

## **Protective clothing for process industries – A need based approach**

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### **ABSTRACT**

This paper attempts to give a general scenario of the need for Protective clothing(PC), its awareness among the safety professionals and workers, and the need for training these workers about the best way of usage and application of protective clothing. PC is a part of technical textiles that are defined as comprising all those textiles – based products, used principally for their performance or functional characteristics rather than their aesthetic characteristics. The purpose of PC is to shield or isolate individuals from chemical, physical and biological hazards that may be encountered during operations. In India there are about 70,000 small and large scale chemical manufacturing units (Department of chemicals and petrochemicals – Draft National Chemical Policy –December 2013). India manufacturing sector has the potential to touch US \$ one trillion by 2025 ([www.ibef.org](http://www.ibef.org)). These Process Industries have a huge number of manpower engaged. A little negligence may cause havoc. In most of the cases, injuries could have been preventable if the right type of workwear/PC is worn by the attendant. Keeping the safety of workers in mind, a detailed survey was conducted on 250 respondents in the Northern and Western regions of India with safety professionals in leading process industries dealing with toxic chemicals where use of PC is compulsory. However it was found through the survey that there exists a problem of noncompliance in the use of Personal Protective Equipments (PPEs) even when a maintenance job is carried out handling toxic chemicals. Many a times the personnel get away from the harm due to sheer luck. The workers reasoned that these PCs are very uncomfortable and boring. Hence these PPEs have to be improved by use of modern fabrics that are comfortable. As the primary application of PPEs is providing safety to people at work place. There is scope of growth of this sector in view of enhanced awareness and regulations.

**Key Words :** Safety professionals, Personal protective equipment (PPE), Protective clothing, Safety and comfort

### **INTRODUCTION**

In the light of extensive utilization of Protective clothing in the process based Industry

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this paper attempts to discuss Protective clothing – the need and its scope of versatility. Origin of clothing started with the need of protection and modesty. A need to have protection as the functionality-gave rise to protective clothing segment. Protective clothing (PC) is part of Personal Protective Equipment (PPE), which is designed with a sole intention of protecting the wearer from injury or infection. PC includes all clothing and equipment worn over or in place of normal work clothing for the purpose of protecting the workers from harmful chemicals, heat exposure, toxic gases etc. Protective clothing may not do much to reduce the harmful effect of chemicals but it creates a barrier against chemicals thus enhancing the safety of the people working under hazardous conditions. While selecting or designing protective clothing many factors have been found to influence its effectiveness. Each potential hazard has different problem areas and requires specific solutions in form of PC. This research paper concentrates on the PC segment for Process based industries specifically OEM's, Chemical and Petrochemical.

Process Industries are the industries with procedures involving chemical, physical, electrical or mechanical steps to aid in the manufacturing of an item or items, usually carried out on a very large scale. Petrochemical Industries are industries which derives chemicals from petroleum or natural gas. The chemical industry comprises the companies that produce industrial chemicals. Central to the modern world economy, it converts raw materials (oil, natural gas, air, water, metals, and minerals) into more than 70,000 different products ([https://en.wikipedia.org/wiki/Chemical\\_industry](https://en.wikipedia.org/wiki/Chemical_industry)).

In these industries individuals are required to use protective clothing to prevent adverse exposure to physical, chemical and environmental stress factors. During the last decade the interest in research on protective clothing and their effects has grown (Mani and Sivakkumar, 2011).

According to PR Newswire (New York) January, 2014 the Protective Clothing Market is expected to grow at a CAGR of 6.0% over the next five years to reach \$8 billion by 2018. During 2013 to 2018, the flourishing economy and expansions in industrial section of Asia pacific will experience the second highest growth in demand after North America. The major users of this clothing are by the consumers for personal use and industrial users in risky and hazardous working conditions (<http://www.researchandmarkets.com/research/protective>).

There is a distinct lack of safety culture in India, inspite of so many chemical Industries the concept of protective clothing is still at an infancy stage. The solution to this problem lies in educating the workers about safe handling of chemicals. In majority of the units/industries workers are wearing work clothes which hardly provides any protection against harmful chemicals or the Protective suit available is uncomfortable. Workers are provided with accessories like goggles, gum boots, masks helmets and gloves, which are hardly used because of discomfort in wearing them in hot and humid climate (Suri *et al.*, 2002).

