Recycling of hydrocarbon from textile printing

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In India and in many developing countries hydrocarbons are still being used for pigment printing. In India, over 136 million litres of kerosene/mineral turpentine or solvent naphtha are used in pigment printing and also in reactive colour printing. After printing, the hydrocarbons vapours from the fabric is evaporated to the atmosphere during drying and curing. Due to inherent risk of explosion at the printing machine dryer, more air is pumped into the printing machine dryer to maintain the hydrocarbon vapour level below 0.5%. Thus the conventional vapour recovery systems are not suited for the recovery of this thin vapour. After several years of R&D activities for the first time in India, a hydrocarbon vapour recovery plant for textile printing has been developed. Subsequently, the plant has been setup and is been in continuous operation in a printing unit near Mumbai. The recovery efficiency is above 70%. This results in minimising air pollution and to save hydrocarbon which otherwise would have gone to the atmosphere. The recovered hydrocarbon is reused for printing.

Saving the environment will be a challenge before the new millennium. Major air pollution problems in textile wet processing originate in finishing and printing of textiles. The textile industry in India consumes about 136 million litres of hydrocarbon per annum in the process of fabric printing. Due to constraints of the technology employed, the entire quantity is lost at various stages of printing and fabric drying processes. The largest portion of about 78% is, however, lost through evaporation during machine drying of the printed fabrics. In the absence of an effective and economical vapour recovery system, enormous amount of hydrocarbon vapours so generated are released into the atmosphere, resulting in colossal wastage of hydrocarbon, apart from the health hazards to workers due to high levels of environmental pollution around the printing units. Although, various technologies such as chilling, packed column recovery system, membrane technology, etc., were examined to harness the hydrocarbon vapours but, exorbitant costs of these technologies made their adoption unaffordable for the Indian industry. Against the above backdrops, a project for the recovery and recycling of hydrocarbon vapours from textile printing units was conceptualized by the author.

Role of Hydrocarbon in Textile Printing

Hydrocarbon constitutes 60-80% of the print paste or emulsion thickener used in pigment printing of textiles, other constituents are binder, water, urea, DAP, gum, emulsifiers and fixing agents. In this process, the use of hydrocarbon ensures sharpness of prints, consistency of colourant shade and quick drying of the printed fabric. Therefore, among the various methods of textile printing in vogue in the country, pigment printing accounts for the largest share of 46% making the role of hydrocarbon in the process extremely important.

Hydrocarbon forms the main body 70% of the print paste used in pigment printing and acts as the medium through which the desired colour pigments and patterns are transferred to the cloth. While 22% of hydrocarbon is lost at various points during this process; the remaining 78% is left on the printed cloth alongwith colour print paste. Finally when the printed cloth is dried on the printing machine dryer at a temperatures at 120°-145°C, the hydrocarbon vapours evaporates into the environment resulting in pollution and health hazard to people working in and around the printing unit.

Scope for Hydrocarbon Vapour Recovery

The studies have shown that the loss of hydrocarbon takes place at various stages ranging from as little as 0.5% to as high as 78%. Subsequently, 5% of the hydrocarbon is lost before the printed fabric enters the float drying chamber; 11% in the process of washing of the screen, blanket, residual paste, drainage, etc., and another 5.5% is lost.

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during curing. However, a whopping 78% of hydrocarbon is lost through evaporation during fabric drying. In India, the hydrocarbon emission levels from fabric printing is very high, since these vapours are not treated. WTO is sensitive to environment which aims that trade and environment policies should complement each other.

In this regard, the permissible limit of hydrocarbon effluent standards for developed countries reported are as follows:

- US: 10 mg/L of liquid transferred
- European Union: 35 mg of vapour/cubic metre of vapour exhausted
- German: 10 mg of vapour/cubic metre of vapour exhausted

### Design and Development of Hydrocarbon Vapour Recovery Plant

Many attempts were made in the past to develop a hydrocarbon vapour recovery system for the textile printing industry but these were hampered by technical snags. Since hydrocarbon vapours at concentrations above 0.7% are highly explosive, the level of hydrocarbon vapours expelled through the printing machine dryer exhaust needs to be maintained at 0.5% to ensure operational safety. As the exhaust also contains 99.5% hot air, these vapours get diluted making their recovery difficult.

