ABRASION RESISTANCE OF MATERIALS USED FOR CHEMICAL PROTECTIVE CLOTHING AT VARIOUS WASHING INTERVALS.

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ABSTRACT: *This study describes a detailed investigation of effect of washing cycles on abrasion resistance of available chemical protective clothing materials in order to evaluate their safety limits against cuts or abrasives faced by the worker in an industry. The sample was collected from 15 chemical industries (fertilizer manufacturing units) in Pakistan. This study was based on laboratory work performed at a reputable mill. The samples were evaluated at 5000, 15000 and 25000 rubbing revolutions with 0, 5, 10, 15 and 20 washing intervals. The results showed that all the samples had great mass loss when abraded and evaluated through ASTM D 4966 test method with Martindale tester. Moreover, their condition even became worse with repeated washing cycles.*

KEY WORDS: Chemical protective clothing, Abrasion resistance, Rubbing cycles, Washing cycles.

INTRODUCTION

Various researches depict that around 90% industrial staff has to work in an environment where there is a threat to expose themselves to toxic substances and compounds [1]. There is less importance given to health and safety issues in Pakistan, especially in terms of occupational hazards and risks [2]. For this, it is essential to create awareness among the staff, including workers, managers and owners to take all the necessary precautionary measures at the work area [3]. Chemical protective clothing is one of the major components of providing safety and minimizing the risks of potential hazards for the workers having exposure to certain chemicals while at their workplace.

It becomes essential to evaluate the materials used for manufacturing chemical protective clothing [4]. Because it is not recommended to reuse these materials unless they have to be tested for their physical, mechanical, chemical or biological characteristics in order to protect the wearer from such type of hazards. For example, evaluation of materials help in determination of decontamination effects in terms of losing their performance [5].

The abrasive strength of chemical protective clothing serves as an indicator to take action either in the form of repairing the garment or replace it. As the abraded surface shows significant or insignificant surface changes which can lead us to predict the performance level of other characteristics as well, such as water, liquid, fluid or chemical resistance [6]. If a specific material can be able to perform well for its functional properties except to provide satisfactory strength, even then it cannot be considered adequate for its end use.

Abrasion is the friction or wearing up of any area of the fabric against another surface. Abrasion occurs during the life of a garment while it is being used, worn, laundered or dried. When a fabric rubs either with the body or during washings, it affects its abrasive characteristics. Low abrasive quality of fabric even causes pilling [7]. So, it is very necessary to determine the abrasive strength of protective clothing items as they assure the safety and protection to the wearer. It also assists in providing a better understanding and assessment about the durability and serviceability of fabrics for a specific end purpose.

Abrasion shows insignificant or little visible changes or damage to the fabric in the early stage. When the abrasion process is further carried out, significant changes are noted such as change in the shade of the textile material, mass or thickness loss, breakdown of yarns and threads or even appearance of holes in it [8]. There are several factors that affect the abrasive strength of garments such as nature of fiber used in their manufacturing process, kind of yarns, construction technique, fabric surface characteristics and quality of finishes applied over their surface [9].

There are two important approaches commonly associated with the determination of abrasion resistance of textile materials. The first approach dictates to abrade a specimen till the breakage of two yarns or appearance of hole and record the number of rubbing revolutions. The second approach suggests to abrade a specimen for a predetermined number of revolutions and evaluate it on the basis of change in color or appearance, mass or thickness loss, loss in tear or tensile strength or any other relevant characteristic [10].

It is very necessary for the fabrics maintain their performance behavior after many launderings. Washing is very essential to eliminate contaminations from the fabrics. Washing procedure is beneficial only if it is done appropriately. When it is not performed correctly, it badly affects performance of fabrics. There are different features that affect the quality of fabrics during washing such as nature and standard of detergents, quality of water, time and temperature of washing, nature of drying, heat given for drying, number of washings.

MATERIALS AND METHODS

In this study, the main purpose was to assess the effect of washing on abrasive strength of chemical protective clothing available in Pakistan. The sample of protective coveralls was selected from 15 chemical industries comprised of fertilizer manufacturing units in Pakistan who were using locally manufactured protective clothing for their employees. Collected samples were categorized into three groups according to their fiber content as shown in the Table 1 .

Table 1: Fiber Content of Collected Coveralls

Sample Name	No. of Collected Samples	Fiber Content
Group A	5	Cotton
Group B	5	Polyester
Group C	5	Blend (Cotton / Polyester)

The collected samples were washed by using the standard AATCC Monograph M6 [11]. Samples were washed in Front loading machine under standard speed at 45±10 rpm. Various steps such as washing, rinsing, spinning and drying were performed. Temperature of washing was set at 54±2.9°C for about 11±1 minutes. 0.1g/liter washing detergent was added in the machine. Samples were rinsed for two minutes in the first rinsing cycles. For another 5 minutes, samples were rinsed in the second rinsing cycle with liquid softener. Then these samples were spun at 1300±150 rpm for about 12 minutes. Afterwards, they were tumble dried at 68±6°C for 1 hour 30 minutes. All the samples were given 20 washing cycles. After a interval of every 5 cycles, they were evaluated for the abrasive strength by following the test method ASTM D 4966 with Martindale tester [12].

