

Abstract - Permanent magnet motor are used in various fields because of their relatively small size, high power and high efficiency. However, the permanent magnet device may be degraded because of the demagnetization phenomenon, so the motor should be designed considering the demagnetization characteristics. In this paper, the demagnetization characteristics and eddy current loss of a 48V 5kW BLDC machine are analyzed according to magnet segments. For the comparison of eddy current loss, 3D analysis was performed by dividing the magnet into Non segment, three segments, five segments, and seven segments. The magnet demagnetization according to the change in eddy current is analyzed. The rotor temperature was measured to determine the difference in heating caused by the change in eddy current loss. The electromagnetic characteristics were analyzed by ANSYS EM 19.0. The validity of the results was verified by comparing the simulation and experimental data.

I. Introduction

- In electrical equipment, loss makes heat so loss is a very sensitive part.
- In permanent magnet devices, eddy current loss is caused by the permanent magnet.
- Eddy current loss produces the skin effect and heat. Unless this heat is properly taken into consideration, it can reduce efficiency and improve demagnetization
- Demagnetization deteriorates the characteristics of the permanent magnet, which shortens the life of the equipment

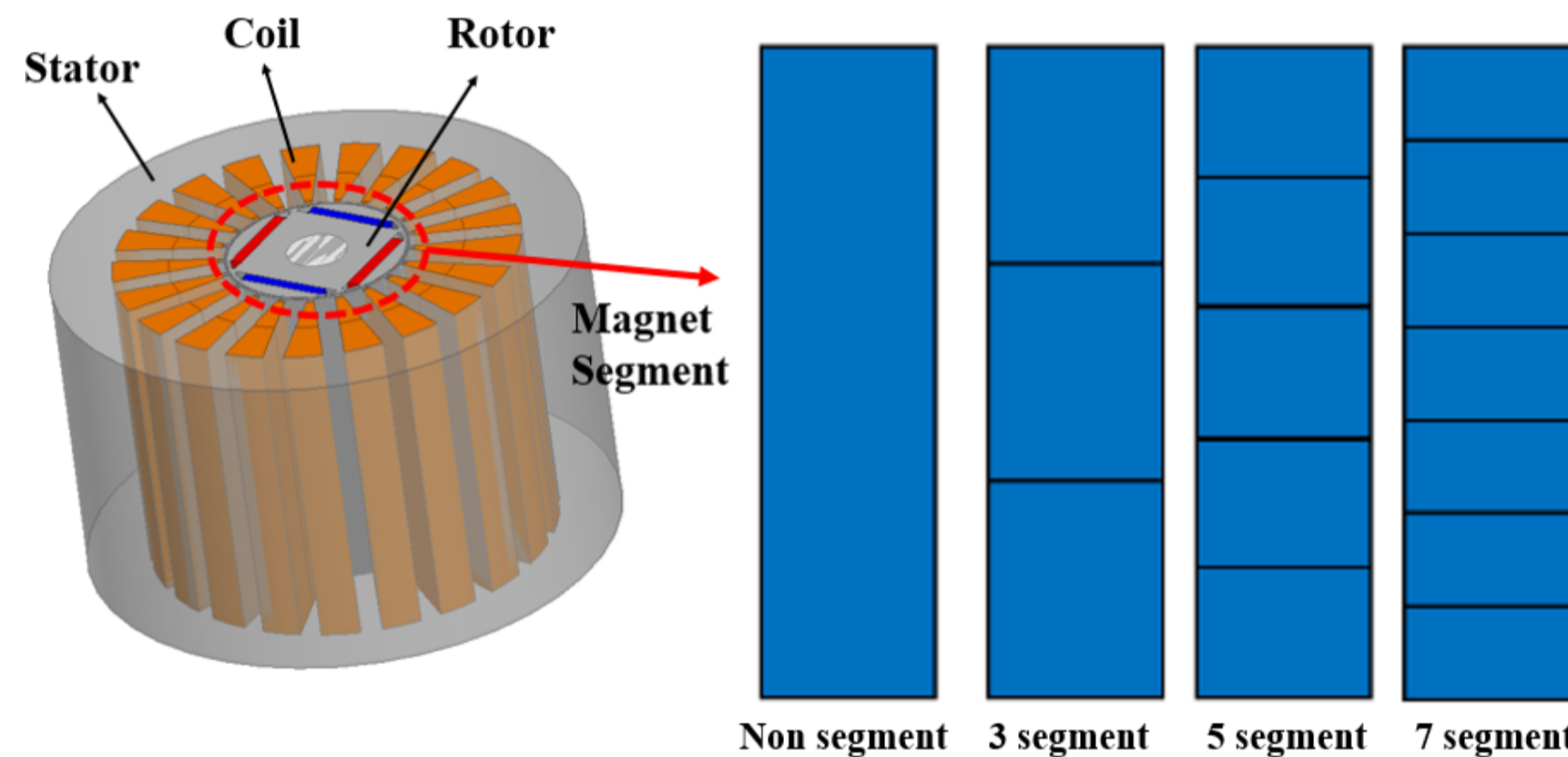


Fig.1 Model shape by magnet segment

II. Electromagnetic Simulation Analysis

Eddy Current loss simulation

RPM	Motoring		Generating	
	3000	4000	4000	12000
Non seg	32.18	14.25	63.88	
3 segs	2.5	1.47	10.75	
5 segs	1.56	1.02	7.43	
7 segs	0.98	0.71	5.13	

Table.1. Eddy current loss according to magnet division

- Table 1 shows the values of eddy current reduction by magnet division.
- The more segmented the magnet, the greater the reduction in eddy current loss.

