Vaida VALUNTAITĖ

THE INVESTIGATION AND ASSESSMENT OF THE MAN-MADE OZONE FORMATION AND DISPERSION

Summary of Doctoral Dissertation
Technological Sciences, Environmental Engineering (04T)

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Vilnius LEIDYKLA TECHNIKA **2009**

VILNIUS GEDIMINAS TECHNICAL UNIVERSITY

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General characteristic of the dissertation

Topicality of the problem

People spend most of their time indoors, but here they are also not protected from ozone, though the concentration of this pollutant in premises without any additional ozone sources is lower than outdoors. The worldwide use of ozone generators, electrostatic air filters and other electrical appliances in premises, during operation of which ozone is formed, is ever-increasing. Moreover, ozone can be formed in premises during discharges (corona discharge during photocopying, arc discharge during welding).

The ozone formation in the troposphere under pollution conditions is determined by the photochemical reactions between its precursors, among which volatile organic compounds (LOJ) and nitrogen oxides (NO_x) are most important. Ozone can be attributed to the most dangerous pollutants, therefore it causes danger not only to the inside surfaces, but to humans as well. Ozone is also dangerous because it can react with other inside materials forming new pollutants. Therefore, it is very important to investigate the ozone formation in premises and ability of various materials to induce decay of ozone to ensure safe level of this pollutant in the environment of residential and working premises.

People being in premises and breathing air which contains ozone sometimes do not even realize the cause of their ailments. Though ozone has a specific strong smell, but it is not the indicator of the ozone concentration level. Being a strong oxidant, ozone inhibits smell receptors and after some time the ozone smell is not scented. Therefore, it is necessary to observe and evaluate the ozone concentration levels both indoors and outdoors to ensure the optimal health of population.

The investigation object is ozone formed during technological processes (photocopying, welding) in working premises and under field conditions (near high-voltage transmission lines).

The aim of the work is to investigate the changes of the ozone concentration formed during technological processes and causes inducing them in different environments.

Tasks of the work are:

1. To master and apply methods of measurement of the technogenic ozone concentration and other parameters as well as to improve the measurement methodology.

2. By using the experimental chamber, to determine the rates of the ozone concentration deposition on different floor surfaces.
3. To evaluate the contribution of ozone formed during technological processes to the general ozone concentration level in working premises.
4. To determine the dispersion of ozone formed near high-voltage transmission lines and its contribution to the ozone concentration level in the atmospheric boundary air.
5. To apply the RISK model in the evaluation of the ozone concentration variation in working premises.
6. To recommend ways for reducing the ozone concentration level in premises ensuring the occupational safety of people.

Methodology of research

For the evaluation of ozone concentration changes nearby technogenic sources experimental and theoretical research was done. For the determination of the ozone concentration UV absorption and passive sampling methods were used, while for measurements of other parameters standard methods were applied. By using the RISK program the ozone dispersion in working premises was evaluated.

Scientific novelty and its significance

Complex experimental and theoretical investigations of ozone concentrations formed during technological processes, evaluation of the ozone dispersion and its relation with meteorological parameters near high-voltage transmission lines as well as peculiarities of the ozone concentration variation near technogenic ozone sources.

Practical value

The research carried out in this work is useful in simulating the ozone dispersion processes indoors and outdoors, forecasting the ozone concentration levels under different meteorological and microclimatic conditions, it allows forecasting the measures of the ozone concentration reduction to be taken. Referring to the research results, factors determining the ozone concentration increase in the human environment can be foreseen. The applied model allows evaluating and forecasting concentration changes of ozone formed during technological processes.

Defended propositions

1. The high-voltage transmission lines in the nonurbanized regions are an additional local source of air pollution with ozone, the intensity of which

depends on the meteorological conditions (wind speed and direction as well as relative humidity).

2. The concentration of ozone formed in working premises during technological processes depends on the source intensity and the dependence is described by the degree function.
3. The selection of the environment conditions and proper floor surfaces reduces the ozone concentration level in the working premises to the values not dangerous for human health.

The scope of the scientific work

The dissertation comprises the general characteristic of the work, 5 chapters, conclusions and recommendations, references and list of published works on the topic of the dissertation. The dissertation covers 149 pages, 78 illustrations, 17 tables.

