INDUCTION MACHINE 2-D MAGNETIC FIELD MODEL

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ABSTRACT

This work deals with 2-D magnetic field solution of 3-phase 1.1kW induction motor. Finite element method was used to solve it in ANSYS. There are some steps necessary to achieve the right solution. For example to generate divided geometry, available element type, available materials and B-H curve specification, generate meshes, end conditions definition, solution settings and finally results plot.

1. INTRODUCTION

For numerical calculation of electromagnetic field distribution are available various mathematical methods. Finite element method, gap analysis finite difference method and boundary element method belong to the widespread methods. At calculation there may come problems with a numerical stability, convergences or with generation of computational nets.

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 (ANSYS), in which memory demand factor increases with nodes. This factor is even more increasing for calculations in 3-D. Accuracy depends on density nets.

UNIVERSAL METHOD OF SOLUTION

- Boundary Element Method (BEM) is universal method for solving integral quadratic equations. The method is based on surface discretization to elements. The tasks doesn´t have an enclosure border. It is possible to be used for solving spatially boundless fields. Aplication of that method is at fields calculation combined with radiation.
- Finite Element Method (FEM) is effective method to solve of all border tasks described by differential quadratic equations. Nodes describing the fields, may be distributed in the area non-uniformly and they may trace so to form better border surfaces. In places where the field change is expected, larger nets density should be used. FEM is searching a field solution of complicated geometrical forms.
- Finite difference method (FDM) is based on analogous solving like FEM This method isn´t available for complicated geometry.

2. FINITE ELEMENT METHOD FOR 2-D MAGNETIC FIELD SOLUTION

2.1. GEOMETRY

Geometry was made by other graphic program for its complexity. This way created geometry of induction machine is necessary to adjust, because during an import from ACIS file to ANSYS could make the wrong import of some geometry parts. The next step is to create an optimal divided geometry for uniform meshes distribution.

Motor parameters: 1.1kW, 400V, 2.4A (Y), I_{10} = 1.52A, n = 2845 min^{-1}, η = 77%.

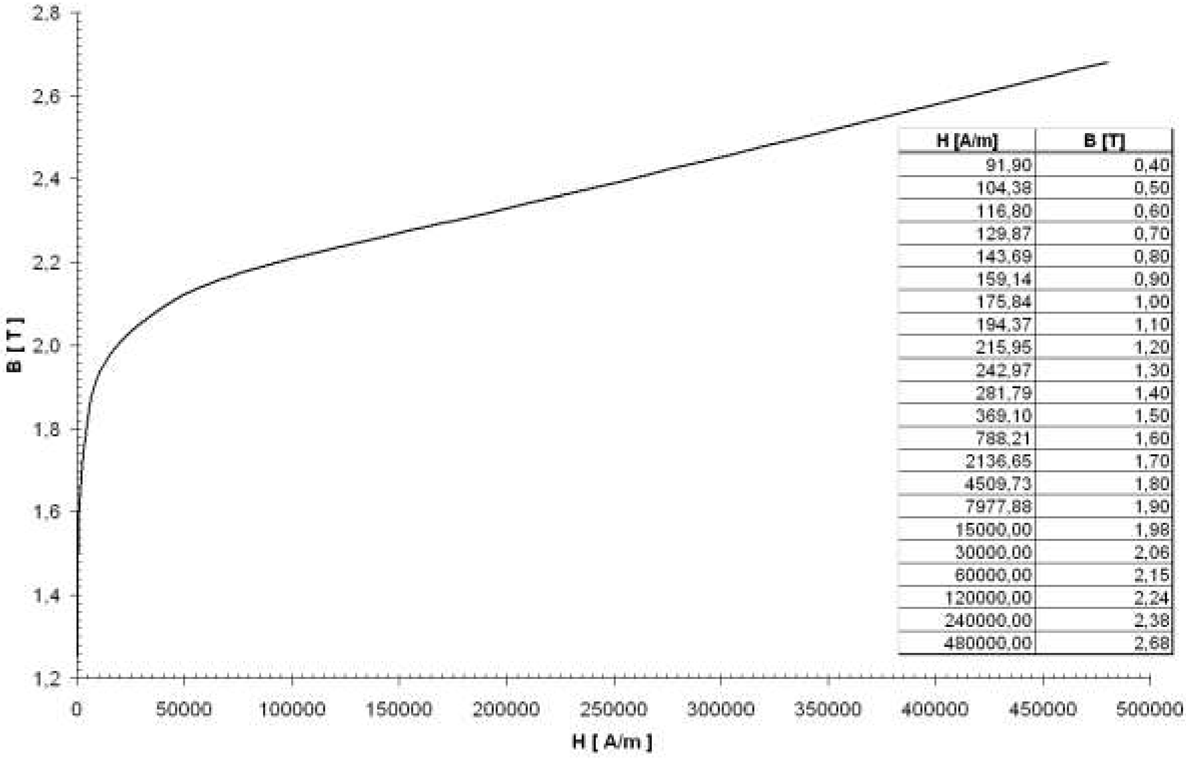
Stator sheet: 18 winding U-slots, inner diameter 64.5mm with dimensional accuracy H9 and outer diameter 125mm. The 83 coils with diameter 0.63mm are inserted in the stator windings.

