Reducing Volatile Organic Compounds to Zero to Meet Future Industrial Environmental Standards

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Abstract

The human population is increasing exponentially and it is having a direct effect on the environment. Global warming is no longer a theory, but a fact of reality. It is not near in the future that industrial business will face harsher environmental emission standards due to this fact. It is likely that Gravure printing plants will have to find ways to reduce there volatile organic compound emissions to zero with in the next twenty years. These businesses must anticipate these environmental standards to ensure success in the future. Currently, the best method to capture volatile organic compound emissions is with solvent vapor capturing systems. These systems can capture up to 97 percent of volatile organic compound emissions when capturing both dryer exhausts and fugitive vapors with 100 percent efficiency. However, the remaining 3 percent is retained in the printed product and released after press production. Therefore, if standards call for zero volatile organic compound emissions, solvent vapor capturing systems will not be a solution. The only technology that could develop into a solution is water based inks. Note, this technology must be combined with solvent free cleaning agents to be effective. By using this method, solvent is removed from the gravure printing process, thus removing all volatile organic compound emissions. Unfortunately, current water based gravure ink technology can only print at a maximum speed of 1000 feet per minute. Until these inks can print at speed of 3000 feet per minute or more, it will not be cost effective for business to switch.

Introduction

It is apparent that the environment is becoming increasingly important to legislatures and that volatile organic compound emission standards are becoming more stringent. Gravure plants are going to face multiple environmental laws that will limit the amount of volatile organic compounds emissions. It is quite possible that zero emissions will be allowed in the future. Therefore, the gravure industry must take action to reduce their emissions to stay ahead of industry standards. Being strategically prepared for the future is necessary for a successful business. If gravure plants are unable to find cost effective ways to reduce their emissions today, their existence is questionable in the future. The question at hand is how to reduce volatile organic compound emissions to zero in a cost effective manner to prepare for future environmental standards. This paper will only address this question with the use of solvent vapor capturing systems or with the use of water-based inks.

Methodology

To understand solutions to the question at hand, we must first discuss what volatile organic compounds are, where and how they occur in the gravure printing process, and current or possible future legislation regarding these emissions. Secondary research was used in preparation of this research paper with the Internet being the sole tool used in finding sources regarding this topic. Solvent vapor capturing systems and water-based inks will be researched as ways to reduce emissions.

The US Environmental Protection Agency defines volatile organic compounds as any compound of carbon, excluding carbon monoxide, carbon dioxide, carbonic acid, metallic carbides or carbonates, and ammonium carbonate, which participates in atmospheric photochemical reactions(U.S. EPA). All references to volatile organic compounds will be noted as VOC's from this point on. The main source of VOC emissions in the rotogravure print process is ink, which is pigment and solvent based. For the ink to dry on paper, the solvent must be evaporated with the use of dryers after every print unit. There are many health effects related the intake of VOC's including eye, nose, and throat irritation. Headaches, loss of coordination, nausea, damage to liver, kidney, and the central nervous system are all symptoms as well ("Organic Gases"). Some VOC's have been known to cause cancer in animals and are suspect to causing cancer in humans. The signs and symptoms related to the exposure of VOC's are conjunctival irritation, nose and throat discomfort, headache, allergic skin reaction, dyspnea, declines in serum cholinesterase levels, nausea, emesis, epistaxis, fatigue, and dizziness ("Organic Gases").

VOC's are the only significant air pollutant from gravure printing which are a result of the raw inks, coatings used at the printing presses, and solvent used for dilution and press cleaning (Publication Gravure Printing). Gravure ink is low viscosity ink with the nonvolatile components being pigments, binders, and varnishes. Solvent must be added to raw ink to achieve the low viscosity required for printing. The main two solvents used in industry today are toluene and touene-xylene-naphtha. Raw ink includes 40-60 percents solvent at purchase and when prepared, consists of 75-80 percent solvent. Only 3-4 percent of the solvent is retained by the paper, which will evaporate after leaving the press. This leaves up to 75% of the ink to be evaporated as VOCs during production. "There are numerous points around the printing press from which fugitive emissions occur. Most of the fugitive vapors result from solvent evaporation in the ink fountain, exposed parts

of the gravure cylinder, the paper path at the dryer inlet, and from the paper web after exiting the dryers between printing units" (Publication Gravure Printing) The majority (over 75%) of solvent vapors occur at the dryer exhausts. See figure A in the appendix for an illustration of the gravure printing process.

