Optimal Process Parameters Design and Implementation by SmartDO

TECO General Research Laboratory

SmartDO Successful Example

1 40 Frames 100W Servo Motor

Application : Servo Motor TECO Electric Corp.

Goal : Optimize the performance of electric motor

Result : Successful optimization using SmartDO and JMAG

2 6.4kW Hub Motor

Application : Hub Motor for Motorcycle

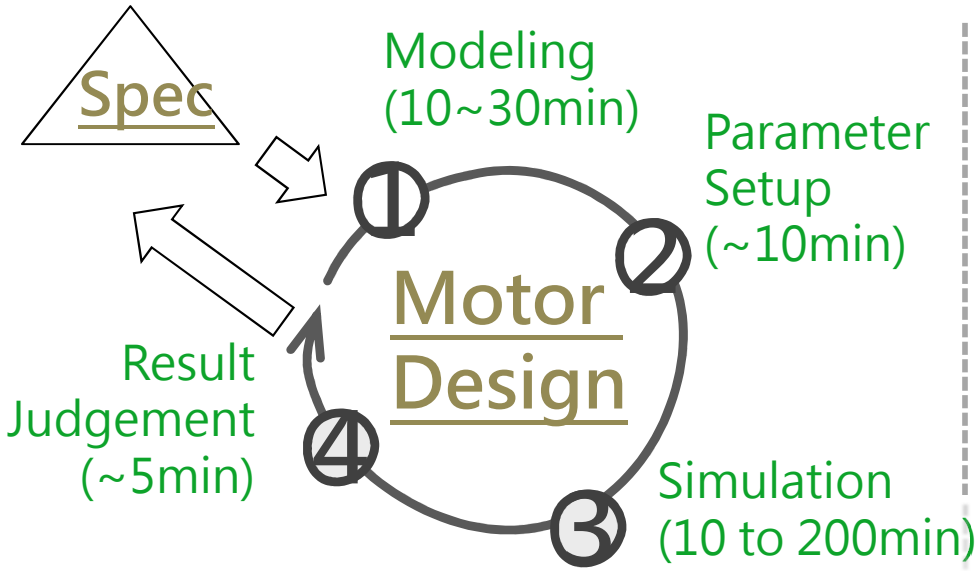
Goal : Develop 6.4kW hub motor according to customer’ s spec

Result : Successful optimization which meet customer requirement using SmartDO and JMAG

SmartDO Successful Example

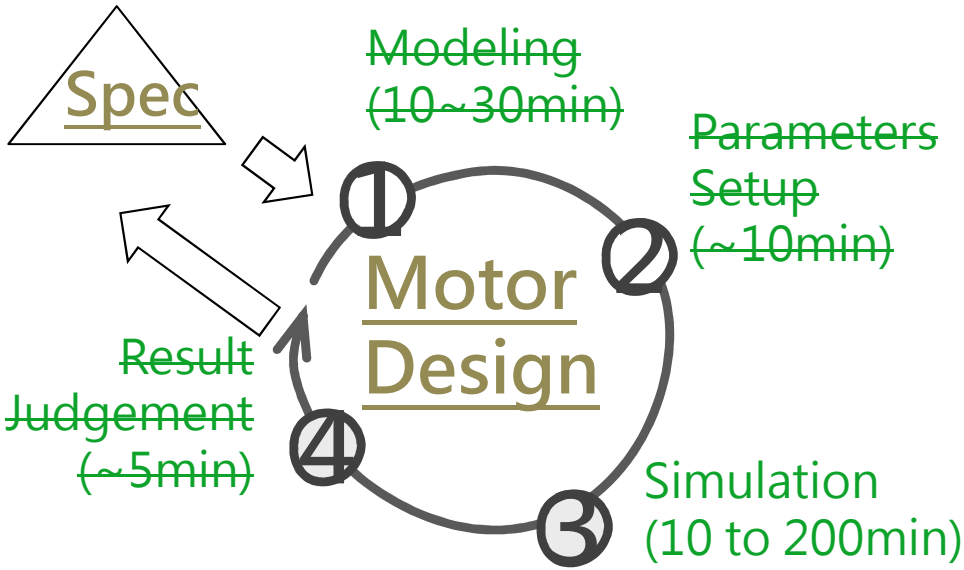
- More precise. Faster. Save human iteration time.

Original :



- 2D design for 1 cycle takes about 1 hr
- Using traditional optimization (DOE,…,etc.)
- Dedicated 8 hours office hours per man

SmartDO Optimization:



① 2D design for 1 cycle save about half hr.
② Push-button and smart optimization for less time
③ 24 hours continuous/automatic smart design
④ Save 1 man powerful for more productive activites.

Case 2

2 6.4kW Hub Motor

Purpose：

Optimize the hub motor of rare wheel with direct driving. Must reduce the weight of magnet and silicon lamination yet still satisfying performance requirement. Cost is the main concern。

