Materials Physics and Mechanics 31 (2017) 86-88 Received: October 6, 2015

EXPRESS - EVALUATION OF CMG GYRO RESPONSE IN CASE OF RANDOM VIBRATION

S.A. Shevchenko

JSC "Command Devices Research Institute", Saint Petersburg, Russia

e-mail: shevchenko.sergei.a@yandex.ru

Abstract. Express-evaluation of gyro of CMG response in case of random vibration and receiving of frequency-response characteristic are represented. Comparison of calculation results and test data indicates their satisfactory conformity.

1. Introduction

Development of gyroscopic devise is rather difficult and labour-intensive process, which demands solid approach while construction design and its production as well. In the contemporary world, under conditions of constantly reducing time of devise delivery, less and less time is assigned for each development stage including calculations. Such tendency makes it necessary to search for a compromise between speed and accuracy in given task.

Express-evaluation of CMG gyro response in case of random vibration and receiving of frequency-response characteristic in places of gyro motor fastening in order to get operating conditions for its stand-alone tests are represented in this work. Comparison of findings is conducted regarding experimental data. Assessment was carried out using "ANSYS" software.

2. Analytical model of CMG gyro

Figure 1 depicts geometrical model of CMG gyro. On its basis the finite-element model was developed to assess the construction response on the operation of broad-band random vibration.

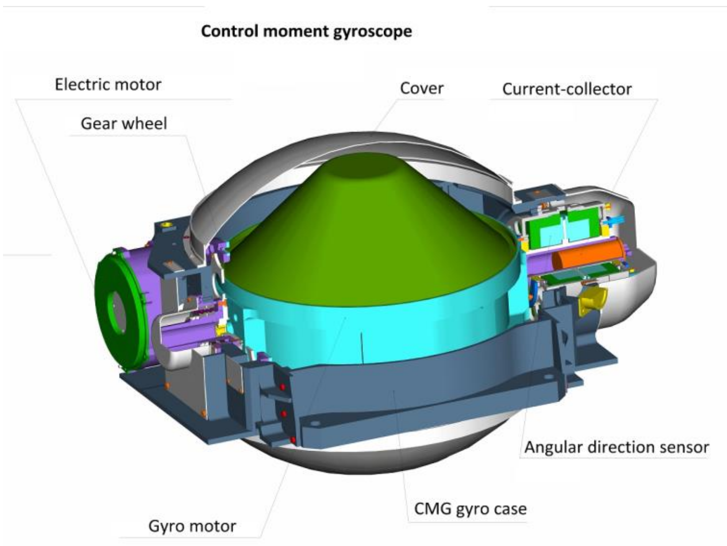

Fig. 1. Geometrical model of CMG gyro.

With the purpose of assessment, implementation within specified period the geometrical model of CMG gyro was simplified considerably. All details and elements that do not influence devise stiffness were excluded from the model. At the same time, the case of CMG gyro was considered absolutely stiff. Such assumption was made on the principal that case stiffness is a good deal more than stiffness of ball-bearing support of devise axis suspension. All excluded from the model details and elements, with the exception of the case and placed on it elements, were modeled with point masses with corresponding moments of inertia and center of mass. Ball-bearing of rotor axis and gyro motor axis suspension were modeled with spring elements with linearized values of stiffness and damping calculation factor. With the aim of determining damping factors of resilient elements, which model ball-bearing rotor and gyro motor, the total stiffness of all elements from spinner till the axle of spinner and from axle of spinner till the axis of gyro motor correspondingly - was used. Thus, finite element model of CMG gyro includes spinner, power caps, gyro motor case, pivots of suspension axis and sockets. It should be noted that with the aim of cutting time for calculation, work on mesh was not carried out; it was took in automatic mode under standard settings. Obtained finite element model is shown on Figure 2.

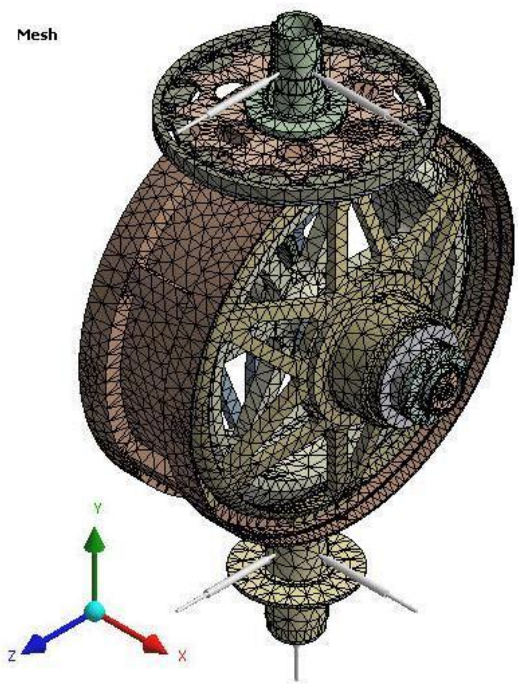

Fig. 2. Finite element model of CMG gyro (the cage cover is hidden).

3. Receiving construction response on operation of random vibration

Initially, in order to determine values of CMG gyro frequency the modal analysis was conducted. Whereby, by means of harmonic analysis in the field of lowest resonance frequency the amplification factor of construction was derived. Conducting of harmonic analysis is necessary for control of the amplification factor while calculation on random vibration, because damping factors specified in resilient elements which model ball-bearing are being ignored in it. After that, at the model input, the mode of band-broad random vibration was set and construction response on operation was calculated. Due to the fact that the goal of calculation was obtaining of modes for stand-alone gyro motor tests, the construction response was defined in places of ball-bearing gyro motor axis suspension installation. As an example, the Figure 3 depicts reaction of CMG gyro when subjected to loadings along an axis Y. The diagram represents dependency of power spectral density (y-axis) from frequency (x-axis).

