

Konferencja m–nar. 7th International Conference Environmental Engineering and Design, Zielona Góra, 23–24.10.2025 DOBRZYŃSKA Elżbieta, Hazards associated with additive manufacturing in the working environment

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Hazards associated with additive manufacturing in the working environment

Fused Deposition Modeling (FDM) is one of the most widely used additive manufacturing technologies, thanks to its simplicity, affordability, and ability to create durable parts. However, it involves potential risks of ultrafine particles (UFP) and volatile organic compounds (VOCs) emissions and requires proper safety measures to ensure the operator's safety.

Tests were conducted in the lab chamber on particulate and chemical emissions during 3D printing process using common polymer materials. The materials came from various Polish manufacturers and differed, often unreported, in the additives affecting the physicochemical properties of the printed product. For each filament considered, the highest particle concentrations were obtained at the beginning and end of the 3D printing process. The values of particle emission parameters during 3D printing from PETG filament (PETG-3 1.63×10^5) were an order of magnitude smaller than during 3D printing from ABS filament (ABS-3 was 1.11×10^6). Significantly lower concentrations of VOCs were also measured when printing with PETG filament than with ABS. However, total endocrine-active compound PAEs in the inhalable and gaseous fractions were found to be significantly higher when using PETG filaments. Thus, attention should be given to the materials used in the printing process.

By following proper safety guidelines and taking proactive steps to mitigate risks, users can ensure a safe printing environment while maximizing the efficiency and effectiveness of the FDM process.

*This task was completed on the basis of results of research carried out within the scope of the 6th stage of the National Programme "Governmental Programme for Improvement of Safety and Working Conditions", funded by state services of the Ministry of Family, Labour and Social Policy (task no. 3.ZS.05). The Central Institute for Labour Protection – National Research Institute is the Programme's main co-ordinator.

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CERTIFICATE

PARTICIPATION OF 7TH
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ENVIRONMENTAL ENGINEERING AND DESIGN

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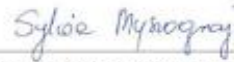
ELŻBIETA DOBRZYŃSKA, TOMASZ JANKOWSKI,
MAŁGORZATA SZEWCZYŃSKA

with poster

Hazards Associated With Additive Manufacturing in the Working Environment



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HAZARDS ASSOCIATED WITH ADDITIVE MANUFACTURING IN THE WORKING ENVIRONMENT

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AIM OF WORK

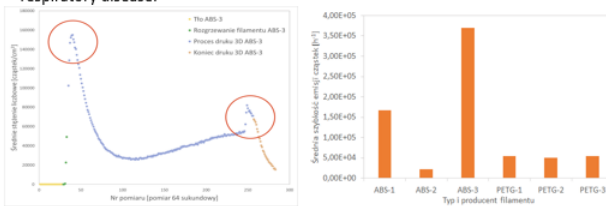


Identification and analysis of hazards associated with the use of various types of materials in a selected 3D printing technology used in the work environment.

RESULTS

Research focused on identification and analysis of the risks associated with the use of different types of materials in FDM printing technology. Tests were conducted in the lab chamber on particles and chemical emissions during 3D printing process using common polymer materials (ABS, PETG) from various Polish manufacturers and differed, often unreported, in the additives affecting the physicochemical properties of the printed product.

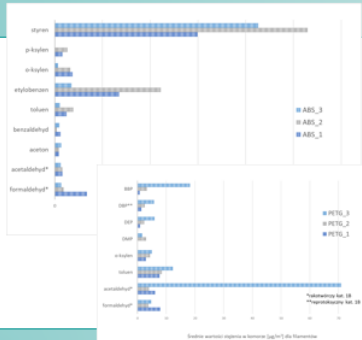
3D printing involves potential risks of ultrafine particle (UFP) and volatile organic compounds (VOCs) emissions. Particles with a diameter <100 nm can penetrate the blood and be carried to various human internal organs, and can cause irritation of the eyes, nose and throat, and aggravate symptoms of coronary heart disease and respiratory disease.



The highest particles concentrations were obtained at the beginning and the end of the 3D printing process.

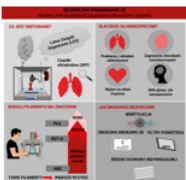
The values of particle emission parameters during 3D printing from PETG filament (PETG-3 1.63×10^5) were an order of magnitude smaller than during 3D printing from ABS filament (ABS-3 was 1.11×10^6). When printing with ABS filaments, it is necessary to use mechanical ventilation that ensures at least twice as much air exchange in the room as when 3D printing with PETG filaments

RESULTS...



VOCs can cause eye, nose and throat irritation, fatigue, nausea, headaches and dizziness, shortness of breath and skin problems. A comparison of VOCs emissions **results** in significantly lower concentrations when printing with PETG filaments than with ABS. The dominant chemical compound emitted during printing with ABS filaments was styrene (the highest concentration of 264.75 $\mu\text{g}/\text{m}^3$ was measured for ABS2). Carbonyl compounds emitted during ABS printing ranged from 1.49 to 33.56 $\mu\text{g}/\text{m}^3$. The highest formaldehyde concentrations (33.56 $\mu\text{g}/\text{m}^3$) were measured during 3D printing with ABS-1 filament. Carbonyl compounds emitted during PETG printing ranged from 1.73 to 70.9 $\mu\text{g}/\text{m}^3$. The highest acetaldehyde concentrations were measured during 3D printing with PETG-3 filament (70.90 $\mu\text{g}/\text{m}^3$). A comparison of the total PAE in both the inhalable and gaseous fractions show slight differences between the three ABS filaments tested and significantly greater differences when using PETG filaments.

CONCLUSIONS



- Materials used for 3D printing can release chemicals that pose a risk to the user. Source of exposure for VOCs and particles are thermal decomposition products of filaments and their additives (dyes, plasticizers, flame retardants). Selection of the same filament from a different manufacturer may result in lower emissions of particles and chemicals.
- The emission of nanoparticles and the presence of carcinogenic and reprotoxic or endocrine disrupting substances in air samples increases the risk estimated at the printer operator's workplace and requires appropriate preventive measures.
- Effective management of exposure to hazardous substances in the workplace is only possible if everyone is well informed about the risks and the actions to be taken to prevent them effectively.
- PRACTICAL TOOLS AND GUIDELINES TO RAISE AWARENESS have been prepared in CIOP-PIB to build awareness of safe work with 3D printing.