電機設計之優化分析-案例探討

演講人:王培仁

博士生:蘇韋銘

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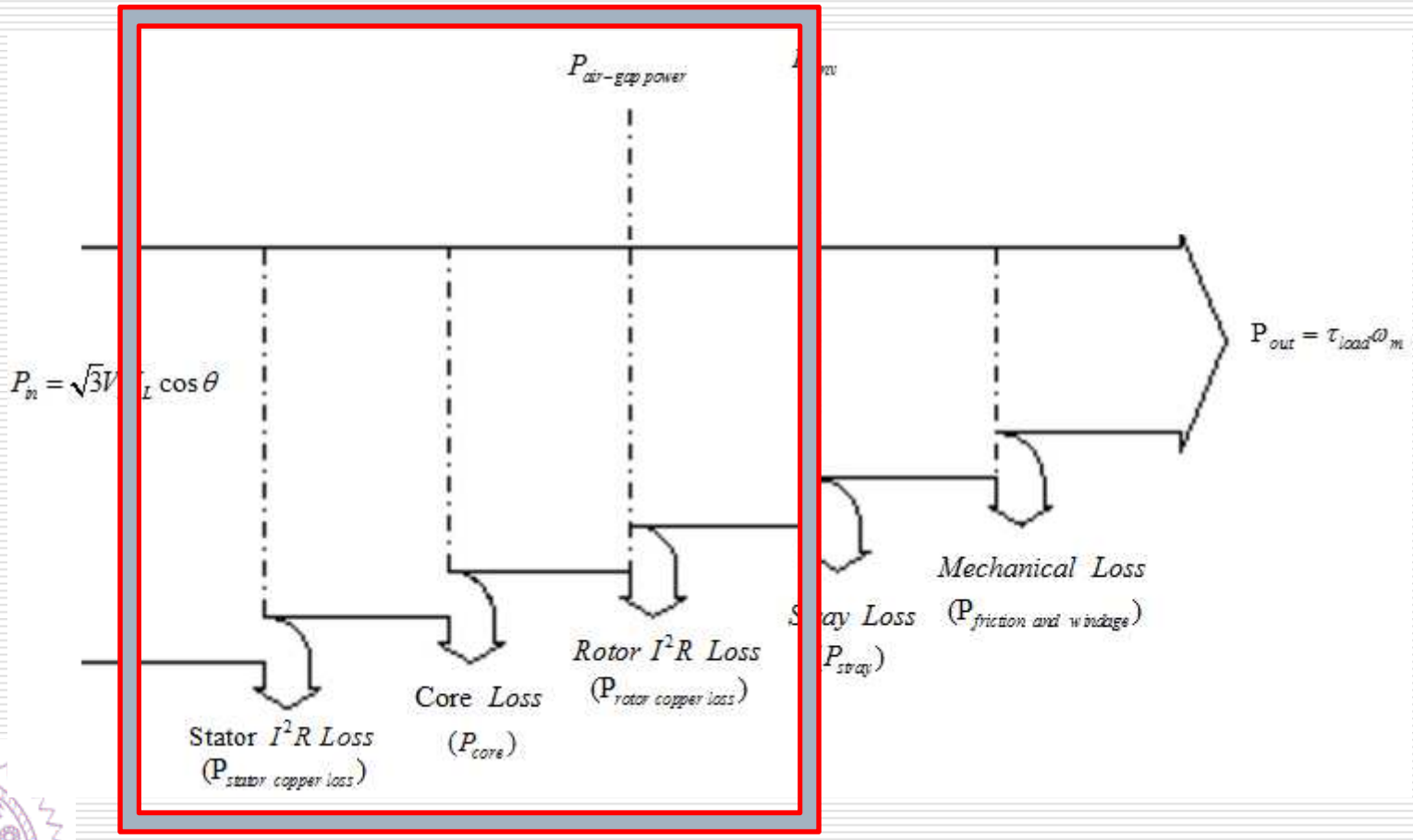
Outline

- ANSYS RMxprt- design pack for major electric machines in mathematical formulae.
- SmartDo- script settings for IM optimization with constraints.
- Case study- optimal design of Induction motors
- Concluding Remarks

