Design of a Non Rare Earth Spoke Type Permanent Magnet Motor for Considering Magnetization after Assembly

Han, Jung-ho[1], Lee, Jae-Kwang[2], Lee, Ju[2]

1. LG Innotek, 197, Hwangsae-ro, Osan-si, Gyeonggi-do, South Korea
2. University of Hanyang, 222, Wangsimni-ro, Seongdong-gu, Seoul, South Korea

LG Innotek

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Background

The development of non-rare-earth motors is required to secure the stability of permanent magnets and reduce the prices of all motors.
There is a method of concentrating magnetic flux using a larger amount of magnets by changing the existing Bar type to Spoke type using ferrite, which is one of the non rare earth. In this paper, we propose a multi-pole magnetization design and performance verification for non rare earth permanent magnet used in spoke type permanent magnet motor. In particular, since non rare earth with low magnetic flux density are used, a process of passing through several times of magnetization is required in order for the permanent magnet to be attracted easily.

Objectives

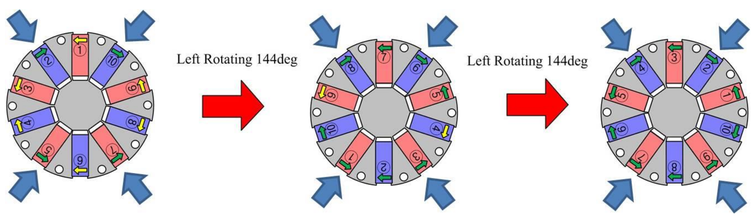
- Based on the simulation results, we propose the magnetization conditions of the non rare earth permanent magnets.
- It will be verified by applying to Spoke type permanent motor.

Conclusion

- To verify the design of the magnetized yoke, a magnetized yoke was fabricated.
- Based on the simulation results, the magnetization conditions of the non rare earth permanent magnet were found and the validity of the proposed magnetization method was verified.
- It is applied to Spoke type permanent magnet synchronous motor to verify its design and analysis.
- It is expected to be useful for the development of non rare earth permanent magnet synchronous motors through the design and verification of multi magnetization technique using non rare earths.
- The market for non rare permanent magnet synchronous motors is expected to expand globally.

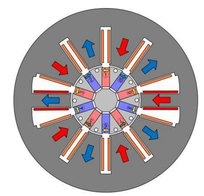
Methods

Three times Magnetized method for magnet after assembly



- In order to improve the mass productivity, we proposed three rounds for overlapping.
- In the proposed method, there are four target permanent magnets (two permanent magnets overlapping each other).
- Improve the demagnetization by wrapping the auxiliary winding to cope with the great magnetism for the magnetization

Three times divide Magnetization model



- Yoke Size : 165mm
- Number of turns per teeth : 12 Turns
- Number of turns accident winding : 13 Turns
- Stack Length : 50mm

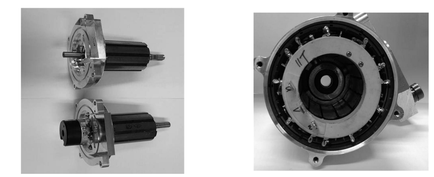
Samples

Magnetization yoke model

< Electric Steel Core> < Yoke Inner Structure> < Yoke Final Model>

- Parallel circuit design considering material change of magnetization yoke, current density and resistance condition

Spoke type permanent magnet model

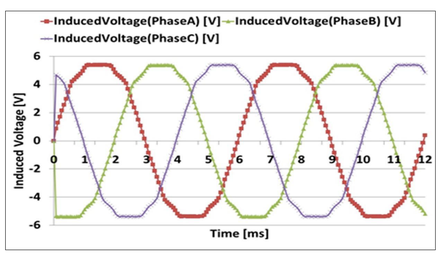


<Rotor assembly included back cover> <Stator assembly>

- Through the experiments of the 3 times divide magnetized yoke and the 1 time magnetized yoke, it was verified that the performance of the 3 times divide magnetized magnetization method is superior.

