MODELING OF AN ULTRASONIC ENGINE WITH THREE DEGREES OF FREEDOM

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Abstract: In the work is presented the modeling of ultrasonic motor with three degrees of freedom. The basic and operating diagram of ultrasonic motor with piezoceramic active elements. The presentation of all vibration modes discovered by computer is make it and the possibility of being accomplished from practical viewpoint. From viewpoint all vibration modes presented are briefly described and as for the features of the useful are exhibited more to length.

Key words: ultrasonic motor; vibration modes

1. Theoretical considerations

The modeling of motor with three degrees of freedom represents a very important step in the advanced study and design of one ultrasonic motor.

The stage of modeling using the method of finite element is very useful because reduces a lot the necessary time of experimentations.

This thing is owned to the fact that the practical scan range of frequencies is not anymore necessary in ultrasonic domain starting with the frequency of f=18000 Hz

The method of finite element designate the frequency in which there are produced the oscillations of traveling necessary for transformation and delivery from piezoceramic active element to active element.

2. Description of the operational way to an engine with three degrees of freedom

In this work will be studied, design and achieve one ultrasonic engine with three degrees of freedom who can realize two translational motions and a motion of rotation.

The ones three degrees of freedom consist in the translational motion along the OX si OY axis and in the motion of rotation around OZ axis of whole system.

For the realization of translational motions are used two piezoceramic active elements and from lamella shape and as for the rotation motion is used an piezo-ceramic element which acts the whole system.

According as what was presented , the piezoceramic active femelements that serve this system are lamella and ring type.In this chapter will be presented the modelling of the two types of piezoceramic elements , in first part the piezoceramic active element of lamella type and in the second part of the chapter the active element of disk type.

In this way shall be defined the frequencies of useful vibrations which there are able to produce through their shapes of ‘’traveling’’type the desirable movements.

3. Modelling of the piezo-ceramic active element from lamella type

Foget the liniar displacement on two directions of ultrasonic engine is used two piezo-ceramic plates having the lenght L= 45 mm, width l=15mm and thickness h=2.5mm. For the realization of modal analyses that involve the introduction of a piezoceramic material properties was choose right as an element of digitization a structure of Scalar Brick 5 type which has a parallelepiped form.

Bellow it is presentet ones of the several modes of vibration which belong to piezoceramic plates.

Another mode of vibration which can't be used-up in the ultrasonic engine operation is produced to frequency f=54246 Hz and is presented in figure 1.

The oscillations of ''traveling'' type searched in sight of realization the movement are produced to frequency f=45105 Hz and there are presented in figure 2.

Around this frequency the experiments were concentrated and where the movement of activated element with constant values in time was obtained . The motion of mobile element is continuous and produce the movement of mass driven by motor in both directions of plan.

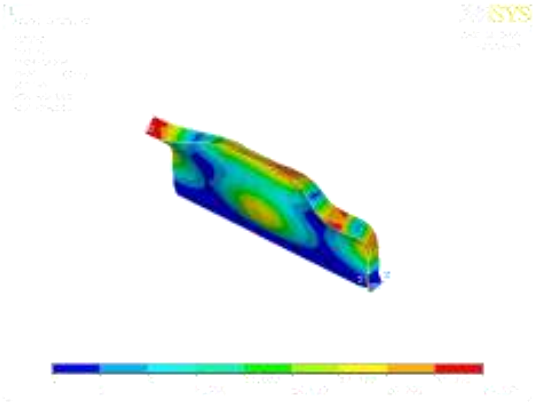

Figure 1. The mode of vibration to a frequency f = 54246 Hz.

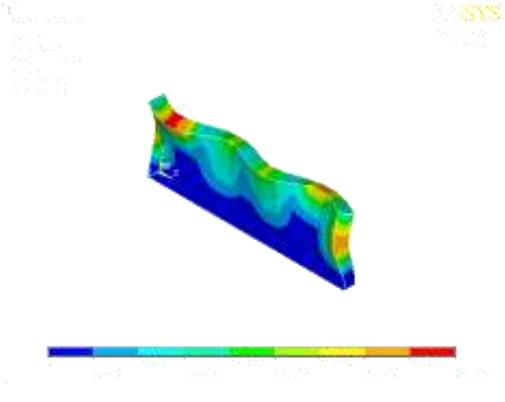

Figure2. The vibration mode of'' traveling'' type to frequency f = 45105 Hz.

In figure 3 is presented another one interesting mode of vibration which is produced to frequency f=90477 Hz in which the oscillation are from ''traveling type''but there are produced in two plans XOY and XOZ.In this situation the utilization of vibrations in the ultrasonic engine actuation is very difficult.. the continuation of the study for this kind of vibration is very interesting, only that is not represent a part from the activity of this work.

