Motor conceptual development
-
Accelerating process from customer to production

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SKURKA AEROSPACE INC.

a subsidiary of TransDigm Inc.

Designer & Manufacturer of Electro-Mechanical Devises

- Design, development and manufacturing of customized electro-magnetic equipment
- Specialized A.C. and D.C. electric motors
- Fans, blowers, speed transducers and tachometers

Customers

* Argo-Tech Corporation
* ATK Alliant Techsystems
* BAE Systems Applied Technologies, Inc.
* Bell Helicopter, HR Textron
* Eaton Aerospace
* Fairchild Controls
* General Dynamics
* Honeywell International
* Hydro-Air Division
* ITT-Gilfillan
* Lockheed-Martin
* Meggitt Airdynamics
* Monogram Sanitation
* MOOG, Inc.
* Northrop Grumman
* Parker Hannifin
* Raytheon
* The Boeing Company
* Senior Aerospace
* Government Agencies
* Major Airlines

Personal Background

- Mechanical Engineer
  - MS Automotive Engineering
    - Engine Development
    - CNC programming
    - Program Management / Pressure Sensor Development
    - Motor Design

Challenge

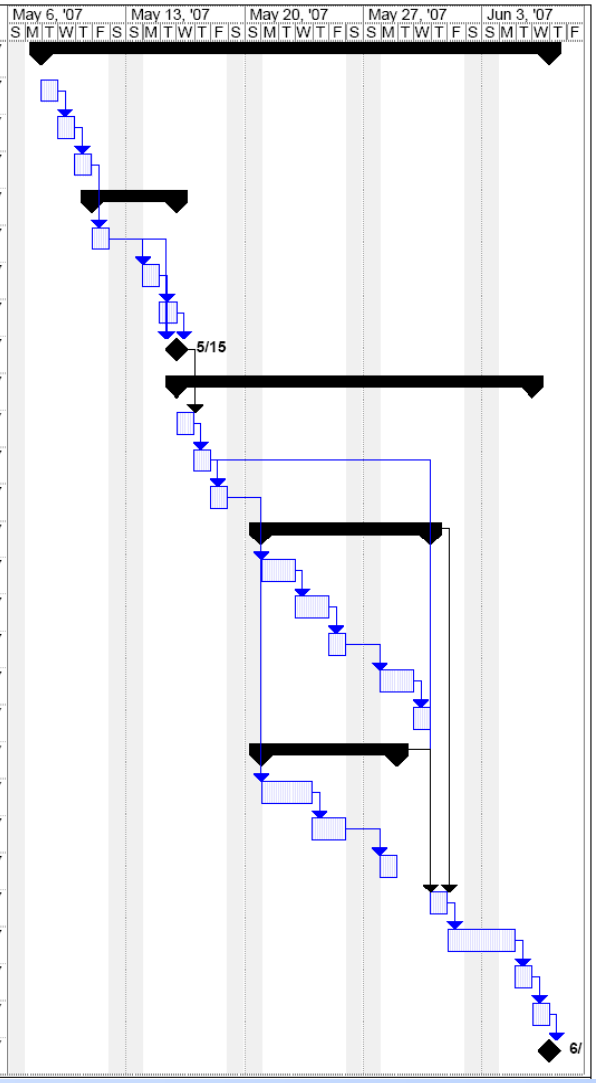
Develop and build prototype motor within 4 weeks.

Requirement

- Dimensional:
  - OD: 3.625 max
  - Stator Length: 2.00 max
- Input:
  - 115 / 200 VAC, 3 Phase, 400 Hz
  - Input power: 1800 W max.
- Performance:
  - Two speed on separate winding
  - Torque @ 11400 rpm: 1.2 Nm
  - Torque @ 5700 rpm: 0.3 Nm

