Optimal design of Cycloid Permanent Magnetic Gear

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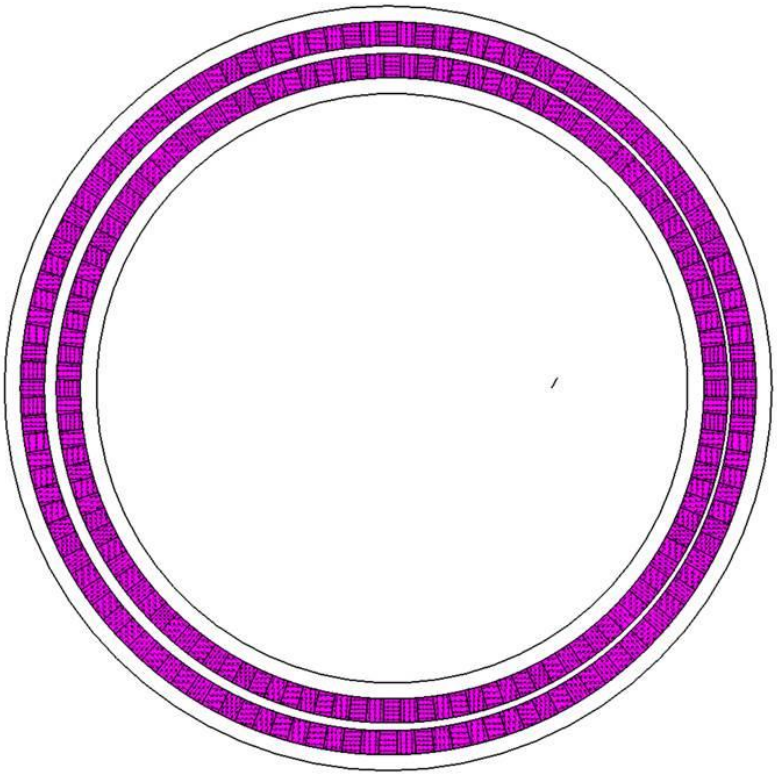
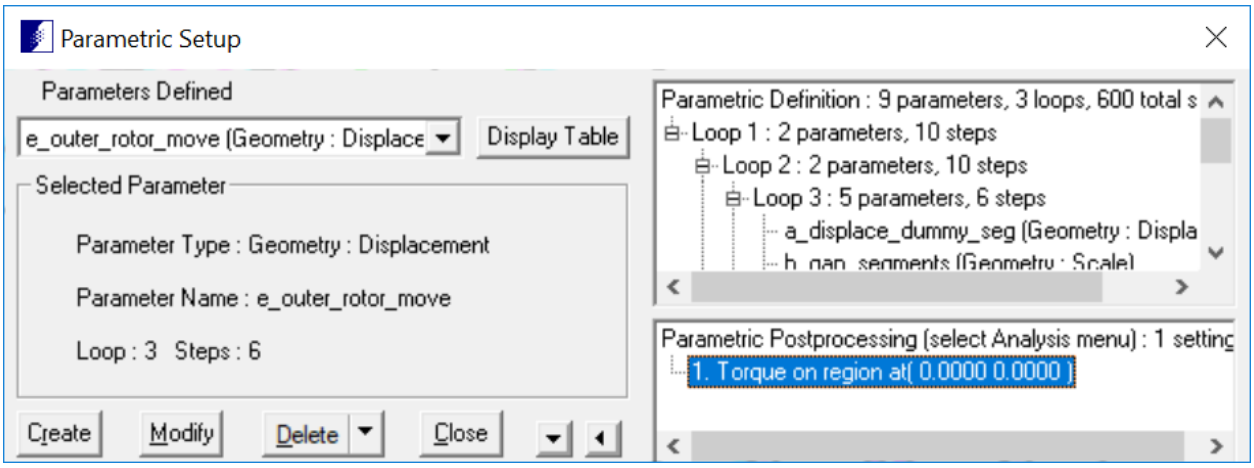
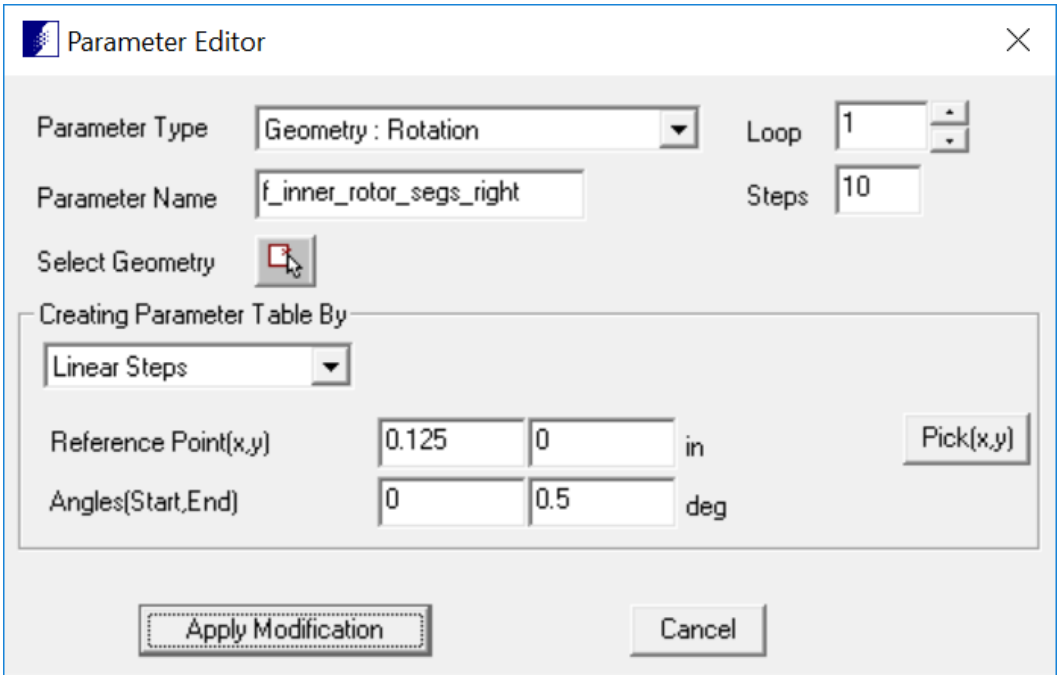
The following example demonstrates how to use Parametric and Find Optimal Parametric Result dialog to find the optimal size of magnets and rotor configuration to maximize the torque of a cycloid permanent magnetic gear.

