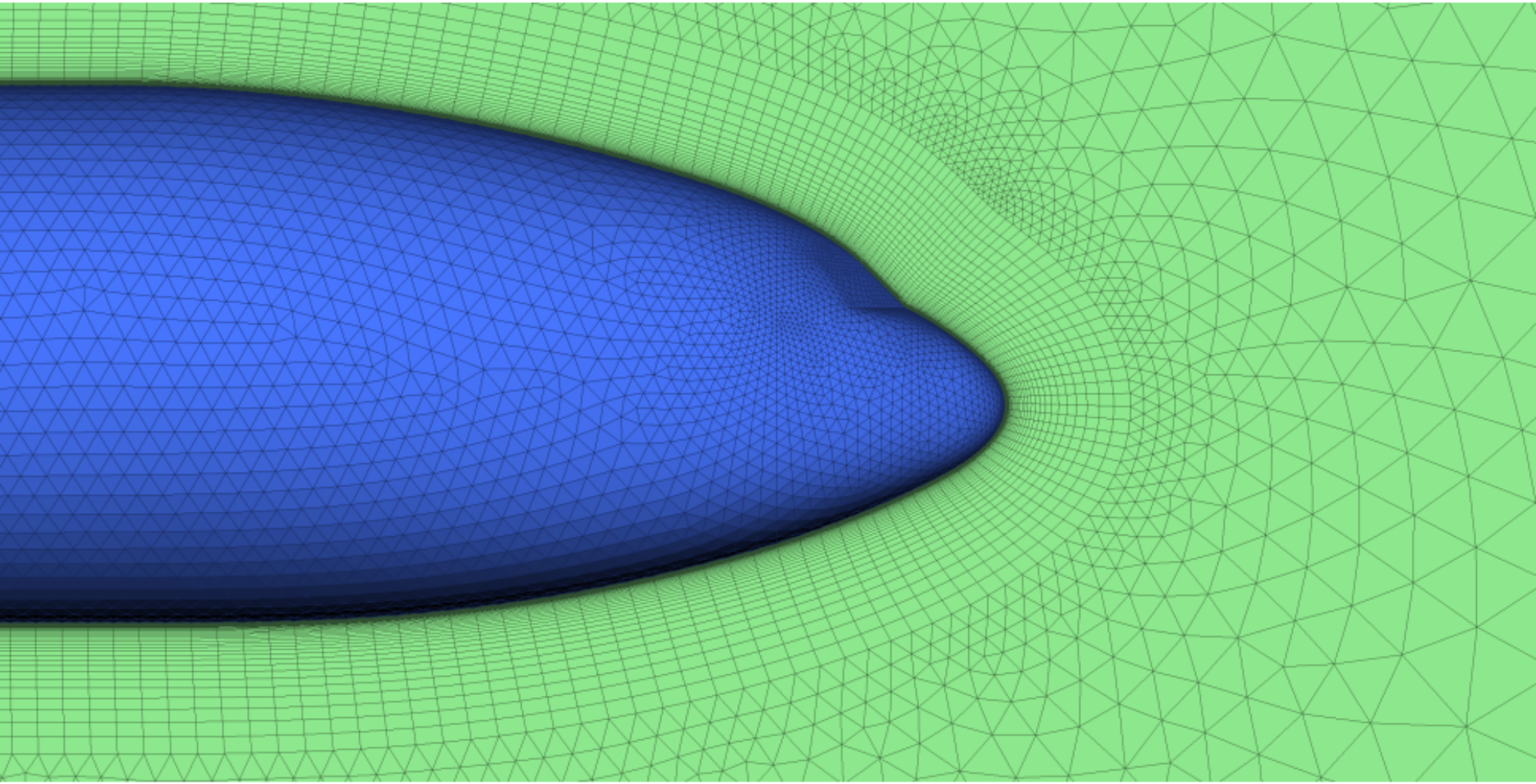

