Environmental Protection

Flexographic Printing and Integral Approach to Pollution Prevention and Control

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1.Introduction

The awareness of environmental, economic and sociological problems is rising. The purpose of such an approach is to reconcile industrial development with environmental capacities. This approach to environmental protection dates back to the time when the devastation of environment brought on by human factor, the intensification of production process and a build-up of harmful pollutants first became visible.

The measures aiming at protecting the environment are a part of the organisation system within the production. They are carried out by means of the BAT-*Best Available Techniques* and are based on contemporary technology, which guarantee a high degree of environmental, energetic and economic efficiency.

2.Integral approach to pollution prevention and control

The Integrated Pollution Prevention and Control Directive *(IPPC Directive EU 61/96)* presents a significant change in the approach to waste control with the emphasis on the prevention of waste production at the source of emission. The Directive reflects an integral approach to environmental protection and, as mentioned earlier, its implementation is mandatory in the context of the prevention of waste production, while only secondarily it concerns the application of some of the ecologically acceptable waste recycling techniques in cases when waste production cannot be avoided. It is thus evident that there has been a significant shift from waste control toward prevention of waste production.

A further specific feature of the Directive is that it encompasses the totality of the effects of particular production processes on the environment and does not consider them in terms of individual media, such as the air, water or soil, as previous approaches did.

Furthermore, one of the aims of the integral approach to pollution prevention and control is to avoid shifts of pollution from one medium to another.

In addition to applying the best techniques available, the Directive contributes to preserving natural resources, optimising energy consumption and reducing the risk of accidents.

In the course of the EU accession process, the Republic of Croatia is implementing amendments to laws and regulations that will affect business practices of Croatian companies. The companies are required to submit environmental impact studies and status reports to the Ministry of Environmental Protection, Physical Planning and Construction for evaluation and assessment. Upon obtaining approval by the Ministry, the company applies for the integrated environmental permit. This permit regulates the entire environmental impact of the industrial plant (use of raw and auxiliary materials, emissions, process waters, waste, noise, soil and groundwater protection, management, self-control, maintenance, emergency plans…) The permit is valid for a predefined number of years. In this period of time the company is expected to keep up to date with technological development and to invest accordingly into its environmental protection program. When the permit expires, the application is to be renewed.

Considering the time needed for adaptation, the complexity and the costs of implementation, the companies are entitled to a longer period of time for the implementation of new technologies.

3. Flexographic printing and environmental quality

One of the challenges in the further development of flexographic printing is the reduction of negative impact on environmental quality. Not only the conventional methods of preparing the printing forms for printing, but also the solvents and other toxic chemicals present in printing inks, varnishes and cleaning agents used to clean machine parts can exert harmful effects on the environment.

Inks and solvent-based cleaning agents are the main source of volatile organic compounds in flexographic printing. A part of the emission of pollutants is accounted for by the ink container, free surfaces and the printing substrate. However, most of the emission (75%) is attributed to print dryers.

Exposure to VOC can seriously affect human health, causing headaches, liver and kidney impairment, allergic skin reactions, central nervous system side effects, etc.). Some compounds are even suspected of producing carcinogenic effects. These compounds also interact with other compounds in the outer atmosphere, forming troposphere ozone, PAN compounds, aldehydes, ketones and other photochemical oxidants. Some solvents are not biodegradable, and hence they may represent a risk for soil and groundwater pollution.

Measures to control and purify air include regenerative processes (solvent adsorption with steam regeneration) and somewhat more frequently non-regenerative methods (thermal oxidation, catalytic oxidation). Carbon dioxide, a well known greenhouse gas, is produced as a by-product of these non-regenerative methods, which is considered to be an evident drawback of these methods.

The disposal of VOC is a complex procedure with less than hundred percent efficacy. It is assumed that in the future legal regulations might require zero VOC emission. In that case, the outlined emission control systems would not be a reasonable solution.

In addition to solvent-based inks, flexographic printing uses water-based inks, as well as inks dried by means of UV radiation or an electron beam. Neither of these ink types is superior in terms of environmental effects. All ink types have advantages and disadvantages in terms of impact on the environment, the human health and the quality of printing on certain substrates.

