

Analysis of Thermal Management of Electric Motors

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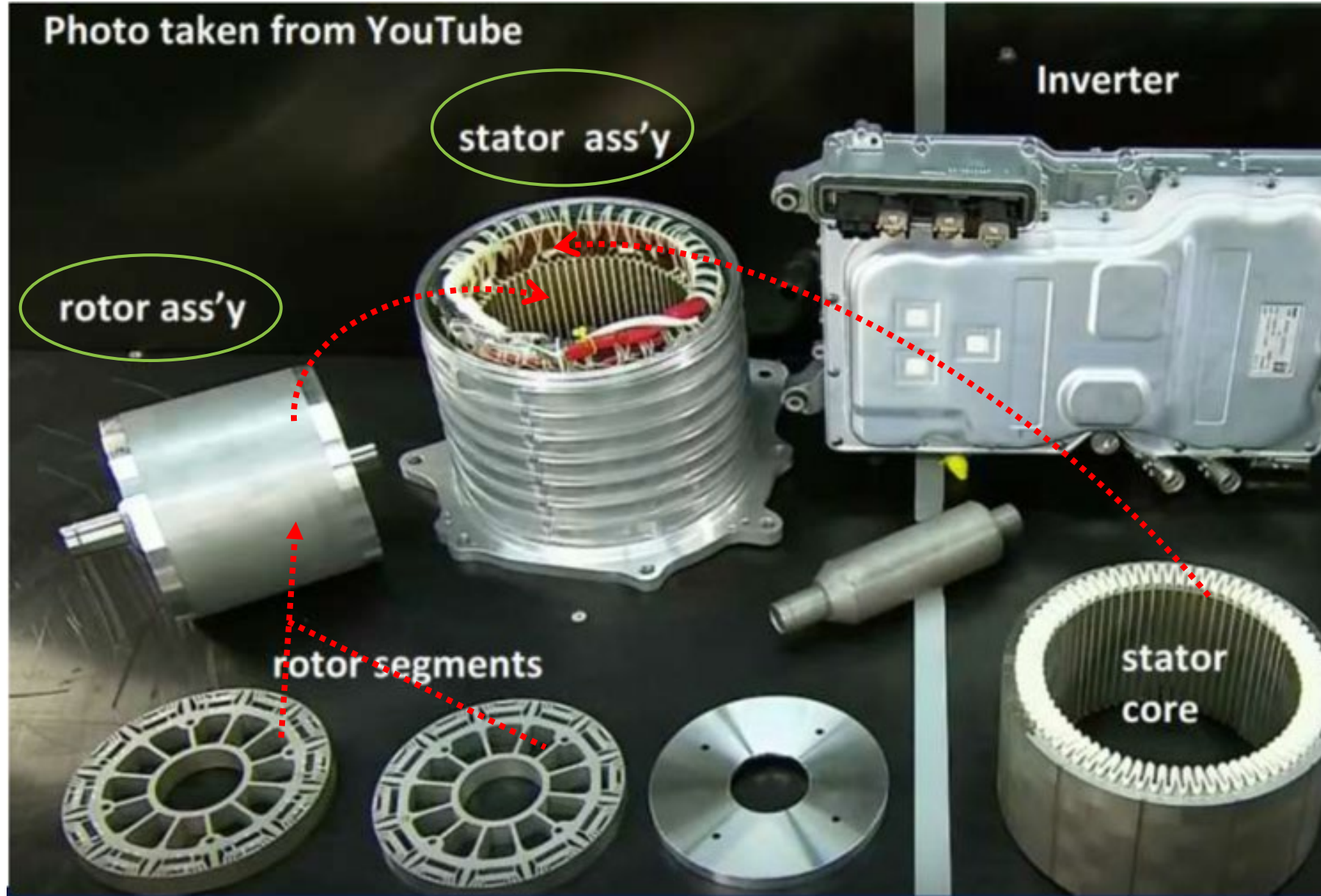
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»» Introduction