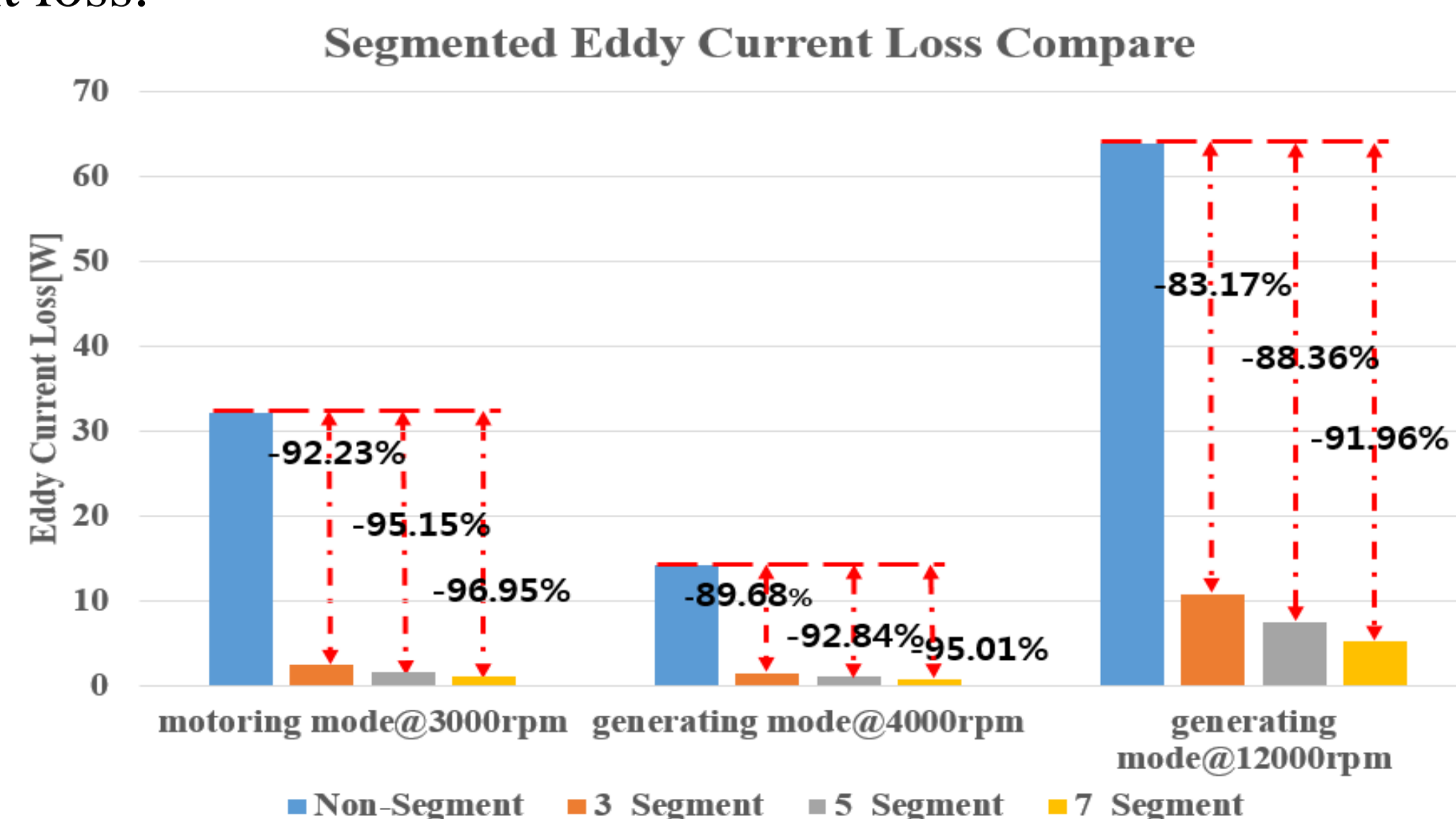


Fig. 2. Segmented magnet eddy current loss comparison

Demagnetization simulation

- Irreversible demagnetization characteristics by current driven at 100 °C is analyzed
- Rated current is 350[A] but inputted current is three, five and seven times to occur demagnetization at 3000[rpm]

[%]	Rated	Three times	Five times	Seven times
Non seg	-0.83	-2.00	-16.72	-36.06
3 segs	0.4	0.29	-11.11	-28.13
5 segs	0.25	0.11	-11.17	-27.62
7 segs	0.27	0.28	-10.94	-27.33