Three specimens from each of the samples were taken with the measurement of 1.5 inches diameter. They were conditioned by placing them in a standard atmosphere of 21° ±1°C temperature and 65% ±2% relative humidity for 4 hours before testing. The specimens were placed in such a way that the wear side was kept downward into a holder of Martindale tester. The holder was then placed on a machine. The 12kPa weight was applied to provide pressure on the specimen. The machine was switched on and set at a preselected number of rubs such as at 5000, 15000 and 25000 rubs. The specimens with their holders were taken out from the machine at these intervals and assessed for their abrasive strength by determining their mass loss that was the difference between the percentage of their mass loss before and after giving rubbing revolutions.

RESULTS AND DISCUSSION

The abrasion resistance of available chemical protective coveralls was measured and the results were given in the Table 2.

Table 2 shows the percentage of mass loss at 5000, 15000 and 25000 rubbing revolutions with 0, 5, 10, 15 and 20 washing cycles. The mean values of all groups at 5000 rubbing cycles were as follows.

The mean value of Group A was recorded as 6.56±1.99 at 0-wash, 8.02±1.05 at 5-wash, 8.54±1.06 at 10-wash, 9.16±1.07 at 15-wash and 9.92±0.95 at 20-wash. The mean value of Group B was recorded as 2.66±0.82 at 0-wash, 3.12±1.01 at 5-wash, 3.5±0.96 at 10-wash, 4.12±0.90 at 15-wash and 4.9±1.01 at 20-wash. The mean value of Group C was recorded as 4.72±1.07 at 0-wash, 5.3±1.12 at 5-wash, 5.82±1.22 at 10-wash, 6.42±1.23 at 15-wash and 7.38±1.32 at 20-wash.

The mean values of all groups at 15000 rubbing cycles were as follows.

The mean value of Group A was recorded as 9.32±2.51 at 0-wash, 11.32±1.99 at 5-wash, 12.24±1.10 at 10-wash, 12.94±0.89 at 15-wash and 13.66±2.12 at 20-wash.

Table 2: Mass Loss at Various Rubbing Cycles

Wash Cycle	Specimen		Mass Loss at 5000 cycles (%age)		Mass Loss at 15000 cycles (%age)		Mass Loss at 25000 cycles (%age)	
		N	Mean	SD	Mean	SD	Mean	SD
0	Group A	5	6.56	1.99	9.32	2.51	10.88	2.68
0	Group B	5	2.66	.82	5.30	.94	7.50	.87
0	Group C	5	4.72	1.07	7.60	.97	10.18	1.58
5	Group A	5	8.02	1.05	11.32	1.99	13.68	1.16
5	Group B	5	3.12	1.01	6.26	1.18	8.84	1.57
5	Group C	5	5.3	1.12	8.84	1.19	12.18	1.86
10	Group A	5	8.54	1.06	12.24	1.10	14.70	.25
10	Group B	5	3.5	.96	7.20	1.55	9.88	1.91
10	Group C	5	5.82	1.22	10.02	1.59	13.52	1.14
15	Group A	5	9.16	1.07	12.94	.89	15.38	.46
15	Group B	5	4.12	.90	7.70	1.43	11.20	1.43
15	Group C	5	6.42	1.23	11.60	1.57	14.92	1.36
20	Group A	5	9.92	.95	13.66	2.12	15.14	2.38
20	Group B	5	4.9	1.01	9.64	1.87	12.62	1.32
20	Group C	5	7.38	1.32	13.84	1.70	16.04	2.17

The mean value of Group B was recorded as 5.30±0.94 at 0-wash, 6.26±1.18 at 5-wash, 7.20±155 at 10-wash, 7.70±1.43 in 15-wash and 9.64±1.87 at 20-wash. The mean value of Group C was recorded as 7.60±0.97 at 0-wash, 8.84±1.19 at 5-wash, 10.02±1.59 at 10-wash, 11.60±1.57 at 15-wash and 13.84±1.70 at 20-wash.

The mean values of all groups at 25000 rubbing cycles were as follows.

The mean value of Group A was recorded as 10.88±2.68 at 0-wash, 13.68±1.16 at 5-wash,14.70±0.25 at 10-wash, 15.38±0.46 at 15-wash and 15.14±2.38 at 20-wash. The mean value of Group B was recorded as 7.50±0.87 at 0-wash, 8.84±1.57 in 5-wash, 9.88±1.91 at 10-wash,11.20±1.43 at 15-wash and 12.62±1.32 at 20-wash. The mean value of Group C was recorded as 10.18±1.58 in 0-wash, 12.18±1.86 at 5-wash, 13.52±1.14 at 10-wash, 14.92±1.36 at 15-wash and 16.04±2.17 at 20-wash.

