

Subsystem For the Computer-Aided Thermo-actuator Design

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Abstract – In the paper the dedicated application to the Computer-Aided Thermoactuator Design using ANSYS as third-party software is presented. Both, the algorithm and GUI are described. Finally, the simulation results obtained for thermoactuator shown some linear dependencies.

Keywords – CAD, MEMS, thermoactuator,.

I. INTRODUCTION

Microsystem devices (MSD) are currently one of the fastest growing interdisciplinary scientific and technological domain. In recent years the rapid development of MSD technology has shown great potential of this area and allowed producing a lot of devices that could not be manufactured using macro technologies [2]-[5]. In macro processes the heat transfer is rather inertial [6]-[10], but in microsystems with thermoelements due to small characteristic dimensions, operating frequency reaches hundreds of hertz [11]-[15]. The main advantage of thermoelements is their structural simplicity, as well as strength created by actuators [16]-[20]. Solid parts in the most MSD sensor with thermoelements can significantly increase their load limit [16]-[21].

Besides, the most important feature of microsystems is their development is associated with different domains of science such as mechanics, electromagnetism, hydrodynamics, etc. However, the theory suitable for macro objects are not always suitable to describe the behavior of micro objects [22]-[24].

Therefore, the design of integrated element models taking into account their small dimensions is one of the main direction in MSD development. Simulation allows determining the mechanical and physical parameters of elements, finding the optimal design value without experimental study. It is not always possible to measure physical values such as temperature field or the velocity distribution in the gas flow on the microscale without introducing changes into them. These values play an important role in thermosensors, which are based on convective heat transfer.

Therefore, the development of the database driven with materials and their properties for automated generation of code for modeling bimetallic thermoactuator for ANSYS with the ability to change the geometry of thermoactuator is a vital task.

II. ALGORITHM FOR THERMOACTUATOR SIMULATION WITH DIFFERENT HEATING TEMPERATURES

We propose to use cycles in order to automate the study of maximum value of stress and displacement in thermoactuator plates depending on the applied temperature. It reduces the software code and automates the research process. The algorithm of the proposed solution is presented in fig. 1. Presented algorithm chart was introduced in the work [1].

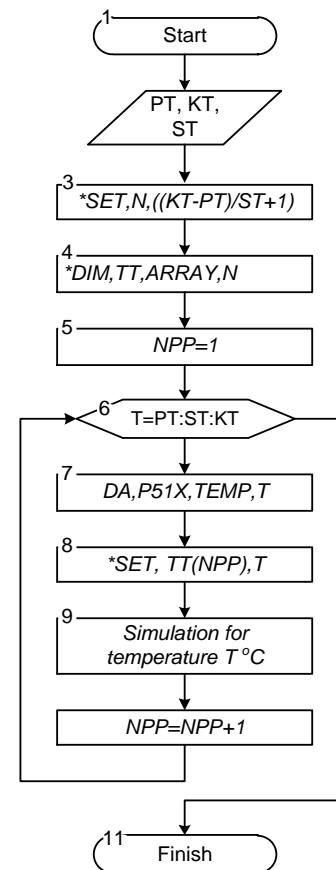


Fig.1. Algorithm for thermoactuator simulation with different heating temperatures

III. CODE AUTOMATION USING MICROSOFT ACCESS

MS Access was chosen as a software environment. It allows coding programs for automated generation of a batch file for ANSYS system without additional specialized software. The developed program makes it possible to

generate software code for the ANSYS system with various input parameters. It significantly reduces time, labor efforts, other expenditures like qualified personnel, errors caused by human factor and increases productivity.

IV. EXPORT OF DATABASE TABLES INTO A TEXT FILE

ANSYS format is not supported by standard MS Access features. It was necessary to create such a data converter. Suitable macros was developed in accordance with ANSYS format specification. They export selected tables containing code generated by system into a text file and stores it on the hard disk drive.

V. GRAPHICAL USER INTERFACE

The main window of the developed application is presented in fig. 2. Presented application contains library of materials and their properties and evoking ANSYS is able to generate accurate code.

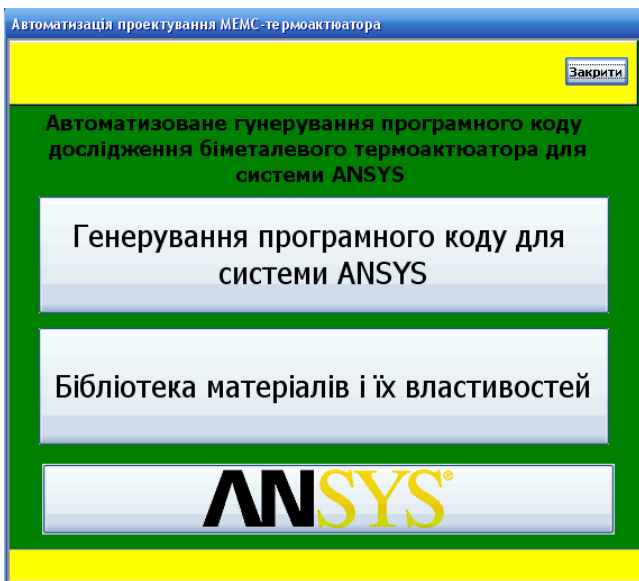



Fig.2. Application main window


It is necessary to have ANSYS program installed on given computer. Then clicking the "ANSYS" button runs the ANSYS environment.

