UDC 004.942

3-D MODELING OF ELEMENTS OF SKIP-ELECTROMAGNET SYSTEM

Aikeyeva A.A.[1], Zhautikov B.A.[2], Rogovaya X.S.[1], Zhautikov F.B. [3], Mukhtarova P.A. [4]

[1]Karaganda State University named after E.A. Buketov, Kazakhstan
[2]Atyrau State University named after Kh. Dosmukhamedov, Kazakhstan
[3] Karaganda State Industrial University, Temirtau, Kazakhstan
[4] Asia Pacific University Innovation and Technology, Kuala Lumpur, Malaysia
aikeeva@mail.ru

The purpose of this work aims to the modeling system elements of electromagnetic lifting installation. This paper presents the description of the principles in the process of the electromagnetic lifting installation. In addition, 3-D simulation of the "skip-electromagnet" system elements specifically focused on the skip and directing devices of constant magnets and electromagnets. Each stage of modeling process is provided by figures with the image of modeling elements. This article presents the analysis of the three core elements providing comparative graphic diagram, which are based on the 3D modeling process results.

Keywords: electromagnetic lifting installation, skip, 3D-model, ANSYS program, traction force.

Introduction

Development of computer projection and calculation of constructions created an opportunity to make models, which became the ordinary tool in various areas of radio electronic, mechanical engineering, automotive, mining and other industries. Consistency of computer models allows to define the major factors which determine the properties of the studied object-original (or the whole class of objects), in particular, to investigate the response of the modeled physical system on the changes of its parameters and initial conditions [1].

During the research of different modeling programs, 14.0 ANSYS showed itself as a best software program for the project. Moreover, 14.0 ANSYS is the final version of the program product and belonging to the class of CAD/CAM/CAE systems. The system modeling is directly carried out in the subsection of ANSYS Multiphysics. Modern information methods are based on the system analysis and consider above-mentioned features of manufacturing techniques and operation on the basis of machines modeling, their realization by methods of the nonlinear theory of electromagnetic field. Besides, modern theoretical methods of calculation and projection of various products and constructions assume active use of the method of final elements, which concentrated expression, is the package of the applied ANSYS programs. In this plan, the package of the applied ANSYS programs can be used both at theoretical and analytical researches [2].

For automation of elements of system, it is necessary to develop a method of calculation and modeling of electromagnets of electromagnetic lifting installation, with including constructive technology factors and create system of the automated analysis for ensuring their durability, reliability and high quality. In addition, all parameters were calculated, to achieve automatic switching of elements. According to the results of the automated system analysis, were created the models of electromagnets of installation which are considering constructive technology factors in a complex.

Theoretical part

Before modeling is started was made a question of a choice of the interacting elements. According to the plan, on "skip" should be placed permanent magnets or electromagnets, and in the directing devices of electromagnetic lifting installation – the electromagnets switching automatically in the set parameters. Initially the choice took place between two devices: solenoid and directly electromagnet. As a result, while using the solenoid the course would be fast and sharp, and then the electromagnet was chosen as an element of interaction.

Imitating modeling of dynamic processes of interaction of basic elements of skip electromagnets and electromagnets of the directing devices of electromagnetic lifting installation pursues the purpose to determine the optimum and rational parameters of system without expensive experiments in the calculating way. Possibilities of modern computers and packages of applied programs allow to realize rather full system approach to the description of multiple-factor dynamic conditions of integrally interconnected links of uniform dynamic system "skip - electromagnet" [3].

Imitating modeling was made in the format of 3D-model and taking in the account its axis symmetry, the solution was carried out for a quarter of section of electromagnets shown as the first quadrant. On the working plane shown in Figure 1 represented the metal steel core surrounded with area of air space. The steel core is represented as one object that is a parallelepiped constructed by the set parameters of the core and area of air gap between the core and winding.

Experimental technique and discussion of results

In constructing two parallelepipeds (the core and area of air gap) are intersected at each other and unite in the common element. The air space surrounding the object and uniting the core and area of air gap is represented in the form of a quarter of the cylinder. The parameters of magnetic permeability are set for air, and the parameters of vector of magnetic induction B and intensity of magnetic field H are set for the core. For splitting the section area of the core the is used element SOLID96 [4]. This element is used only for 3D models. Modeling stages in the program ANSYS environment were carried out as showed in the figure 1.

a) creation areas b) determining boundary lines

Fig. 1. Stages of imitating 3-D modeling of electromagnet

For creation the areas imitating a quarter of section of electromagnets, on coordinates of three tops was presented parallelepiped. The areas that imitating environment (air) are cylinder segments. The next stage consists of splitting into final elements of model areas. It is necessary to notice that when more elements are formed while splitting, then the solution of the problem will be more accurate. Splitting areas into final elements is presented in figure 2.

