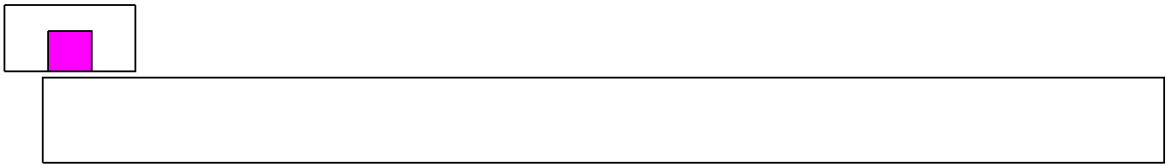
Optimal design of an actuator by parametric optimization

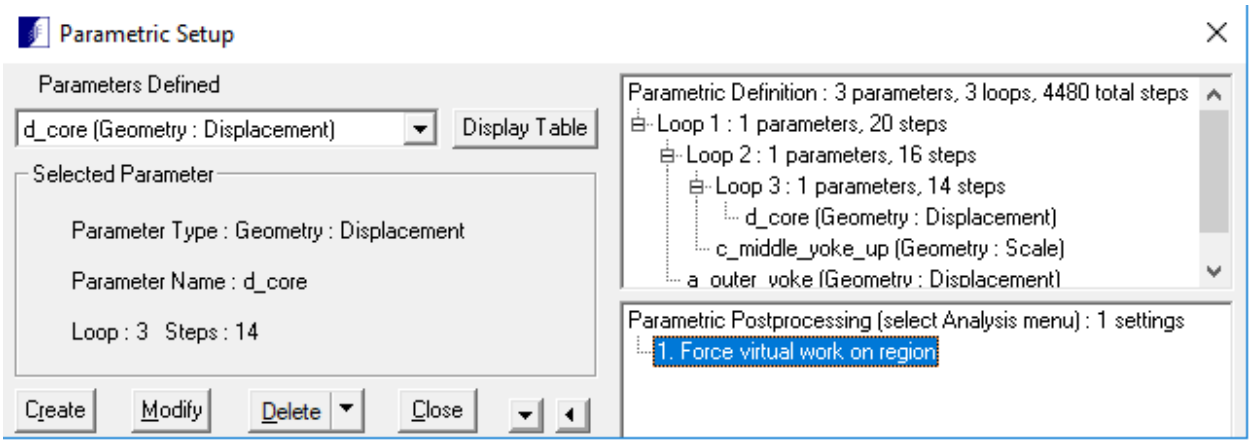
By David Tong: Senior R & D Engineer

The following example demonstrates how to use Parametric and Find Optimal Parametric Result dialog to find the optimal design of an actuator. The optimal actuator configuration will have the best force per area ratio for a given current density.

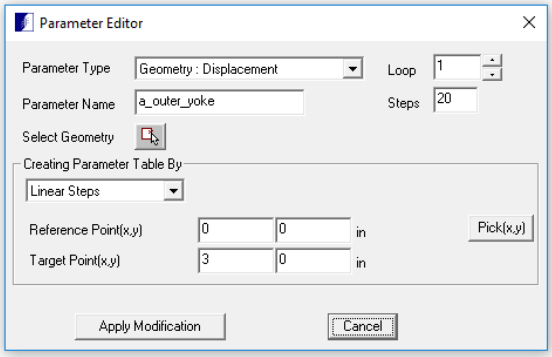
The actuator is made of 1010 Steel and has a current density 2.604E6 A/m^2 assigned to the coil (magenta).

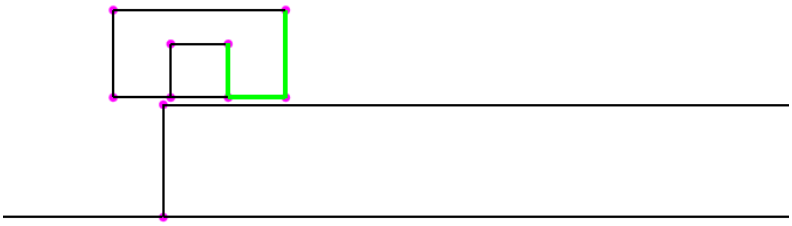


A parametric with 3 parametric variables in 3 loops is setup up to change the actuator shape while keeping current density constant. The total number of steps is 4480. The Force virtual work on the yoke is calculated for each step.

