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A Study of the Frequency Reponse of Pressure Mechanical Transducer by Using Finite Elements Method

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Abstract:

Geometrically, the corrugated tube is a thin- walled revolution cosing cross- corrugated on its side surface, due ti its theoretically linear characteristic and its quality to distort under load, the corrugated tube is frequently used as a primary elastic element in the construction of the mechanical automatic system.

Amog the main technical areas thet use such applications the following can be mentioned: aeronautical industry, armament industry,nuclear industry, chemical industry, fine mechanics industry, machine industry, robotics and others.

This paper represents a study elaborated by applying the finite elements method to the analysis of the frequency reponse of the corrugated tube as elastic elements, and for this the authors intend to construct a tridimensional model of corrugated tube disposed in a lever measuring chain, required for simulating the functioning of pressure transducer employed in aeronautical systems.

Key-Words: *aeronautical systems, corrugated tube, finite elements method*

1 General Remarks

Statical analysis does not offer a global answer for the problems of the corrugated tube, because the working of this systems is associated with dynamic effects, such as:

- time variation of working continuously or by leaps;
- occurrence and transmission of vibrations and impact within the system;
- occurrence of dissipative forces caused by frictions among the system components or by the viscosity of fluid.

The dynamic analysis of a corrugated tubular element leads to the achievement of a complete representation of its functioning within the mechanical system whose component it is.

While the static analysis of a corrugated tubular element can be studied by totally isolating it from the rest of the installation, the dynamic analysis considers as place in the functional chain, its links with other elements in the system, the working medium the fluid to be measured, etc.The dynamic analysis was carried out using the corrugated tube built in the Military Technical Academy on a smalle-scale production. The average wall tickenss of the corrugated tube analysed is 0,12 mm and the material used is the copper and beryllium 2% alloy (Cu Be 2%).

2 Tridimensional Model of the Corrugated Tube Employed as Pressure Transducer

The corrugated tube is literally a flexible element, bat because of the partial little deformation, it is considered as an elastical element. If it works under focused target or as cosequence of an interval pressure, the characteristics of a corrugated becomes linear (geometrically line) between certain limits The use of corrugated tubes in mechanical structures is conditioned by the knowledge of how they function and influence the system of wich they are part. Evaluation by computing of how the corrugated tube functions as a pressure transducer implies some difficulties related to the complexity of form and its modification. The results, for first approximate computation, are based on small distorsions, tests being performed in the state considered free of deformation.The method of analytic calculus, based on the theory of the axial-symetric plane and band plates of toroidal form. The simulation of the working of mechanical systems, by the means of the three-dimensional dynamic finite elements method, can now lead to high fidelity solutions in cases whose complexity woreld render them unopproachable through traditional method. For simulating dynamic analysis this paper used the COSMOS program.

The transition to a tridimensional model is necessary considering the diversty of movements effected by the corrugated tube within its dynamic mode (*Fig 1*). [1,2].

Figure 1 The tridimensional model fitting equipped corrugated tube.

Plate quandrangular elements with four <***SHELL***> knots, were used when modelling
The corrugated tube, in order to obtain numerical solutions with a reasonable calculation effort.
The finite elements used for digitization were alloted as follows:

- 14784 <***SHELL 4***> finite elements for corrugated tube;
- 498 <***SOLID***> finite elements for the fitting;
- 2 <***MASS***> finite elements for modelling the reduced mass of the linkage at the level of the upper fitting eye.

The employment of plate elements instead of the volume ones consderably reduces the number of unknowns of the problem without influencing, the precision of the results, provided that the density of the digitization network maintained on the median surface. [2]

3 Harmonic Analysis

Harmonic analisys of dynamic systems aims at obtaining the frequency feature required when analyzing the dynamic characteristics of mechanical systems and represents recordings of the steady reponse for a harmonic excitation input.

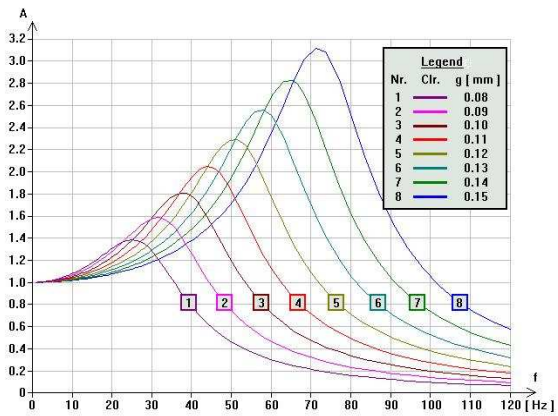

Figure 2. Amplitude-frequency features of the corrugated tube laid out for the thickness range between 0,08; 0,09; 0,10; 0,11; 0,12; 0,13; 0,14;

To obtain the input frequency features spectrum, frequencies are applied successively and the reponse of the system to each of them is analyzed.
The analysis is carried out after installing the stationary mode.
The input frequency varies within the frequency range, possible from a practical point of new, from 0 to 120 Hz and the output values observed are amplitude and reponse phase.
The result of recording the values observed in relation to the excitation forces frequency, showed graphically, represents the frequency features:

- **Amplitude-frequency** feature, in *figure 2*;
- **Phase-frequency** feature, in *figure 3*.

