PRESSURE EQUIPMENT ENGINEERING SERVICES, INC.

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FINITE ELEMENTS ANALYSIS OF CONICAL ROOF

PROBLEM DESCRIPTION:

An Aluminum Chloride storage silo (original design per API-620) was evaluated for re-rating to a higher pressure. The original internal design pressure for the silo was 0.5 psig @ 100 °F. The client had requested re-rating to 10 psig @ 100 °F or to the maximum possible internal pressure. The API-620 calculations were performed for the various components of the silo. Based on the API-620 criteria, the cylindrical shell and conical hopper were found to be fit-for-service for the 10 psig internal pressure in the silo.

The roof design was also checked. It was found that for external pressure and the specified live loading, the stress check criteria and the stability criteria were satisfied. However, it was found that for the available thickness of 0.218", the roof was overstressed for the 10 psig pressure loading. The additional calculations revealed that for the available thickness of 0.218", the roof rating could be 7.76 psig without the presence of large closely spaced roof nozzles. With several large closely spaced nozzles present on the roof, the actual pressure rating of the roof would be lower than 7.76 psig.

It was decided to perform finite element analysis for the conical roof to obtain a reasonably high pressure rating for the roof and obtain code compliance per API-620 even if some modifications are required for the roof.

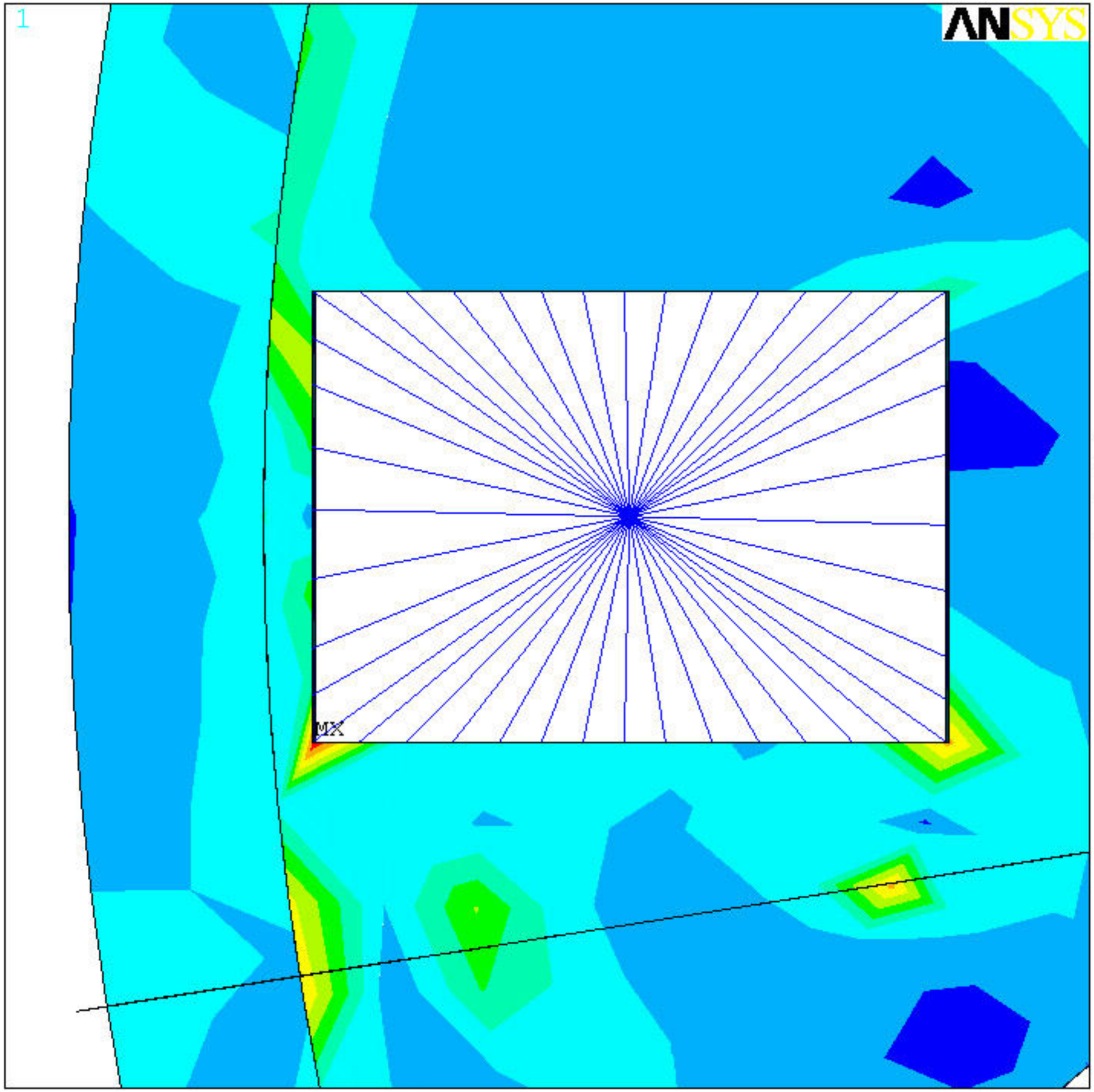
FEA MODEL & RESULTS:

To obtain a reasonably high internal pressure rating for the roof, the following modifications were proposed and modeled for the FEA model. A new compression ring was installed at the cylinder-roof juncture. Nine (9) radial stiffeners were installed on the roof extending from the new circular stiffener at the center and extending to the end of the compression ring installed at the cylinder-roof juncture. These radial stiffeners were contoured to the profile of the conical roof to compression ring juncture. A new reinforcing pad was installed around the rectangular nozzle.

The 3-D finite element analysis was performed using the FEA software ANSYS. The finite element model consisted of the conical roof, upper portion of the cylindrical shell, compression ring at the shell-roof juncture, nine (9) radial stiffeners, central circular stiffener ring, six (6) round nozzles and one (1) rectangular nozzle. To avoid the distortion of the nozzle ends, the end flanges were modeled as fairly stiff radial spider beams at the end of each nozzle.

The three different pressure loadings (10, 8, 7.5 psig) were applied to all the internal surfaces of the silo shell, roof and nozzles for the three (3) load cases. The FEA analysis was performed for the above load cases. The stress analysis results for the conical roof, nozzles and stiffeners were checked against the ASME code, Section VIII, Div.-2, Appendix-4 criteria. The modified design for the silo roof was certified to be in code compliance with API-620. Based on the fitness-for-service evaluation (API-620 calculations and FEA results), the silo was re-rated to 7.5 psig (INT.) @ 100 ° F / 0.361 psi (EXT.) @ 100 °F.

The attached FEA plots show the FEA model and results for one of the load cases.