The permanent magnetic gear has an outer rotor with 124 magnets and an inner rotor with 120 magnets. A 600 steps parametric has been setup to change the shape and size of both the outer and inner rotor magnets, gap distance between the outer and inner rotors, and position of the outer rotor relative to the inner rotor. The torque on the outer rotor is calculated for each step.



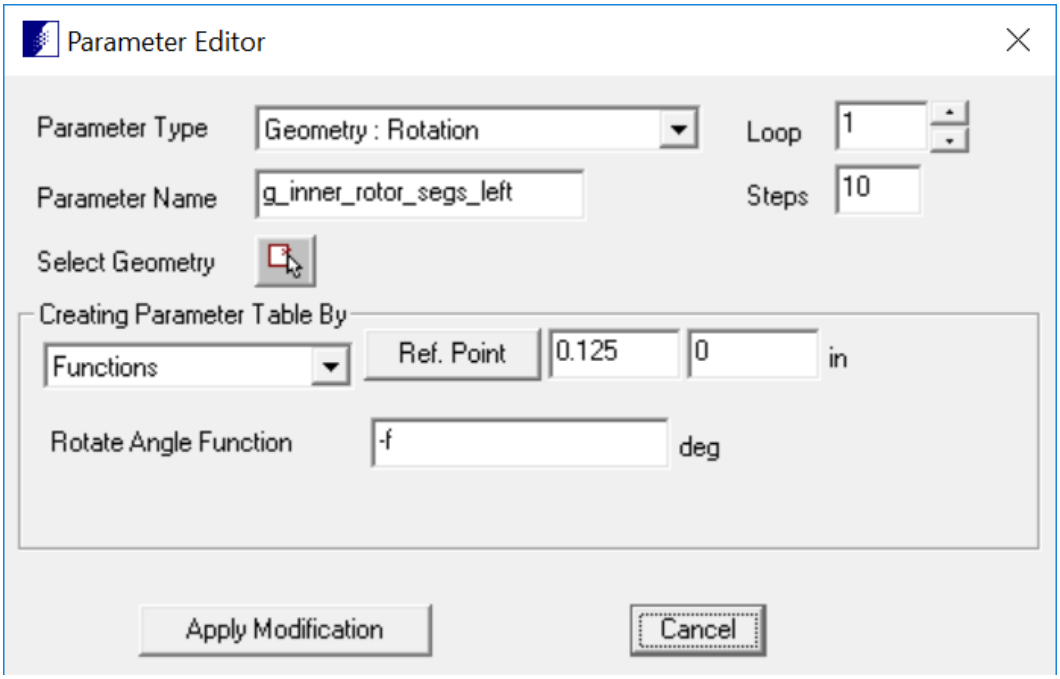


In Loop 1, inner rotor magnets are resized by rotating and stretching their two sides. For parameter f_inner_rotor_segs_right, one side of the magnets are rotated and stretched to the right.



