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Study of VOC emission in printing industries, impact, and its reduction by formulation of guidelines

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ABSTRACT
Printing industry is a revolutionary field and expanding industry. This research paper gives the description of various operations, performed in gravure, flexography printing industry. Solvent based inks used for these printing processes, and cleaning solvents contain high concentration of VOC. This research examines the effects of VOCs, inks and solvents used in the printing industry. Measures to reduce and manage these impacts are outlined and guidelines have been formulated.
Keywords— VOCs, Pre-Press, Press, Post-Press

1. Introduction

Pre-press, make-ready, press, and post-press are the four standard processes in the printing process. A pre-press operation involves converting artwork or designs (typically in the form of negative or positive films) into an image carrier, most frequently a plate but also sometimes a cylinder. This procedure includes such physical or chemical procedures as photoengraving, development, and additional processing, as well as exposure to ultraviolet (UV) radiation or laser. The press is set up during make-ready by assembling the plate on the machine and making necessary mechanical adjustments. The actual printing is known as press. Finally, post-press is the process of attaching printed materials to the finished printed product. Gravure printing, flexographic printing processes produce graphic images on substrate of plastics [1].

1.2 Flexographic printing

The image area is elevated in relation to the non-image area on the flexographic plate, which is constructed of rubber, plastic, or another flexible material.

Flexographic plates are produced using light-sensitive photopolymers, much like lithographic plates. A negative of the picture is placed on the plate material and exposed to UV light to harden the image portions on the plate in order to create the printing plate. After exposure, the plate's non-image portions (unexposed coating material) are typically cleaned out with water. After allowing the plate to fully dry, the curing procedure is finished by exposing it to UV radiation. Low-viscosity, quickly drying inks based on alcohols, water, and hydrocarbon solvents, or UV monomers are used in flexographic printing. The anilox roller is first covered with ink. Before transferring the ink to the image area of the plate cylinder to print onto the surface of the substrate, the cells are then filled and treated shown in figure1.

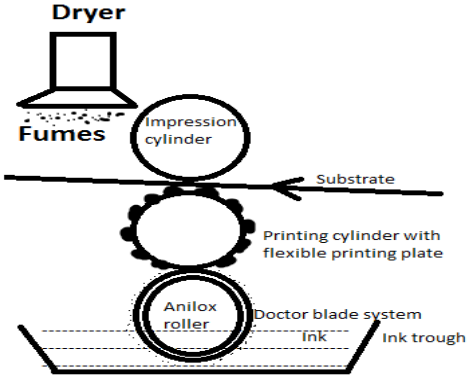

Fig 1. Principle of Gravure printing process

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1.3 Gravure printing

In contrast to flexography, the image in gravure printing is created on the plate cylinder. The recessed picture cells that are positioned on the cylinder in a regular grid contain the ink during printing. The cylinder rotates through a trough of ink, and is scraped by a metal doctor blade to remove excess ink from the cylinder's non-image surface while the cup-like form of each cell holds the ink in place. The dimensions and depth of these cells, which in turn regulate the amount of ink released, determine the various hues of tonal gradations shown in figure 2.

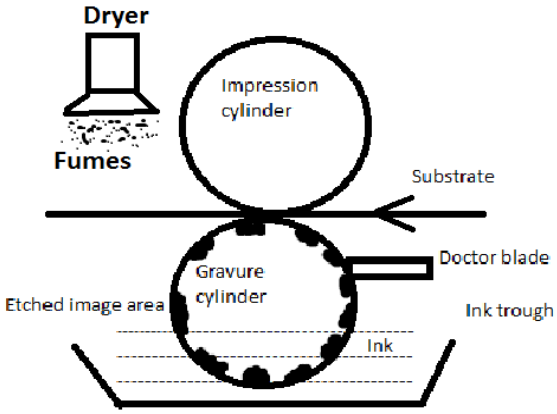

Fig 2. Principle of Gravure printing process

1.4 VOCs emission

Despite the fact that, VOCs are necessary and required as component of inks, cleansers, solvents, emulsions, thinners. VOC emissions and their influence on air quality are now considered a serious environmental problem. Volatile organic chemicals have a high vapor pressure, are highly flammable, and have low water solubility. VOCs are extremely difficult to manage since they are chemical species with varied chemical reactivity.

The most important Sources of VOCs associated with the printing industry come from Pre-press chemicals, Printing inks, Solvent, and Cleansing solvents.

Various pre-press chemicals are employed during the pre-press stage, particularly during the preparation of the image carrier, as was discussed in the section on printing processes. These chemicals are used for photographic reproduction, photoengraving, etching, fixing, developing, etc. Numerous of these compounds are carefully made blends that have already been combined in the appropriate ratios and don't need any more processing [2]. The chemical components that make up printing inks are complex mixes with a variety of solvent bases, drying processes (such as oxidative polymerization, absorption, and evaporation).

Most cleaning solvents emit volatile organic compounds (VOCs), which pose a serious threat to both the environment and occupational health and safety. Principal printing press exhausts and the vaporization of cleaning chemicals during cleanup are significant sources of VOC emissions.

It is necessary to regularly clean the printing components to avoid the buildup of dried ink and paper dust. Kerosene, glycol ether, alcohols, toluene, hexane, and specifically developed proprietary solvent blends are among the often used cleaning solvents. If safety precautions are not sufficient, these solvents might pose threats to both your health and your home.