The following stage of electromagnet modeling is the setting the parameters of winding: the number of winds, internal radius, external radius, current in winding, winding thickness and the direction of current is also specified, with which electromagnet poles can be defined.

In this case, at the direction of current clockwise that is located in the southern pole downwards, and the northern pole - upwards. In the result, the created model which ready to the solution is represented in figure 3 where shown the fourth part of the steel core surrounded with winding.. For clarity of representation of the element of model, the winding is shown in full [5].

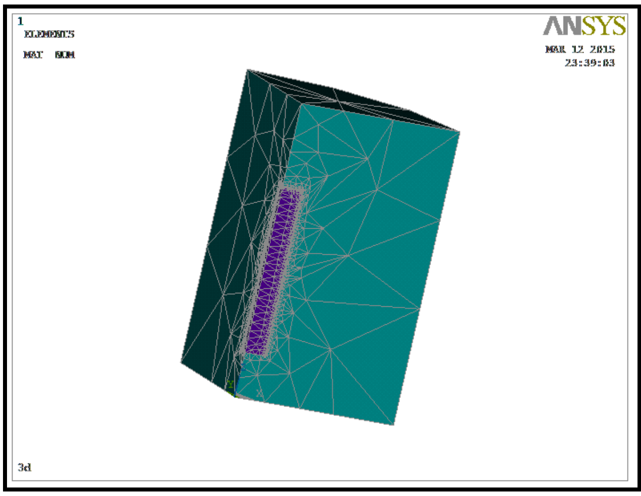


Fig.2. Determining splitting areas

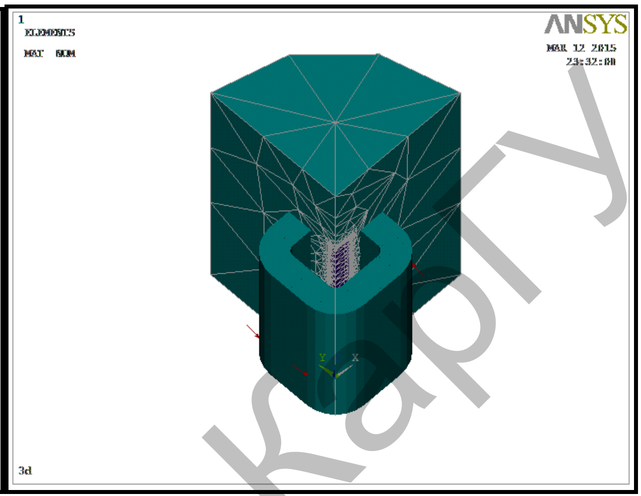


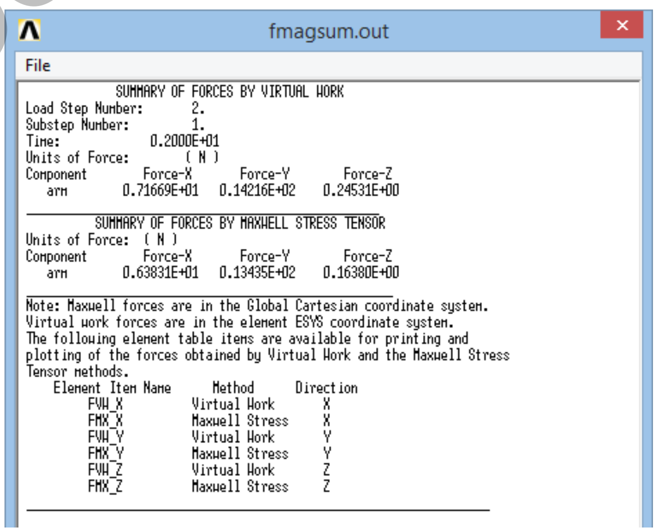
Fig.3. Electromagnet model

The traction force developed by the electromagnet can be calculated by Maxwell formula received from the analysis of the magnetic poles operating on the poles' surface. If a pole in the working gap is homogenous and the poles are non-saturated, then the electromagnet Maxwell formula will be as following:

$$P = \frac{1}{2\mu_0} B_b^2 = \frac{1}{2} \frac{F_b^2}{\mu_0 S}$$

where B_b (Tesla) - induction; F_b (Veber) – magnetic flux in a working gap; S(sq.m) – the area of the pole [6].

