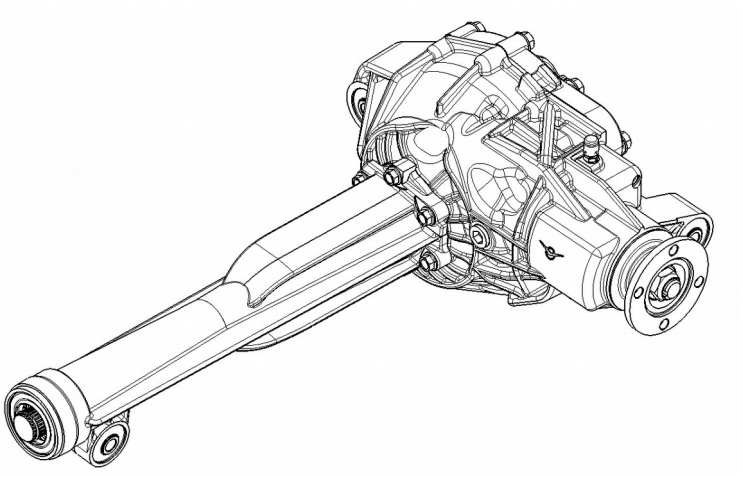
Final drive lubrication modeling



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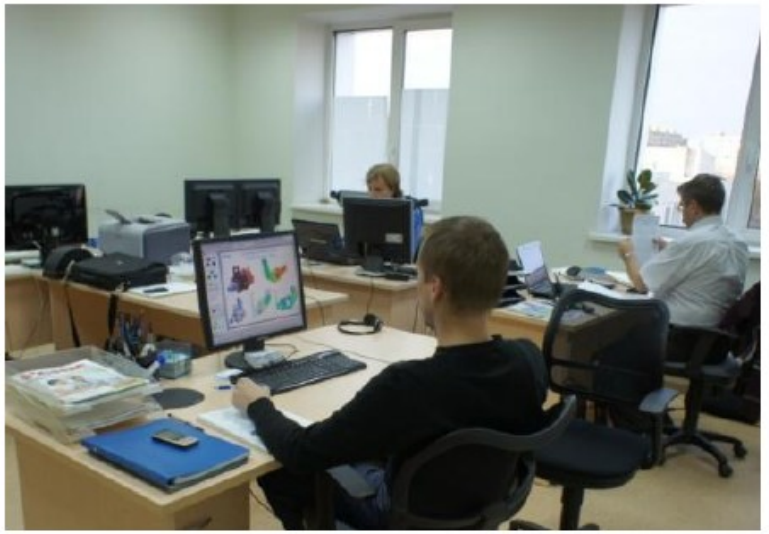
Company Description

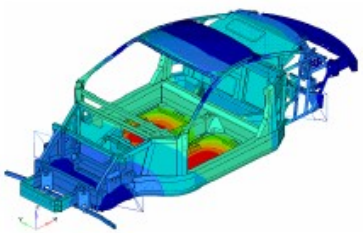


- Engineering Office, Togliatti
- Quality System: plans to certificate ISO 9001
  + elements of ISO 16949 (FMEA and others) in 2017
- Team
  - All engineers are Master degree
  - + 2 Phd, 2 postgraduate students
  - More than 50 scientific articles, 2 books
  - Experience in automotive industry more 20 years
  - Experience in CAE more 10 years
- Qualification, experience, learning
  - Catia, NX, SolidWorks
  - LS-Dyna, MSC.Nastran, Ansys, SimulationX, PRADIS, Ansys CFX, Star CCM, Fluent, Ansa, HyperMesh, OptiStruct, Code-Aster, OpenFoam, Matlab
  - Learning of ISO/TS 16949, VDA 6.3, APQP, NPI, 5S, Lean office, PPAP, LS-Dyna, Catia, NX
- Software/Hardware
  - CAD: Catia V5 (license), NX (rent)
  - CAE: LS-Dyna (license + cluster rent), ANSYS CFX (cluster rent), MSC.Nastran (rent), PRADIS (home design software), Code-Aster, OpenFoam, Salome (GNU)
  - Project and Data Development: PDM Redmine
- Statistics for 12 years (2005-2017)
  - More 511 projects for automotive industry and others
  - Projects duration from 2 weeks to 2-3 years
  - Work with 6 Worldwide OEMs

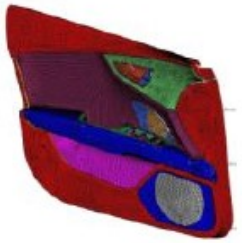
Please visit:
http://laduga.com
laduga@laduga.com

