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ENVIRONMENTAL INTERACTION ASSESSMENT OF VOC'S EMISSION FROM PRINTING PLANT HOT ROTARY HEAT-SET

OCENA ODDZIAŁYWANIA NA ŚRODOWISKO EMISJI LZO W PROCESIE DRUKU GORĄCY OFFSET ROTACYJNY (HEAT-SET)

Abstract

The paper presents an analysis of gaseous emissions arising from the operations of printing using a printing process hot offset rotary. The first part presents the general characteristics of the process and the paint used. The following part shows the results of modelling the emission of pollutants according to the efficiency of the cleaning system, as well as depending on other parameters influencing the dispersion process impurities.

Keywords: modelling of emissions, printing industry, rotary offset (heat-set)

Streszczenie

W pracy przedstawiono analizę emisji zanieczyszczeń (LZO) powstających w wyniku działalności zakładu poligraficznego wykorzystującego w procesie druku gorący offset rotacyjny. Część pierwsza prezentuje ogólną charakterystykę procesu oraz wykorzystywanych farb. W dalszej części przedstawiono wyniki modelowanie emisji zanieczyszczeń w zależności od sprawności układu oczyszczającego, a także w zależności od innych parametrów wpływających na proces dyspersji zanieczyszczeń.

Słowa kluczowe: modelowanie emisji zanieczyszczeń, gorący offset rotacyjny

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1. Introduction

From the time of Johannes Gutenberg, who is considered to be one of the precursors of industrial printing method, printing processes have undergone many changes and modifications. Constant competition forces the use of ever newer solutions to optimise printing costs, while maintaining appropriate quality parameters. In the case of multi-format printing, a frequently used technique is the process of printing by hot rotary heat-set, which enables to print significant amounts of paper in a relatively short time. Multi-format printing implies the use of the equipment of printing machines that are significant sources of emissions of dust and gas pollutants, mainly organic compounds.

The paper presents an analysis of the emission of dust and gas emitted by modern offset printing, in which a large part of printing is done on automatic thermoforming machines.

2. Analysis of the sample printing offset in the context of emissions of dust and gas into the atmosphere

2.1. The object of the study

The object of the analysed company is printing activity.

The printing plant prints colour magazines, newspapers, advertising catalogues and leaflets, etc. A flat indirect (offset) printing technique with the fixation of paint at elevated temperature (*heat-set*) applies in the production process.

The printing plant is located in one of the outlying districts of the city in an area planned for the activities of production and services. The immediate surroundings of the plant are the lands used for the purposes of business production and service.

2.2. Printing technology

Web offset printing is a relatively cheap and quick way to obtain a large number of prints. Lightweight aluminium matrix formed on the drum printing sends an image on an intermediate drum with a rubber coating, which in turn transfers the image to paper. Hence, there is the second important definition of this technique – *indirect* print. This printing unit is capable of rotation at high speed.

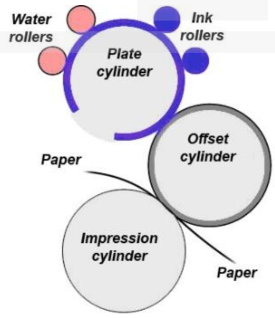

Fig. 1. Offset printing

Common use of colour web offset printing in addition to speed arises from the variety of possible use of media, i.e.: from coated paper (*non-absorbent* surface), the newsprint to cardboard (substrate *absorbent*).

2.3. Raw materials used in the printing process

Due to the volume of raw materials, which are used and the characteristics of the fusing mechanisms of printing inks in the process of web offset printing, determination of the characteristics of used inks is essential in order to assess the impact of the installation on the atmospheric air. Fusing mechanisms of inks of the type of *heat-set* occur due to the influence of the delivery of significant amounts of heat (blow heat, drying tunnels, which are heated by gas burning, etc.). Depending on the drying system, the paper has a temperature ranging from 90 to 150°C, which corresponds to a temperature of 200÷300°C of the drying agent. At these high temperatures, it evaporates mineral oil, which is a solvent for paints of *heat-set* type and water (moisture) from paper and wetting agents.