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EFACET=1
AVRES=Mat
DMX =.362085
SMN =.848E-07
SMX =59578

YV =1
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*YF =26.615
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Z-BUFFER

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26479
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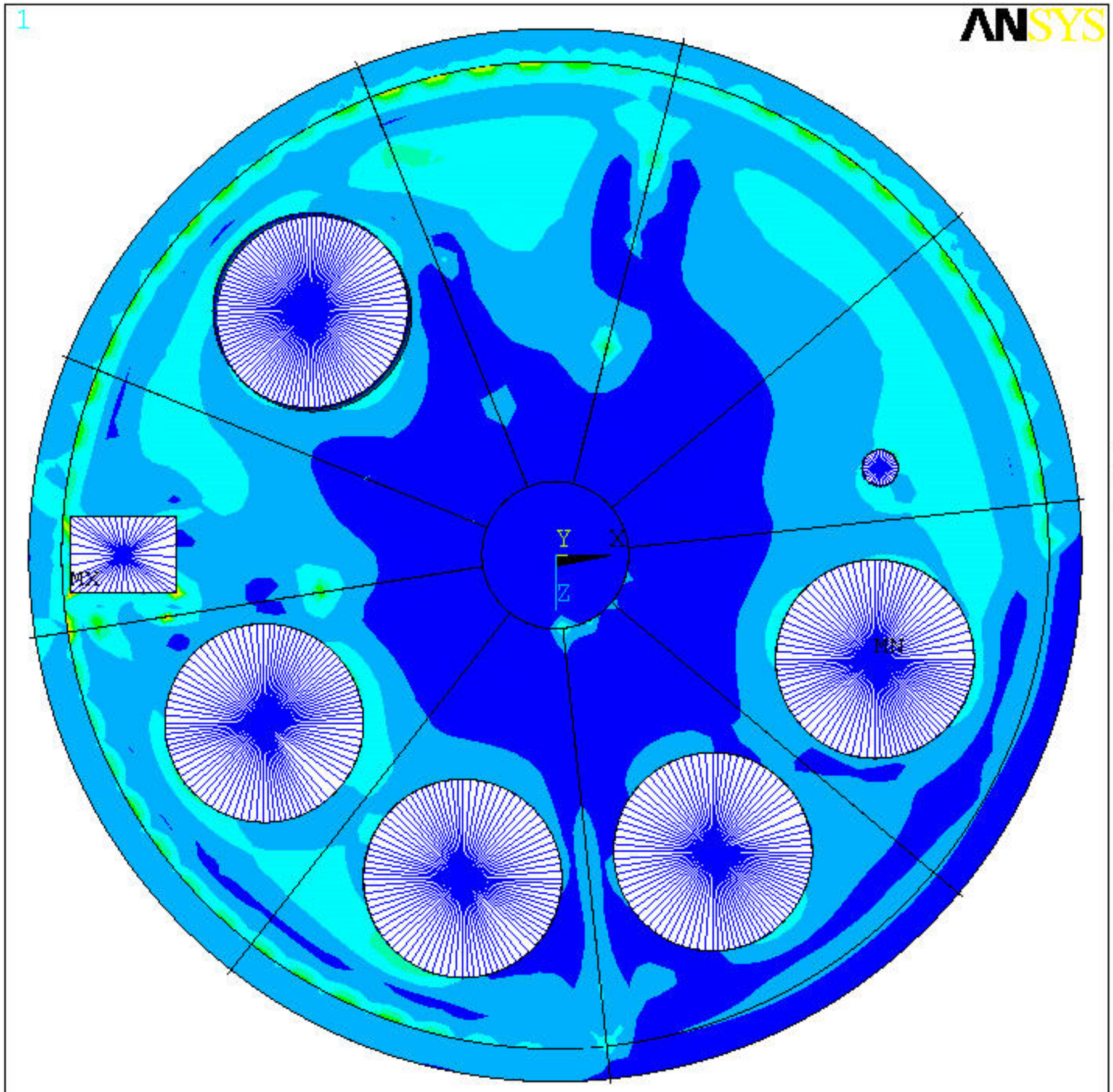
59578



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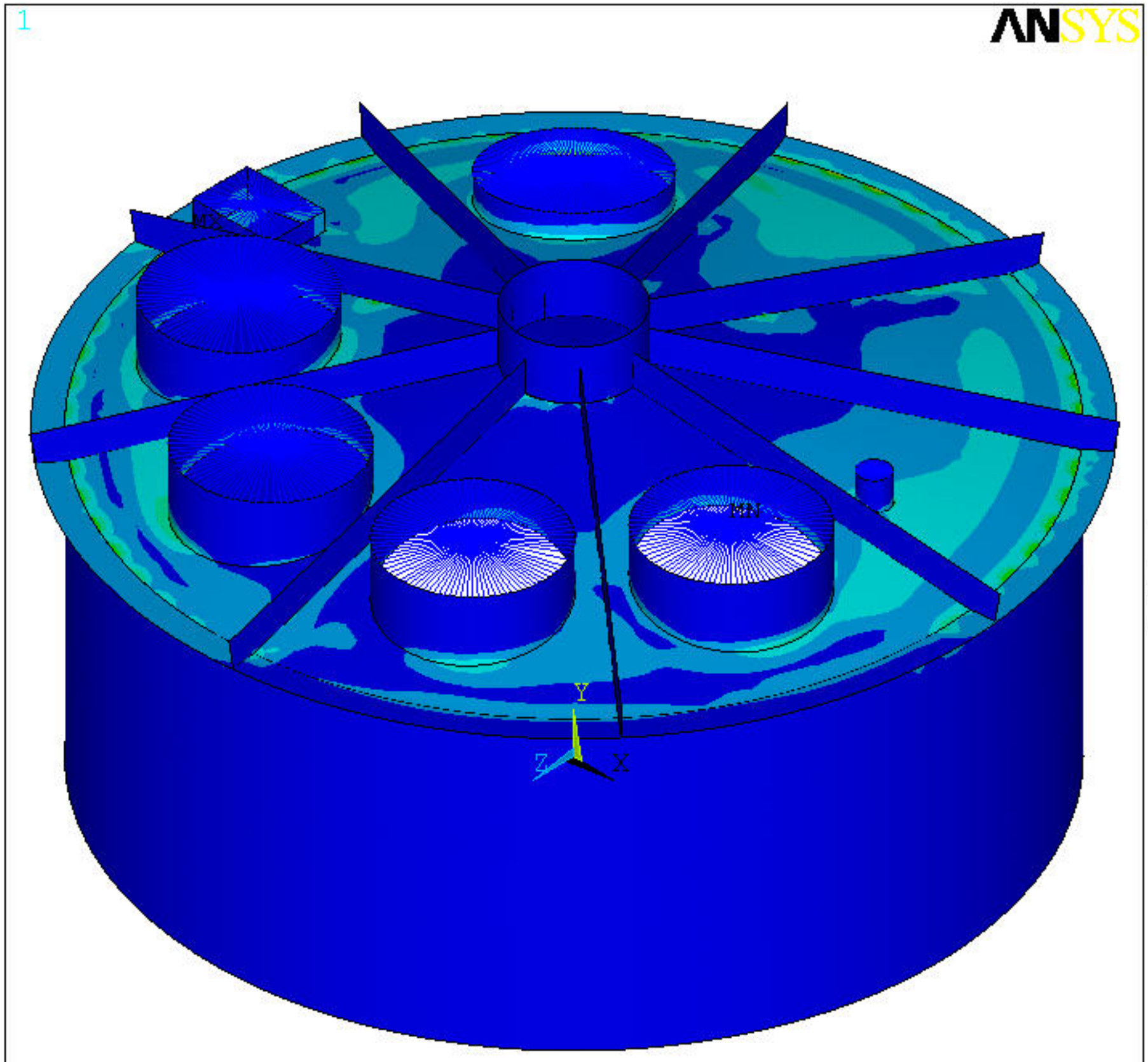