LADUGA ENGINEERING SERVICE

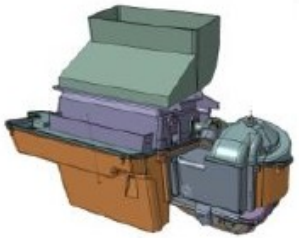
COMPANY COMPETENCIES



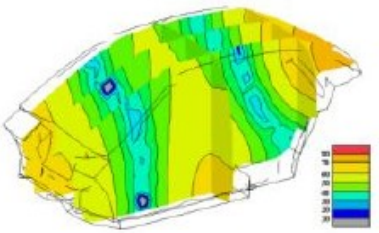
BiW Engineering



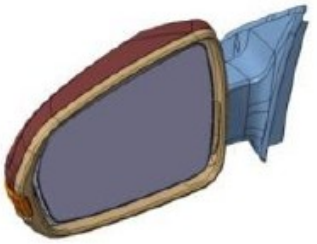
Interior&Exterior Engineering



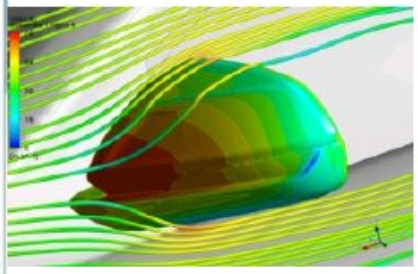
HVAC Engineering



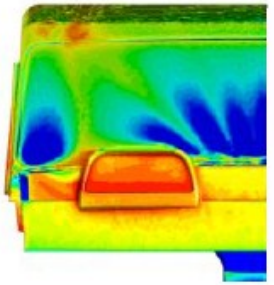
NVH Engineering



Units Engineering

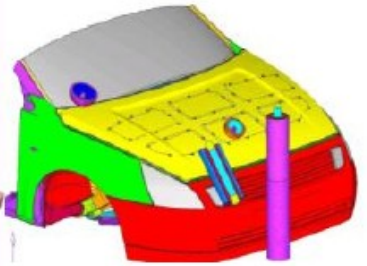


Aerodynamics



Thermal Engineering

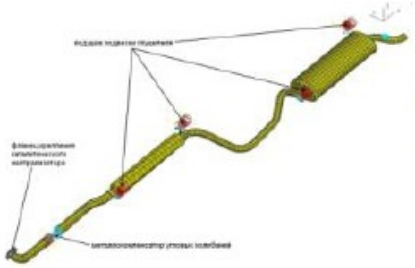
Passive Safety Engineering



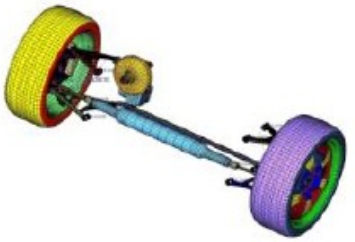
Pedestrian Safety Engineering

Brake system Engineering