2D FEM for optimization



Electrical machine Design: RMxprt

Driving conditions

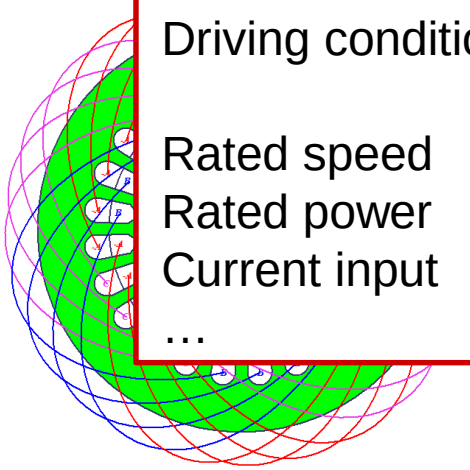
Rated speed
Rated power
Current input
…

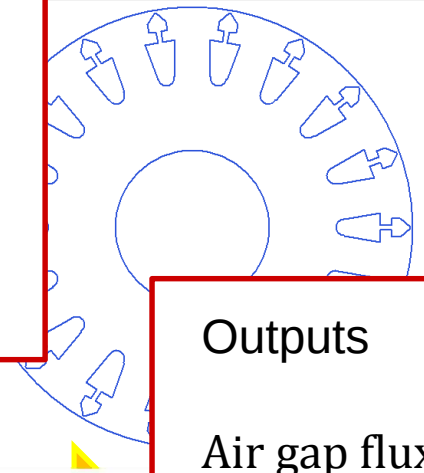
Inputs

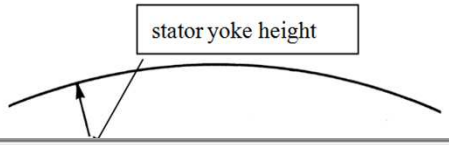
Dimensions
Materials
Windings
…

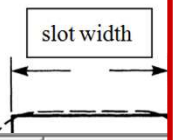
Outputs

Air gap flux density
Output torque
Efficiency
…



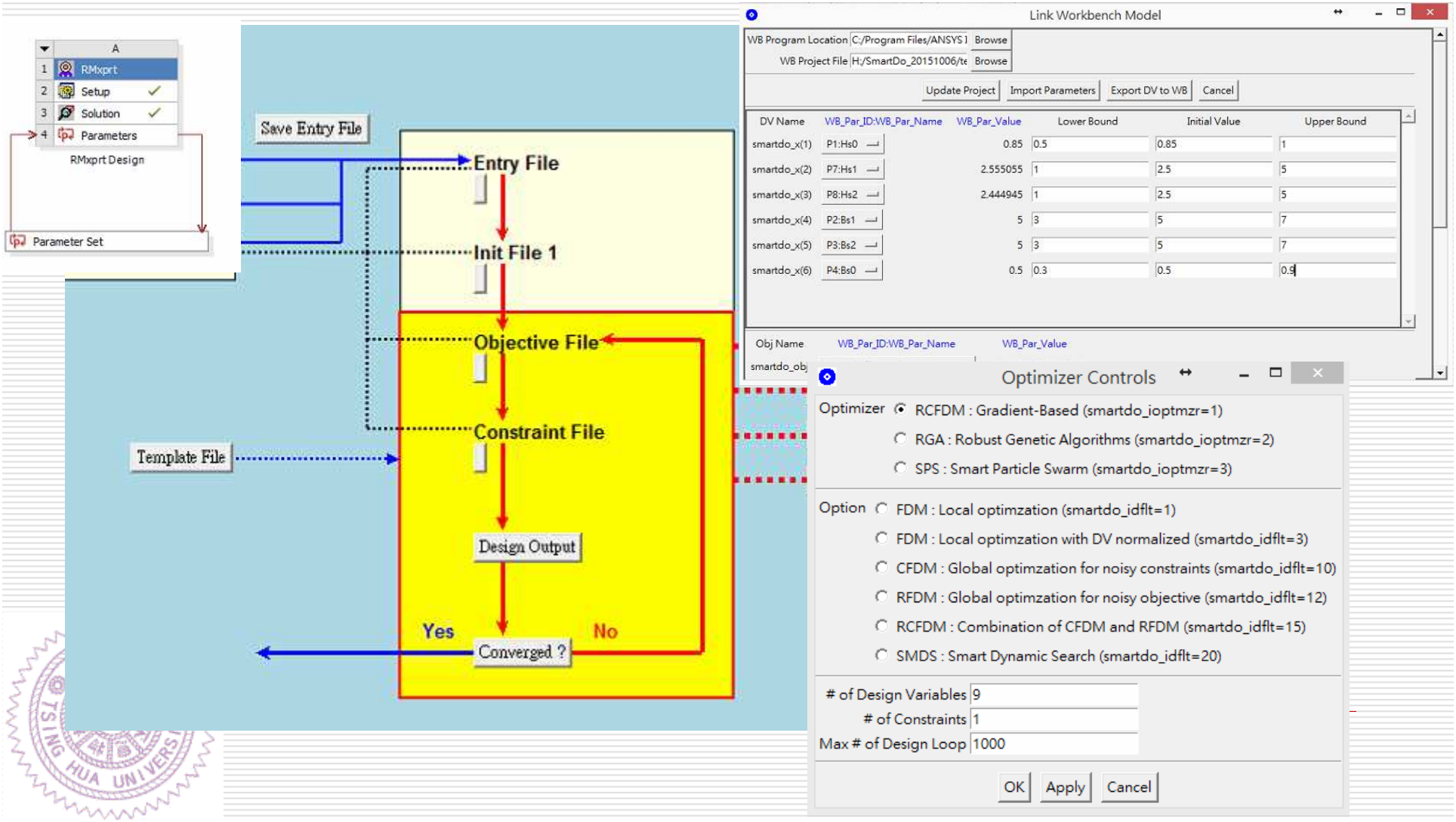






	Value	Unit	Evaluated		
Name	Setup2				
Enabled	☑				
Operation T...	Motor			Motor or generator	☑
Load Type	Const Speed			Mechanical load ty...	☐
Rated Outp...	7460	W	7460W	Rated mechanical ...	☐
Rated Volta...	220	V	220V	Applied or output r...	☐
Rated Speed	3523.2	rpm	3523.2rpm	Given rated speed	☐
Operating T...	69.8	cel	69.8cel	Operating tempera...	☐