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XV =1
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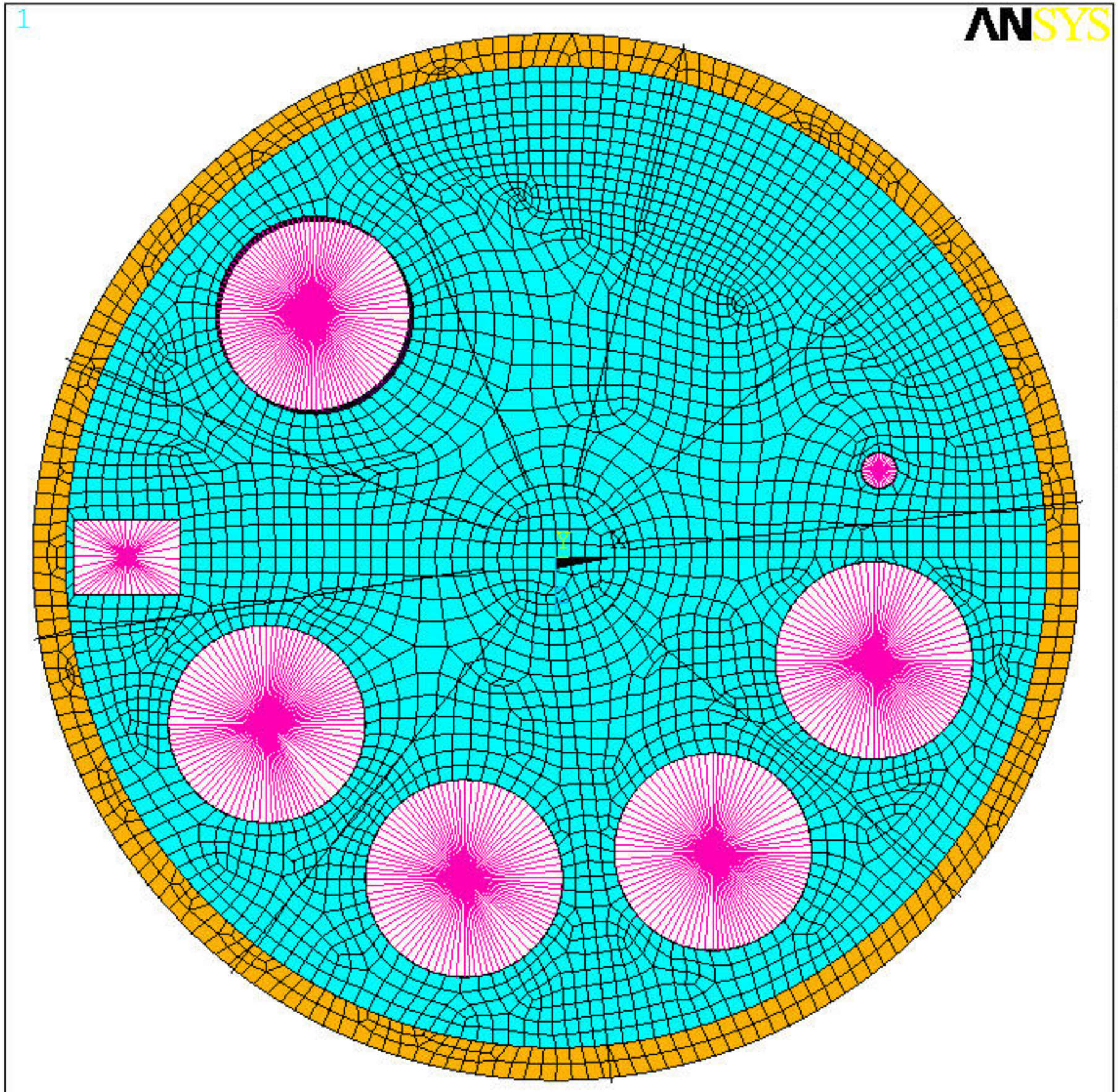

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AVRES=Mat
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YV =1
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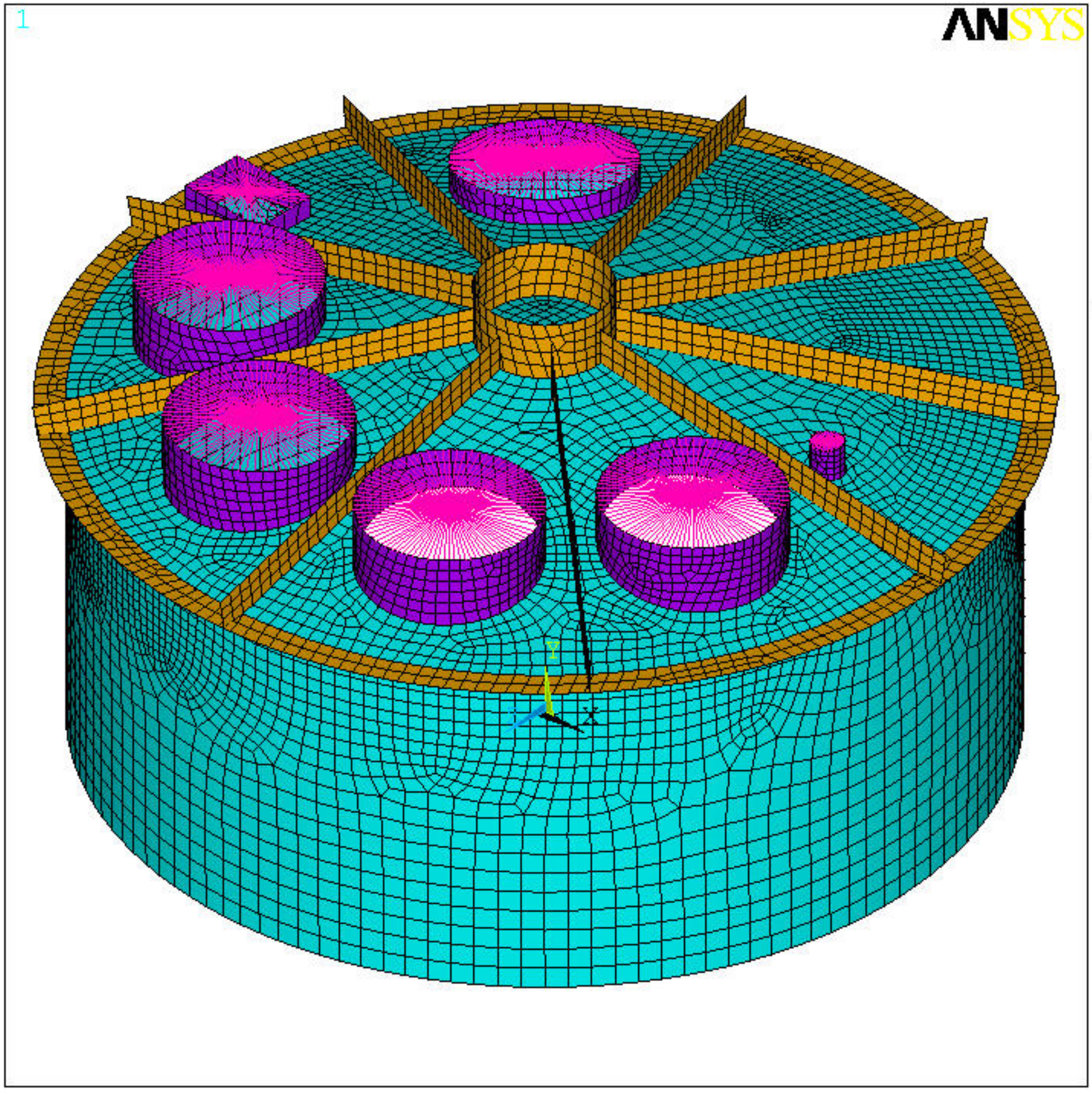
*XF =.36907
*YF =25.672
*ZF =.132502
Z-BUFFER