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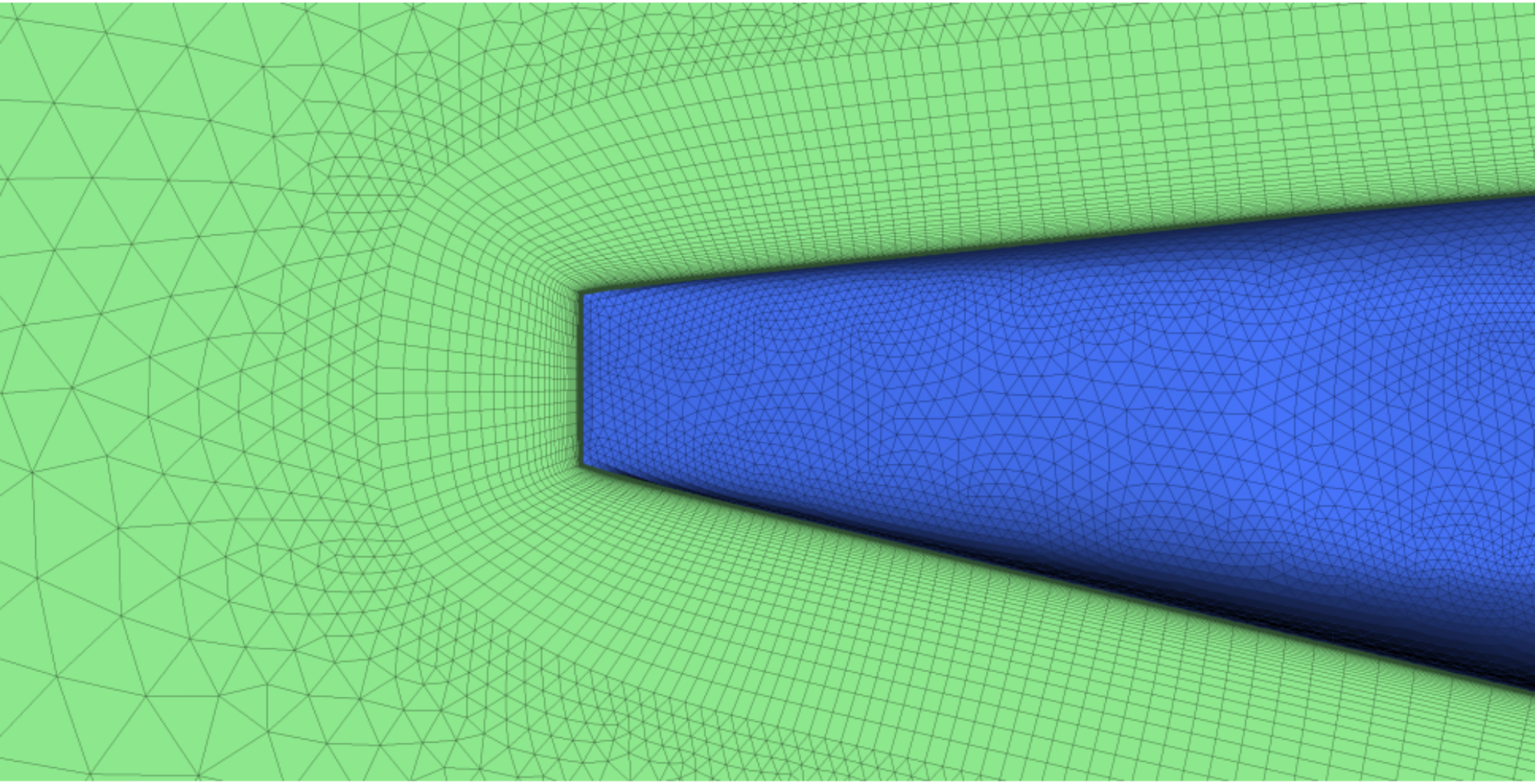

