INFRASOUND EMITTING AT THE START OF A SPACE ROCKET LAUNCH

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INTRODUCTION

The analysis of acoustic radiation during the launch of a heavy space rocket is the main goal of this work. Particular attention is paid to the determination of sound pressure levels in the vicinity of the rocket body and its potential effect on the body, flexible connections and internal devices. Additionally, the generation of infrasonic waves in the Earth's atmosphere and their interaction with atmospheric phenomena are investigated.

To achieve this goal, several tasks are solved in this work. First of all, the basic principles of generation, propagation and direction of sound waves and infrasound during the launch of a space rocket are studied. Then a method is developed for analyzing acoustic sources and radiation in the initial seconds of a rocket flight.

Additionally, an analysis is made of the relationship between the characteristics of acoustic radiation and sound pressure levels near the body of the launch vehicle. A general technique for studying acoustic radiation during the first 14 seconds of a space rocket flight is being developed.

An important part of the study is the study of the interaction of infrasonic waves with magnetic particles and their influence on geomagnetic variations. Comprehensive observations, analysis and modeling are being carried out to better understand and explain the relationship between seismic activity, infrasonic vibrations and atmospheric phenomena.

PURPOSE AND TASKS

The purpose of this work is to study and analyze acoustic radiation during the launch of a heavy space rocket. Determine the sound pressure levels in the vicinity of the rocket body and evaluate its effect on the body, flexible connections and internal devices. And also to study the generation of infrasonic waves in the Earth's atmosphere and their interaction with atmospheric phenomena.

The following tasks are solved herein:

– to study ideas about the generation, propagation and direction of

sound waves and infrasound during the launch of a space rocket;

– to develop a method for analyzing acoustic sources and radiation during the launch of a space rocket and their acoustic fields in the first seconds of flight;

– to analyze the relationship between the characteristics of the source of acoustic radiation and the levels of sound pressure near the body of the launch vehicle;

– develop a general methodology for studying acoustic radiation during the flight of a space rocket in the first 14 seconds of flight;

– to study the interaction of infrasonic waves with magnetic particles and its effect on geomagnetic variations;

– to conduct complex observations, analysis and modeling in order to understand and explain the relationship between seismic activity, infrasonic oscillations and atmospheric phenomena.

MAIN PART

There is acoustic field appeared during the start of a heavy class space rocket in the atmosphere. The research directions of acoustic emitting at the start of a space rocket launch based on ideas about the generation and propagation of sound waves and modeled as a volume acoustic source. On fig.1 is showed launch of a space rocket.

Figure 1 - Launch of a space rocket

A sound suppression level calculations are carried out at the stage of preliminary design. It is based on the results of the physical and

mathematical analysis of acoustic oscillations sources. After the engine starts, various acoustic emissions are generated during the rocket moving in the atmosphere, and acoustic fields are formed in the atmosphere. One of the most relevant problems here is to analyze and assess the acoustic radiation's intensity levels, especially at infrasonic frequencies [1]. It is important to make an assessment of the acoustic pressure impact on the shell of the case, penetrating acoustic radiation inside the cavities of the compartments and its impacting on flexible connections both inside the devices and on their fastenings. Therefore, it is necessary to create a method that will allow identifying features and determining the directions of acoustic radiation researches based on existing ideas about the generation, distribution and direction of both sound waves and infrasound. A method of analysis of the acoustic sources and of radiation during the launch of space rockets (SR) and their acoustic fields in the first seconds of flight was developed. The method is based on the determination of the wave parameter kR of the source of acoustic radiation and allows us to provide valid data on the levels of sound pressure and intensity at specific points in air [2]. This is an important factor that gives an idea of the acoustic field direction and makes it possible to simplify the calculation of sound pressure magnitude as a function of distance variation from the source of oscillations to the point where the conditioned observer is located. It is needed to make an analysis of the relationship between the acoustic emitting source characteristics appeared in the first seconds of the rocket launch and at the indicated points near the carrier rocket body. The points are located near the tail section, the instrument section, the first-stage intertank compartment, and the third-level fairing. A general methodology of researching the acoustic emissions during the flight of a space rocket in the first 14 seconds of flight is developed. To calculate the acoustic characteristics of the volumetric type emitters, an algorithm and a program on Java programming language have been developed. An analysis of the relationship between the acoustic emitting source characteristics and the acoustic field's characteristics is established. Also, the calculation of the amplitude-frequency characteristic of acoustic emitting is given. As a result of the calculations, it was found that the sound pressure levels at the indicated points vary from 155 to 185 dB [3].

