INNOVATION IN WOODWORKING INDUSTRY AND ENGINEERING DESIGN, 2/2013 (4): 23–30

QUALITY OF INDOOR AIR IN SMALL CZECH FURNITURE COMPANIES

Daniela Tesařová, Petr Čech
Mendel University in Brno, e-mail: tesar@mendelu.cz, Cech.P007@seznam.cz

ABSTRACT

This paper investigates the problematic of emission volatile organic compounds emitted to working, indoor air of the wooden furniture company. The main goal of this research were assessment of quality of indoor air in working environment, which was load of emission VOC emitted from production processes of made furniture. The one part of this research deals of the influence individual technological operations in wooden made furniture in dependence on quality and quantity composition of VOC, which they effects of quality external and internal environment of the furniture company. We analyzed emissions of VOC emitted during the furniture production by the gas chromatograph in conjunction with mass spectrometer and Direct Thermal Desorption. The result of analysis is qualitative and quantitative data in form graph and numerical expression.

Key words: VOC emissions, the furniture company, working environment, gas chromatograph

INTRODUCTION

The subject of this contribution is assessment of influence production of wooden and upholstering furniture on a quality of air in working environment from furniture companies, especially in section of industrial process of finishing furniture parts. The goal of this research was judge influences, which they were affect of a quantity and constitution of emission volatile organic compounds emitted by production of wooden and upholstering furniture into working environment of furniture companies. Volatile organic compounds shape a significant problem that we need to solve with requirement to environmental requirements in present time, because Volatile Organic Compounds (VOC) are among the largest pollution sources of both the internal and external environments.

Volatile organic compounds emitted by the air of the working environment from the furniture companies release not only their own processed wood-based materials, but also in their finishes coatings, completing in operations bonding structural joints and sheathing and veneering.

The staffs in the furniture firms come into contact with chemicals especially with Volatile organic compounds during industrial process of upholstered and wooden furniture, depending on the used materials and production technologies. It is very important to monitor quality of air in working environment, namely qualitative and quantitative of composition volatile organic compounds of air in internal working environment, especially in workplace with manual work, where used chemical compounds are there.

It should to take, how VOC emitted by workplace are influence on a quality of external atmosphere in the surrounding of production plant and they are affect quality of atmosphere in working and nonproductive environment of the company.

Except to determination significant sources of emission VOC in individual manufacturing operations at furniture, joinery or upholstery firms, it is very important, exactly to identify places with the higher amount of volatile organic compounds, so the places with incidence of sources of

VOC. These places are: mixture preparation of organic coatings, mixture preparation of adhesives, spreading of organic coatings, curing and desiccation of organic coatings, curing of adhesives, buffer stock of organic coatings and adhesives. The amount of emission VOC is subject on the way spreading in dependence on consistence of organic coatings and amount of damages spreading organic coatings used existing technology and way of finishing. However, other currently non-measured places, where volatile organic compounds volatilize into the internal working environment, they are: places of correction, places of sanding and polishing of coating films, assembly of products, store products.

Antecedent to development shows, that emission of volatile organic compounds (solvents and thinners) escape from finished product, namely in dependence on time (exponentially) for twenty-eight days. For these reasons, we fixate on places, where newly made products are storage, manipulated and dispatched. These finished products emitted relatively considerable amount of emission VOC. The places, where finished product are storage, they are not equipped by intensive exhaustion.

THE AIM OF THIS STUDY IS:

1. Assessment of quality of indoor air in working environment, which was load of emission VOC emitted from production processes of made furniture.
2. Influence individual technological operations in made furniture in dependence on quality and quantity composition of VOC, which they effects of quality external and internal environment of the furniture company.