In introduction chapter the problem topicality is considered, the aims and tasks of the work are formulated, the novelty of the research is described, the author's reports and publications as well as the dissertation structure are presented. Chapter 1 is intended for the review of literature. The survey of ozone sources in working premises and the environment air is presented as well as methods of the ozone concentration determination and its dispersion simulation are discussed. At the end of the chapter conclusions are formulated and the dissertation tasks are concretized. In chapter 2 the methodology of the ozone concentration determination with the ozone analyzer and passive samplers as well as the measurement methods of aerosol particles and meteorological, microclimatic parameters are described. In chapter 3 the results obtained during experimental investigations are discussed: the ozone concentration changes near technogenic sources of this pollutant, the influence of meteorological and microclimatic parameters on the ozone concentrations changes, the relation of aerosol particles with the ozone concentration. Ozone concentrations measured by different methods are compared and the results of comparative measurements are discussed. In chapter 4 the results of the ozone dispersion from the source simulated by the RISK program are presented. In chapter 5 the technological version of solution which allows reduction of the ozone concentration near the technogenic sources of this pollutant is suggested and the description of the mobile stand constructed for the experiment is provided.

1. Formation and change of ozone in different environments

The ozone concentration levels in the boundary air layer of the atmosphere are constantly observed but the data on the ozone concentration formation and

dispersion in premises are scarce. Due to the ever-increasing use of devices, during the operation of which ozone can be formed, both in working and living premises, the research of the ozone formation and dispersion becomes relevant. Investigations carried out on the ozone and aerosol particle interaction and changes in working premises with the ozone source are not numerous, but some data are found that the impact of both these pollutants on human health is significantly stronger than the impact of each separate pollutant. In the scientific literature there are some controversial results of research on the ozone formation using the shielded metal arc welding. This problem is scantily considered in the scientific literature, therefore experimental investigations are needed. The high-voltage transmission lines are the atmospheric anthropogenic ozone source not investigated yet. Therefore, methods of investigation of the ozone concentration changes at such places are needed. The rates of the ozone decay on the surface of particular building materials presented in scientific literature differ by some orders of magnitude, thus the deposition rates should be specified.

2. Methods and devices of experimental research

Investigations of the ozone concentration variation were carried out in working premises, near the high-voltage transmission lines and in experimental chambers. The investigation of ozone concentration changes was performed in the premises with no ozone sources, in working premises where ozone is formed during technological processes (photocopying, welding) and in premises with the ozone generator. Ozone concentration measurements were performed by two methods: the ultraviolet absorption and passive sampling. The number concentration of aerosol particles as well as meteorological or environment parameters were measured during the investigation. All parameters were measured continuously by automatically entering data into the computer. Meteorological parameters were measured with the portable meteorological station (*PC Radio Weather Station*). For the investigation of the ozone concentration variation due to the high-voltage transmission lines a mobile stand with the ozone analyzer and a portable computer, which is pushed at a constant rate perpendicular to the lines, was constructed. For the investigation of the ozone deposition on the floor surface, two polythene chambers of different form and thickness, in which during the operation of bactericidal UV lamp and the ozone generator the deposition of formed ozone on various surfaces was observed, were installed.

3. The results and analysis of experimental research

The ozone concentration measurements were carried out in a standard office room, where all possible ozone formation sources did not operate. After opening the window, ozone penetrated from outside. The obtained experimental data show that having opened the window after five minutes a constant ozone concentration (75±5 μg/m^3) settles at a measured point. The half-life of this pollutant inside is 7 min. It has been determined that the ozone concentration changes only at a distance of up to 2 m from the window. Further from the window the ozone distribution inside the room is almost uniform, therefore at the distance of 2–5 m from the window similar ozone concentrations were registered.

When performing investigations of the ozone concentration variation with the operating copying machine, the photocopying intensity was of five modes: 1 – copying is not in progress; 2 – from 1 to 30 copies/min; 3 – from 30 to 60 copies/min; 4 – from 60 to 90 copies/min; 5 – from 90 to 20 copies/min.

The copying intensity significantly determines the dynamics of ozone and aerosol particles in office premises (Fig. 1).

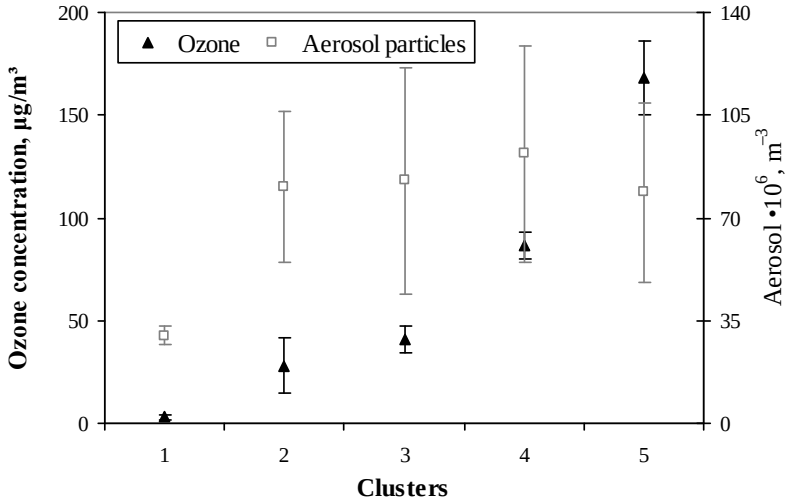

Fig. 1. Dependence of ozone and aerosol particle concentration on the copying intensity