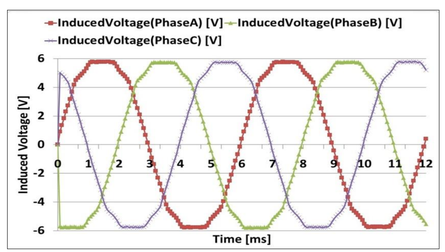
Results

Compare Results of 1 Time Magnetization and 3 Times divide Magnetization



	A phase (Vpp / Vrms)		B phase (Vpp / Vrms)		C phase (Vpp / Vrms)		Phase_AVG (Vpp / Vrms)	
1 Time Magnetization B-EMF Result	10.8	4.14	10.8	4.13	10.8	4.13	10.8	4.13

< 1 Time Magnetization B-EMF Simulation>



	A phase (Vpp / Vrms)		B phase (Vpp / Vrms)		C phase (Vpp / Vrms)		Phase_AVG (Vpp / Vrms)	
3 Times divide Magnetization B-EMF Result	11.6	4.43	11.6	4.42	11.58	4.41	11.59	4.42

< 3 Times divide Magnetization B-EMF Simulation>

		A phase (Vpp / Vrms)		B phase (Vpp / Vrms)		C phase (Vpp / Vrms)		Phase_AVG (Vpp / Vrms)		Vpp Ratio (%)	Vrms Ratio (%)
Simulation Results	Master	12.18	4.66	12.18	4.65	12.18	4.65	12.18	4.65	-	-
	1 Time Magnetization	10.8	4.14	10.8	4.13	10.8	4.13	10.8	4.13	88.7	88.8
	3 Times divide Magnetization	11.6	4.43	11.6	4.42	11.58	4.41	11.59	4.42	95.2	95.1
Production Results	Master	11.64	4.08	11.85	4.18	11.65	3.99	11.71	4.08	-	-
	1 Time Magnetization	9.93	3.53	10.15	3.48	9.99	3.43	10.02	3.48	85.6	85.3
	3 Times divide Magnetization	10.46	3.67	10.60	3.72	10.46	3.68	10.51	3.69	89.8	90.4

< Compare Results of Master, 1 Time and 3 Times B-EMF >

Compare Results according to each frequency (3 Times divide Magnetization standard)

Condition		A phase (Vpp / Vrms)		B phase (Vpp / Vrms)		C phase (Vpp / Vrms)		Phase_AVG (Vpp / Vrms)		Vpp Ratio (%)	Vrms Ratio (%)
Simulation Results	Master	12.18	4.66	12.18	4.65	12.18	4.65	12.18	4.65	-	-
	First of 3 Times	11.03	4.21	11.06	4.19	11.03	4.19	11.04	4.20	90.6	90.3
	Second of 3 Times	12.05	4.56	12.05	4.57	12.01	4.54	12.04	4.56	98.9	98.1
	Three of 3 Times	12.18	4.65	12.16	4.63	12.18	4.64	12.17	4.64	99.9	99.8

< Compare of Back-EMF versus Master according to the number of times of 3 times division through simulation>

Condition		A phase (Vpp / Vrms)		B phase (Vpp / Vrms)		C phase (Vpp / Vrms)		Phase_AVG (Vpp / Vrms)		Vpp Ratio (%)	Vrms Ratio (%)
Master	Master	11.56	4.10	11.70	4.03	11.62	4.15	11.63	4.09	-	-
Using of 3 Times divide Magnetization yoke	First of 3 Times	8.53	2.73	8.53	2.57	8.54	2.76	8.53	2.69	73.3	65.8
	Second of 3 Times	11.15	3.76	10.79	3.57	10.90	3.58	10.95	3.64	94.2	89.0
	Three of 3 Times	11.48	3.98	11.57	3.99	11.57	4.09	11.54	4.02	99.2	98.3

< Compare of Back-EMF versus Master according to the number of times of 3 times division after production >

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