For the production of *heat-set* paints, adhesives containing the composition of phenol-formaldehyde resins and alkyd resins, polymerised linseed oil, mineral oil (fraction with a boiling point of 240÷300°C), colorants, tinters and excipients are used. Mineral oils used for the production of paints of the type *heat-set* are special species usually of naphthenic mineral oils. They are refined in such a way that they are almost odourless and colourless. Depending on the distillation, the boiling point is in the range of 240÷270°C, 260÷290 and 270÷300°C. In the *halftone* paints, mineral oils vary in their boiling points because paints of different colours are to be traversed in the printing path of different distances. Therefore, a black colour which has the longest distance to go, has in its composition an oil having the lowest volatility. The yellow ink goes in turn the shortest possible route and, therefore, contains mineral oil with high volatility [1].

2.4. Characteristics of emerging emissions

For the production of *heat-set* paints, mineral oils containing aromatic compounds are used. In addition, wetting agents containing alcohol, iso-propyl or organic alternatives are used in the printing process. Depending on the drying system, it evaporates mineral oil, in varying amounts, which is a solvent of *heat-set* paint and water (moisture) from paper and wetting agents. The main pollution are therefore volatile organic compounds (VOCs) emitted in the installation in the amount of approx. 30 kg/h of VOC.

Furthermore, due to the demand on the substantial amount of thermal energy for the drying process of the paper, the fuel is typically used for natural gas, in which the products of combustion (mainly nitrogen oxides, carbon monoxide, carbon dioxide) also flow to the atmosphere.

2.5. Legal requirements relating to the issue of emerging contaminants

Legal requirements for environmental protection regulate the Framework Law of 27 April 2001. Environmental Protection Law (Polish Journal of Laws of 2013 item. 1232, as amended.) and implementing acts to the above Law. According to the Regulation of the Minister of Environment of 26 January 2010 on reference values for certain substances in the air (Polish Journal of Laws of 2010 no. 16 item. 87) [2] plant, which leads pollution in an organised manner to the atmosphere is obliged to use solutions that will not exceed the permissible reference value, ice. appropriate normative values concerning excess emissions will be saved.

Moreover, in the case of large printing plants, which consume large quantities of raw materials (this translates into considerable use of VOC), additional requirements apply for the protection of atmospheric air as defined in the Regulation of the Minister of Environment of 4 November 2014 on emission standards for certain types of installations, combustion plants and equipment incineration or co-incineration of waste [3]. The processes carried out in the system used in this printing plant include (in accordance with Annex 7 to the above regulation to hot offset rotary process, which identified the following emission standards (Annex 8 point 1):

For VOC usage> 25 Mg / year
S1 = 20 mg / m^3 VOC
(counted on organic carbon).

2.5. Methods of reducing emissions of pollutants

Systems of injecting air containing solvents are usually designed to maintain an adequate atmosphere within the workspaces and equipment significantly below the permissible concentrations of pollutants. Deriving solvents from the key sources can lead to disposal system of waste gases because of the need to comply with regulations on environmental protection. When designing injecting systems, some things must be taken into account:

- the amount of the discharged air,
- level of solvent,
- type of utilisation, its cost-effectiveness and impact on the environment,
- number of working hours per year.

When injecting a large amount of air relative to the solvent increases the size of reduction system, and may increase the amount of energy required as drive, which supports combustion. In the case of large printing plants using web offset printing generally used methods are based on oxidation of pollutants through the use of thermal afterburners. In certain cases, it is reasonable to use catalytic afterburners, which through the use of a catalyst operate at lower temperatures than thermal afterburners (this translates into energy savings).

Moreover, in the case of large printing plants, there are also solutions in which every single print line may have a dedicated system of waste gas treatment. For example, if it is integrated into the dryer(s), the system allows for easy use of heat or exhaust gases for heating the air in the dryer. Printing presses in such a case depend on the central system of waste gases.

2.6. Sources of emissions in the tested offset printing plant

When injecting pollutants into the air is related to the functioning of the basic technological processes (sources of emissions from the production equipment). Vapours produced during drying of the printed paper web are extracted on machines and routed to a thermal afterburner, which reduces pollution. Burners with the installed thermal capacity in the range 850÷1600 kW function for particular drying tunnels of web offset printing machines for drying the printed paper.