INFRASOUND WAVES AND THEIR INTERACTION WITH THE ATMOSPHERIC PHENOMENA, INFLUENCE ON THE CLIMATE AND THE WEATHER

Formation of space and atmospheric weather, changes in the Earth's climate is now involved in many world organizations. In Ukraine it is States Space Agency and anthers organization that are the party of it from

Dnipro, Kyiv, Lviv. In world that are Intergovernmental Oceanographic Commission, World Metrological Organization. In USA it is National Center for Atmospheric Research, Colorado, Boulder; University Corporation for Atmospheric Research. Intergovernmental Group of Experts on Climate Change (IPCC). Recently more and more attention it is given to every possible oscillating motions of atmosphere, including to infrasonic waves. At the present stage less all is clarified atmospheric links at levels below 200 km. Without their definitive installation it will be difficult to solve completely and bottoms of is solar-terrestrial relationships of cause and effect. Infrasonic oscillations in an Earth's atmosphere grow out of activity of the numerous parents: earthquakes (earth crust oscillations), a tsunami. It is known that the infrasound sources are: eruptions of volcanoes, falls, thunder-storms, oscillations of a surface of the sea, forest fires, the strong wind, turbulence of atmosphere, activity of the person (explosions, gun shots, electromagnetic radiations, motions of meteors, galactic rays, gravitational actions of moon and the Sun, corpuscular flows from the Sun. It is earthquake, mountains, the storms of the sea, the sources of vortices in atmosphere, geomagnetic variations and others [4]. On fig. 2 the apparats for discovery of atmosphere of the Earth have displayed.

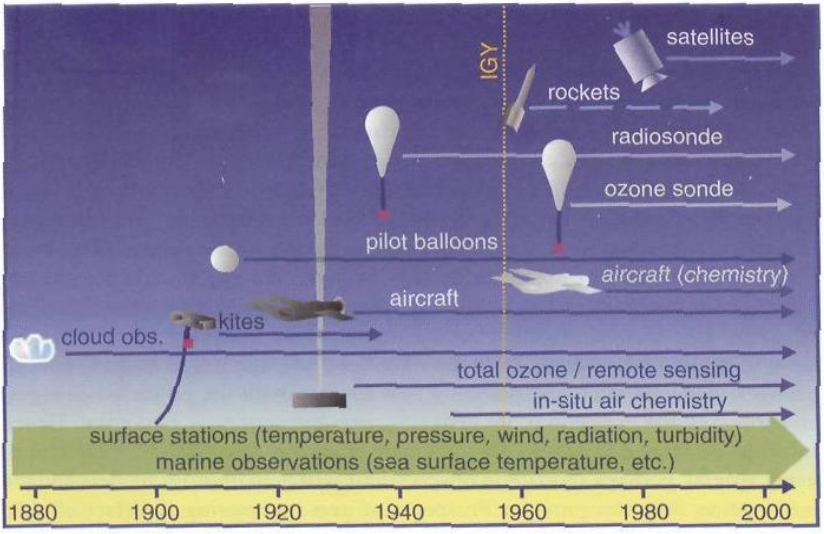

Figure 2 - The apparatus for discovery of the atmosphere of the Earth

The scientists of the department of Ukrainian Institute of Space of State Space Agency of Ukraine Science Academy (SSAU) in Lviv regis-

tered the infrasound of earthquakes in Turkey (A.A. Negoda, S.A. Soroka and other scientists) [5]. They defined that the infrasound is connected with the sun activity. When the sun activity is high the infrasound decries in atmosphere and vice versa when the sun activity is decries high in atmosphere the level of the infrasound is drops.

