BPM Motor Demagnetization Analysis and Magnetization

Emerson Climate Technologies

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EMERSON

Overview

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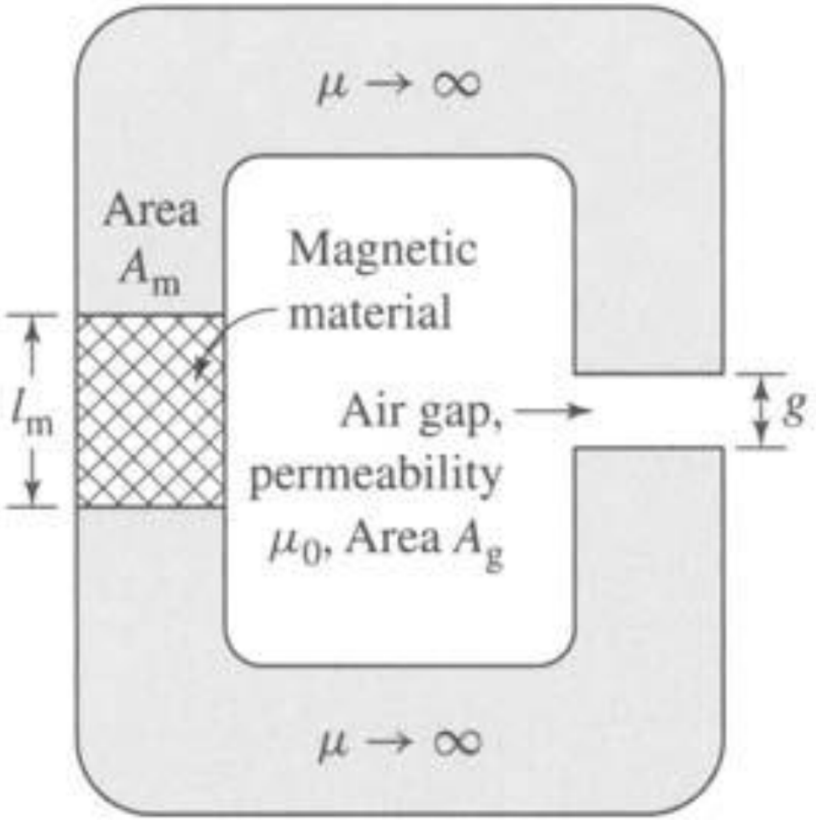
Emerson Climate Technologies (Suzhou) R&D
艾默生环境优化技术（苏州）有限公司 – 研发中心

- Founded in 2002
  成立于2002年
- Located in International Science Park，
  Suzhou Industry Park
  坐落于苏州工业园区国际科技园
- 7 Divisions from Emerson Climate Technologies joint investment
  艾默生环境优化技术事业部内的多个子公司共同投资
- More than 400 employees
  400 多名员工
- Products: AC and Ref. compressors

