International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 3 **Issue:** VII **Month of publication:** July 2015

DOI:

www.ijraset.com

Call: 08813907089 | E-mail ID: ijraset@gmail.com

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Comparison of Cleaning Treatments for Conservation and Restoration of Cotton, Wool and Silk Fabrics

Kanika Sachdeva[1], Mona Suri[2], Simmi Bhagat[3]
[1]*Department of Fabric and Apparel Science, Lady Irwin College, University of Delhi, India*
[2]*Academic Vice-president, Royal University for Women, Bahrain*
[3]*Reader, Department of Fabric and Apparel Science, Lady Irwin College, University of Delhi, India*

Abstract- Cleaning ensures sanitization and thus safety of the artefact itself and others stored/displayed in its vicinity. At the same time, the process invariably alters the character of textile to a certain extent. Cleaning ensures removal/deactivation of soil and harmful organic matter from the artefact. However, small amount of surface molecules from the textile might be eroded in the process as well. This leads to weakening of the textile and might cause alteration in colour spectrum/ depth etc. Controlled cleaning techniques in conservation laboratories focus on minimizing this damage. However, not much scientific data is available on efficacy of present cleaning techniques employed in conservation laboratories. Presently aqueous cleaning and solvent cleaning are primary modes utilised as next step to dry tools. Additionally novel cleaning technologies like enzyme wash and ultrasonic wash provide soil specific methodology that would reduce the threat to base fabric.

Present paper is a systematic analysis of these cleaning techniques and their impact on aged museum fabrics, i.e., cotton, wool and silk. Change in tensile strength parameters, whiteness index and yellowness index have been used as indicators to test efficacy of different cleaning techniques on aged museum textiles. Numerical data generated by laboratory experiments clearly indicates that there is no standard cleaning treatment available for the three natural fibres. Each fibre has exhibited suitability to different cleaning treatment, while balancing between restored whiteness and minimizing strength loss.
Keywords- Cleaning, Conservation, Cotton, Wool, Silk

I. INTRODUCTION

Cleaning is an important part of conservation and restoration. Cleaning of historic textiles is an essential step which not only helps to prolong the life of the textile, but also eradicates the decaying material to some extent (Naithani & Kharbade, 1987). An unsanitized artefact doesn't only pose hazard to its own longevity, it also becomes a potential threat for artefacts stored or displayed around it. At the same time, cleaning is also one of the most complicated tasks in conservation laboratory. Invariably, the artefact is at risk of alteration in structural and functional properties, as an after-effect of cleaning. As Per Balazsy, 2006, 'A large part of the weight decrease of cellulose on washing originates from the elimination of the lower molecular weight water-soluble deterioration products. The washing of highly degraded cellulosic textiles should be considered with great caution because the elimination of too many deterioration products may cause disintegration of the textile '. Older the artefact, higher is the risk. Again, the impact is different for different fibres. Thus, it is very important to ascertain, various possibilities for safe cleaning of aged textiles, keeping in mind change in strength and visual parameters. Traditionally, conservation laboratories have been largely dependent on surface cleaning through vacuuming and other dry techniques. Occasionally, wet cleaning with laboratory reagents is used, after ensuring the strength parameters of the artefact. Dry-cleaning/ solvent cleaning has been another common approach for sanitizing museum textiles. Recently, enzymes have been making their presence felt in these laboratories. Ultrasonic cleaning techniques are also supplementing options for conservators. However, lack of experimental data about efficacy of any of these techniques and their impact on fabric strength, discourages museum workers from making confident choices about the same. As noted by Brooks, 2006, 'Categorical distinctions between clean and dirty are not fixed but are culturally defined, which means they alter over time, space and context. Perceptions of cleanliness are therefore not absolute'. Any cleaning treatment in conservation laboratory has to balance between loss in strength and cleaning perceptions.

