Computational Analysis for Induction Heating of Moving Wire

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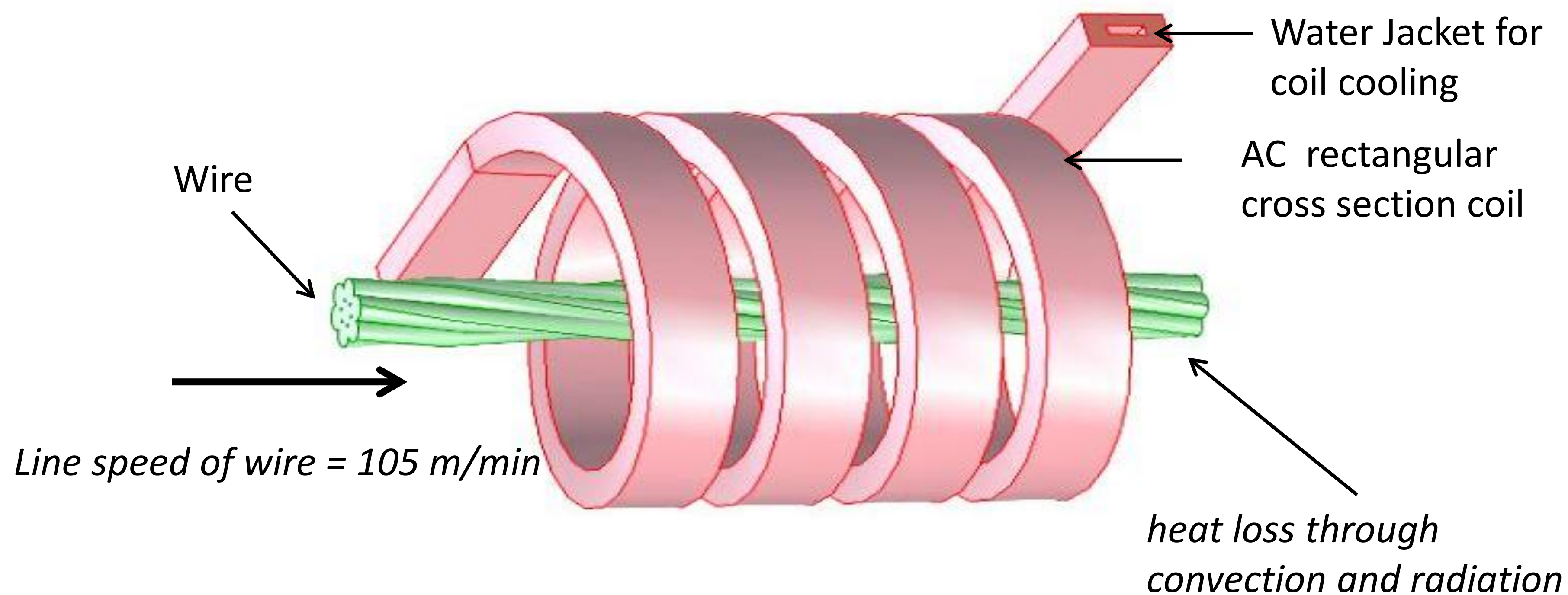
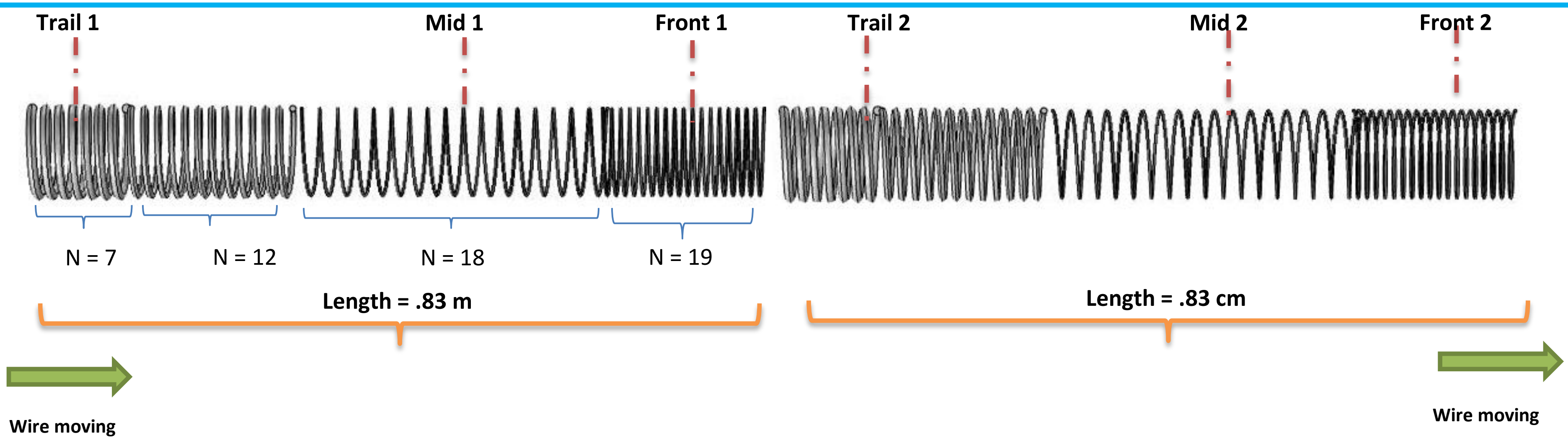
Background