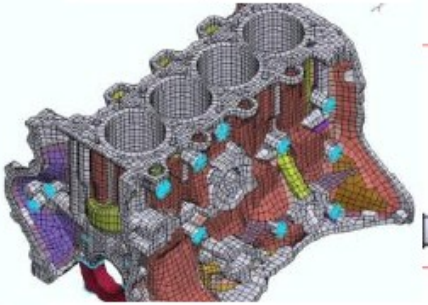
Intake Engineering



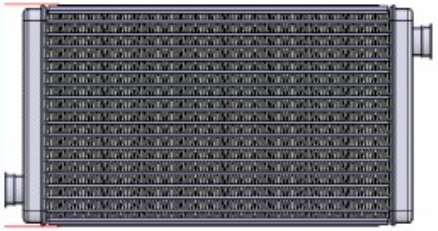
Exhaust Engineering



Suspension Engineering

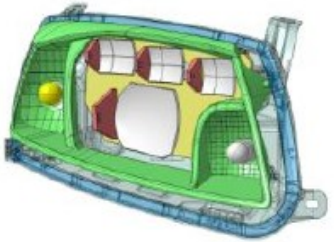


Engine Subsystems Engineering

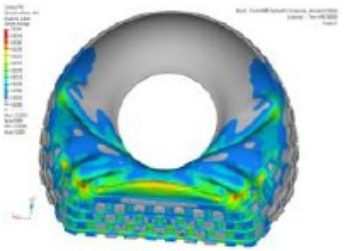


HeatExchanger Engineering

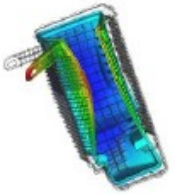
Transmission Engineering



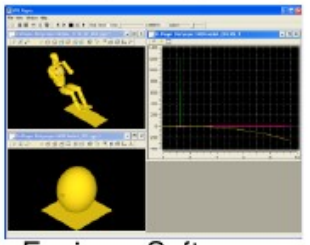
Lighting Engineering



Rubber Engineering



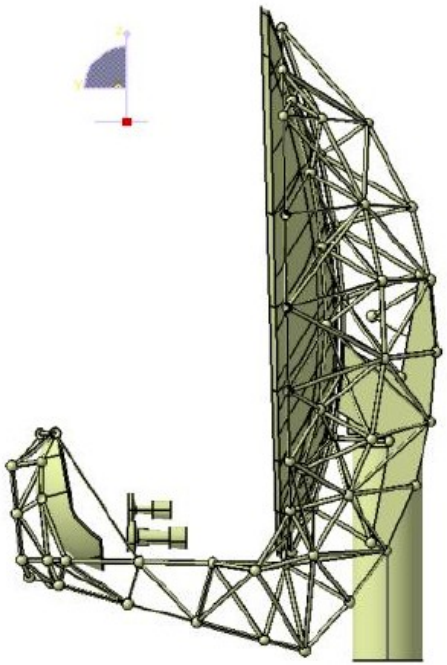
MoldFlow Engineering

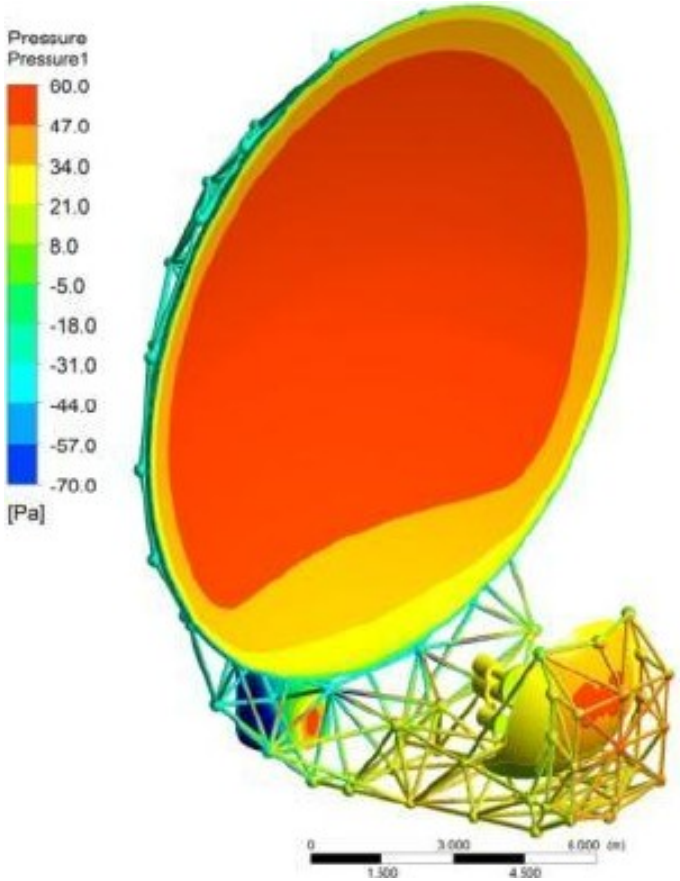


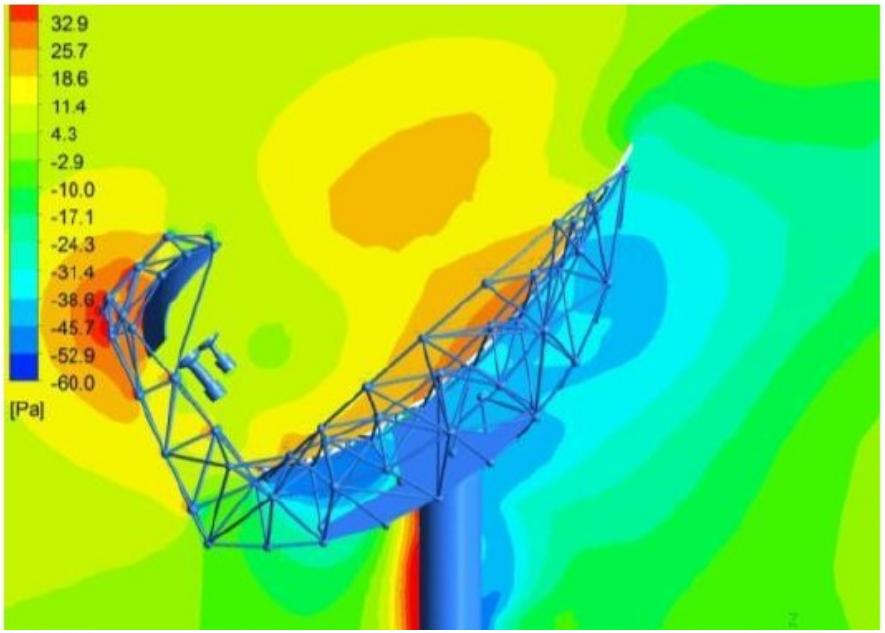
Engineer Software Development