DISPLACEMENT
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XV =1
YV =1
ZV =1
*DIST=67.979
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*YF =25.672
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Z-BUFFER

1

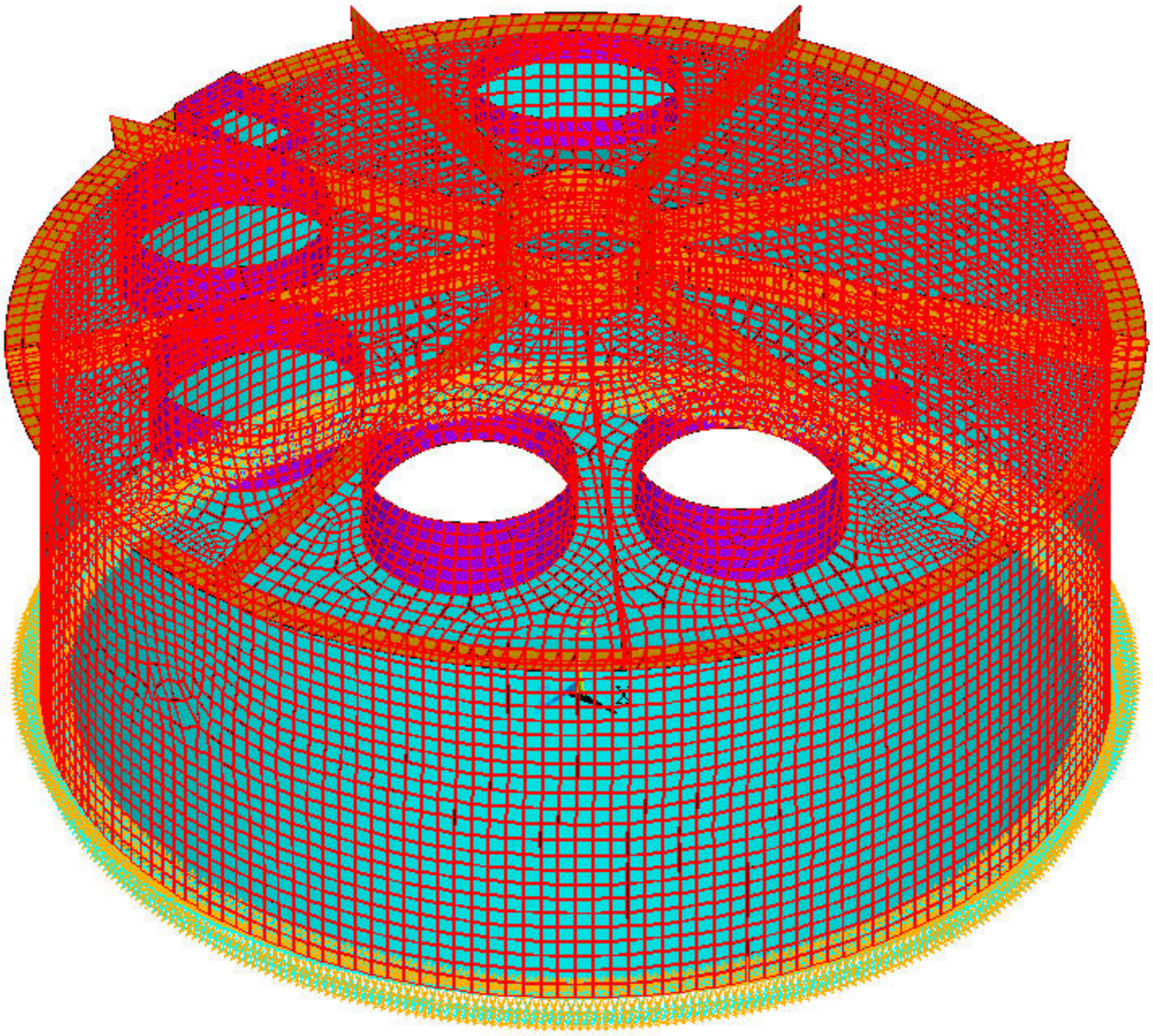
ELEMENTS

REAL NUM

U

ROT

ANSYS



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ELEMENTS