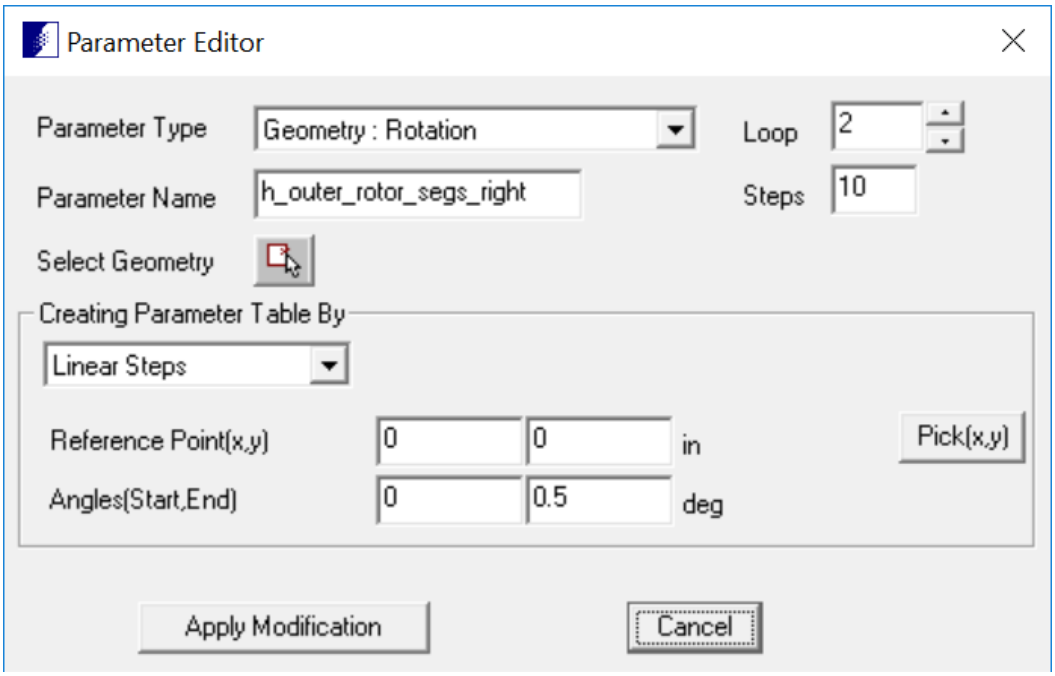
For parameter g_inner_rotor_segs_left, the other side of the magnets are rotated and stretched in the opposite position to change the size of magnets. The “f” in the function definition will be substituted with values from parametric variable f_inner_rotor_segs_right.

Note: the 1st letter of a parametric variable can be used in a function of another parametric variable. The “#” symbol can also be used in a function to substitute for the current step number.