Table.2. Demagnetization rate comparison

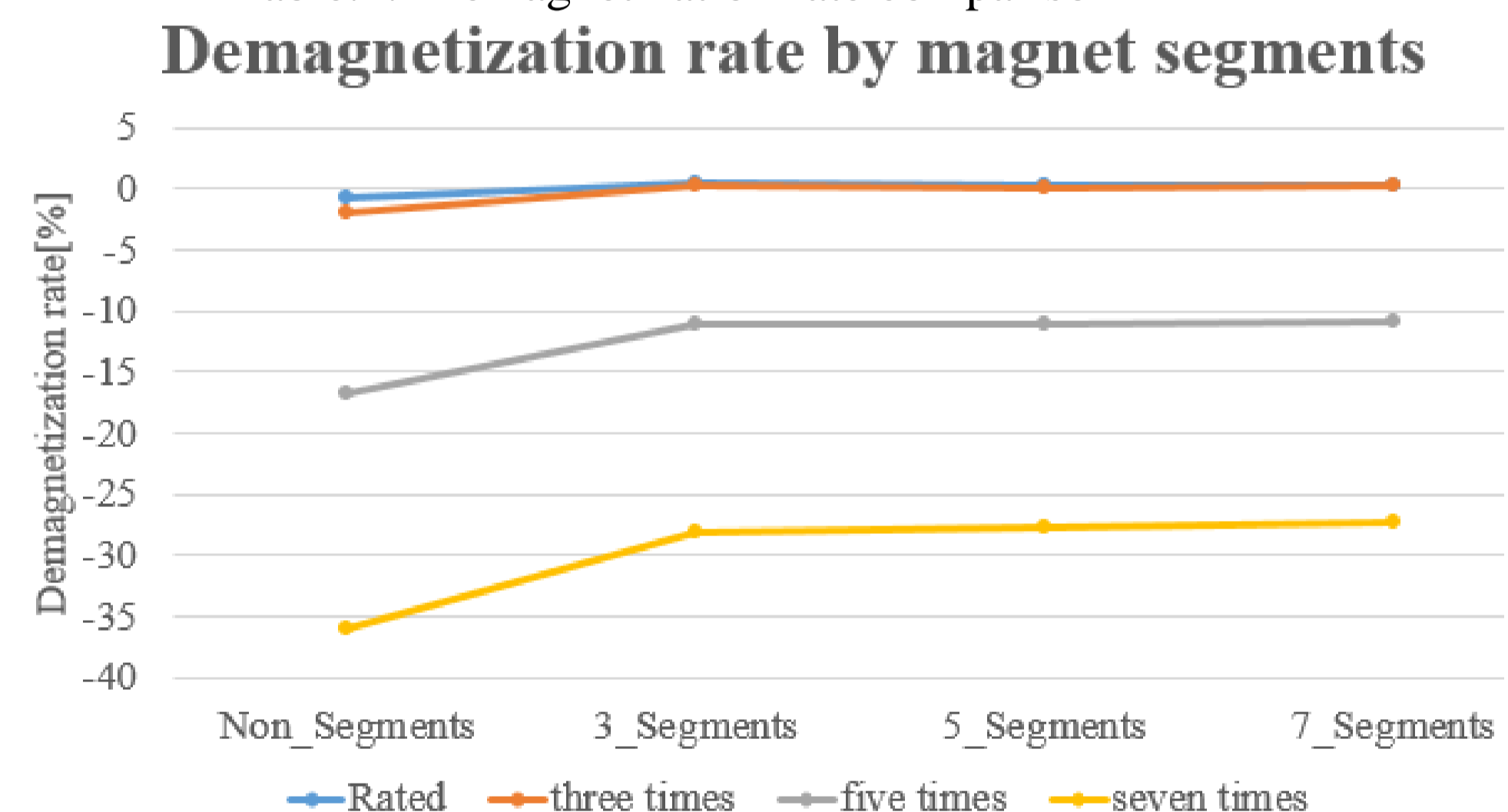


Fig. 3. Demagnetization rate comparison by magnet segments

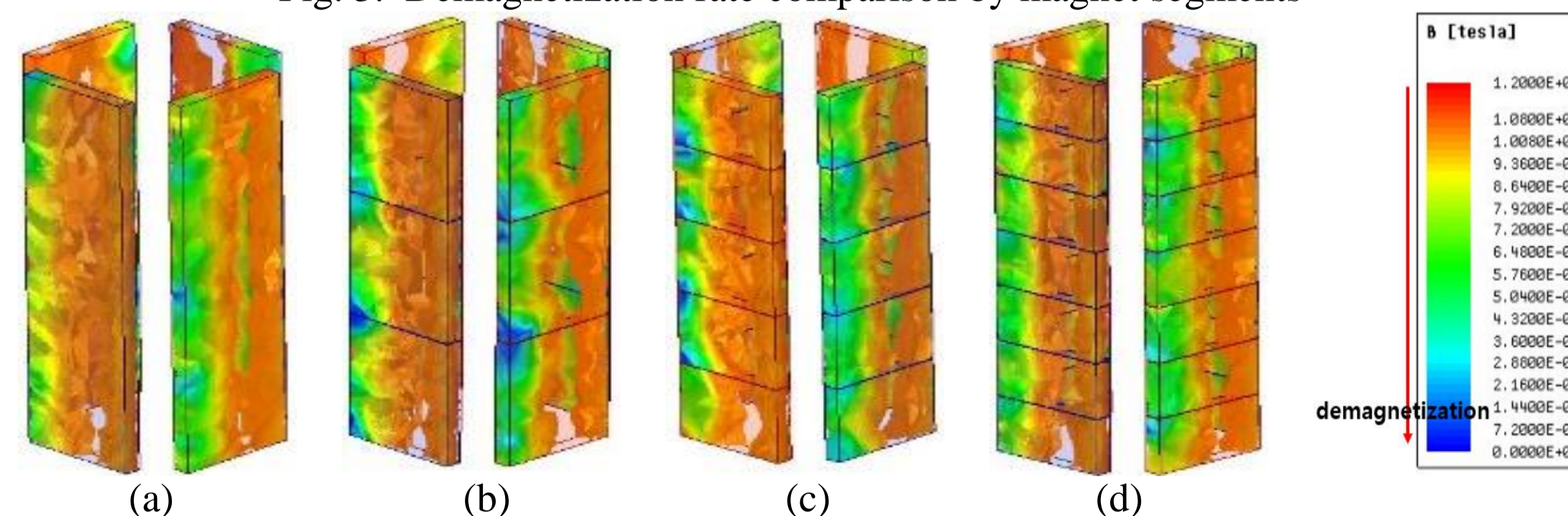