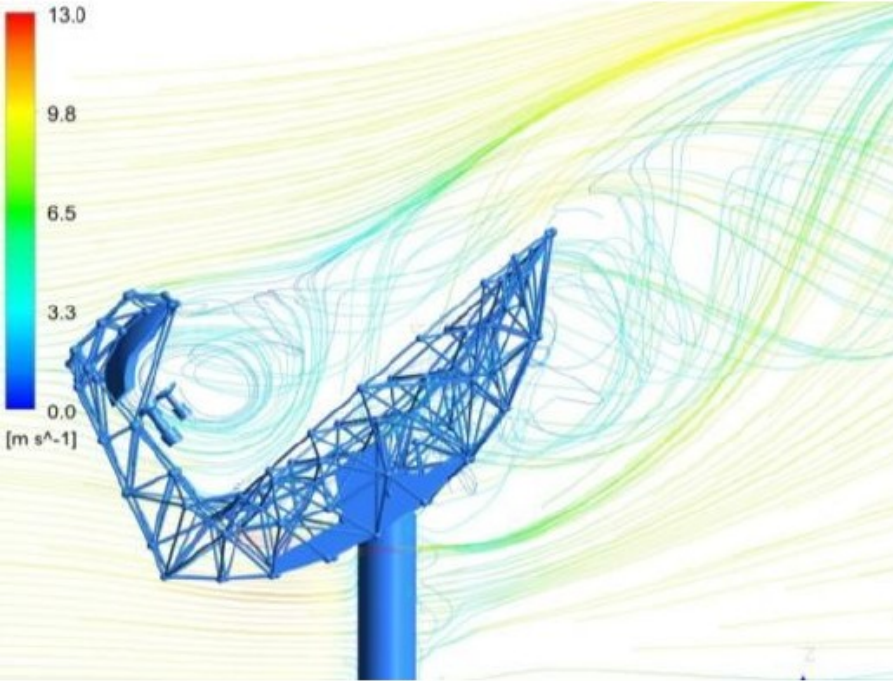
FROM NUMBER TO KNOWLEDGE

MeerKAT Antenna CFD analysis

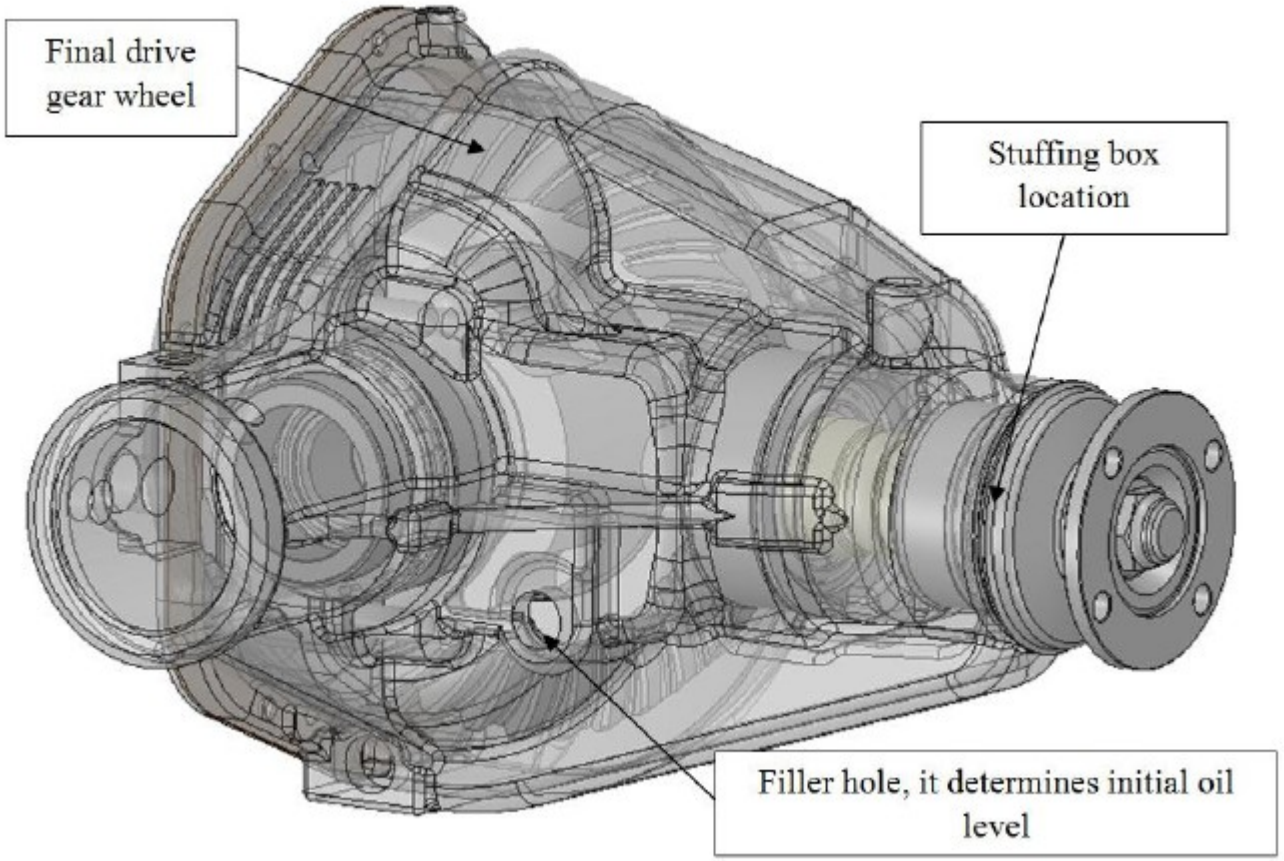




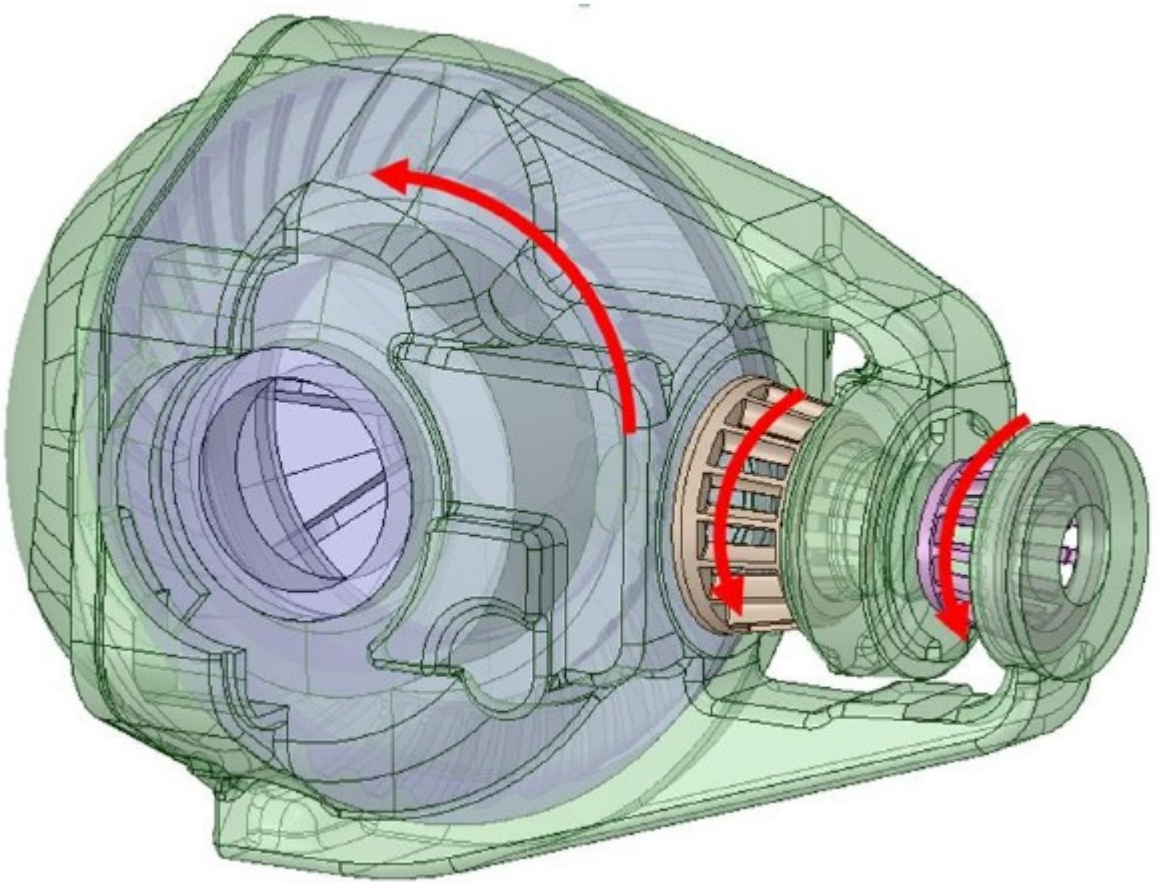




Final drive CAD model



The final drive internal volume, gear wheel and bearings rotation directions.



Convergence criteria

1. $$\mathbf{A}\,\mathbf{x} = \mathbf{b}$$

2. $$0 = -\mathbf{A}\,\mathbf{x} + \mathbf{b}$$

3. $$\mathbf{x} = (\mathbf{I} - \mathbf{A})\mathbf{x} + \mathbf{b}$$

4. $$\mathbf{x}_{k+1} = (\mathbf{I} - \mathbf{A})\mathbf{x}_k + \mathbf{b}$$

Simple (Jacobi) iteration method

5. $$e_k = \mathbf{x} - \mathbf{x}_k$$
