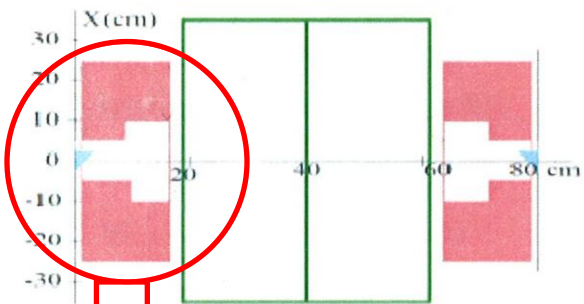
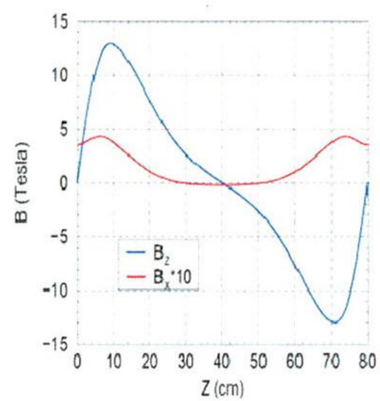
Solenoid for Stage 4 Cooling

I. Novitski, A. Zlobin
MSD TD

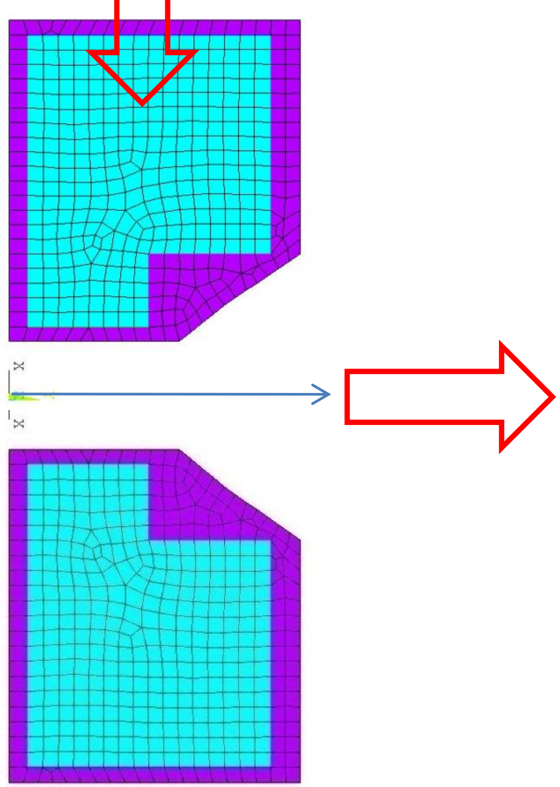
ANSYS Model

Stage 4



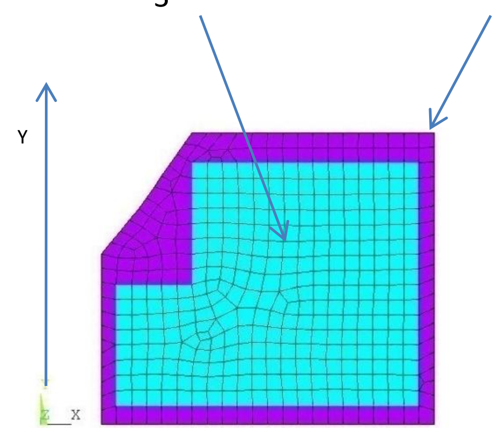


Half-gap: =1.25 cm