After a run or after a color change, the rollers are cleaned. Workers often perform this manually while using rags that have been moistened with solvent [3].

1.5 Impact of VOCs used in printing

Dermatitis, irritation or sensitization of the skin and respiratory tract are some of the negative health consequences associated with exposure to organic solvents through inhalation and skin contact at work. After absorption into the body, internal organs including the liver, kidneys, and lungs, among others, may suffer long-term health effects. Organic solvents may also depress the central nervous system, which can lead to symptoms including tiredness, poor coordination, inattentiveness, and balance problems [4].

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2. Experimental Methods or Methodology

This article addresses the VOCs and its impacts in printing activities on environmental components are quantified within the impact zone. This study emphasizes on VOC and socio-economic components and other parameters of interest. This research study involved a printing industry in India with record of VOCs exposures. To collect data, a VOC meter is used. The areas for monitoring VOCs are prepress, press, post press.

2.1 VOCs Sampling

VOC meter (ISC-14042WM-001) is used for estimation and quantification of volatile organic compound (VOC) generated, during various operations (Pre-press, Press, Post-Press) of pre-identified printing industry in India. The name of printing workers and selected printing industries are kept confidential. The collected data is be analyzed to obtain the required result. The results obtained from observations will help in formulating guidelines to reduce the VOCs and its impact generated from printing organizations to their workers health.

3. Results and Discussion

3.1 VOCs emission

In pre-press operation, the raw materials (ink, solvent, and substrate) are stored and image carriers are prepared by the chemical etching/laser engraving method for flexography and gravure printing. VOCs emission concentrations were found within the permissible limits in the pre-press operation. But, in press operation, ink and solvents are used for print production and cleaning of machines, which release VOCs in large concentrations as compare to others, operations of printing process shown in table 1, it also has toxic effects on the health of workers.

In post-press operations, a nominal amount of VOCs concentration is evaporated from the printed substrates as shown in table 1. The details of the VOCs concentrations in various work areas at pre-identified printing industry are shown in Table 1. The descriptive and analytical results out in research from randomly selected areas of printing industry are presented in table below.

Table 1: VOCs concentrations at work areas of pre-identified printing industry, (n=06)

Industry work Areas	VOCs concentrations (mg/l)
Pre-Press	55.4-71.5 64.7±5.6
Press	88.3-98.9 93.7±3.49
Post-Press	0.10-0.40 0.32±0.11

Where n is the number of observations

VOCs concentration at pre-press, press, and post press areas of pre identified printing industry were in between range of (64.7±5.6), (93.7±3.49), and, (0.32±0.11) respectively.

3.2 Safety Measures

Adopting the proper preventive measures is the main thing to think about in order to eliminate or substitute the hazards at their source. If such measures are not feasible, other control measures such as chemical or process separation should be implemented. To reduce employees' exposure to risks, personal protection equipment should only be used as a last option or as an additional measure. Many times, a safer alternative that eliminates or reduces the hazards to a manageable level can be used in place of the hazardous product, piece of equipment, or procedure [5].

The following should be included in standard safe work practices to lessen the worker's exposure to VOC emissions:

(a) Restricting the time spent of workers to the danger

(b) Storing printing inks and solvents in closed containers or bottles when not in use

(c) Avoiding skin contact with solvents and printing inks

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Printing inks of solvent based can be replaced by vegetable-based inks (including soy oil-based inks) or aqueous-based inks, due to health and safety concerns, as well as environmental consideration. Printing techniques and tools can be changed to reduce VOC emissions and the dangers associated with hazardous materials. Equipment, material application techniques, and process systems can all be altered or changed.

To eliminate the need for manual cleaning and reduce worker exposure to organic solvents, automated blanket washers are installed in some printing machines. In order to clean rollers, employees often dip a sponge or cleaning cloth into a cleaning solution container that is always left open. In reality, similar task can be facilitated without the negative effects of solvent vapor by using a spring-loaded plunger [6].

The main goal of employing protective equipment is to shield the skin or clothes from contact with dangerous substances and stop contamination from spreading. Employees should always wear appropriate protective clothes while working with printing inks or solvents, including dispensing, storing, and performing maintenance. Additionally, employers must to supply emergency apparel to their staff. Gowns, overalls, aprons, and gloves are examples of protective wear. It's crucial to pick protective clothing made of materials that can withstand chemical abrasion or damage. Chemical-resistant gloves must be worn because printing employees frequently handle a variety of dangerous chemicals by hand [7].

Emergency situations in the printing sector are often brought on by chemical spills, however fire and explosion may occasionally occur. Every piece of emergency gear should be kept up to date and subjected to frequent performance checks. Replace any items that have expired. All employees should be informed of where the emergency supplies are located in the workplace.

Employers should ensure that their workers fully understand the hazards at work and that the work practices may help them execute their duties safely after analyzing the dangers in the workplace and implementing suitable preventative measures. Employees should get the necessary safety knowledge, training, and guidance to accomplish this [8].

Conclusion

As per research and findings, this study will help the industry and society by aware them about VOCs and its impact generated from printing industry on the health of workers and the environment. The causes of VOCs exposure are due to inadvertent handling of solvents without sufficient safety precautions. VOCs emission could be reduced by improving the ventilation system of working spaces and teaching workers about bio-safety.

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