$$e_{k+1} = \mathbf{x} - \mathbf{x}_{k+1}$$

6. $$\mathbf{x} - \mathbf{x}_{k+1} = (\mathbf{I} - \mathbf{A})(\mathbf{x} - \mathbf{x}_k)$$

7. $$e_{k+1} = (\mathbf{I} - \mathbf{A})e_k \qquad e_{k+1} = \mathbf{M}\,e_k$$

Convergence criteria $\lambda(M) < 1$

Mesh adaptation parameter

Gershgoring Circle theorem

$$\left|\lambda - \mathbf{M}_{ii}\right| \leq \sum_{i \neq j} \left|\mathbf{M}_{ij}\right|$$

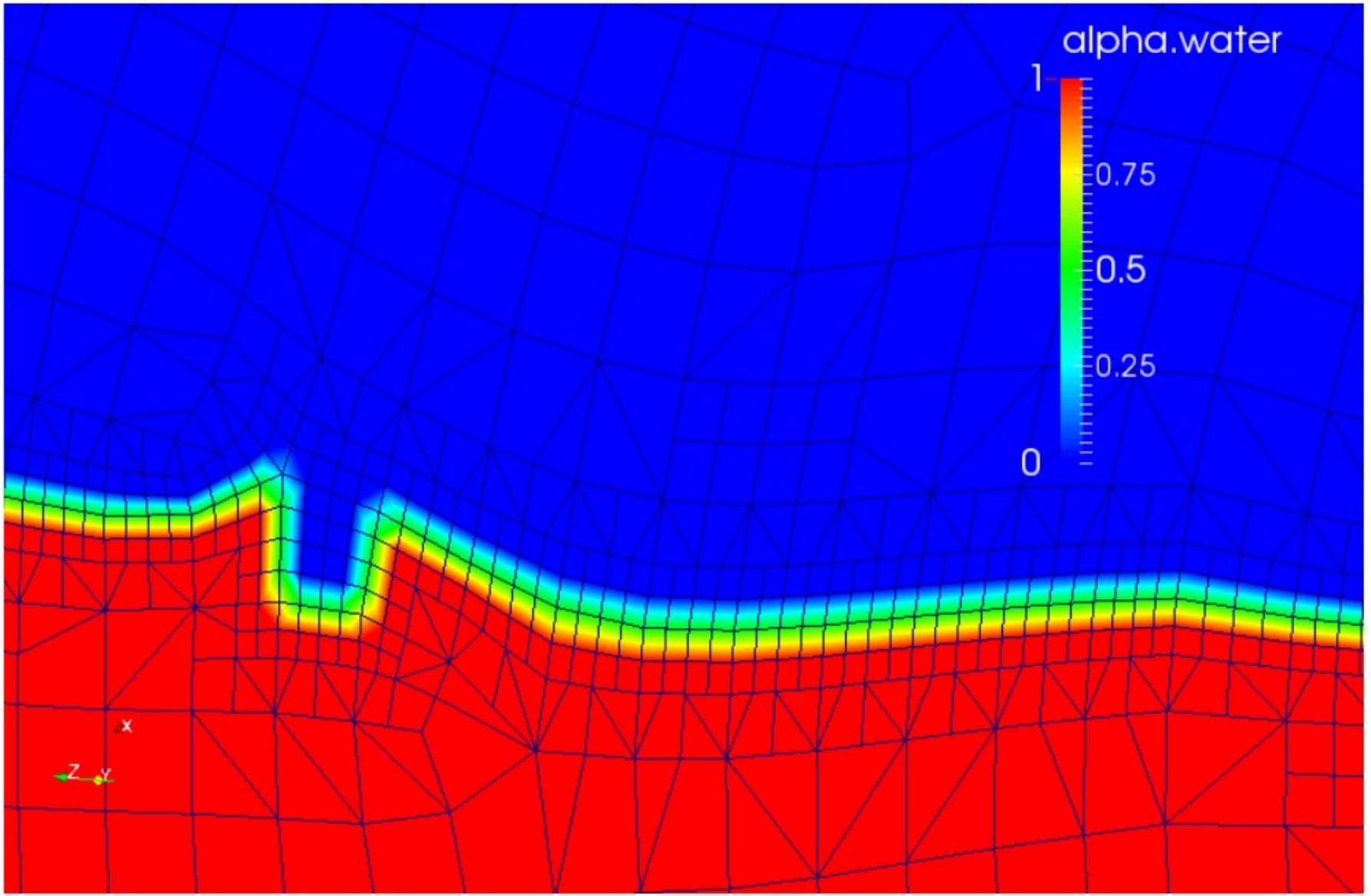
Mesh adaptation parameter

1. Discretization matrix $\mathbf{A}$ initialization.
2. Matrix $\mathbf{M} = \mathbf{I} - \mathbf{A}$ calculation.
3. Eigenvalues estimation matrix calculation.

