P-Q Characteristic of the Electromagnetic Pump with the Flowrate of 60 l/min

Hee Reyoung Kim, Jong Man Kim, Jae Eun Cha, Jong Hyun Choi, Ho Yoon Nam
Korea Atomic Energy Researrch Institute, Dugjindong 150 yuseong Daejeon, kimhr@kaeri.re.kr

1. Introduction

In general, an EM pump has been employed to circulate electrically conductive liquids like molten metals by Lorentz force generated from the magnetic field and its perpendicular current. Especially, at the Liquid Metal Reactor (LMR) which uses liquid sodium with high electrical conductivity as a coolant, an EM pump is noticed due to advantages over mechanical pump such as no rotating part, no noise and simplicity. In the present study, the EM pump of a pilot annular linear induction type with the flowrate of 60 l/min is designed by using electrical equivalent circuit method that is applied to linear induction machines. The designed pump is manufactured by consideration of the requirements of material and function in high temperature and sodium environments. Experimental characterization is carried out according to input currents and frequency. And compared analyses between theoretical prediction and experimental results are performed.

2. **Design and Manufacturing of EM Pump**

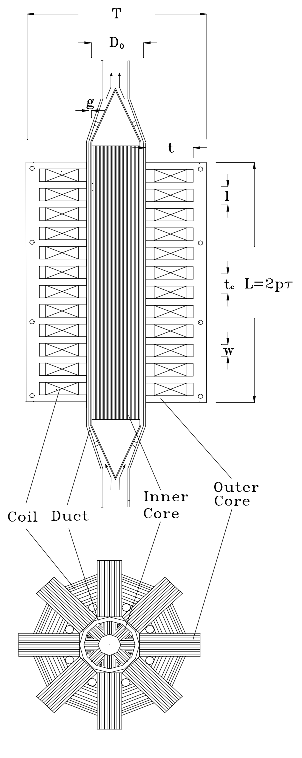

Figure 1. Cross-sectional view of the annular linear induction EM pump
(T : Diameter of the pump, D_0 : Diameter of the Inner Core, g : Inter-core Gap, t : Slot Depth, l : Tooth Pitch, t_c : Slot Pitch, L : Core Length, w : Slot Width)

Fig. 1 shows the cross-section of the annular linear induction EM pump to be designed.

It is divided into two parts of electromagnet made up of the inner and outer cores with high magnetic permeability and exciting conductor coils, and the ducts with a narrow annular channel gap for the sodium flow.

Firstly, the pump has geometrical variables of inter-core gap, diameters of inner core and core length represented by the number of pole pairs of moving magnetic field and pole pitch, and electrical variables of input current, voltage and frequency. Therefore, by equivalent circuit method design variables are determined from the characteristic analyses on the developing force and the efficiency according to varying variables [1- 3].

Table 1. shows the design specification of the annular linear electromagnetic pump with the flowrate of 60 l/min and developing force of 1.3 bar by the equivalent circuit analyses.

Table 1. Design specification of an annular linear EM pump

	Design Variables	Design Values
Hydro dynamical	Flowrate Q [l/min]	60
	Developing Force P [bar]	1.3
	Slip s [%]	55
Geometrical	Inter-core Gap g [mm]	10.45
	Core Length of Pump L [cm]	37
	Diameter of Pump T [cm]	30
	Inner Core Diameter D_0 [cm]	3
	Pole Pitch - [cm].	20
Electrical	Input Current I [A]	20
	Input Voltage V [V]	53
	Input Power VI [VA]	1,086
	Turns/Slot N [#]	120
	Frequency f [Hz]	20
	NO. of Pole Pairs p [#]	1

According to the design specification, the pump was practically manufactured and fabricated by the consideration of the operation environment such as high temperature of 600 ℃, chemically reactive sodium fluid, magnetic field distortion, and etc.[4].

Fig. 2 shows design cross-section of an annular linear induction electromagnetic pump with sodium pool-immersed type and the photograph of the completed pump.

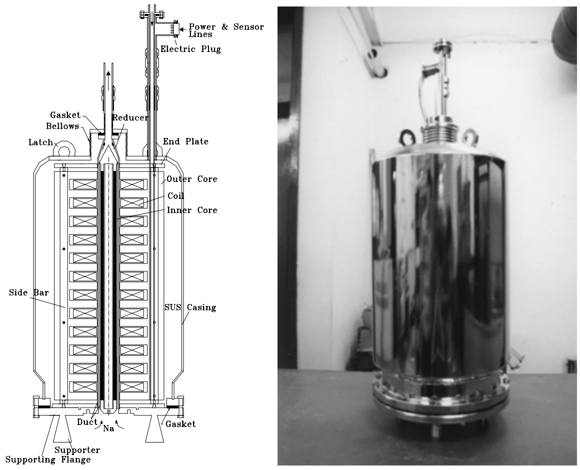

Figure 2. Cross-sectional view and completed appearance of an annular linear induction EM pump with sodium pool-immersed type

3. Experimental Characterization and Results

Pumping flowrates and developing pressures were measured at the varying input current and frequency. The electromagnetic flowmeter and differential pressuremeter for sodium environment were used to obtain the experimental value. P-Q curves at 60Hz of commercial frequency and 20Hz of optimum frequency are shown in the Fig. 3 and Fig. 4 respectively.

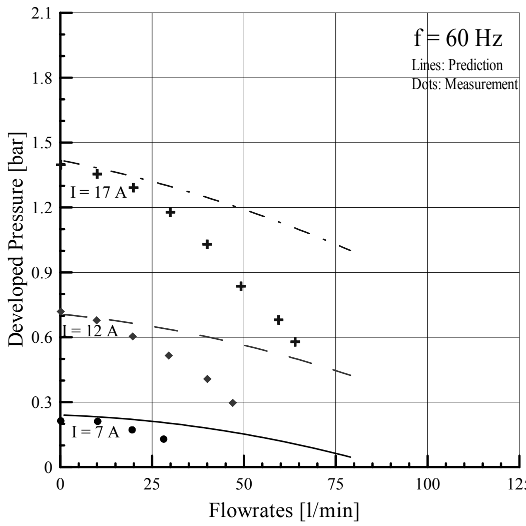

Figure 3. P-Q characteristic of the EM pump at 60Hz

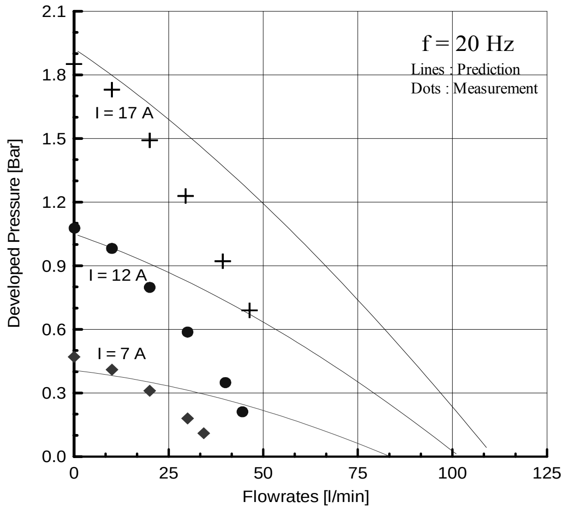

Figure 4. P-Q characteristic of the EM pump at 20Hz

4. Results and Conclusion

As predicted, the developed pressure is seen to be higher at optimum design frequency than commercial frequency. The lower flowrate is, the smaller the difference between prediction and experiment is. It is thought that higher flowrate causes more head loss in the piping system and so gives more difference.

In the near future, further experiments will be carried out and uncertainty analysis will be given.

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