# Optimal design of Permanent Magnetic Generator by parametric optimization

By David Tong, Senior R & D Engineer

The following example demonstrates how to use Parametric and Find Optimal Parametric Result dialog to find the maximum torque of a permanent magnet generator and the angle of the magnet at which the maximum torque is produced. The final result is verified graphically by plotting the torque vs angle using data from the parametric run.

In the permanent magnet generator below, the magnetic field of the rotor is produced by Neodymium 10 MGEOe Bonded permanent magnet (green) with magnetization angle at 90 degrees. The core (purple) is made of Linear Steel.
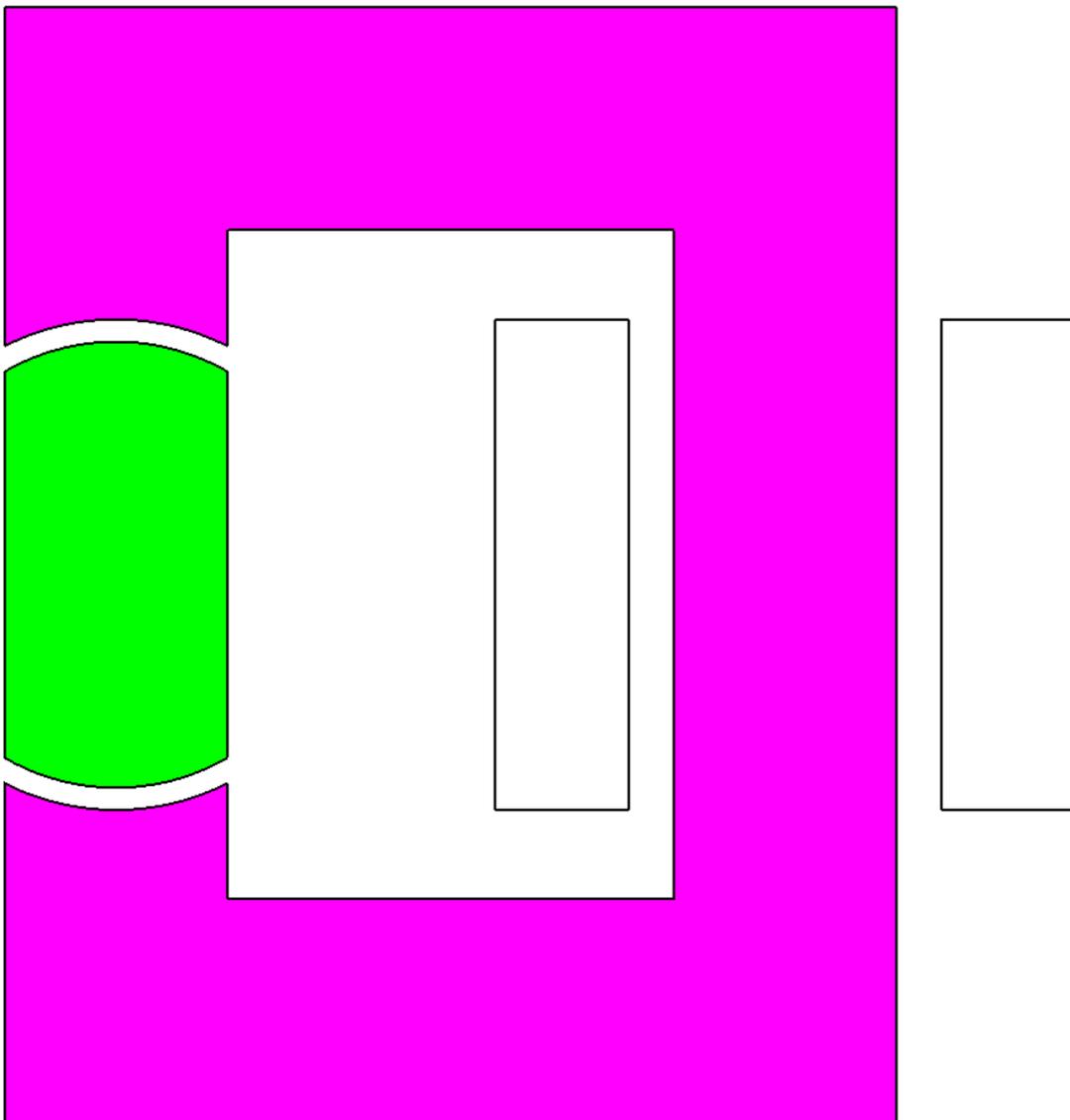
A 100 steps parametric run is setup to rotate the permanent magnet and torque is calculated on the magnet for each step.