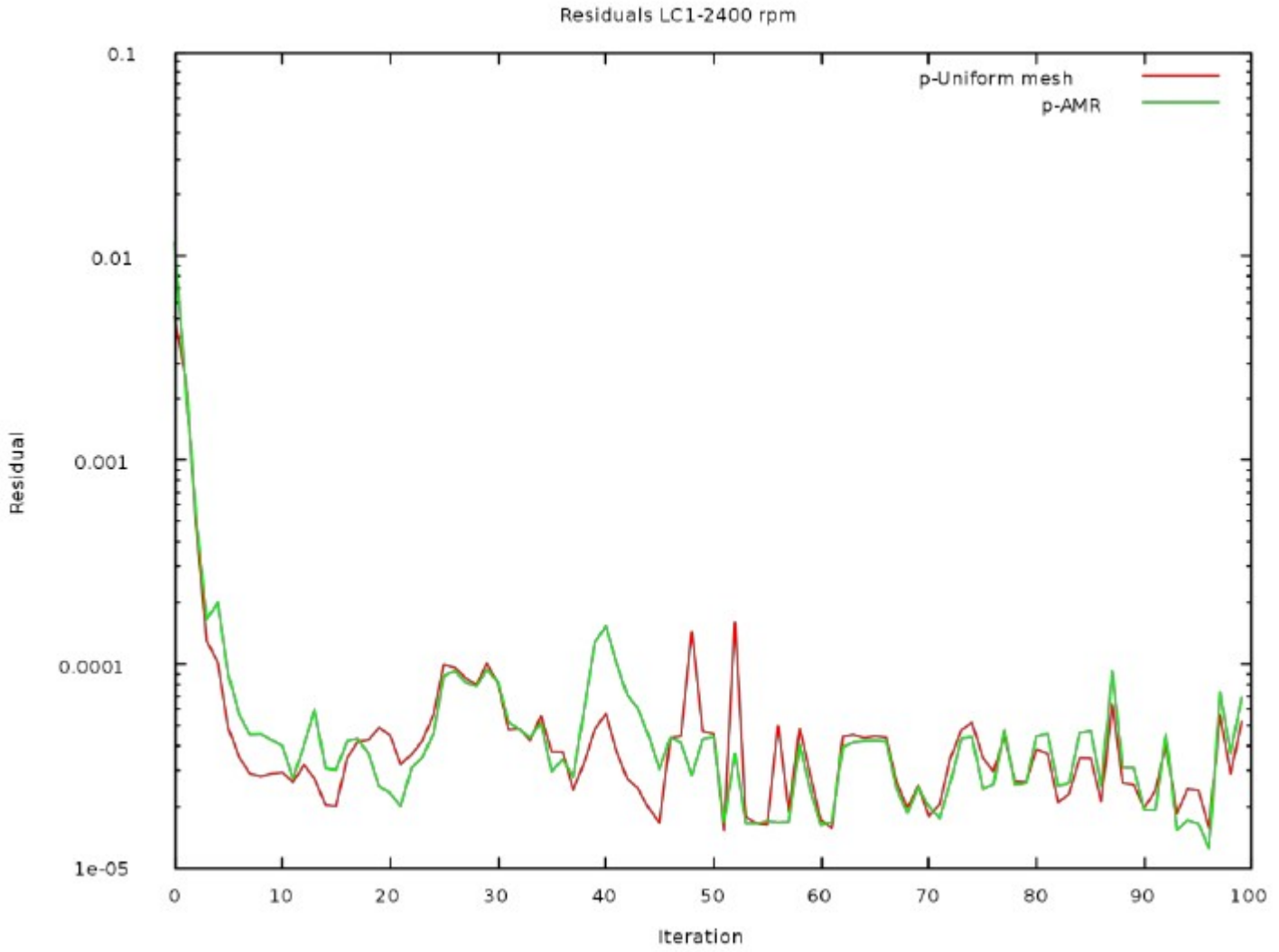
$$\mathbf{F}_i = \left| m_{ii} \right| + \sum_{i \neq j} \left| m_{ij} \right|,$$

where m_{ii} and m_{ij} diagonal and off-diagonal elements of matrix $\mathbf{M}$.