The objective of this study is to test efficacy of all these cleaning techniques in restoring whiteness of artificially aged fabrics made in cotton, wool and silk. Also, change in strength parameters have been numerically established, so that conservation laboratories

©IJRASET 2015: All Rights are Reserved

can make an informed choice about methods available for cleaning and restoration purposes.

II. METHODOLOGY

Cotton, wool and silk samples were selected for research. The samples were tested for determination of tensile strength and Whiteness Index and yellowness index. Samples were subjected to accelerated ageing as per the method suggested in AATCC Test Method 26-1994. This ascertained that samples were brought to a condition of approximately 20years of ageing. Aged Cotton, Wool and Silk samples were taken for Tensile Strength testing and Spectroscopy. Standard testing procedures were followed to measure the indicators. Thereafter, the aforesaid samples were divided in 4 groups for wet cleaning i.e., home laundry, enzymatic cleaning, dry cleaning and ultrasonic cleaning. The samples were subjected to treatments as appropriate for their fibre content. For example in the home laundry group cotton was exposed to the detergent, temperature and conditions prescribed for selected fabrics. After wet treatment, the samples were again tested for loss in tensile strength and removal of yellowness. Recorded values for whiteness Index and tensile strength were then compared to determine the best possible method.

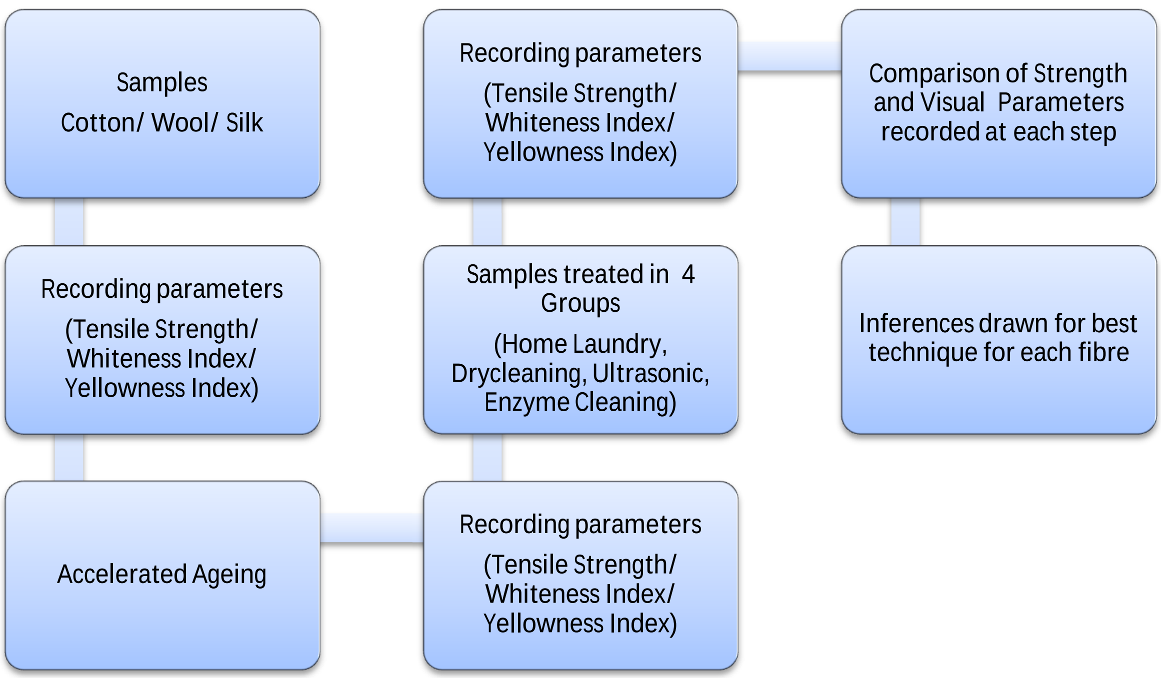


Figure 1: Process chart for comparison of wet cleaning treatments for conservation and restoration in Cotton, Wool, & Silk