Fig. 4. Demagnetization characteristics according to magnet division (five times the rated current): (a) Non Segmented (b) three Segmented (c) five Segmented (d) seven Segmented with flux density value [T]

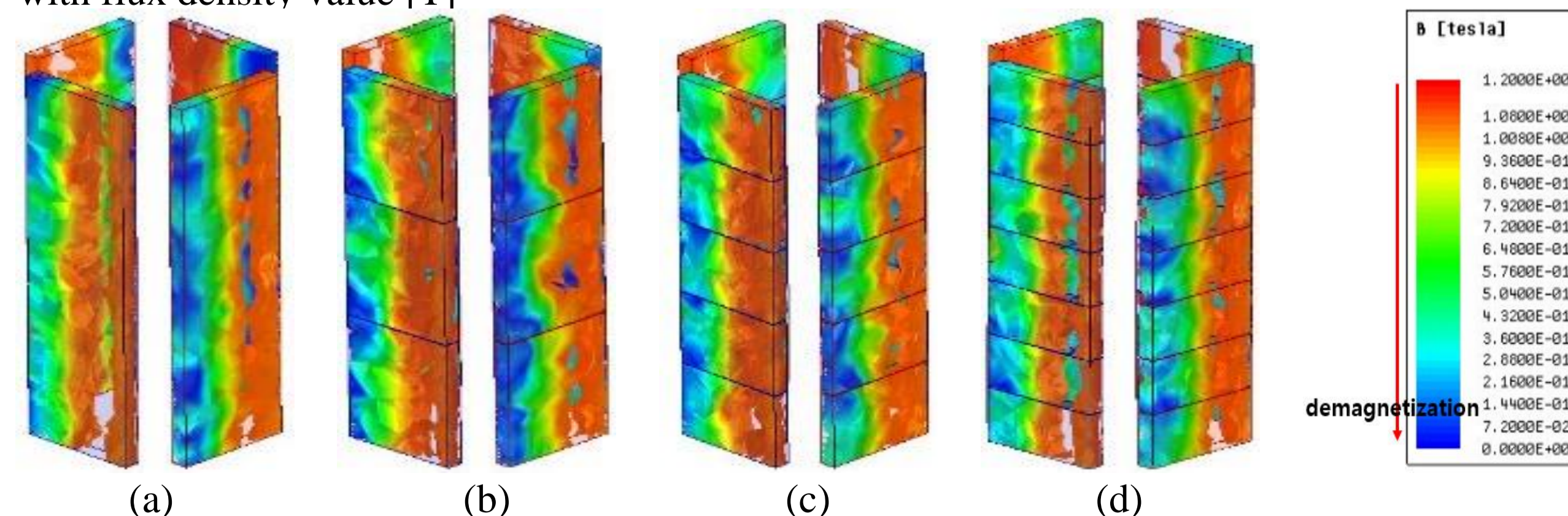


Fig. 5. Demagnetization characteristics according to magnet division (seven times the rated current): (a) Non Segmented (b) three Segmented (c) five Segmented (d) seven Segmented with flux density value [T]

