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THE MODELING OF AN ULTRASONIC ENGINE WITH THREE DEGREES OF FREEDOM

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Abstract: *In the work is presented the modeling of ultrasonic engine with three degrees of freedom. The basic and operating diagram of ultrasonic engine with piezo-ceramic 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*: diagram of ultrasonic; vibration modes*

1. THEORETICAL CONSIDERATIONS

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

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 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 piezo-ceramic active element to all-actives.

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 basic diagram of an ultrasonic engine with three degrees of freedom is presented in figure 1.

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 piezo-ceramic active elements 1 and 2 from lamella shape and as for procurance of the rotation motion is used an piezo-ceramic element 13 which acts the whole system.

The piezo-ceramic elements 1 and 2 are rigid fixed in framework 13, which on her turn is fixed by the support 15 through a flexible system composed from many more pre-stressing screws each of them being equiped with one spring to can achieved the movement on vertical way for piezo-ceramic elements.

To can have a control of the contact area between the two elements is necessary this displace. This check means the modification of friction force between the active element and the activated one that drives to the control speed of mobile activated elements and the tensile force developed by this.

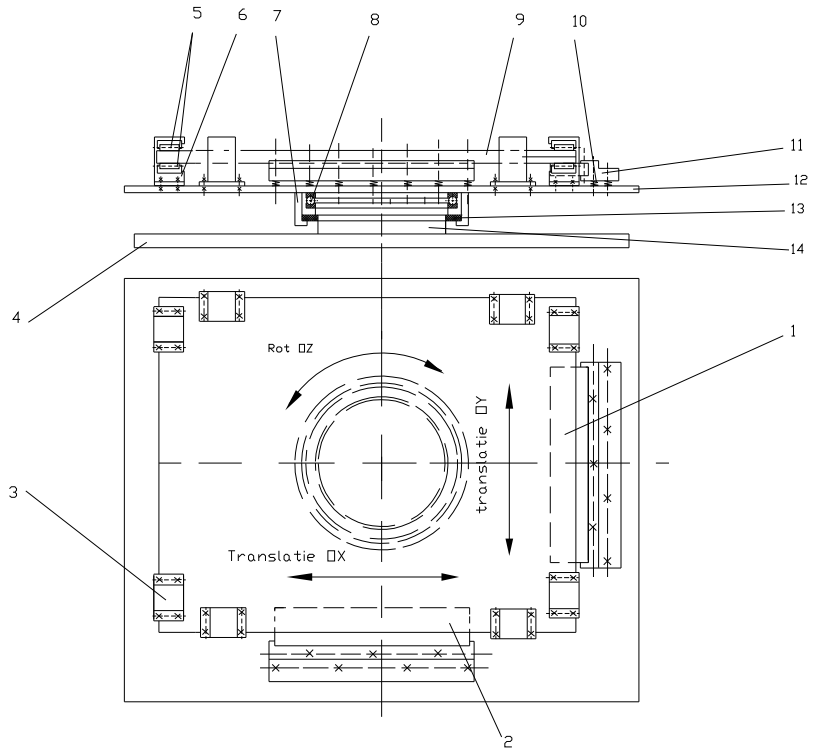

Figure 1. The basic diagram of ultrasonic engine with three degrees of freedom
1 – piezo-ceramic active element of lamella type for the realization of translation on OY; 2 piezo-ceramic active element of lamella type for the realization of translation on OX; 3.- systems with reels for committal and orientation of mass system (activated element) ; 4.- base plate; 5.- Reels of contact; 6. – framework; 7.- cylinder with collar (activated element for the motion of rotation); 8.- axial bearing; 9.- position mass (activated element for the translational motions onto OX and OY) ; 10.- System of pre-stressing for piezo-ceramic plates on the surface of the activated element; 11.- fixing framework for piezo-ceramic plates; 12.-bracket plate ; 13.- piezo-ceramic active element of ring type ; 14.- bracket axle;

As much as the friction forte is more bigger which means an increased pre-stressing force ,the tensile force of engine is much higher. This advantage means a pronounced process of wastage for piezo-ceramic plate that goes to a quick deterioration of this. A force of pre-stressing diminished means a detrition diminished of piezo-ceramic active element but also the delivery value of the engine start to decrease.

The position mass of the system 9 which represents as a matter of fact the activated element is displaced through the sliding between reels 5 installed in the framework 6.

This system was designed to reduce the friction force and to have the possibility of displacement the mass more easily in the directions OX and OY

In this way the mass of the system is consoled on 8 such systems of rolling and the desirable movements can be realized by her.

The frameworks 6 which there are eight in number are fixed with screws on bracket plate 12. This plate on her's turn is rested to the superior ring of the axial bearing 8. This ring pressed enters easy into a special turned hole on the inferior part of bracket plate. In this way can be realized the rotation of the plate around vertical axis OZ. In the inferior ring of bearing is fixed the vertical axle 14 which the piezo-ceramic active element 13 is easy pressed on this. At the excitation moment of piezo-ceramic

element on the inferior part of this will be produced oscillations of ''traveling'' type where will drive to the implementation of rotation motion belongs to cylinder 7 wherewith enter in contact

This collar cylinder represents as a matter of fact the activated element that it will rotate and this one is fixed on braket plate 12.