- Inductive heating is common in the steel industry.
- This study concerns the induction heating of a strand wire running at line speed of 105 m/min or 1.8 m/s.
- Transient - Frequency state (AC) modeling of the magnetic fields is coupled with the heat transfer.

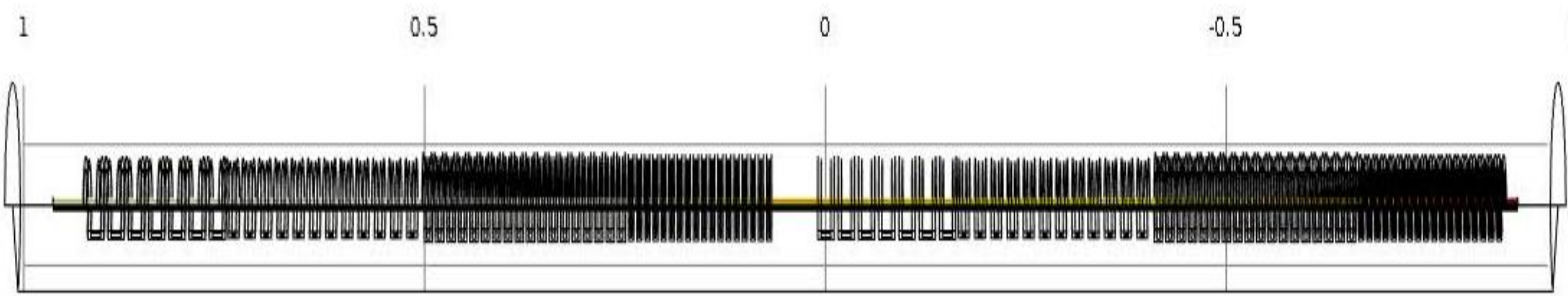


Schematic of the complete Induction furnace

Furnace 1 **Furnace 2**



CAD model of the Complete Induction Furnace designed in COMSOL



Coupling Maxwell and Energy equations

$$V_{Coil} = \sum_i v_i \qquad J_s = \frac{\sigma V_{Coil}}{2\pi r}\phi$$

Maxwell equation, involving Ampere & Faraday law :