REAL NUM

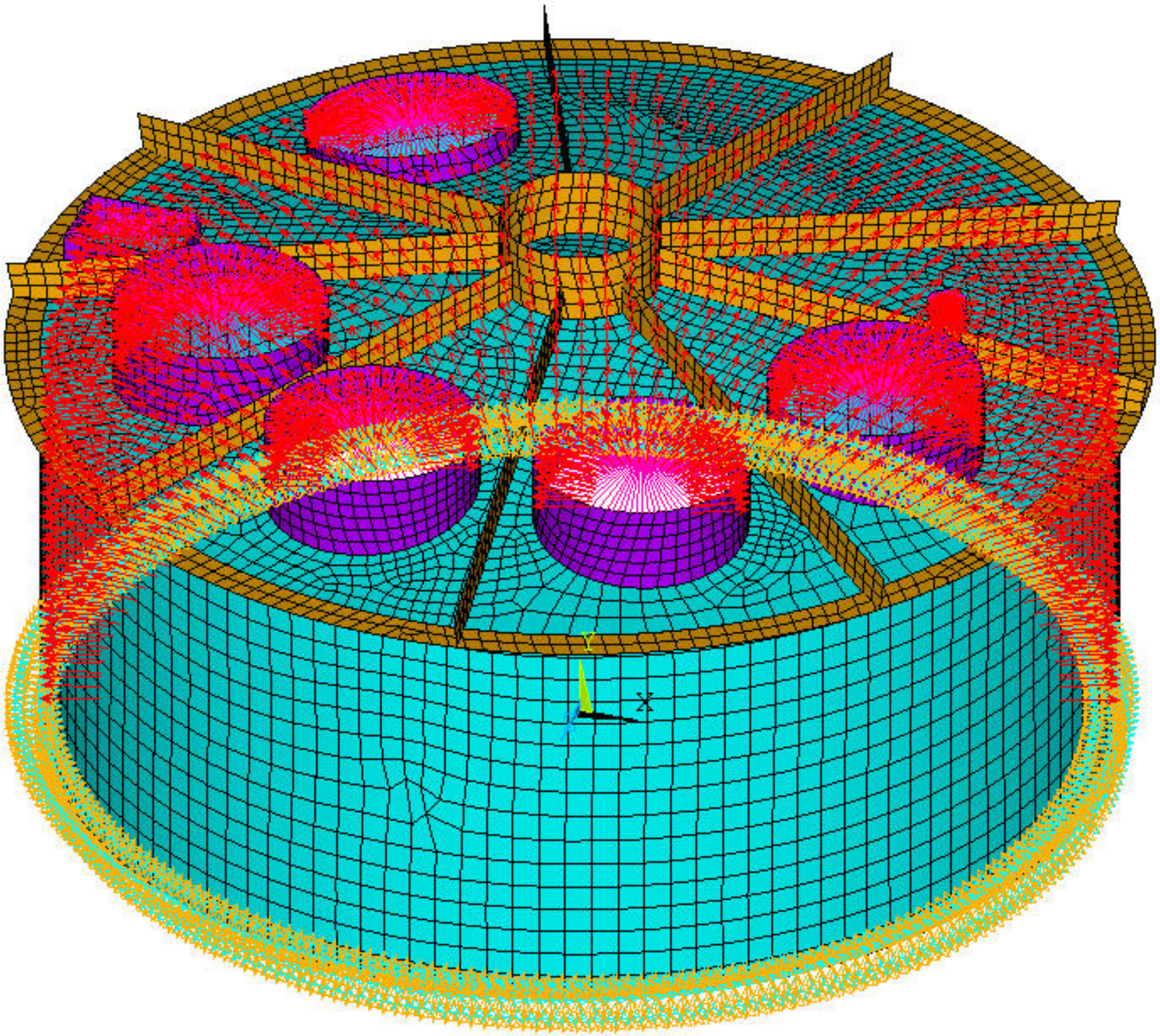
U

ROT

PRES-NORM

10

ANSYS



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ELEMENTS

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U

ROT

PRES-NORM

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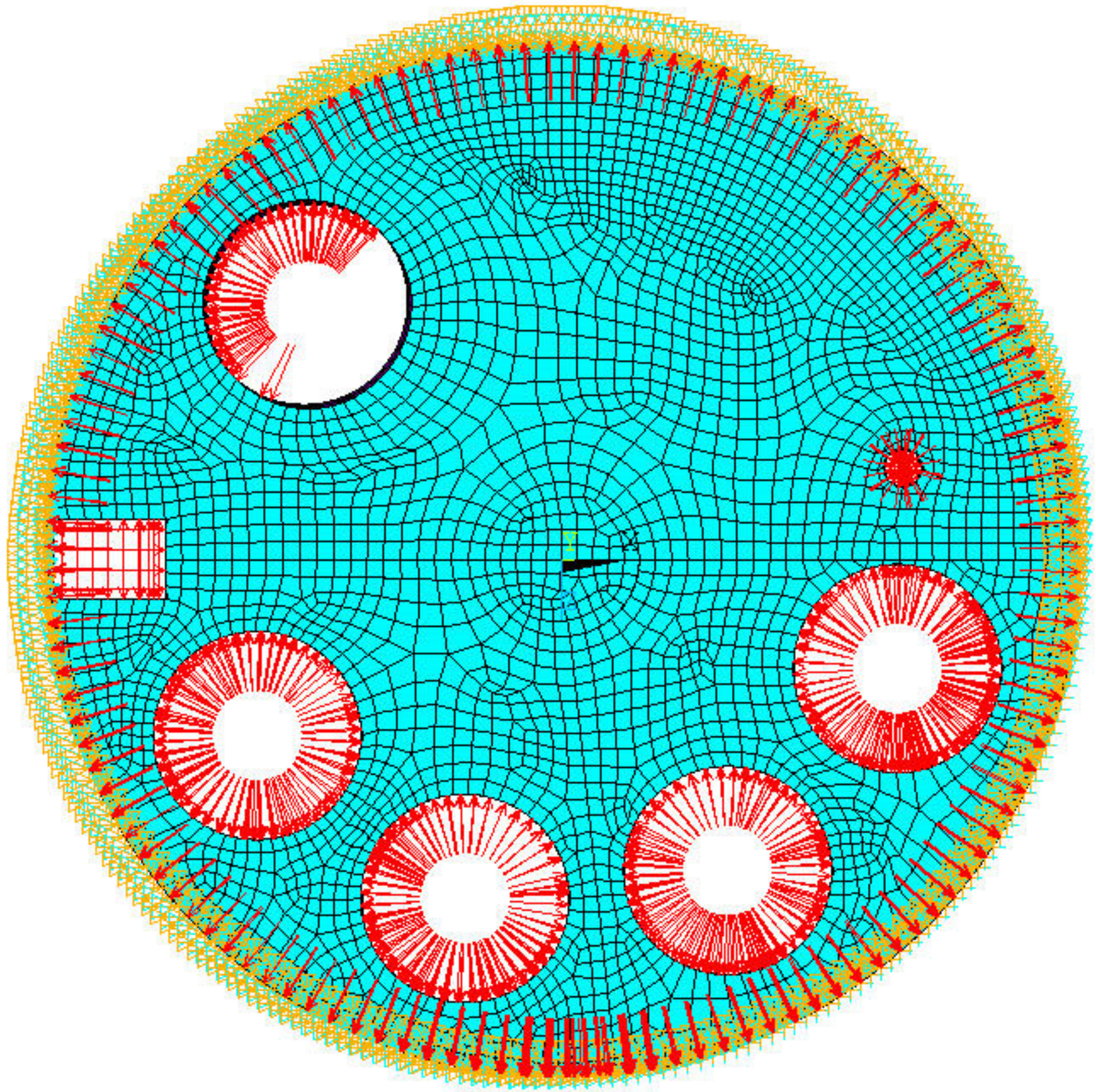
ANSYS



