

Comparison of COMSOL Simulation of Annular Linear Induction Pump with Mesh-Matrix and Equivalent Circuit Based Methods

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Contents

- Introduction
- Electrical Equivalent Circuit approach
- COMSOL Model
- Assumption in COMSOL model
- Aspects not covered in COMSOL Model
- Applicable Equations
- COMSOL Model
- Simulation Results & Discussion
- Conclusion

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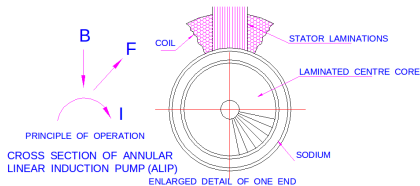
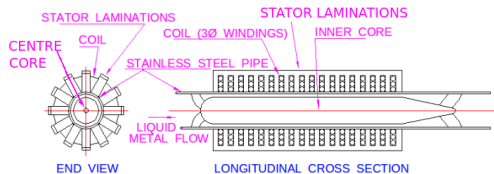
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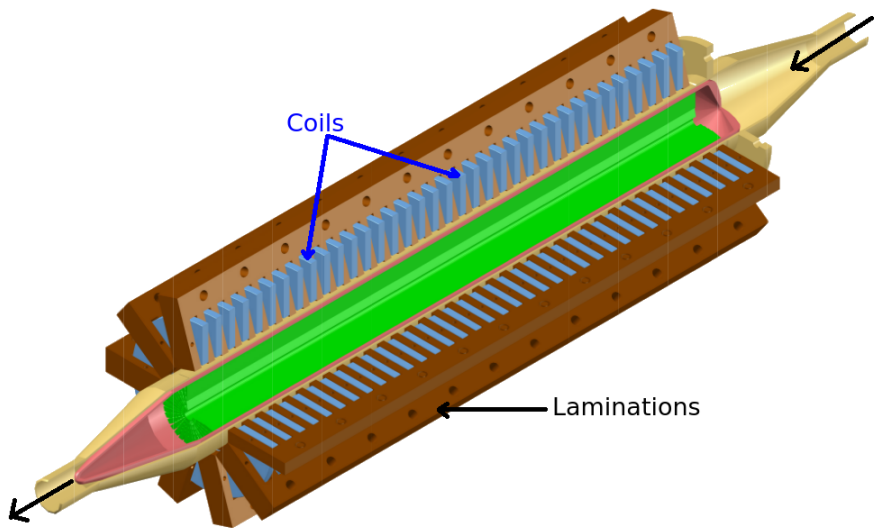
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- ALIP has many similarities with induction motor, in particular, the linear induction motors, yet there are many differences also
- A detailed analysis of ALIP requires solution of Maxwell's equations to take into account the discontinuous magnetic circuit and end effects.

- An **Annular Linear Induction Pump (ALIP)** has an annular construction and the induced currents circulates in annular (azimuthal) direction.

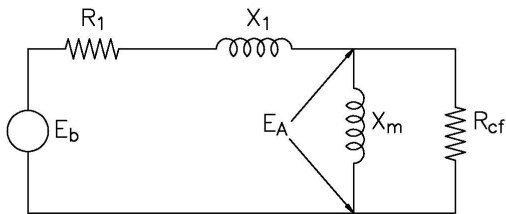
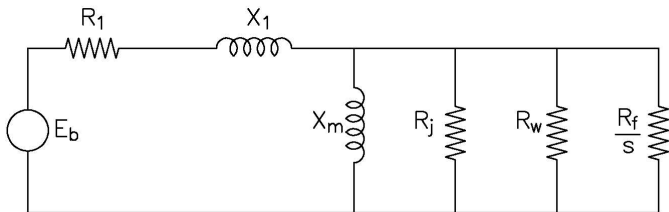
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- The stator consists of three-phase circular distributed winding over the duct. The coils are placed in the slots of laminated stator stacks.





Electrical calculations are done using Electrical Equivalent Circuit based method.



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- Flux variation with depth of penetration is not included

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- Electrical conductivity of laminations stacks has been taken as 1 so that the losses in the laminations are not taken into account in simulation.