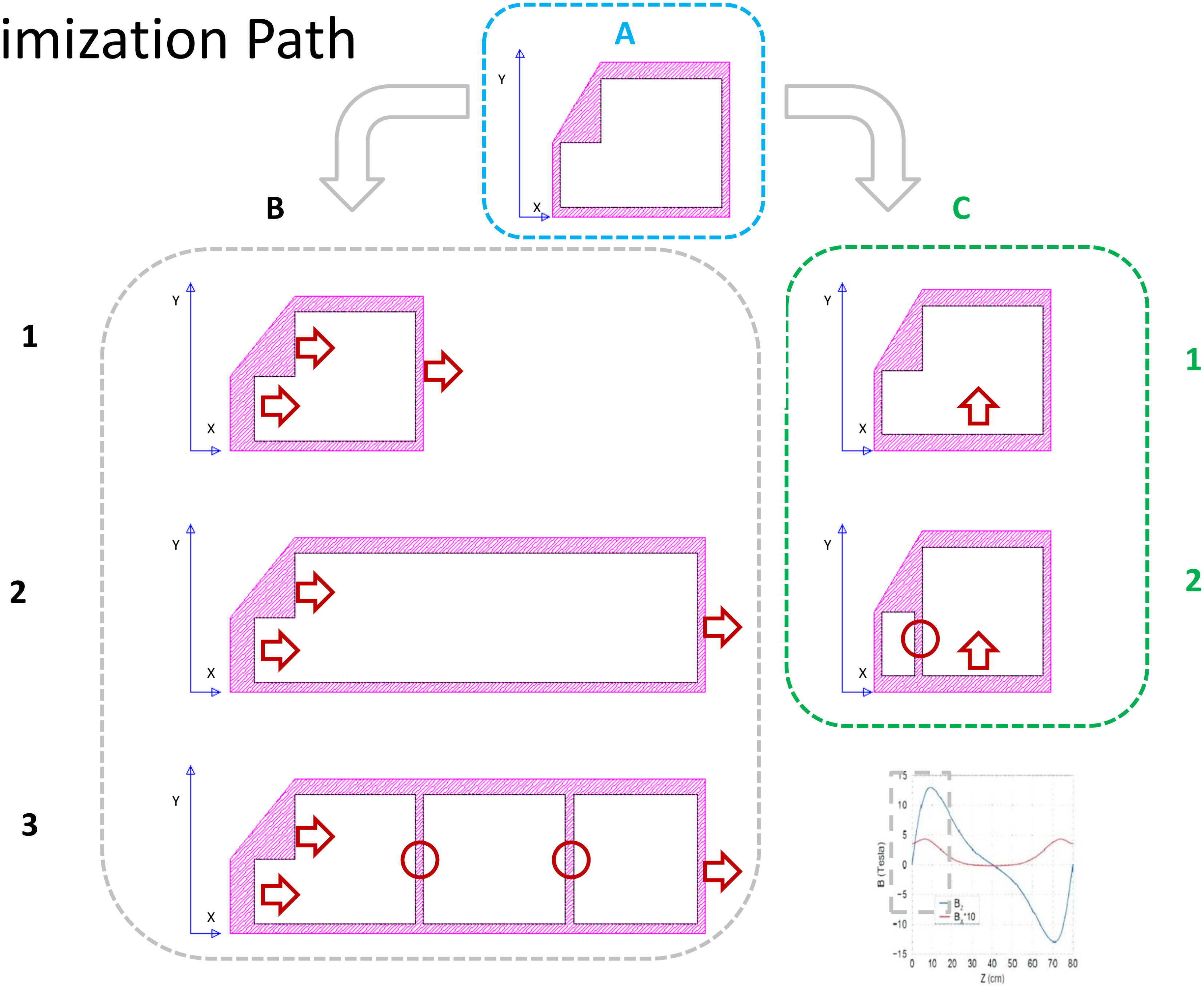
Nb$_3$Sn Coil

SS Frame



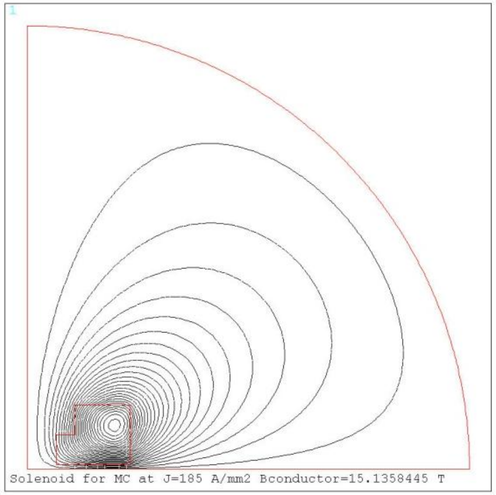
ANSYS Axisymmetrical 2D Model

Optimization Path



B **A** **C**

1



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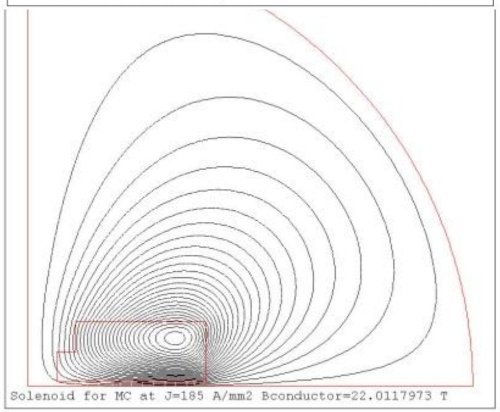