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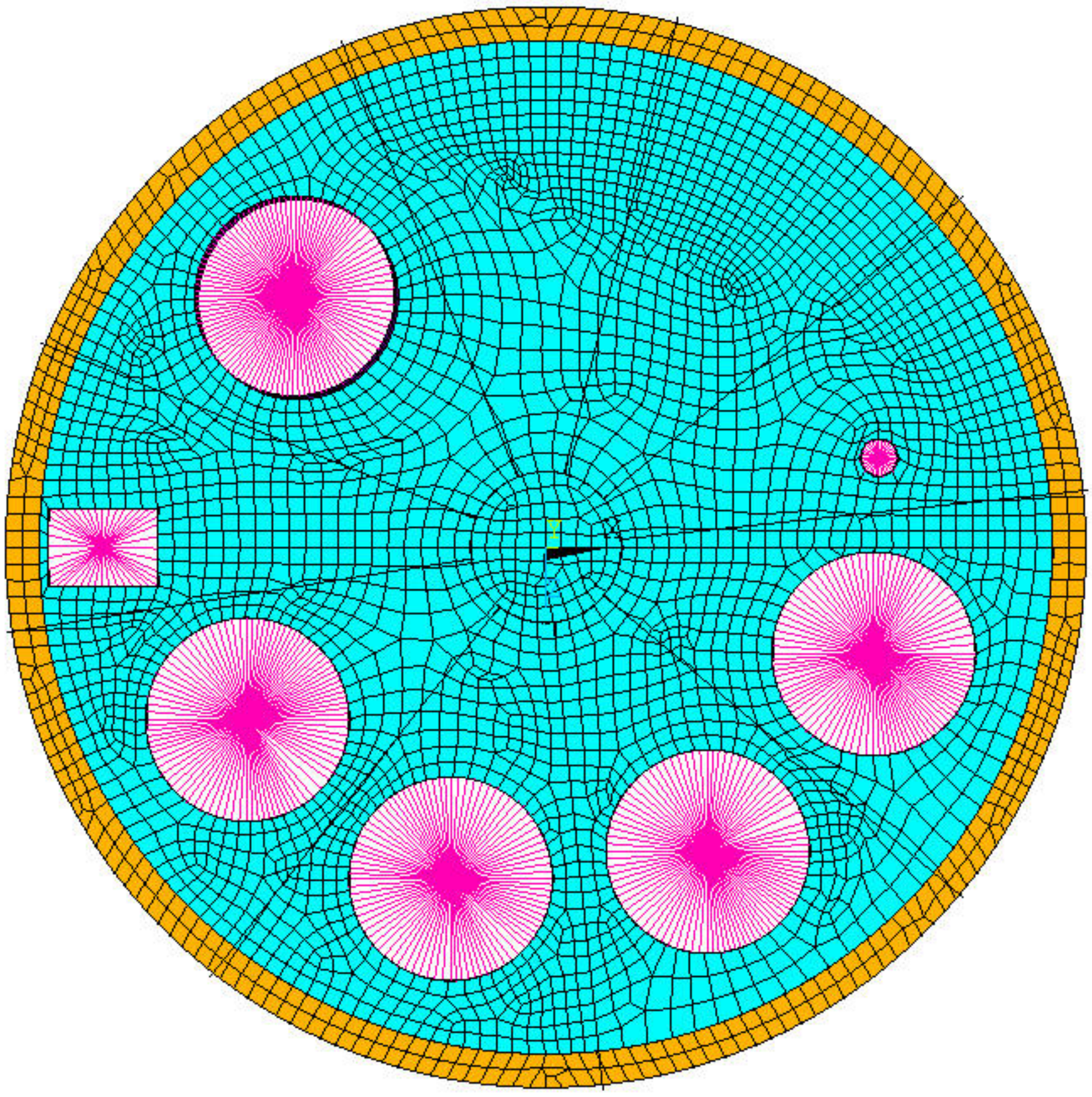

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ELEMENTS

REAL NUM

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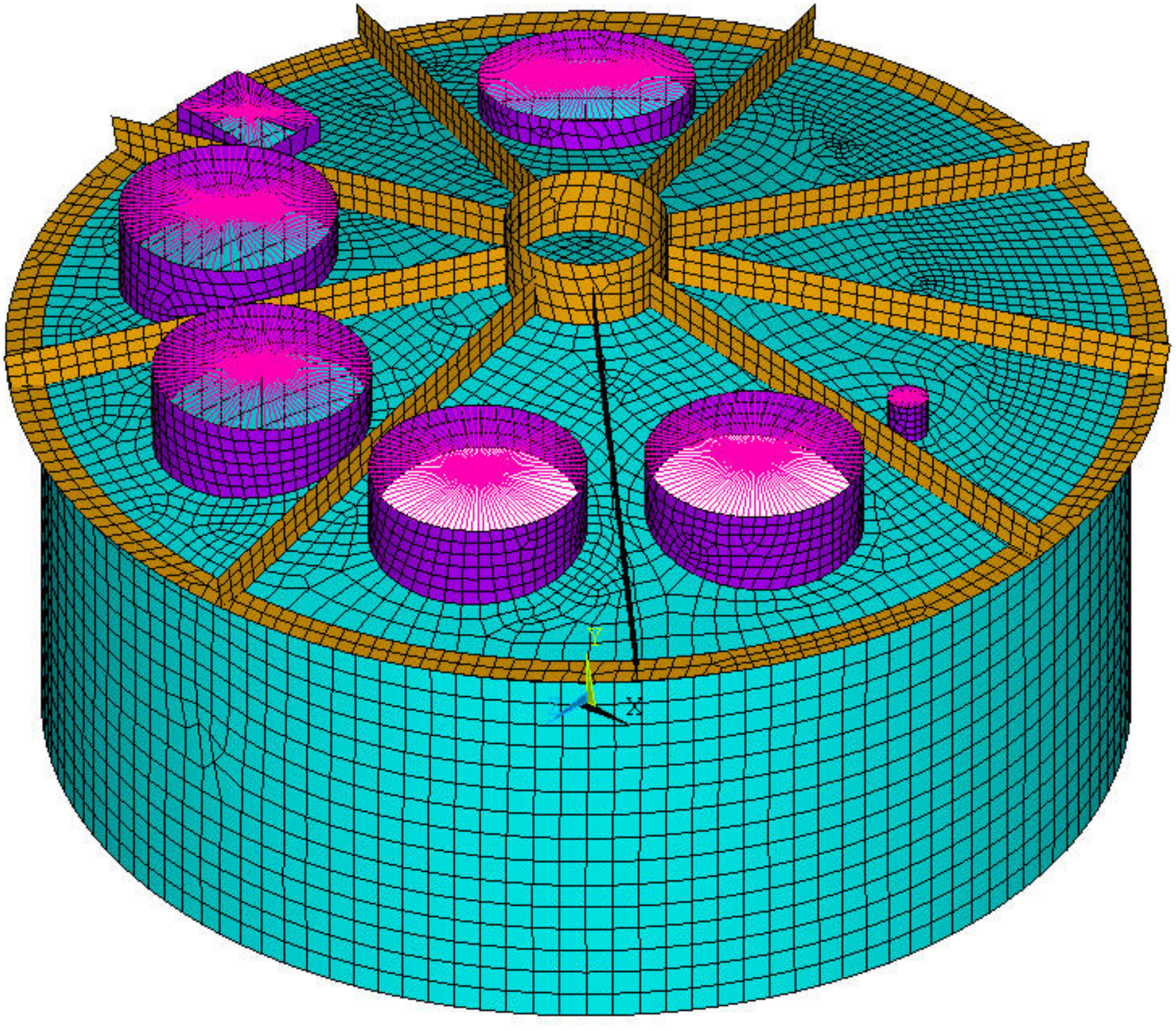