The highest ozone concentration and the lowest aerosol particle concentration were determined during automatic photocopying. When copying

automatically, leaves are not thumbed by the operator and significantly less aerosol particles are formed in working premises. Meanwhile during a manual operation similar courses of ozone and aerosol concentration changes are observed. This dependence allows us to state that the ozone source is the photocopying machine, while the main aerosol particle source is the copying process, e. g. paper dustiness.

The aerosol particle (0.4–2.0 μm) spectrum was investigated in the copying room. It has been determined that during copying the aerosol particles of 0.4–0.5 μm changed most $(10–60)\cdot10^6$ m^{-3}, and the concentration of particles larger than 1.5 μm changed the least $(0.5–1.8)\cdot10^6$ m^{-3} in working premises.

The investigations of ozone concentration in the premises, where welding was done, were carried out in the premises without ventilation and with local exhaust ventilation. Lower ozone concentrations in welding premises recurred more frequently than higher values. Due to intensive ventilation in ventilated premises lower ozone concentrations (0–100 $\mu g/m^3$) were determined 2.5 times more frequently than in unventilated premises. The investigated ozone concentration and UVB radiation intensity variation at a different distance from the electrode is shown in Fig. 2.

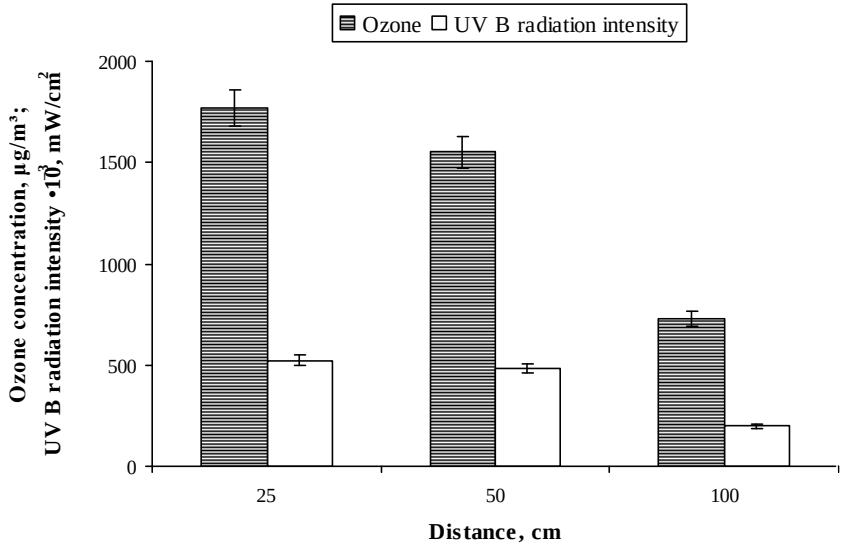

Fig. 2. Ozone concentration and UVB radiation intensity variation

The obtained data show that with the increase in the distance from the electrode the ozone concentration and UVB radiation intensity increase. The highest ozone concentration was determined at the 25 cm distance from the electrode, where the ozone concentration varied from 380 to 1850 μg/m^3. At this distance the UVB radiation is the most intensive, with its average value of 0.52 mW/cm^2. During the investigation period the correlation coefficient of 0.99 between the ozone concentration and UVB radiation intensity was determined, which confirms that their source is the same.

The ozone concentration measurements were performed near two 330 kV high-voltage transmission lines and at the 220 m distance from them, which was regarded as a "background" concentration. The courses of main measured parameters − ozone concentrations near high-voltage transmission lines, background concentrations, difference between these concentrations, aerosol particle concentrations, wind speed and direction − are presented in Fig. 3.