Table 1. Chemical elements and their permissible exposure limit (PEL) and the maximum allowable concentration (MAC-P) according to Government Regulation No. 361/2007

Volatile organic compound	No CAS	Occupational exposure limits [mg.m^{-3}]	
		PEL	MAC-P
Acetone	67-64-1	800	1500
Benzene	71-43-2	3	10
Toluene	108-88-3	200	500
n-Butyl acetate	123-86-4	950	1200
o,m,p-Xylen (sum)	1330-20-7	200	400
Etylbenzene	100-41-4	200	500
Styrene	100-42-5	100	400
Butoxy-ethanole	111-76-2	100	200
1-methoxy-2-propanole	107-98-2	270	550
1,2,3-Trimethylbenzene	526-73-8	100	250
1,2,4-Trimethylbenzene	95-63-6	100	250
1,3,5-Trimethylbenzene	108-67-8	100	250

Government Regulation No. 361/2007 Coll. Laying down conditions for the protection of health at work

MATERIAL AND METHODS

The material

During the research project were assessed these furniture and joinery companies.

1. The furniture company near Valašské Meziříčí, producing wooden furniture
2. The furniture company near Uherské Hradiště (region of Zlín)
3. The furniture company Furniture company near Brno, producing upholstered furniture (South Moravia)

The air quality of the working environment, have been selected from the furniture and upholstery companies is presented in Table 2.

Table 2. Assessed work rooms and offices

Assessed room	Manufacture of wooden furniture	Manufacture of upholstery furniture
1	paintshop	upholstery of corpora bed
2	joinery workshop	assembly of lamellar gratings
3	warehouse	warehouse
4	office	office

Used equipment

- short path thermal desorption, Silco treated, Thermal Desorption Tube 786090, inner diameter 4 mm, filled in with 100 mg of Tenax TA (Scientic Instrument Services Company) for collection of VOC emissions tested samples into the air in chamber
- air sampler Gilian – LFS 113 SENSEDNE with air flow 12 $l.h^{-1}$,
- gas chromatograph Agilent GC 6790 with MS (mass spectrometer) detector 5973 with cryofocusation, thermal desorption and library of spectra NIS 0,5 type HP-5 (AGILENT ISA)

Used method

Methods of VOC testing were set via standards

- ISO 16000: 2007 Indoor air;
- ISO 16000-1: 2007 General aspects of sampling strategy;
- ISO 16000-5: 2007 Sampling strategy for volatile organic compounds (VOCs);
- ISO 16000-11:2007 Determination of the emission of volatile organic compounds sampling, storage of samples and preparation of test specimens;

The intimation 6/2003 Intimation for determination hygienic limits of chemical, physical and biological indices for indoor air sojourn rooms of some building;

- The methodology for measurement and determination chemical, physical and biological indices of quality indoor air according to intimation 6/2003;

GV 331/2007 Coll. laying down the conditions of health of workers at work (Annex 2) - Chemical substances, their health limits and procedure for their determination, PART A: List of chemicals and their permissible exposure limit (PEL) and maximum permissible concentrations (NPK-P

In the connection with the term VOC there is the new term TVOC (total volatile organic compounds) which is used to describe the total amount of volatile organic

compounds in the indoor atmosphere. The TVOC value indicates the level of indoor air pollution. The TVOC value can be obtained on the gas chromatograph as the sum of all peak areas of all VOCs which are emitted between hexane and hexadecane, which is calibrated to the value which is equivalent to the toluene.

RESULTS

Figure 1 show a graphical representation of the concentration of VOC emitted into the air of working environment at working activity in paintshop and joinery workshop, currently they are impact atmosphere of internal environment in office (in winter time). The highest concentrations of volatile organic compounds were found in Toluene, n-Butyl acetate. These chemicals were emitted into the atmosphere of office and paintshop.