Product Spec/Target：

-Rotor outer diamenter270mm

-stack length 50mm

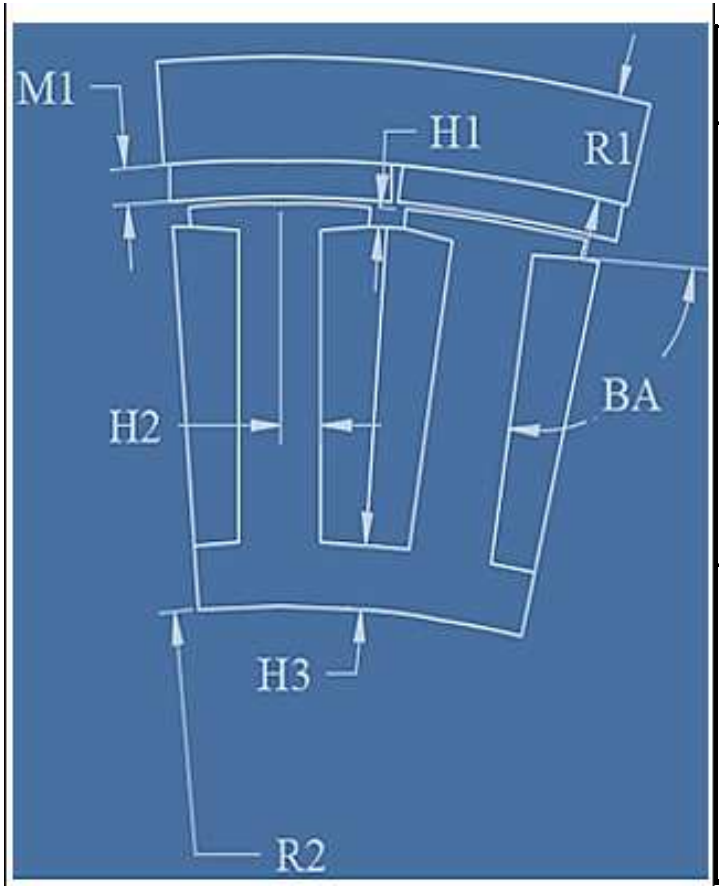
-Air Gap 0.5mm

- N42SH magnet
- 35CS250 silicon lamination
- 96Vdc

Development Goal:

- Maximize the efficiency
- Minimize the weight of magnet
- Minimize the weight of silicon lamination

Case 2



	Name	Sym	lower limit	initial	upper limit
Geometry	rotor back-iron	R1	7	8	10
	stator inner radius	R2	87	92.5	95
	magnetic width	M1	2	2.9	3
	shoe height	H1	1	1.5	2
	tooth width	H2	3	3.5	4
	stator yoke height	H3	4	5	8
	stator boot angle	BA	90	95	110
Electricity	max phase angle	beta	160	180	200
	max current(*Arms*)	current	50	70	90
	# of turns	TU	8	11	14
	# of strands	NS	1	4	7
	wire diameter	WD	0.9	1.1	1.2

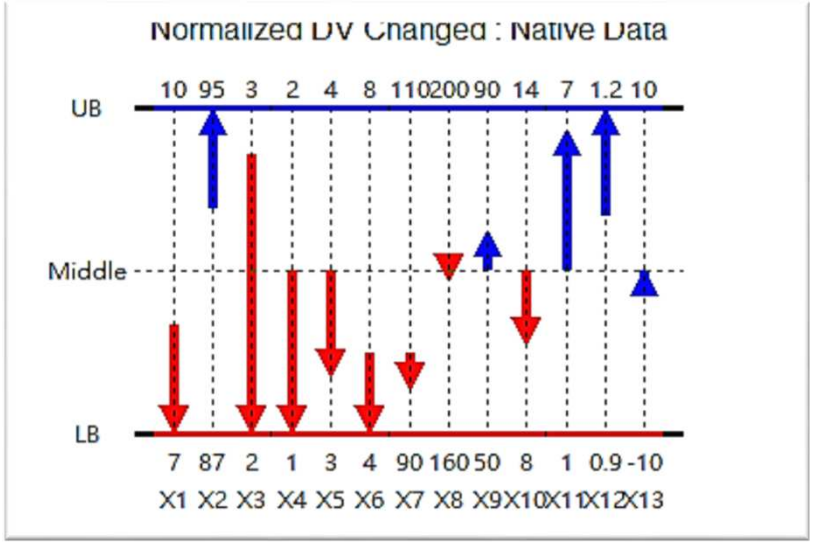
7 Design Variables for geometry and 5 Design Variables for electricity conditions.4 constraints : maximum torque > 215 *N.m* ; counter EMF < 60 *Vrms* ; current density < 12 A/mm^2 ; fill ratio < 55 % , model defined as : maximize torque, minimize weight of magnet and silicon lamination。

Case 2

Result of SmartDO optimization

	Name	Sym	lower limit	initial	OPT	upper limit
Geometry	rotor back-iron	R1	7	8	7.00	10
	stator inner radius	R2	87	92.5	95.00	95
	magnetic width	M1	2	2.86	2.00	3
	shoe height	H1	1	1.5	1.00	2
	tooth width	H2	3	3.5	3.13	4
	stator yoke height	H3	4	5	4.00	8
	stator boot angle	BA	90	95	92.62	110
Electricity	max phase angle	beta	160	180	178.73	200
	max current(*Arms*)	current	50	70	74.96	90
	# of turns	TU	8	11	9.72	14
	# of strands	NS	1	4	6.58	7
	wire diameter	WD	0.9	1.1	1.20	1.2
Specification	max torque	Tout		254.6	215.00	
	Counter EMF	EMF		71.9	57.40	
	current density	CD		18.4	10.10	
	fill ratio	SFF		36.4	54.70	
	efficiency	Eff		84.9	90.70	
	magnetic weight	Mweight		836.4	592.50	
	silicon lamination weight	Cweight		6769.2	5959.70	

Constraints	max torque	Tout	>	215	N.m
	Counter EMF	EMF	<	60	Vrms
	current density	CD	<	12	A/mm²
	fill ratio	SFF	<	55	%
Objective	efficiency	Eff	maximize		
	magnetic weight	Mweight	minimize		
	silicon lamination weight	Cweight	minimize		



Conclusion

- The optimal design by SmartDO (compared with prototype)
  - efficiency improved by 6.8%
  - Weight of magnet reduced by 29.2%
  - Weight of silicon lamination reduced by 12.3%
- Winding parameters will be finalized by further post-processing/optimization utilities.