The primary function of protective clothing is to act as a physical barrier between the skin and chemical. If garments are to serve as effective barriers against chemicals penetration, they should cover areas that are most exposed to chemicals and be made of fabric that can prevent the penetration. Various parameters of fabric contribute towards penetration performance. In industry cotton and polyester-cotton blends offer more protection though none of them provides complete protection. Spun bonded olefin fabrics (Tyvek®) and

Polytetrafluoroethylene laminates (Gortex®) have been specially made to provide dermal protection from harmful chemicals but their cost and availability are the limiting factors (Ranson and Sweeney, 1991).

Thus, the current status of PC shows clearly a need for developing PC that is functional and comfortable.

### **Objective of the study:**

– To identify the Process Industries in Petrochemical, Agrochemical, Fluorochemical and various other Industrial organic and inorganic chemicals industries; and to assess the clothing needs of the workers in these Industries

## **METHODOLOGY**

The present study has been undertaken to study and review the need of Protective clothing for work wear in process industries like petrochemical, agrochemical, Fluorochemicals, various OEM's etc and to create awareness about protective clothing.

A study was conducted in a phased manner.

### **Phase I :**

- Identifying 10 Process Industries through Convenient Sampling and Personal Contacts.
- Referring various libraries for collecting secondary data.

### **Phase II :**

– Sample selection: The total sample size comprised of 10 industries from the Northern and Western regions of India like Bhiwadi, Chittorgarh, Udaipur(Rajasthan), Gurgaon (Haryana), Dahej, Silvassa, Bhavnagar(Gujarat), Bhiwandi, Mumbai (Maharashtra)

- Assessment of clothing needs in process industries was undertaken with over 200 workers and 50 Industry Safety Professionals, their Supervisors and Engineers through convenient sampling technique

Tools and Techniques of data collection–Semi structured Interview Schedule was designed for all.

### **Written Ethics:**

Permissions and consents were taken from the industries to ensure no disturbance occurs while the research was ON. The respondents' confidentiality and anonymity was maintained throughout the study and thereafter respondents were given the assurance too.

This Interview schedule was conducted to understand how the workers actually do their job, how they use their personal protective equipment and how they can be exposed to multiple hazards in completing their everyday task. It was also studied whether the worker knew the correct way of wearing PC and the suitable use of PC for various hazards. It also helped to understand same parameters for supervisors with respect to selection of such PC.

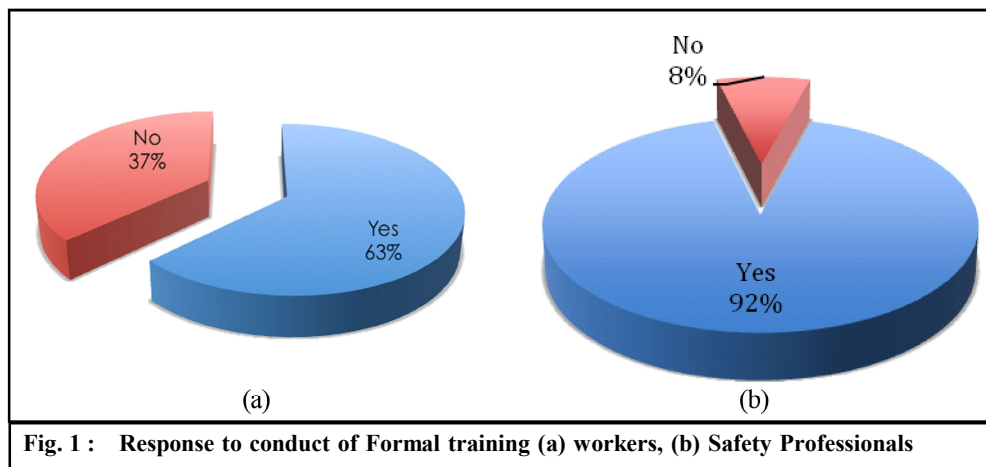
## **RESULTS AND DISCUSSION**

Designing for Protective Clothing for process Industry is a vast scope of work and a

complicated task that depends on a number of theories of heat losses, thermal insulation, chemical exposure, fabrication etc. The smart textiles and wearable PPE demands merging of methodologies across disparate disciplines to inform the application of wearable technologies in smart clothes that have the potential to enhance the quality of life of the target wearer.