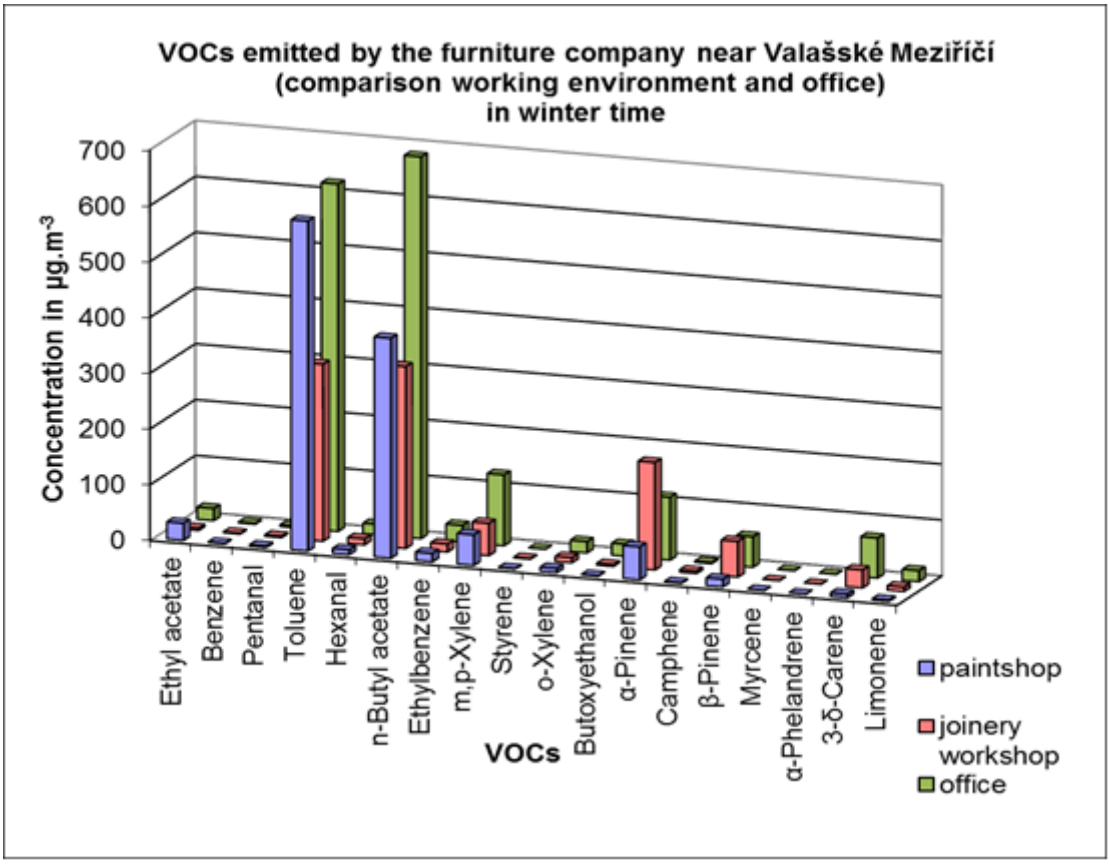

Figure 1: VOCs emitted by the furniture company near Valašské Meziříčí – comparison working environment and office during the winter

Reversely large quantity of terpenes (α and β-Pinene and 3-δ-Carene) were emitted by joinery workshop.

Figure 2 shows the concentrations of VOCs emitted into the air working environment (paintshop, joinery workshop, warehouse) and into the atmosphere of office from the furniture company near Uherské Hradiště, in winter time. The graph shows that the highest concentration of VOC was emitted into the atmosphere of the paint shop air. This fact is incurred to working activities in paintshop (spreading of organic coatings and their caking, curing of coating films) as it releases considerable of VOC. The highest concentration of Ethyl acetate, Toluene, n-Butyl acetate, Ethylbenzene, m, p, o-Xylene, and Butoxyethanol

were emitted into the indoor air of the paint-shop.

