ABSTRACT

This thesis presents contributions towards the 'Analysis and Design of (Polyphase) Flat Linear Induction Pumps' (FLIP) for handling liquid sodium for a Fast Breeder Test Reactor. The work was carried out as part of a sponsored research project.

The features which are specific to FLIP and absent in the double-sided linear induction motor (DLIM) counterpart used for ground transportation schemes are first outlined. Two methods of analysis have been developed to take the effects of these specific features into account:

a) A finite length or longitudinal analysis.
b) A finite width or widthside or transverse analysis.

The x-axis is laid along the longitudinal direction, z-axis along the width direction and y-axis along the thickness direction. The origin is at the centre of the pump.

The longitudinal analysis takes into account the entry and exit end effects as well as the presence of velocity and conductivity profiles in the transverse cross-section of FLIP. Transverse edge effects and effects of primary end winding currents are omitted.
A velocity profile along the y-axis is built into the longitudinal analysis by treating the FLIP to be an induction machine with as many secondary layers as there are distinct velocity values. In FLIP, there are three such layers i.e., wall, fluid and wall associated with two distinct velocity values. Within any such layer if there is an additional velocity profile along the z-axis, a suitable transformation is made to convert the actual machine layer into an equivalent model layer having a single constant distinct velocity value along the z-axis. In case of FLIP, this occurs in the fluid thickness layer portion. Since the sidebar, duct wall thickness and duct rib thickness portions of this layer are stationary as compared to the moving fluid portions, these stationary portions are transformed in the model into an equivalent portion moving at the same velocity as that of the fluid portions. The details of this major transformation along with procedures for taking into account conductivity profiles and then computing the complete performance characteristics of the pump on the basis of this longitudinal analysis are presented in the thesis. This is termed as Model I.

A width side or transverse analysis treats the velocity and conductivity profiles along the y- and z-axis as such without any alteration. Additionally, the effects due to fringing at the edges as well as the influence of the primary
end winding currents are taken simultaneously into account. Only longitudinal entry and exit end effects alone are omitted in this analysis. With primary end winding currents omitted, this is termed as Model II and when they are included this is termed as Model III.

Two computer programs have been implemented to predict performance characteristics of FLIP under voltage-or current-fed mode of operation through Models I, II or III as the case may be.

A systematic new procedure has then been outlined to design a FLIP with prescribed performance requirements using the above analysis programs. Based on this, a 20 m$^3$/hour, 8-bar, sodium pump - designated as FLIP20 - has been designed. The complete design data as well as performance characteristics of FLIP20 have been given. FLIP20 is currently under fabrication at Reactor Research Centre, Kalpakkam, India.

Further, the FLIP analysis programmes have enabled prediction of performance of DLIMs employing a secondary of ribbed hollow construction. The performance characteristics especially including the air-gap flux density distribution along the longitudinal as well as transverse axis of the 2500 hp american DLIM are then compared with the extensive experimental data reported by Bevan. This has enabled validation and comparison of FLIP analysis programs.
The longitudinal analysis program of FLIP is capable of studying terminal imbalance characteristics. A valid harmonic equivalent circuit representation has been derived. Comparison between predicted and experimental imbalance characteristics are presented for full 10-pole as well as several part winding excitations for the American 2500 hp DLIM. The correlation is good.