SmartDo Optimization

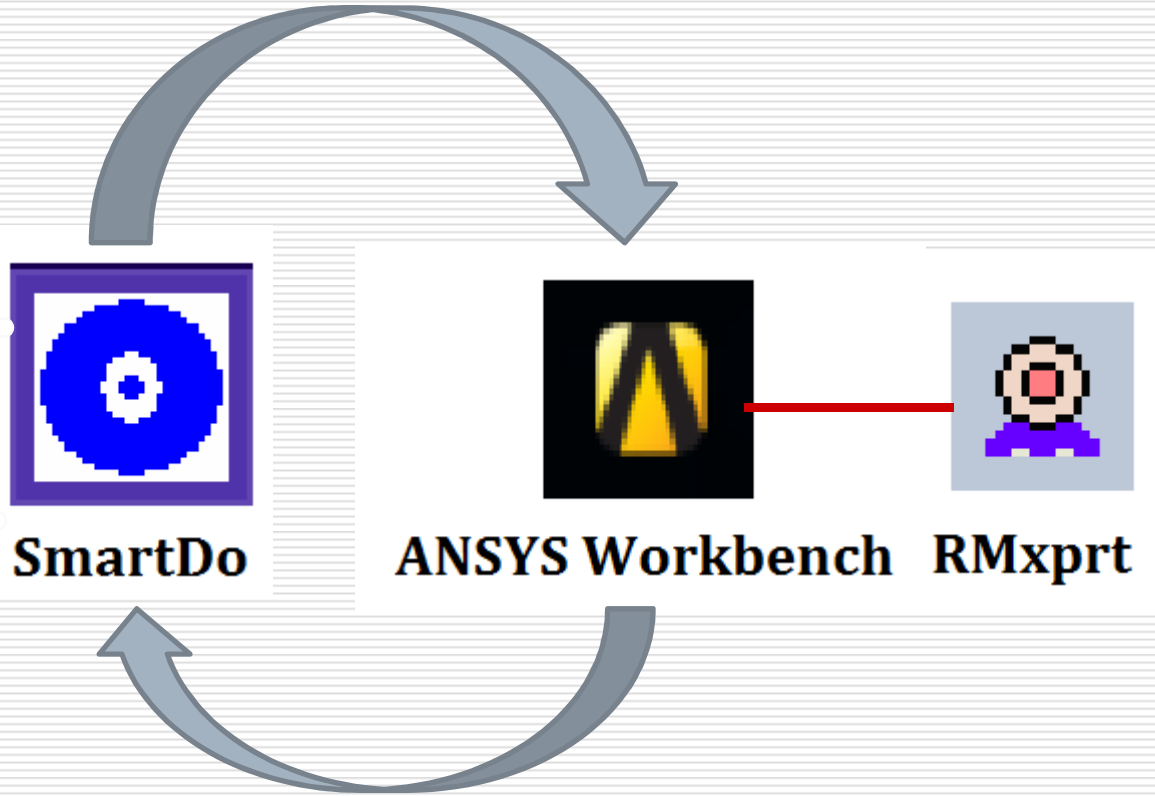


SmartDo optimization with RMxprt

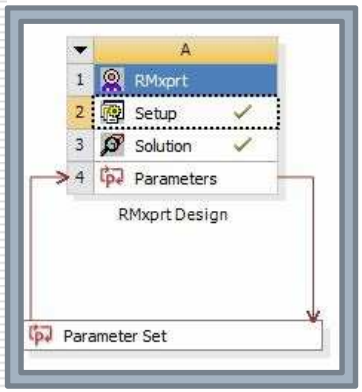
Design constrain

optimization objective

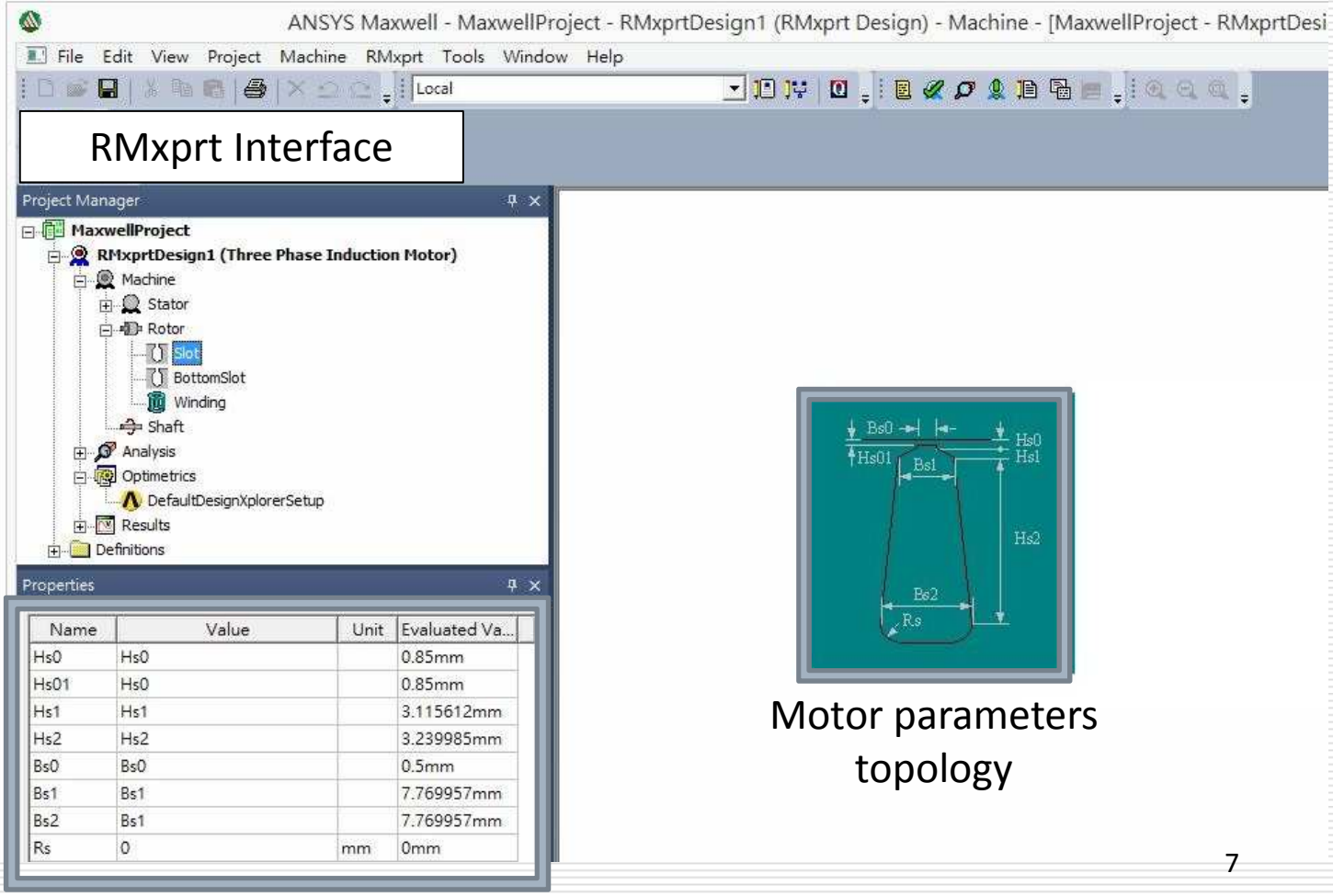
optimization Strategies



Parameter setting in ANSYS WB