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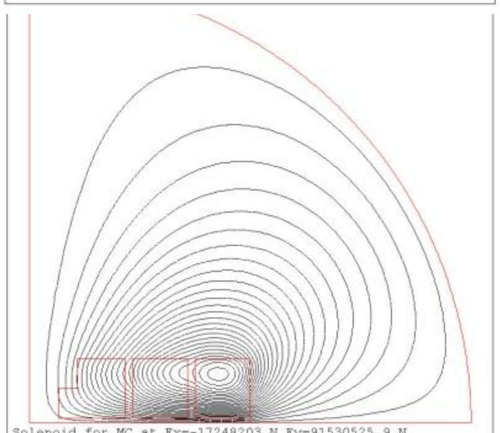
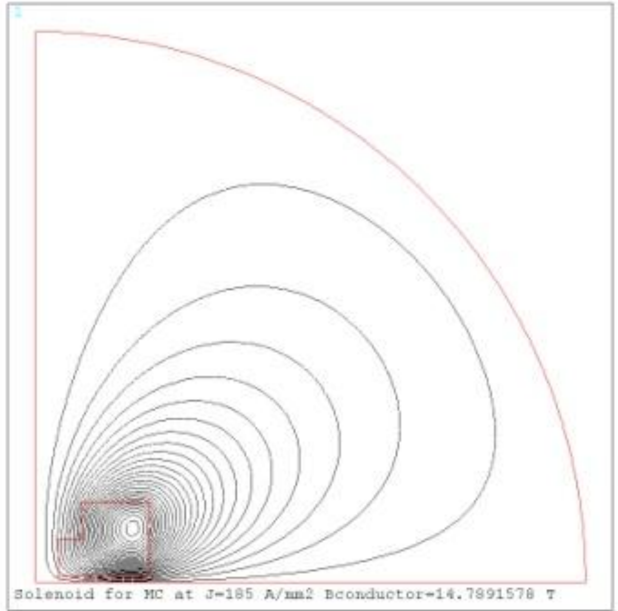
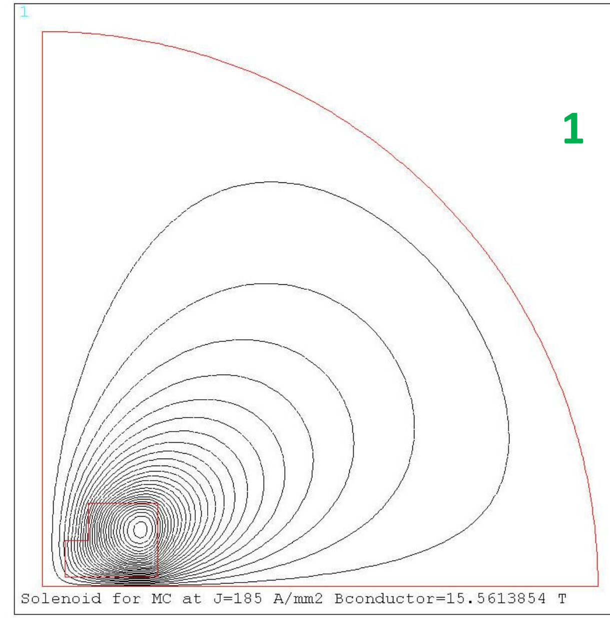
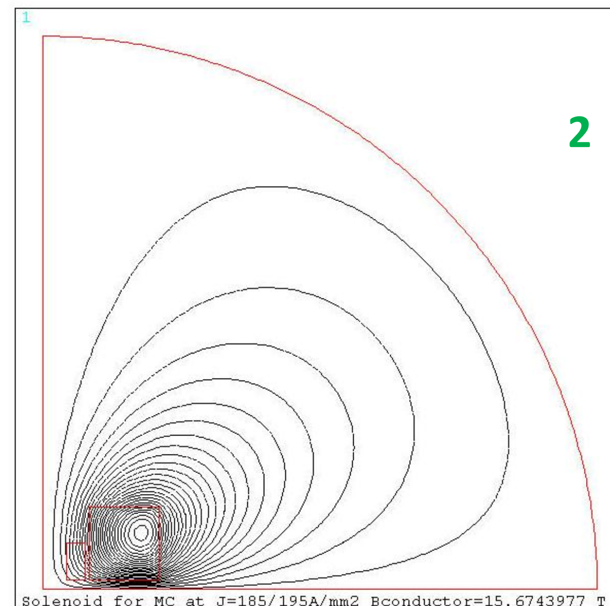




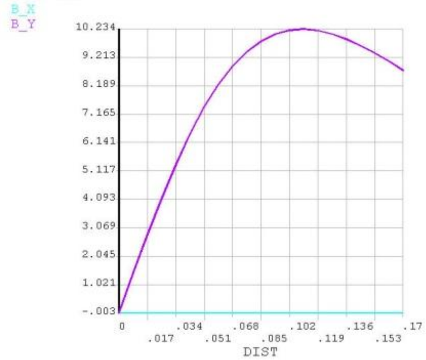




2D Magnetic Flux

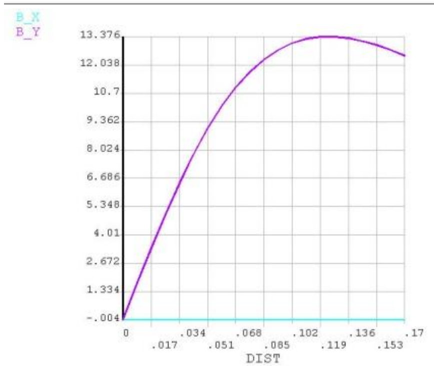
B

1



Solenoid for MC at J=185 A/mm2 Bconductor=15.1358445 T

2



Solenoid for MC at J=185 A/mm2 Bconductor=22.0117973 T

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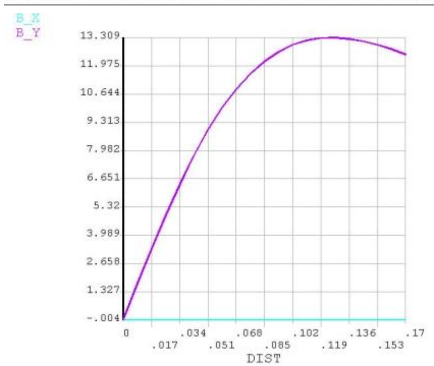
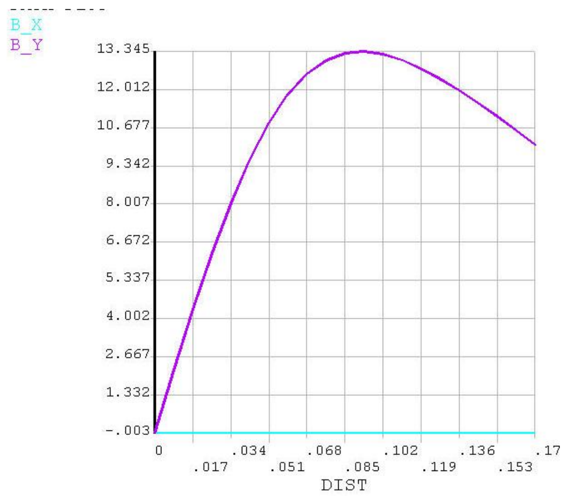