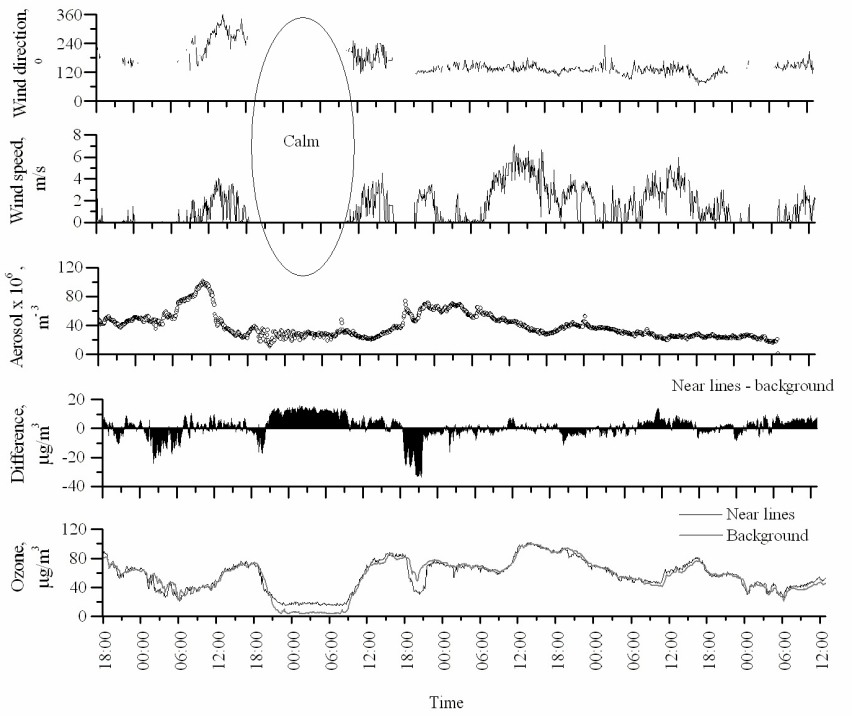

Fig. 3. Variation of ozone concentration and meteorological parameters near high-voltage transmission lines on 22–27 September, 2007

The influence of meteorological parameters on the ozone concentration level in the environment of high-voltage lines was evaluated. It should be noted that in the daytime average ozone concentrations both near the high-voltage transmission lines and at the background integrated monitoring station were close, they differed by up to 23 %. During the nighttime this difference was significantly larger, up to 72 %. During the experiment the air temperature changed in the 2–23 ºC interval, and the relative humidity changed from 43 to 100 %. During the investigation the wind speed and the wind direction were variable. During the experiment low wind speed was prevailing, and during a major part of observation calm was registered.

It has been determined that high-voltage transmission lines are not local aerosol particle source or it is very weak and whose contribution during this experiment could not be evaluated. Aerosol concentration variation was influenced by air mass transport, the direction of which most frequently coincides with the wind direction.

The ozone concentration distribution in the environment of high-voltage transmission lines is shown in Fig. 4.

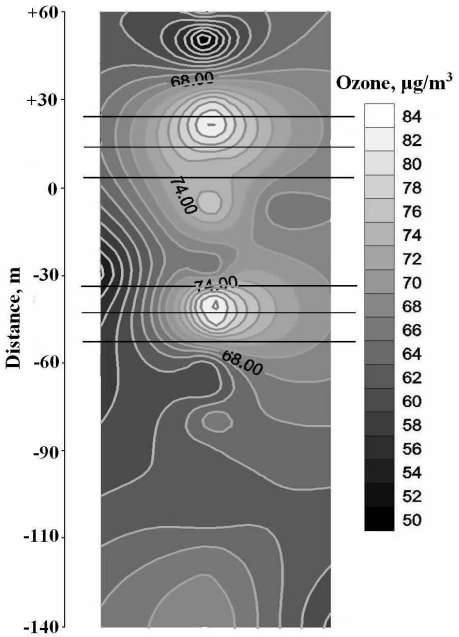

Fig. 4. Ozone concentration changes receding from the high-voltage transmission lines

The results of measurement have shown that by approaching the high-voltage transmission lines the ozone concentration increases. The ozone concentration at the 220 m distance from the lines during this experiment varied about 60.2±3.8 μg/m^3, the prevailing wind direction was across transmission lines, and the instantaneous wind speed did not exceed 3.5 m/s.

In working premises different building materials, furniture and equipment made of various materials are used. The ozone concentration in premises depends on the rate of ozone deposition on these surfaces. Therefore, the ozone deposition on surfaces of 10 different most frequently used materials was investigated. In the chamber during the experiment the relative humidity was 60±5 %, and the air temperature – 20±2 ^{o}C. The calculated rate of ozone deposition on different materials in the chamber is presented in Table.

