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Safety in Aviation And Space Technologies

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SYMPOSIUM 7
ENVIRONMENTAL PROTECTION

Chairman – O. Zaporozhets, National Aviation University, Ukraine.
Secretary – K. Kazhan, National Aviation University, Ukraine.

11 October, 14:00, room 5.611.

1. Methods of aircraft engines emissions assessment within the airport.
K. Ulianova, K. Synylo, National Aviation University, Ukraine.

2. Numerical simulation of the jet from the aircraft engine by OPENFOAM.
K. Synylo, A. Krupko, National Aviation University, Ukraine

3. Performing the optimization of compressed air specific consumption depending on the defining dimensionless structural and operating parameters of the motor-car pneumatic motor.
O.I. Voronkov, D.B. Glushkova, I.N. Nikitchenko, E.V. Teslenko, A.O. Nazarov, Kharkiv National Automobile and Highway University, Ukraine.

4. The impact of airports on visual safety of environment.
M.M. Radomska, National Aviation University, Ukraine.

5. Electromagnetic screens application for population protection from electromagnetic fields and radiation.
V. Glyva, National Aviation University, Ukraine.
O. Panova, National University of Construction and Architecture, Ukraine.

6. External environmental air distribution exchange by using UAV.
A.G. Sitnik, L.M. Sitnyanskych, I.V. Kravets, National Aviation University, Ukraine.

7. Monitoring of electromagnetic environment at the civil aviation aerodromes.

V. Glyva, O. Tykhenko, National Aviation University, Ukraine.
O. Tymoshenko, Odesa International Airport, Ukraine.

8. Stirling engine in residential heating systems.
M.V. Dudnyk, O.L. Marchenko, Oles Honchar Dnipro National University, Ukraine.

9. The impact of aviation and rocket-space technology on the ozone layer: causes of destruction and recovery methods.
I.A. Bida, A.V. Kononenko, V.S. Prokopchuk, M.P. Savchuk, L.M. Teleniuk, V.V. Horupa, National Aviation University, Ukraine.

10. Detailed flight operation data for accurate aircraft noise assessment.
Oleksandr Zaporozhets, Larisa Levchenko, National Aviation University, Ukraine.

11. Noise monitoring for improvement of operational performances of the aircraft in vicinity of airports.
O. Zaporozhets, National Aviation University, Ukraine.
A. Jagniatinskis, Gediminas Technical University, Lithuania.
B. Fiks, Gediminas Technical University, Lithuania.
M. Smiesek, Politechnika Rzeszowska, Poland.
A. Chyla, M. Bukała, SVANTEK, Poland.

12. PARE preliminary analysis of ACARE Challenge 3 environmental impact goals (towards quiter and cleaner environment in aviation sector.
Oleksandr Zaporozhets, Volodymyr Isaienko, Kateryna Synylo, National Aviation University, Ukraine.
L.Campos, Instituto Superior Tecnico, Portugal.
Joana Soares, INOVAMAIS S.A., Portugal.

13. Risk methodology as a tool for aircraft noise assessment and control.
Oleksandr Zaporozhets, Larisa Levchenko, National Aviation University, Ukraine.

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I.A. Bida, A.V. Kononenko, V.S. Prokopchuk, M.P. Savchuk, L.M. Teleniuk, V.V. Horupa,
(National Aviation University, Ukraine)

The impact of aviation and rocket-space technology on the ozone layer: causes of destruction and recovery methods

The paper presents the impact of aviation and rocket-space industry on the ozone layer of the Earth. The urgency of research aimed at the restoration and preservation of the ozone layer is established. Further priority directions of research for protection of the environment and the ozone layer in particular are determined.

In recent years, the rocket-space industry has been developing rapidly all over the world. Space exploration and the development of appropriate technologies require large investments, so in the last century the development of the space rocket industry was the prerogative of the most developed countries of the world, and rocket launches into space were outstanding events for all of humanity. However, in recent years the radical changes in this area had its place.

Firstly, a large number of private enterprises appeared in the rocket and space industry. Companies that demonstrate the desire to fly into space have been appeared around the world. Table 1 presents the most well-known private companies in the rocket-space industry and companies with state ownership.