Solenoid for MC at J=185 A/mm2 Bconductor=22.2989882 T

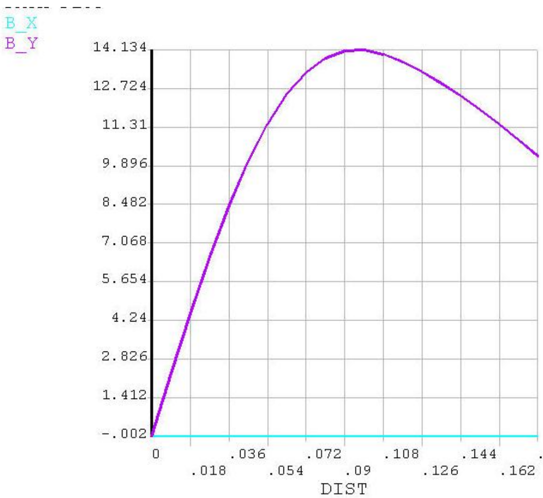
A



Solenoid for MC at J=185 A/mm2 Bconductor=14.7891578 T

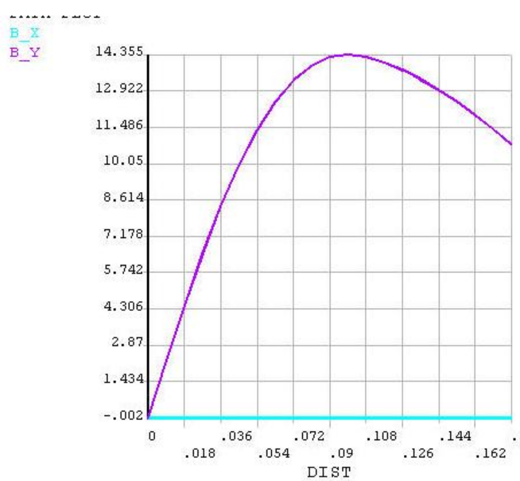
C

1



Solenoid for MC at J=185 A/mm2 Bconductor=15.5613854 T

2



Solenoid for MC at J=185/195A/mm2 Bconductor=15.6743977 T