To avoid heavy government fines, gravure plants must meet government regulations on VOC emissions. While the standards allow some VOC emissions, it is clear standards are becoming strict and will eventfully call for zero VOC emissions. States such as California have all ready enacted the California Global Warming Solutions Act of 2006, which calls for a cost-effective reduction of greenhouse gases. By January 1, 2008 the Air Quality Board must establish a cap for 2020 which will begin the start of an environmentally aware industrial age (AB 32 Fact Sheet). While other states are behind California's progress, it is only a matter of time till they catch up.

Santa Barbara's current standards for VOC emissions are as follows: "No person shall use any inks, coatings, or adhesives unless the VOC content, as applied, is less than 300 Grams per Liter (g/l) (2.5 pounds per gallon), less water and less exempt organic compounds. (Air Pollution Control District)". Secondly "no person shall use a solvent as an ink additive or to perform cleaning operations unless the solvent has a VOC composite partial vapor pressure of 33 mm Hg or less at 20°C (68°F) and the solvent VOC content is less than the following limits (Air Pollution Control District)." These are just examples of how complicated environmental standards are today. They will inevitably become much more stringent in the future.

The fundamental idea behind a solvent vapor capturing system is to capture the VOC emissions from the gravure printing process and then destroy it or recycle it by condensing it back into liquid form. There are two parts to this system: the solvent vapor capture system and the

emission control device (Publication Gravure Printing). The solvent vapor capture system recovers the VOC emissions with the use of fans to direct air flow into air ducts strategically placed around the press. The emission control device condenses the VOC's back into re-usable solvent or destroys it.

Where the air vents are placed around the press impacts the efficiency of these systems greatly. Once air vent is placed above each dryer, it is capable of capturing 85 to 89 percent of all VOC emissions. An older system will only capture 84 percent. These air vents all connect to a large header above the press that directs the solvent laden air to the control device. To increase VOC recovery, fugitive vapors need to be recovered as well, which could allow for the system to capture 93 to 97 percent of all emissions. Because these fugitive vapors come from various parts of the process, recovery has to involve all the air around the press. This can be done by placing one large air duct above the press, partial enclosure around the press, by a system of multiple spot pickup vents, multiple floor sweep vents, or by total pressroom ventilation capture. Combinations of all these methods are common in industry as well (Publication Gravure Printing). Figure B in the Appendix illustrates the amount of VOC emissions from dryer exhaust, fugitive vapors, and printed product. A 75 percent control system is compared to an 85 percent control system. Notice that 3 percent of VOC emissions are from printed product and not recovered in either. This could be eliminated with the use of water-based inks, which will be discussed later.

Once the solvent laden air reaches the control device it is either recovered or destroyed. Solvent recovery is a complicated process that separates the air from the solvent for direct reuse on the press. "Fixed-bed carbon adsorption by multiple vessels operating in parallel configuration, regenerated by steaming, represents the most used control device (Publication Gravure Printing)." There are three types of solvent destruction devices: thermal oxidation, catalytic oxidation, and

regenerative thermal combustion. The end result of all this methods is the complete destruction of the solvent laden air.

The EPA control techniques guideline recommendation for State regulations on existing presses is an 85 percent control level, which requires a 95 percent efficient control device capturing 90 percent of total VOC emissions. (Publication Gravure Printing) To reach these current standards, vapor-capturing systems must capture both dryer exhausts and fugitive vapors.