Gantt Chart

ID	Task Name	Duration	Start	Finish
1	**Accelerated Motor Prototype schedule (30 days!)**	**22 days?**	**Tue 5/8/07**	**Wed 6/6/07**
2	Quote inquiry from customer	1 day	Tue 5/8/07	Tue 5/8/07
3	Assign Motor Part number	1 day	Wed 5/9/07	Wed 5/9/07
4	Kick off Operations and Quality (accelerated schedule)	1 day	Thu 5/10/07	Thu 5/10/07
5	**Initial Design Phase**	**3 days**	**Fri 5/11/07**	**Tue 5/15/07**
6	Determine slot count	1 day	Fri 5/11/07	Fri 5/11/07
7	Create preliminary BOM and verify availability	1 day	Mon 5/14/07	Mon 5/14/07
8	Simulation in RmXprt	1 day	Tue 5/15/07	Tue 5/15/07
9	Design Review	0 days	Tue 5/15/07	Tue 5/15/07
10	**Prototype Production Phase**	**15 days?**	**Wed 5/16/07**	**Tue 6/5/07**
11	Release drawing package for Stator and Rotor to Manufacturing	1 day	Wed 5/16/07	Wed 5/16/07
12	Ensure Test housing / shaft availability	1 day	Thu 5/17/07	Thu 5/17/07
13	Release work orders for 5 motors	1 day	Fri 5/18/07	Fri 5/18/07
14	**Stator Built**	**8 days?**	**Mon 5/21/07**	**Wed 5/30/07**
15	Stack and weld	2 days	Mon 5/21/07	Tue 5/22/07
16	Machine OD and ID	2 days	Wed 5/23/07	Thu 5/24/07
17	Wind coils	1 day	Fri 5/25/07	Fri 5/25/07
18	Install coils and connect	2 days	Mon 5/28/07	Tue 5/29/07
19	Send to Engineering	1 day?	Wed 5/30/07	Wed 5/30/07
20	**Rotor Built**	**6 days**	**Mon 5/21/07**	**Mon 5/28/07**
21	Stack, machine slots and weld	3 days	Mon 5/21/07	Wed 5/23/07
22	Machine OD and length	2 days	Thu 5/24/07	Fri 5/25/07
23	Send Rotor to Engineering	1 day	Mon 5/28/07	Mon 5/28/07
24	Initial performance evaluation	1 day	Thu 5/31/07	Thu 5/31/07
25	Varnish Stator and Rotor	2 days	Fri 6/1/07	Mon 6/4/07
26	Return to Engineering for final test	1 day	Tue 6/5/07	Tue 6/5/07
27	Send Motor to Final Inspection for First Article.	1 day	Wed 6/6/07	Wed 6/6/07
28	Ship Motor to customer	0 days	Wed 6/6/07	Wed 6/6/07



Traditional Design Steps

1. Establish new design parameters by interpolating performance data from know motors.
2. Build prototype
3. Performance test
4. New interpolation
5. Final design

Using following parameters lamination currently in stock to build stator and rotor :

- Poles = 120 * f / n = 120 * 400 / 11700 = 4.1 →

  P = 4 for n = 11700 rpm

  P = 8 for n = 5800 rpm

- OD = 3.5”; 24 or 36 slot count in stator (both suitable for 4 and 8 pole)

→Closest motors:

a) OD = 3.5” ; ID = 2.0” ; L= 2.75”; 4 Poles; 24 slot

b) OD = 3.0” ; ID = 1.75” ; L= 2.00”; 4 Poles; 36 slot

c) OD = 3.5” ; ID = 2.0” ; L = 2.38” ; 8 Poles; 36 slot

→ No exact fit in portfolio

Disadvantage of Traditional Method

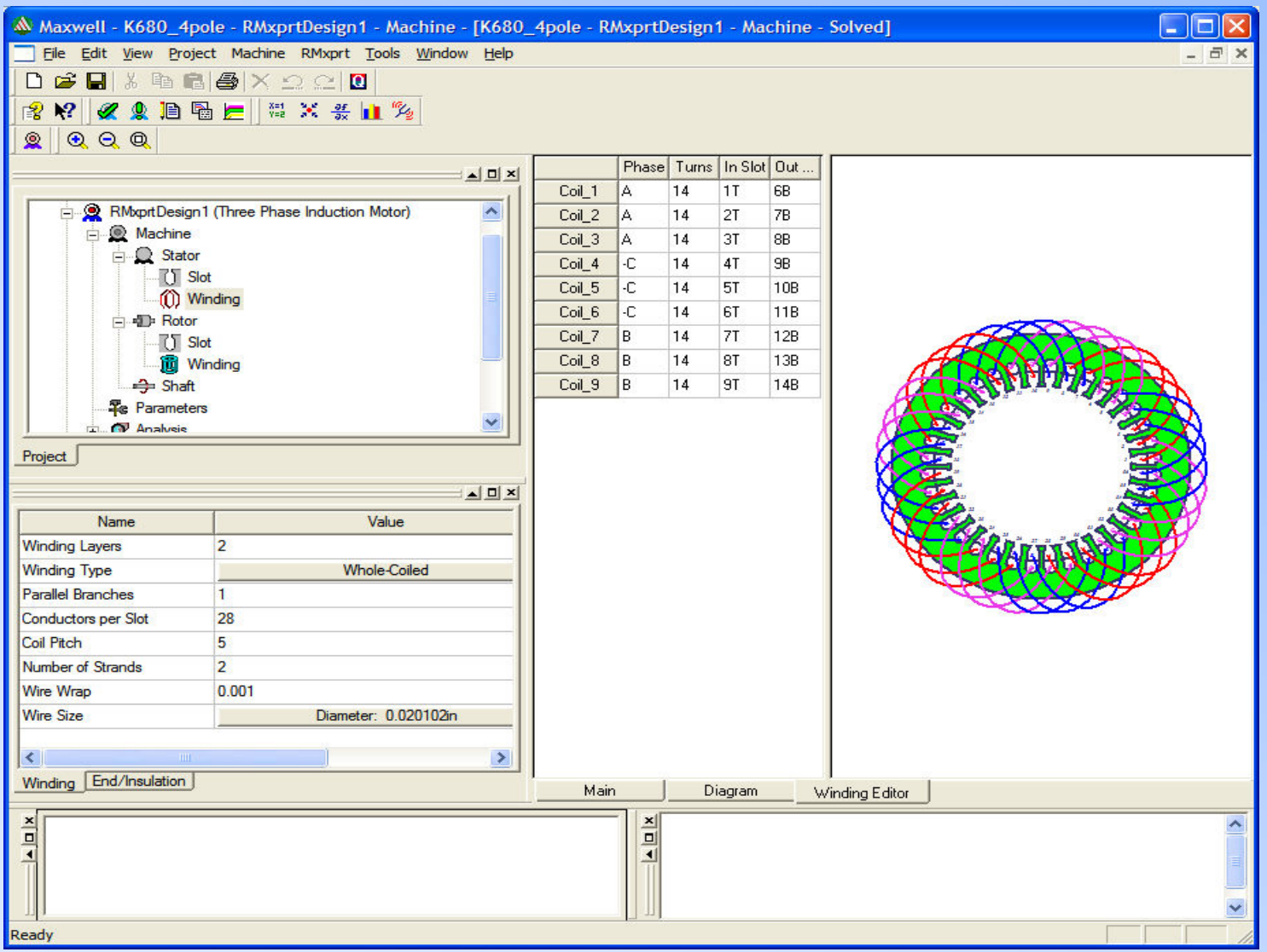
- ✓Large portfolio combined with experienced designer needed.
- ✓Usually at least one iteration from original design required.
- ✓Time consuming