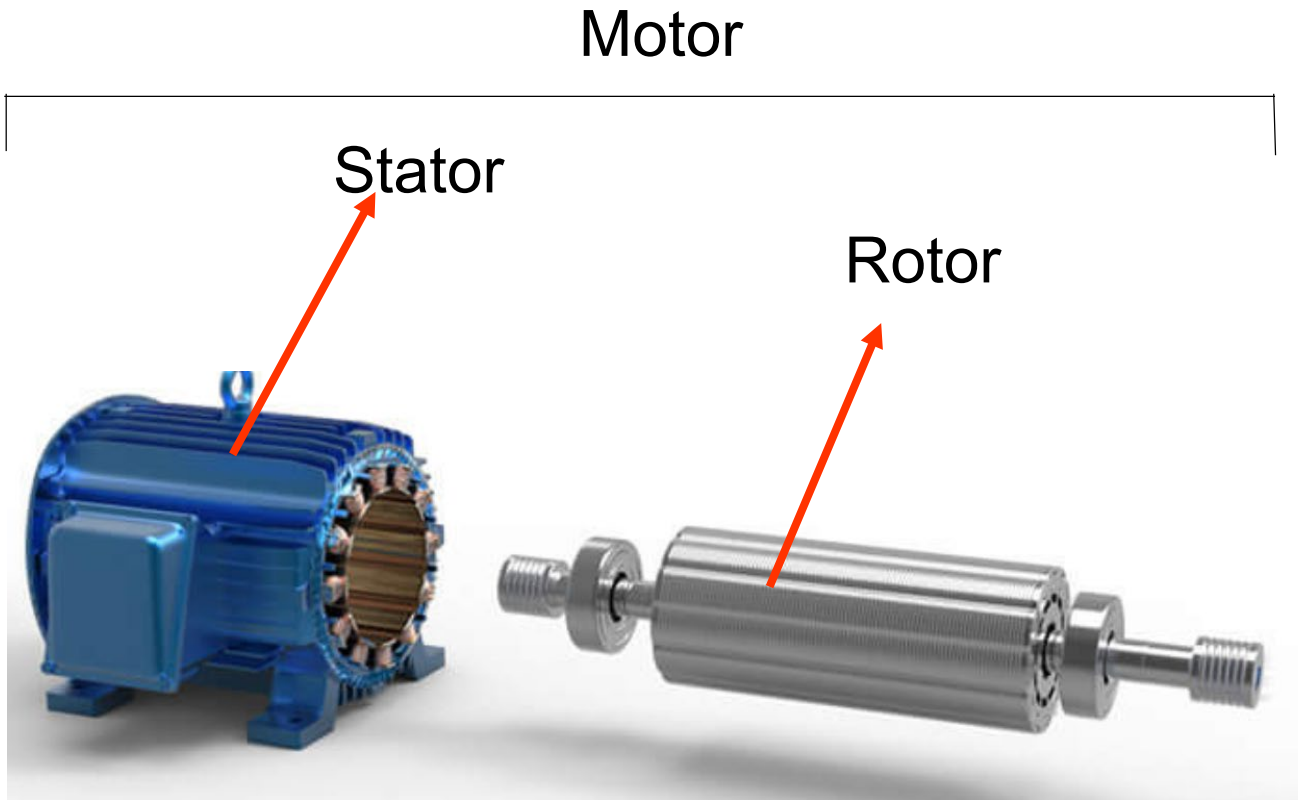
- Electric vehicles (EVs) are important in reaching a sustainable environment.
- Research shows that their capacity is limited due to temperature rise in the motor ^[1].
- My project focused on thermal management of the BMW i3 motor, involving computational modeling, analyzing thermal profiles, and exploring options for better thermal management.