Ozone half-life and deposition rate on surfaces

Material	τ, **s**	v_q, **cm/s**
Glass	7620	$1.1\cdot10^{-4}$
Wood-wool plate	6600	$1.2\cdot10^{-3}$
Plastic	5040	$2.3\cdot10^{-3}$
Carton	4980	$2.6\cdot10^{-3}$
Empty	4740	$3.9\cdot10^{-3}$
Red bricks	4560	$4.9\cdot10^{-3}$
Gypsum plate	4260	$6.8\cdot10^{-3}$
Ceiling plate	2280	$3.2\cdot10^{-2}$
Fir planks	1680	$5.2\cdot10^{-2}$
Carpeting	1680	$5.2\cdot10^{-2}$
Wallpaper	1200	$8.2\cdot10^{-2}$

The obtained ozone deposition rate on different thickness polyethylene was different: on the 0.3 mm thickness polyethylene the ozone deposition rate was $1.1\cdot10^{-2}$ cm/s and on the 0.6 mm thickness – $3.9\cdot10^{-3}$ cm/s. The obtained data show that the polyethylene composition and thickness have large influence on the ozone deposition. The lowest ozone deposition rate was determined on glass – $1.1\cdot10^{-4}$ cm/s. The obtained data show that wallpaper and carpeting are materials inducing the largest decay of ozone, therefore it is recommended in premises where ozone is formed, with operating other additional sources of this pollutant, to floor them with these materials in order to reduce a possible ozone impact on the environment.

4. Simulation of ozone dispersion

The experimental investigation and numerical simulation of the ozone dispersion from the ozone generator by the RISK program were performed in the premises consisting of three rooms. By simulating the ozone dispersion in premises the volume of rooms was defined: room 1 – 46 m^3, room 2 – 56 m^3, and room 3 – 5 m^3. The height of rooms was 2.8 m. Ozone concentration variation in the rooms (ozone generation in room 1 was maintained 30 min) are shown in Fig. 5.

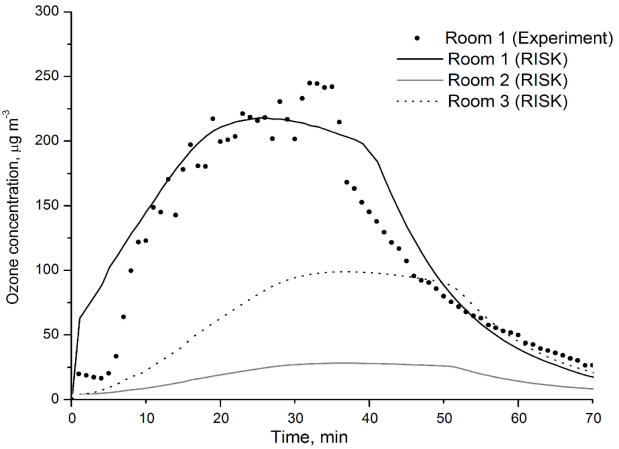

Fig. 5. Ozone concentration variation in different rooms with the ozone source in room 1

Having analyzed the experimental and simulation data it has been determined that the RISK model can be applied for the simulation of the ozone dispersion in premises with the additional ozone source, various sizes of rooms, air flows between premises and different floor surfaces. A close correlation ratio between simulation and experimental results was obtained, therefore, this model expands research of ozone concentration changes in premises and factors causing them.

5. Development of the methods for measuring the ozone concentration

For the investigation of pollutant dispersion near high-voltage transmission lines, a mobile stand allowing avoiding formation of additional pollutants, when

motorcars and trains are used in the investigations, has been constructed. A mobile stand is electromotor-driven. When using it, no special road (railing, highway, etc.) is needed. During the experiment the meteorological parameters were measured to evaluate the ozone concentration dispersion near high-voltage transmission lines under the same meteorological conditions. Therefore, the wind direction changes could be observed and the driving trajectory could be changed. By applying the experimental chamber, the ability of building materials, most frequently found in premises, to destroy ozone has been investigated.