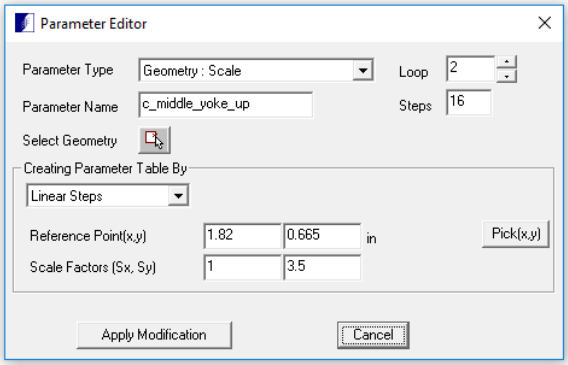


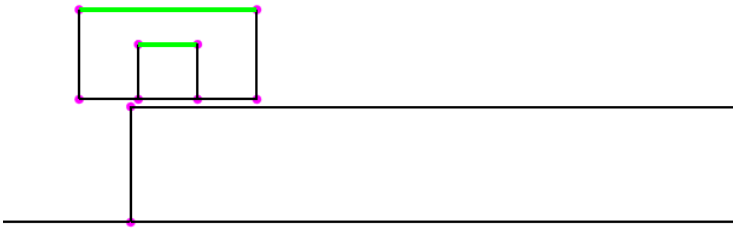
In Loop 1, the outer yoke is stretched to the right along the X axis. The amount of displacement is between 0 to 3 inches.



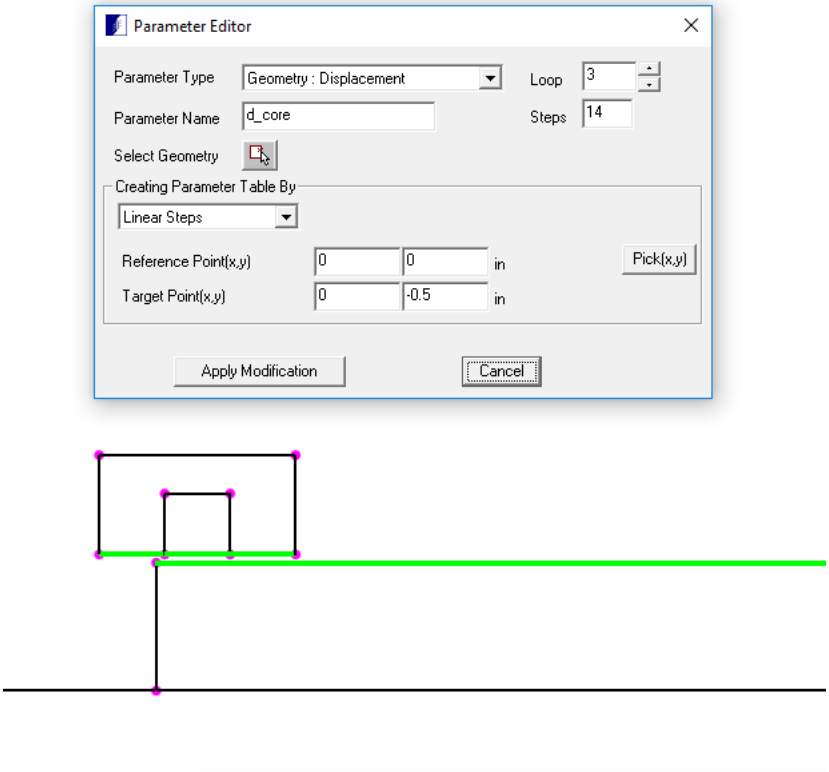


In Loop 2, the yoke is stretched up along the Y axis. The amount of scaling is between 1 and 3.5.