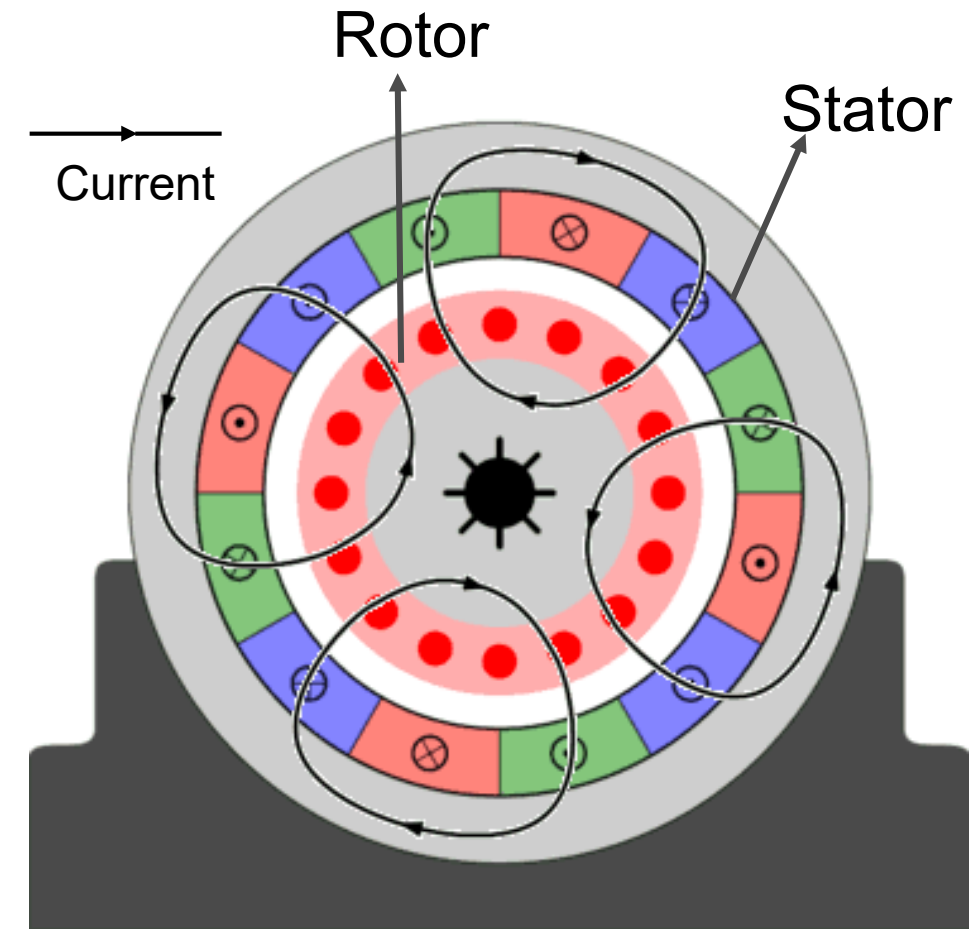
The Motor Assembly



»» How a Motor Works



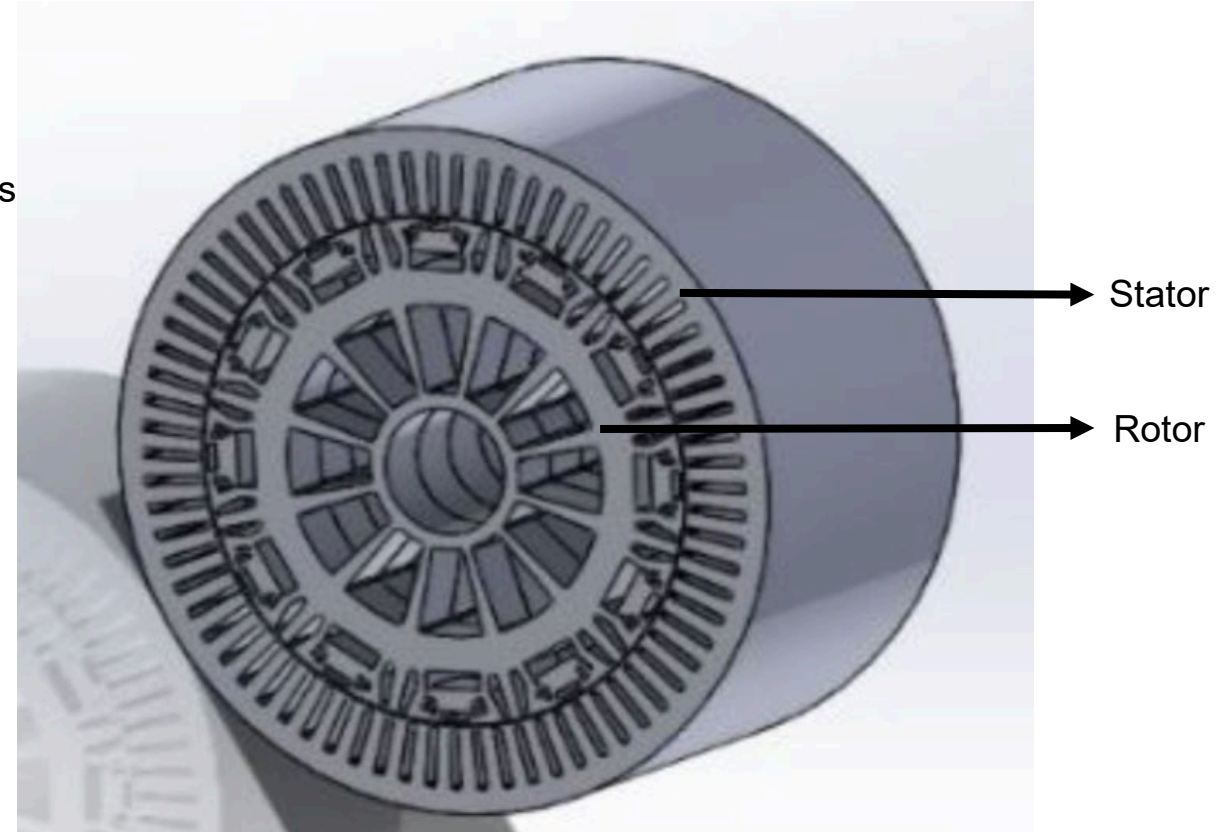
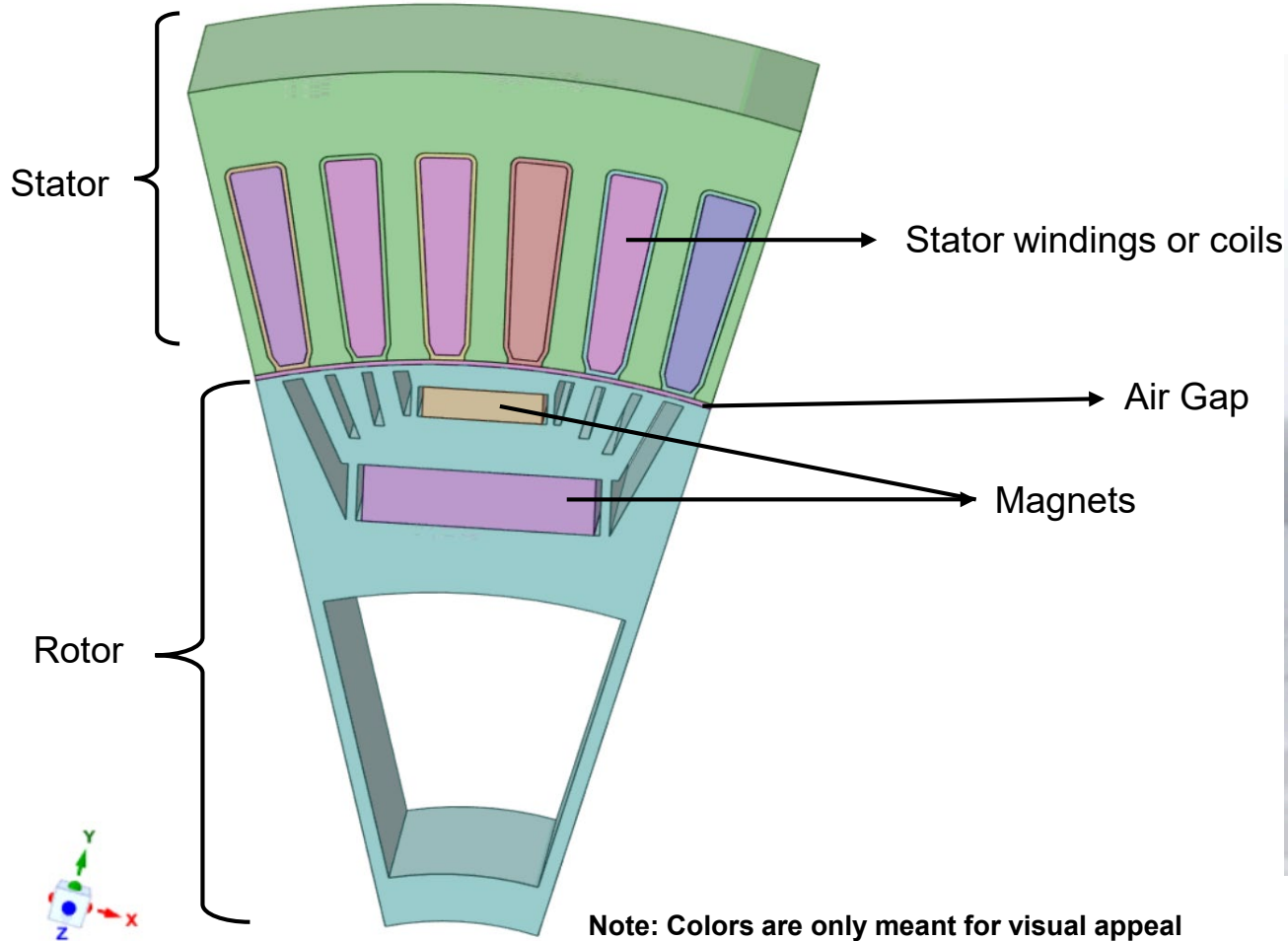
Credits: Saveonenergy.com