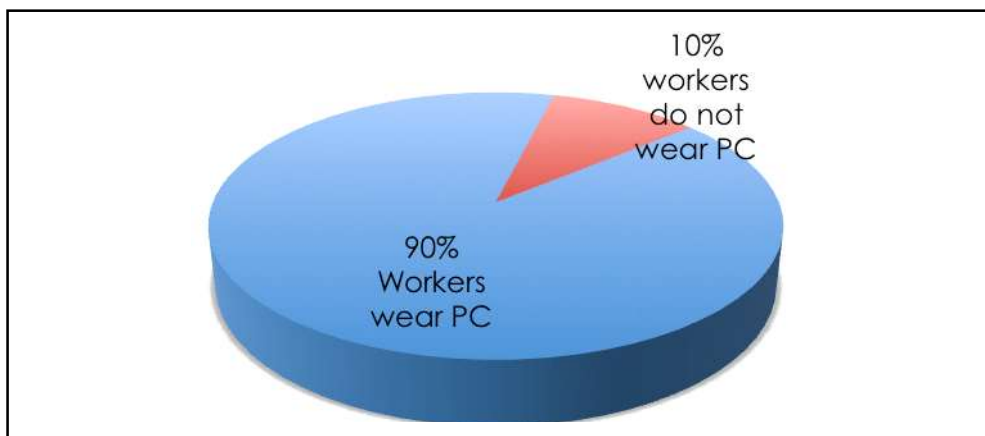
Survey was conducted in September 2016 –December 2016. The results from survey conducted with safety professionals and Engineers stated that 80 per cent of the workers employed with Industries comprised of more than 600 employees and the remainder 20 per cent worked for companies with 200 employees or less. The respondents occupational roles included 40 per cent of Safety Directors, 08 per cent of Purchasing Team, 12 per cent of Environmental managers, 10 per cent of General managers, 7 per cent of Industrial Hygienists, 8 per cent of Engineers and the remaining 15 per cent hold other positions. Respondents were mainly employed in the Safety Department and Quality Control department of Chemical Industries, Lead manufacturing, fertilizer manufacturing, Plastics, Petrochemical and others.

The exhaustive data collected by interviewing the workers, supervisors and engineers of Process industries was analyzed. Since results of all parameters under study were found to be same for workers and supervisors, they are presented collectively. However difference was observed in the response of workers and supervisors with respect to conduct of formal training. Hence the results are represented separately as can be observed in Fig. 1. The collective response of compliance of wearing PC can be seen in Fig. 2. However it was observed that the kind of PC they wore was not appropriate.