It is apparent that capture and destruction or recyclization on VOC emissions for rotogravure printing is a complicated process that doesn't contain 100 percent of emissions. One way to eliminate VOC emissions from the process is to use water-based inks instead of solvent based inks combined with the use of solvent free cleaning agents. This completely eliminates solvent from the process thus eliminating all VOC emissions. However, United States Patent 5972088 describes single fluid water based gravure ink, which provides direct proof of the existence of such inks. Unfortunately, the printing industry is "set in its way" as Kevin Cooper states. Thus until industry finds it cost effective to switch to water based inks or forced to by environmental standards it is unlikely they will be widely utilized in gravure plants.

The main reason that water based inks are not used in industry is because it takes higher temperatures and longer exposure time to drive off water than solvent(PNEAC.org). Publication Gravure is currently running at speeds of 2,000 to 3,000 feet per minute and water based inks are currently only capable of running at 1,000 feet per minute(PNEAC.org). These plants would need to slow down their presses by up to 2000 feet per minute that would result in lost profits. However, water-based inks are being used in packaging gravure for low quality projects such as paperboard

packaging, plastics, aluminum, and laminates. Note, these products are only capable of printing at 1000 feet per minute.

Results

Current solvent vapor capturing systems are unable to reduce VOC emissions to zero. The best systems will only be able to capture 97 percent of VOC's. These systems would have to utilize air vents above each drier with a 100 percent capture of fugitive solvent vapors. 3 percent of VOC's will forever be retained in the printed product and released after the press production, which is why these systems will never capture 100 percent of VOC's. If environmental laws call for zero VOC emissions in the future, solvent vapor capturing systems will not be a solution.

If water based inks and cleaning agents are utilized in the gravure printing process, VOC emissions could be reduced to 0. However, water based ink technology unable to reach gravure industry printing speed standards of 2000 to 3000 feet per second (PNEAC.org). Secondly, is highly likely that gravure technology will allow for speeds faster than this in the future. It isn't unlikely that waterbased inks will have to be capable of printing at speeds above 3000 feet per minute for the gravure industry to switch. Therefore, water based ink will have to find ways to dry at lower temperatures, shorten exposure time, or develop new drier technology. Furthermore it must become a cost effective method for reducing VOC emissions to zero.

Conclusion Remarks

There are currently no solutions for reducing VOC emissions to zero in the gravure printing process. Water based inks used with solvent free cleaning agents are the only technology that currently exist that lends its self to possibly creating a VOC free process. Even if the technology

were developed, it would have to become cost effective to be embraced by the gravure industry. This means that companies such as Quad graphics, a leader in gravure printing for the United States, will have to drive this change for the technology to come to maturity. Currently, solvent vapor capturing systems are the best way to reduce VOC emissions. However, these systems must utilize fugitive vapor capture techniques and be 100 percent efficient to reduce VOC emissions to 97 percent. This result will be acceptable for many years to come, but further research and development in the area of water-based inks should be a top priority for the gravure industry.

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Appendix

Figure A: Diagram of Rotogravure printing process(Publication Gravure Printing).

