2-D MODEL OF DC MACHINE MAGNETIC FIELD

Roman Bok
Doctoral Degree Programme(1), FEEC BUT
E-mail: xbokro00@stud.feec.vutbr.cz

Supervised by: Čestmír Ondrůšek
E-mail: ondrusek@feec.vutbr.cz

ABSTRACT

The paper focuses on dependences of individual winding on magnetic saturation with 2-D magnetic field solution of 4-pol DC machine. Finite element method was used to solve it in ANSYS. Available element type and B-H curve specification of materials, generate meshes, end conditions definition, analysis type and solution settings are necessary to achieve the correct solution.

1. INTRODUCTION

Magnetic saturation may strongly influence the properties of electrical machines, therefore it is important for some advanced drive control methods to have the information on how much and where the machine is saturated in order to function properly.

Finite element method belongs to the widespread methods. The professional programs for calculation of electromagnetic field problems are very expensive for their universality. The most of these programs are built on finite element method, in which memory demand factor increases with nodes. This factor is even more increasing for calculations in 3D. At calculation there may come problems with a numerical stability, convergences or with generation of computational nets. Accuracy depends on density nets.

2. FEA ANALYSIS

A finite element analysis (FEA) of the motor was carried out with a 2D FE computer package following the procedure (A) – (C):

A. Pre-processing – Consisting of: (I) Conception of the geometric model of the motor according to the initial design configuration. (II) Mesh generation – triangular or quadrilateral elements should be automatically generated or adjusted by user (Figure 1); (III) Assignment of physical properties – different materials were selected and assigned to the different regions defined in step (I); (IV) Specification of excitation sources – here, values of current sources are assigned to the coils (slots); (V) assignment of boundary conditions.
B. Solution step – After generating the FE mesh and assigning the physical properties to the model a nonlinear system of equations is assembler and solved.

C. Post-processing – The results of simulations are visualized and analyzed through a set of graphics, curves, for instance the flux density along the air-gap, and equipotential lines, color shades and vectors. In addition, relevant global quantities can be computed, such as inductances, energy, and forces.

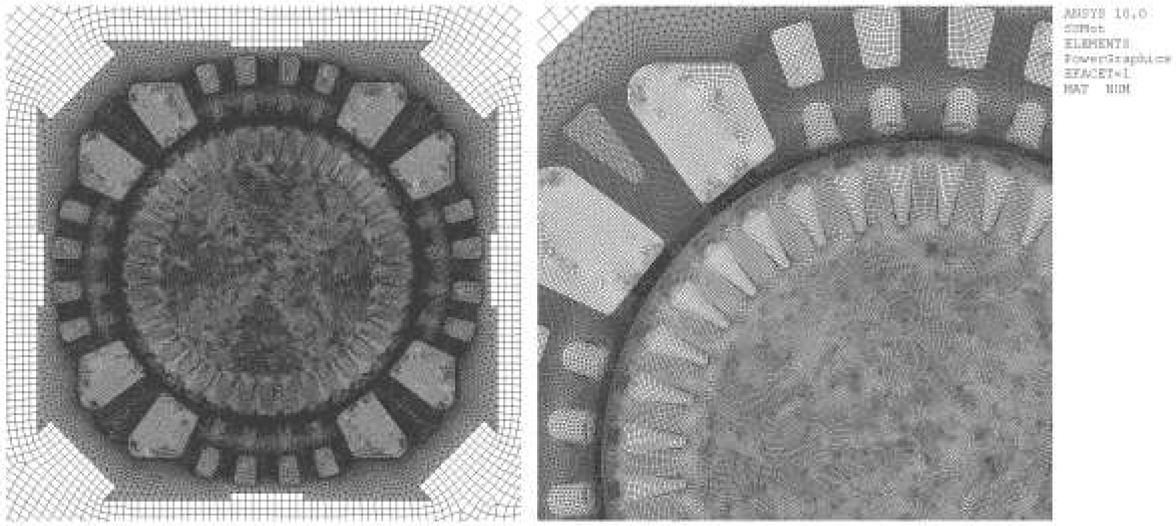


Figure 1: Finite element mesh of DC motor.