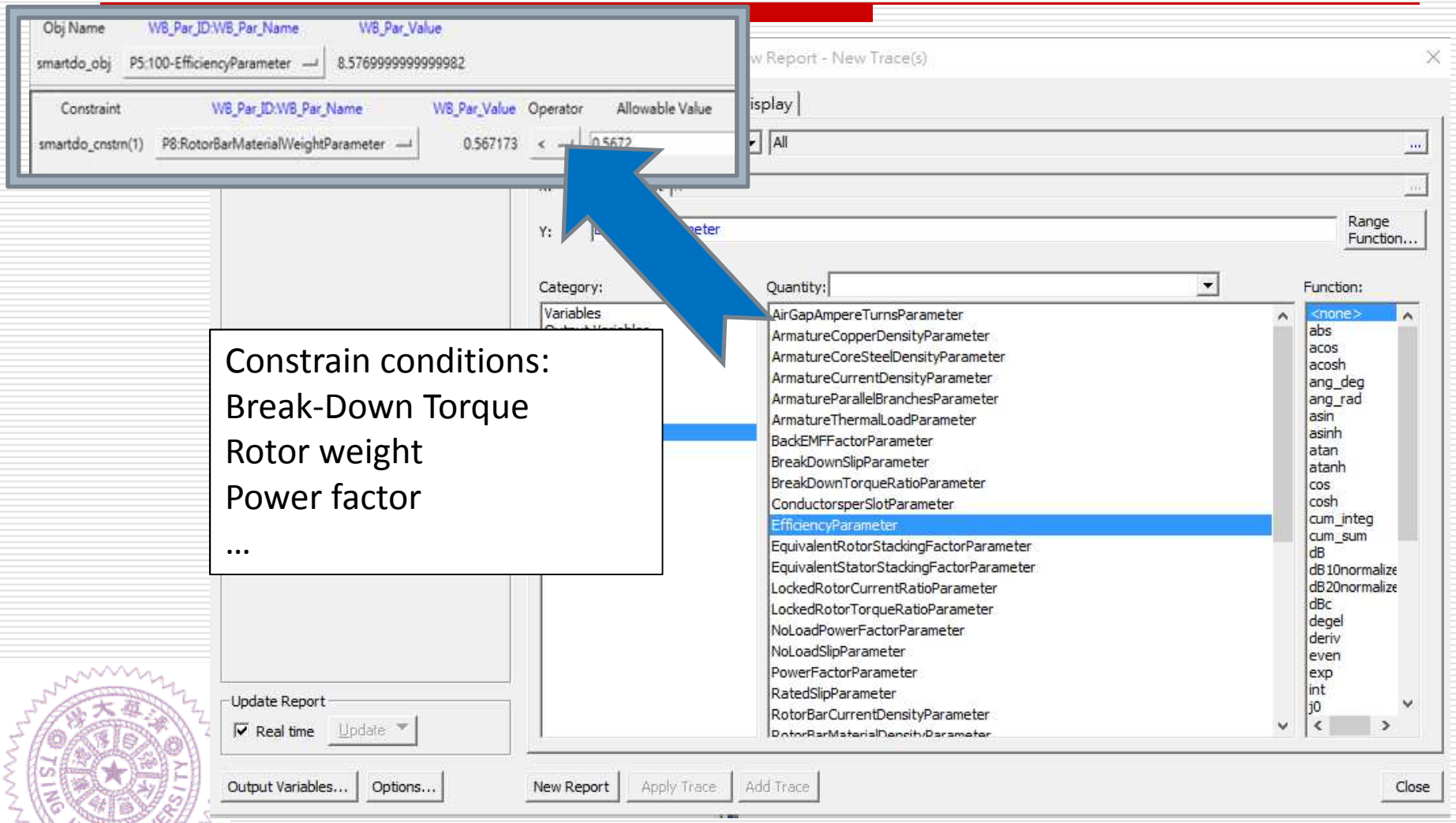
ANSYS WB Interface



Motor parameters setting

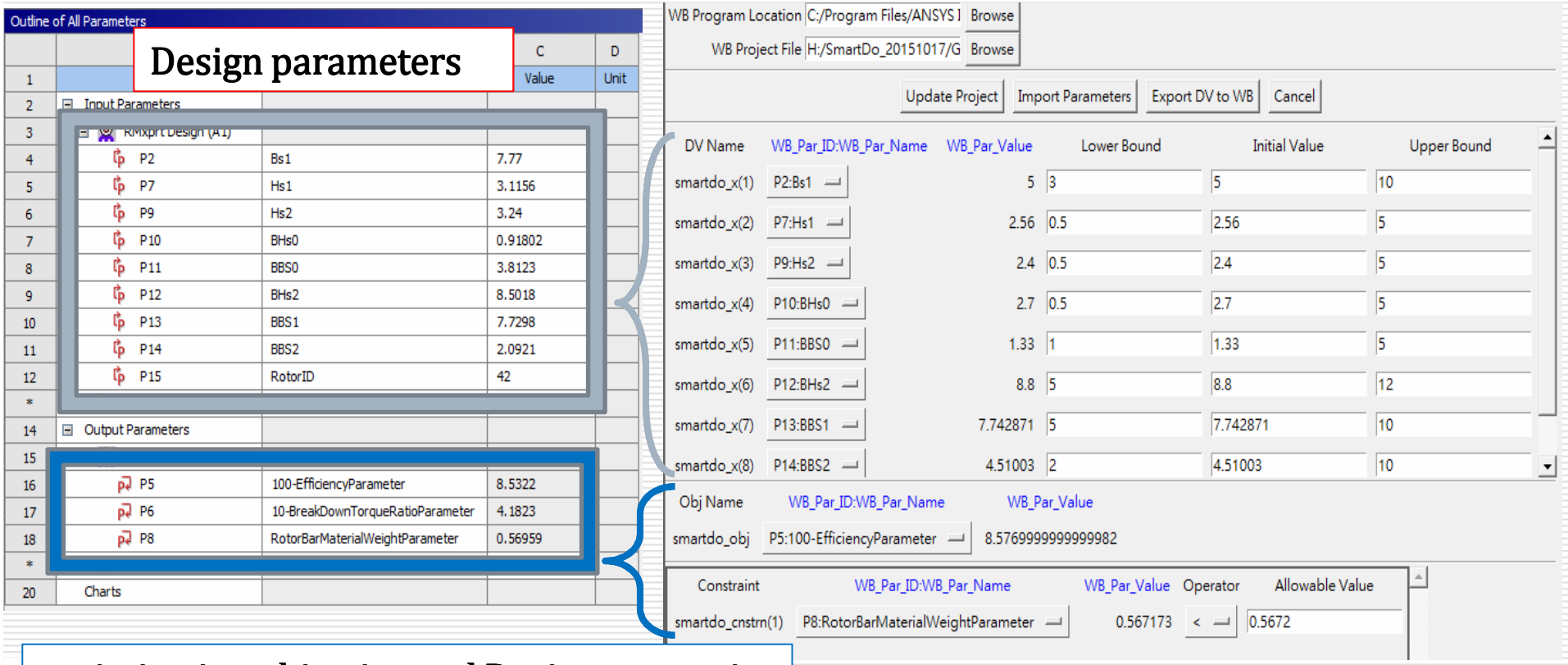
Motor parameters topology

Parameter setting for constraints



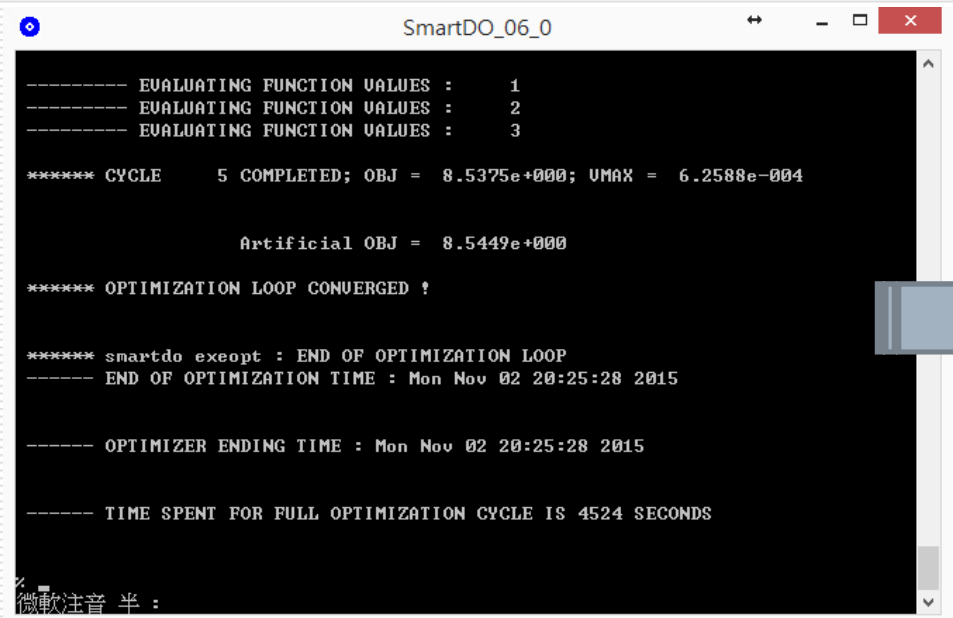
Constrain conditions:
Break-Down Torque
Rotor weight
Power factor
…

