Progress Notes on Motor Design Code

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1 NEXT STEP

~~Talk with Aaron about MotorCAD manual, talk about FEM with Justin,~~ use total mass as objective

~~Use Tucker's resources to figure out what to do to model loss~~

Hanselman book will be the best resource for this, use it to define loss and other necessary parameters. See specific notes

2 High-Level Notes

Goal: Make strides in unifying motor design process using OpenMDAO.

Ideas/paths for making progress

- Implement the lowest-fidelity analyses possible (existing surrogate models, analytic stuff)
- Focus on improving fidelity of one, two, analyses (EM, Thermal)
- Focus on defining optimization goals (objectives, constraints, design space)
- Menial tasks: analytic derivatives, clean up code, split across .py files

1. Seems to be current focus. Going to look through MotorCAD manual to replicate their models with Aaron

Communicating with Tucker, will send some material on EM when he can

Also need to consider thermal and rotordynamic analyses

2. Build something in EMpy? Or MFEM?

Haven't started on this yet

3. With losses modeled as they are (dependent only on electric frequency and representing a different motor), can't use them as objective. Want to try minimizing mass instead, see what optimizer does.

Currently using design space bounds,

Upper limit on current density

Lower limit on torque

Objective is losses, but don't make sense to use as they are

4. Do these to pass the time

Especially need to clean up comments, remove deprecated lines

3 Notable Commits

ef18621 2019-07-02: Added this notes.tex file

91029b2 2019-07-02: The surrogate models for magnetic/wiring eddy and core losses work, as do the mechanical loss models. Optimization doesn't make sense as they are.

4 Specific Notes

May need to look at magnetic flux density/max flux calculations (assumed constant) See pg. 156 EMF book

Model magnetic field as a function of the properties of the coils in the motor. See pg. 161 EMF book

MATlab code modeling three phase rotating magnetic field. See pg. 168 EMF book

Core loss reductions, high dependence on lamination thickness and resisitivity of material (find this out for Hiperco). See pg. 219 Hanselman

Amazon links to good books:

https://www.amazon.com/Electric-Machinery-Fundamentals-Chapman/dp/007108617X

Hysteresis Losses:

$$P_h = k_h f B_{pk}^{n} \tag{1}$$

or

$$P_h = k_h f B_{pk}^{n+mB_{pk}} \tag{2}$$

k_h, n, m, are material constants. B_{pk} is peak flux density,

To be useful for optimization, we need to compute B in general (steady state)

For B_{pk},

$$B(\theta) = \sum_{n=-\infty}^{\infty} B_n e^{jn\theta} \tag{3}$$

And $B_o = pk$ is maximum of $B(\theta)$. Check (7.23) and (7,24) for stator tooth, (7.32) and (7.33) for yoke. (pg. 158 Hanselman)

$$\phi_i(\alpha) = \sum_{n=-\infty}^{\infty} \left\{ \frac{2L_{st}R_s}{N_m} B_{gn} \int_{-\theta_s/2}^{\theta_s/2} K_{sl}(\theta) e^{jn\theta} d\theta \right\} e^{jn\alpha} \tag{4}$$

But I need to see if the magnetic field is sinusoidal.