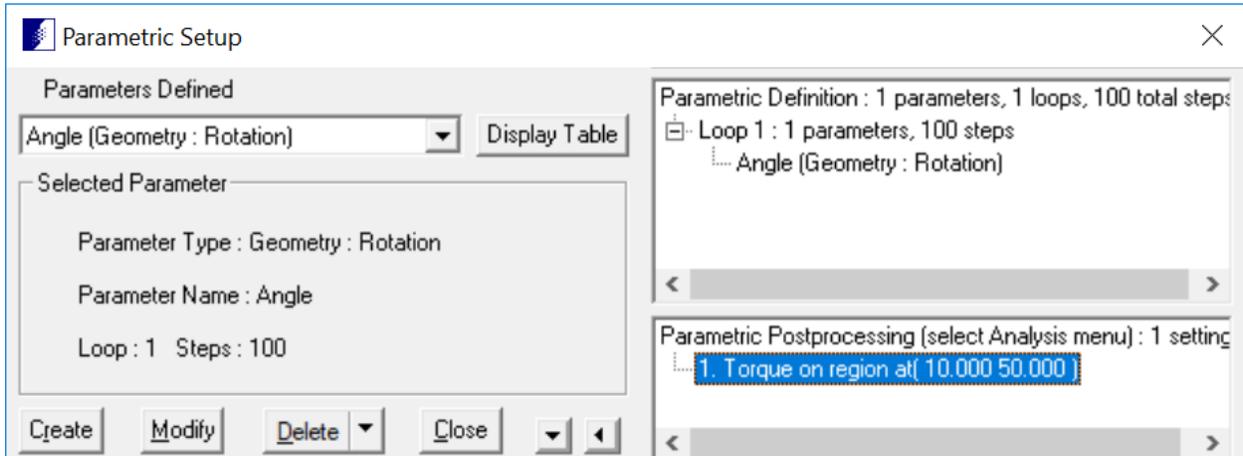
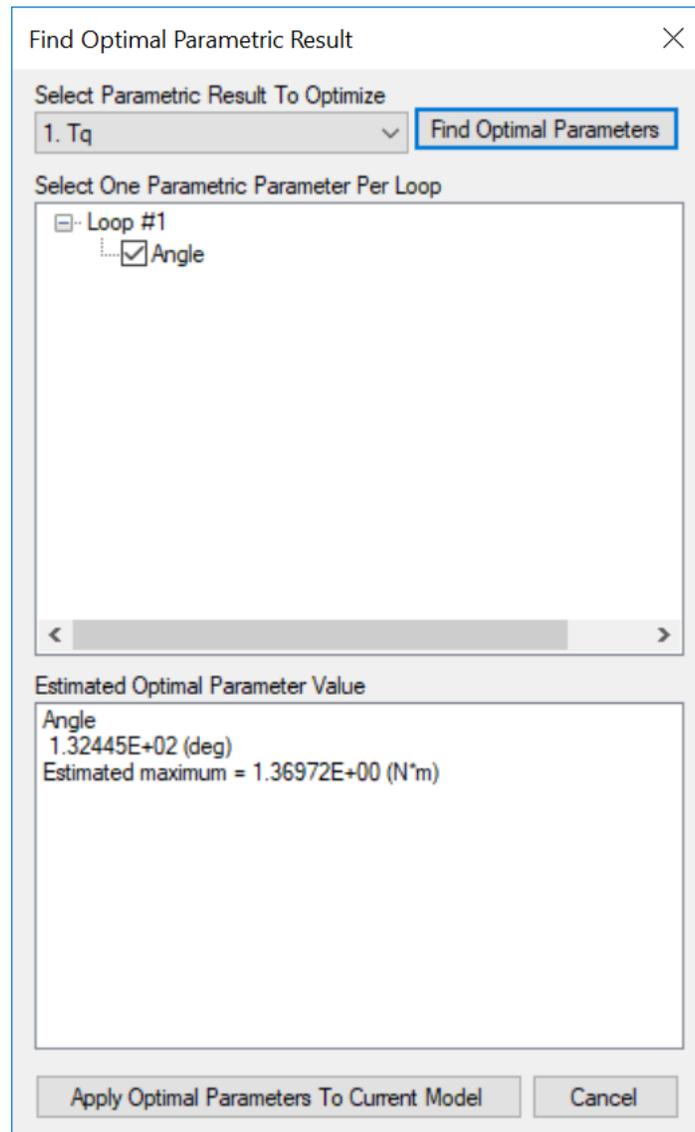The permanent magnet is rotated from 0 to 180 degrees in 100 steps.
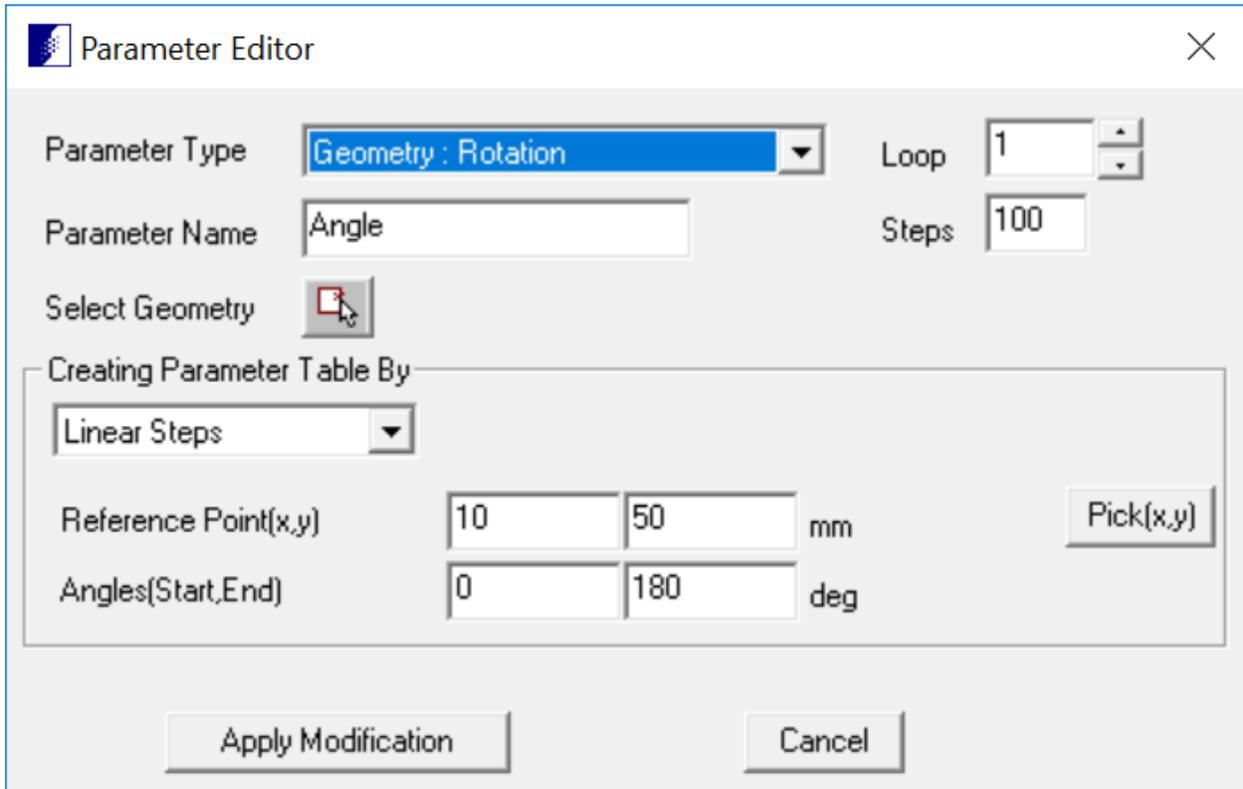
After the parametric run is completed, the torque values calculated for each permanent magnet rotation angle are listed in the Final Parametric Table.