2.7. Maps of the distribution of concentrations of selected pollutants around the premises

Simulations of the changes of individual pollutants concentrations in the atmosphere were made using modelling software a steady-state Gaussian plume model on the basis of measurements of pollutants emissions carried out by an accredited laboratory according to Polish reference methodology [2]. The resulting simulations are expressed as map of spatial concentration distribution and demonstrated in Figs. 2 a and b to show the greatest concentration of major pollutants in the vicinity of the plant.

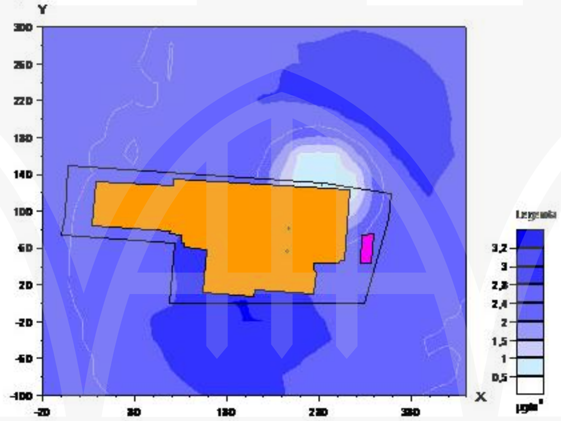

Fig. 2a. The map showing isolines of the peak concentrations of selected pollutants (aromatic hydrocarbons)

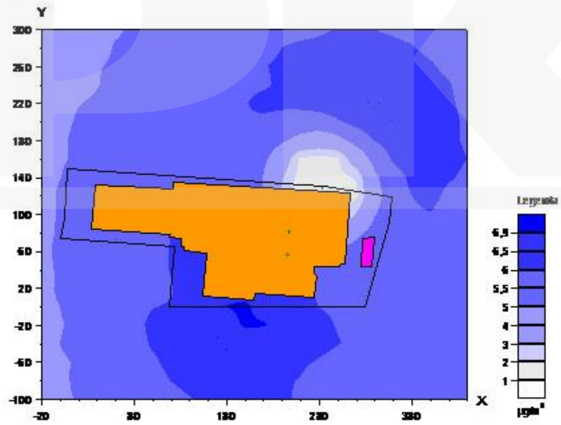

Fig. 2b. The map showing isolines of the peak concentrations of selected pollutants (aliphatic hydrocarbons)

3. Calculation of the concentrations of dust and gas pollutants emitted into the atmosphere depending on changes of selected technical parameters of the installation

According to the measurements carried out by the accredited laboratory, the afterburner efficiency in the test plant is approx. 99% of VOC. The tables 1 and 2 show how the change in volume would have affected the maximum concentration of emitted pollutants (VOC) by using afterburner with a different efficiency, as well the change of peak levels when choosing the other technical characteristics of the emitter (height, diameter) was presented.

This simulation was performed to investigate whether the use of relatively cheap and fast to carry out technical solutions (change in height or diameter of the emitter) instead of afterburners with extremely high efficiency, can significantly reduce the impact of printing plant on the atmospheric air.

Table 1

The average increase in the concentrations of pollutants compared to the actual afterburner efficiency

Pollution	Maximum concentration of impurities (depending on the efficiency of the afterburner) [mg/m^3]				
	95%	96%	97%	98%	99%
Benzene [1]	2.03	1.84	1.64	1.44	1.24
Xylene [2]	2.08	1.74	1.39	1.04	0.69
Styrene[3]	1.09	0.90	0.70	0.50	0.30
Toluene [4]	1.69	1.41	1.12	0.84	0.56
Aromatic hydrocarbons [5]	14.42	11.71	8.99	6.28	3.57
Ethylbenzene [6]	1.21	1.02	0.82	0.62	0.42
Aliphatic hydrocarbons [7]	31.34	25.43	19.53	13.63	7.72
The average increase in the concentrations of pollutants compared to the actual afterburner efficiency [%]	+ 218.28	+ 163.67	+ 109.10	+ 54.52	–

