Ozone layer destruction and ways of its recovery

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***Abstract*- The authors analyze the process of stratospheric ozone layer destruction. The ozone layer is a protective biosphere shield. The authors identify and study the main causes of ozone sphere destruction having both natural and anthropogenic nature. The article explains a mechanism of the ozone layer depletion—this is caused by stratospheric aviation and natural sources, for example, nitric oxides, formed in the lightning channel. The authors stress an aggravating influence of nitrogen fertilizers getting into the atmosphere. They are considered to be one of the most destructive artificial pollution sources. It is pointed to the manifestation of the consequences of destructive factors in the biosphere life in the form of yield decrease in some world regions and the growth in the number of skin cancer incidence. The authors propose two compatible approaches for recovering the destroyed ozone layer. The first approach includes the use of laser emissions for the irradiation of ozone-containing atmospheric layers and ozone freezing in refrigerating machines on the Earth. The second way stipulates for the location of reflecting mirrors at the Earth orbit allowing to direct a part of solar energy to the atmosphere and generate electric discharges in the stratosphere by means of the radio waves of extra-high frequency.**

***Keywords*- ozone layer, ozone, ozone holes, UV radiation, chlorofluorocarbons.**

INTRODUCTION

Environmental problems are not the least in terms of their importance in the list of global modern problems. To add more, they are the most urgent and relevant today. The change of climatic conditions, global warming, toxic wastes, pollution of water sources, soil and air pollution will finally affect every person on the planet. The global problem nature is also pre-conditioned by the fact that its solution requires a huge amount of funds and time.

Today one of the most relevant environmental issues is ozone layer preservation. The ozone layer is a stratosphere part at the height of 20-25 km, formed as a result of the UV solar radiation action on the molecular oxygen (O).

Despite its insignificant thickness (it is often compared with one book page compared with the overall thickness of books in the library), it protects the flora and fauna of the Earth from harmful short-wave UV rays of the sun. It doesn't mean it fully reflects solar rays, it decreases the action of radiation by approximately 6,500 times making it relatively harmless.

The report considers the issues related to the sources of ozone layer destruction and the ways of its recovery.

THEORY

The human activity significantly affects the ozone layer depletion and the formation of "ozone holes". For example, they are formed at the rocket launch. The planes, moving at the height of 12-16 km, also contribute to the layer destruction. The other destructive factors are the "greenhouse effect", mass cattle breeding, industrial emissions of harmful substances, etc.

An "ozone hole" is the phenomenon of decreasing a general ozone amount over the Antarctic during the autumn period. Both the above ground and satellite measurements show a systematic decrease in the ozone concentration, by approximately 1.5-2 times in spring. The strongest effect was observed in spring 1987 when a general amount of ozone decreased 3 times. It was also revealed that the region of this phenomenon increases every year. Thus, in 1987 the region limit virtually coincided with the circle of 60 degrees of the southern latitude. The measurements of ozone's concentration vertical distribution, made with the help of satellites, showed that ozone concentration significantly decreased (by 97%) in the layer maximum at the height of 14-20 km. At the same height one can observe very high concentrations of chlorine oxide Cl and boron compounds.

According to the today's considerations, the cause of the "ozone hole" formation is mainly connected with a systematic increase of chlorine amount and other gallogens in the stratosphere due to the growing emissions of gallogen-containing compounds into the atmosphere. However, such a dramatic change in the concentration 03 in the Antarctic against the today's level of air pollution is caused by the nature of a meteorological situation in the Antarctic stratosphere in winter and spring.

In winter there is a stable cyclone — a so-called polar vortex – in the polar stratosphere of the southern semisphere. Air inside the vortex mainly moves in closed trajectories not passing beyond the vortex limits. By the way, in the Antarctic in winter there is virtually no air exchange between the polar and middle-latitude atmosphere. By the end of winter the vortex air significantly cools down (to 70-80 Celsius degrees), and polar stratospheric clouds are formed from the ice crystals and subcooled liquid drops. The particles of polar clouds bind nitrogen compounds (first and foremost NO2) and facilitate the action of the chlorine cycle of ozone destruction. In the course of heating of the Antarctic atmosphere the polar vortex is destroyed, and the air exchange with the mid altitudes rich in ozone is recovered, stratospheric clouds disappear, free molecules of NO2 don't bind the chlorine oxide molecules any more thus decreasing the action of the chloric cycles on ozone and the amount of the latter is recovered up to the unperturbed values.