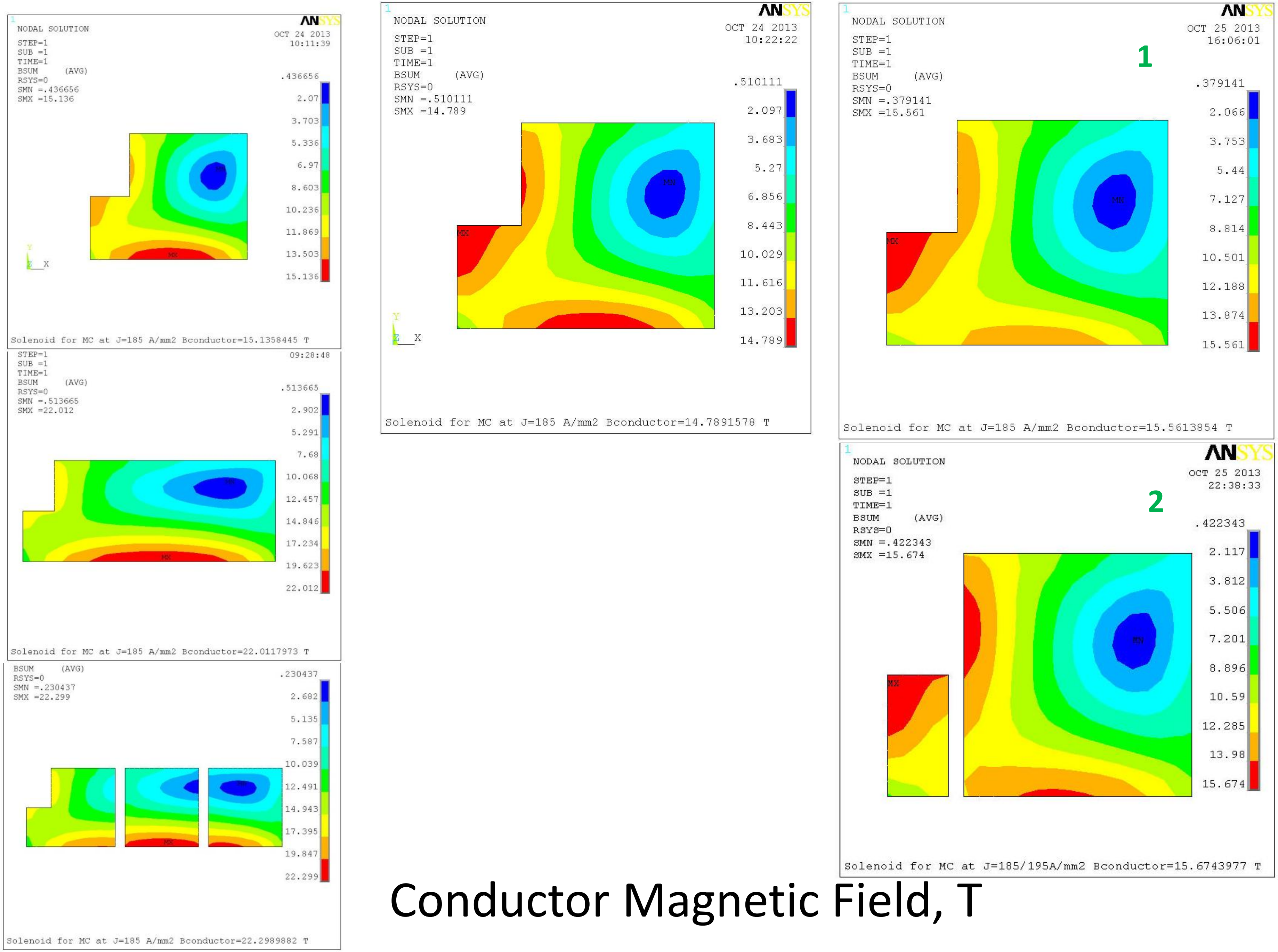
Magnetic Field on Solenoid Axis, T

B A C

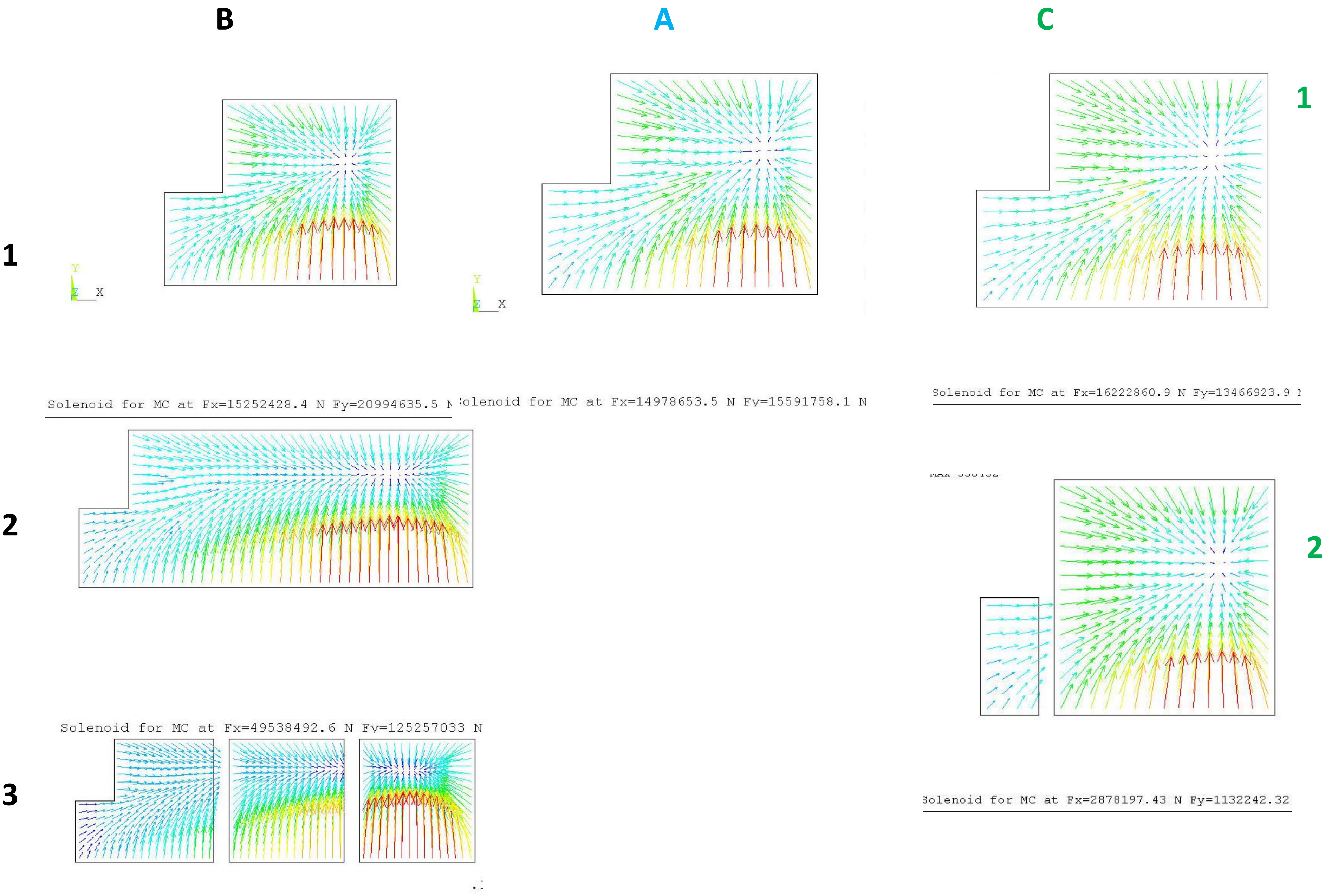
1

2

3



Conductor Magnetic Field, T

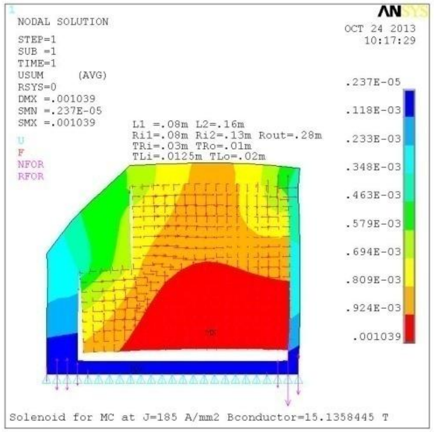


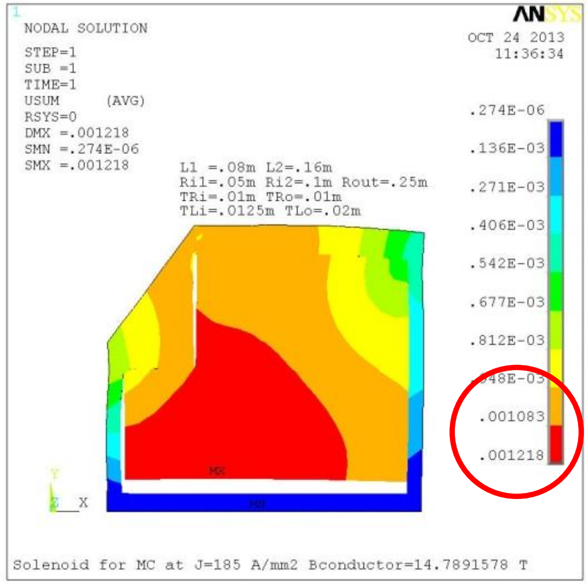
Solenoid for MC at Fx=-17248203 N Fy=91530525.9 N