$$\nabla \times H = -J = -(J_{induced} + J_s) = -(\sigma E + J_s)$$

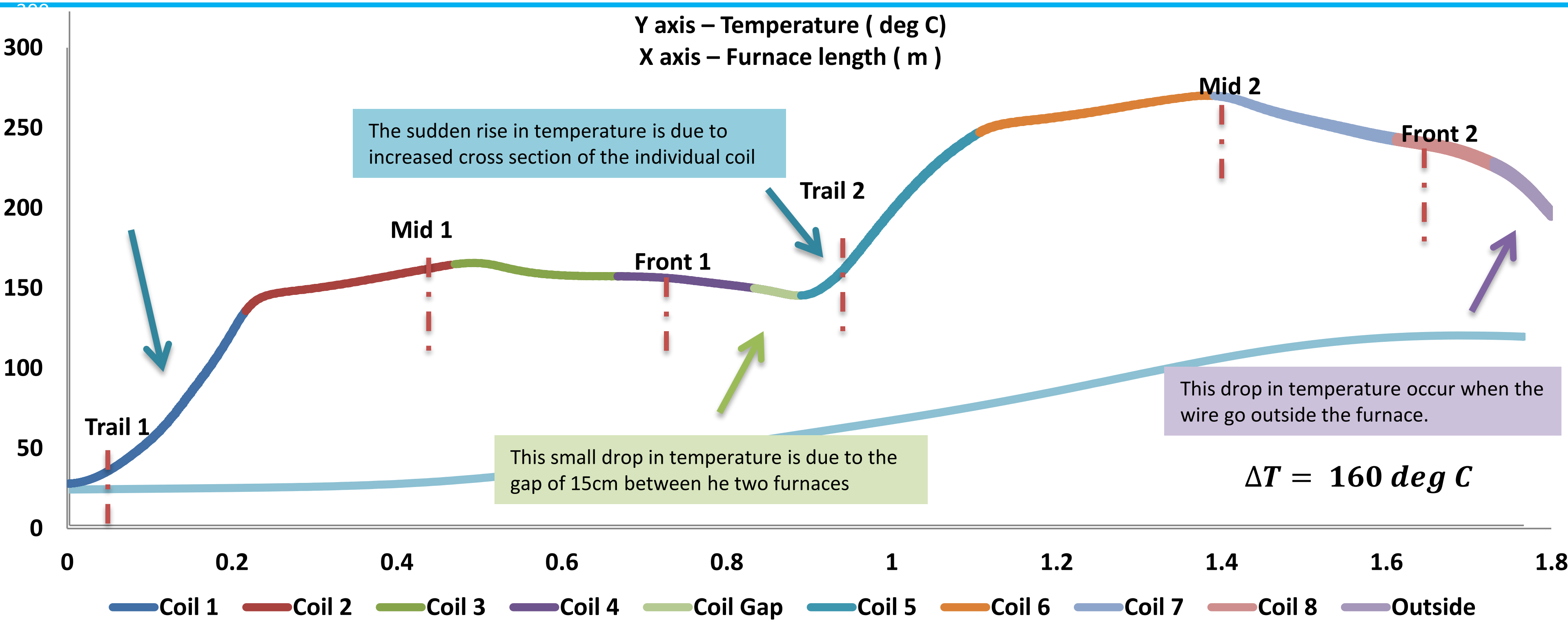
$$\sigma \frac{\partial E}{\partial t} + \nabla \times \frac{1}{\mu}(\nabla \times E) = -\frac{\partial J_s}{\partial t}$$

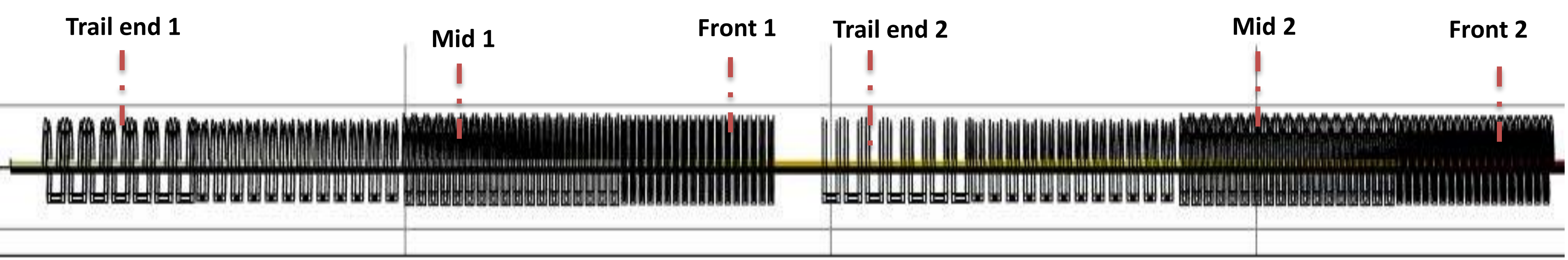
Electromagnetic heat generation inside the load

$$\rho C_P \frac{\partial T2}{\partial T} + \rho C_p u \cdot \nabla T2 = \nabla \cdot (k \nabla T2) + Q$$