2.1. CONCEPTION OF THE GEOMETRIC MODEL

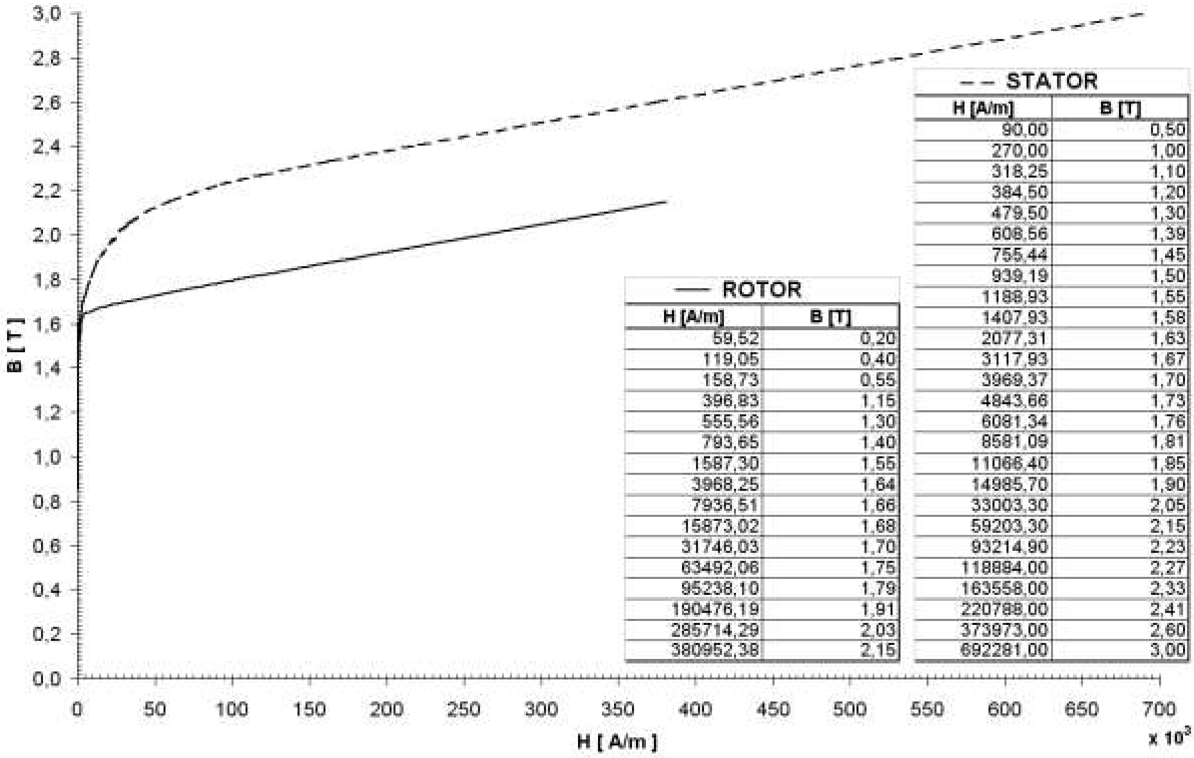
Geometry was made by other graphic program for his complexity. During an import from ACIS file to ANSYS could make to the wrong import of some geometry parts. This step is easier than is making of geometry in ANSYS program.

Motor parameters - Stator sheet: 4 windings of main poles and compensating windings in these poles, 4 windings of commutation poles, 16 vents for cooling of stator, inner diameter 208.3 mm and outer measurement (316 x 316) mm. Rotor sheet: 36 winding W-slot, 8 vents for cooling of rotor, inner diameter 25.5 mm and outer diameter 204.7 mm. Air gap between main pole and armature has wideness 1.8 mm.

2.2. ASSIGNMENT OF PHYSICAL PROPERTIES

The application of suitable B-H curve for non-linear magnetic material of DC machine has a considerable influence to results. The B-H curve must be defined for the whole extent of solution.

Magnetic materials can be defined by user from chart or can be chosen from materials library in ANSYS program. Magnetic material “EmagSa 1010” is used for the stator and “EmagSilicon” for the armature laminations. These materials (Figure 2) are from ANSYS materials library.