Design with RmXprt

Input Parameters

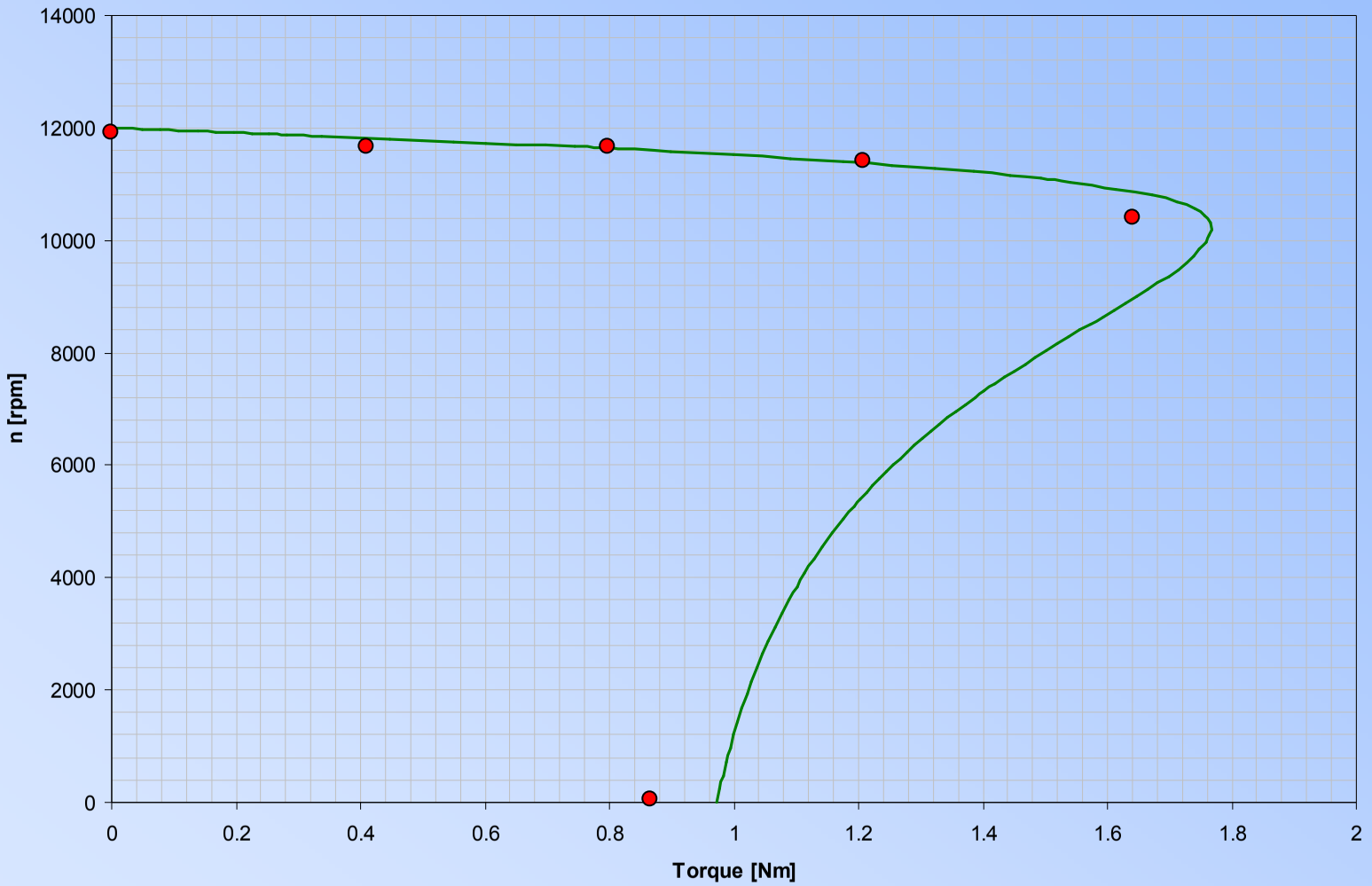
- ✓ 3.5” OD and 2.0” ID;
- ✓ 36 slot for stator;
- ✓ 41 slots for rotor
- ✓ Maximum slot fill 55%
- ✓ Two independent configurations
- ✓ 44% slot fill for 4 pole