Basic Magnetic Circuit



$$B_g = \frac{A_m}{A_g} B_m \qquad \frac{H_m l_m}{H_g g} = -1$$

$$B_g^2 = \mu_0 \left(\frac{l_m A_m}{g A_g} \right) (-H_m B_m)$$

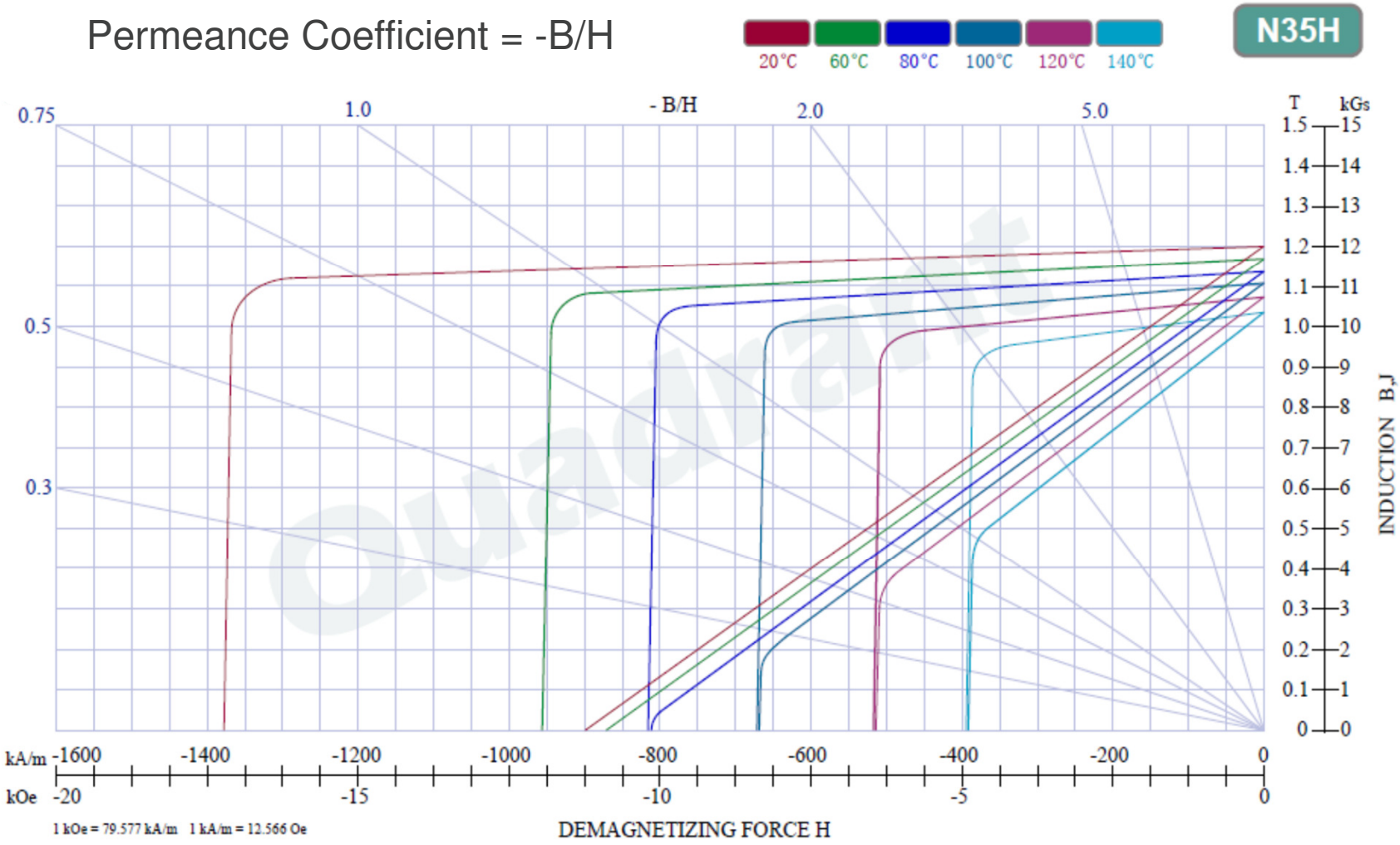
$$= \mu_0 \left(\frac{\text{Vol}_{mag}}{\text{Vol}_{\text{air gap}}} \right) (-H_m B_m)$$

$$\text{Vol}_{mag} = \frac{\text{Vol}_{\text{air gap}} B_g^2}{\mu_0 (-H_m B_m)}$$

The larger energy product of operation point, the smaller size magnet volume

Neo Magnet B-H Curve

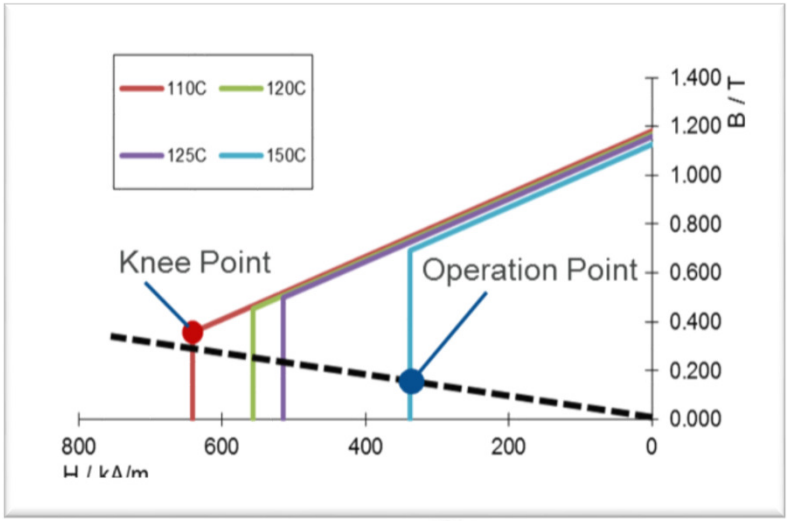
Permeance Coefficient = -B/H



PC is close to 1 when operation point locates around the max. energy product point