In Loop 3, both the core and yoke are stretched down the Y axis. The amount of displacement is between 0 to 0.5 inches.



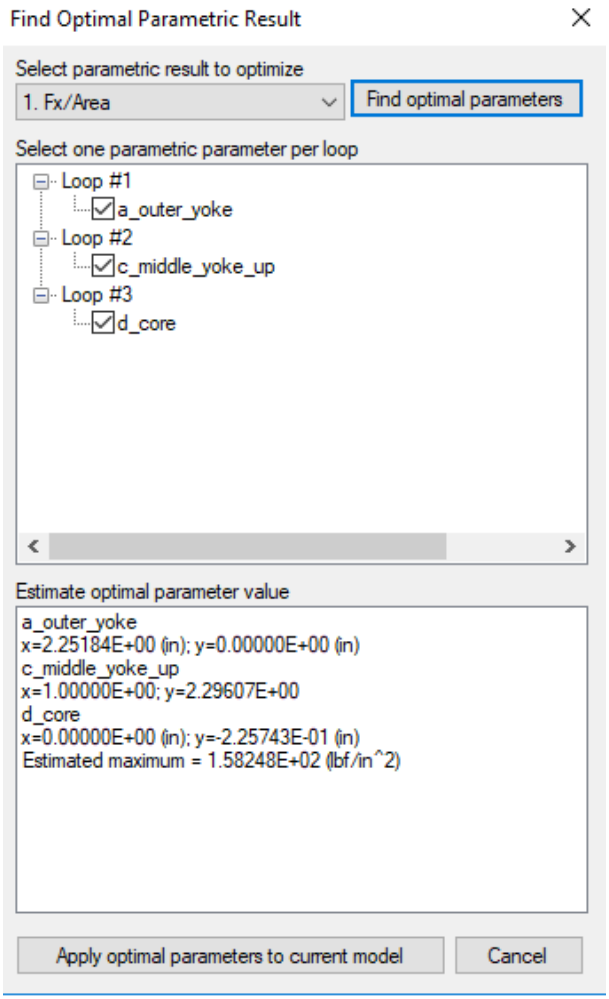
After the parametric run is completed, the Final Parametric Table is shown below. The table contains the values for the parametric variables at each step and force components calculated on the yoke. Also included in the table are the force per area on the yoke. The force per area will be used by optimization in the next step.