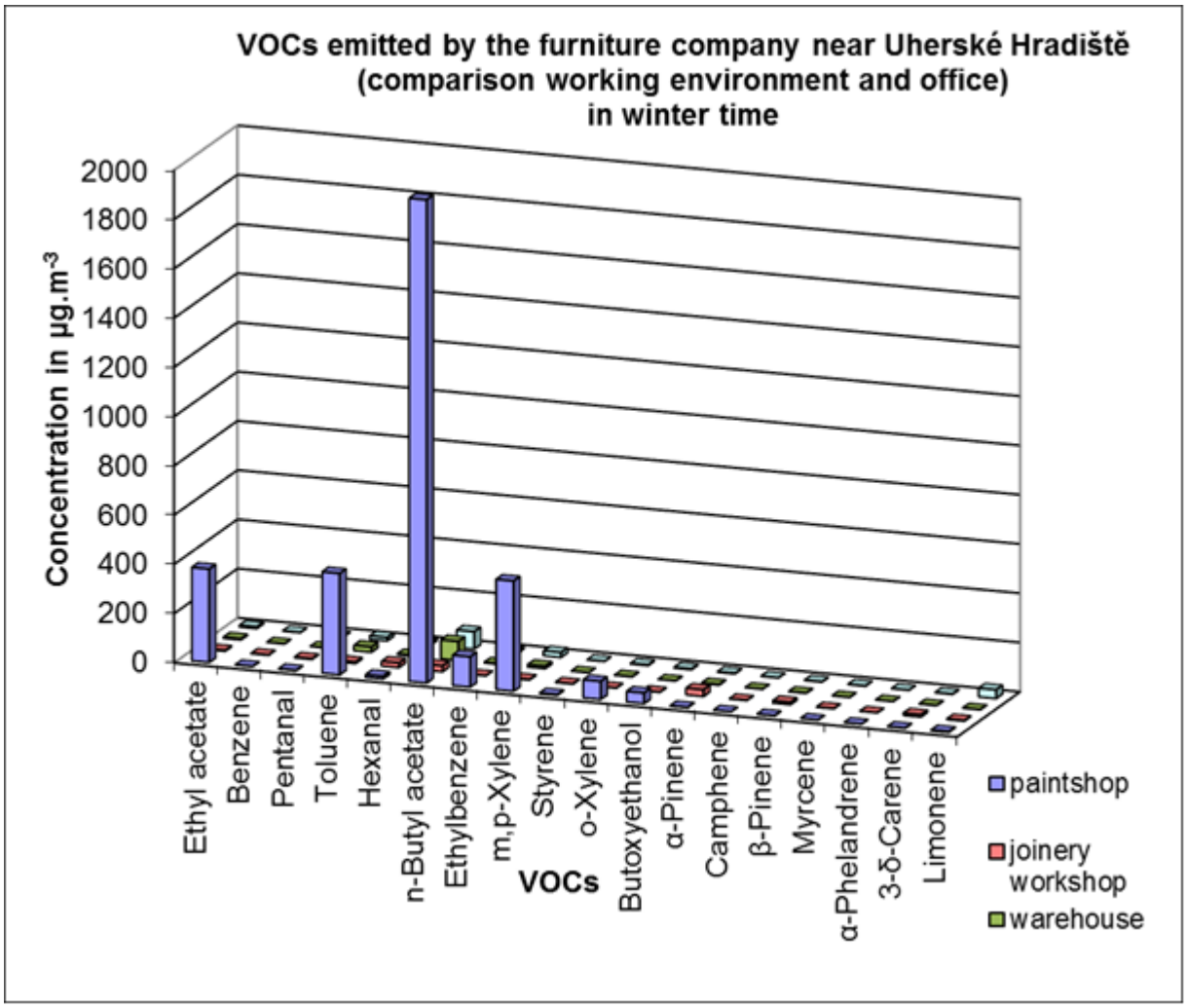

Figure 2: VOCs emitted by the furniture company near Uherské Hradistě - comparison working environment and office during the winter

Figure 3 shows the comparison of VOC concentrations contained in the atmosphere of working places where volatile organic compounds were released by individual technological operations of production upholstered furniture (upholstery of corpora beds, assembly of lamellar gratings, warehouse), when VOC were emitted by spreading of adhesives and creation of glued joint. Currently volatile organic compounds were slackening into the indoor air of the office. The technological operation upholstery of corpora beds was released first these chemicals: Ethyl Acetate, Toluene, Hexanal and terpenes (α, β Pinene, 3-δ-Carene and Limonene). Aldehydes (Pentanal, Hexanal) and terpenes ((α a β-Pinene, 3-δ-Carene a Limoneme) were emitted into indoor air during the technological operations of the assembling of lamellar gratings. The finished products, which they saved in warehouse, emitted mainly into the internal working environment these chemicals: Ethyl Acetate, Toluene, Hexanal and terpenes (α, β-Pinene, 3-δ-Carene and Limonene). The increased concentration of Limonene was found in the indoor air of the office.