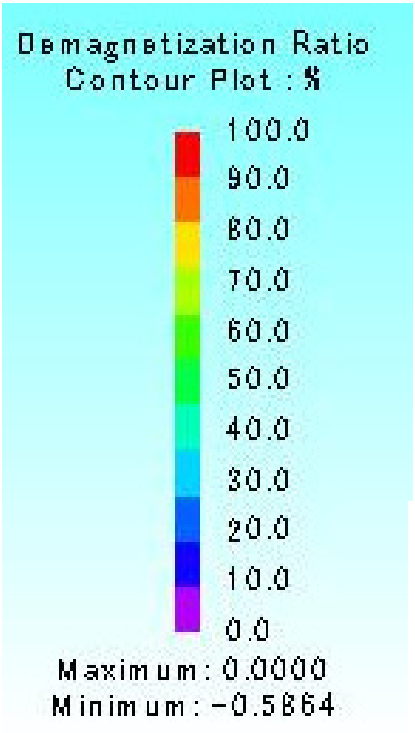
Demagnetization Definition

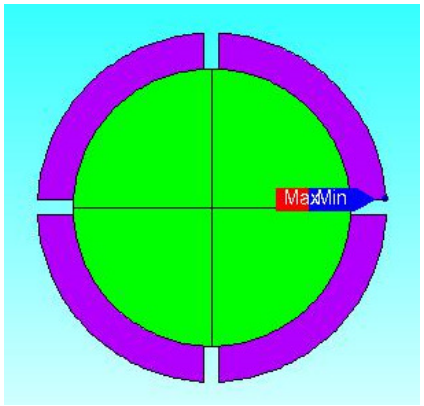
- Definition
  - Magnet operation point is below the knee point of B-H curve
- Demagnetization cases in compressor
  - High temperature in magnet
  - Over stator current
  - High eddy current in magnet
  - Reversal stator current field
  - ……
  - ……



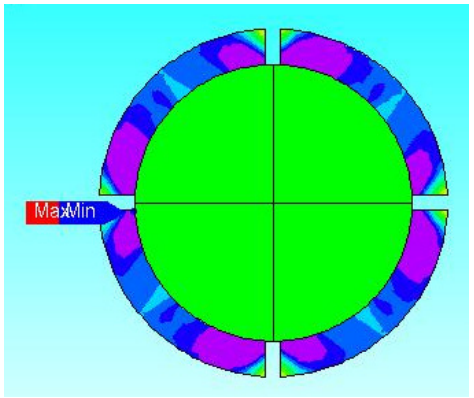
To avoid demagnetization, the operation point needs to be above the knee point of magnet at specific temperature

JMAG Demagnetization Example – SPM Motor





Before Demag.



After Demag.