Final Parametric Table

| Steps	Loop Steps	Angle (1) Rotation Rotate Angle(deg)	1. Tq(N*m)	1. Area(m^2)	
1	(1)	0	-2.41843251e-07	0.000765289182	
2	(2)	1.81818182	-0.0864657979	0.000765289182	
3	(3)	3.63636364	-0.168416663	0.000765289182	
4	(4)	5.45454545	-0.244398074	0.000765289182	
5	(5)	7.27272727	-0.315167522	0.000765289182	
6	(6)	9.09090909	-0.383020666	0.000765289182	
7	(7)	10.9090909	-0.449673784	0.000765289182	
8	(8)	12.7272727	-0.518512142	0.000765289182	
9	(9)	14.5454545	-0.583881315	0.000765289182	
10	(10)	16.3636364	-0.648102495	0.000765289182	
11	(11)	18.1818182	-0.711430986	0.000765289182	
12	(12)	20	-0.772838914	0.000765289182	
13	(13)	21.8181818	-0.832113412	0.000765289182	
14	(14)	23.6363636	-0.889525143	0.000765289182	
15	(15)	25.4545455	-0.945070348	0.000765289182	
16	(16)	27.2727273	-0.99802225	0.000765289182	
17	(17)	29.0909091	-1.04984965	0.000765289182	
18	(18)	30.9090909	-1.09942542	0.000765289182	
19	(19)	32.7272727	-1.14695551	0.000765289182	
20	(20)	34.5454545	-1.19725973	0.000765289182	
21	(21)	36.3636364	-1.23396122	0.000765289182	
22	(22)	38.1818182	-1.27484447	0.000765289182	
23	(23)	40	-1.30025776	0.000765289182	

CSV Export   XML Export   Copy To Clipboard   Graph Results ...   Close

From the program menu, select Solution -> Run Parametrics -> Find Optimal Parametric Result to open the Find Optimal Parametric Result dialog. The parametric variable "Angle" is automatically selected for optimization. Select "Tq" from the Select Parametric Result To Optimize drop down list and click Find Optimal Parameters button. The result of the optimization is displayed in the Estimated Optimal Parameter Value window which show the estimated maximum torque of 1.37 Nm will occur at "Angle" approximately 132 degrees.

Find Optimal Parametric Result   ×

Select Parametric Result To Optimize
1. Tq   ∨   Find Optimal Parameters

Select One Parametric Parameter Per Loop
⊟ Loop #1
    ☑ Angle

Estimated Optimal Parameter Value
Angle
 1.32445E+02 (deg)
Estimated maximum = 1.36972E+00 (N*m)

Apply Optimal Parameters To Current Model   Cancel

IMPORTANT: If you have more than one parametric variable defined in a loop, it is important to define all the parametric variables to be dependent to a single parametric variable in the loop. **The optimization algorithm can only optimize one parametric variable per loop.** If a parametric variable cannot be made dependent on another parametric variable in the same loop, consider moving the parametric variable to a new loop. Failure to follow this rule would produce erroneous results.