III. Experiment



Fig. 6. Segmented magnet actual image (a) three-segment magnets (b) seven-segment magnets

- The comparative analysis model is shown in Fig 6, which illustrates two model magnets divided into three segments and seven segments. The experiment was conducted at 3000 rpm, 4000 rpm, and 12000 rpm

[rpm]	Segment	Efficiency[%]
3000	3	71.9
	7	72.2
4000	3	90.7
	7	90.9
12000	3	83.9
	7	84.1

Table. 3. Efficiency change according to segment

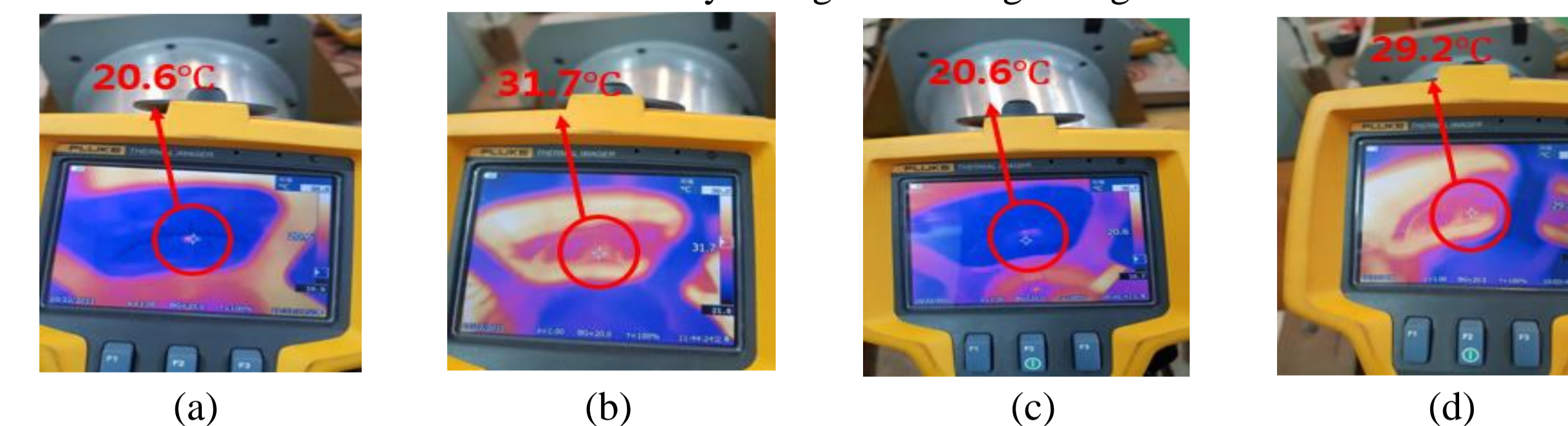


Fig. 7. Rotor temperature measurement (a) three segments beginning temperature (b) three segments 10minutes later temperature (c) seven segments beginning temperature (d) seven segments 10minutes later temperature

[°C]	1 min	3 min	5 min	7 min	9 min	10 min
3segs	20.6	24.2	26.2	28.8	30.4	31.7
7segs	20.6	22.9	25.6	26.7	29.8	29.2

Table. 4. Measurement of rotor temperature with time change

Conclusion

In this paper, the eddy current loss and demagnetization characteristics of magnetic segments of the BLDC machine were analyzed. Simulation results confirmed that the eddy current decreased with magnet division, proving that the efficiency increased through the experiment. It was also confirmed that dividing the magnet has a positive effect on the rotor temperature. When dividing the magnet, the characteristics of demagnetization also improved as the eddy current loss is reduced. If we divide magnet into 3segments, demagnetization is much better than Non segment. But if we divide magnet more and more, demagnetization rate is not too different.