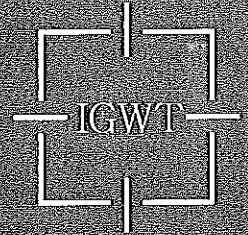


The 16th Symposium of IGWT



Achieving Commodity & Service Excellence in the Age of Digital Convergence

Proceedings Volume II

August 18 - 22, 2008, Suwon, Korea

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USING OF LIQUID CARBON DIOXIDE IN DRY-CLEANING

Liberatore L., DASTA, Taddeo R., DASTA
Università degli Studi di Chieti-Pescara "G. d'Annunzio",
V.le Pindaro 42, 65100 Pescara
l.liberatore@unich.it, raffaellataddeo@yahoo.it

Murmura F., ISA
Università degli Studi di Urbino "Carlo Bo", Via Saffi 42, 61029 Urbino murmfede@virgilio.it

In the past dry-cleaning technology has privileged the use of chlorinated and fluorinated solvents. Today they have recognized like highly harmful for the atmosphere and the users. In fact Montreal Protocol of 1987 has classified like toxics, cancerogenic and destroyer of ozone, many compounds such as Perchloroethylene (PERC). Now there are new substances, like liquid dioxide carbon (LCO_2), that will be able to replace chlorinated solvents: it isn't toxic, inflammable and polluting for subterranean waters. Through improvements of washing technologies and washing machines, the new solvent will be able to become competitive from environmental and economic point of view.

Keyword: Dry Cleaning, Perchloroethylene, liquid dioxide carbon

Introduction

In Europe the dry cleaning of textiles is conducted in 60.000 dry cleaning shops, employing 180.000 workers; while in Italy there are over 25.000 companies with 60.000 workers.

The major solvent used is Perchloroethylene (nowadays it is used in 95% of dry-cleaning shops in Europe), a chlorinated organic compound that at ambient temperature is liquid, colourless, non flammable and volatile. Perc has been the predominant dry-cleaning solvent used since the 1960s when it replaced petroleum solvents; advantages of perc over petroleum solvents are its non-flammability and superior solvent properties [1].

Perchloroethylene is a very dangerous solvent for men and harmful for environment. Exposure to perchloroethylene is the primary health hazard for workers in dry cleaning industry [2]. Signs and symptoms of workers exposure to perc include depression of central nervous system, dizziness, headache and irritation of the mucous membranes. Perchloroethylene is a known animal carcinogen and has been associated with an elevated risk of cancer of urinary tract, esophagus and pancreas [3]. In particular, perc can enter in the body when breathed in with contaminated air or when consumed with contaminated food or water [4]. Once in the body, perc can remain stored in fat tissue. Moreover, perc has risks to reproduction and may also be teratogenic for pregnant women. So this volatile compound is regulated as hazardous air pollutant due to its toxicity [2].

It's important to remark that in Europe dry cleaning operations release more than 70.000 tonnes of perc for year and the technology has always caused a wide groundwater and soil contamination at most dry cleaners. Moreover perc has been attributed to the phase out of ozone depleting substances for which it is an intermediate feedstock [1].

So to limit the emissions of volatile organic compounds due to the use of organic solvents has been introduced the Directive 1999/13/EC - Volatile Organic Compounds (VOCs) resulting from certain industrial activities; it imposes a major restrict on the use of chlorinated hydrocarbons.

As a result of normative dispositions, the attention has been turned to new watering and oil base solvents. Really in both cases there are various disadvantages concerning to costs, performance and environmental impact. The costs of purchase of new solvents are in some cases more of 400% than traditional ones. Moreover for the use of hydrocarbons, main problems have been in storage operation, product management and complexity of the system due to the feature of flammability of the compound. Watery base solvent used in the washing system involves, instead, high energy consumptions, high water consumptions and onerous costs for waste water [5].