The use of various admixtures, solvents and additives during the printing process tends to increase health risks. The following components of flexographic inks may have serious adverse effects on the health of all people employed in the printing process: acrylic polymers (glycerol propoxylate triacrylate) and acrylic polyols (dipropylene glycole diacrylate, hydroxypropyl acrylate) can be found in UV inks; organophosphorus compounds are a part of solvent-based inks and UV inks; ethylene glycol ethers (butyl carbitol, ethyl carbitol), alcohols, alkyl acetates, propylene glycol ethers are found in water-based inks and alkyl acetates, amides, nitrogen compounds, organic and organometallic pigments in all ink types.

Health can be affected either via the skin or by inhalation. The health hazard depends on the degree of toxicity of the chemicals and the extent of human or environmental exposure. It also varies depending on ink type and composition, as well the mode of application. The health risk includes neurotoxicity, serious effects on the respiratory and central nervous system, gastrointestinal and cardiovascular system, the kidneys, liver, blood and enzymes. Skin and eye irritations are also possible.

Since most solvents are extremely flammable, special attention should be paid to the solvent's ignition point and explosive features as specified in the Material Safety Data Sheet. As most solvent-based inks are considered to be dangerous waste during waste disposal, their ignition points should not be below 60°C.

Water-based inks should contain less than 25% of VOC. Depending on the formulation, different VOCs are used and some formulations may even contain HAP (hazardous air pollutants). Water-based inks are generally regarded as environmentally friendlier than solvent-based ones. However, their health and safety hazard directly correlates with their VOC and HAP content. Ecological acceptance can be increased by reducing the VOC content and by replacing resins by compounds that facilitate drying.

Water-based inks and process water must not be discharged into the sewerage. Process water contains pigment, pigment carriers (emulsions or colloid dispersions), alcohols, glycerol, glycerol ether and additives (wax, defoamer). Inks can also be contain different metals (copper, barium, nickel, magnesium and cobalt compounds, chrome and lead in traces), which makes them potentially dangerous waste.

The most convenient method of pollution management and prevention is minimisation of water consumption, which does not only result in cost containment, but also reduces the amount of waste water. Of the two approaches to pollution management and prevention mentioned, reducing the amount of incoming water or recycling, the former is considered to be ecologically more acceptable. It can be implemented by draining as much ink from the container as possible, by scraping machine parts clean before employing water, by cleaning machine elements before the ink has dried, by using low-pressure jets and by employing machines with reducible water flow.

Waste waters discharged during the printing process utilizing water-based inks contain the following compounds: adsorbing organic halogens 1500mg/l, copper 20mg/l, hydrocarbons 1000-5000 mg/l and CPVC 1000 mg/l. Purification process starts with a PH-adjustment and flocculation, after which pigments and resins settle in the sludge. Material separation is done by means of filtration. In addition to the previously mentioned methods, waste waters can be treated by using membrane separation methods: microfiltration, ultrafiltration, nanofiltration and reverse osmosis, which all produce satisfactory water quality for re-use. Furtehrmore, waste waters can be treated by oxidation techniques, including UV/ozone or UV/hydrogen peroxide oxidation. The choice of method depends on the quality and the amount of process waste water. The method most frequently used in flexographic printing is the first method described.

Inks that are dried by means of UV radiation do not contain VOC. The ignition point of monomers and oligomers is above 100°C, They are not considered dangerous waste and are not toxic. However, they can cause skin irritations. Compounds from the group of acrylic polyols and amides can pose a serious health hazard for people who come into contact with them either by inhaling or touching them. New and improved formulations of inks and varnishes that are dried by means of UV radiation should meet the requirements for less offensive odour and less unwanted emission from the printed surfaces. In this context one should also mention the substitution of photoinitiators.

Cationic dyes cause less irritation to the skin than the components of traditional inks which are dried by means of UV radiation. However, minor benzene emissions may occur.

Inks that dry by means of an electron beam do not contain solvents or photoinitiators, which makes them environmentally friendlier in comparison with traditional or UV-dried inks. They are especially suitable for food packaging. Binders used in such inks are most frequently resins with acrylic and metaacrylic groups on the polyester epoxide and urethane base. Acrylates may exert negative effects on the skin, so safety precautions are required. Since X-rays are produced during the process, the working parts of the machine must be covered with lead for workers' protection.