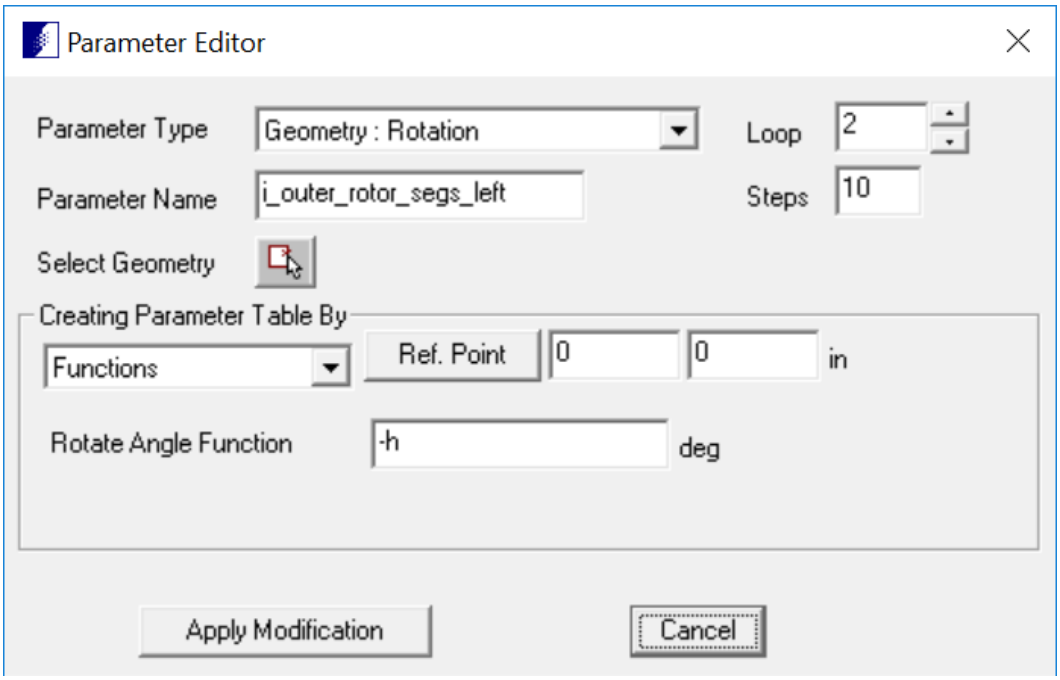


IMPORTANT: If you have more than one parametric variable defined in a loop, it is important to define all the parametric variables to be a function of a single parametric variable in the loop. **The optimization algorithm can only optimize one parametric variable per loop.** If a parametric variable 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.

In Loop 2, outer rotor magnets are resized by rotating and stretching their two sides. For parameter h_outer_rotor_segs_right, one side of the magnets are rotated and stretched to the right.

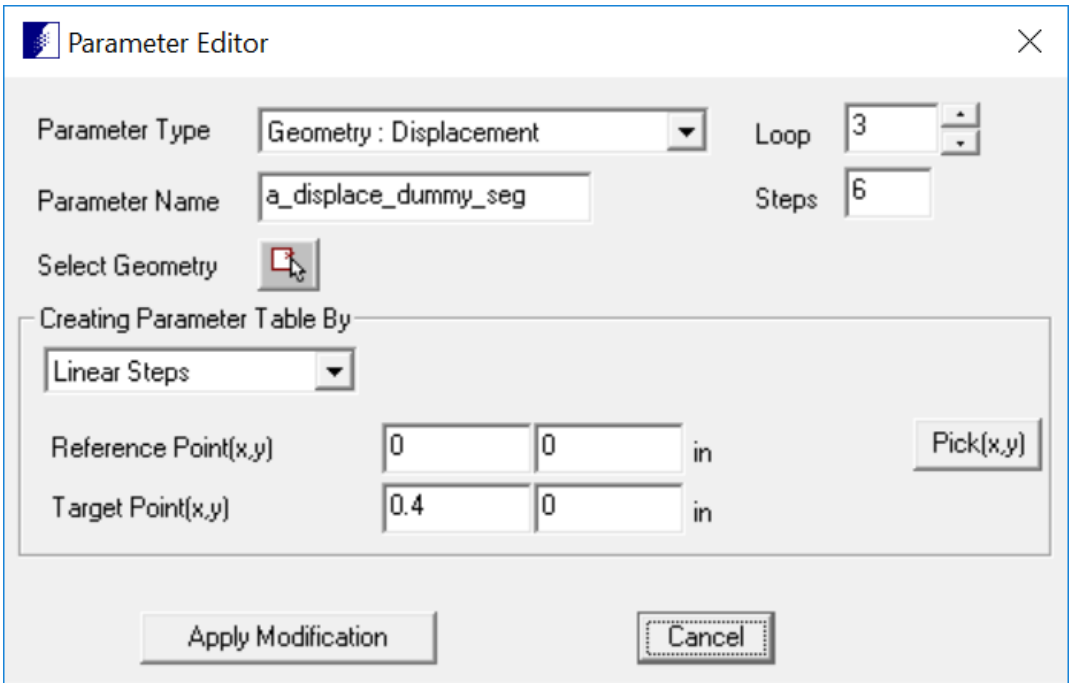


For parameter i_outer_rotor_segs_left, the other side of the magnets are rotated and stretched in the opposite position to change the size of magnets. For each step, the "h" in the function definition will be substituted with values from parametric variable h_outer_rotor_segs_right.