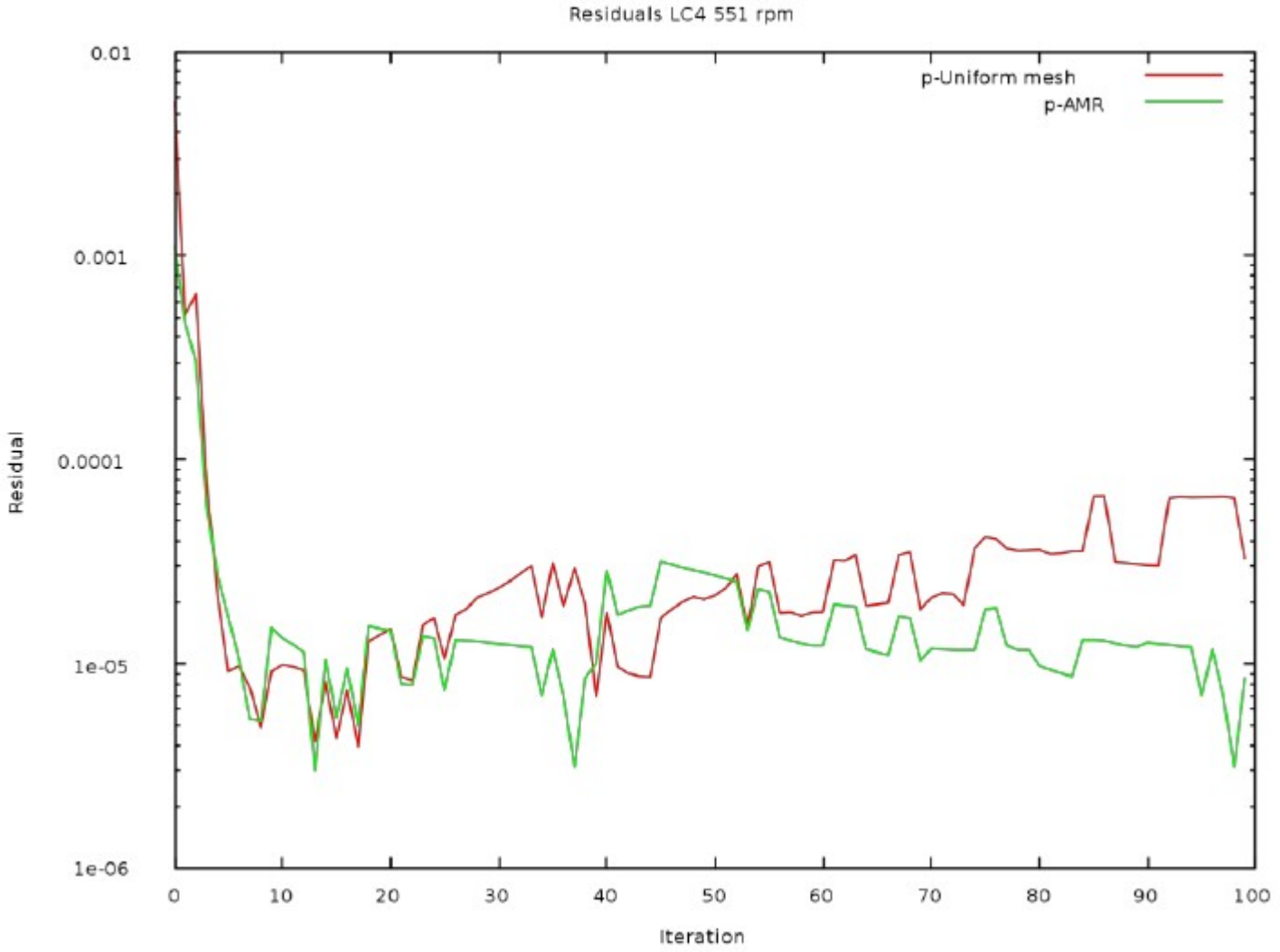
Adaptive mesh refinement, mesh fragment



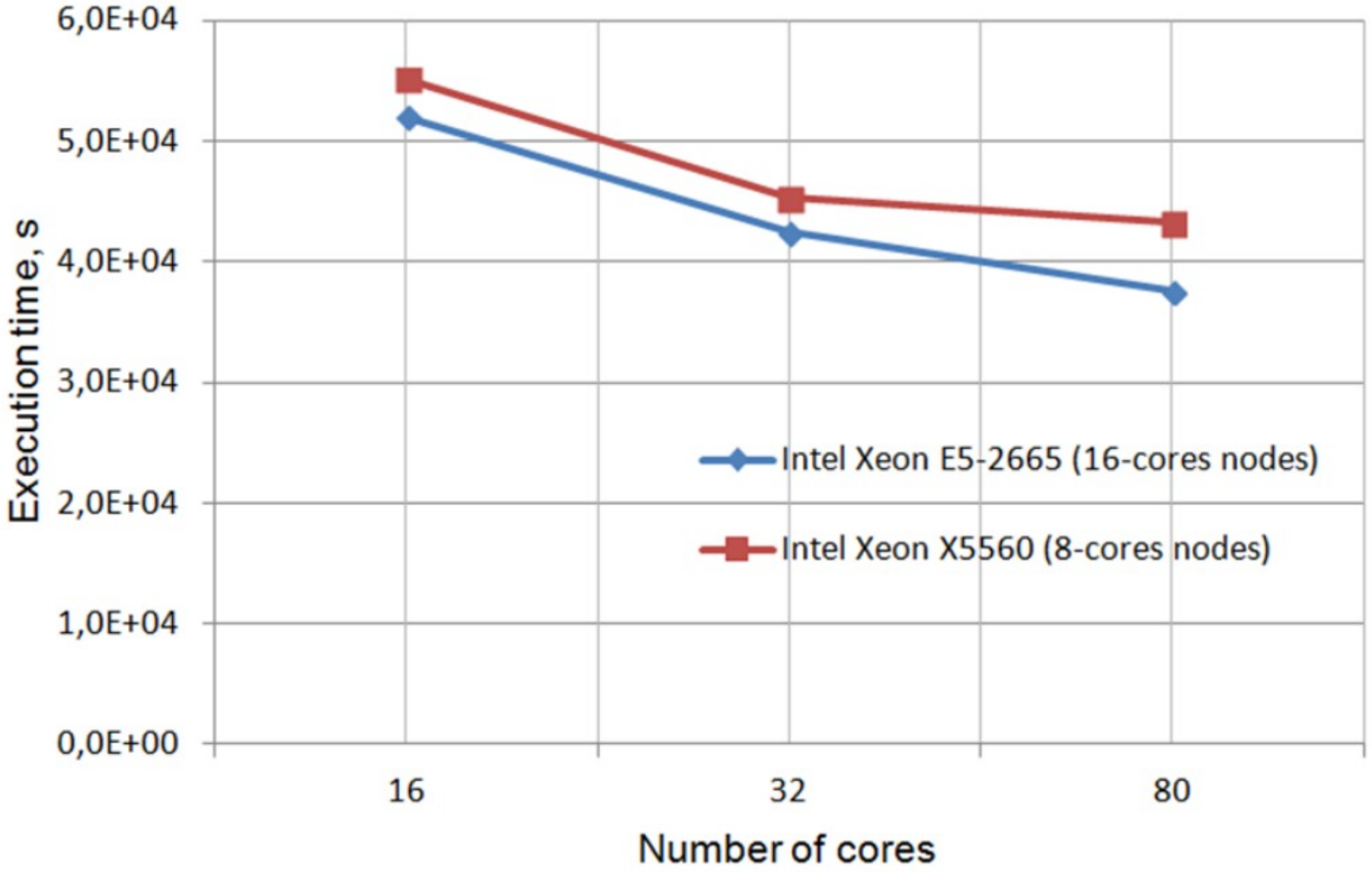
p residuals comparison for uniform and AMR cases for 2400 rpm frequency