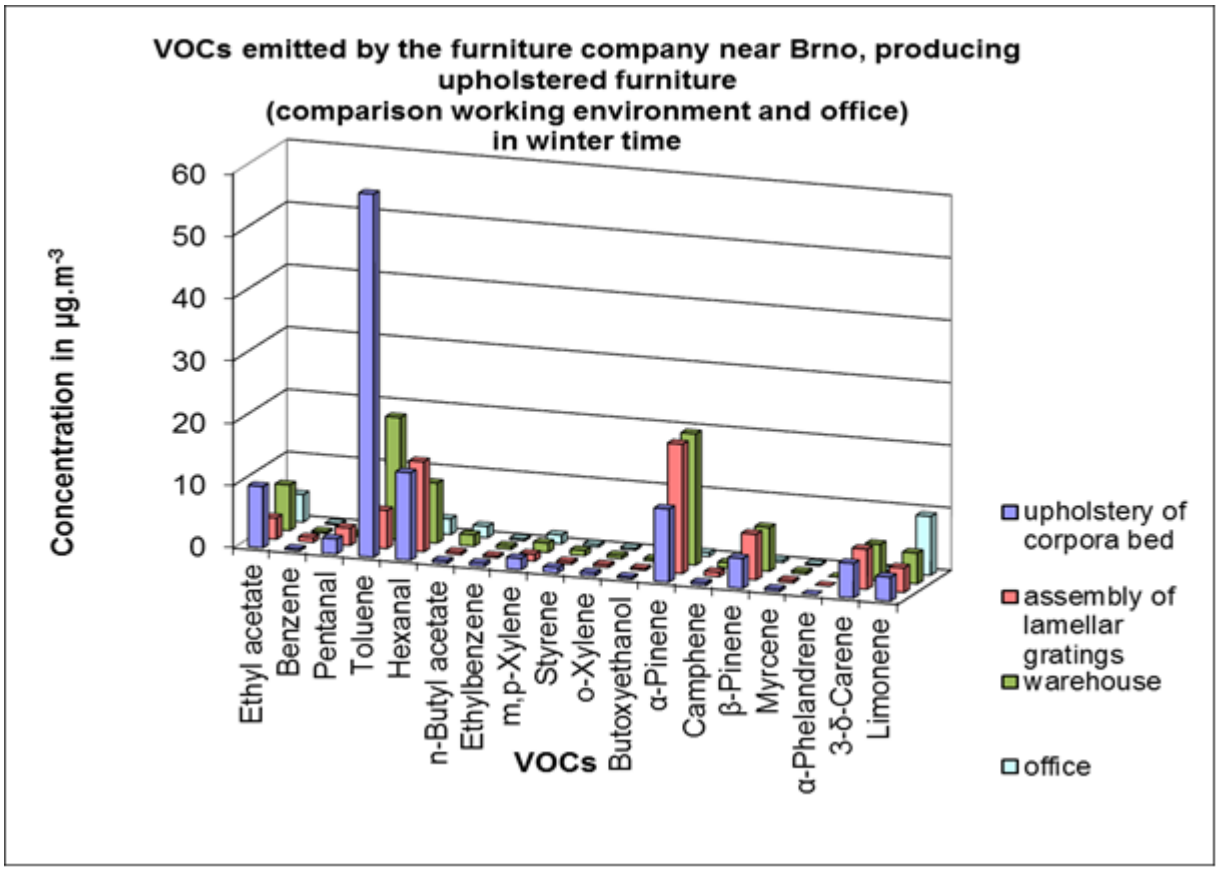

Figure 3: VOCs emitted by the furniture company near Brno, producing upholstered furniture – comparison working environment and office during the winter