A good alternative, instead, is the use of liquid carbon dioxide that is not toxic for men and environment, beyond that effective in the washing clothes.

Main Properties of Liquid Carbon Dioxide

Carbon dioxide is in gaseous shape, but it can be in solid or liquid shape depends from temperature or pressure value.

LCO₂ is non-toxic, non-flammable, produced as an off-gas in almost pure form in the oil refining and ammonia production, causes no groundwater contamination and it's very sustainable. LCO₂ is a renewable resource that is removed from combustion processes thereby reducing its release as a greenhouse gas. It replaces a non renewable resource such as perc and hydrocarbons, which are both made from mineral oils that are being depleted [6].

This substitution carries many environmental and human health benefits: thanks to its use it's possible to eliminate the pollutant emissions of perc in the atmosphere; it is able to improve the job conditions for workers and to prevent future perc groundwater contamination. Carbon dioxide is an extraordinary solvent and cleaning process is very simple.

Soiled items are placed in a sealed, closed washing chamber from which air is removed creating a vacuum. The gaseous CO₂ is then introduced under a pressure of 50 to 60 atmospheres. Recycled and cleaned CO₂ is added, partly filling the chamber. A small amount of our proprietary biodegradable washing agent is added and the washing process begins. A rotating drum sees to it that the fluid CO₂ penetrates the fibres thereby removing fat, oil and other dirt particles, which are gently extracted. The liquid CO₂ with impurities is drained into a separate distillation tank where impurities are separated from the CO₂ through a distillation process. The pure CO₂ is then transferred from liquid to gas and compressed back into the storage tank. Pressure in the cleaning chamber is lowered and the hatch can be opened. Only a small amount, approximately 2% of the CO₂ used, escapes into the air and 98% of the carbon dioxide can be re-used [5].

The cleaning performance of LCO₂ relative to perc was 60-100% depending on the nature of the stain [6]. Using of LCO₂ permits to operate at a low temperature, high pressure and in a nearly state and it's able to remove dirt and stains from cotton, synthetics, wool, leather, fur and suede. Moreover it doesn't produce harmful chemicals, hazardous by-products or smells like perc. The development and use of LCO₂ is still in an initial phase; it will necessary new and further improvements to allow this promising alternative dry cleaning solvent to impose itself and to replace perc definitively.

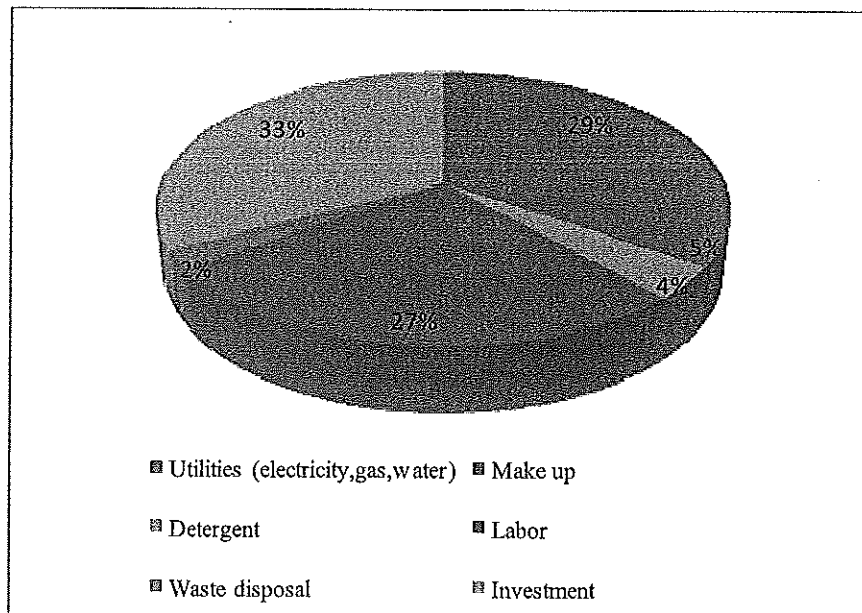


Figure 1. Cost of dry cleaning with PERC (%/year)

Environmental and Economic Analysis of Liquid Carbon Dioxide

Using of LCO₂ as new solvent in dry-cleaning plants is a good alternative respect to chlorurate compounds. In fact, it's a sustainable and important method and it is possible to demonstrate the effectiveness of washing of new detergent; recent studies [6] have proved that the performance of LCO₂ washing is into a range from 60% to 100% regards the results obtained with per, even if in many cases it depends from spot.