When changing the performance of an afterburner from 99% to 95%, we can observe up to 218% average increase in the concentration of pollutants in the air. Even in the case of restriction of performance of afterburner from 99% to 98% we can observe up to 50% average increase in peak concentrations in the atmosphere. A summary of calculation results is also presented graphically in the chart below:

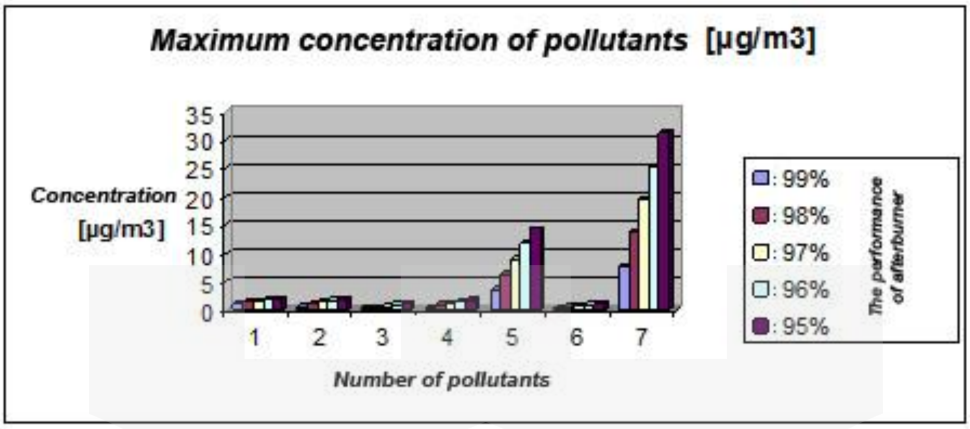

Fig. 3. A graph showing maximum concentration of selected impurities depending on the performance of afterburner

The change of the height of the emitter can affect the concentration pollutants as follows:

Table 2

The average decrease in the concentrations of pollutants depending on the height of emitter of afterburner

	Maximum concentration of impurities (depending on the amount of boost emitter) [m]				
	14	**16**	**18**	**20**	**22**
The average decrease in the concentrations of pollutants depending on the height of emitter of afterburner [%]	–	- 6.05	- 11.32	- 14.36	- 18.31

When changing the diameter of the emitter, concentrations of pollutants can achieve the values as follows:

Table 3

The average decrease in the concentrations of pollutants depending on the diameter of emitter of afterburner

	Maximum concentration of impurities (depending on the diameter of emitter) [m]				
	1,4	**1,3**	**1,2**	**1,1**	**1,0**
The average decrease in the concentrations of pollutants depending on the diameter of emitter of afterburner [%]	–	- 2.46	- 4.96	- 6.30	- 9.18

4. Conclusions

- From the presented analysis of emissions (VOC) resulting from the operations of the printing plant using hot offset, in a printing process, we can conclude that the concentrations of VOCs are within the range of permissible emission standards.
- Change of the performance of afterburner to a varying degrees results in the maximum concentration of each pollutant.
- Change of performance of afterburner from 99% to 98% causes – according to modelling, which was carried out – more than 50% increase in peak concentrations of impurities.
- Change of the diameter of the emitter by about 0.2÷0.4 meter or change of the height of the emitter by 2 to 6 meters allows for a reduction of the maximum concentrations of pollutants by approx. 5 to 15%.
- In the case of small deviations from the normative reference values of pollutants in ambient air can be considered as a method to reduce nuisance on a change of parameters of emitter (height, diameter).

References

[1] Jakucewicz S., *Farby drukowe*, Michael Huber Polska Sp. z o.o., Wrocław 2001.

[2] Regulation of the Minister of Environment of 26 January 2010 on *reference values for certain substances in the air*, Polish Journal of Laws of 2010, no. 16, item 87.

[3] Regulation of the Minister of Environment of 4 November 2014 on *emission standards for certain types of installations, combustion plants and equipment incineration or co-incineration of waste*, Polish Journal of Laws of 2014, vol. 1, item 1546.