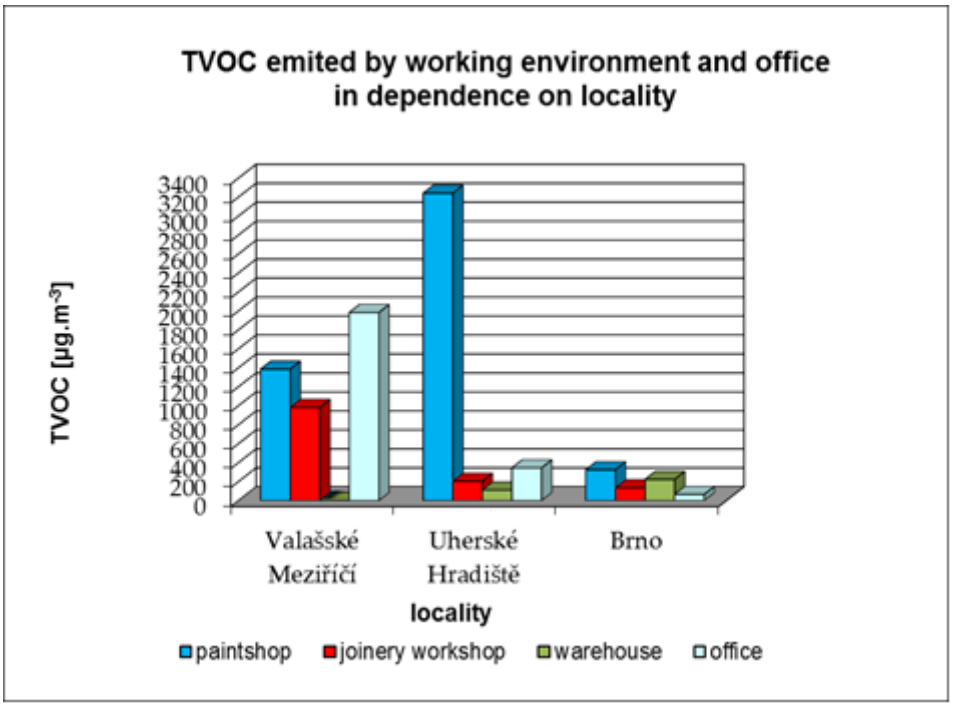

Figure 4. TVOC emitted by working environment and offices in the furniture companies

Figure 4 graphically shows the contents of TVOC indoor air of the different tested furniture companies. The highest TVOC value from all measurements of the working

environment was found in the indoor air of the paint shop in the furniture company near Uherské Hradiště. This fact is incurred by working activities on this place (spreading of organic coatings, creation of coating films). The highest TVOC value of working environment in warehouse was measured in the furniture company producing upholstered furniture (near Brno). Work place of office was emitted the highest TVOC value by working environment in the furniture company near Valašské Meziříčí.

DISCUSSION

1. The furniture company near Valašské Meziříčí

This furniture company, especially their indoor air of office contains the highest amount of VOCs of atmosphere from tested the furniture company. The highest concentrations of VOCs were determined in indoor air of office, followed internal working environment of paint shop and joinery workshop.

The maximum value of all monitored VOCs was measured in air office especially at n-Butyl acetate in amount 683,6 $\mu g.m^{-3}$, followed Toluene in amount 622 $\mu g.m^{-3}$. The measured value of toluene exceeds more than twice admissible hygienic limit according to publication of Ministry of Health in Czech Republic no.6/2003, where value permitted limit of toluene is 300 $\mu g.m^{-3}$,but this measured value of toluene don´t exceeds 1/3 PEL according to Government Regulation No. 331/2007 Coll. The highest value TVOC was found in office in amount 1983 $\mu g.m^{-3}$, followed paint shop by concentration 1386 $\mu g.m^{-3}$. The explicit results of VOCs emissions reflect that air circulation is badly controlled in this firm and VOCs emitted by finishing of furniture sections are dramatically influence of quality in indoor air of office. This emissions VOCs cumulate in office especially in winter time