Rotor sheet: 23 winding V-slots, inner diameter 24.4mm and outer diameter 64.5mm. These sheets have a thickness 0.65mm. Both packets consists of 116 sheets; the length of which 74mm after assembly.

Air gap width 0.25mm.

2.2. MATERIAL PROPERTIES

In this case the material properties have a considerable influence to results. Mainly, the application of suitable B-H curve for non-linear magnetic material. The B-H curve must be defined for the whole extent of solution.



H [A/m]	B [T]
91,90	0,40
104,38	0,50
116,80	0,60
129,87	0,70
143,69	0,80
159,14	0,90
175,84	1,00
194,37	1,10
215,95	1,20
242,97	1,30
281,79	1,40
369,10	1,50
788,21	1,60
2136,65	1,70
4509,73	1,80
7977,88	1,90
15000,00	1,98
30000,00	2,06
60000,00	2,15
120000,00	2,24
240000,00	2,38
480000,00	2,68

Fig. 1: *B-H Curve M54*

2.3. MESH

Generating the meshes is a time-consuming and depends on element size, quantities and shape. For instance, many area elements can be both triangular and quadrilateral shaped within the same meshed area. Volume elements can often be either hexahedral (brick) or tetrahedral shaped, but a mixture of the two shapes in the same model isn't suitable.

The element sizes can be adjusted by user, because the sizes that the program choose for the above model may or may not be adequate for the analysis, and depending on the physics of the model structure. Smart element sizing gives the mesher a better chance of creating reasonably shaped elements during mesh generation. Air gap nets are consisting of 5 elements in width (thinnest area).

A 2-D model uses 2-D elements to represent the geometry of the structure. Although all objects and structures are 3-D, one can and often should consider using a 2-D model analysis when the geometry makes possible to use planar or axisymmetric modeling. This is because 2-D model is usually much easier to generate and takes less time to solve.

The 2-D elements use a magnetic vector potential. Each node has only one vector potential degree of freedom, vector potential in the Z direction.