"Library of materials and their properties" button opens the window presented in fig. 3. This window is used to add, modify and delete materials and their properties.

Назва	Позначення	Модуль пружності, 10^9 Па	Густина, 10^{-3} кг/м ³	Коефіцієнт Пуассона	Коефіцієнт тепл. розшир., 10^{-6} 1/К	Коефіцієнт тепл. провідності, Вт/м ² К
Алюміній	Al	70	2.7	0.33	23	230
Мідь	Cu	1100	8.96	0.37	23.4	388.7
Золото	Au	77.9	19.23	0.42	14.2	299
Титан	Ti	110.3	4.59	0.3	8.8	21.68
Кремній	Si	160	2.4	0.22	2.6	157
Діоксид кремнію	SiO2	73	2.3	0.17	0.55	1.4
Нітрид кремнію	Si3N4	323	3.1	0.25	2.8	19

Fig.3. Library of materials and their properties window

The window presented in fig. 4 is opened with left-most button  on "Library of materials and their properties". This window displays the properties of specific material. This data is able to be edited. To add a new material the

button  located in the upper left corner of the window should be clicked.

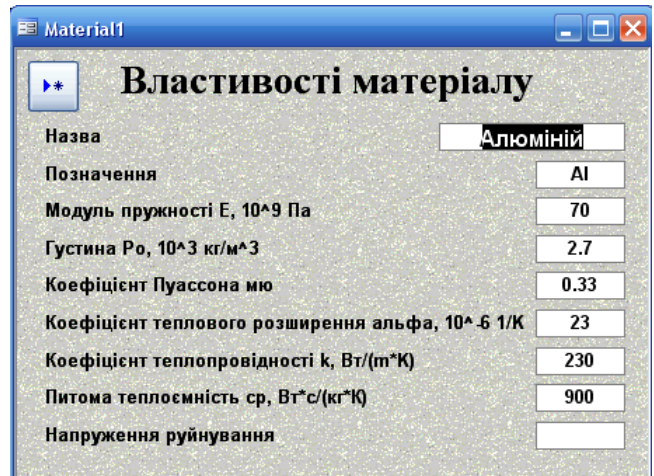


Fig.4. Material Properties window

When we click on the button "Generate code for the ANSYS system" the window presented in fig. 5 opens. User can set parameters of simulation as follows: geometric dimensions of thermoactuator, where L - length of thermoactuator plates, W - width, Sd - thickness of dielectric and Sm - thickness of metal.

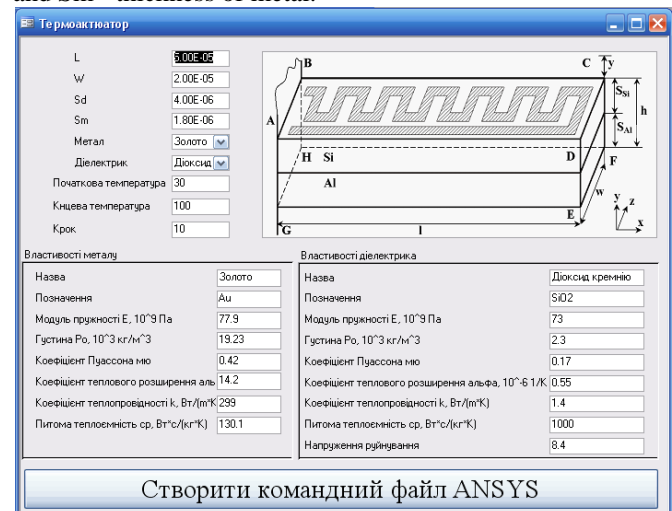


Fig. 5 Thermoactuator parameters set up window

Using "Metal" and "Dielectric" drop-down menus respected materials can be chosen. The last three fields are intended to enter modeling temperature – initial and final ones as well as step of simulation. The properties of the material do not need to be set. Material should be chosen from the list and the application automatically selects their properties from the library and present in the bottom of the window for visual control. Fields representing material properties are designed in order to control the accuracy of data entry before the simulation. Properties can also be changed here. Having set the abovementioned data the application generates a file ProgramL3_Z.txt.

VI. SIMULATION RESULTS

During the thermal analysis, temperature limits and temperature increments are set by the user. This allows the

investigation of the thermoactuator properties for different heating temperatures. For each temperature it is also possible to save data with stress in thermoactuator plates and displacement.

After setting parameters of thermoactuator, batch file running, user gets the results as graphic files. An example is shown below.