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- In actual ALIP the inner duct is supported by means of non-magnetic stainless steel supports at regular intervals along the length of the pump. These supports have not been modeled in COMSOL model and therefore the hydraulic losses may be somewhat lower than actual.
- Temperature variation in different parts of the pump like conductor, lamination and duct are not modeled. The electrical conductivity for winding and duct is calculated assuming a uniform specified temperature.

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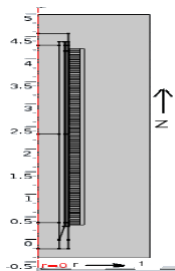
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Mass conservation for steady state conditions yields

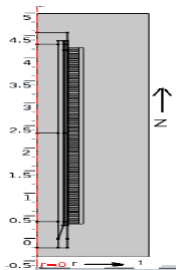
$$\nabla \cdot (\rho \vec{v}) = 0 \quad (7)$$

COMSOL Model & its Solution



The simulation of ALIP has been done in the following three stages in COMSOL.

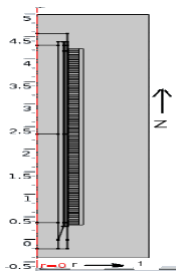
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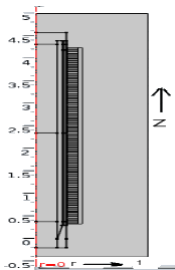
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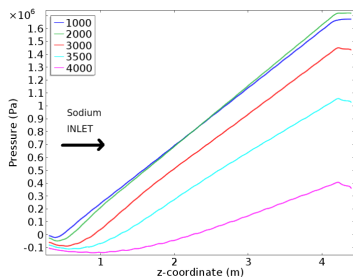
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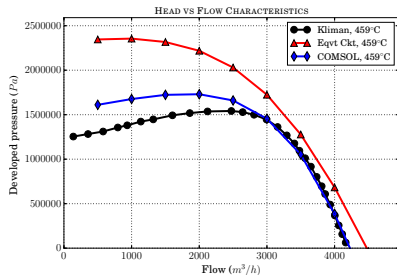
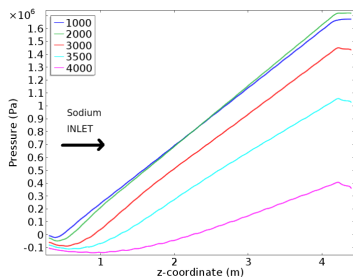
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- 1 First Navier Stokes equations are solved for flow and the velocity profile is obtained for the specified flow.
- 2 Electromagnetic force is computed for the velocity obtained in 1.
- 3 Flow equations are once again solved for the electromagnetic force obtained in 2 and the pressure developed at the pump exit is obtained.

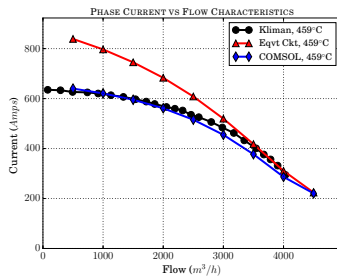
Results



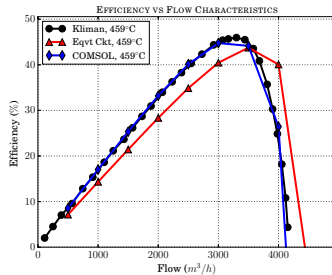
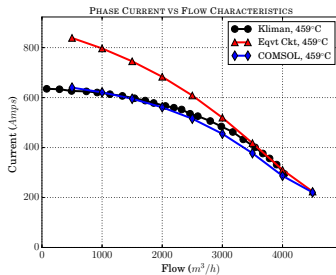
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- This may be because at large gap for sodium flow, the effect of skin depth as well as end effects become prominent which are not sufficiently accounted for in equivalent circuit model.
- Predictions of COMSOL and Mesh/Matrix method meet almost exactly in the negative slope region of the P-Q curve whereas in the positive slope region of P-Q curve some deviation is observed.

Conclusion

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- Fairly good agreement found with results in literature

Thanks