ROTOR	
H [A/m]	B [T]
59,52	0,20
119,05	0,40
158,73	0,55
396,83	1,15
555,56	1,30
793,65	1,40
1587,30	1,55
3968,25	1,64
7936,51	1,66
15873,02	1,68
31746,03	1,70
63492,06	1,75
95238,10	1,79
190476,19	1,91
285714,29	2,03
380952,38	2,15

STATOR	
H [A/m]	B [T]
90,00	0,50
270,00	1,00
318,25	1,10
384,50	1,20
479,50	1,30
608,56	1,39
755,44	1,45
939,19	1,50
1188,93	1,55
1407,93	1,58
2077,31	1,63
3117,93	1,67
3969,37	1,70
4843,66	1,73
6081,34	1,76
8581,09	1,81
11066,40	1,85
14985,70	1,90
33003,30	2,05
59203,30	2,15
93214,90	2,23
118884,00	2,27
163558,00	2,33
220788,00	2,41
373973,00	2,60
692281,00	3,00

Figure 2: Rotor and stator B-H curve.

2.3. RESULTS

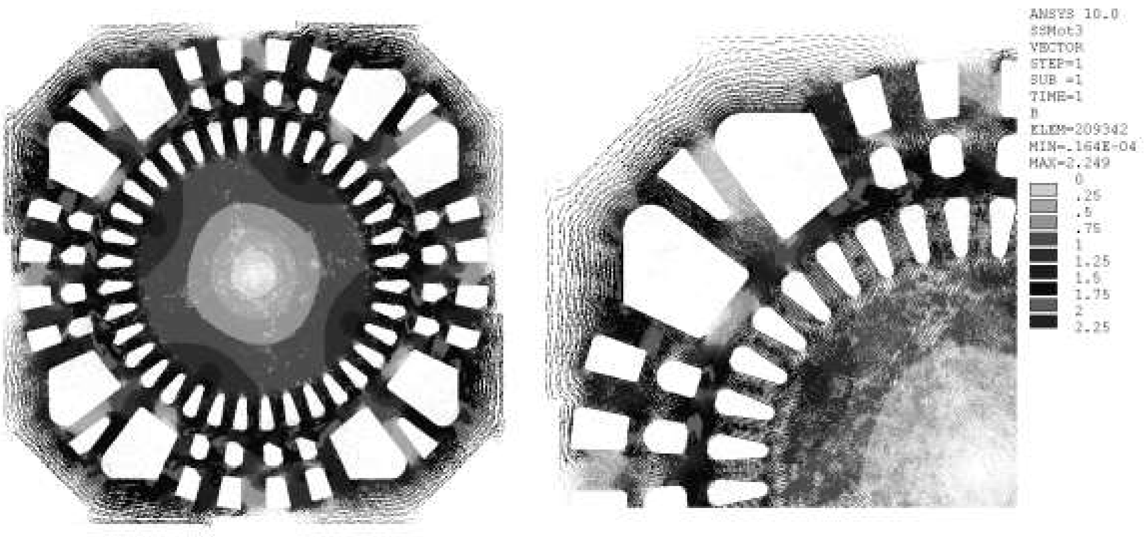


Figure 3: Magnetic flux density: armature and main poles excited

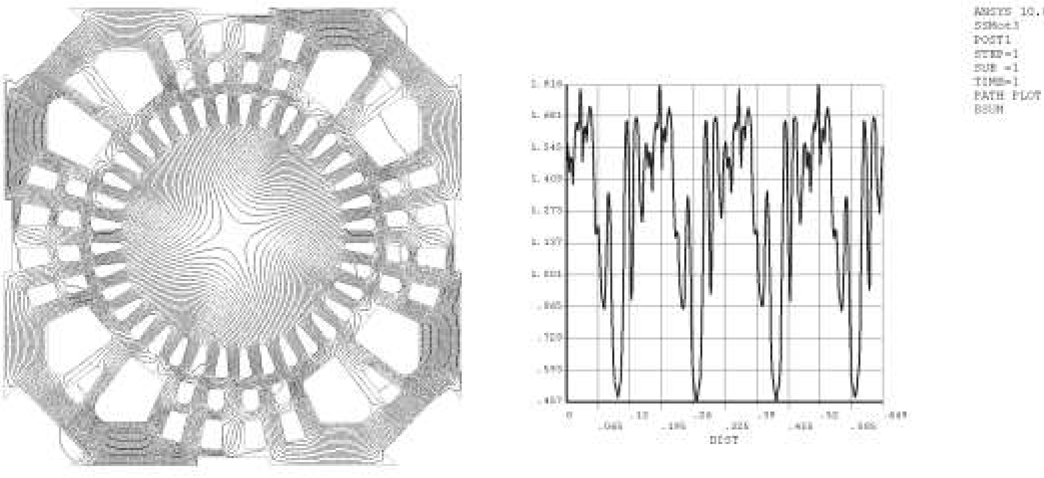


Figure 4: 2-D flux lines and absolute value magnetic flux density in air-gap: armature and main poles excited

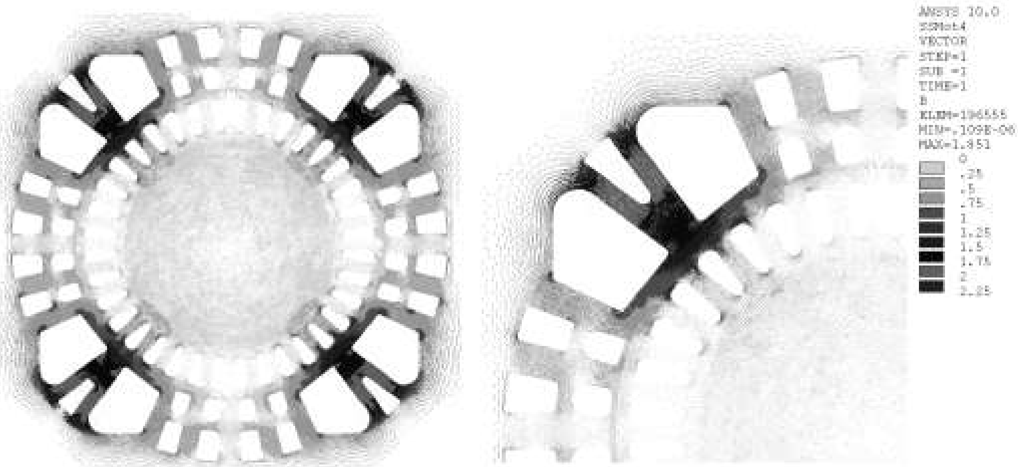


Figure 5: Magnetic flux density: commutation poles excited only

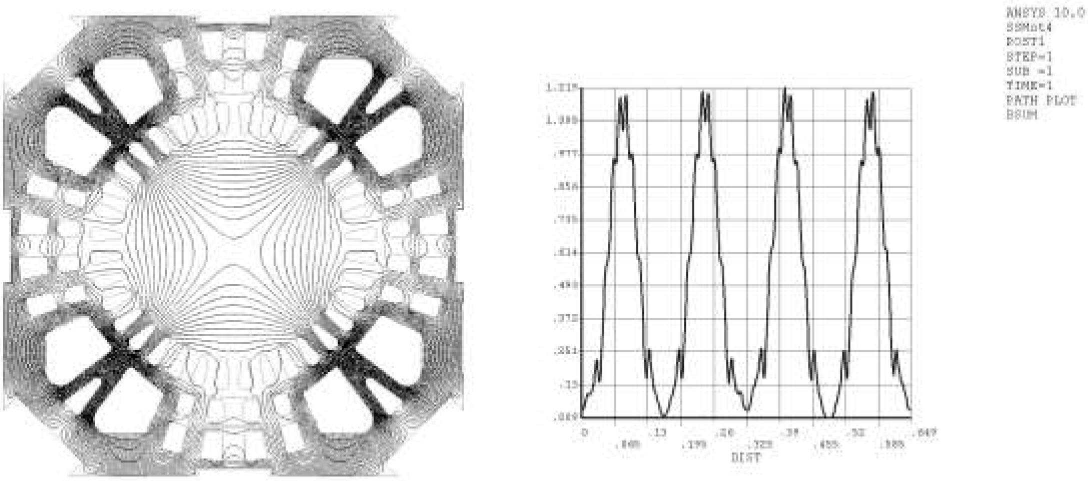


Figure 6: 2-D flux lines and absolute value magnetic flux density in air-gap: commutation poles excited only