Figures 6-7 depicts the stages of designing of thermoactuator geometry and partitioning on a finite elements grid that are created automatically and stored in graphical files.

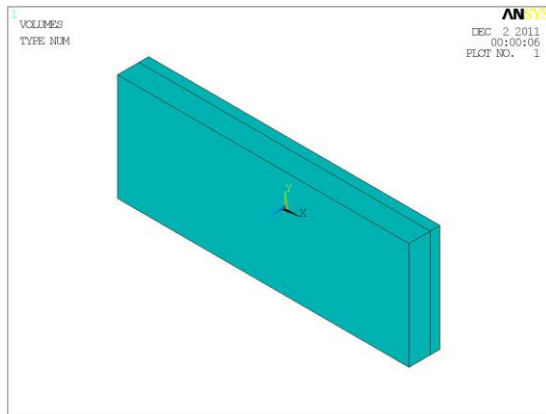


Fig.6. Geometry of thermoactuator plates

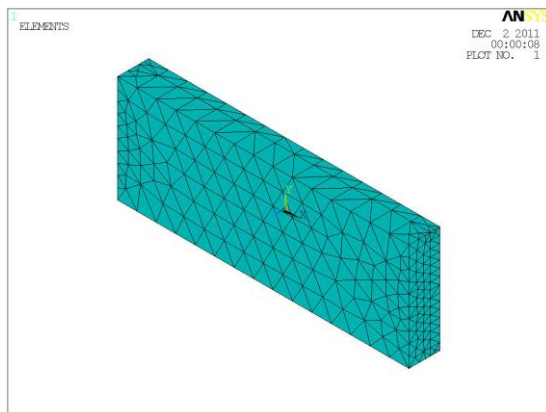


Fig.7. Breakdown into finite element mesh

In fig.8 the relationship between the maximal stress in thermoactuator plates and the heating temperature is presented. Increasing of heating temperature caused the raise of tension in the thermoactuator plates.

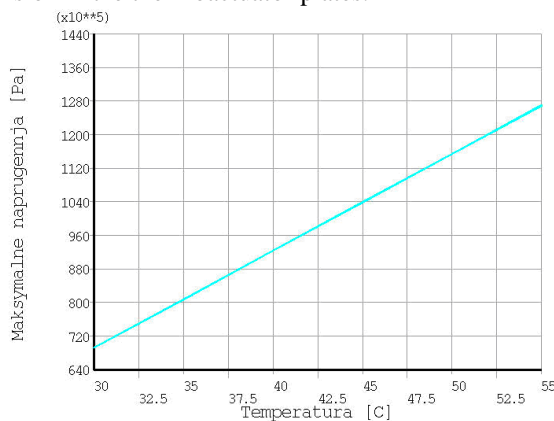


Fig.8. Graph of dependency between maximum stresses in thermoactuator plates and the heating temperature

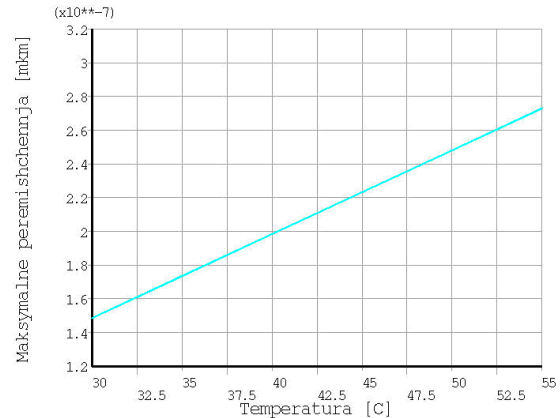


Fig.9. Graph of dependency between maximal displacement of thermoactuator and the heating temperature

Dependency between the maximal displacement of thermoactuator and heating temperature is shown in Fig. 9. As can be seen from the graph, with increasing heating temperature increases the maximal displacement of thermoactuator plates. As can be observed from the graphs in figures 8-9 dependencies are linear.

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VII. CONCLUSIONS

When developing CAD application for MEMS - thermoactuator design the following challenges has been solved:

- the presented algorithm provides a possibility to conduct simulation for different heating temperatures of thermoactuator plates. This allows users during exact calculations for large number of different temperatures to run the task and be available for other tasks;
- automatic recording of each stage of thermoactuator geometry construction into image files is implemented;
- automatic recording of results of thermal analysis into graphic files is implemented;
- a Visual Basic application is developed to run ANSYS system;
- when creating code for the ANSYS system cycles were actively used. This significantly allows the reduction of program code, speeding up its performance, and making it multipurpose.

Research of thermoactuator identified the maximal stress in the thermoactuator plate and their displacement according to the heating temperature as linear dependencies. The results of the implementation code for the ANSYS system generated by the developed application are presented. All obtained results was created and stored automatically in the working directory of the project in the form of graphical and text files.

VIII. ACKNOWLEDGEMENTS

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