Table 1

Private companies in the rocket-space industry

Name	Country	Name
SpaceX	USA	Falcon Dragon
United Launch Alliance	USA	Atlas Delta. Delta II, Delta III и Delta IV X-37B
Bigelow Aerospace	USA	Henezys -1,2; BEAM
Blue Origin	USA	New Shepard New Glenn
Vector Space Systems	USA	Vector-R
Rocket Lab	USA	Electron
Virgin Galactic	USA	SpaceShipOne SpaceShipTwo
Sierra Nevada Corporation	USA	Atlas V
Private companies with state ownership		
Arianespace	France	Ariane 5 Vega Союз
Mitsubishi Heavy Industries	Japan	HII-A и H-IIB H-II
Orbital ATK	USA	Delta II и Delta IV,

Secondly, attempts and successful launches of rocket carriers became much more frequent. In some cases, the missiles even returned to Earth (landing Falcon 9 on a floating platform).

By analyzing activities and perspectives (space tourism, launching tens of thousands of satellites to distribute the Internet anywhere in the world, scheduled flights to the Moon and Mars) of all industry players, the following conclusion can be drawn: in the near future, due to the rapid development and practical application of the rocket and space industry, humanity will face the problem of the destruction of the ozone layer.

The destruction of the ozone layer began in the middle of the 20th century, when strategic aviation, rocket and space technology appeared, and nuclear weapons tests began.

The ozone layer is a layer of atmosphere (stratosphere), within which the concentration of ozone molecules (O 3) is ten times higher than at the Earth's surface. Atmospheric ozone is considered to be the most important energy component of the stratosphere. It absorbs about 1% of all solar radiation falling on Earth.

As it turned out, one of the reasons for the destruction of the ozone layer was nitrogen oxide (NO). This gas, like other nitrogen oxides, with the exception of NO2, does not occur in nature. It is formed as a result of heating the air during the flight of an airplane or rocket when there is a thermal ionization of oxygen molecules and nitrogen by reactions:

$$NO + O \rightarrow NO_2 + O, \qquad NO + O_3 \rightarrow NO_2 + O_2.$$

Thus, nitric oxide NO is not consumed, that is, it is a catalyst, and in order for the reaction to occur, its concentration in the air is only 0.1% sufficient. It turns out that the oxidation rate of NO increases not with the increase in temperature, but with its decrease. This makes nitric oxide NO a powerful factor in the destruction of the ozone layer.

Next by the level of danger in the process of destruction of the ozone layer is water vapor and chloride oxide ClO. Oxygen compounds of halogens (ClO) enter the atmosphere in the procces of solid rocket fuel, matches, pyrotechnic products production. A typical rocket system with solid fuel is the “Space Shuttle” accelerators. While climbing up to a height of 50 km, such a space shuttle throws into the atmosphere 346 tons of water vapor, 187 tons of chlorine and chloride compounds and 7 tons of nitrogen oxides [1].

Ozone is destroyed as a result of the influence of water vapor, which is contained in a significant amount in combustion products, as well as nitrogen oxides and oxygen in the air under the influence of high temperatures in rocket engines torches, and during the flight of almost any rocket carrier in the ozone layer, an ozone window is formed.

The destruction model of the ozone layer during the single launch of the rocket carrier "Enerhiya" can be imagined in this way. At the rocket track with a diameter of several hundred meters, ozone collapses completely at all altitudes almost instantly. Under the influence of macroturbulent diffusion, emitted substances are mixed within a radius of many kilometers in a few hours. The amount of ozone in this pillar at 16 ... 24 km altitude decreases by 15 ... 20% in 2 hours, and then the ozone is gradually recovered. The cloud of emissions in the atmosphere after one week reaches the size of several hundred kilometers. The maximum destruction of ozone in the cloud occurs at altitudes of 24 ... 30 km approximately 24 days after the passage of PH. The ozone is reproduced at the same time in the troposphere and ionosphere. Taking into account the complex positive effect, the total ozone amount in the rocket carrier "Enerhiya" launch area (within the vertical pillar with a diameter of 550 km) decreases in 24 days by 1.7%, or in mass terms by 27 thousand tons. Table 2 shows the data for the destruction of the ozone layer [2].

Table 2

The diameter of ozone`s zone of destruction by the reaction with CO at different heights.

Carrier rocket	Height, km			
	20	30	40	50
Orion □ 4	0,9	1,0	2,6	9,2
Proton	1,2	1,4	3,5/2,7	9,7
Atlas	1,5	1,7	4,3	15,3
Titan	4,6	5,4	13,5/1,7	6,0
Space shuttle	3,6	4,3	10,7	0
Enerhiya	3,2	3,8	9,5	0
Del□ta	2,9/1,8	1,3	3,2/0,8	2,8
Skaut	1,2/0,9	1,0	2,5/1,2	4,3

In addition to the spacecraft, the aviation industry also makes a significant contribution to the ozone layer destruction. Aviation transport, in comparison with other types, is a specific pollutant with a fairly wide range of environmental impacts. The negative impact of aviation transport on the environment has both a global and a local character.