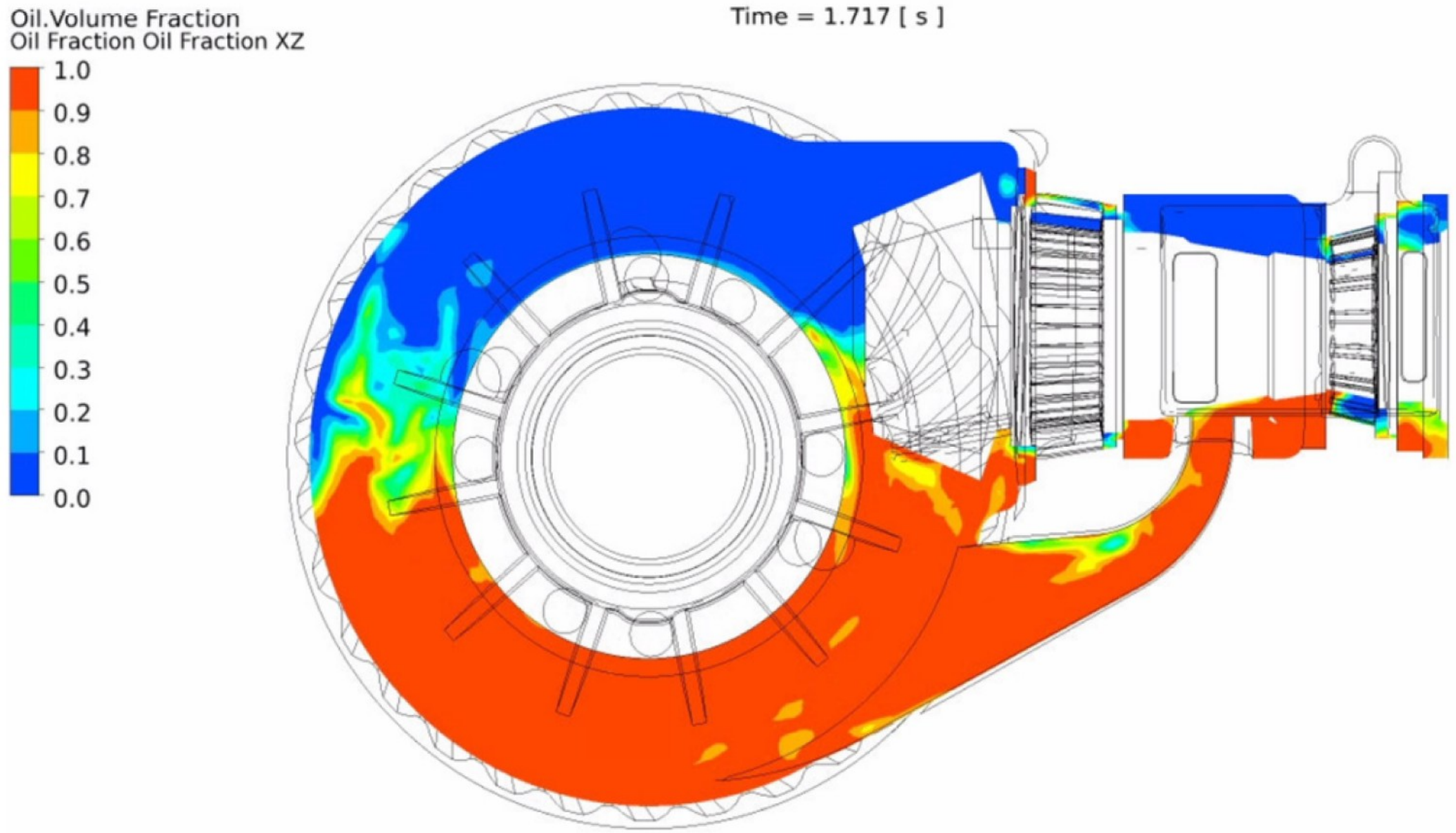
p residuals comparison for uniform and AMR cases for 551 rpm frequency



Execution time for different number of cores and nodes types



Results. 551 rpm, t = 1.7 s



Thank you for attention!