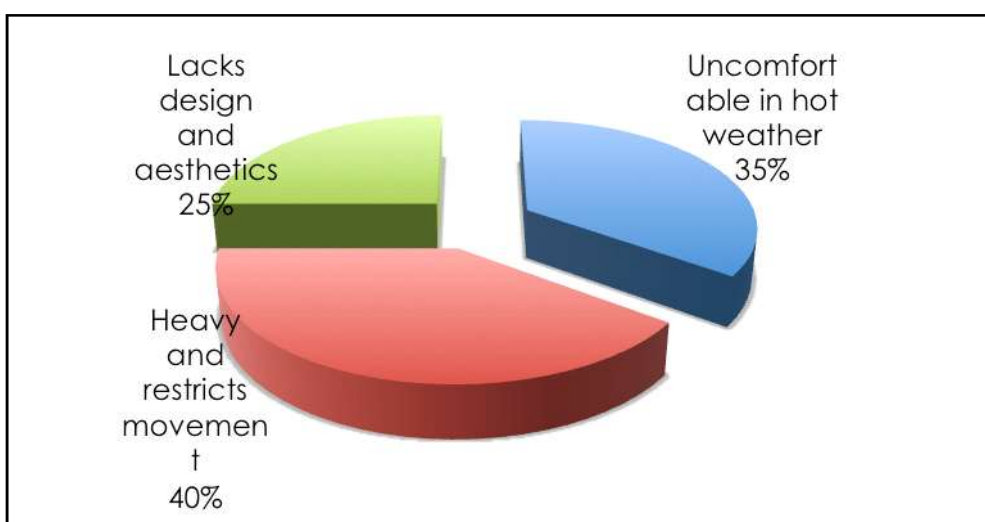


**Fig. 1 : Response to conduct of Formal training (a) workers, (b) Safety Professionals**

The analysis, suggested that though most of the workers wore PC, they were not comfortable with the protective clothing as can be seen in Fig. 3. The duration of working at the plants is maximum 12 hours, and is on higher side only during peak time of production. Safety Professionals suggested to design one piece Jumpsuit for employees working for shorter duration and two-piece for longer duration at the plant. The base material used for the making of PC is Cotton. It was suggested to develop a material for workers working with acids and at the same time doing welding process, or to provide a design solution which caters to both the hazards at the same time. Discussions with safety professionals concluded



**Fig. 2 : Workers conforming wearing PC**

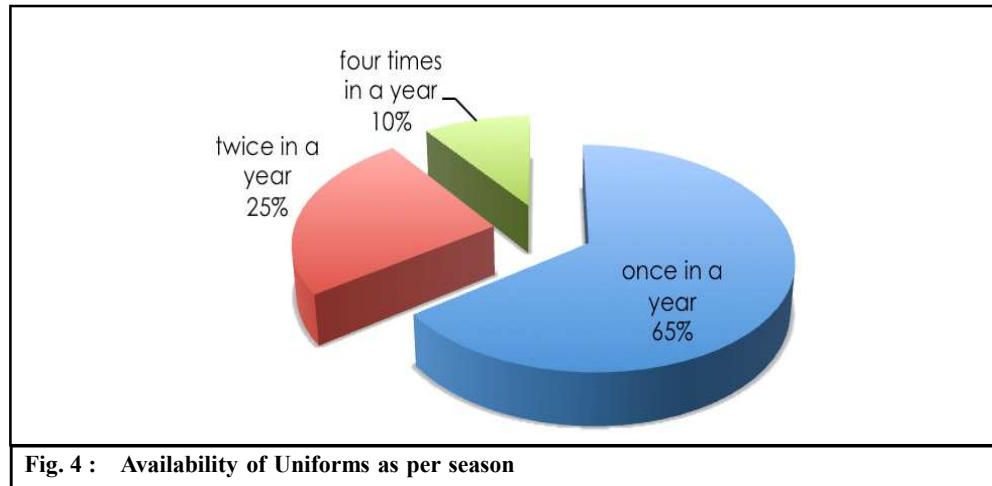


**Fig. 3 : Reasons given by workers for not wearing PC**

that most of the industries provided PC to their employees once in a year, and others twice a year (Fig. 4). They also concluded that few industries have no budget limit for the purchase of PC and few stated that it is approximately Rs.15 to 30 lakh per annum

All the Industries surveyed stated that they follow the Factory Act 1948 with amendment 1987 for the compliance of safety of their workers. The major reasons for non-compliance to wear PC was mainly discomfort due to extreme heat and restriction of movements. Hence it was suggested that developing PC which are smart and with design aesthetics, will help find a motivation for the workers to wear them. They all agreed that PC is essential for process based industries and also need training for knowing how to wear PC in the right manner.

It was concluded that vast majority of workers who have experienced on-the-job injuries were not wearing PC. An attentive and increased compliance of PC is very crucial to create



incomparable workplaces that are healthy, safe and productive.

The main reason for non compliance, reported by one third of workers was a feeling of vulnerability, lack of awareness of workplace hazards, lack of training on how to use PPEs, ill fitting, uncomfortable garments, lack of breathability and inadequate supplies.