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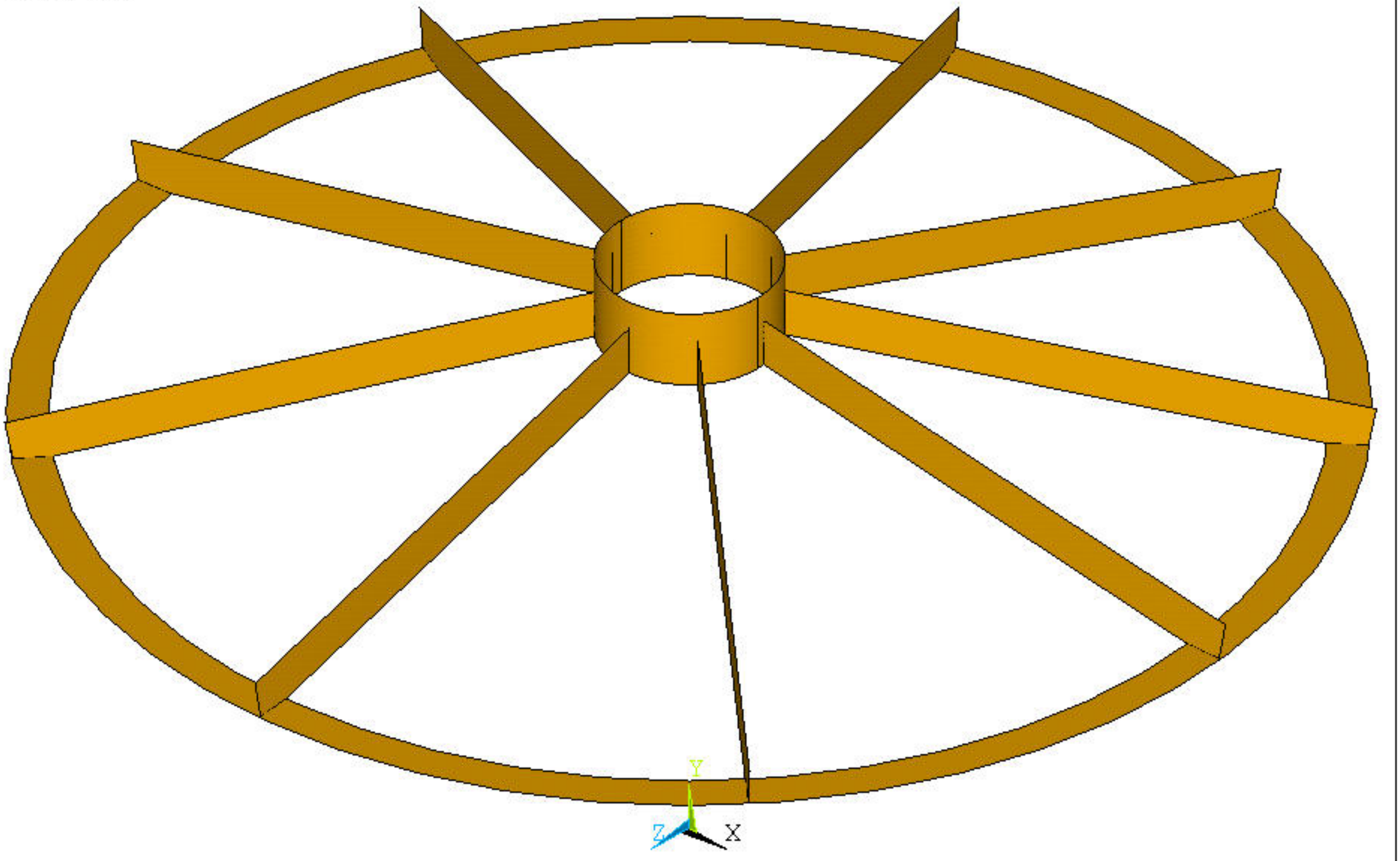
ANSYS

AREAS

REAL NUM



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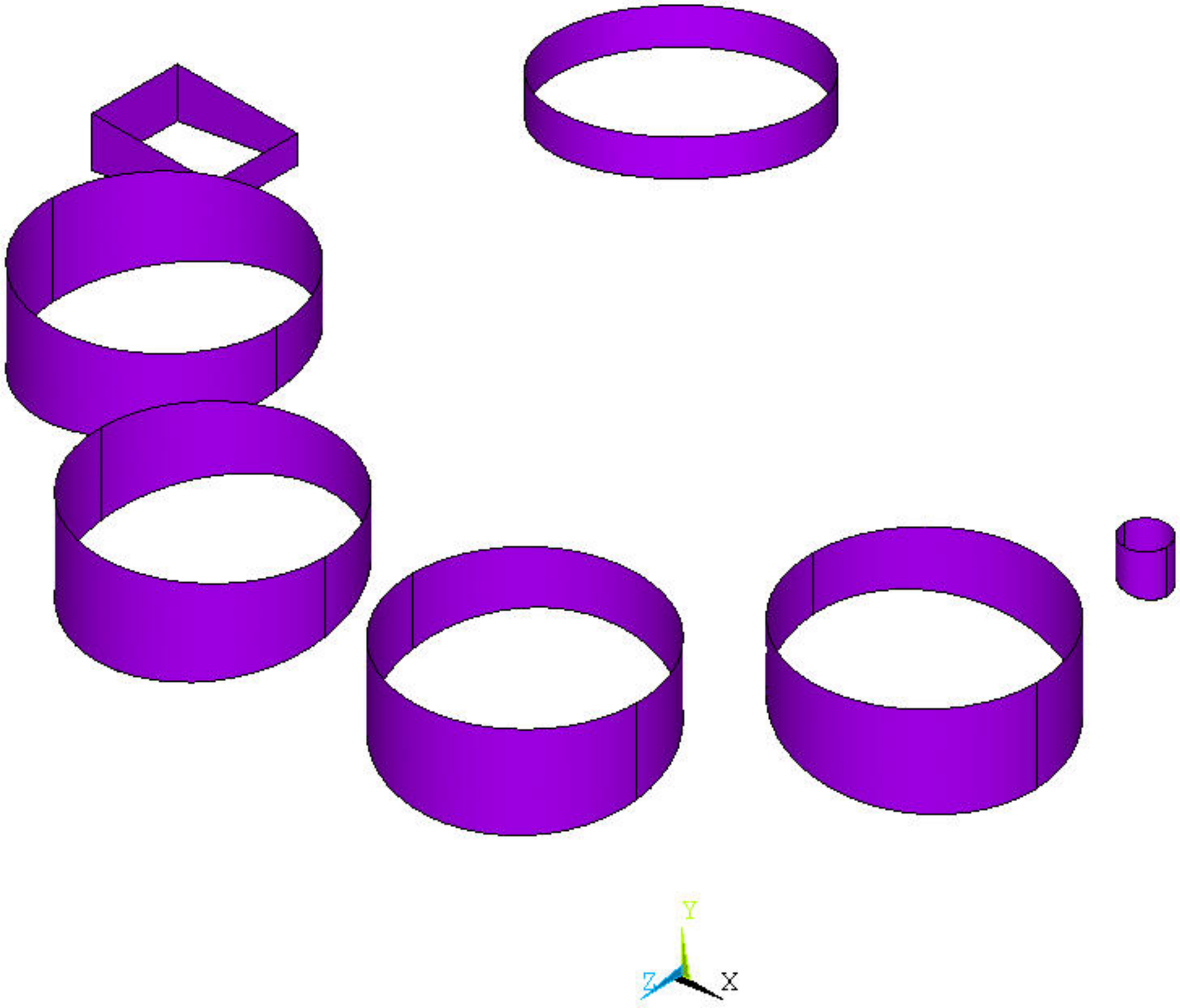