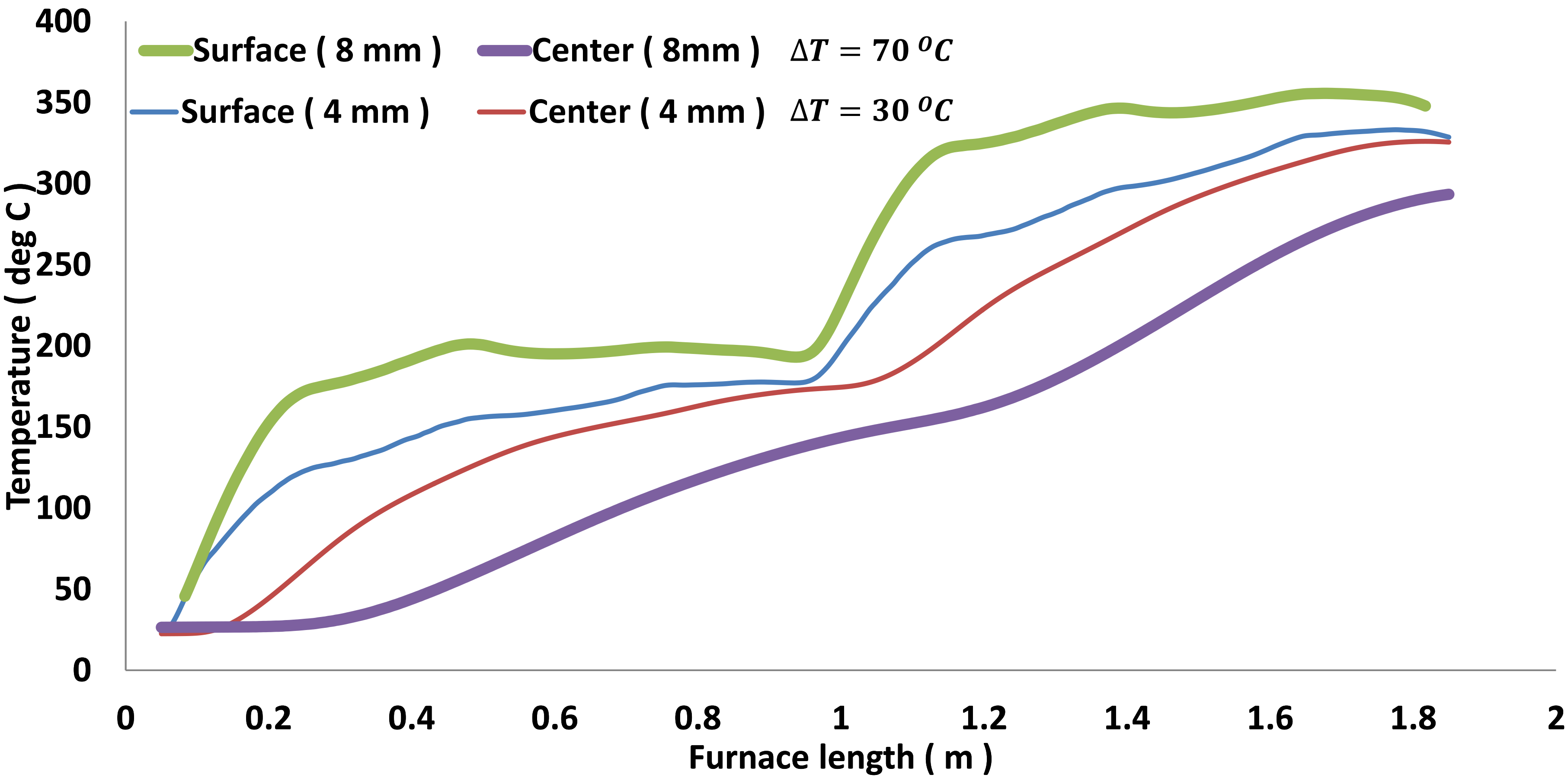
$$Q_{rh} = \frac{1}{2} R_C (J \cdot E),\ Q_{ml} = \frac{1}{2} R_C (J \omega B \cdot \mathrm{H}), \qquad Q = Q_{rh} + Q_{ml}$$

Running wire (12 mm) surface temperature profile (deg C) along the length of the wire, 105m/min line speed, f= 4500 Hz