General conclusions

1. By applying the experimental chamber, the ozone deposition rates on different floor surfaces used in workplaces were investigated. It has been determined that wallpaper (deposition rate – $8.2 \cdot 10^{-2}$ cm/s) and carpeting ($5.2 \cdot 10^{-2}$ cm/s) are the materials destroying ozone the most.
2. It has been found that in working premises, where ozone penetrates through the open window, the half-life of this pollutant is 7 min. The ozone deposition rate in standard working premises was obtained to be $4.5 \cdot 10^{-2}$ cm/s.
3. It has been determined that the ozone concentration in working premises depends on the environment parameters (most of all on the source power and relative air humidity). The ozone concentration near high-voltage transmission lines depends on the meteorological parameters (most of all on the wind speed, direction and relative humidity).
4. In the investigated unventilated working premises the average 8-hour ozone concentration near the photocopying machine exceeded the marginal ozone concentration value of 200 μg/m^3 determined by the Lithuanian hygiene standard HN 23:2007 by 40 %, but if the copying machine operated intensively (90–120 copies/min), the ozone concentration would exceed the standard by 300 %.
5. The contribution of ozone formed near high-voltage transmission lines to the ozone concentration level in the boundary air layer has been evaluated. It has been obtained that near high-voltage transmission lines the registered ozone concentration is by 50 % higher than the ozone concentration at the 25 km distance from the lines (at the background integrated monitoring station), but at the 220 m distance from the lines the increased ozone concentration has been determined.

Recommendations

1. In working premises where ozone is formed during technological processes, for the reduction of its concentrations we recommend using floor surfaces highly destructing ozone and over the pollution source applying the exhaust ventilation removing ozone.
2. For the investigation of pollutant dispersion near high-voltage transmission lines we recommend using a mobile stand which allows avoiding formation of additional pollutants in the investigated environment using other transport means.
3. In recreational zones or settlements with the nearby situated high-voltage transmission lines we recommend that not only magnetic and electric field magnitudes and the noise level, but also ozone concentrations should be evaluated.
4. Seeking to evaluate the possible ozone impact on the health of workers, whose work is related with the ozone formation, we recommend using passive samplers for the control of the obtained ozone dose.
5. The RISK model is recommended for the forecast of exceedances of ozone concentration levels in the working premises.

List of published works on the topic of the dissertation

In the reviewed scientific periodical publications

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3. Valuntaite, V.; Girgzdiene, R. 2008b. The influence of high-voltage transmission lines on pollutant concentration in nonurbanized areas, *Lithuanian Journal of Physics* 48(4): 367–374. ISSN 1392-1932 (Thomson ISI Web of Science).
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8. Žydelytė, A.; Valuntaitė, V.; Girgždienė, R. 2006. Ozono koncentracijos sklaidos nuo šaltinio patalpoje tyrimas [Investigation of ozone concentration distribution from the source in premise], iš *9-osios Lietuvos jaunųjų mokslininkų konferencijos „Mokslas – Lietuvos ateitis“, įvykusios Vilniuje 2006 m. balandžio 7 d., pranešimų medžiaga. Fizika ir fizinė kompiuterija* [Proceedings of the IX Conference of Lithuanian Young Scientists “Science – Future of Lithuania”, held in Vilnius on 7 April, 2006. Physics and physical computering]. Vilnius: Technika, 212–216 (in Lithuanian). ISBN 9986-05-989-5.
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TECHNOGENINIO OZONO SUSIDARYMO, SKLAIDOS TYRIMAI IR VERTINIMAS

Mokslo problemos aktualumas

Žmonės didžiąją dalį laiko praleidžia patalpose, tačiau ir čia jie nuo ozono nėra apsaugoti, nors ir šio teršalo koncentracija patalpose, kai nėra papildomų ozono šaltinių, yra mažesnė nei lauke. Pasaulyje vis plačiau patalpose naudojami ozono generatoriai, elektrostatiniai oro filtrai bei kiti elektros prietaisai, kuriems veikiant susidaro ozono. Be to, ozonas patalpose gali susidaryti išlydžių metu (vainikinis išlydis kopijuojant, lankinis išlydis suvirinant).

Troposferoje ozono susidarymą užterštomis sąlygomis apsprendžia fotocheminės reakcijos tarp jo pirmtakų, vieni svarbiausių yra lakieji organiniai junginiai (LOJ) ir azoto oksidai (NO_x). Ozonas priskiriamas kenksmingiausių oro teršalų klasei, todėl jis kelia pavojų net tik patalpoje esantiems paviršiams, bet ir žmogui. Ozonas taip pat pavojingas dėl to, kad gali reaguoti su kitomis patalpoje esančiomis medžiagomis ir sudaryti naujus teršalus. Todėl labai svarbu ištirti ozono susidarymą patalpose ir įvairių medžiagų gebėjimą suardyti ozoną, kad užtikrintume saugų šio teršalo lygį gyvenamojoje ir darbo aplinkoje.