In the field of flexographic printing, Wetflex technology provides certain advantages in terms of both the environment and technology. By employing digital photopolymer printing plates, the use of solvents is avoided, energy consumption and the emission of greenhouse gases are reduced and waste disposal is eliminated. Another benefit is the reduction in the time needed for printing plate preparation as the wash and drying procedures are skipped. The Wetflex technology uses UniQure inks which do not contain VOC. However, the handling of these inks requires special safety precautions.

The cleaning of printing units requires large amounts of solvents and similar chemicals. Automatic cleaning increases machine utilization by approximately 25 %. Less harmful cleaning products are also available, containing either a smaller VOC content or no VOC at all, for instance lactate-based products which remove the ink very efficiently. Jet cleaning is a method free of harmful emissions, and it can utilize plastic grains, small particles of dry ice, etc.

In case of solvent-based cleaning, the machine should contain an integrated recycling unit. The ignition point of the solvent used in the procedure should be above 60°C. The solvent is only replaced in case of lack of efficiency. Recycling is carried out by means of distillation, which significantly reduces the amount of dangerous waste.

Automatic cleaning can reduce the amount of waste. Most systems include a prewash procedure, which utilizes used solvent/water. After each cleaning cycle the polluted solvent/water is diverted back to the tank and is re-used several times. Clean solvent/water is only used for the final wash procedure.

Water-based inks will begin to dry on certain parts of the machine shortly after the completion of the printing process, which requires more frequent cleaning. In case of irregular cleaning, highly volatile compounds, emitting VOC and HAP compounds will have to be used

Inks that dry by means of UV radiation are not drying until they are exposed to UV radiation, which reduces the need for cleaning. Cleaning agents are the exclusive cause of problems with compounds such as VOC and HAP. Due to their specific drying features, inks that dry by means of an electron beam also require less frequent cleaning.

The analysis of material consumption in the printing process showed that inks that are dried by means of UV radiation required the smallest amount of material, whereas printing with solvent-based inks increase material consumption four times.

The effect of energy consumption on the environment depends on the environmental acceptability of an energy-generating product, which means that even an efficient system in terms of energy consumption can be harmful to the environment.

Printing with solvent-based inks is much more energy-consuming in comparison to printing with water-based inks or inks that dry by means of UV radiation. This is due to additional energy required for air purification in this printing technique. In addition to energy consumption, the environmental impact of the source of energy is another important factor. Generation of energy in flexographic printing represents a significant source of air pollutants. This process also produces carbon dioxide, the most frequent greenhouse gas, which contributes to the greenhouse effect, and causes emissions of hydrocarbon, nitrogen and sulphur oxides as well as carbon monoxide. Nitrogen oxides are reactants in the production of smog, which causes numerous detrimental effects on human health, i.e. eye irritation, headache, respiratory problems, and heart and lung problems in chronic patients). It also exerts negative effects on the vegetation, materials (it destroys plastomers and elastomers), it damages buildings and diminishes visibility. The environmental impact of energy consumption will depend on the ecological acceptability of the energy source, so that even an effective system as far energy consumption is concerned can provide worse results from the point of view of the environment.

Printing processes employing inks that are dried by means of UV radiation consume much less energy in comparison with the conventional drying process required for solvent-based inks. Studies have demonstrated that the emission of greenhouse gases is about 80 % lower compared to water-based inks. Water-based ink drying systems consume significant amounts of energy. Water possesses considerably higher latent evaporation heat than the most common flexographic solvents, which means that it needs up to three times more energy to vaporise than ethanol. Printing with inks that are dried by means of an electronic beam is extremely efficient.

4.Conclusion

The development of flexographic printing has resulted in reduced environmental risks, such as emission of harmful chemicals, and improved energy and material consumption. However, achieving zero emission and developing clean techniques is still a great challenge for future research.

The development of guidelines for the selection and use of BAT as well as the implementation of requirements of the IPPC Directive need to be continued.

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