One of the causes of local ozone sphere destruction is the launch of space vehicles. According to the NASA specialists' computations, if the frequency of launches exceeds 85 times per year, the ozone layer destruction will become dramatic and irreversible.

Stratospheric aviation also destroys the ozone layer. Besides, there are natural sources of ozone destruction, for example, nitrogen oxides, occurring in the lightning channel. However, they are quickly removed from the atmosphere by rain (during the year each square kilometer of the earth surface gets about 1.5 tons of bound nitrogen because of rains).
The results of ozone layer depletion have been already manifesting in the biosphere life in the form of yield decrease in Australia and New Zealand and also in the growth of skin cancer incidence.
During a reactive plane flight a large amount of discharge gases is emitted in the air. The main part of these gases consists of nitrogen oxides and water vapours. The emissions from stratospheric planes are not the only and even not the main artificial sources of nitrogen oxide emissions in the atmosphere.
The greatest source of pollution are nitrogen fertilizers. An expansive agriculture industrialization manifests itself, in particular, in a more and more intensive use of chemical fertilizers, and in the first place, these are nitrogen compounds. Getting into the soil, such fertilizers (N2O mostly) are diffused, and some of molecules reach the ground air. Further, a whole chain of processes occur: turbulence in the ground air, upside motion in the troposphere, transfer of the gas rich in nitrogen oxides into the low latitudes, upside flows from the troposphere through a tropical tropopause move into the stratosphere, reverse gas horizontal transfer to the higher latitudes and in the stratosphere. Despite the complexity of the NO2 molecules path from the ground air to the stratosphere height, it really takes place, and every day from a large area of the fields, cultivated with fertilizers, new billions of nitrogen oxide molecules make their way up through this path. The estimates at the early 2000s show that because of nitrogen use in fertilizers, each year about 10 megatons of N2O get into the atmosphere. This value is 25 – 40% of the natural admission of nitrogen oxides (this value keeps growing now).
Nitrogen oxides get into the atmospheric gas (mainly in the form of N2O) also during the combustion of industrial fuel. According to the available estimates, the amount of nitrogen oxides getting in the air with smoke from power plants, operating with standard (not a nuclear one) fuel, is itself rather high and equals 3-4 megatons per annum, although it is not so dangerous as compared to nitrogenous fertilizers.
The results, obtained by Johnston and Crutzen agitated the world and triggered fast development in the ozone research. One of the important results of the intensive study of ozone and its photochemistry was the establishment of the fact that the catalytic cycle of ozone destruction is possible not only with nitrogen oxides, but also with hydrogen and freon oxides, and other substances.
A lot of NOx compounds, which contain hydrogen, take part in the hydrogen cycle. Hydrogen gets in the atmosphere, mostly in the form of water. The path of molecules from the troposphere in the stratosphere (as well as the path of other particles) is similar to the one described above.
Hydrogen gets in the atmosphere in the form of methane CH4 as well. The methane natural sources are rain forests, swamps and rice fields where it is formed, mainly as a result of the activity of the anaerobe bacteria. A significant contribution to the general methane admission is made by ruminants (large cattle). The anthropogenic methane sources are the emissions from coal mines (mine gas) as well as the oil and natural gas extraction. According to various estimates, these sources generate 16-210 megatons of the methane in the atmosphere per annum, which makes up a significant part of its general admission (440-850 megatons per annum).
The civilization development leads to the accelerated emission of chlorine compounds into the atmosphere, and one of the leading parts in this process is taken by Freon's. The growth of freon production in the second half of the previous century took a dramatic speed (manufacture of refrigerating appliances, aerosols, lubrications, expanded plastics, etc.).

Considering the substances, contributing to the ozone layer destruction, freons are the most dangerous ones. Freons are the gases which not enter into any chemical reactions at the planet surface. For a long period of time they have been used in the diffusing aerosols, now they are quite popular in the industrial manufacture.
Lifting to the upper atmospheric layers, freon enters into a chemical reaction, transforming ozone in oxygen and thus splitting the ozone screen.