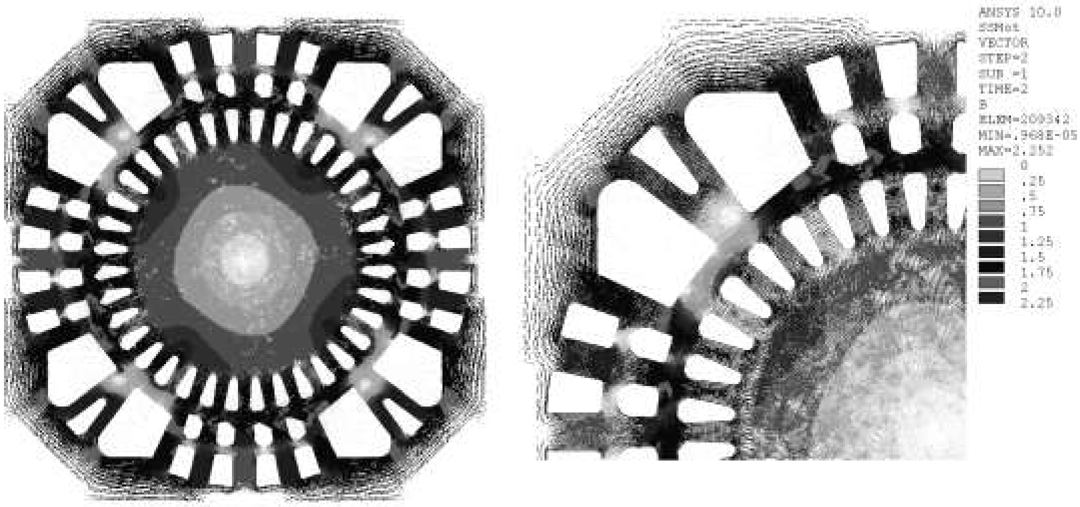


Figure 7: Magnetic flux density of DC machine

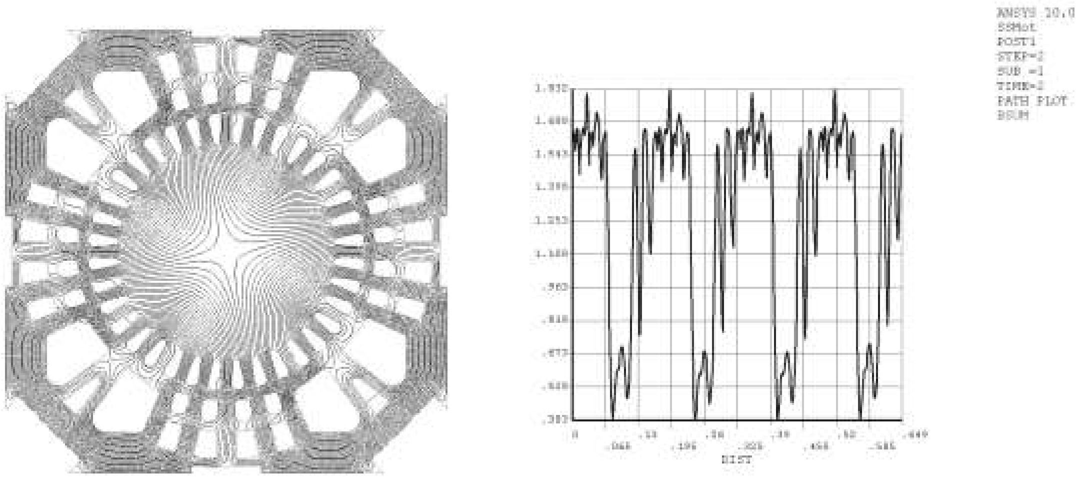


Figure 8: 2-D flux lines and absolute value magnetic flux density in air-gap of DC machine

3. CONCLUSION

This 2-D magnetic model of DC machine contains the results of the magnetic flux density and 2-D flux lines. Separated simulations present model with power supply of the armature with winding of main poles and only commutation poles winding and last one all winding used in DC machine.

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