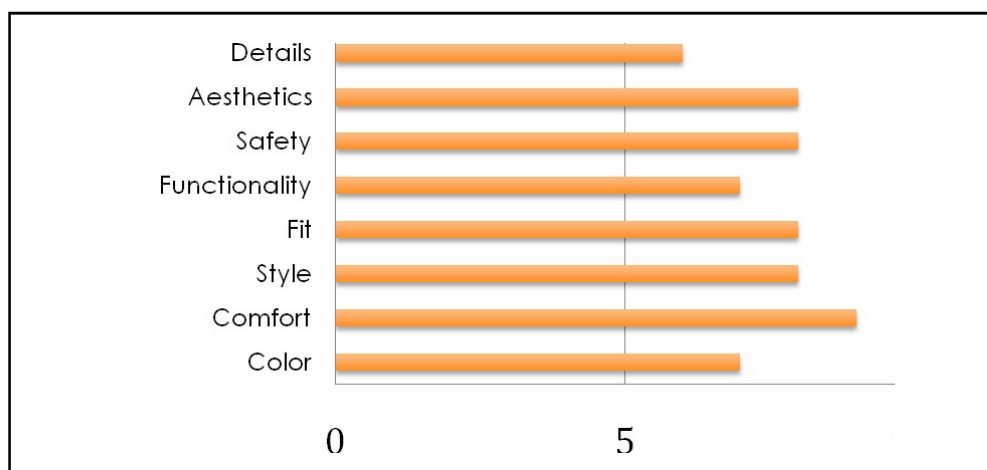
The requisite characteristics of PC as referred by the Safety Professionals and Workers:

- It should give adequate protection against the nature, severity and type of hazard.
- It should be of minimum weight, should give minimum discomfort with protective efficiency.
- Attachment of PC and accessories to the body should be flexible yet effective.
- The wearer should not be restricted in movement and vision required for the job.
- It should be durable and functional yet appealing.
- It should not cause any hazard through its material, design, defect, use or failure
- It should conform Indian Standards and tests required.
- It should be easy to clean, repair and maintain.
- Clothing that keeps the wearer warm in below zero degree working conditions.
- While working with drilling and welding machine to wear tight clothing.
- To train people to use PPE and to spread awareness about its importance &, motivate them to wear
- To talk about the limitations of PC
- Winter clothing of PC

An effort needs to be made to achieve the maximum of the above.

The clothing designed should always be ergonomically fit. Along with safety, comfort and fit plays an important role. No discrimination to be done amongst workers and higher safety officials for the uniform designed and gain 100per cent acceptability amongst all. The protective clothing should be similar to the uniforms worn by the workers to ensure greater acceptability by them.

The choice of materials, design parameters, fiber and fabric properties all play critical roles in the designing of protective clothing as can be seen in the Figure 5 based on analyzing inputs give by the workers. In the entire blueprint response is targeting risk, working safer,



**Fig. 5 : Importance given by workers to various criteria related to design of protective clothing**

working smarter and working together.

PPEs have to be improved by use of modern fabrics that are comfortable. There is a need for comfort and fit that plays a part in durability, since garments that fit better wear better. The focus is on three areas: continuing and improving the high level of protection; increasing movement through the back and arms while bringing the garment closer to the body and improving on the look of PC to encourage compliance.

### **Conclusion:**

The present protective clothing has been many times evaluated mainly from the viewpoint of its protective performance. With increased regulations and heightened awareness, it's disturbing and hard to believe that workers are unaware of the need to protect themselves. The authors interacted with senior officers and workers in leading chemical industries dealing in toxic chemicals where use of PPE is compulsory. However, according to the ever-increasing requirements for protective clothing, the end user expects more comfortable and functional PC. This resulted in a different approach while designing and evaluating individual components of a clothing system. This attempt will move towards developing a user-needs determined design methodology addressing an extent of technical, functional, physiological, social, cultural and aesthetic considerations that impinges on the design of clothing with embedded technologies. The need of the right PC is the first and foremost requirement, which ensures safety of the wearer, comfort and the self willingness to wear PC instead of compulsion. This practice will also promote uniformity in the industries, when not just workers but supervisor and safety officials adorn these uniforms, where safety and comfort play a vital role in motivating them.

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