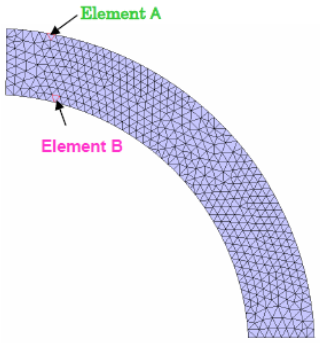


Fig. 3.3. Selected element

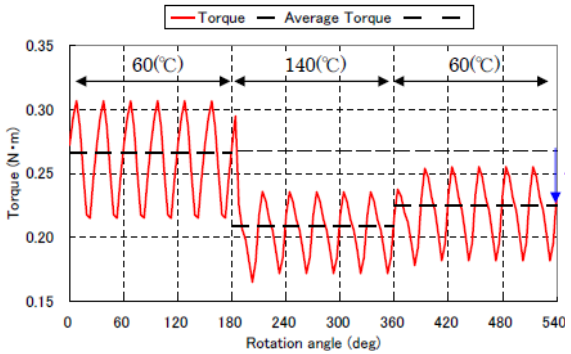
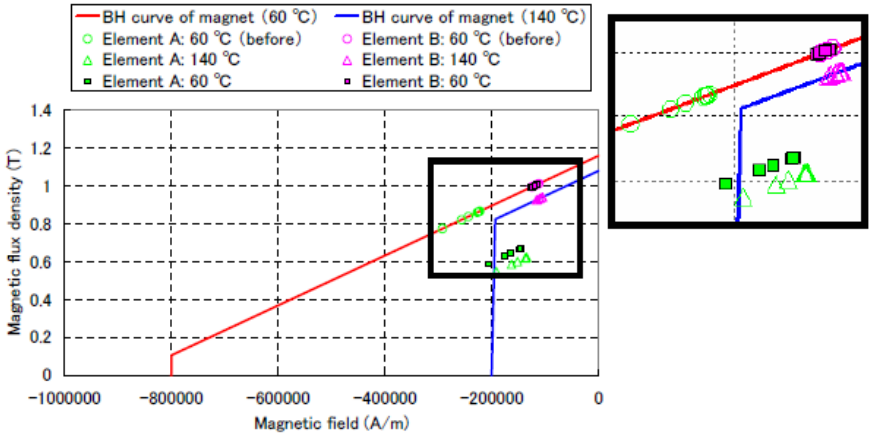


Fig. 3.1. Torque waveform

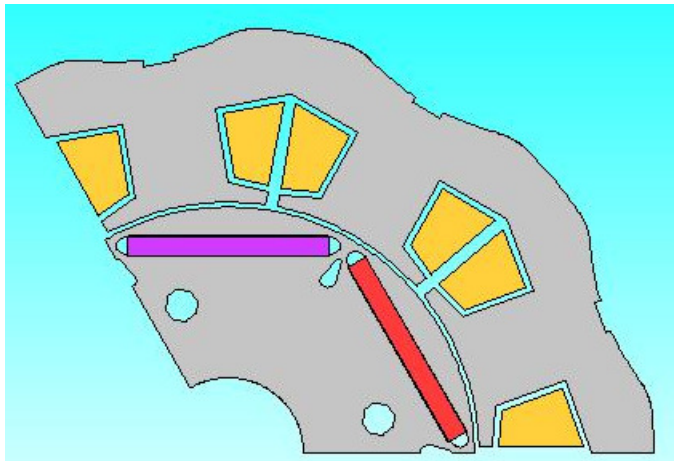


$$\text{Demagnetizing ratio (\%)} = 100 \times \left(1 - \frac{B2}{B1}\right)$$

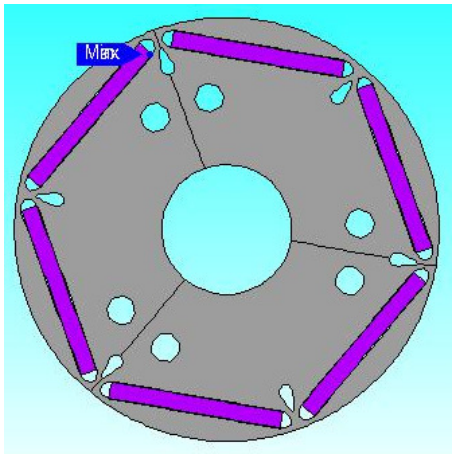
Demagnetization ratio clearly shows the flux density difference between before demag. and after demag.

Emerson IPM Demag. Analysis – 42A @ 100C

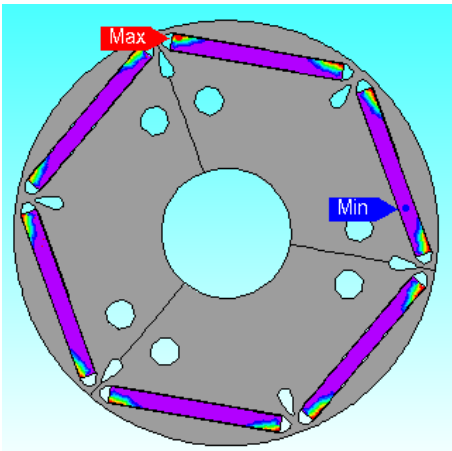
FEA Model



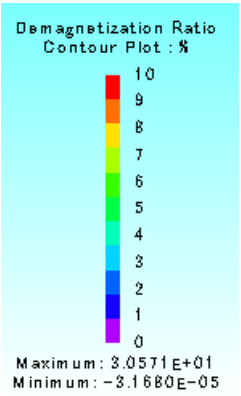
Before Demag.