There are presents the vibration ways of piezoceramic element from ring type , element that achive the rotation motion of the engines. The second one piezoceramic active element is from ring type and has the inside diameter d= 40mm, outside diameter D=46 mm and the thickness h=7 mm. For obtain the desirable vibration modes was achieved a modal analyses from which are presented the main vibration modes from the domain of ultrasonic frequencies. In figure 6 is presented the first mode of vibration to frequency =38857 Hz, which practically don't presents any kind of interest.

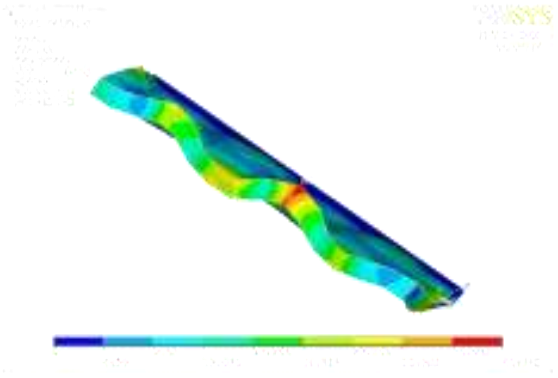

Figure 3. The vibration mode of'' traveling'' type to at frequency f = 90477 Hz.

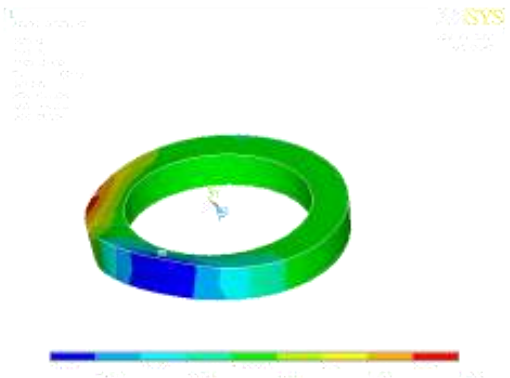

Figure 4. The mode of vibration at frequency
f=38857 Hz.

In the figures below are presented a mode of oscillations which isn't a ''traveling type''.

After the procurance of periodic desirable oscillations to frequency f=45057Hz, these disappear in a such way as it can see it in figure5, these become unsymmetrical and can't be useful from practical viewpoint.

This kind of rotation motion with same features is also obtained to a frequency f=65628 Hz .The researches were concentrated around frequency f=65000Hz which is the most used in the operation of this ultrasonic motor.

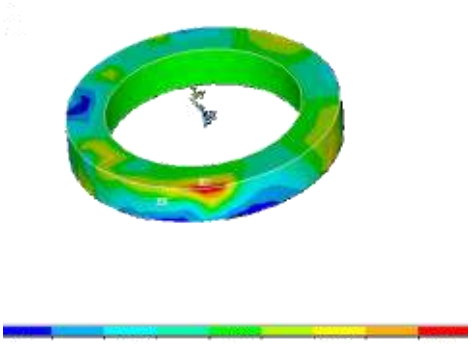

Figure 5. The mode of vibration from ''traveling'' type at frequency
f = 45057 Hz.

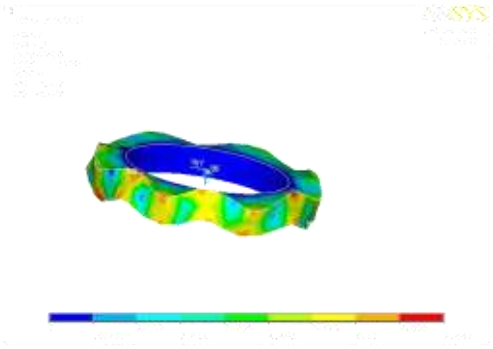

Figure 6. The mode of vibration from ''traveling'' type to frequency
f = 65628 Hz.

4. Conclusions

The modeling stage using the method of finite element is very useful because reduces a lot the necessary time of experimentations and give the possibility of understanding what phenomena are produced to under-microscopically level.

In this way can be created an image for vibration modes of piezo-ceramic active elements therefore these must be useful for the production of activated element movements. The reduction of working time is owed the fact that is not anymore necessary the scanning of frequency ranges from the ultrasonic domain starting with a frequency f=18000Hz. The method of finite element denotes with higher precision the frequency where the oscillations of traveling type necessary transformation and transmission from piezoceramic active elements to the activated ones are produced.

According as what was presented the points situated on the surface of piezo-ceramic element due to vibration form of travelling type, they will execute trajectories of elliptical shapes which will drive through the friction force among the two elements to the ‘’step–by-step’’ movements of the mobile activated elements

In the same time the method of the finite element helps to understand this kind of oscillation and builds mentally one model of operation the ultrasonic engines.In a certain way in the article is presented the vibration modes of piezo-ceramic active elements from lamella and disk type used in the construction of the engines with three degrees of freedom.

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