Final Parametric Table

		d_core (3)		a_outer_yoke (1)		c_middle_yoke_up (2)							
		Displacement		Displacement		Scale							
Steps	Loop Steps	X Disp.(in)	Y Disp.(in)	X Disp.(in)	Y Disp.(in)	X Scale	Y Scale	1. Fx(lbf)	1. Fy(lbf)	1. Fm(lbf)	1. Fa(deg)	1. Area(in^2)	1. Fx/Area(lbf/in^2)
1	(1,1,1)	0	0	0	0	1	1	1.75691611	-6.09768461	6.34574754	-73.9268064	0.4656	3.77344525
2	(1,1,2)	0	-0.0384615385	0	0	1	1	2.24401589	-7.74668179	8.06515257	-73.8450474	0.502523077	4.46549819
3	(1,1,3)	0	-0.0769230769	0	0	1	1	2.80459365	-9.59065596	9.99231842	-73.699507	0.539446154	5.19902426
4	(1,1,4)	0	-0.115384615	0	0	1	1	3.43410918	-11.6160436	12.1130333	-73.5304759	0.576369231	5.95817575
5	(1,1,5)	0	-0.153846154	0	0	1	1	4.11441739	-13.835277	14.4341026	-73.4382602	0.613292308	6.70673796
6	(1,1,6)	0	-0.192307692	0	0	1	1	4.88641916	-16.2261661	16.94596	-73.2406191	0.650215385	7.51507772
7	(1,1,7)	0	-0.230769231	0	0	1	1	5.69914294	-18.8000352	19.6448862	-73.135565	0.687138462	8.29402405
8	(1,1,8)	0	-0.269230769	0	0	1	1	6.6236553	-21.5459753	22.5411149	-72.9115453	0.724061538	9.14791761
9	(1,1,9)	0	-0.307692308	0	0	1	1	7.59391697	-24.4032991	25.5575543	-72.7146325	0.760984615	9.97906764
10	(1,1,10)	0	-0.346153846	0	0	1	1	8.65404787	-27.4282262	28.7610872	-72.4886738	0.797907692	10.8459261
11	(1,1,11)	0	-0.384615385	0	0	1	1	9.86917992	-30.5890977	32.1417736	-72.11837	0.834830769	11.8217731
12	(1,1,12)	0	-0.423076923	0	0	1	1	11.071121	-33.8082526	35.5748178	-71.8680343	0.871753846	12.6998246
13	(1,1,13)	0	-0.461538462	0	0	1	1	12.4800265	-37.115222	39.1572569	-71.4147356	0.908676923	13.7342836
14	(1,1,14)	0	-0.5	0	0	1	1	13.9302468	-40.3023049	42.6419521	-70.9326023	0.9456	14.7316485
15	(1,2,1)	0	0	0	0	1	1.16666667	2.40195815	-8.27519936	8.61674692	-73.8141085	0.5432	4.42186698
16	(1,2,2)	0	-0.0384615385	0	0	1	1.16666667	2.97262226	-10.1772589	10.6025036	-73.7177207	0.580123077	5.12412344
17	(1,2,3)	0	-0.0769230769	0	0	1	1.16666667	3.64826762	-12.2708169	12.8016722	-73.4421268	0.617046154	5.9124712
18	(1,2,4)	0	-0.115384615	0	0	1	1.16666667	4.30469002	-14.550084	15.1735065	-73.518976	0.653969231	6.58240451
19	(1,2,5)	0	-0.153846154	0	0	1	1.16666667	5.07564441	-17.0355276	17.7755834	-73.4088558	0.690892308	7.34650589
20	(1,2,6)	0	-0.192307692	0	0	1	1.16666667	5.91560967	-19.6414208	20.5129191	-73.2387318	0.727815385	8.12789863
21	(1,2,7)	0	-0.230769231	0	0	1	1.16666667	6.83245582	-22.4889959	23.5039866	-73.1005214	0.764738462	8.93436927
22	(1,2,8)	0	-0.269230769	0	0	1	1.16666667	7.83169281	-25.4303337	26.60897	-72.8829168	0.801661538	9.76932586

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

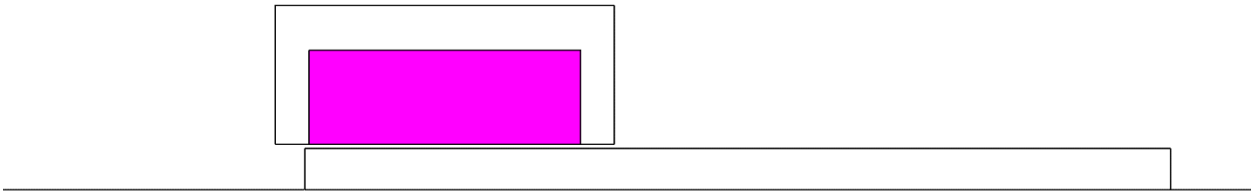
From the program Solution menu, select Run Parametrics -> Find Optimal Parametric Result to open the Find Optimal Parametric Result dialog. The parametric variable in each loop should have been selected automatically for optimization. Select "Fx/Area" from the Select Parametric Result To Optimize drop down list. Click Find Optimal Parameters button. The estimated optimal parameter values and estimated maximum force per area 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.



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.

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.

Click Apply Optimal Parameters To Current Model button will modify the current model to the configuration that produced the optimal force per area.



Solve the model and calculate the force on the yoke to give actual force in X direction 677.7 (lbf). The yoke area is 4.3 in^2. The actual force per area is 677.7 / 4.3 = 157.6 (lbf/in^2)