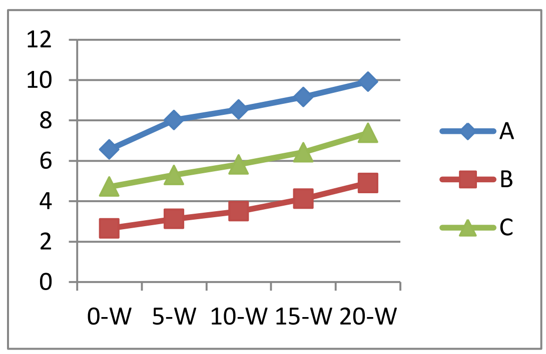

Figure 1: ***Mass Loss at 5000 Cycles***

Figure 1 depicts the mass loss of all groups at 5000 cycles with 0, 5, 10, 15 and 20 washing intervals. It clearly explains that mass loss was more in Group A that was comprised of specimens made with cotton fabric. And mass loss was less in Group B which was comprised of Polyester fabrics. Whereas, Group C made of a blend (Polyester and Cotton) showed the results in between these two groups. It was investigated that nature of fiber content had a great effect on the dimensional characteristics of fabrics. The nature and kind of yarns also play an important role in making fabrics more abrasion resistant[13]. It was investigated that compact yarns showed less friction value due to their even and uniform structure which led to their higher abrasion resistance[14]. It is reported compact yarns with 40-50% better abrasion resistance as compared to the ring spun yarns [15].

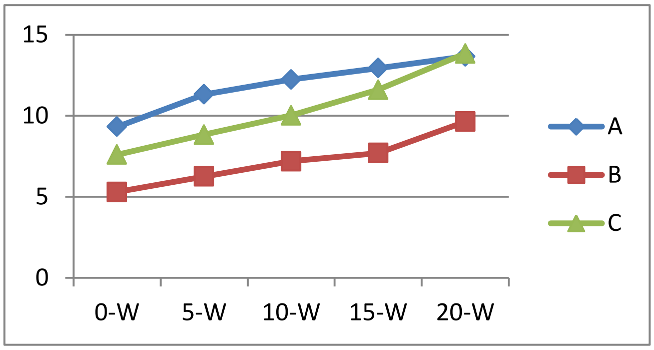

Figure 2: *Mass Loss at 15000 Cycles*

Figure 2 depicts the mass loss of all groups at 15000 rubbing cycles with 0, 5, 10, 15 and 20 washing intervals. It clearly explains that all groups showed increase in mass loss with increasing number of washing cycles. One possible reason of great increase in mass loss was due to low quality of fibers and yarns used in the manufacturing of these coveralls. Moreover, finishes applied over the surface of fabrics were not of good quality so that's why they easily removed with rubbing cycles and deteriorated them.

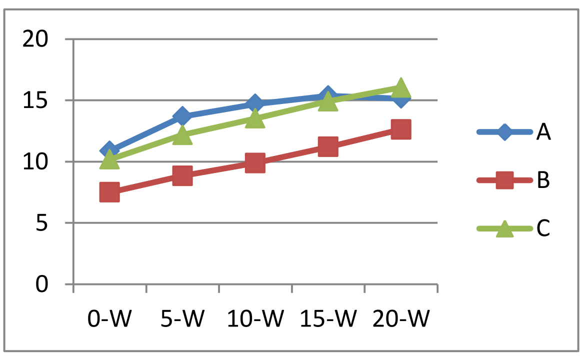

Figure 3: *Mass Loss at 25000 Cycles*

Figure 3 depicts the mass loss of all groups at 25000 rubbing cycles with 0, 5, 10, 15 and 20 washing intervals. It clearly explains that Group A reduced its mass at 0-10 washing cycles and then remained somewhat stable at 15 and 20 washes. Group B and C showed increase in mass loss with increasing number of washings. It was due to the fact that during washing procedures, fabrics were badly rubbed with each other and their lint was removed from the surface and thus became weaker in their strength. It was also found out in a research study that repetitive number of launderings significantly decreases the abrasion resistance of fabrics and their pilling performance also became worse[16].

CONCLUSION

Chemical protective clothing helps its wearers in industry to protect themselves from any risks, injuries, cuts or abrasives etc. It is concluded that none of the collected protective coveralls able to resist better abrasion according to the international standard. And their condition was becoming even worse with the number of laundering cycles. It is highly needed that protective clothing should be made of good quality that helps to maintain its abrasive strength even after repeated washings and use.

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