Design parameters in SmartDo



optimization objective and Design constrain

Optimization feedback to ANSYS WB



Outline of All Parameters

	A	B	C	D
1	ID	Parameter Name	Value	Unit
2	Input Parameters			
3	RMxprt Design (A1)			
4	P2	Bs1	7.4569	
5	P7	Hs1	3.2116	
6	P9	Hs2	3.2184	
7	P10	BHs0	0.5	
8	P11	BBS0	3.8113	
9	P12	BBS1	7.5505	
10	P13	BBS2	3.3487	
11	P14	BHs2	7.7962	
*	New input parameter	New name	New expression	
13	Output Parameters			
14	RMxprt Design (A1)			
15	P5	100-EfficiencyParameter	8.5238	
16	P6	10-BreakDownTorqueRatioParameter	4.2008	
17	P8	RotorBarMaterialWeightParameter	0.5731	
*	New output parameter		New expression	
19	Charts			

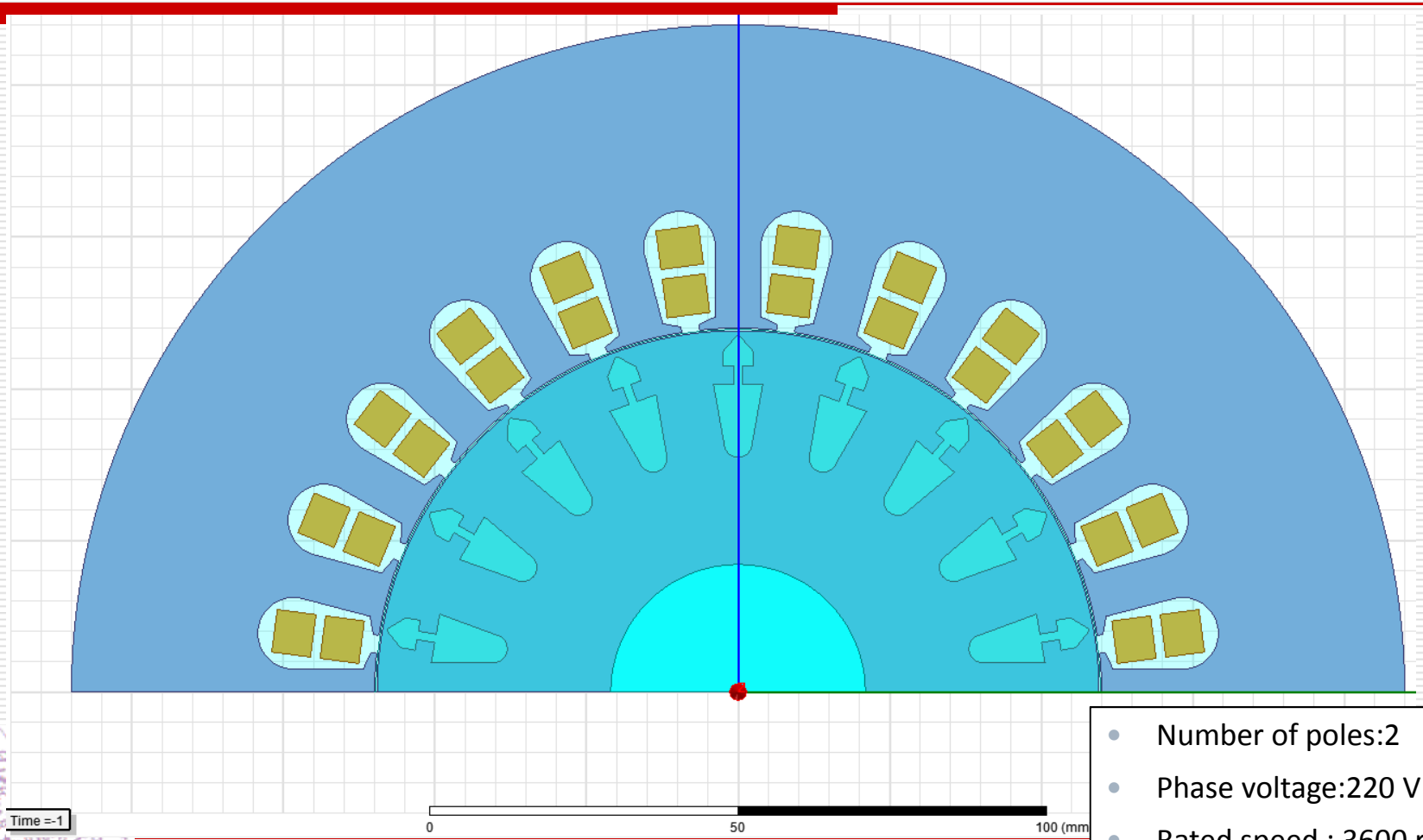
SmartDo

Result rewrite to ANSYS WB automatically

ANSYS Workbench

RMxprt

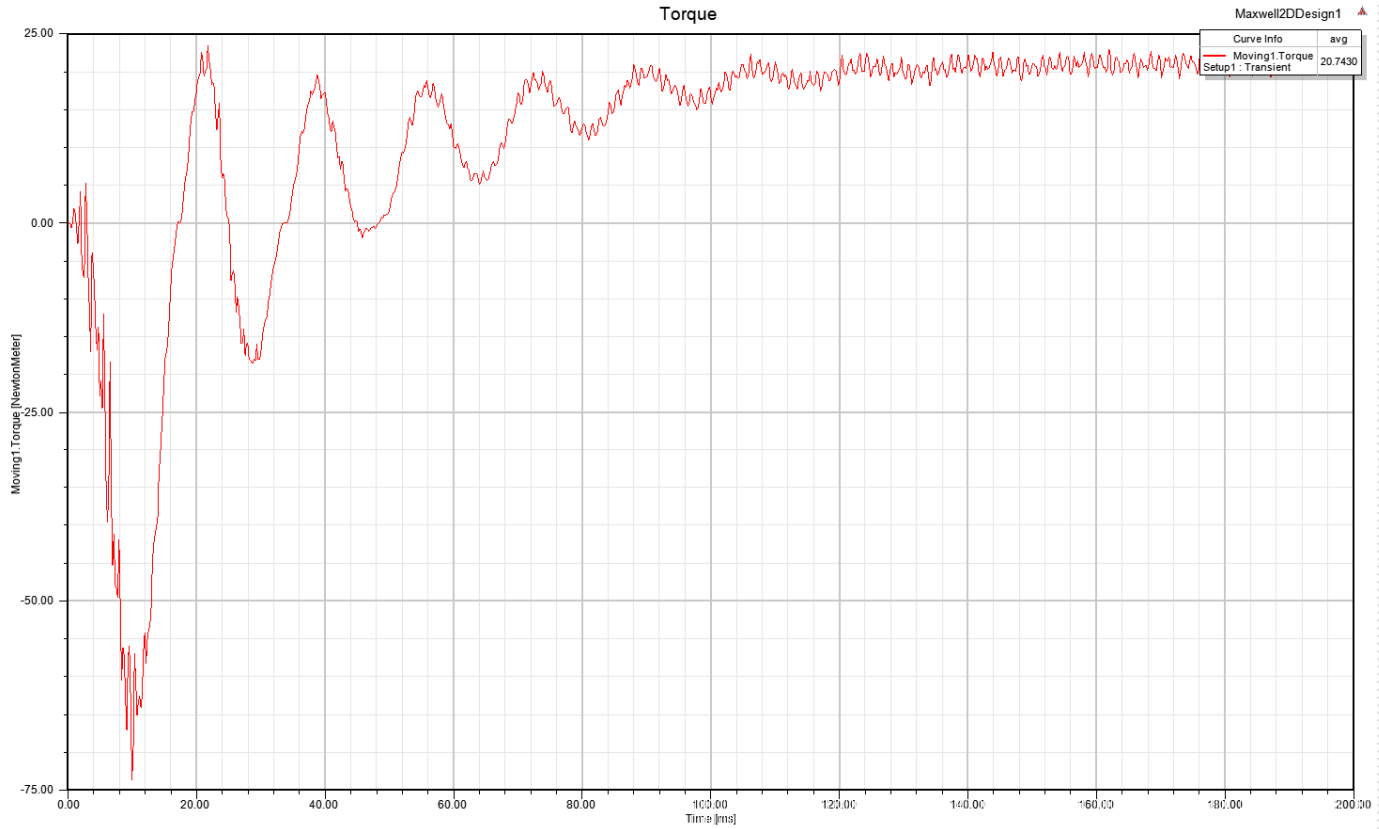
Induction Machine Design Optimization



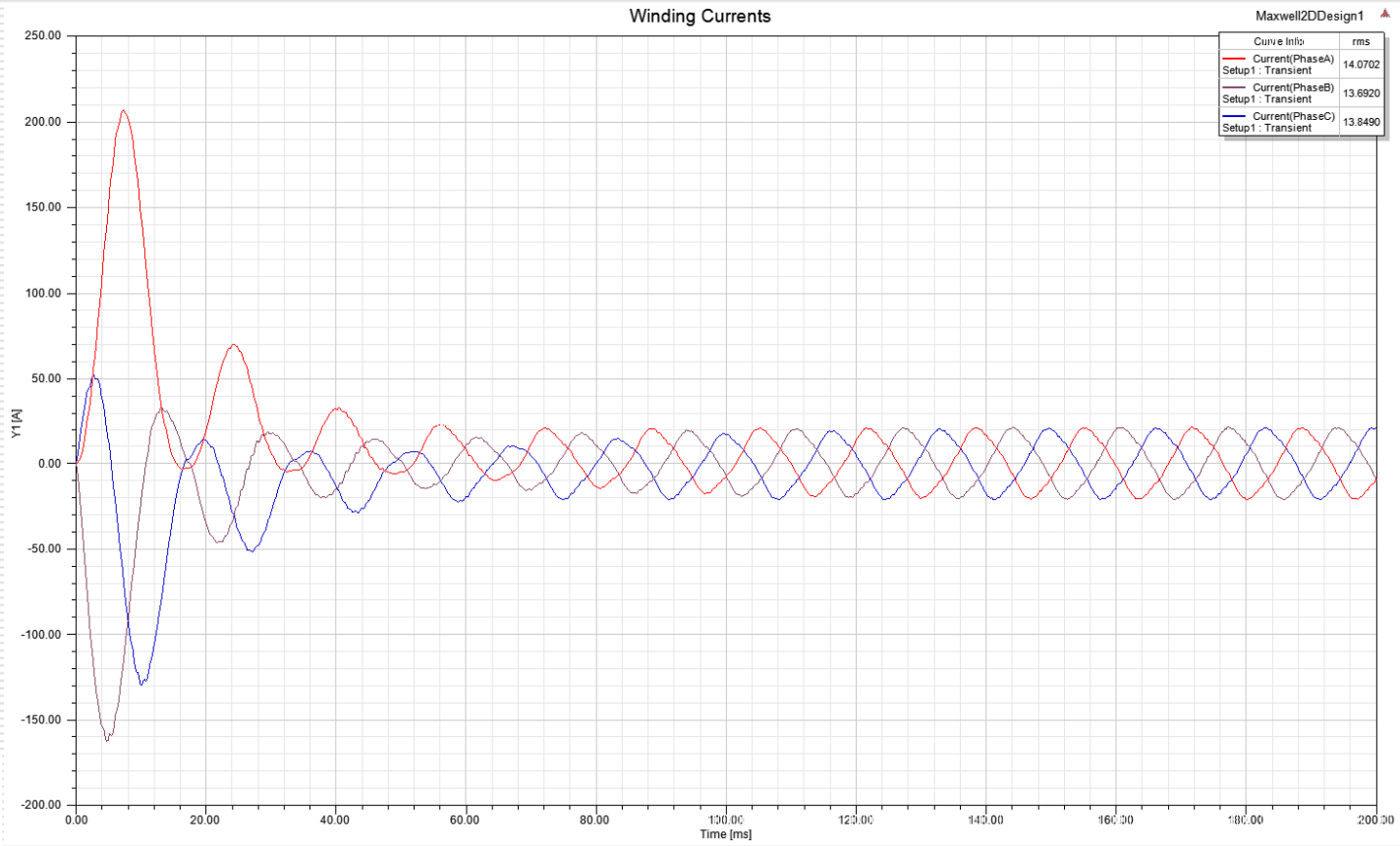
Induction motor Design A

- Number of poles:2
- Phase voltage:220 V
- Rated speed : 3600 rpm
- Rated output Power: 10 HP