At start of the model solution in the ANSYS program the traction force of an electromagnet was received (figure 4).



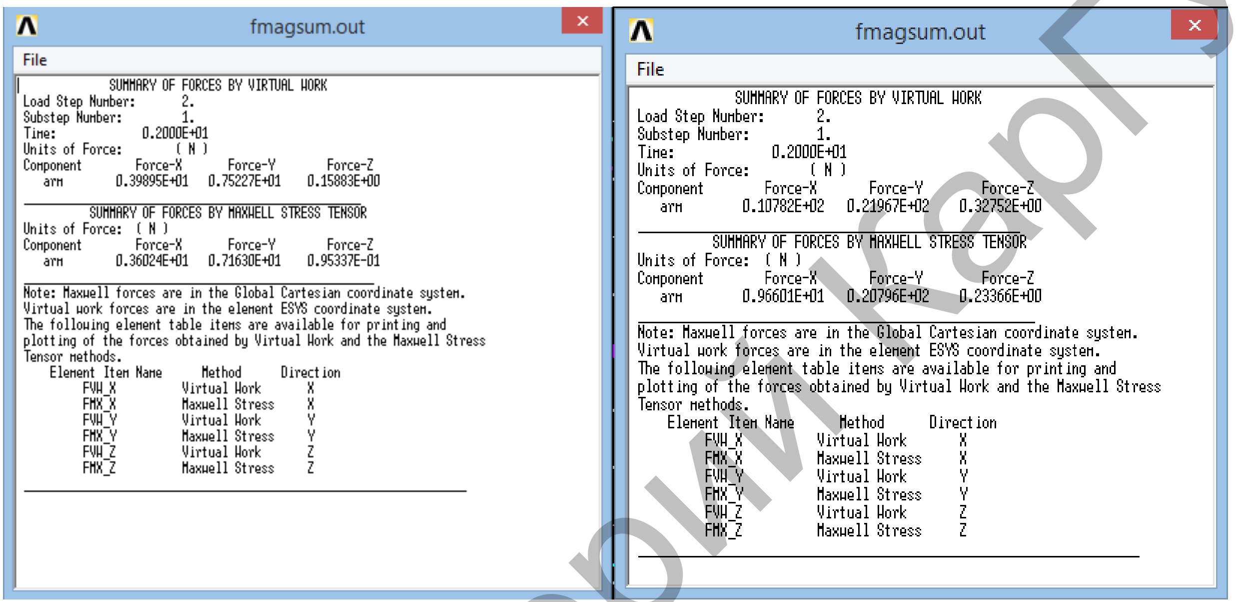
```
fmagsum.out
File
                SUMMARY OF FORCES BY VIRTUAL WORK
Load Step Number:        2.
Substeр Number:          1.
Time:               0.2000E+01
Units of Force:          ( N )
Component        Force-X        Force-Y        Force-Z
   arm         0.71669E+01    0.14216E+02    0.24531E+00

             SUMMARY OF FORCES BY MAXWELL STRESS TENSOR
Units of Force:  ( N )
Component        Force-X        Force-Y        Force-Z
   arm         0.63831E+01    0.13435E+02    0.16380E+00

Note: Maxwell forces are in the Global Cartesian coordinate system.
Virtual work forces are in the element ESYS coordinate system.
The following element table items are available for printing and
plotting of the forces obtained by Virtual Work and the Maxwell Stress
Tensor methods.
    Element Item Name      Method           Direction
         FVW_X             Virtual Work        X
         FMX_X             Maxwell Stress      X
         FVW_Y             Virtual Work        Y
         FMX_Y             Maxwell Stress      Y
         FVW_Z             Virtual Work        Z
         FMX_Z             Maxwell Stress      Z
```

Fig.4. Solution of model

The traction force of electromagnet needs to be determined for the analysis of power interaction of elements of electromagnetic lifting installation. This model allows to make a number of virtual experiments at various set parameters of the unit that considerably saves costs of physical model of installation. Except model with the steel core during experiments were considered two more options of cores: the core from ferromagnetic material and the iron core. The calculations were based on the various indicators of magnetic characteristics. As a result, calculation of traction force of the electromagnet with the ferromagnetic core is presented in figure 5 (a), and calculation of traction force of the electromagnet with the iron core is presented in figure 5 (b).



a) b)

Fig.5. The solution of the model with iron (a) and ferromagnetic (b) cores

As a result, of carrying out the analysis and the solution for three types of the core, the comparative histogram presented in figure 6.