Before initiating the work, various studies were carried out at Bombay Textile Research Association laboratory and shop-floor levels to design and develop a viable vapour recovery system. These studies showed that techniques such as adsorption, compression and chilling, mechanical refrigeration, cooling and condensing by physical means are either not feasible or are too expensive. Persistent efforts, however, bore fruit with the successful design and development of a thin hydrocarbon vapour recovery system, which is efficient, simple and rugged. It is based on the principle that hydrocarbon is liquid at room temperature and immiscible in water and therefore, hydrocarbon vapours when cooled by direct contact with water below 40°C, condenses into two separate layers of hydrocarbon and water. The recovered hydrocarbon (kerosene) obtained from the plant is found to be superior in quality and the comparative details are as given in Table I. It may be noted that the quality of recovered hydrocarbon is improved, since it has undergone further distillation. The flash point goes up from 41 to 57°C and the sulphur content is also reduced considerably. On checking the structural units prediction of fresh hydrocarbon, indicated the presence of aliphatic and aromatic hydrocarbon. Whereas in the recovered hydrocarbon, aromatic fractions are missing and only methyl substituted alkyl groups are indicated.

### Commissioning of Thin Hydrocarbon Vapour Recovery Plant and its Working

Based on the above concept, a full scale thin hydrocarbon vapour recovery plant was designed and commissioned at the premises of M/s. Dhanalaxmi Fabrics Ltd., Dombivli (East), in Thane District of Maharashtra. The plant employs a combination of vapour control and cooling through intimate contact with water. It incorporates an electronically operated vapour delivery system. The hydrocarbon vapour - air mixture above 120°C are transferred from the fabric printing machine dryer to the main header through exhaust fans operating under precisely controlled electronic signals. The mixture is led to a recovery column where it is partially cooled by water spray and then passed through a specially designed baffle plates, which scrub it by intimate contact with circulating water. In this process, nearly 70% of the hydrocarbon vapours are condensed and collected in the settling tank forming two separate layers i.e. water at the bottom and hydrocarbon on top. The top layer consisting of condensed hydrocarbon drains into the hydrocarbon tank automatically. A level controller monitors water level at the bottom of the recovery column and replenishes it with fresh water through a solenoid valve. The BTRA schematic process of kerosene (hydrocarbon) vapour recovery is given in Fig. 1.

The water used for cooling of hot vapour is again cooled and recirculated into the system. This plant is simple and rugged in construction and requires little
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Fig. 1 - Schematic process of kerosene vapour recovery

Fig. 2 - The cycle of hydrocarbon in textile printing

maintenance. It has no moving parts and is easy to operate as no heating or stripping is involved. The cycle of hydrocarbon in textile printing is given in Fig. 2. This newly developed plant meets the International hydrocarbon emission standards and is suitable for treating other volatile organic compounds.

Cost Economics and Benefits
Cost economics and benefits are:
- Eliminates explosive hazards associated with hydrocarbon fumes.
- The installation of this unique hydrocarbon vapour recovery plant by the individual textile printing units yields substantial cost benefits as it recovers 70% of the hydrocarbon presently being lost through evaporation on a recurring basis. The capital investment of Rs. 16 lakhs required to
install a new plant gets recovered within three years of commissioning. Operating and maintenance cost are also negligible.

- Recovery of large volumes of hydrocarbon vapours emitted by the printing units eliminates environmental pollution within and around the units.
- This further facilitates compliance with the stringent environmental norms being enforced in the country and saves workers from the health hazards arising from continuous exposure to hydrocarbon vapours.
- The recovered hydrocarbon obtained from the plant is found to be superior in quality for printing as the lower fractions are lost during drying of fabric.
- Petroleum is a non-renewable and scarce resource. Conservation of petroleum products is a responsibility to be shared by all concerned in the interest of the country and humanity as a whole.

Conclusions
This new development is extremely useful in reutilization of hydrocarbon and cleaner production through prevention of air pollution and saving of fuel. Recycling is clearly the best option for Eco-balance.

Increasingly, the focus worldwide has converged on matters such as cleaner processing, more efficient and cost-effective effluent abatement methods. The quantity of hydrocarbon saved, will minimise air pollution and reduce printing cost. The emission level of hydrocarbon vapour per cubic metre have been brought near to the European Union Standard. This type of hydrocarbon vapour recovery plant being the first of its kind in the world. This plant can be used for the treatment of volatile organic pollutants or other condensable emissions. This plant is free from pollution and will not produce any secondary effluents.

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