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AREAS

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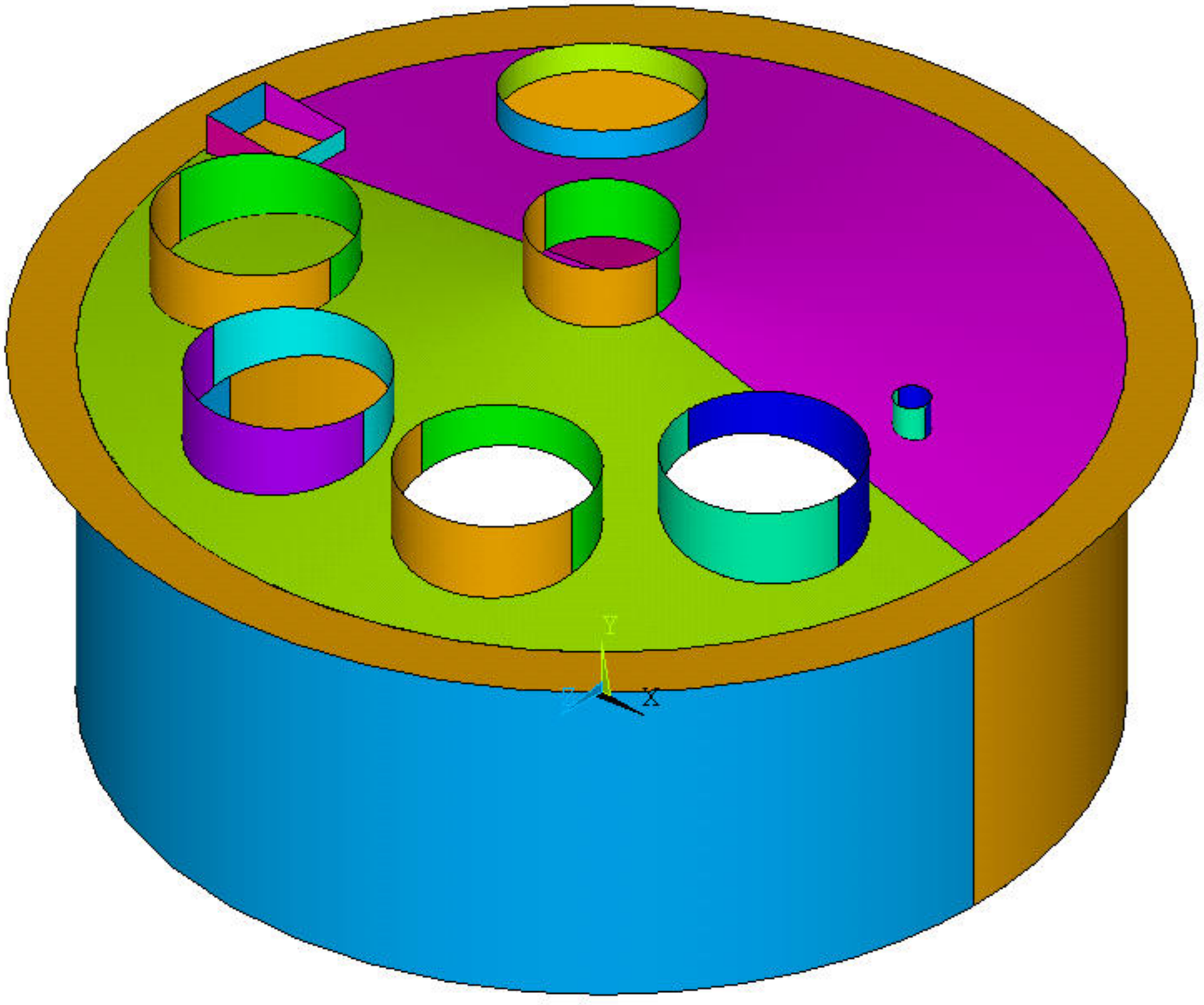

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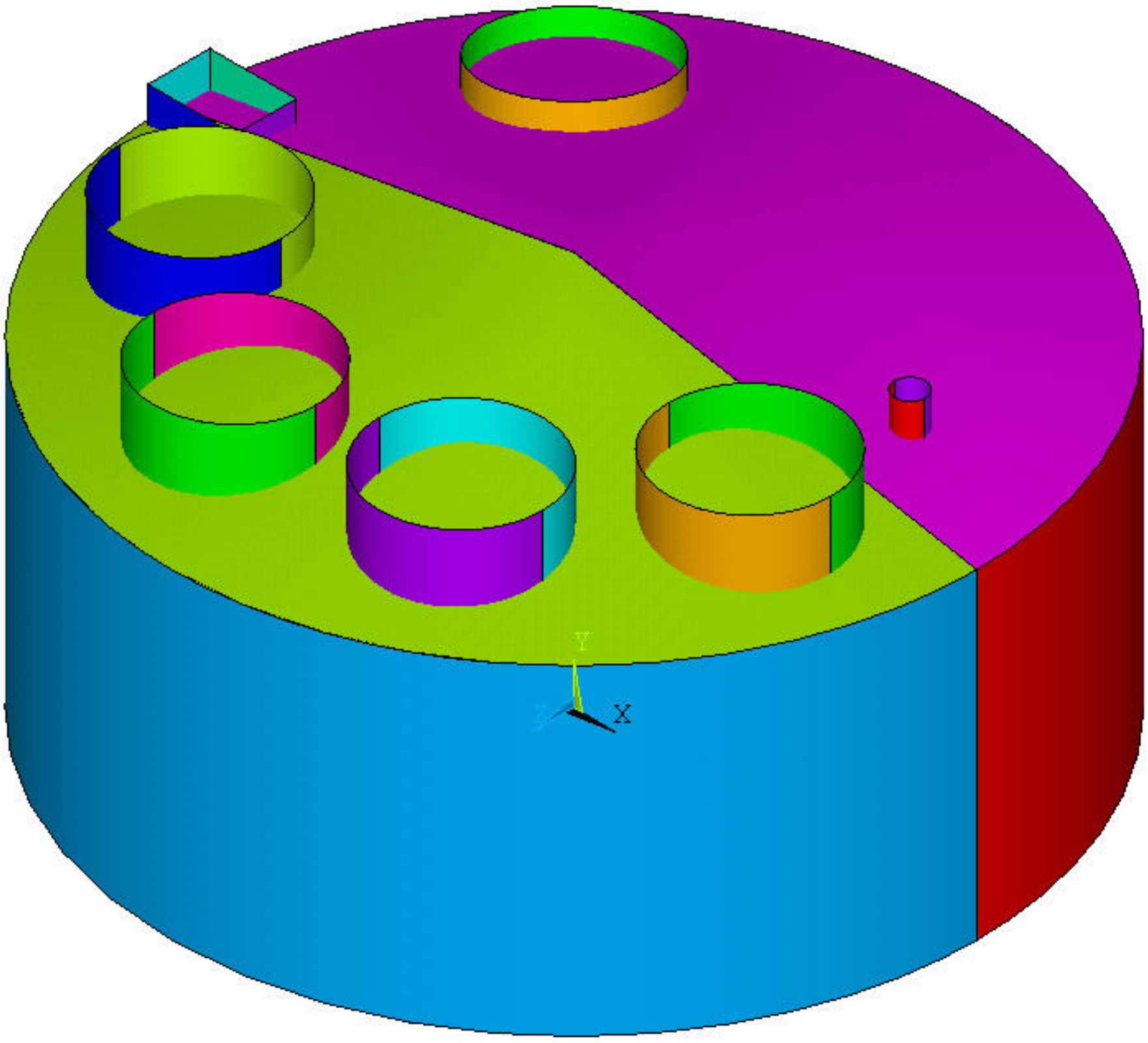

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AREAS

AREA NUM

ANSYS