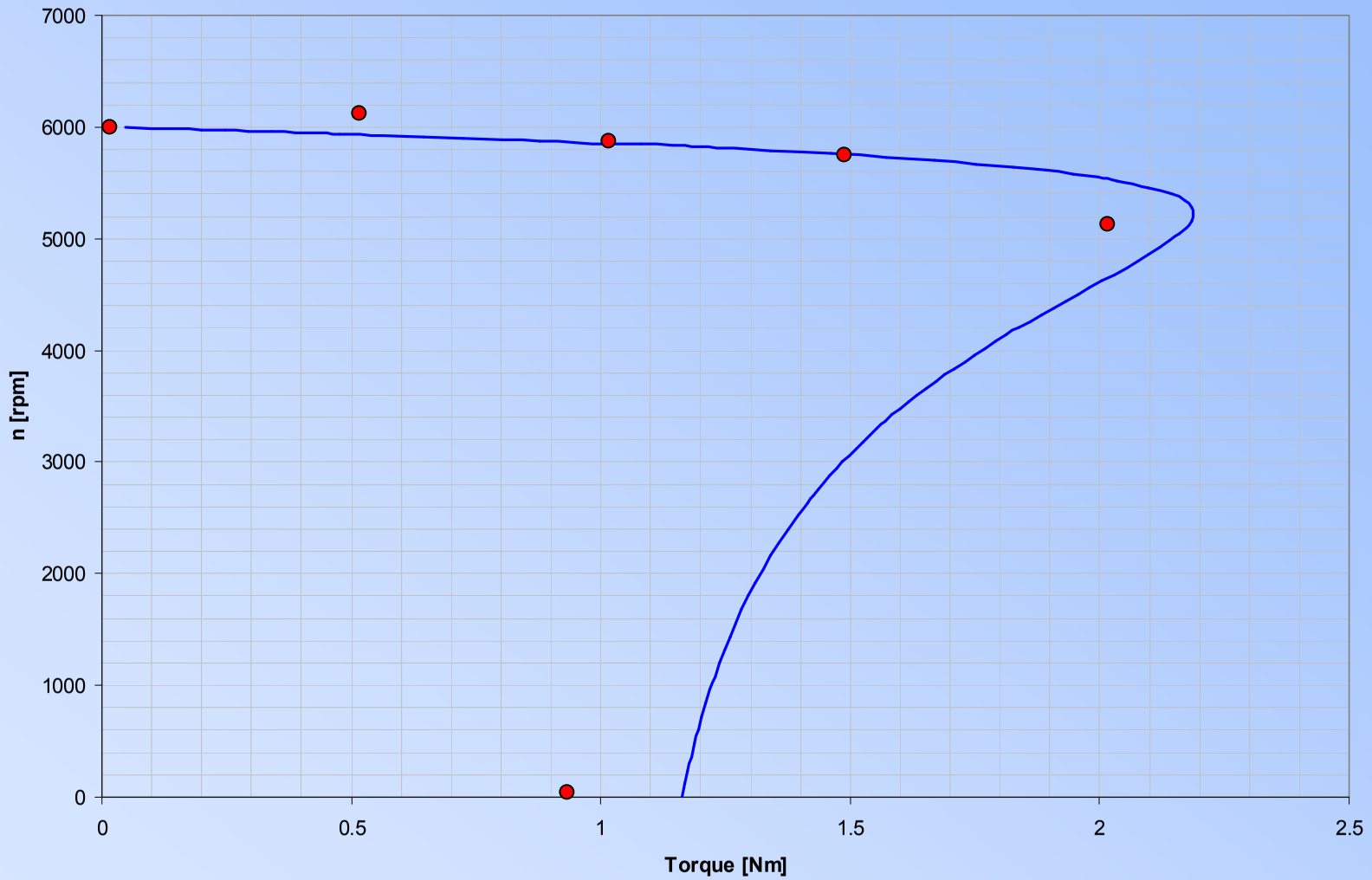
RmXprt


Maxwell - K680_4pole - RMxprtDesign1 - Machine - [K680_4pole - RMxprtDesign1 - Machine - Solved]
File Edit View Project Machine RMxprt Tools Window Help
RMxprtDesign1 (Three Phase Induction Motor)
Machine
Stator
Slot
Winding
Rotor
Slot
Winding
Shaft
Parameters
Project
Name Value
Winding Layers 2
Winding Type Whole-Coiled
Parallel Branches 1
Conductors per Slot 28
Coil Pitch 5
Number of Strands 2
Wire Wrap 0.001
Wire Size Diameter: 0.020102in
Winding End/Insulation
Phase Turns In Slot Out ...
Coil_1 A 14 1T 6B
Coil_2 A 14 2T 7B
Coil_3 A 14 3T 8B
Coil_4 -C 14 4T 9B
Coil_5 -C 14 5T 10B
Coil_6 -C 14 6T 11B
Coil_7 B 14 7T 12B
Coil_8 B 14 8T 13B
Coil_9 B 14 9T 14B
Main Diagram Winding Editor
Ready

RmXprt Output

- Solution Data
- Design Sheet
- Curves


4 Pole
14000
12000
10000
8000
6000
4000
2000
0
n [rpm]
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
Torque [Nm]


8 Pole
7000
6000
5000
4000
3000
2000
1000
0
n [rpm]
0
0.5
1
1.5
2
2.5
Torque [Nm]

Result at Load Point

	Requirement	RmXprt	Test	Delta
P in max (4 Pole)	1865 W	1778 W	1615 W	9%
P in max (8 Pole)	365 W	344 W	325 W	6%
Torque @11400 rpm	1.2 Nm	1.26 Nm	1.2 Nm	5%
Torque @ 5700 rpm	0.3 Nm	0.38 Nm	0.4 Nm	5%

Summary

- First try within 10%
- Design sheet provides flux densities but for higher accuracy model needs to be evaluated with Maxwell FEA
- Impact of geometry and winding changes can be quickly evaluated