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Analysis of the dynamics of movement of the landing vehicle with an inflatable braking device on the final trajectory under the influence of wind load

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Abstract

This research work is devoted to analysis of angular motion of the landing vehicle (LV) with an inflatable braking device (IBD), taking into account the influence of the wind load on the final stage of the movement. Using methods to perform a calculation of parameters of angular motion of the landing vehicle with an inflatable braking device based on the availability of small asymmetries, which are capable of complex dynamic phenomena, analyzes motion of the landing vehicle at the final stage of motion in the atmosphere.

1. Introduction

Landing stage of the landing vehicle on surface of the planet is responsible for the successful conduct of the flight. To perform this it is proposed to use a special inflatable braking device, allowing to carry out a "soft" landing of landing vehicle on the planet's surface without the use of a parachute system.

During the movement in the atmosphere of the planet of landing vehicle with an inflatable braking device subjected to significant aerodynamic loads, which can lead to changes in non-rigid shell shape inflatable braking device and the emergence of the current asymmetries.

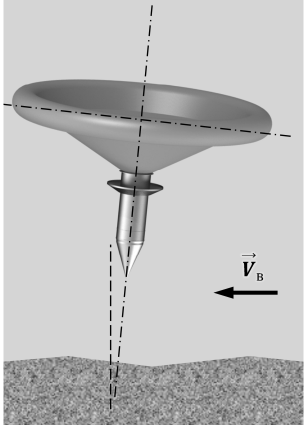

Figure 1. Exterior view of the landing vehicle deployed with an inflatable braking device

In author's work [1, 2], in more detail the methods for calculating the parameters of the angular motion of space landing vehicle with an inflatable braking device. In the scientific work [3] that a description of the project RITD - Re-entry: inflatable technology development in Russian collaboration

2. Modeling

As shown above in the final trajectory the landing vehicle moves almost vertically to the surface of the planet. Wherein the spatial angle of attack is of the order of two degrees.

Consider the additional effect of the horizontal wind on the dynamics of angular motion of the landing vehicle. For example, take a longitudinal horizontal wind with a speed of six meters per second, the effect on the last five hundred meters before landing on the planet's surface.

At Figure 2 shows the pattern of the angular movement of the longitudinal axis of the of the landing vehicle relative to the velocity vector in the absence of additional asymmetries. From Figure 2 shows that the center of the vibrational motion of the landing vehicle relative velocity vector is shifted by about 5.5 degrees. This corresponds to the average angular displacement of the longitudinal axis of the of the landing vehicle relative to the velocity vector in the presence of wind. Thus the character of the dynamics of angular motion of the landing vehicle does not change. Only shifts the center of the vibrational motion of the landing vehicle.

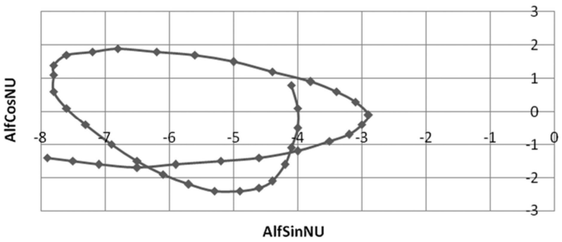

Figure 2. Angular movement of the longitudinal axis of the of the landing vehicle relative to the velocity vector in the absence of additional asymmetries.

Consider the dynamics of angular motion of the landing vehicle under the same conditions, but with additional asymmetry. Figure 2 shows a picture of the angular movement of the longitudinal axis of the of the landing vehicle relative to the velocity vector in the presence of additional asymmetry of the external form (mz = 0.004). This asymmetry may be due to the additional stiffness not inflatable braking device.

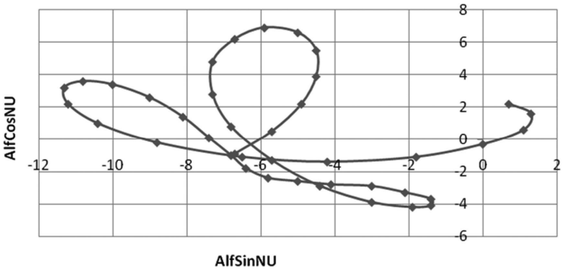

Figure 3. Angular movement of the longitudinal axis of the of the landing vehicle relative to the velocity vector in the presence of additional asymmetry of the external form.

We next consider the dynamics of angular motion of the landing vehicle under the same conditions, but with smaller magnitude of the asymmetry caused by the deformation of the outer shape (mz = 0.002).

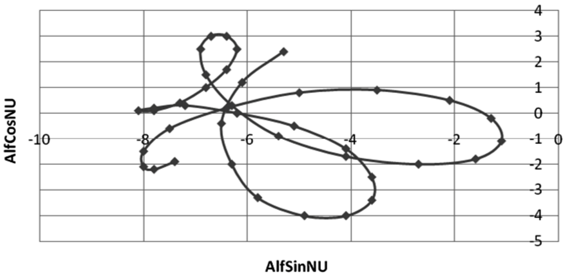

Figure 4. Angular movement of the longitudinal axis of the of the landing vehicle relative to the velocity vector in the presence of asymmetry in the external form (mz = 0.002).

Figure 4 shows a picture of the angular movement of the longitudinal axis of the of the landing vehicle relative to the velocity vector in the presence of additional asymmetry of the external form (mz = 0.002).

3. Summary and Conclusions

Comparing the pattern of angular motion of the landing vehicle presented in Figure 2 and Figure 3 see that the presence of asymmetry caused by the deformation of the outer shape, changes the nature of the angular motion. Increases the value of the spatial angle of attack. Instead, nearly circular motion to the longitudinal axis relative to of the landing vehicle velocity vector appears loop-like movement of the longitudinal axis. Almost three times increase lateral deviations of the longitudinal axis from the velocity vector. The center of the oscillation is roughly the same as that in the absence of additional asymmetry.

Comparing the pattern of angular motion of the landing vehicle shown on Figure 4 and Figure 3 we see that a decrease in the asymmetry due to the deformation of the external form, the nature of the angular movement of little change. Reduces the magnitude of the spatial angle of attack. Reduces the deviation of the longitudinal axis of the velocity vector. But in general, the angular movement of the longitudinal axis of the of the landing vehicle relative to the velocity vector in the presence of additional asymmetry persists.

Acknowledgements

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References

[1] V.V. Koryanov, V.P. Kazakovtsev. Methods of calculating the parameters of motion of landing vehicles // Natural and technical sciences, 2014, no. 9-10 (77). pp. 179-184.

[2] V.P. Kazakovtsev, V.V. Koryanov. Method for Studying Dynamics of Angular Motion of Descent Spacecraft with Inflatable Brake Device // Herald of the Bauman Moscow State Technical University, Series «Mechanical Engineering», 2012, no. 3 (88), pp. 39–46.

[3] Jyri Heilimo, Ari-Matti Harri, Sergey Aleksashkin, Vsevolod Koryanov, Ignacio Arruego, Walter Schmidt, Harri Haukka, Valery Finchenko, Maxim Martynov, Boris Ostresko, Andrey Ponomarenko, Viktor Kazakovtsev, Susanna Martin, and Tero Siili.
RITD - Adapting Mars Entry, Descent and Landing System for Earth. Geophysical Research Abstracts Vol. 16, EGU2014-5506-1, 2014, EGU General Assembly 2014