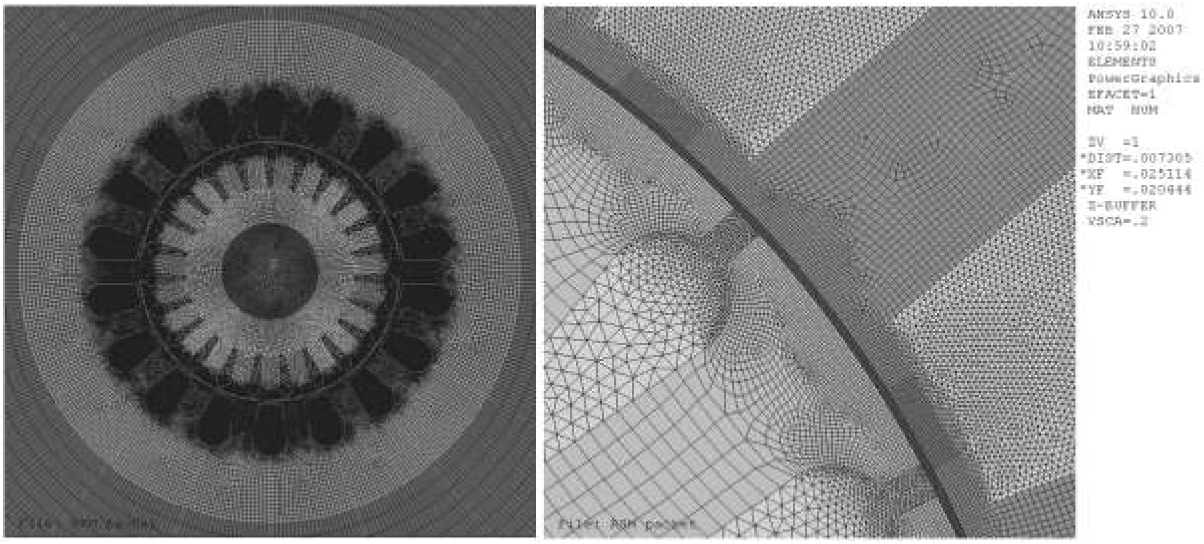


Fig. 2: *Divided geometry of induction motor with meshes(left), detail(right)*

2.4. SOLUTION CONTROL SET

Solution control setting involves definition of the analysis type and common options for an analysis, as well as specifying load step options for it in the solution controls dialog box. The solution controls dialog box provides default settings that will work well for many analyses, which means that you may need to set only a few, if any, of the options.

Load: The setting current density value on selected areas and end conditions definition (define magnetic flux parallel on model border). That means, current density on winding area surface is $1.33.10^6$A/m^2 (only in one phase), and $6.65.10^5$A/m^2 (in other phases) by $J = \frac{N.I}{S}$.