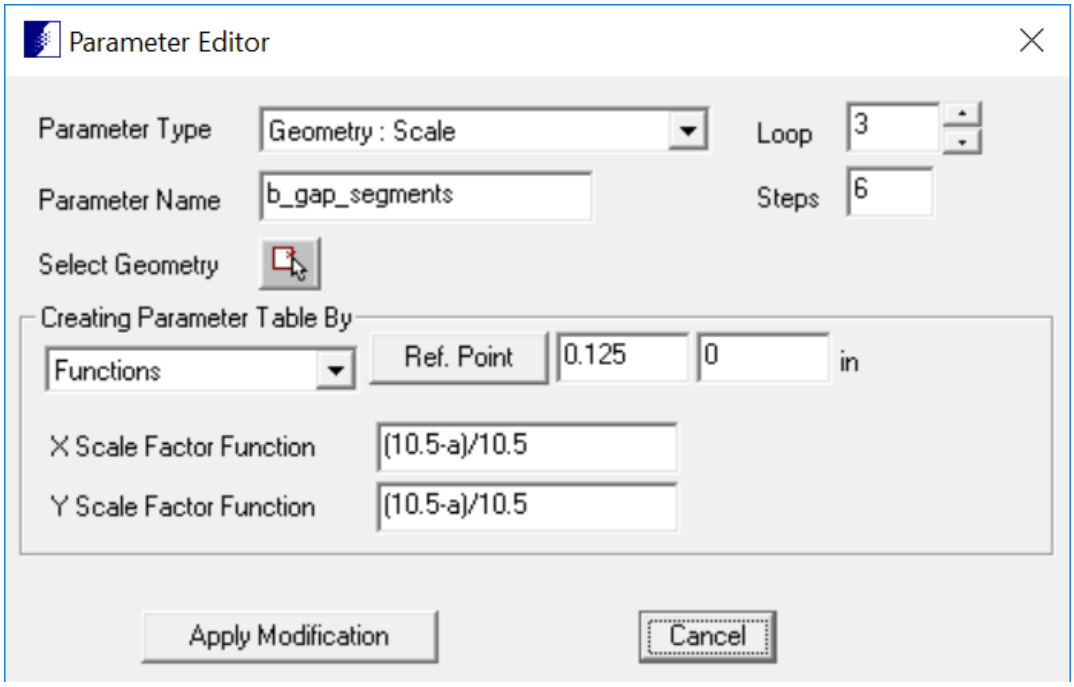


In Loop 3, 4 parametric operations are required. In order to make these 4 parametric variables to operate simultaneously in the same loop, an independent parametric variable will be created to tie all 4 parametric operations together. All 4 parametric variables will be dependent on this new parametric variable.

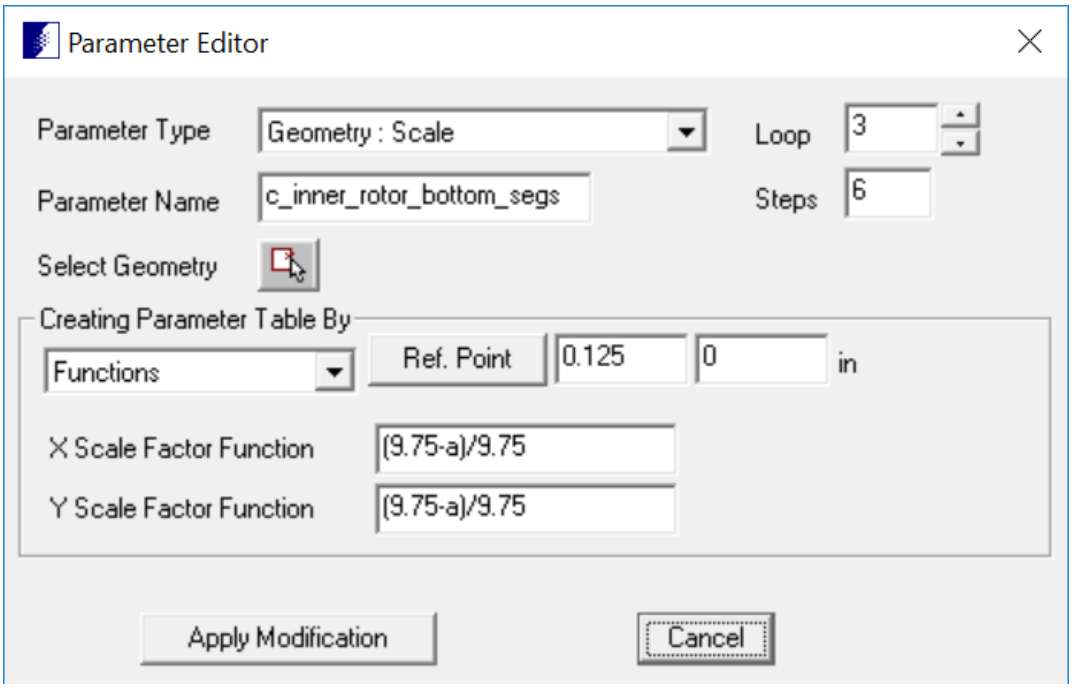
A dummy segment is created in the model and a new parametric variable a_displace_dummy_seg is created to move this segment parametrically from (0,0) to (0.4,0). The only purpose of this parametric variable is to supply the rest of the parametric variables in the loop values between 0 and 0.4.