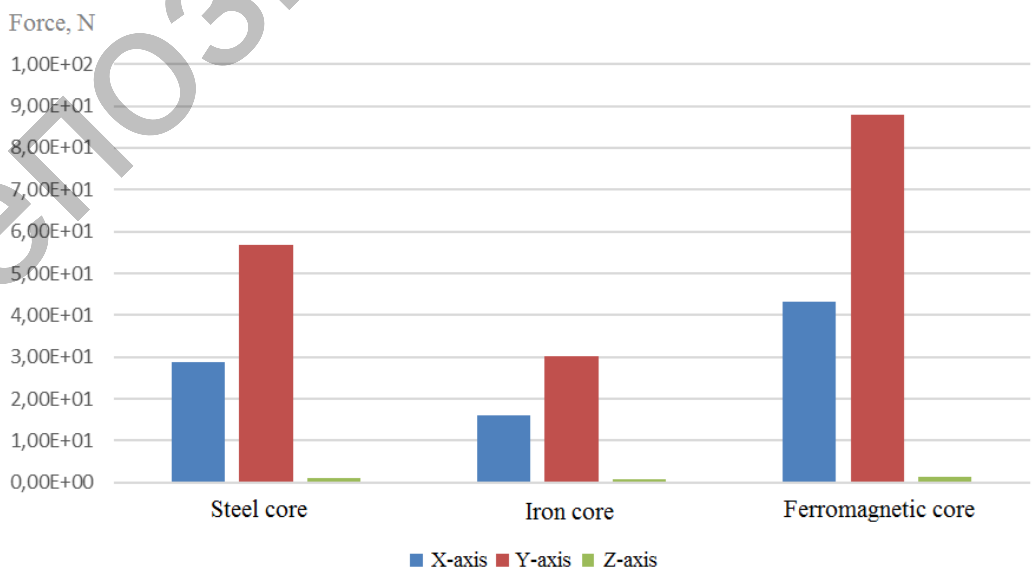


Fig. 6. Comparative histogram

Traction force defined in our case with multiplication by 4, the reason is that calculation was made for the quarter of the electromagnet [7].

Conclusion

By gradual change of electromagnets' parameters and electrical parameters was conducted the number of experiments and researched fluctuations of electromagnet's traction force. This research is the first stage of creation the model of interaction of electromagnets of a skip and electromagnets of the directing devices of electromagnetic lifting installation.

Acknowledgements

This article is written on the basis of results of the researches, which are carried out within grant financing of Ministry of Education and Science of the RK by the sub priority of "Technologies of minerals development", on the theme of "Justification and Development of Energy Saving Technology of Dredging of Rock Mass by Creation of Electromagnetic Lifting Installation" № 2684/GF3, by the priority "Power and mechanical engineering" on the theme "Development of the System of Automatic Control and Complex Protection of Energy Saving Electromagnetic Lifting Installation" № 0686/GF4.

REFERENCES

1 Bassov K.A. *ANSYS in examples and problems*. Moscow, Computer Press, 2002, 224 p.

2 Andreyeva E. G., Shamets S. P. *Calculation of stationary magnetic fields and characteristics of electrotechnic devices by means of the software package ANSYS*. Omsk, Publishing house OMGTU, 1992, 92 p.

3 Reference system ANSYS 6.1, ANSYS Inc., 2002.

4 Zhautikov B.A., Aikeyeva A.A., Zhautikov F.B., Mukhtarova P.A. The introduction of energy-saving technology for transporting rock mass by creation electromagnetic hoisting installation. *Eurasian Physical Technical Journal*, 2013, Vol. 10, No. 2(20), pp.49-52.

5 Zhautikov B.A, Aikeyeva A.A, Zhautikov F.B., Aidarkhanov A.M., Zhanasbayeva A.S., Belgibayev A.S., Modeling electromagnetic systems. *Eurasian Physical Technical Journal*, 2014, Vol.11, No. 1(21), pp.45-51.

6 Aikeyeva A.A., Zhautikov B.A., Zhautikov F.B., Mukhtarova P.A. Research of the area of possible shift loaded skip barycentre of electromagnetic. *Eurasian Physical Technical Journal*, 2014, Vol.11, No. 2(22), pp.62-69.

7 Zhautikov B.A, Aikeyeva A.A, Mukhtarova P.A., Zhanasbayeva A.S. Create electromagnetic hoisting installation-solution transportation of rocks from deep horizons. *Education and science without borders*, Prague, 2014, Vol.5, No. 9, pp.168 - 170.

Article accepted for publication 23.11.2015