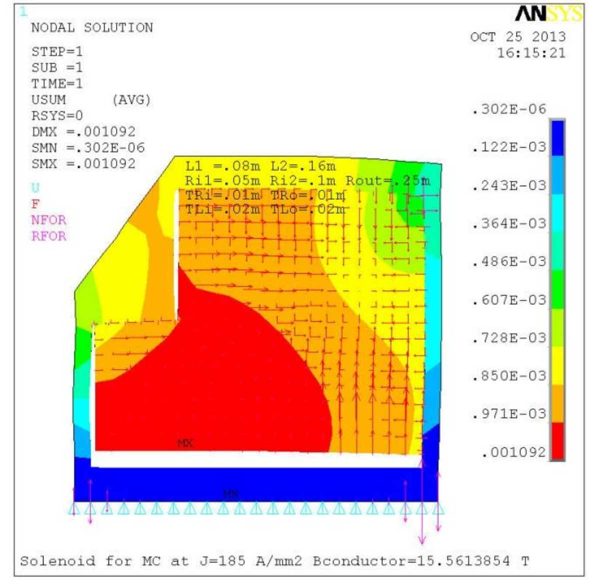
Lorentz Forces, Nm

B A C

1







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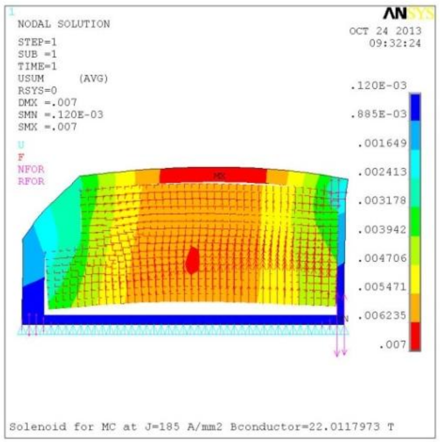

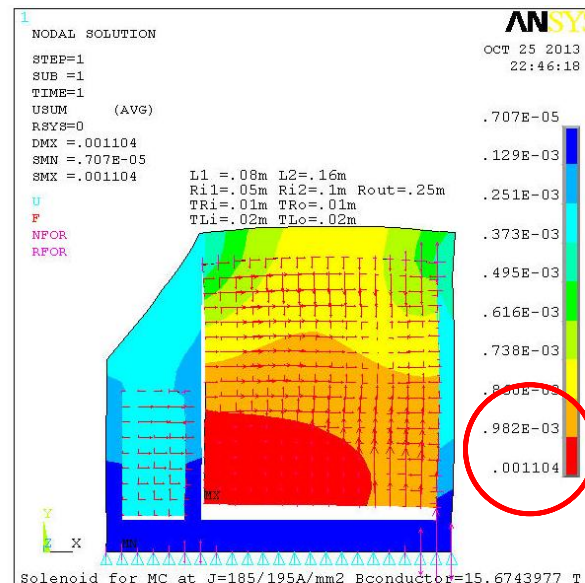

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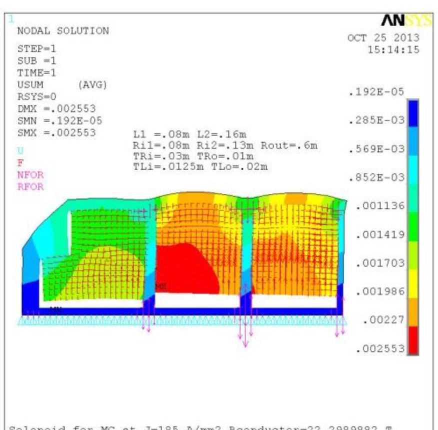