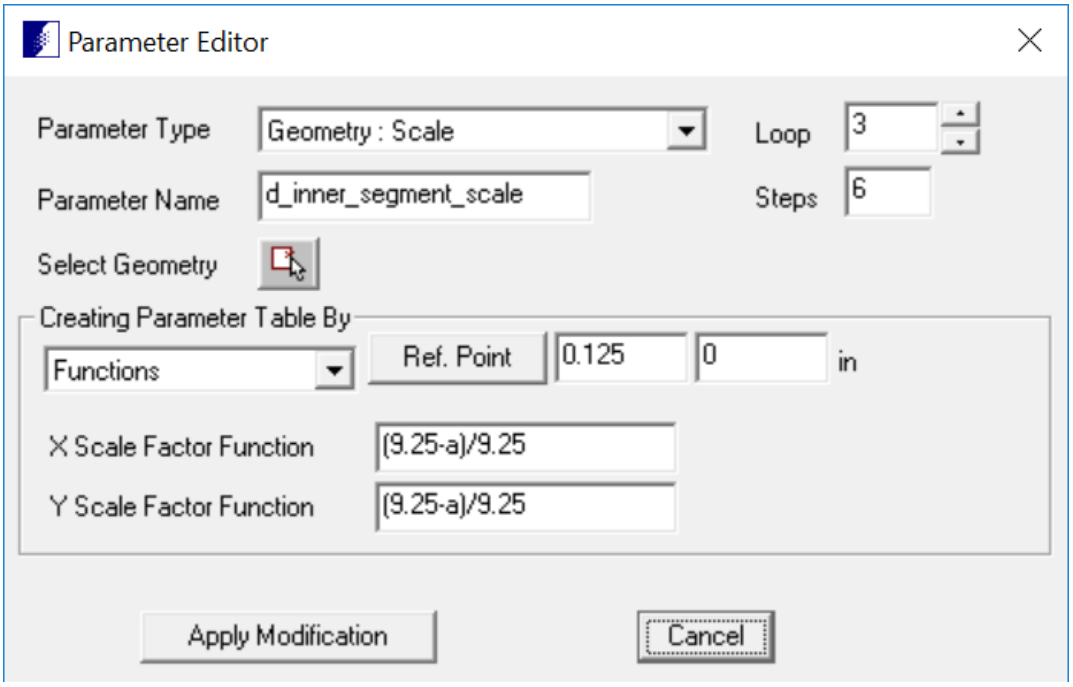
For parametric variable b_gap_segments, the gap between the outer rotor and inner rotor is adjusted by scaling the top segments of the inner rotor magnets. The variable “a” in the function will take values from parametric variable a_displace_dummy_seg from each step.



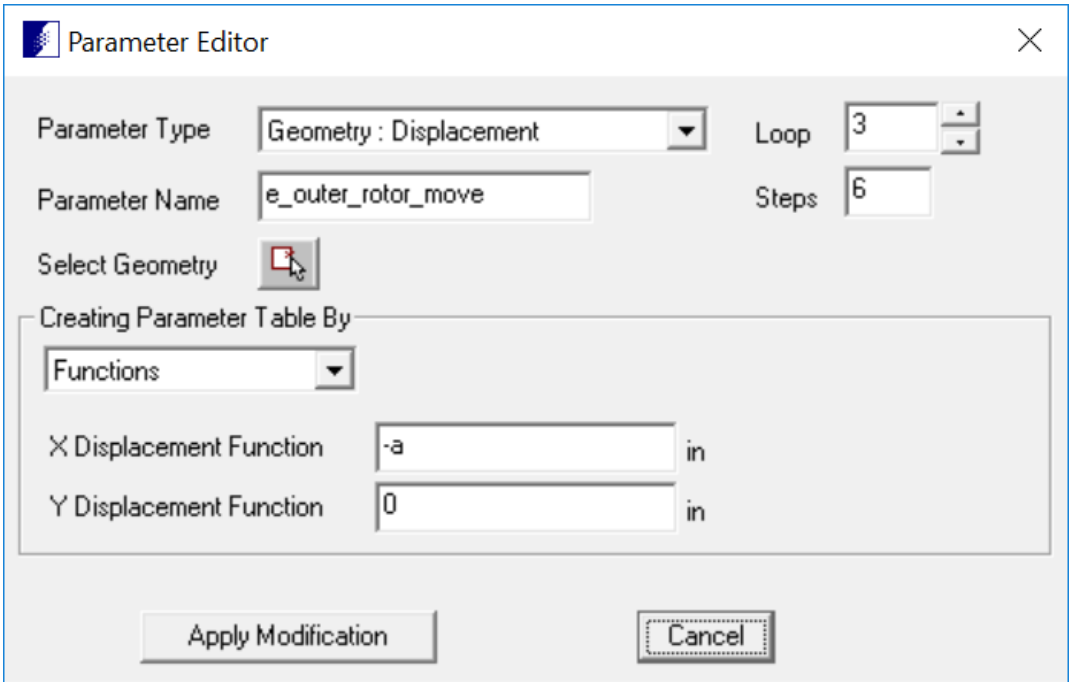
The size of the inner rotor magnets is adjusted by scaling the bottom segments of the inner rotor magnets. Again, the variable “a” is used in the function making this parametric variable a function of parametric variable a_displace_dummy_seg.