Žmogus, būdamas patalpoje ir kvėpuodamas oru, kurio sudėtyje yra ozono, kartais net nenutuokia savo negalavimų priežasties. Nors ozonas turi aštrų specifinį kvapą, tačiau jis nėra ozono koncentracijos lygio indikatorius. Būdamas stipriu oksidatoriumi, ozonas slopina uoslės receptorius ir po kurio laiko ozono kvapas yra neužuodžiamas. Todėl būtina stebėti ir vertinti ozono koncentracijos lygius tiek patalpose, tiek lauko sąlygomis siekiant užtikrinti optimalią gyventojų sveikatą.

Tyrimų objektas yra ozonas, susidarantis technologinių procesų (kopijavimo, suvirinimo) metu darbo patalpose ir lauko sąlygomis (prie aukštosios įtampos elektros perdavimo linijų).

Darbo tikslas − ištirti ozono, susidarančio technologinių procesų metu, koncentracijos pokyčius ir juos lemiančias priežastis skirtingose aplinkose.

Darbo uždaviniai

1. Įsisavinti ir pritaikyti technogeninio ozono koncentracijos ir kitų parametrų matavimo metodus, patobulinti matavimo metodiką.
2. Naudojantis eksperimentine kamera nustatyti ozono koncentracijos nusėdimo greičius ant skirtingų paklotinių paviršių.
3. Įvertinti technologinių procesų metu susidarančio ozono indėlį į ozono koncentracijos lygį darbo patalpose.
4. Nustatyti prie aukštosios įtampos elektros perdavimo linijų susidarančio ozono sklaidą ir indėlį į ozono koncentracijos lygį pažemio atmosferoje.
5. Pritaikyti RISK modelį ozono koncentracijos kitimui darbo patalpose įvertinti.
6. Rekomenduoti būdus, mažinančius ozono koncentracijos lygį patalpose ir užtikrinančius saugų žmonių darbą.

Tyrimų metodika

Ozono koncentracijos pokyčiams prie technogeninių šaltinių įvertinti atlikti eksperimentiniai ir teoriniai tyrimai. Ozono koncentracijai nustatyti

pritaikyti UV sugerties bei pasyvaus kaupimo metodai, kitiems parametrams matuoti – standartiniai metodai. Naudojantis RISK programa įvertinta ozono sklaida darbo patalpoje.

Mokslinis naujumas ir jo reikšmė

Technologinių procesų metu susidarančio ozono koncentracijų kompleksiniai eksperimentiniai bei teoriniai tyrimai, ozono sklaidos bei ryšio su meteorologiniais parametrais prie aukštosios įtampos perdavimo linijų įvertinimas, koncentracijos kitimo prie technogeninių ozono šaltinių ypatumai.

Praktinė vertė

Atlikti tyrimai naudingi modeliuojant ozono sklaidos procesus patalpose ir lauke, prognozuojant ozono lygius prie skirtingų meteorologinių bei mikroklimatinių sąlygų, leidžia numatyti, kokios ozono koncentracijos mažinimo patalpose priemonės gali būti veiksmingos. Remiantis gautais rezultatais galima numatyti veiksnius, lemiančius ozono koncentracijos padidėjimą žmogų supančioje aplinkoje, o pritaikytas modelis leidžia vertinti ir prognozuoti technologinių procesų metu susidarančio ozono koncentracijos pokyčius.

Ginamieji teiginiai

1. Aukštosios įtampos elektros perdavimo linijos neurbanizuotuose rajonuose yra papildomas lokalus oro taršos ozonu šaltinis, kurio intensyvumas priklauso nuo meteorologinių sąlygų (vėjo greičio ir krypties bei santykinio oro drėgnio).
2. Ozono, susidarančio darbo patalpose technologinių procesų metu, koncentracija priklauso nuo šaltinio intensyvumo ir priklausomybė aprašoma laipsnine funkcija.
3. Aplinkos sąlygų ir tinkamų paklotinių paviršių parinkimas sumažina ozono koncentracijos lygį darbo patalpoje iki žmogaus sveikatai nepavojingų verčių.

Darbo apimtis. Disertaciją sudaro įvadas, 5 pagrindiniai skyriai, darbo išvados ir rekomendacijos, literatūros sąrašas, publikacijų sąrašas. Bendra disertacijos apimtis – 149 puslapiai, 80 iliustracijų, 17 lentelių.