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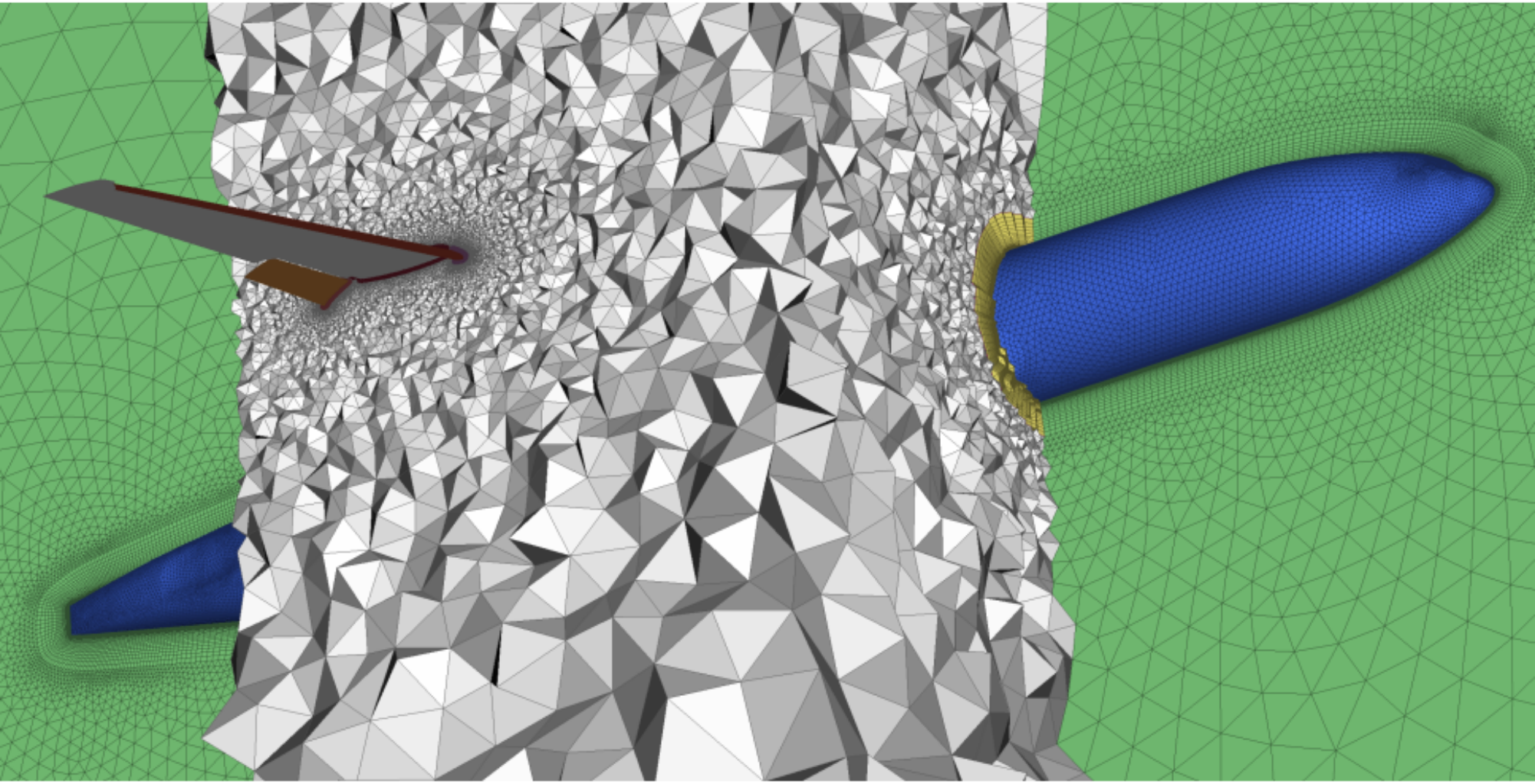

Comments - Geometry

No problem was identified after importing the geometry model.

The surfaces of the model must be fully connected before meshing. No problem with that either.

No geometry simplification or clean-up was necessary.

COMMENTS - SURFACE MESH

At rst we started by the medium mesh, then moved to coarse mesh and nally to ne mesh. But it was necessary to make some adjustments in the initial surface mesh topology to avoid a large area of collapsing layers due to dif culties in growing layers on concave areas of the model.

Therefore, the medium and coarse meshes were modi ed to have the same mesh topology as the ne mesh. There were 5 iterations until the nal family of meshes was ready to run.

Comments - Surface Mesh

When most of the surface mesh are made of quad elements, one must keep the aspect ratio on the top cap of the last layer below 8 in order to avoid problems with tetra generation. Otherwise the tetra algorithm will have difficulty in creating the transition between hexa and tetra elements.

Comments - Volume Mesh

At the time the first family of grids was generated, some quality criteria as [FLUENT] Solid Maximum Skewness, [FLUENT] Solid Non Orthogonality and [IDEAS] Solid Maximum Warping were not properly taken into account during the volume generation.

It had bad consequences on the flow solution of the wing upper surface due to bad tetra and pyramid elements with extreme valeus of skewness and non-orthogonality.

It took a few tries to get the right mesh quality settings to avoid bad elements and keep maximum skewness and non orthogonality within acceptable values.

Comments - Volume Mesh

We had some issues with the fine mesh where the tetra algorithm crashed or blocked during volume generation.

A workaround for this problem was to change the surface mesh resolution in order to keep the aspect ratio of the quads on the top cap of the last layer at a maximum value of 8.

Comments - Generation Time

The first mesh takes more time because one must first define and create the surface mesh topology on the wing, slat and flap which meets the meshing guidelines requirements. Defining the topology means creating the MAP Mesh boundaries and how the mesh points are distributed in them. Once the topology is done, the other meshes of the family are defined by the required resolution.

For the coarse mesh it took 6.5 hours, 12 hours for the medium and 28 hours for the fine mesh. This is the elapsed and labor time needed to complete the process from MAP Mesh to solver output. The difference in mesh size between each mesh level is a factor of aproximately 3X, as required, and the difference in generation time is a factor of 2X between each mesh level.

Thank you