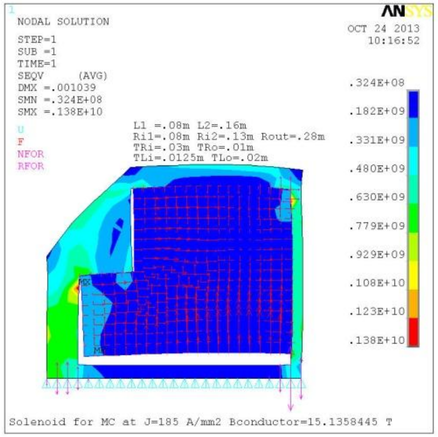
Displacement Vector Sum, m

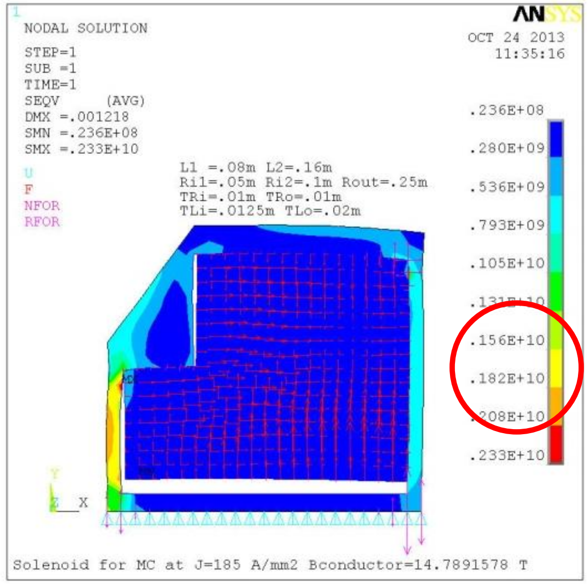
B

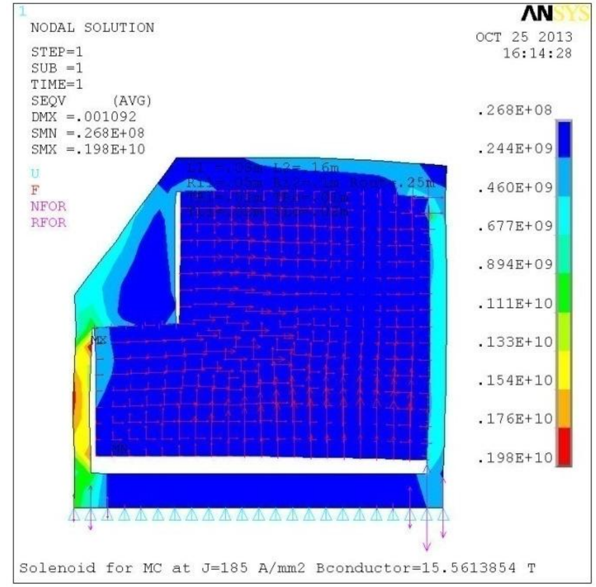
A

C

1

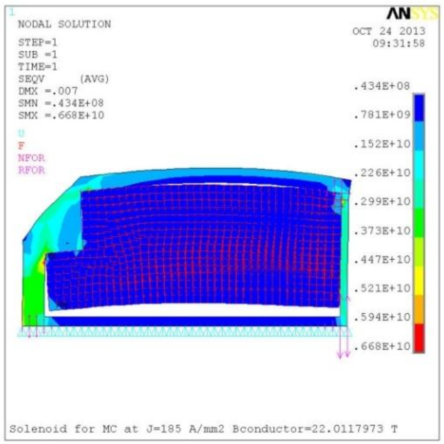


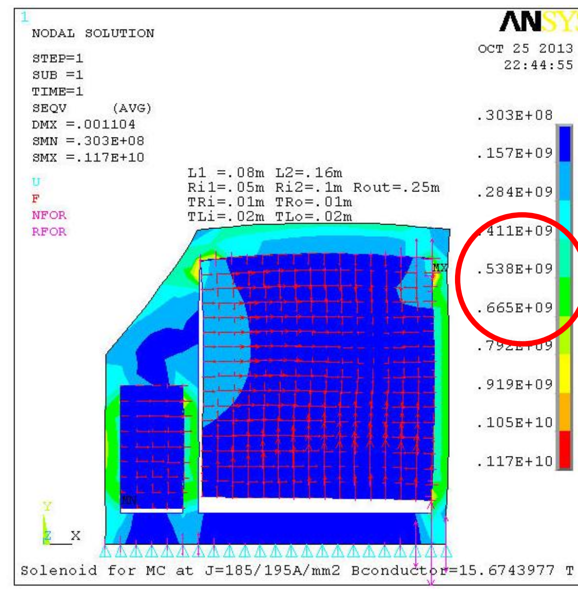




1

2





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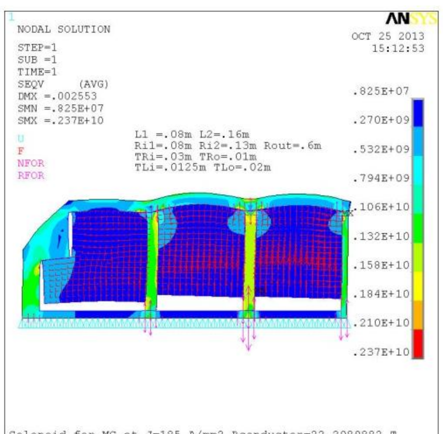
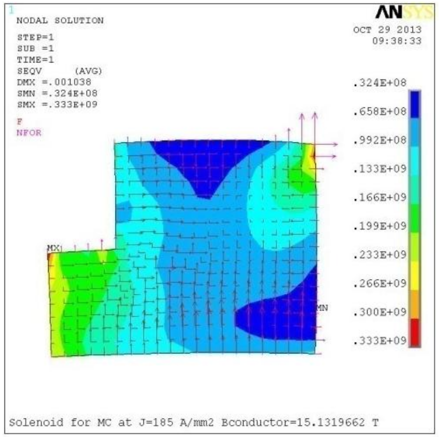


Equivalent Stress, Pa

B

1



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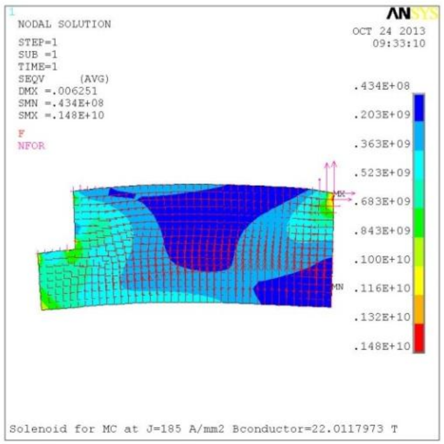