Frequency feature have been established, by means of numerical simulation, for tickness values of the walls of the corrugated tubes ranging from 0,08*;* 0,09; 0,10; 0,11; 0,12; 0,13; 0,14; 0,15 mm.
Amplitude-frequency feature, in *figure 2* have been represented as relative values.
The reference value is represented by the static motion, caused by the action of the pressure load, and is equal to the amplitude of the excitation pressure.
In other words, in the y-coordinate of the reference axes system, the dynamic amplification factor "A"has been represented.
The analysis has been performed considering the actual working conditions of the pressure transducer. The main perturbance source of the hydraulic system, on which the pressure transducer is mounted, in the hydraulic pump with axial pistons whose operating speed is between 700 rot/min and 2000 rot/min Due to its axiale pistons the pump will deliver pulsed pressure with a main stationary component, overlapped by the alternating component, which acts as the disturbance force of the system.
Consequently, in the case of such a pump, the minimum frequency of the disturbance force induced to the hydraulic system has a value of 80 Hz [3,4,5,6]
In fact, the disturbance force higher than 80 Hz causes the designed pressure mechanical transducer to have
Figure 3, shows the phase-frequency features laid out for wall tickness values ranging from 0,08mm to 0,15mm. The difference has been given in degrees (^{0}).

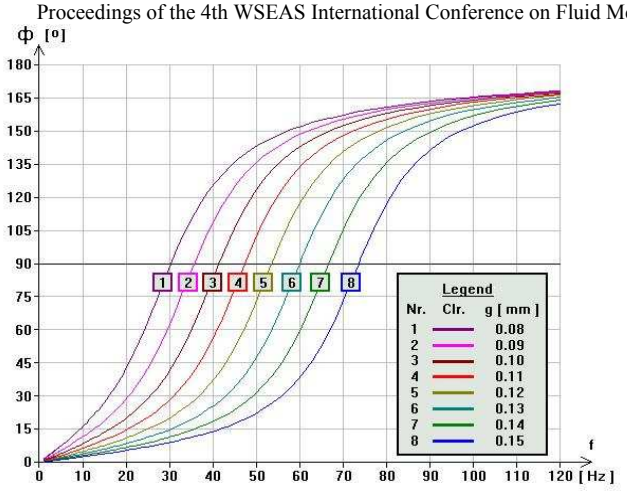

Figure 3. Phase-frequency features of the corrugated tube laid out for a range of tickness between 0,08; 0,09; 0,10; 0,11; 0,12; 0,13; 0,14; 0,15 mm

4 Concluding Remarks

Following the analysis of the frequency feature of the amplitudes laid out in *figure 2* and phase-frequency features laid out in *figure 3*, some conclusions can be reached that are needed in the evaluation of the transducer functioning:

- From the theoretical study and from experimental obtained results that the most indicated corrugated tube from the point of view of the performances of the metrological characteristics for the goal is the one achieved from the alloy Bz Be 2%; [2,8]
- Resonance occurs depending on the tickness of wals;
- The amplification factor is higher as the rigidity of the corrugated tube increases, acquiring fractionary value after exceeding the rezonance regime;
- The chosen mean wall thickness of 0,12 mm, for the corrugated tube represents the justified geometrical design solution;
- Phase difference is an important parametre of the transducer functioning when the alternanting component of the input signal is tracked;
- For a correct functioning of the systems incorporating pressure transducers with corrugated tubes and working in a variable regime, corrections are needed, made on the basis of the phase- frequency feature and meat to eliminate the difference caused by the inertial behaviour of the transducer.

References:

[1] FUIOREA, Ion. *Finite elements method for aeroelastic structure,* Military Technical Academy Publishing, Bucharest, 1998

[2] MOLDOVAN, Elena. *Mechanical pressure transducers for the automatic aircraft systems*, Military Technical Academy Publishing, ISBN 973-640-044-1, Bucharest, 2004.

[3] MOLDOVAN, Elena. *Pressure transducers as dynamic linear systems*, The 1ST International symposium on „Future aviation technologies", pp. 53, ISSN1417-0604, FAT 2002, Budapest, 2002.

[4] MOLDOVAN, Elena. *Elastically elements as dynamic linear systems*, The 33nd international scientific symposium, Military equipment and technologies research agency (METRA), ISBN 973-0-03501-6, Bucharest, 2002.

[5] MOLDOVAN, Elena. *Analysis of dynamic answer of corrugated tube as elastic element,* PRINTECH ARTENS, ISBN 973-652-618-6, pp. 231, Constanța, 2002.

[6] MOLDOVAN Elena. *The statically characteristics of performance for corrugated tube***,** Donețk-Sevastopol, ISBN 966-7907-17-1, pp.174, 2003.

[7] MOLDOVAN Elena, FUIOREA Ion. *Corrugated tubes employed in the board equipments*, Military Technical Academy Revue, pp. 71, ISSN 1453-259X, Bucharest, 2003.

[8] MOLDOVAN Elena, MUSTATA Stefan. *Bronze and Beryllium in aircraft industries*, ISBN 973-635-125-4, vol. 3, pp. 187, BRAMAT, Brasov, 2003.