The infrasonic waves of the quakes travel in high atmosphere. They amplitude does not change a lot. But on high 80 km there are infrasonic waves. There is in sound channel and infrasonic waves (IS – waves) turn on 90 degrees and continued to travel in direction that is parallels on surface on the Earth. The infrasonic waves moved by meridians to poles of the Earth. When infrasonic waves connecting with magnetic particles, we can see the phenomenon of aurora at North Pole [6].

Because geomagnetic particles connected with infrasonic waves. The conducted operations have displayed, that this interaction makes essential impact on an ionosphere. It is proved, that perturbations of an ionosphere of an infrasound from earthquakes and eruptions of volcanoes it is accompanied by a birth of magnetic storms [7]. Earlier the scientists were supposed and considered that the disturbing in an ionosphere (IOA) is connect only with solar flares. At the present stage the scientists are connect the disturbing in an ionosphere with IS – waves. The factor, making the significant impact on infrasonic oscillations of atmosphere, is seismic activity. And it can be an exposure on preparatory processes and the link of intensity of seismic processes. It can be connect with solar activity.

The scientists found effect at analysis of global seismicity and 11-year-old solar cycles. Influence of seismic activity on IOA is very complex process and is not reduced only to piston radiance fluctuating lithosphere plates. Here it is necessary to consider manifold physicochemical processes, both in lithosphere, and in atmosphere. IOA can create on a surface of the Earth alternate stresses and in pour on the significant depths in lithosphere. Infrasonic oscillations influence on the velocity of fluids travel, on the electrical fields and on local seismic oscillations by stimulation in the lithosphere. Thus, the infrasound in atmosphere can be generating as effect of seismic oscillations and awake the influence on the atmosphere [8].

For examinations of the infrasonic canal of lithosphere-atmospheric links it has been introduced two coefficients of seismic activity. The first proportional to a quadrate of the maximum magnitude in the given day in the given region, second - to a quad-rate of the total of magnitudes of all seismic events with magnitude ≥3 for a day in the given region. It was considered two regions. One of it is dimensioned on a longitude 10 ˚- 45˚E and latitude 35 ˚- 60˚N, and second - on a longitude 10 ˚- 55˚E and latitude 20 ˚- 60˚N. The first and second regions powered up the basic bands of

heightened seismicity of the central and east Europe, and also Turkey.

Recently a lot of attention is given to the infrasonic and magneto hydrodynamic waves originating both in the uppermost atmosphere, and behind its limits below and in a magnetosphere. Pressure of sound waves invokes atmosphere inflating [9].

Waves with the frequency exceeding 0,1 glc, are customary waves and are spread with velocity of a sound (g - acceleration of gravity). Waves with frequency, smaller 0,1 glc, go with a little bit smaller velocity. Last, named by gravity waves, always have a wave length exceeding altitude of a homogeneous atmosphere. Thus, the wave length of gravity waves will be not less than hundred kilometers. Thereof in various bands of atmosphere temperature lapse rates and the thermal instabilities generating IOA are organized.

The organized infra-sound can influence fluctuations of intensity of interaction of ultra-rays with atmospheric aerosols. In earth crust percussions and vibrations of very low sound frequencies from the diversified radiant are, including from explosions are observed [10]. For an infrasound small uptake in various mediums owing to what infrasonic waves in air, water is characteristic and in earth crust can be spread to very far distances.

Conclusion

This paper shows that after the engine is started, various acoustic radiations are generated in the atmosphere while the rocket is moving, and acoustic fields, including infrasonic ones, are formed in the atmosphere. The calculation of the amplitude-frequency characteristic of acoustic radiation is also given. As a result of calculations, it was found that the sound pressure levels at the indicated points vary from 155 to 185 dB.

The effect of infrasonic oscillations on the Earth's atmosphere and ionosphere is considered. It has been proven that disturbances of the ionosphere by infrasound from earthquakes and volcanic eruptions are accompanied by magnetic storms. Infrasound has a direct effect on the atmosphere, causing changes in fluid velocity, electric fields and local seismic vibrations. Infrasonic waves can be generated by a variety of sources, including earthquakes, thunderstorms, volcanic eruptions, and human activities. They are able to propagate over long distances due to their low absorption in various media. In general, the study of infrasound is essential for understanding and forecasting weather events and climate change on Earth.

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