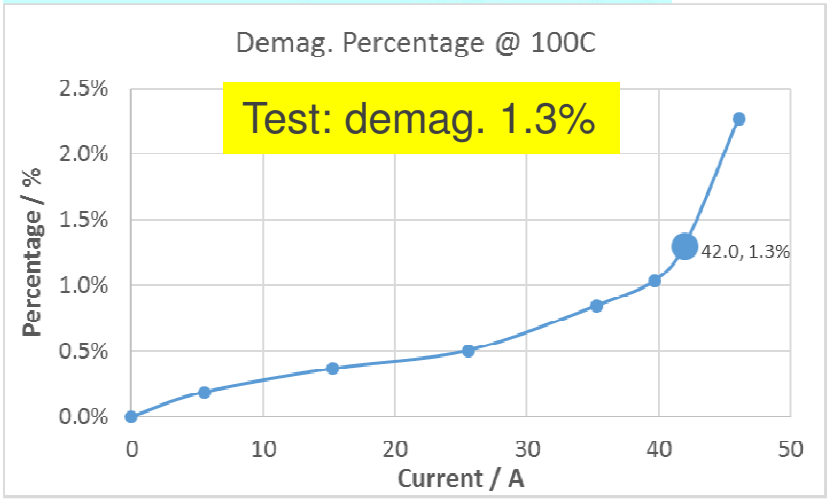


After Demag.