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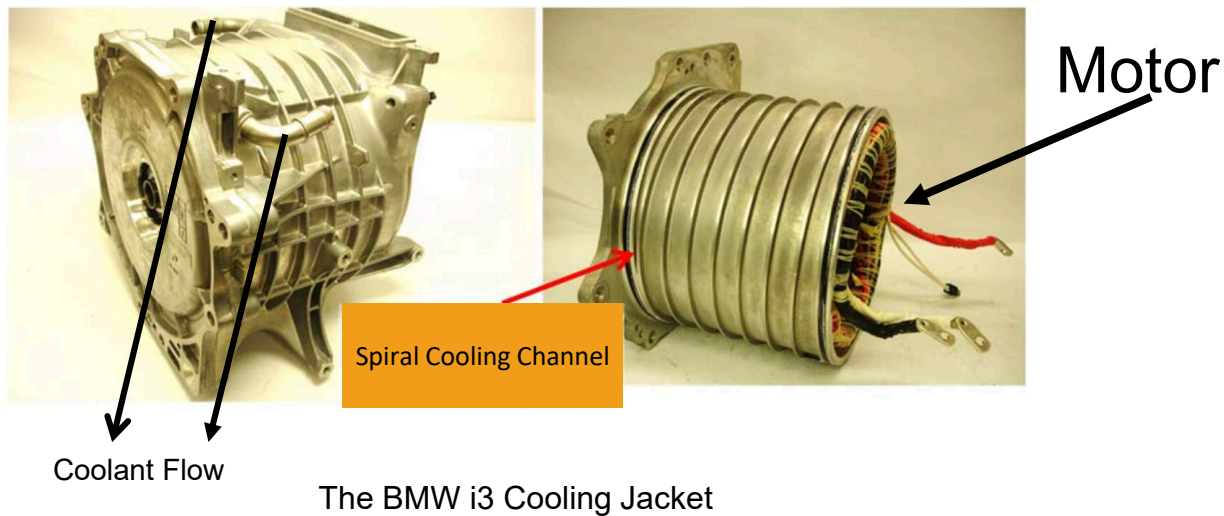