A. A *Home Laundry*

Home laundry techniques are probably the oldest and simplest means of sanitizing fabrics. Primary merit of this method is that worker gets to closely interact with fabric at every stage of treatment. This ensures possibility of simultaneous improvisation, while fabric is still under treatment. A crucial advantage of this technique stands that professionals can modify the procedure as per suitability to the textile, while retaining absolute control over the artefact at the same time. For the purpose of this study AATCC test method 61-2007 was followed. Test no 1A- was used as specimens subjected to this test should show colour change similar to that produced by five typical careful hand launderings at a temperature of 40+/-3^{0}C. Laundering machine was adjusted to maintain the designated bath temperature of 40+/-2^{0}C. The wash liquor was prepared with total liquor volume of 200ml and detergent concentration at 0.37%. Test was run in lever lock stainless steel canisters of size 75X125 mm with 10 steel balls in each canister. The laundering machine was run for 45mins after which each test specimen was rinsed in a separate beaker. Each specimen was rinsed three times in distilled water at 40+/-2^{0}C with occasional stirring and hand squeezing. To remove excess water, flat specimens were pressed between folds of blotting paper. Thereafter, specimens were air-dried, placed flat on a blotting paper. A commercial detergent was used for cotton fabrics whereas a neutral soap was used as ‘non-ionic’ detergent for wool and silk.

B. *Dry Cleaning/ Solvent Cleaning*

©IJRASET 2015: All Rights are Reserved

Volume 3 Issue VII, July 2015
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

A synonym of solvent cleaning, this technique has been widely used for cleaning of sensitive textiles like wool, silk, chiffons. Most sensitive fabrics that behave adversely to aqueous medium stand comfortable to dry cleaning. For the purpose of this research AATCC test method 158-1995 was used where samples were dry-cleaned at a commercial workshop with *perchloroethylene*. Dry-cleaning machine with a commercial rotating cage was used. The sample fabric was placed in the machine and *perchloroethylene* was introduced. Machine was run for the specified period of time. The solvent was thereafter drained and centrifuged. Load was dried in a drying tumbler by circulating in warm air for appropriate time. The specimens were removed from machine immediately and placed on flat surface for drying.

C. *Enzymatic Cleaning*

Literature about use of enzymes is available from late 60's. In 1988, Segal published a paper reporting important factors affecting enzyme activity and various immersion and non-immersion techniques of application. Contemporary studies have repeatedly noted the efficiency of Cellulase enzyme as an effective bio-polishing agent for cotton fabric which considerably preserves the strength and weight parameters of the fabric in contrast to other chemical techniques (Bhat, 2000). Primary advantage of using enzymes is that enzymes are substrate specific. Thus if proven useful, they stand superior to all parallel techniques of achieving a desirable result. The concept utilized in this section of study is that of bio-polishing. The phenomenon talks about removing the damaged superficial layer of the fabric and restoring the fresher subsequent layers (Doshi et. al, 2001). Since the fabrics used in this section of the research were both cellulosic and protein in nature Cellulases and Proteases were the enzymes used for the purpose.

ENZYME	BRAND	MLR	Ph	TEMPERATURE	CONCENTRATION	TIME
CELLULASE (COTTON)	SRL-0348215-EXTRAPURE	1:10	4.5 Using Acetic Acid	60^0C	5% owf	1 hour
PROTEASE (WOOL & SILK)	SRL-1648179 PROTEINASE K,Lyophilised Powder	1:10	8.5 Using sodium hydroxide	60^0C	5% owf	1 hour

(Chikkodi et. al, 1995)

D. *Ultrasonic Cleaning*

Figure 2: Samples under treatment in Ultrasonic machine

The potential of ultrasonic cleaning in conservation has been recognized for some time. Barton et. al. (1986), reported that archaeological conservation in Europe has resorted to this type of cleaning in dealing with waterlogged wood, textiles and leather artefacts. The principle of ultrasonic cleaning is the generation of mechanical impulses through a liquid at high frequencies. These impulses create minute bubbles of vacuum which implode against the immersed object, creating shocks which clean its surface (Dallas, 1976). Thus ultrasonic cleaning technique is effective while remaining gentle in terms of time and handle. Therefore the possibility of using ultrasonic cleaning technique for removal of superficial damaged layer of aged fabrics was explored to restore whiteness without considerable strength loss.