Afterwards, obtained results were compared to experiment results of developed devise. As a result, the difference between calculated and obtained experimentally modes in the lowest resonant frequency doesn’t exceed 20 %, and it shows the satisfactory quality of finite element model.

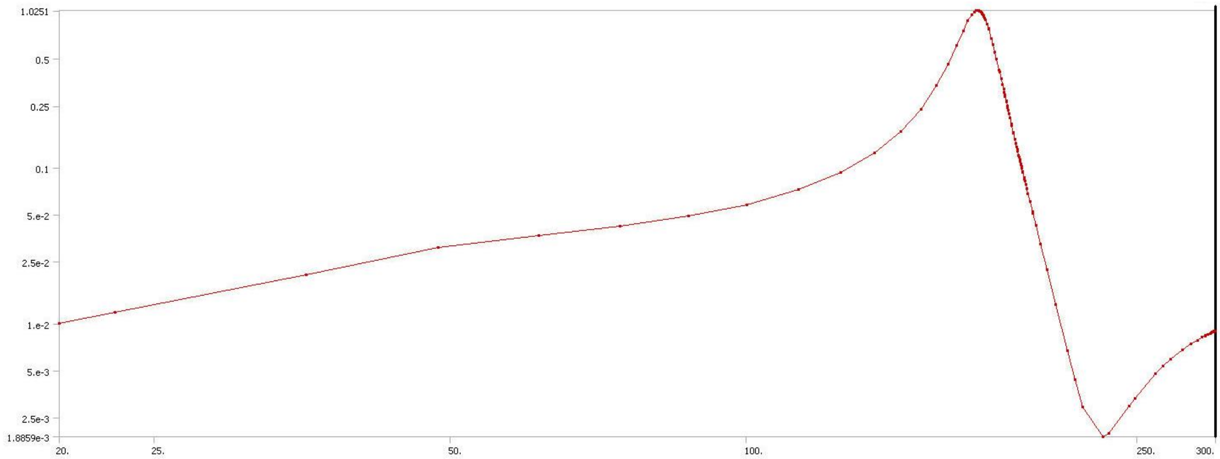

Fig. 3. Reaction of CMG gyro along an axis Y (results of calculation).

Afterwards, obtained results were compared to experiment results of developed devise. As a result, the difference between calculated and obtained experimentally modes in the lowest resonant frequency does not exceed 20 %, and it shows the satisfactory quality of finite element model.

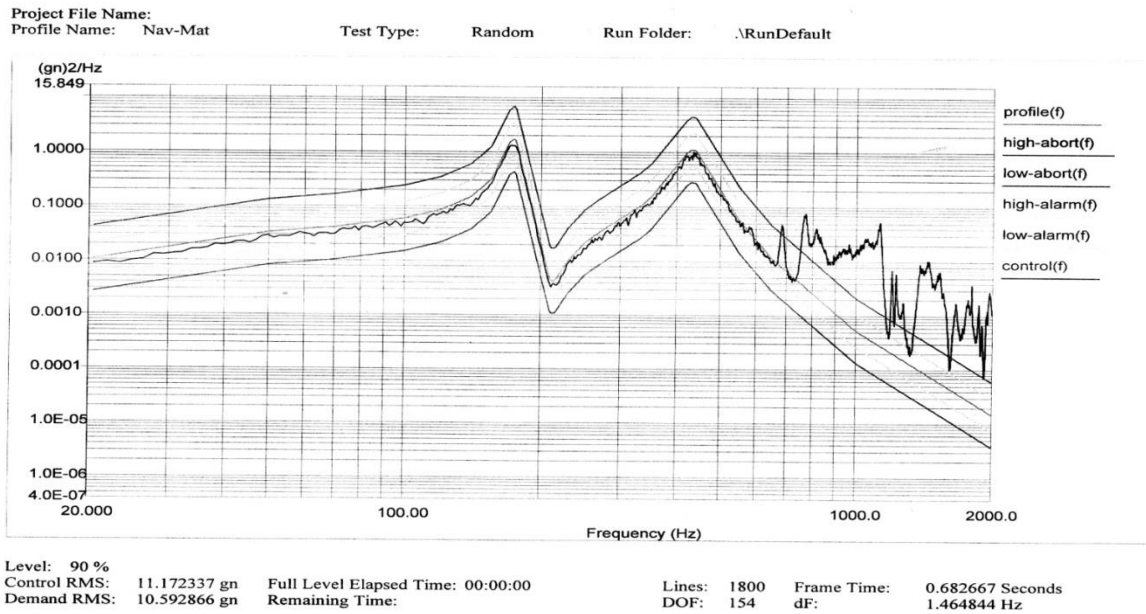

Fig. 4. Reaction of CMG gyro along an axis Y (results of experiment).

4. Conclusion

Summarizing the results of conducted express assessment of CMG gyro construction response in case of random vibration under conditions of considerable model simplification, and absence of mesh work-modes for stand-alone tests of gyro motor were obtained. As follows from the comparison of calculation and experimental values, satisfactory resemblance between them was achieved. That demonstrates the opportunity of employment of such “rough” finite element models for tasks of that kind. At the same time, employment of such models for assessment of construction state of tension leads to considerable imprecisions.