3D model of Motor in ANSYS (30° section) & SolidWorks

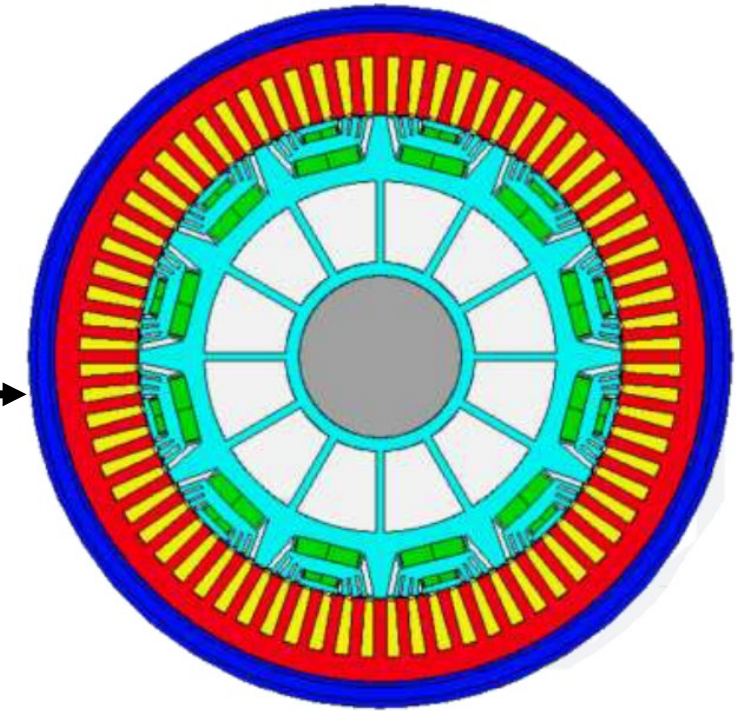


»» Cooling Method

Traditionally, motors are cooled **externally** using a cooling jacket.



External
Coolant
Flow



Front View of BMW i3 Motor in MotorCAD



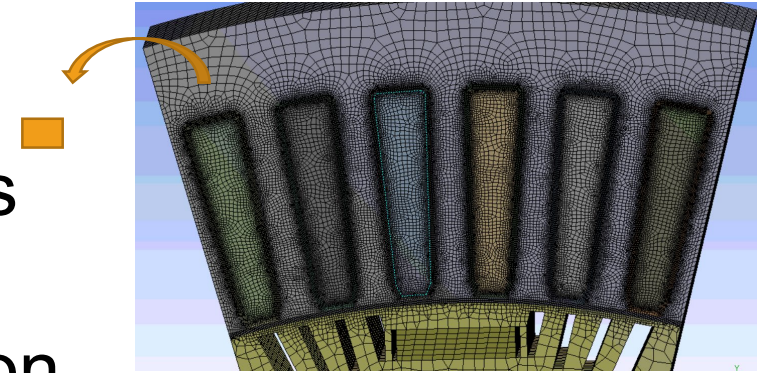
Thermal Profile



ANSYS

Numerical Analysis using Finite Volume Method²

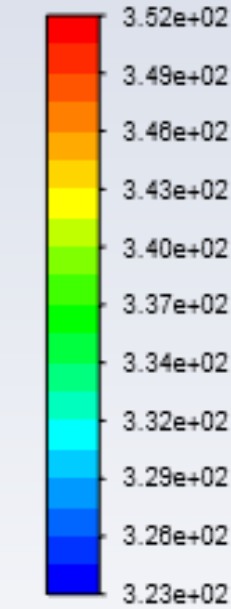
- Division of geometry (domain) into control volumes
- Integration of heat transfer and energy equations on the individual control volumes
- Linearization of the equations and solutions