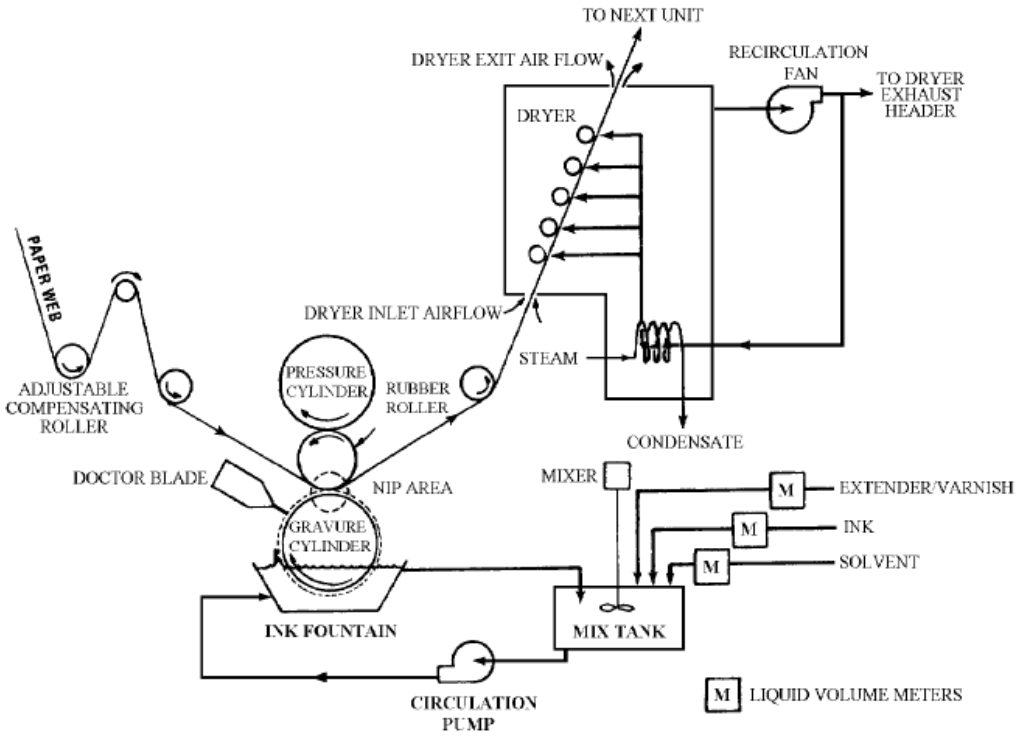

Figure B: Emission Factors for Publication Rotogravure Printing Presses(Publication Gravure Printing).
Emission Factor Rating: C.

Emission Points	VOC Emissions[a]								
	Uncontrolled			75% Control			85% Control		
	Total Solvent	Raw Ink		Total Solvent	Raw Ink		Total Solvent	Raw Ink	
	kg/kg (lb/lb)	kg/L	lb/gal	kg/kg (lb/lb)	kg/L	lb/gal	kg/kg (lb/lb)	kg/L	lb/gal
Dryer exhausts[b]	0.84	1.24	10.42	—	—	—	—	—	—
Fugitives[c]	0.13	0.19	1.61	0.13	0.19	1.61	0.07	0.10	0.87
Printed product[d]	0.03	0.05	0.37	0.03	0.05	0.37	0.03	0.05	0.37
Control device[e]	—	—	—	0.09	0.13	1.12	0.05	0.07	0.62
Total emissions[f]	1.0	1.48	12.40	0.25	0.37	3.10	0.15	0.22	1.86

Revised Outline

I Introduction

a. Environmental Standards

b. VOC emissions reduced to zero

c. Must find cost effective methods to reduce VOC emissions for industry to adopt

II. Methodology

a. What VOC's are

1. The US Environmental Protection Agency defines volatile organic compounds as any compound of carbon, excluding carbon monoxide, carbon dioxide, carbonic acid, metallic carbides or carbonates, and ammonium carbonate, which participates in atmospheric photochemical reactions (U.S. EPA).

b. Where VOC's occur in the gravure printing process

1. Dryer exhaust
2. Fugitive Vapors

c. Current and Future legislation effecting VOC emission levels

d. Solvent Vapor Capturing Systems

1. How they work
2. Fugitive vapor control

e. Water Based gravure ink technology

1. Does it exist?
2. What it's not being used in industry
3. Has potential to eliminate solvent from the gravure printing process

III. Results

a. Solvent Vapor capturing systems can capture up to 97 percent of VOC emissions when 100% efficient
b. 3 percent of solvent will be retained in printing product and released after press production
c. Water based ink technology is not yet cost effective

IV. Conclusion Remarks

a. There are no current solutions for reducing VOC emissions to zero
b. Water base ink technology is the only solution that lends it's self to reducing VOC emissions to zero
c. It must be cost effective for the industry to adopt water based inks
d. Solvent vapor capturing systems are currently the best way to capture VOC's.