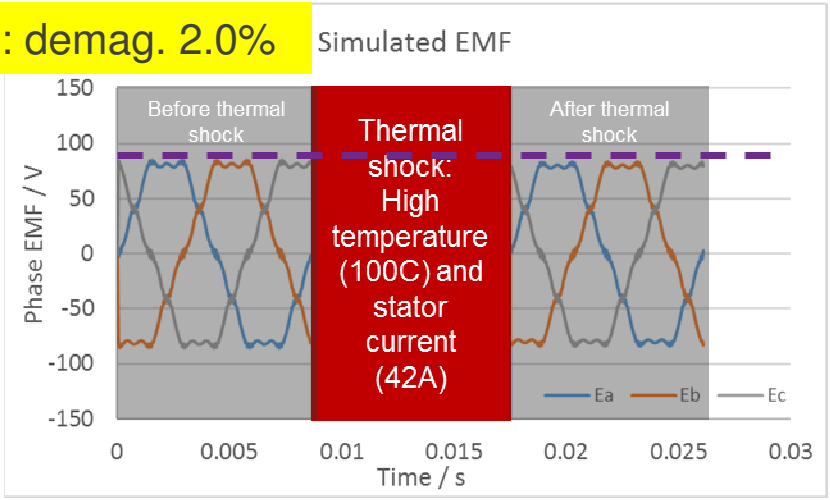


Demag. Ratio





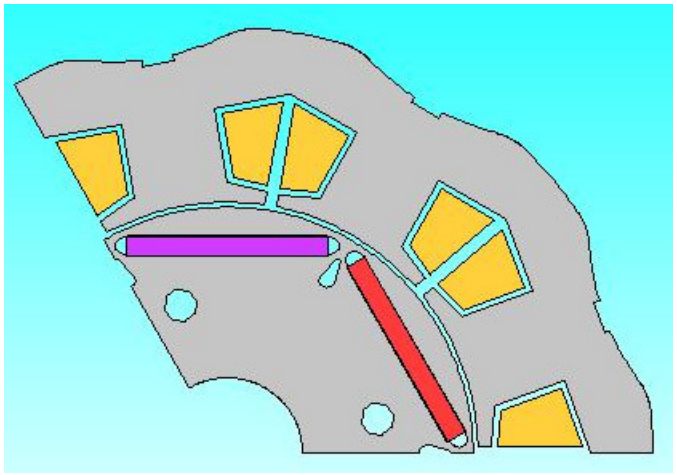
Simu.: demag. 2.0%



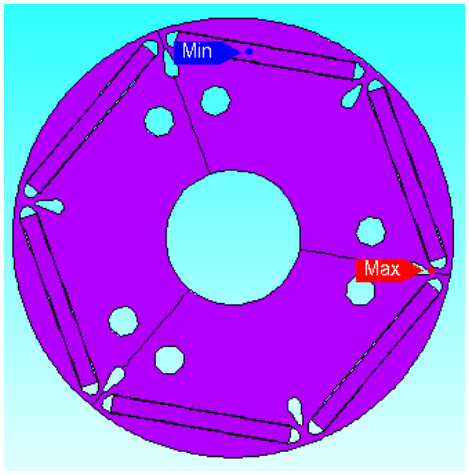
JMAG simulation result is close to the oven test data

Emerson IPM Demag. Analysis – 60A @ 100C

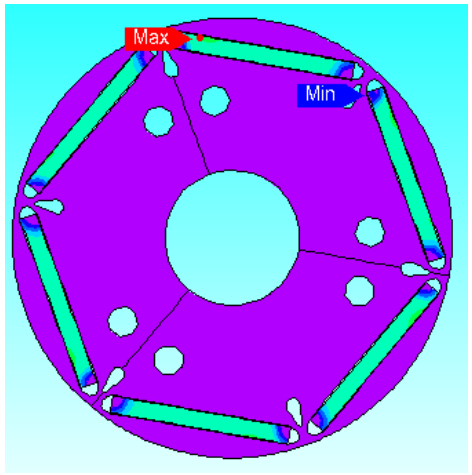
FEA Model



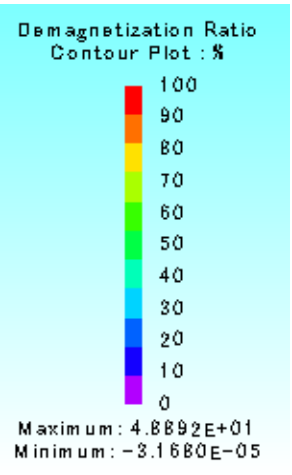
Before Demag.

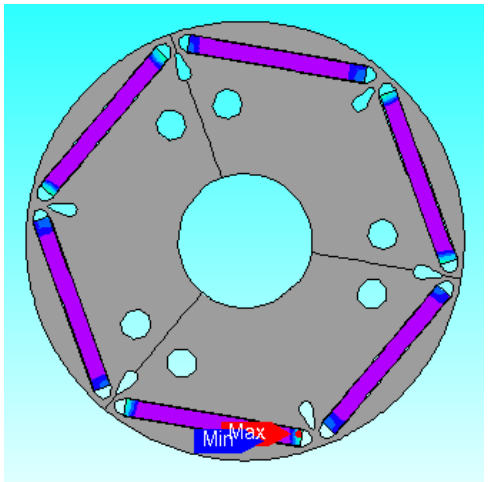


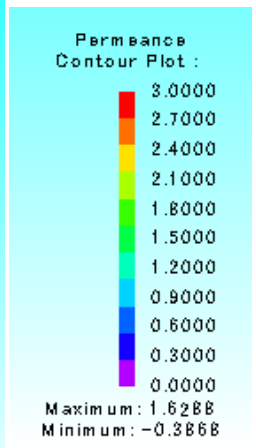
After Demag.