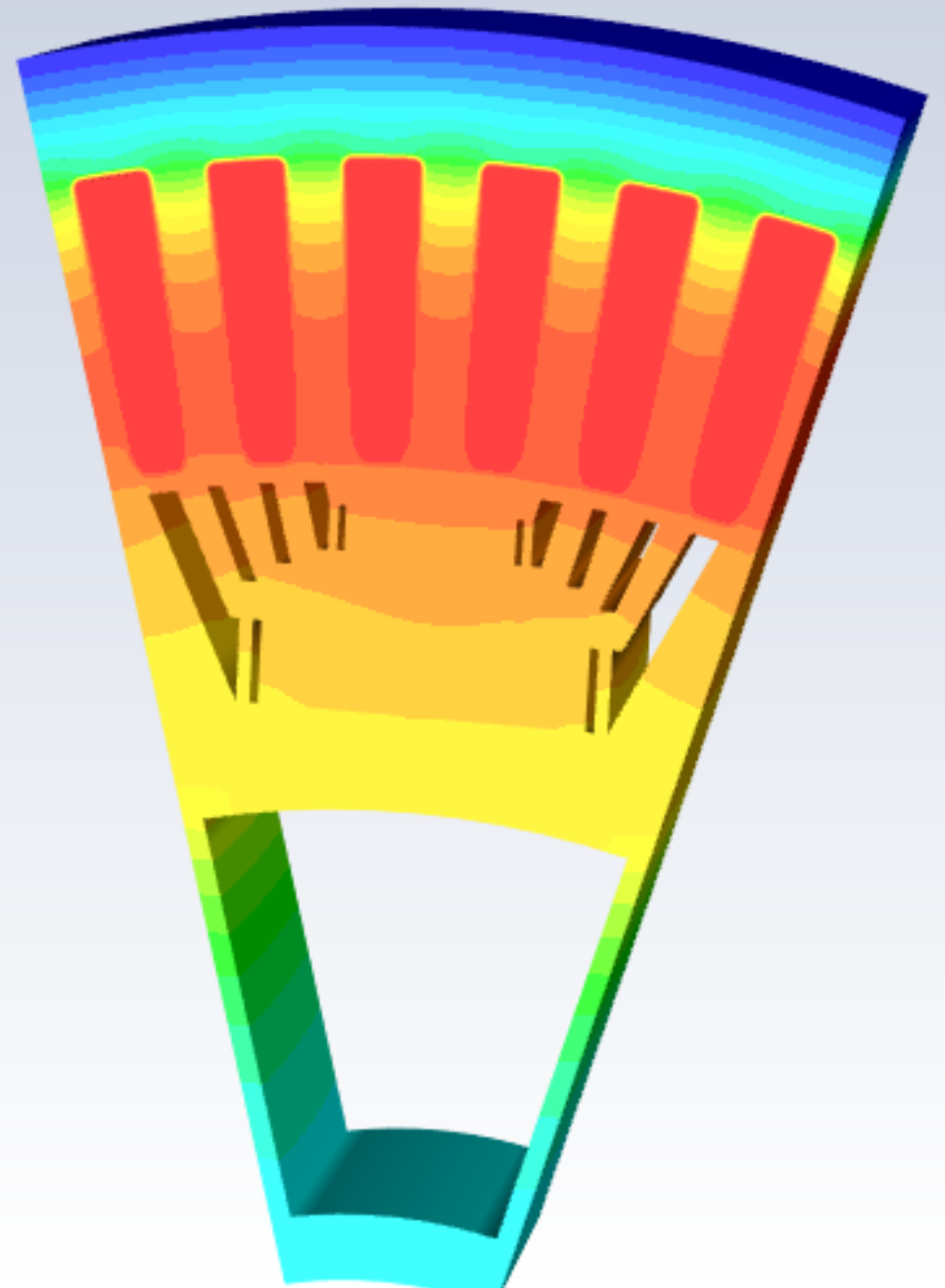
Thermal Analysis of Motor

- The highest heat generation was in the stator's windings.
- It reached over 300K for $3 \times 10^6 \text{ W/m}^3\text{K}$.