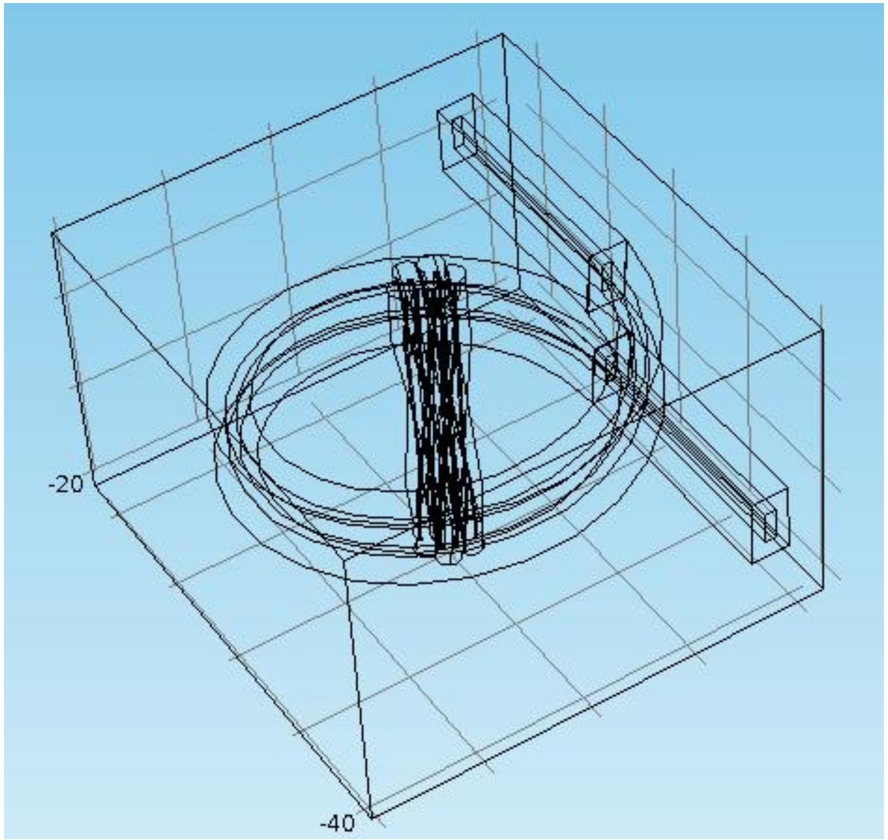


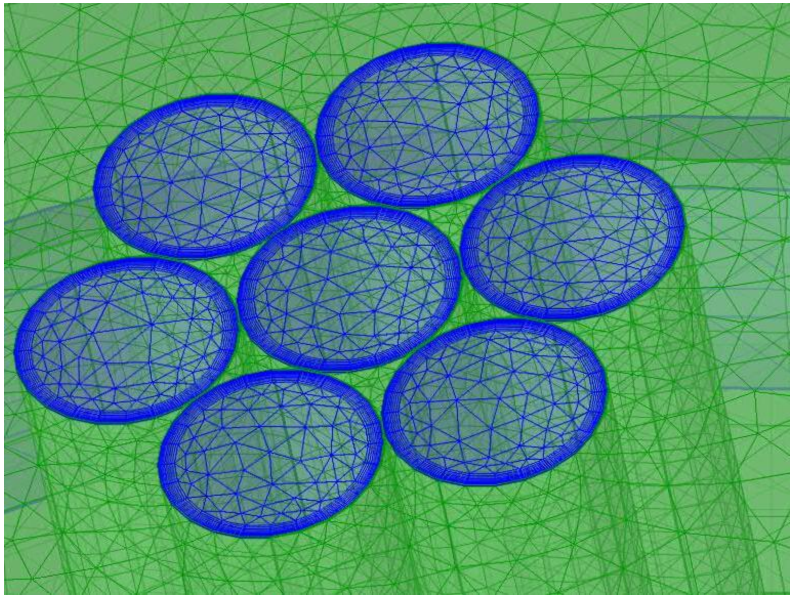


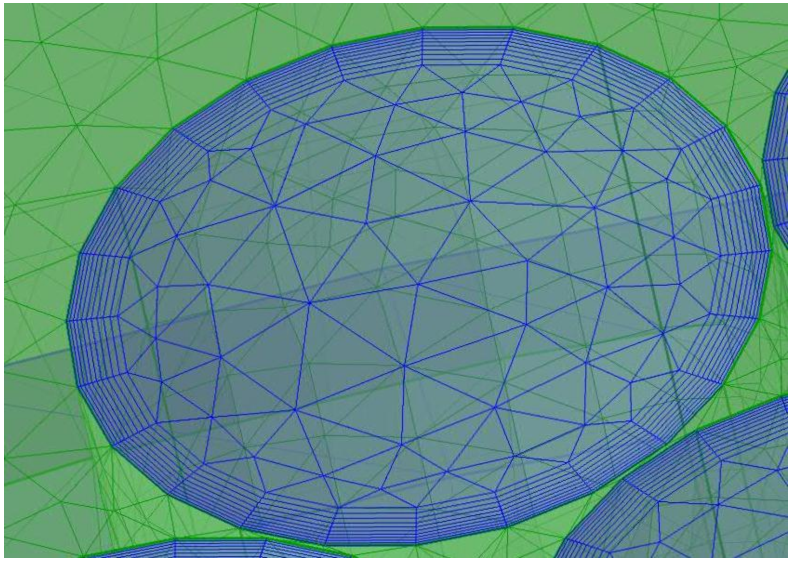
Running wire surface temperature profile (^{O}C) along the length of the wire, 105m/min line speed, f= 4500 Hz