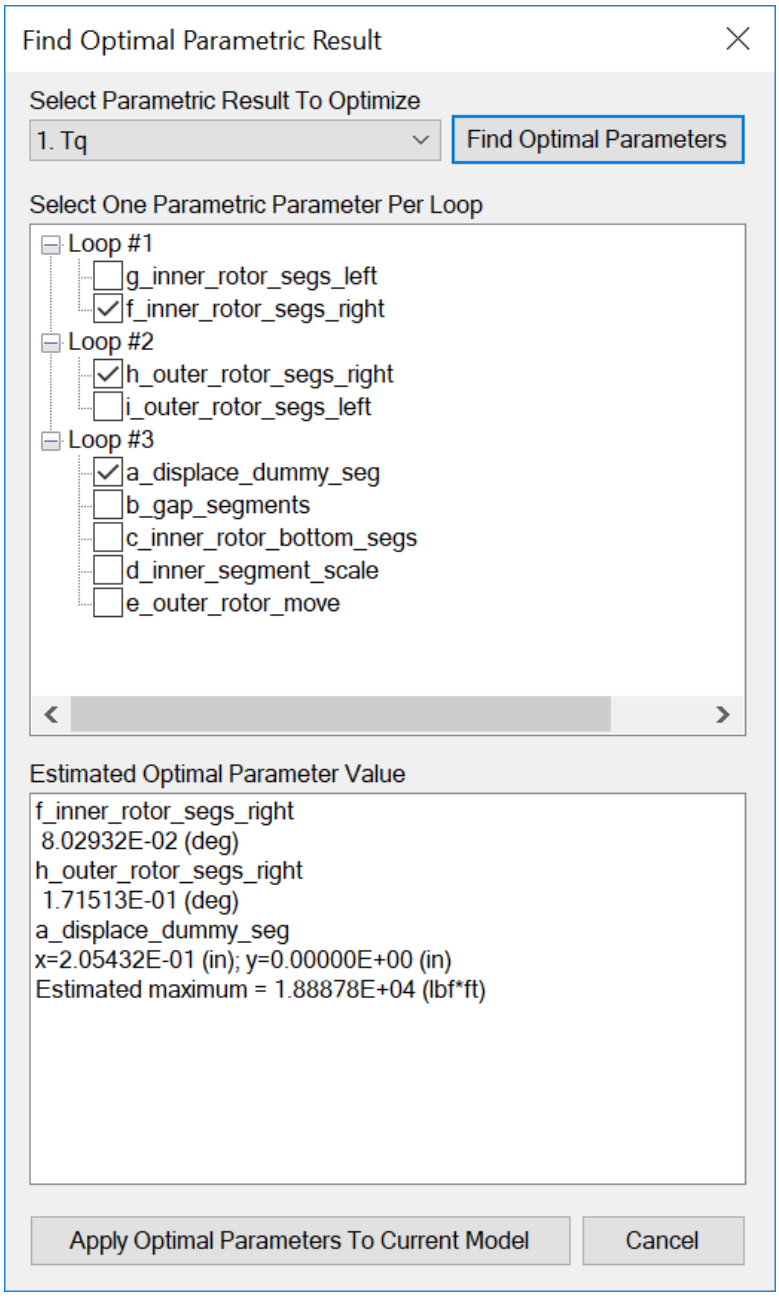
For parametric variable d_inner_segment_scale, the inner rotor core thickness is adjusted to accommodate the increased size of the inner magnets. The amount of scaling is defined as a function of parametric variable a_dispalce_dummy_seg.