Aircraft pollute the atmosphere due to the emission of harmful substances with the exhaust gases of aviation engines. Airplanes move from one airport to another during the flight, and the atmosphere is polluted on a global scale, that is why, significant pollution occurs both in airport zones and on the routes of flight.

The gases generated as a result of the operation of aircraft engines make up 87% of all emissions from civil aviation.

The main components of the exhaust gases of modern aviation engines that pollute the atmosphere:

– sulfur oxides SO_x;

– nitrogen oxides NO_x;

– carbon monoxide CO;

– hydrocarbons not completely burnt down, C_xH_y (methane CH_4, acetylene C_2H_2, ethane C_2H_6, benzene C_6H_6 etc.);

– aldehydes (formaldehyde HCHO, acrolein CH_2=CH=CHO, acetic aldehyde CH_3CHO etc.);

– soot (fine particles of pure carbon) — in the form of a strip from an engine nozzles during take-offs of the aircraft (soot is generally released a bit) [3].

Civil aviation is becoming more and more environmentally dangerous in the process of development. One Boeing aircraft burns 16 tons of fuel for one flight hour, and at the take-off it spends 7.8 tons. Air transport consumes about 14% of global fuel production. A significant danger is the inflow of combustion products in the upper layer of atmosphere. Thanks to the aircraft in the ozone screen, 180 thousand tons of sulfur dioxide, more than 1.5 million tons of nitrogen oxides are injected annually, which causes acceleration of the ozone screen destruction [4].

It is important that ozone determines the ultraviolet climate of our planet. It limits the short-wave part of the solar spectrum (as well as a similar part of the spectrum of stars and the Cosmos) and does not allow radiation shorter than 290 nm reach the Earth, in which case life on Earth would be impossible in modern protein form [5].

Scientists have suggested the following solutions for the restoration of the ozone layer:

1) regulation of ozone-depleting chemical elements emissions into the atmosphere;
2) artificially restoring the amount of ozone in place of ozone holes.

Artificial restoration is carried out with the help of aircraft: dispersing an artificial ozone in the atmosphere at an altitude of 12-30 km. The disadvantage of this method is significant economic costs, and a dispersion of needed ozone amount in the atmosphere, unfortunately, is not possible with modern technology.

In the late 1980s, world governments agreed to protect the ozone layer of the Earth, according to the Montreal Protocol, by gradually abolishing the use of substances that are human waste and destroying the ozone layer. [6].

Figure 1 shows the reduction in the consumption of ozone-depleting substances covered by the Montreal Protocol both globally and within the framework of the EEA-33 (28 EU member states, as well as Iceland, Liechtenstein, Norway, Switzerland and Turkey).

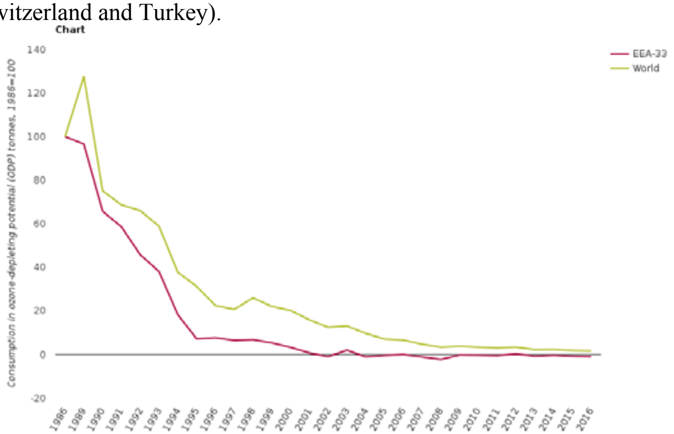

Fig.1. Consumption of controlled ozone-depleting substances

The global measures taken under the Montreal Protocol have stopped the depletion of the ozone layer and allowed its recovery procces, but much more needs to be done to ensure a continuous rise. [7].

Conclusions

The destruction of the ozone layer is a global environmental problem of humanity. The rapid development of the space rocket and aviation industries will have a negative impact on the environment and the ozone layer in particular. The launches of space missiles of any destination will create "holes" in the ozone hole in the hundreds of kilometers in diameter.

To minimize the negative effects of using rocket carriers need:

– to carry out regular monitoring of the ozone layer and to have a clear idea of its condition;

– develop international regulatory documents that will oblige private companies and state corporations (NASA, Roscosmos and others) to minimize harmful effects on the ozone layer;

– to oblige rocket-engine manufacturers to use engines for rockets, the impact of which on the environment will be minimal.

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