total-temp-11
Total Temperature

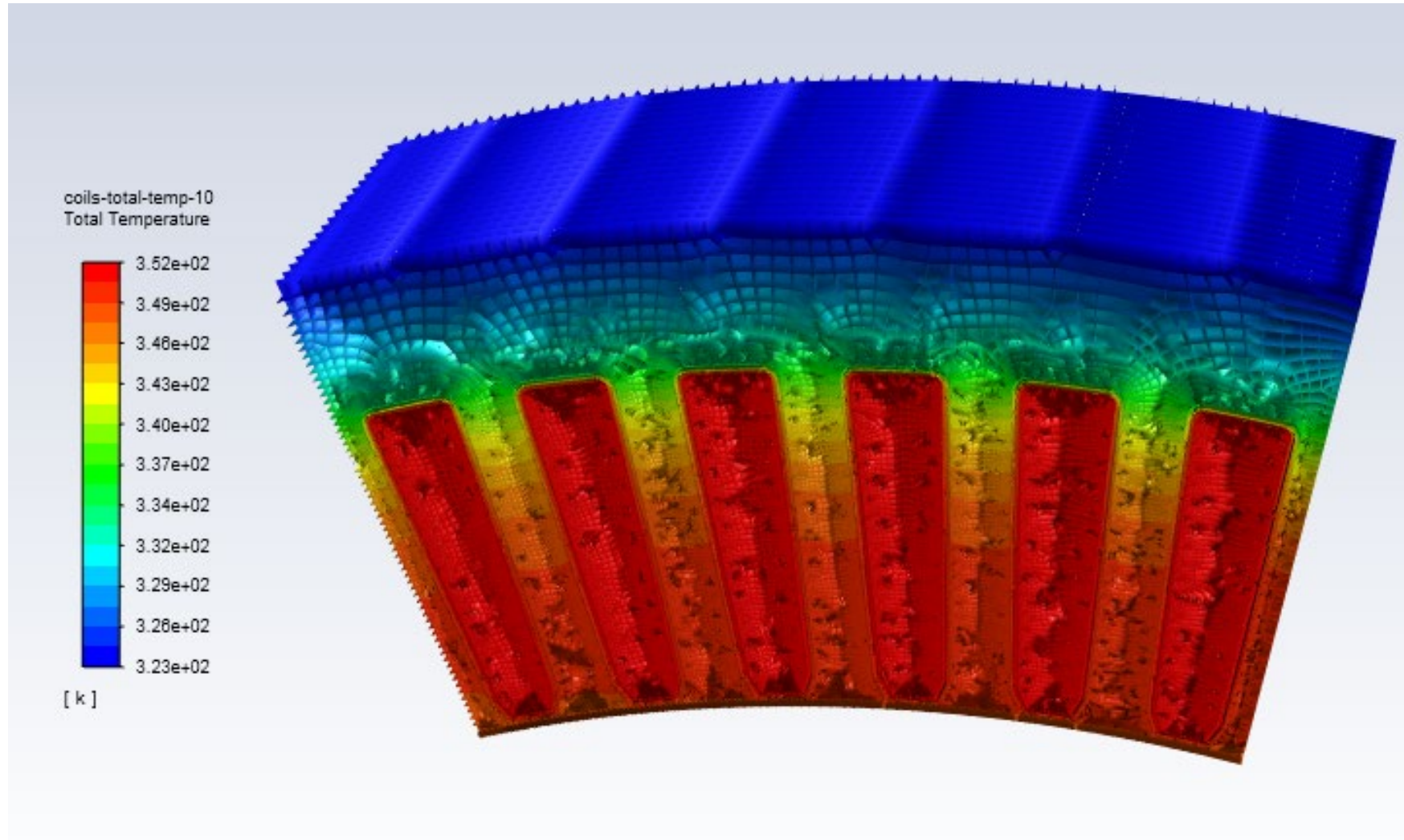


[k]



Thermal Analysis of Coils

Using $3 \times 10^6 \text{ W/m}^3\text{K}$ | Max temp. in coil is 352 K | Min temp is 322.8 K