2.5. RESULTS

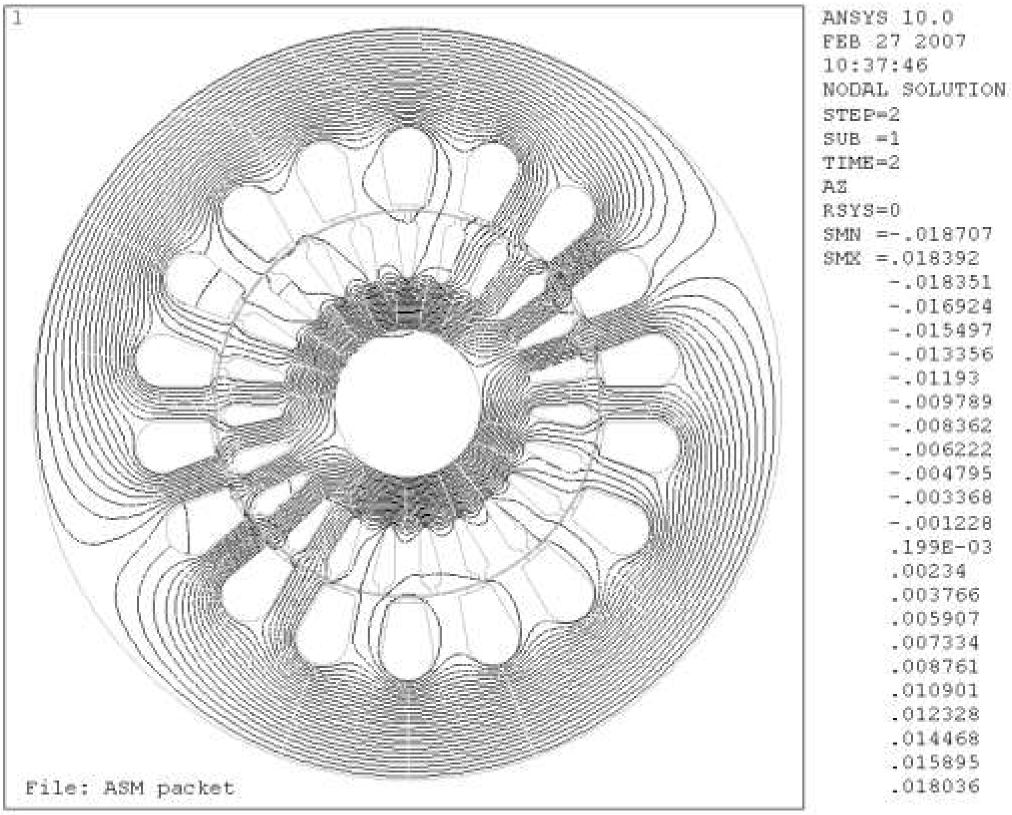


Fig. 3: *2-D flux lines*

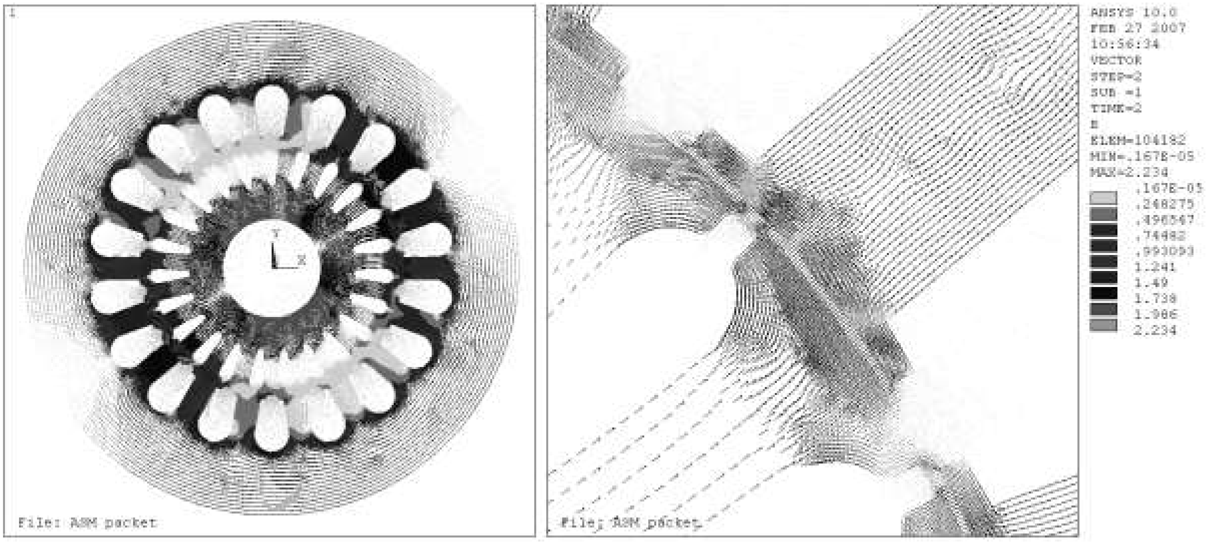


Fig. 4: *Magnetic flux density(left), detail(right)*

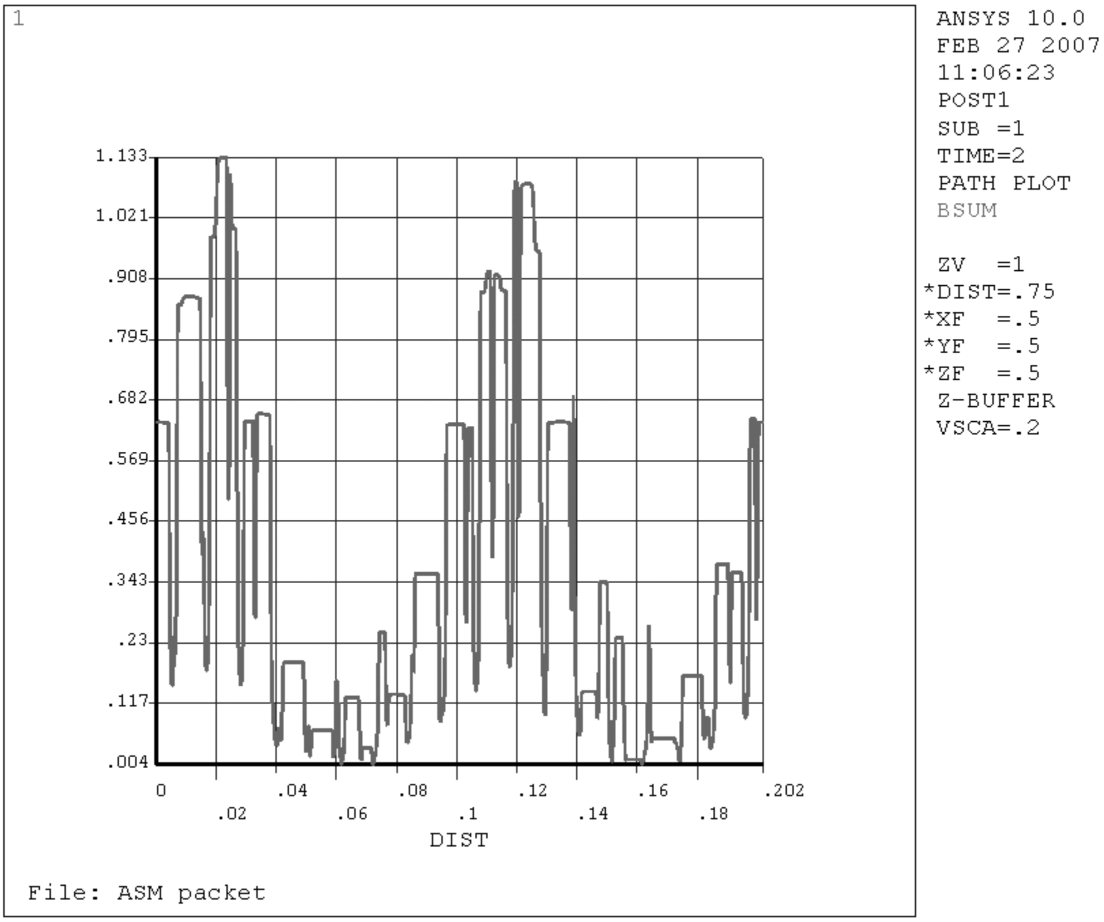


Fig. 5: *Magnetic flux density in air-gap*

3. CONCLUSION

This paper contains the result of a 2-D magnetic model of 3-phase induction machine. This induction machine is really 2 pol that is shown on the Fig.3.. Usually, the magnetic flux density is (2.0-2.2) T in the stator pole, (0.6-0.8) T in the center of air gap, (1.6-1.8) T in the rotor pole and (1.2-1.4) T in the rotor or stator yoke. Magnetic flux density (Fig.4) of this machine is in range (0.25-2.23) T. For instance, in the stator pole (1.8-2.2) T, in the center of air gap 0.58 T - average value, in the rotor pole (1.2-1.7) T and in the stator or rotor yoke (0.9-1.3) T. The level of shades is difficult to differ in this case, because this figure of magnetic flux density is only in the gray scale. In the Fig.5 is shown the absolute value of magnetic flux density under by both pol.

REFERENCES

[1] Dědek, L., Dědková, J.: Elektromagnetismus, VUT Brno 2000, ISBN 80-214-1548-7