Įvadiniame skyriuje nagrinėjamas problemos aktualumas, formuluojamas darbo tikslas bei uždaviniai, aprašomas mokslinis darbo naujumas, pristatomi autoriaus pranešimai ir publikacijos, disertacijos struktūra. Pirmasis skyrius skirtas literatūros apžvalgai. Jame pateikta ozono šaltinių darbo patalpose ir aplinkos ore apžvalga, aptariami ozono koncentracijos nustatymo ir jos sklaidos

modeliavimo metodai. Skyriaus pabaigoje formuluojamos išvados ir konkretinami disertacijos uždaviniai. Antrajame skyriuje aprašomi ozono koncentracijos nustatymo ozono analizatoriumi ir pasyviaisiais kaupikliais metodika bei aerozolio dalelių ir meteorologinių, mikroklimato parametrų matavimo metodai. Trečiajame skyriuje aptariami eksperimentinių tyrimų metu gauti rezultatai apie: ozono koncentracijos kitimą prie technogeninių šio teršalo šaltinių, meteorologinių ir mikroklimato parametrų įtaką ozono koncentracijos pokyčiams, aerozolio dalelių sąryšį su ozono koncentracija. Lyginamos ozono koncentracijos matuotos skirtingais metodais ir aptariami lyginamųjų matavimų rezultatai. Ketvirtajame skyriuje pateikti RISK programa sumodeliuoti ozono sklaidos nuo šaltinio rezultatai. Penktajame skyriuje pasiūlytas technologinis sprendimo variantas, leidžiantis sumažinti ozono koncentracijas prie technogeninių šio teršalo šaltinių bei eksperimentui atlikti sukonstruoto mobilaus stendo aprašymas.

Bendrosios išvados

1. Naudojantis eksperimentine kamera ištirti ozono nusėdimo greičiai ant darbo patalpose naudojamų paklotinių paviršių. Nustatyta, kad labiausiai ozoną ardanti medžiaga yra tapetai (nusėdimo greitis – $8{,}2\cdot10^{-2}$ cm/s) ir kiliminė danga ($5{,}2\cdot10^{-2}$ cm/s).
2. Nustatyta, kad darbo patalpoje, į kurią ozonas patenka pro atidarytą langą, šio teršalo koncentracijos pusėjimo trukmė yra 7 min. Ozono nusėdimo greitis standartinėje darbo patalpoje − $4{,}5\cdot10^{-2}$ cm/s.
3. Nustatyta, kad ozono koncentracija darbo patalpose priklauso nuo aplinkos parametrų (labiausiai nuo šaltinio galingumo ir santykinio oro drėgnio). Prie aukštosios įtampos elektros perdavimo linijų ozono koncentracija priklauso nuo meteorologinių parametrų (labiausiai nuo vėjo greičio, krypties ir santykinio drėgnio).
4. Tirtoje neventiliuojamoje darbo patalpoje 8 valandų vidutinė ozono koncentracija prie kopijavimo aparato viršijo Lietuvos higienos normoje HN 23:2007 nustatytą 200 $\mu g/m^3$ ribinę ozono koncentracijos vertę iki 40 %, tačiau jei kopijavimo aparatas veiktų intensyviai (90–120 kopijų/min), ozono koncentracija viršytų normą iki 300 %.
5. Įvertintas ozono, susidarančio prie aukštosios įtampos elektros perdavimo linijų, indėlis į ozono koncentracijos lygį pažemio atmosferoje. Gauta, kad prie aukštosios įtampos linijų registruojama iki 50 % didesnė ozono koncentracija nei 25 km atstumu nuo linijų (foninėje integruoto monitoringo stotyje), o 220 m atstumu nuo linijų nustatyta padidėjusi ozono koncentracija.

Rekomendacijos

1. Darbo patalpose, kur technologinių procesų metu susidaro ozono, jo koncentracijas siūlome mažinti panaudojant ozoną stipriai ardančius paklotinius paviršius, o virš taršos šaltinio naudoti ištraukiamąją ventiliaciją, pašalinančią ozoną.
2. Teršalų sklaidos tyrimams prie aukštosios įtampos elektros perdavimo linijų siūlome naudoti mobilų stendą, kuris leidžia išvengti papildomų teršalų susidarymo aplinkoje tyrimams naudojant kitas transporto priemones.
3. Rekreacinėse zonose ar gyvenvietėse prie aukštosios įtampos elektros perdavimo linijų siūlome vertinti ne tik magnetinių ir elektrinių laukų dydžius, triukšmo lygį, bet ir ozono koncentracijas.
4. Siekiant įvertinti galimą ozono poveikį darbuotojų, kurių darbo pobūdis susijęs su ozono susidarymu, sveikatai siūlome gaunamos ozono dozės kontrolei naudoti pasyviuosius kaupiklius.
5. RISK modelį siūlome taikyti vertinant ozono koncentracijos lygių viršijimus darbo patalpose.

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