Cost analysis draws some important informations. Textile cleaning with LCO₂ results less expansive in

utility use; in fact electricity, gas and water costs are 10% of all costs, respect 29% obtained in textile cleaning with perc. Moreover we have a low production of disposal waste. Using of LCO₂ determines a high reduction in waste production, a lower environmental impact, more safety for workers and less costs of disposal waste. Investment costs are more important ones: perc plants are 33% of all ones, LCO₂ plants are 42% of all ones (Fig. 1-2). This is due to the higher annual capacity of the LCO₂ textile cleaning machine that makes 2 cycles per hour, compared to perc dry cleaning that makes 2 cycles in 1.5 hour [6].

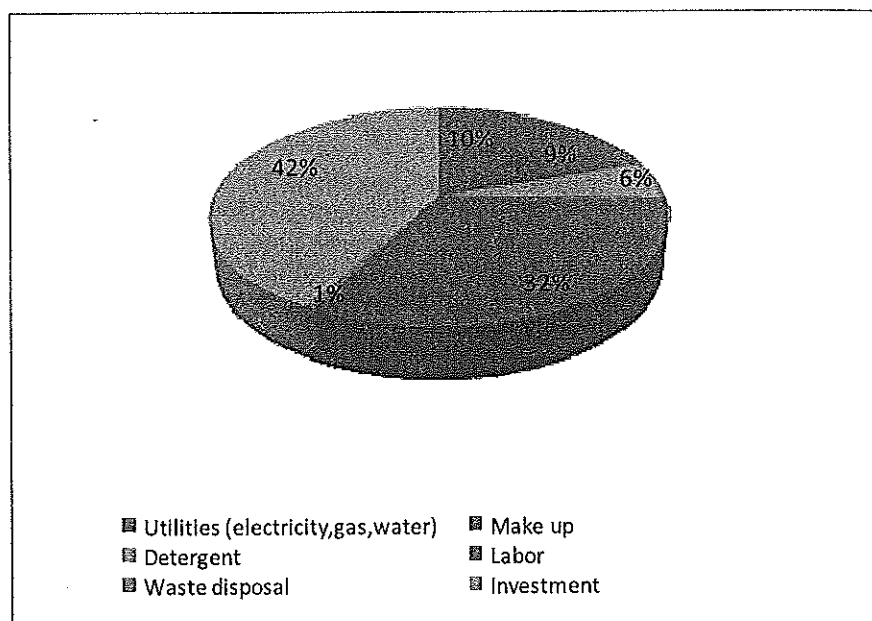


Figure 2. Cost of dry cleaning with LCO₂ (%/year)

Conclusion

Dry cleaning represents a mature industry with companies all over the world. In this process it is commonly used perchloroethylene, a chlorinated solvent, harmful for man and environment. Nowadays, there are various applications of new products and technologies that try to replace this compound, to improve the conditions of job for workers and to reduce the environmental impact. In particular, the attention is focused on liquid carbon dioxide, a sustainable and effective solvent. It is non-toxic, non-inflammable, non-carcinogen and also a renewable resource. It has a great performance of cleaning thanks to its properties, in fact it needs of a low temperature and high pressure to remove stains from garments.

The development of detergents for LCO₂ is still in its early market introduction stage; further improvements are expected to encourage its spread and the definitive replacement of perc.

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