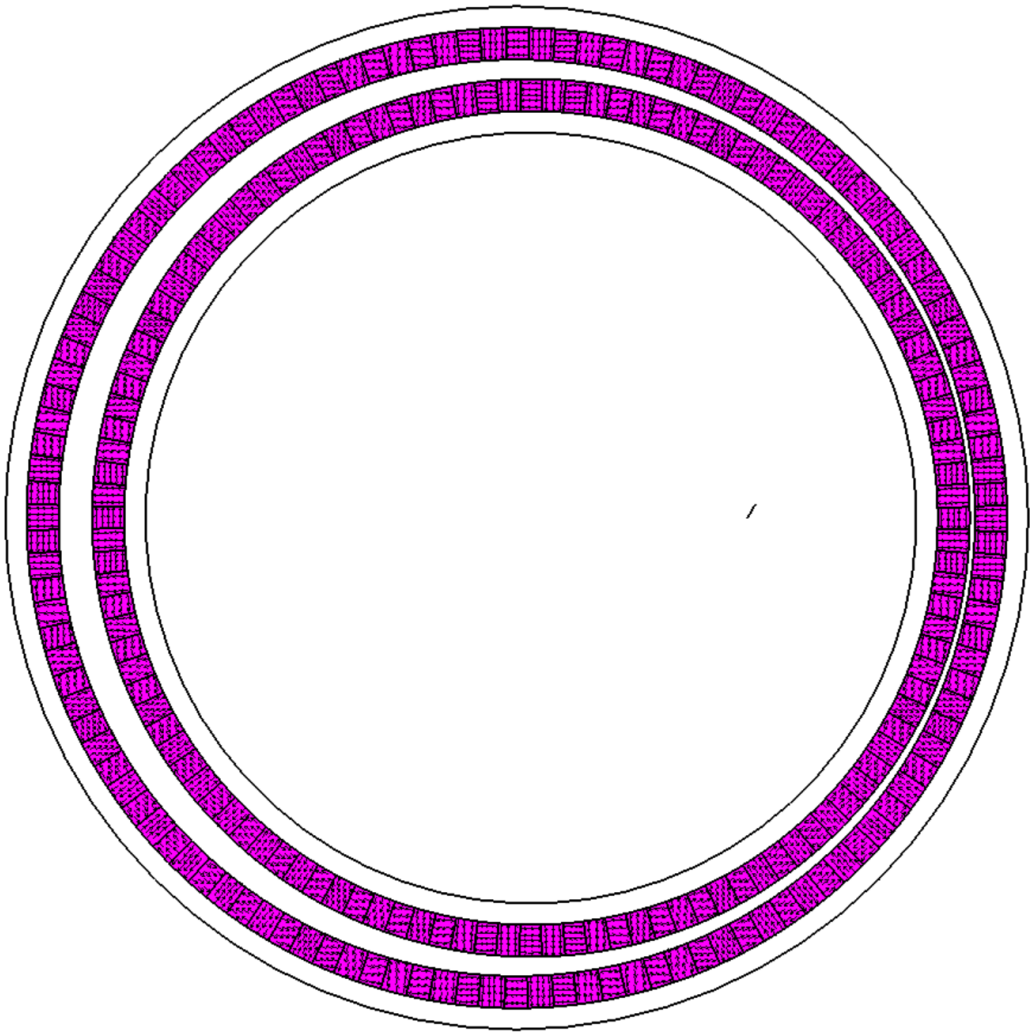
Finally, the entire outer rotor is moved along the X axis to investigate its effect on resulting torque.



From the program Solution menu, select Run Parametrics -> Find Optimal Parametric Result to open the Find Optimal Parametric Result dialog. The parametric variable selected in each loop for optimization should have been selected automatically. **IMPORTANT: It is important to select only the parametric variable in each loop that is not a function of another variable. Failure to do so will produce wrong results.** Select "Tq" from the Select Parametric Result To Optimize drop down list. Click Find Optimal Parameters button. The estimated optimal parameter values and estimated maximum torque will be displayed in the dialog window. Please note that this is an estimate. The actual value can be found by applying the optimal parameters to the model.



Click Apply Optimal Parameters To Current Model button will modify the current model to the configuration that produced the maximum torque value.



Solve the model and calculate the torque at (0,0) will give actual torque value 1.88858E+04 (lbf*ft)