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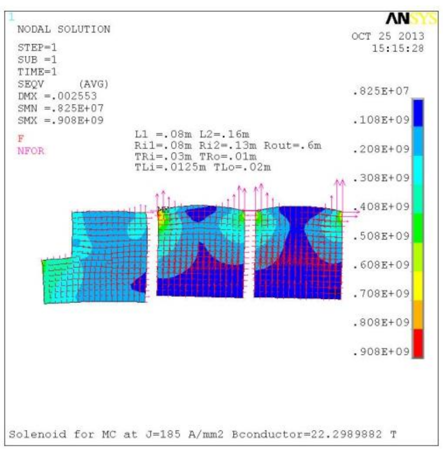
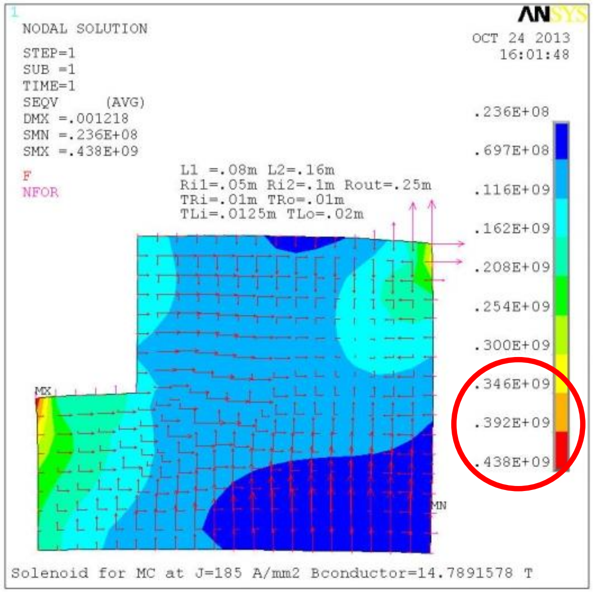
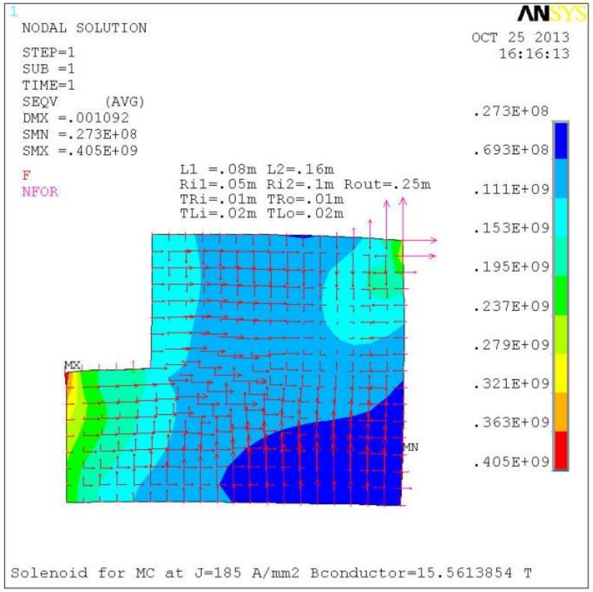


A



C

1



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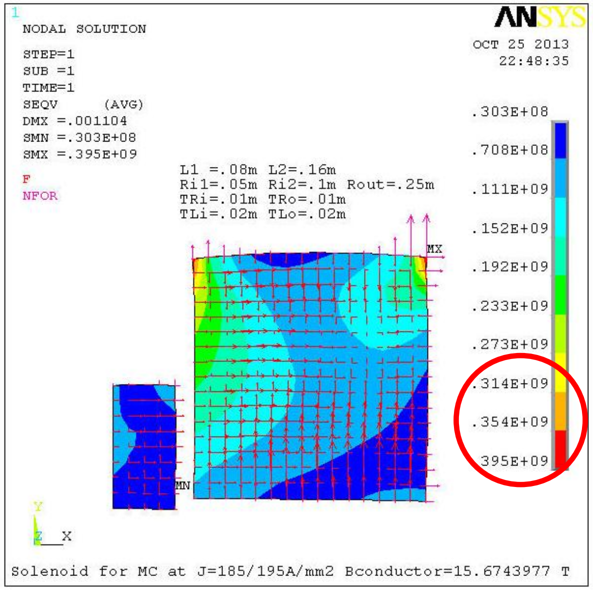

Coil Equivalent Stress, Pa

Summary

Path “B”:

- The “Original Design (A)” required a thicker inner tube wall to reduce carcass stress and coil motion under LF action.
- Increasing wall thickness decreases solenoid bore.
- To preserve the bore diameter, the entire solenoid should be shifted radially outwards.
- Magnetic field on solenoid axis decreases with increasing solenoid inner radius.
- In order to keep the same magnetic field, an increase of coil volume is required.
- Bigger coil volume leads to a bigger outside coil radius, weaker structure, and ribs introduction.
- Ribs divided the coil volume and created an almost identical innermost coil block as in the “Original Design”.
- The new derived design is more complicated than and not as efficient as the original one.

Summary

Path “C”:

- Magnetic field on solenoid axis increases when two solenoids moved apart axially.
- Dividing the coil into two blocks with 10mm coil rib may solve the stress problem in the 10mm inner carcass wall and will keep the original bore diameter.
- Coil displacement is still too large (~1mm); smaller number (0.1mm) is preferred
- Coil stresses should be reduced as well to 150-170MPa level

Next Step

- 3D FEA models are needed for the result verification.

- Using “Conductor in Conduit” may help solving stress-displacement problems since coil rigidity will be increased.