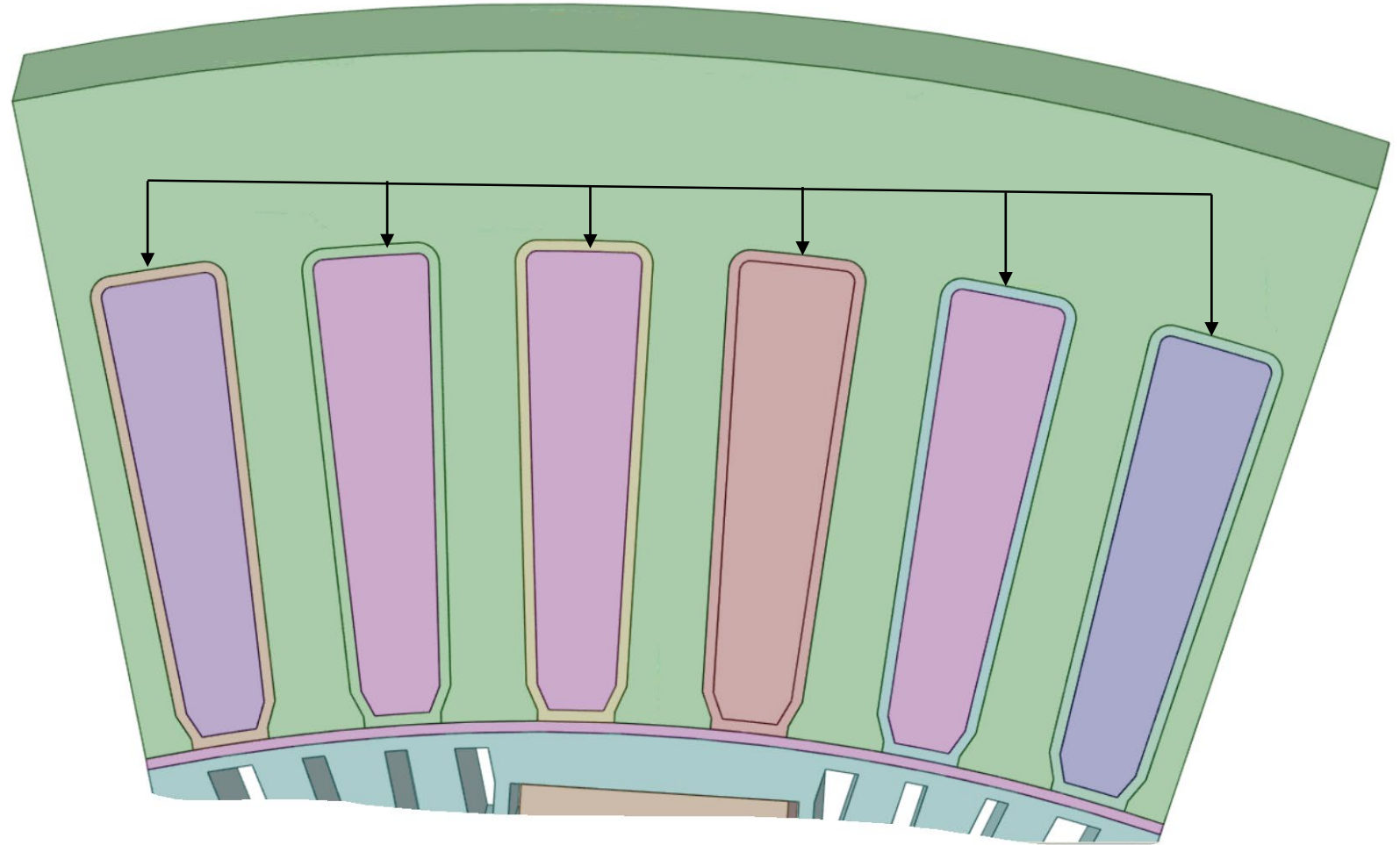


Proposed Thermal Management



Proposed Cooling Method

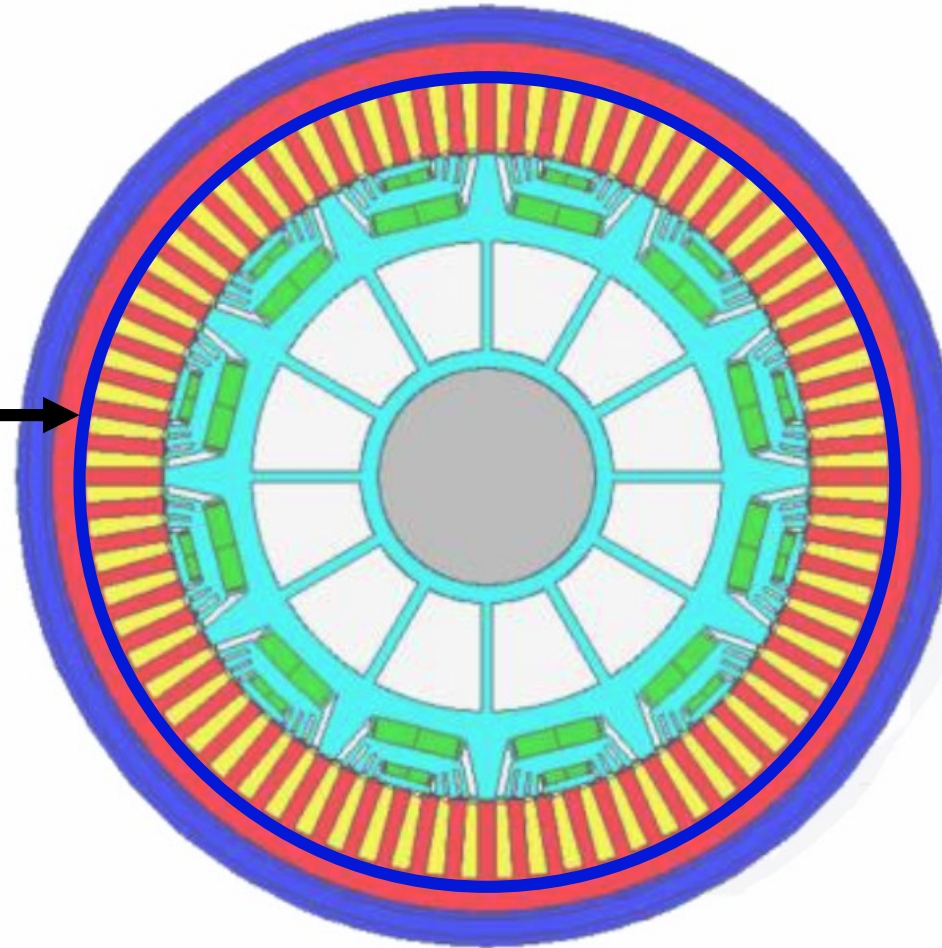
**Internal Thin
Air Gaps around
Stator Windings**





Proposed Cooling Channel

Internal Fluid
Flow



Front View of BMW i3 Motor in MotorCAD



Setbacks

- Obtaining official dimensions of the BMW Motor
- Issues with the ANSYS software



Future Work

- Use Novec 3M Fluids 649 and 7300 as coolants
- Test other heat fluids for thermal management
- Compare with other methods of analysis
- Analyze motors of other EVs

Acknowledgements

- NSF EEC-1757579
- Georgia Tech and IEN
- Dr. Satish Kumar
- Nitish Kumar
- Leslie O'Neill and Dr. Quinn Spadola

Reference

[1] Zabdur Rehman & Kwanjae Seong, 2018; “Three-D Numerical Thermal Analysis of Electric Motor with Cooling Jacket”, Energies, MDPI, Open Access Journal, vol. 11(1), pages 1-15.

[2] S. Ali et. al, “CFD & ANSYS FLUENT,” LinkedIn SlideShare, 10-Sep-2016. [Online]. Available: <https://www.slideshare.net/muhammadshujan/cfd-ansys-fluent>.

QUESTIONS?