For the purpose of present study, samples were cleaned in ultrasonic cleaning machine at North India Textile Research Association, Ghaziabad (Figure 1). Three cotton samples were washed at a temperature of 50^oC with a commercial detergent at a concentration of 5gpl (IS: 5785: 2005). First sample was taken out of the machine after 5mins, second after 8mins and third after 11mins (Sethi, 2012). The samples were then dried on a flat surface. Whiteness Index and tensile strength of these samples were recorded thereafter. Similarly silk and wool samples were treated at temperature of 40^oC with a non-ionic washing detergent at 5gpl. Again the samples were dried flat and values for Whiteness Index and Tensile Strength noted thereafter.

©IJRASET 2015: All Rights Reserved

Volume 3 Issue VII, July 2015
ISSN: 2321-9653

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Thus the samples in all three fibres were subjected to the above-mentioned cleaning treatments. Whiteness Index and tensile properties for these samples were noted before and after the cleaning treatments. Comparison of these values provided insight about utility of these treatments for each fibre.

III. RESULTS AND DISCUSSIONS

It is well known that aesthetically yellowing is the most prominent outcome of ageing, indicating to the changes happening at molecular level of the fibre. Most of the times, this yellowing is caused by a layer of fibre deterioration by-products or the broken molecular chains on the fabric surface (Cardamone, 2000). The process of molecular chain incision cannot be reversed, however, aesthetics of the fabric can be improved by removing these deterioration products from the surface of the fabric and bringing up the lower lying, unbroken molecular chains. Although, broken molecular chains do not contribute much to the fabric strength, their removal might expose the unbroken ones to the surface and slightly hasten the process of ageing. Thus while attempting this process a balance has to be created between restoring aesthetics and conserving fabric strength

A. Cotton

1) *Tensile Strength:* It is evident from Table 1 that cotton undergoes a strength reduction of 31% in warp direction and 33% in weft direction after ageing. None of the wet cleaning treatments have been able to restore this lost strength fully. It can be further seen that fabric loses further 11% strength in warp direction after home-laundry. Further, ultrasonic wash also leads to high strength reduction. Loss in breaking Load is least in case of dry-cleaning, closely followed by enzyme wash. However, the trend changes in the weft direction where all other treatments except home laundry, reverse some breaking load lost due to ageing. The reversal is most in case of dry-cleaning followed by ultrasonic wash. Enzyme wash neither deteriorates the fabric strength further nor restores it. This further explains that warp sizing plays a strong role in fabric deterioration.

Table 1: Effect of Cleaning Methods on Breaking Load, Extension and Colour of Cotton Fabric

	S.No	Unaged Sample	Aged Sample	Home Laundry	Dry-Cleaning	Enzyme Wash	Ultrasonic wash		
							5mins	8mins	11mins
Breaking Load (Warp) (N/m^2)	Average (5 samples)	7.96	5.48	4.86	5.18	5.12	4.82	4.76	4.62
	SD	0.67	0.60	0.62	0.08	0.66	0.29	0.22	0.48
	CV %	8.46	10.98	12.73	1.62	12.91	5.94	4.60	10.31
	% Change	-	31.16	11.31	5.47	6.57	12.04	13.14	15.69
Breaking Load (Weft) (N/m^2)	Average (8 samples)	7.40	4.95	4.46	5.59	4.99	5.30	5.48	5.11
	SD	0.90	0.50	0.43	0.53	0.61	0.54	0.43	0.44
	CV %	12.17	10.07	9.58	9.49	12.29	10.19	7.80	8.59
	% Change	-	33.08	9.90	-12.93	-0.81	-7.07	-10.71	-3.23
Extension % (Warp)	Average (5 samples)	13.00	5.33	3.33	3.33	6.67	8.00	10.00	7.00
	SD	1.83	0.75	0.00	0.00	0.00	0.75	0.00	0.75
	CV %	14.04	13.98	0.00	0.00	0.00	9.32	0.00	10.65
	% Change	-	59.00	37.52	37.52	-25.14	-50.10	-87.62	-31.33
Extensio	Average	20.21	8.33	3.33	6.67	8.54	9.79	14.38	8.54