3D model : Redefined meshing

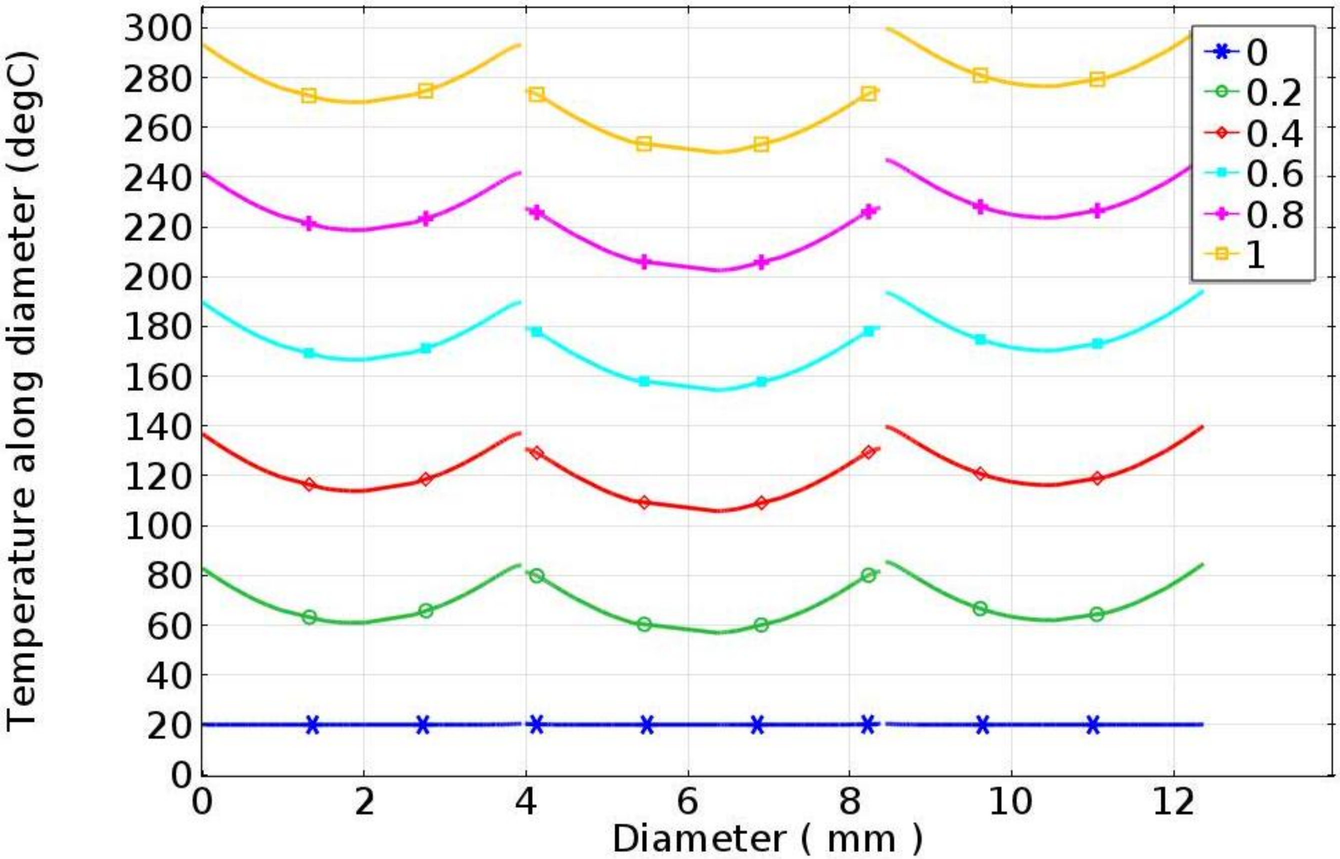






Temperature profile inside the strand

$\Delta T = 40 \ - 45 \ deg \ C$



Future work

- Analysis of the 2D (axisymmetric) and 3D models under varying operating conditions.
  - Dependence of thermal profile with frequency
  - Dependence of line speed with thermal profile

- Developing correlation between the line speed and frequency for the ac supply.

- 3D Modelling of the complete strand wire applying power dissipated as heat source without using the furnace.