2. The Furniture company near Uherské Hradiště

The highest concentrations of VOCs in this furniture company were detected in the workplace finishing of the surface treatment in place of paint shop, so in the place where organic coatings are finished and transformed into the coating films. The highest concentration of n-butyl acetate was found in the paint shop in amount 1961,4 $\mu g.m^{-3}$. This substance is released into the atmosphere during the finishing by waterborne finishes, which this compound contains as the solvent. The high amount of sums xylene (m, p, o) in the amount of over 520 $\mu g.m^{-3}$ was also measured in the atmosphere of the finishing furniture sections,. The highest value of TVOC was in the air in the paint shop. The established value of TVOC in the air in the paint shop was 3241 $\mu g.m^{-3}$, followed by the value of TVOC in the air office 345 $\mu g.m^{-3}$ and the value of TVOC in the air of joinery workshop in quantity 204 $\mu g.m^{-3}$.

3. The furniture company producing upholstered furniture near Brno

The air of the internal environment of the factory producing upholstered furniture, contained the smallest amount of VOC emissions from all tested workplaces, which is due not only to the quality of aspiration, but also the character of production, because the production of upholstered furniture applies only adhesives. The most VOC was contained in the indoor air of the department upholstery corpora bed, followed by air of assembly lamellar gratings and indoor air of office. Toluene, which it found in air at working operation upholstery of corpora bed in amount 58,1 $\mu g.m^{-3}$, was measured as the

highest value of the VOC. The adhesive was used during this operation.

More amount of α-pinene in amount 20,7 $\mu g.m^{-3}$ was found in the indoor air of the technological operation assembling lamellar gratings. The highest value of TVOC in the air was analyzed in air samples collected during operations upholstery corpora bed in quantity of 325 $\mu g.m^{-3}$, followed by assembly operations lamellar gratings in amount of 135 $\mu g.m^{-3}$ and office, the value found was 65 $\mu g.m^{-3}$.

CONCLUSION

The present results exhibit that paint shop is workplace with the greatest release of emission VOCs. These workplaces of course are equipped by intensive extraction. The atmosphere of working environment on these workplaces contains such amount and composition of volatile organic compounds, which they are meets relevant standards and publications.

However, problems occur in workplaces, such as warehouses, assembly plant floor and offices in the non-manufacturing firms, the air is also load by emissions of volatile organic compounds. These workplaces are not equipped so the intensive extraction. Emissions of volatile organic compounds release directly from sources (new-made, pasted and finished furniture section) in assembly departments and warehouses. These sources of emissions VOCs distinctly deteriorate a quality in indoor air of these departments of furniture companies. The solution design of air conditioning and extraction in furniture companies, especially in assembly departments and warehouses, it is necessary to realize dependence of amount volatile organic compounds emitted from products on time.

The emissions of VOCs were emitted by finishing of organic coatings and finished products were subsequently entrained by airflow to the atmosphere of offices. Emissions emitted by production part of the firm burden atmosphere of offices and deteriorate quality of working environment. The present results indicate that it is necessary to deal with way of airflow from sources of emissions direction to the areas of firm without extraction. The staff workings in the offices, are long-term effects of exposure to the increased amount of VOCs, not only reduces the working comfort, but also may occur on effect on their health and quality of work.

Firms should focus on measuring air quality in the company that are not directly incorporated into the manufacturing process, or it is to direct a major source of emissions.

REFERENCES

1. Fisher, B., (1998). Scents sensitivity Environmental Health Perspectives 1998 volume 106, Nb. 12 pp. 594–599.
2. Frietsch, M., (2008). Monitoring and assessment of emissions and odors with and Electronic nose, In Emissions and odors from materials, Brussels, Belgium.
3. Gostelow, P., Longhurst, P., Parsons, S., Stuetz, R., Sampling, Kim, Y., Watanuki. S., (2003). Characteristics of electroencephalographicresponses induced by a pleasant and an unpleasant odor. In Journal of Physiological Anthropology and Applied Human Science 22, pp. 285–291, ISSN 1345-3475

ACKNOWLEDGEMENT:

This work came out from results of research plan MSM 6215648902 financed of Ministry of education youth and sports