©IJRASET 2015: All Rights are Reserved

n % (Weft)	SD	3.01	0.00	0.00	0.00	0.59	0.59	1.77	0.59
	CV %	14.91	0.00	0.00	0.00	6.90	6.02	12.30	6.90
	% Change	-	58.70	60.02	19.93	-2.52	-17.53	-72.63	-2.52
Change in Colour	WI	-178.99	-193.37	-212.56	-187.21	-176.68	-182.34	-187.45	-183.86
	Change in WI	-	14.37	33.56	8.22	-2.32	3.34	8.45	4.86
	YI	97.75	103.39	102.65	101.35	97.70	100.56	101.21	100.50
	Change in YI	-	-5.62	-4.90	-3.59	0.05	-2.81	-3.46	-2.75

Looking at Extension% values, it was realised that fabric loses 59% of its extension value after ageing, both in warp and weft direction. Wet Cleaning Treatments like home-laundry and dry-cleaning further reduce extensibility in warp direction by 37%. Interestingly, loss in weft direction is high in case of home laundry but reduced in dry-cleaning. This indicates that unsized weft yarns, after ageing, are at a greater risk of damage by alkaline detergents.

Although enzyme treatment reverses the loss in extension by 25% in warp direction and 3% in weft direction, ultrasonic wash indicates slightly better results in terms of reversing extension % loss caused by ageing. It can be seen from Table 1 that enzyme wash seems to balance out the two tensile parameters the most. Further SD and CV% values establish the validity of the experiments conducted. However, final conclusion can be deduced only after looking at the spectrometer observations.

2) *Colour Change:* It can be seen from Table 1 that enzyme wash manages to bring the cotton fabric closest to its original, unaged condition, both in terms of WI (Whiteness Index) and YI (Yellowness Index). Ultrasonic wash- 5 minutes stands close second, followed by 11 minutes and 8mins treatment time in ultrasonic wash. Home-laundry and dry-cleaning further reduces the WI, although they counteract yellowness to certain extent. It can be safely concluded from the above data that enzyme wash, i.e., Cellulase treatment is the most balanced option to sanitize aged cotton fabric and restore its whiteness to certain extent. Although treatments like ultrasonic wash seem promising at some parameters, strength loss in warp direction is too high to classify it safe for washing cotton fabrics. On the other hand, home-laundry by alkaline reagents has been proved to be most harmful for aged cotton fabrics, followed by dry-cleaning.

B. *Wool*

1) *Tensile Strength:* It has been observed in the previous section that wool undergoes least loss in strength by 20yrs of ageing. As per the readings in Table 2 the loss in warp direction is close to 2% and in weft direction 10%. However, wet-cleaning treatments might alter this to a certain extent.

