Experimentally established build factors for electro-magnetic performance in a NO20 stator stack

Pontus Fyhr[ab], Stefan Skoog[a], Leonardo Colombo[b], Avo Reinap[b]

[a] *Alvier Mechatronics AB, Helsingborg, Sweden.*
[b] *Lund University, Faculty of Engineering, Lund, Sweden.*

The electro-magnetic performance of the soft magnetic core in manufactured electric machines are known to deviate significantly from datasheet values for the material used in the core. This paper aims to quantify the discrepancy in permeability and losses between datasheet and physical units using *build factors* for a typical hairpin IPM traction machine design.

Keywords: stator; lamination; build-factor; NO20; Brockhaus; traction machine; IPM

1. Introduction

The degradation of laminations during processing and joining is well known, with many proposed methods for modelling [1], however data on modern high-performance laminations is scarce. We have designed an automotive traction machine, manufactured and tested with regards to electro-magnetic performance. The machine design features rectangular slots for a hairpin winding, and is optimized to be paired with an internal-magnet, permanent-magnet (IPM) rotor. Outer diameter is 170 mm, and stack length 165 mm. Three stator stacks are manufactured according to the same drawings using laser cut and bonded NO20-1200 laminations from Sura HI-LITE [2]. After assembly, the stator stacks are measured using a Brockhaus BST-SA measurement system to characterize the magnetic performance in the stator coreback. Measurement results are analysed and with datasheet values with regards to magnetic polarization, permeability and losses. The discrepancy in between measurements (u_m) and datasheet (u_d) for each quantity is quantified in terms of *build factor (F_b)*

$$F_b = \frac{u_m}{u_d}$$

2. Results and discussion

The dehysterized polarization curve from both measurements and datasheet is shown in Figure 1. Relative permeability is calculated from the polarization data.

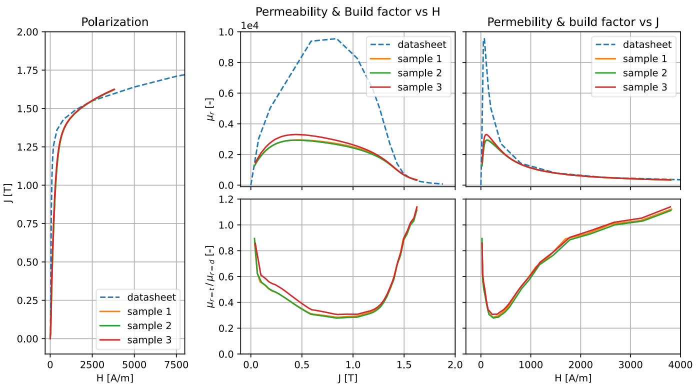

Figure 1: Permeability curves for datasheet and stator measurements.

A 6 parameter Bertotti model [3, 4] is used to fit the measured loss densities (W) across a wide range of excitation frequencies (f) and peak magnetic flux densities (B)

$$W = k_h B^{\alpha} f^{\beta} + k_e B^{\gamma} f^{\delta}$$

The resulting build-factors over a range of frequencies are shown in Figure 2. In the full version of the paper we can supply the full set of measurements for three stators, the stator drawings, and the scripts to perform the build-factor calculations and result plots.

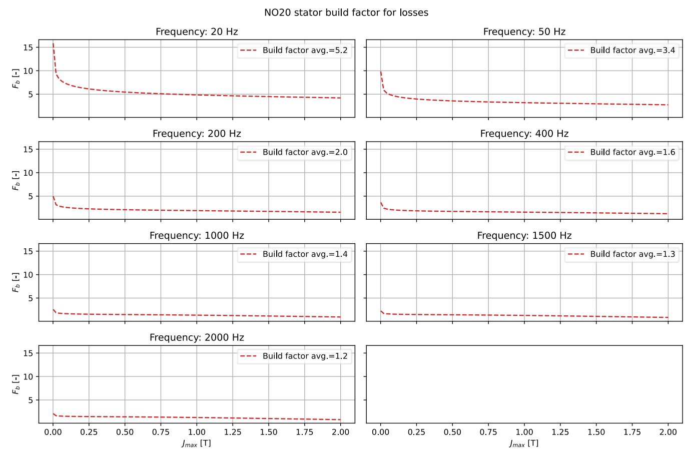

Figure 2: Calculated build factors for losses in stators at different frequencies and flux densities.

References

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[2] Hi-lite NO20-1200H Data Sheet Hi-lite-NO20-1200h, 2021

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[4] ——, “Physical interpretation of eddy current losses in ferromagnetic materials ii. theoretical considerations,” Journal of Applied Physics, vol. 57, no. 6, pp. 2118–2126, 1985.

Acknowledgements: We acknowledge the financial contribution from Alvier Mechatronics AB for the stators and the testing.