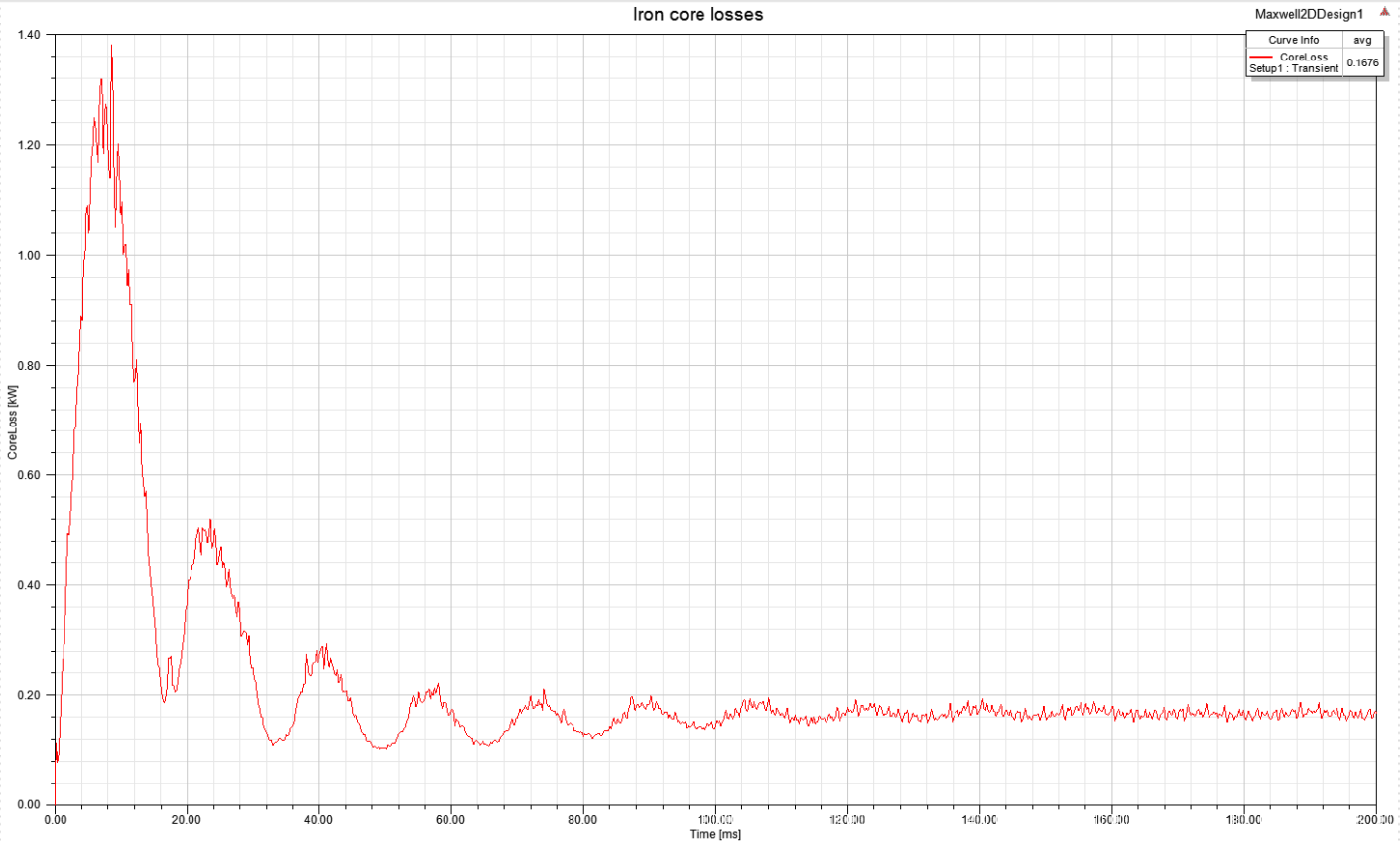
Output Torque for Design A @ 3,525rpm



Line Currents for Design A @ 3,525rpm



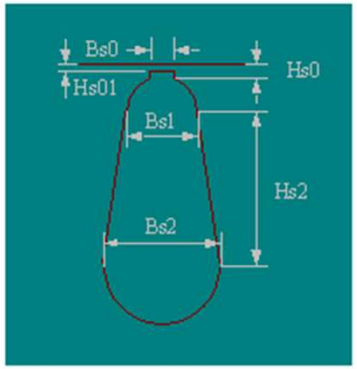
Core Losses for Design A @ 3,525rpm

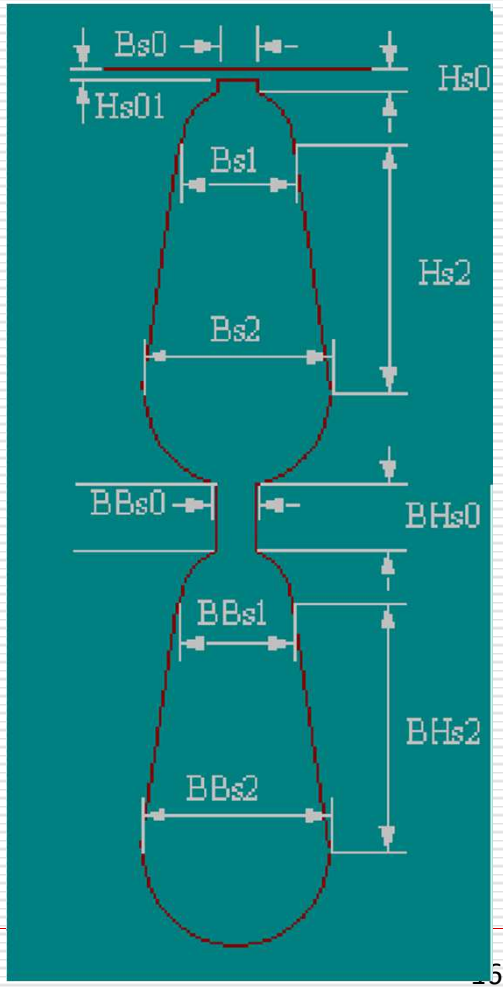


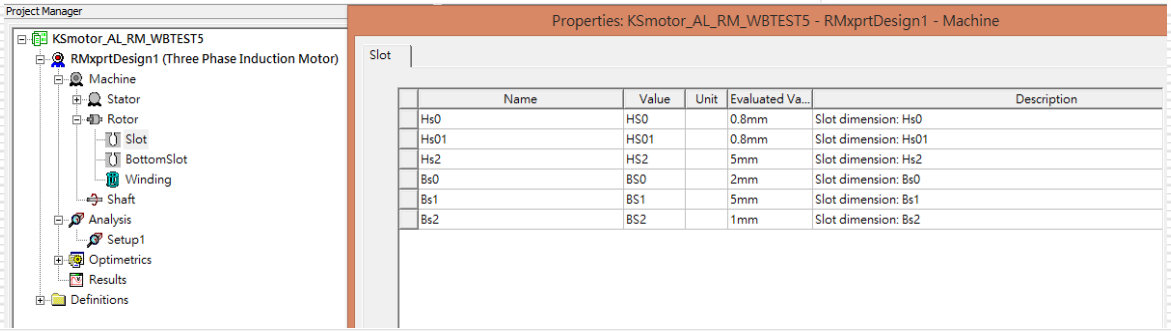
RMxprt Report for IEEE-112-B

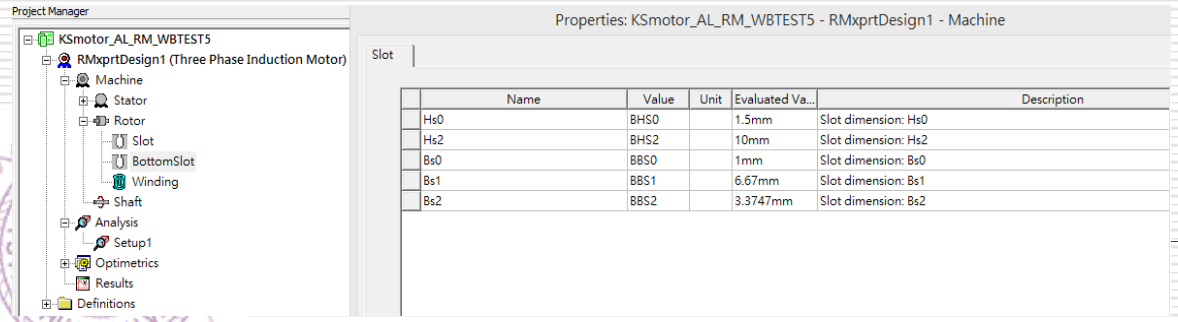
	RMxprt design	IEEE-112-B	Percentage error(%)
Rated Efficiency (%)	91.3756	91.37	0.0044
Output torque (N.m)	21.0513	20.176	4.3383
Iron core losses (W)	140.97	156.289	9.8017
Stator I^2R losses(W)	198.387	198.39	0.0015
Rotor I^2R losses(W)	171.309	169.47	1.0851
Friction and windage losses (W)	91.93	91.93	0
Stray-load losses (W)	115.15	115.15	0
Total losses (W)	733.065	715.91	2.3963

Optimization Approach - Slot Geometry

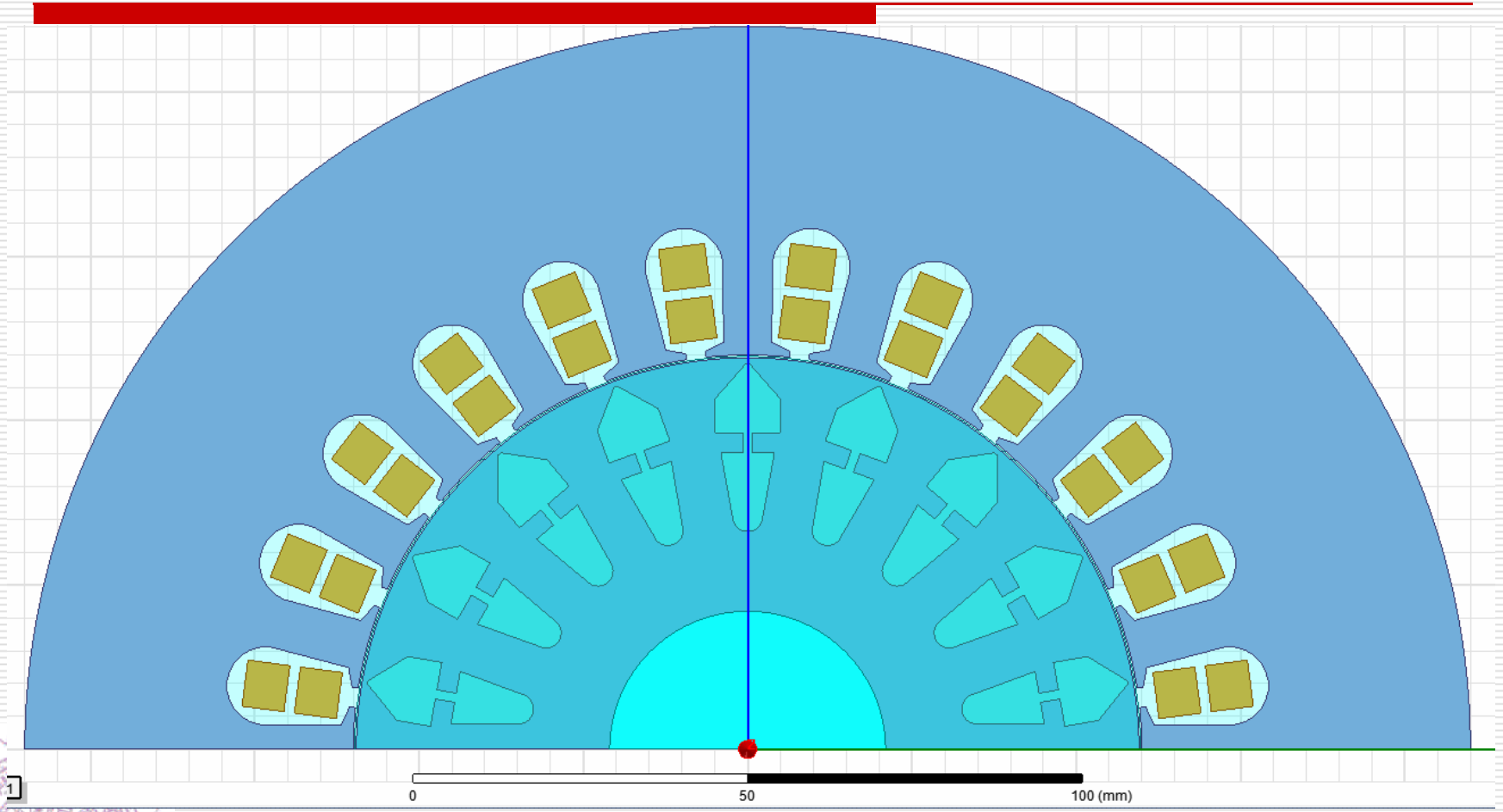








Topology after Optimization



Induction motor Design B with Rotor Slot shape optimization

SmartDo Optimization Results

Rated Efficiency (%)	91.3756	91.7423	0.3667
Output torque (N.m)	21.0513	20.0867	-4.8021
Iron core losses (W)	140.97	160.399	-12.1129
Stator I^2R losses(W)	198.387	189.111	4.9050
Rotor I^2R losses(W)	171.309	113.682	50.6914
Total losses (W)	733.065	671.489	9.17

Concluding Remarks

- Analytical calculations from RMxprt agree well to the IEEE 112B test report. Errors are mainly due to over-estimated iron core-losses. It could be improved by revision of iron core-loss measurement data.

- Resources limitation in CPU cores and memory capacity in ANSYS EM lead to impractical motor design optimization work. SmartDo add-on provides a better and faster way to implement motor design optimization.

Thank you and Q/A