Table 2: Effect of Cleaning Methods on Breaking Load, Extension and Colour of Wool Fabric

	S.No	Unaged Sample	Aged Sample	Home Laundry	Dry-Cleaning	Enzyme Wash	Ultrasonic Wash		
							5mins	8mins	11mins
Breaking Load (Warp) (N/m^2)	Average (5 samples)	21.6	21.22	21.42	19.62	19.56	18.78	18.6	18.58
	SD	0.81	0.86	0.41	0.83	0.26	0.85	0.58	0.41
	CV %	3.76	4.05	1.91	4.22	1.33	4.51	3.11	2.20
	% Change	-	1.76	-0.94	7.54	7.82	11.50	12.35	12.44
Breaking Load (Weft) (N/m^2)	Average	13.25	11.9	10.7625	11.025	11.55	9.65	9.8125	10.875
	SD	0.69	0.36	0.43	0.60	0.16	0.46	0.23	0.43
	CV %	5.21	3.05	4.00	5.42	1.39	4.80	2.34	3.99
	% Change	-	10.19	9.58	7.31	2.94	18.91	17.56	8.57

©IJRASET 2015: All Rights are Reserved

Extension % (Warp)	Average	14.33	16.67	12.33	11.00	13.33	16.67	14.00	13.33
	SD	1.49	0.00	0.91	1.49	0.00	0.00	1.49	0.00
	CV %	10.40	0.00	7.40	13.55	0.00	0.00	10.65	0.00
	% Change	-	-16.33	26.03	34.01	20.04	0.00	16.02	20.04
Extension % (Weft)	Average	27.08	31.67	23.33	23.33	20.83	18.96	15.83	16.67
	SD	3.05	2.52	0.00	1.78	2.36	1.98	1.54	0.00
	CV %	11.28	7.96	0.00	7.64	11.31	10.44	9.75	0.00
	% Change	-	16.95	35.75	35.75	34.23	40.13	50.02	47.36
Change in Colour	WI	-231.97	-255.15	-254.05	-251.99	-250.94	-251.85	-253.74	-252.01
	Change in WI	-	23.18	22.08	20.02	18.97	19.88	21.77	20.04
	YI	107.41	116.90	115.08	114.99	115.88	116.34	117.12	116.46
	Change in YI	-	-9.49	-7.67	-7.58	-8.47	-8.93	-9.71	-9.05

Interestingly, home-laundry of wool in non-ionic detergent conserved the strength in warp direction, in terms of breaking load. However, in weft direction, the strength loss is close to 10%. Strength loss in case of dry-cleaning and enzyme wash is equivalent at 7% in warp direction, but weft direction registers much reduced loss in weft at 2%. Ultrasonic wash at all three durations, are causing higher loss of strength as compared to other wet cleaning treatments, both in warp and weft direction. Coming to loss in extension%, ultrasonic wash again reflects unbalanced results between warp and weft. However, home-laundry, dry-cleaning and enzyme wash register balanced loss in both warp and weft with enzyme wash faring slightly better than rest of the two techniques.

2) *Colour Change:* The data (Table 2) corresponding to WI and YI values clearly reflects superiority of enzyme wash treatment to all other treatments of wet cleaning. Where maximum whiteness is restored by wash, yellowness is most reduced by dry-cleaning, closely followed by home-laundry and enzyme wash. Ultrasonic treatment at 5mins also reflects values close to enzyme wash. Correlating the data obtained by tensile tests and spectrophotometric readings, it can be concluded that all three, home-laundry by non-ionic detergent, dry-cleaning and enzyme wash by Protease enzyme, stand equivalent chances of sanitizing wool fabric with minimum strength loss and some restoration of fabric colour. Ultrasonic wash does not provide clear data, as the readings contradict between warp and weft direction, as in the case of cotton fabric. Thus ultrasonic wash cannot be recommended in its present detail.

C. *Silk*

3) *Tensile Strength:* Table 3 suggests 24% loss in strength in warp direction and 28% loss in weft direction after ageing. As per the data collected post wet-treatments it can be seen that dry-cleaning and ultrasonic wash at 8mins provide most balanced results, closely followed by ultrasonic wash at 11mins.