PRACTICAL RESULTS

All the ways of the ozone layer recovery, discussed in the scientific & technical literature, can be reduced to two compatible approaches: elimination of ozone substances from the atmosphere and ozone accrual.
The first approach — elimination of catalyzers from the atmosphere — has no possible solutions yet. It was suggested using laser irradiation of ozone-containing atmospheric layers with the purpose of freon molecules dissociation. But in the first place, slow dissipation of freon molecules still saves us from the accelerated ozone layer destruction. Secondly, only a small part of laser energy will work for achieving a set goal, its main part will be dissipated in space. The idea of ozone freezing out in the refrigerating machines on the Earth doesn't seem better because in this case a significant part of atmosphere should be passed through such machines. Other suggestions offer to bring chemical substances in the space and diffuse them in the stratosphere: these chemical substances should be capable of reacting with catalyzers and thus eliminate them from the ozone destruction mechanism.
The ozone accumulation mechanisms in the stratosphere seem to be more practical. Thus, one of the projects suggests locating the mirror reflectors at the Earth's orbit, allowing for directing the solar energy part, which had previously overpassed the Earth, into the atmosphere. The project seems to be attractive, however, it will require to solve two complex technical problems: making up special reflectors for reflecting high-level UV radiation and strong orientation of the reflectors in the space.
A similar suggestion stipulates for the lightning of the upper atmospheric layer with an UV laser, placed in the space. The problem consists in the transmission of energy from the Earth to the space for the laser operation.
The most realistic, in our opinion, is the project stipulating for the generation of electric discharges in the stratosphere by means of radio waves of the extra-high frequency. The discharge is produced by means of a fixed phased antenna array (PAA), located n the Earth. The necessary antenna dimensions are about a hundred meters; the control over the phase of separate elements allows

implementing the radiation focusing at a certain height and scanning. Energy supply can be provided from the nuclear power plant with the capacity of dozens mW, and the efficiency factor of a radio technical part in relation to the primary source can reach 80%. The ozone formation mechanism in the course of discharge — plasma-chemical and thermal.

At the plasma-chemical mechanism oxygen molecules are destroyed by electrons formed in the electrical discharge. The energy cost of one oxygen atom is 2.5 eV, that is why the electron energy should not significantly exceed the specified theoretical limit to avoid the generation of the excitations of other molecules and occurrence of unplanned reactions. On the other hand, to avoid discharge fading, it is necessary to have high energy electrons. Machine computations show the possibility of the implementation of such controversial requirements by means of special operation modes.

The thermal mechanism of ozone recovery can significantly reduce the energy costs. The point is that there is a belief that an ozone "hole" occurs only at the temperature - 800 C. If this is true, and assuming such temperature is observed only in some separate hole areas, there is a possibility to compensate the ozone deficit only in these points, thus shifting the mechanism of ozone stabilizing. Therefore, there is a theoretical possibility of ozone layer recovery. The issue is in the necessary costs, and the solution depends on a detailed study of the mechanism of stratospheric ozone destruction. In addition, it is also important because active intervention in crucial biosphere processes is very dangerous as it can have some unexpected consequences.

The control over the changes occurring in the ozone layer is conducted by the ozone metering network of the World Meteorological Organization (WMO), accounting for about 100 stations, equipped with the Dobson meter, the most optimal tool for the specified purpose. In Russia 30 stations conduct continuous observation with filtered ozone meters M-124. The results of observations are sent to a methodical center — the main geophysical observatory n.a. A. I. Vosetkov (Saint-Petersburg). Here the information on the ozone content is processed, transferred to the technical carriers and published in the WMO guide, and is also transferred to other consumers.

At present there are several Russian & American programs on the ozone layer research. In the Antarctic, the "Mirny" station has been conducting observation of the ozone layer condition for 7 years already. In 1992 the Russian & American project was launched; it is dedicated to the ozone layer research by space means. Some time ago the countries started to implement a joint programme on the research of the stratospheric aviation influence on the ozone layer.

A large significance is given to the implementation of protocols on ozone destructive substances that were signed by a group of states in Montreal (1987) and Helsinki (1989). It is assumed that by 2025 the most dangerous freons will not be emitted in the atmosphere.

CONCLUSION

By the results of the research conducted, it is clear that the ozone layer needs to be protected, and this is an urgent issue as the mankind health and existence are at great risk. To avoid the consequences the formation of multiple ozone holes can have and that everybody is aware of, it is necessary to take critical steps. In the first place, these should be amendments and changes to the legislation both at the federal and international levels. The science capabilities have developed greatly for the last decades but some fundamental mechanisms of operation in the atmosphere remain unclear. The further research successes depend on a general strategy combined with the measures taken in various areas of science, law and social morality. The problem of the Earth ozone layer is quite broad, and unfortunately, its severity has not been fully realized by the general public and at the national level. The awareness of the problem urgency is not enough, while the Earth ozone layer is continuously destroyed with a dramatic speed.

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