In this kind is produced also the third motion of ultrasonic system, the motion of rotation. To his row, the arbor 14 is fixed on base plate 4.

According as what was presented , the piezo-ceramic active elements that serve this system are lamella and ring type.In this chapter will be presented the modelling of the two types of piezo-ceramic elements , in first part the piezo-ceramic 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

For the procurance of liniar movements 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 piezo-ceramic material properties was choose right as an element of digitization a structure of Scalar Brick 5 type which has a parallelepiped form.

Bellow I will present ones of the several modes of vibration which belong to piezo-ceramic plates.

To frequency f=35863, the piezo-ceramic active element for obtaining the motion executes only an improper oscillation , that is presented in figure 2

The oscillations of ''traveling'' type searched in sight of realization the movement are produced to frequency f=45105 and there are presented in figure 4.

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 contiguous and produce the movement of mass driven by motor in both directions of plan.

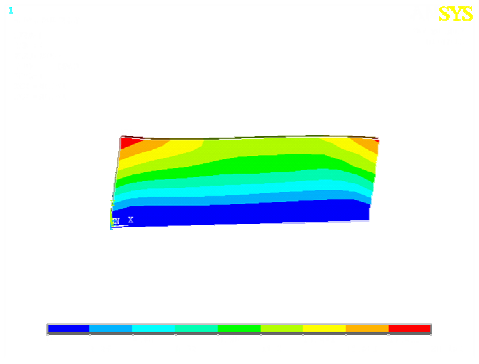

Figure 2.The mode of vibration to a frequency f = 35863 Hz

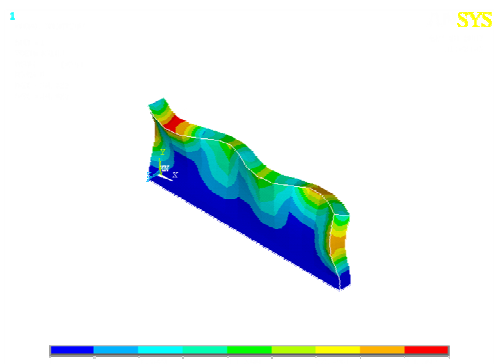

Figure 4. The vibration mode of'' traveling'' type to frequency f = 45105 Hz.

There are presents the vibration ways of piezo-ceramic element from disk type , element that achive the rotation motion of the engines. The second one piezo-ceramic active element is from disk 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 mains 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.

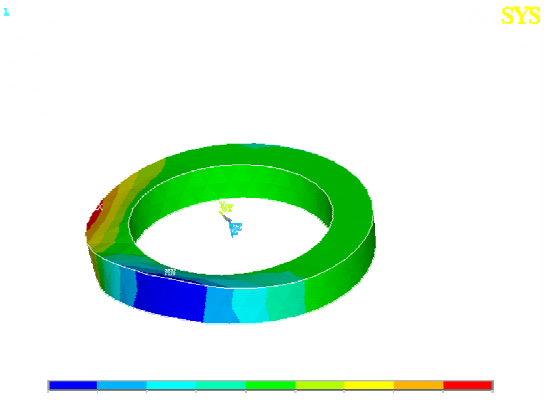

Figure 6. The mode of vibration to frequency f=38857 Hz.

In the figures below are presented a mode of oscillations which isn't from ''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 figure no.8, 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 engine.

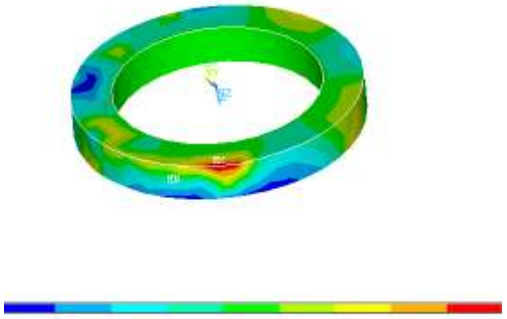

Figure 8. The mode of vibration from ''traveling'' type to frequency f = 45057 Hz.

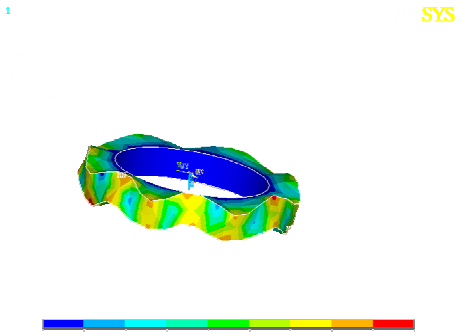

Figure 10. The mode of vibration from ''traveling'' type to frequency f = 65628 Hz.

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 piezo-ceramic 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 traveling 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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