Finally, click the Apply Optimal Parameters To Current Model button to modify the current model to the optimal configuration as shown below.
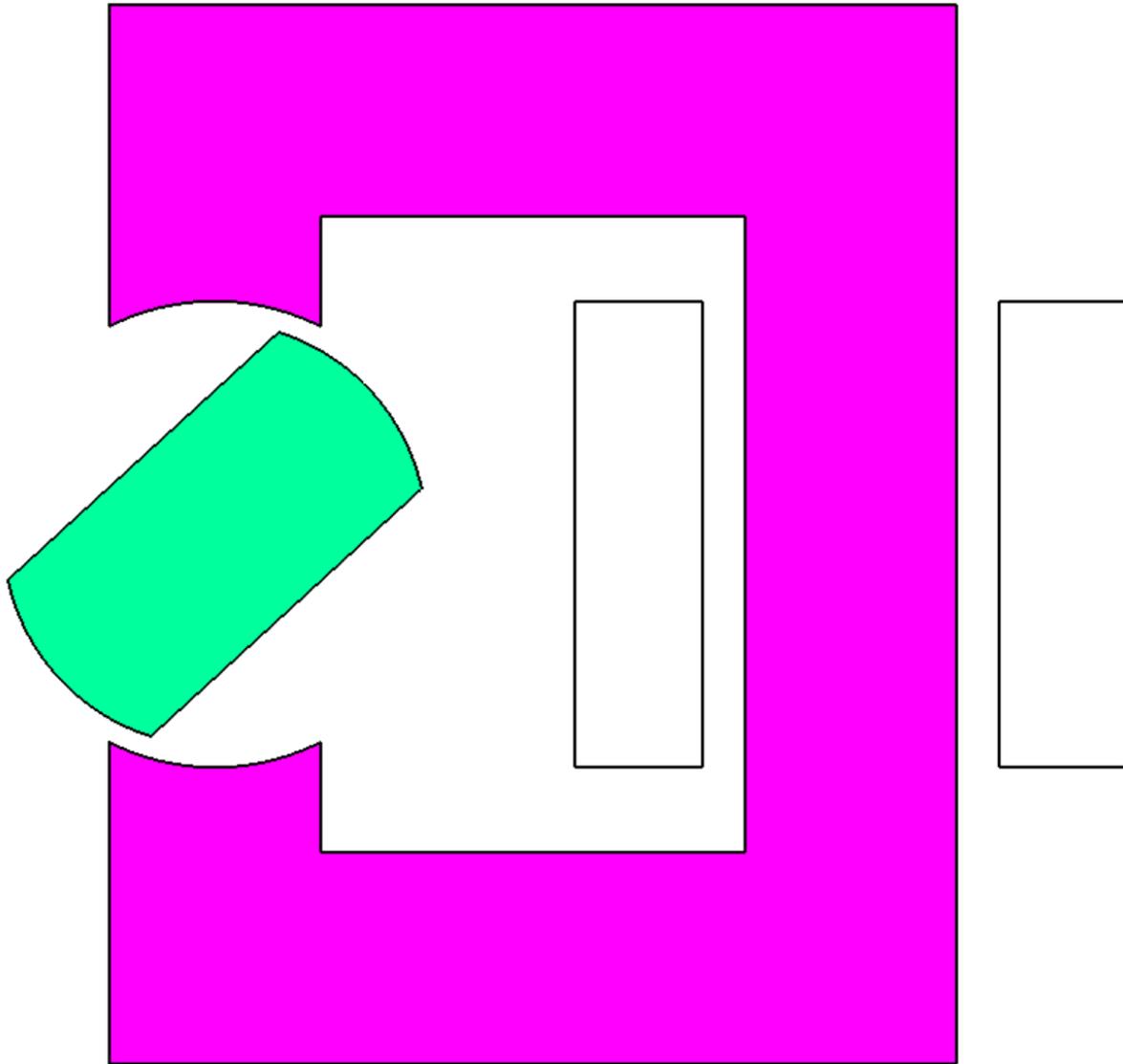
Solving this model and calculating the torque of the permanent magnet at location (10, 50) will yield actual torque value 1.37 Nm.

For this problem, the result can be verified by plotting the torque vs angle from the Final Parametric Table. Open the database "Sample, Permanent Magnet Generator- Parametric Run Completed.dbs" and select Analysis -> Parametric Results to display the Final Parametric Table.

Final Parametric Table

Steps	Loop Steps	Angle [1] Rotation Rotate Angle(deg)	1. Tq(N*m)	1. Area(m^2)
1	(1)	0	-2.41843251e-07	0.000765289182
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CSV Export   XML Export   Copy To Clipboard   Graph Results ...   Close

Select "Angle Rotation" as Independent Variable 1 (X Axis) and "Tq" as Dependent Variable (Y Axis). Click Graph Results button.

Graph Results   ×

Independent Variable 1 (X Axis)   Independent Variable 2

Angle-Rotation(1)   ▼   None   ▼

Dependent Variable (Y Axis)   1. Tq(N*m)   ▼

Loop Step Fixing
    Loop 1

    All ▲
        ▼

Results 1 Curve(s)   Graph Results   Close

The torque vs angle graph for the permanent magnet generator is shown below. The maximum torque can be traced graphically to occur approximately at angle 132 degrees with torque value at 1.37 Nm.

Tq vs Angle

T(N*m)

1.37E+00

0.13273E3
1.36956E0

Tq

8.22E-01

2.74E-01

-2.74E-01

-8.22E-01

-1.37E+00

0.00E+00   3.60E+01   7.20E+01   1.08E+02   1.44E+02   1.80E+02

Ang(deg)