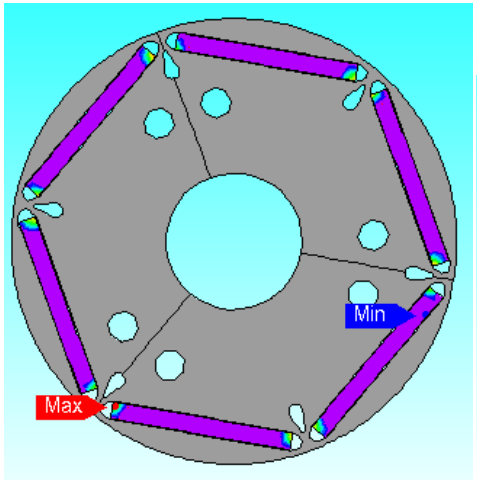
Demag. Ratio

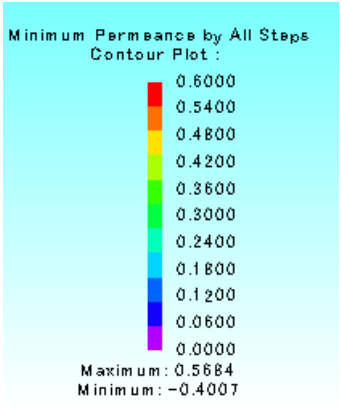






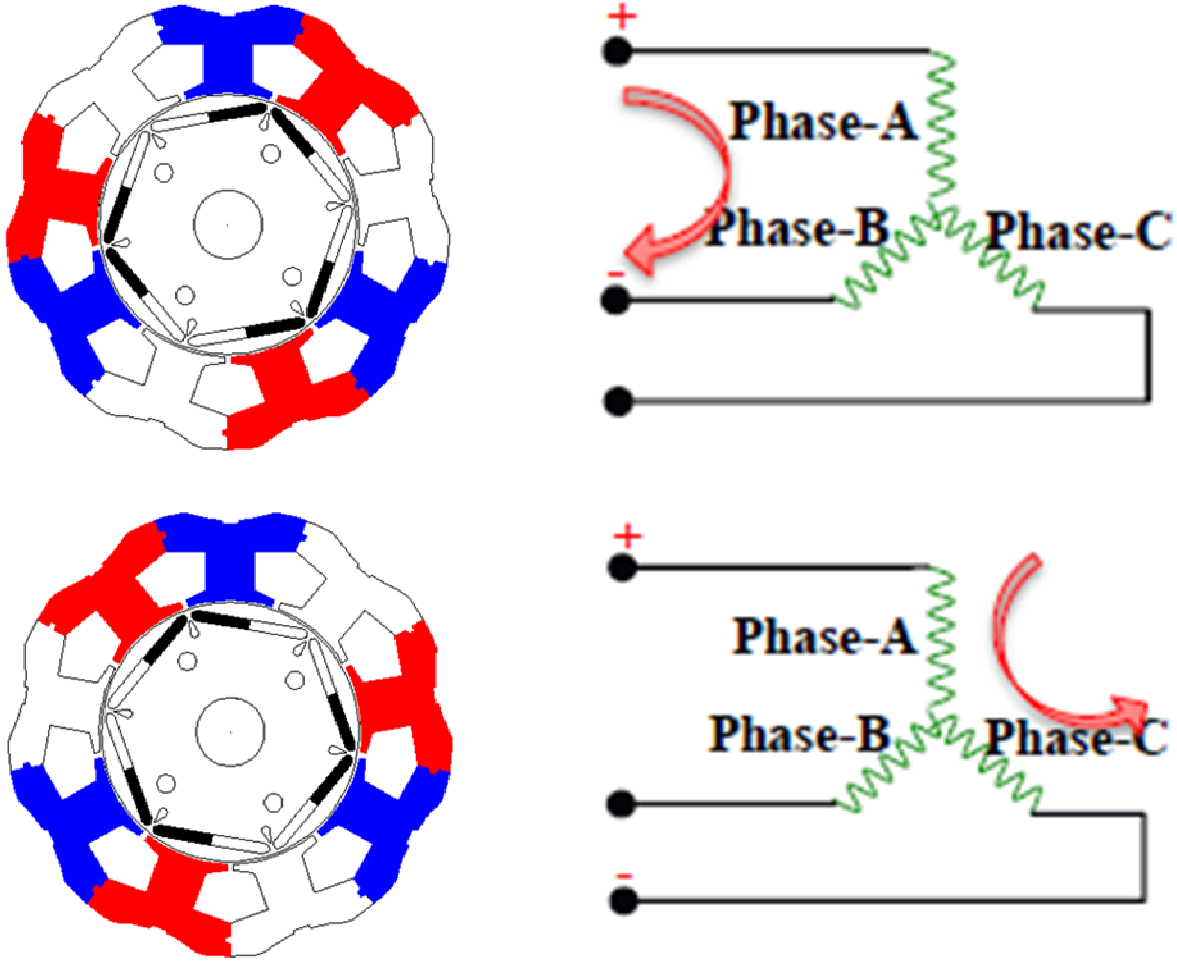
Permeance Coefficient





JMAG simulation shows most of the magnet was demagnetized with 60A at 100C

Magnetization Within Stator



Magnetization needs huge current (strong field) to fully charge the Neo Magnet