Table 3: Effect of Cleaning Methods on Breaking Load, Extension and Colour of Silk Fabric

	S.No	Unaged Sample	Aged Sample	Home Laundry	Dry-Cleaning	Enzyme Wash	Ultrasonic Wash		
							5mins	8mins	11mins
Breaking Load (Warp) (N/m^2)	Average (5 samples)	20.04	15.32	15.06	16.88	15.90	16.84	16.34	15.72
	SD	0.40	1.23	1.86	1.37	2.99	1.08	0.66	1.36
	CV %	2.01	8.01	12.32	8.09	18.80	6.39	4.03	8.67
	% Change	-	23.55	1.70	-10.18	-3.79	-9.92	-6.66	-2.61

©IJRASET 2015: All Rights are Reserved

Breaking Load (Weft) (N/m^2)	Average (8 samples)	29.68	21.24	24.75	27.48	20.26	26.31	23.63	21.39
	SD	2.35	1.45	2.42	1.73	0.82	4.44	3.43	3.36
	CV %	7.91	6.81	9.79	6.30	4.03	16.86	14.53	15.73
	% Change	-	28.44	-16.53	-29.38	4.61	23.87	-11.25	-0.71
Extension % (Warp)	Average (5 samples)	18.00	15.00	10.00	11.33	14.00	19.00	16.67	17.00
	SD	0.75	0.00	0.00	0.75	1.49	0.91	0.00	1.39
	CV %	4.14	0.00	0.00	6.58	10.65	4.80	0.00	8.20
	% Change	-	16.67	33.33	24.47	6.67	-26.67	-11.13	-13.33
Extension % (Weft)	Average (8 samples)	21.67	20.21	14.17	14.38	10.00	19.58	18.13	18.33
	SD	2.82	2.26	1.99	1.77	0.00	0.77	0.59	0.00
	CV %	13.00	11.19	14.06	12.30	0.00	3.94	3.25	0.00
	% Change	-	6.74	29.89	28.85	50.52	3.12	10.29	9.30
Change in Colour	WI	-201.48	-195.67	-206.63	-222.95	-208.91	- 209.32	- 212.64	-208.84
	Change in WI		-5.81	5.16	21.47	7.43	7.84	11.16	7.36
	YI	96.55	98.51	100.96	103.51	101.14	102.32	103.76	101.98
	Change in YI		-1.96	-4.41	-6.96	-4.59	-5.77	-7.21	-5.43

Enzyme wash, home-laundry and ultrasonic wash at 5 minutes do not illustrate uniformity of results in warp and weft direction, thus cannot be recommended in their present form.

3) *Colour Change:* WI and YI readings of silk treated with different wet-cleaning treatments, demonstrates conflicting results (Table 3). It can be seen that uniformly, all wet-cleaning treatments are reducing whiteness of the fabric and increasing yellowness to some extent. Thus, comparison in terms of restoration of colour is not possible in this case. The discussion therefore can only revolve around sanitizing the fabric at minimum colour loss. It can be seen that dry-cleaning and ultrasonic wash at 8mins is causing maximum alteration in fabric colour. At the same time home-laundry renders minimum damage in that respect. Rest all treatments alter fabric colour to similar extent.

Combining the results obtained by tensile tests and spectrophotometer readings, ultrasonic wash at 5 minutes and dry-cleaning can be described as most suitable for sanitizing an aged silk fabric.

IV. CONCLUSIONS

Thus it can be seen that no one method in general can be considered suitable for cleaning of aged fabrics made from different fibres. Enzymatic cleaning by Cellulase enzyme has been proved to be least harmful and most efficient method of cleaning aged textiles. Therefore, Enzyme wash in aged cotton fabrics is the most balanced method of sanitization without much loss of strength and performance parameters. However, in the case of wool fabric; home laundry, dry cleaning and enzymatic cleaning by protease enzyme prove equally beneficial in cleaning the fabric with minimum strength loss. This can be attributed to inherent nature of wool fabric to resist damage due to deterioration. On the other hand, ultrasonic wash at 5 minutes presents most suitable cleaning option

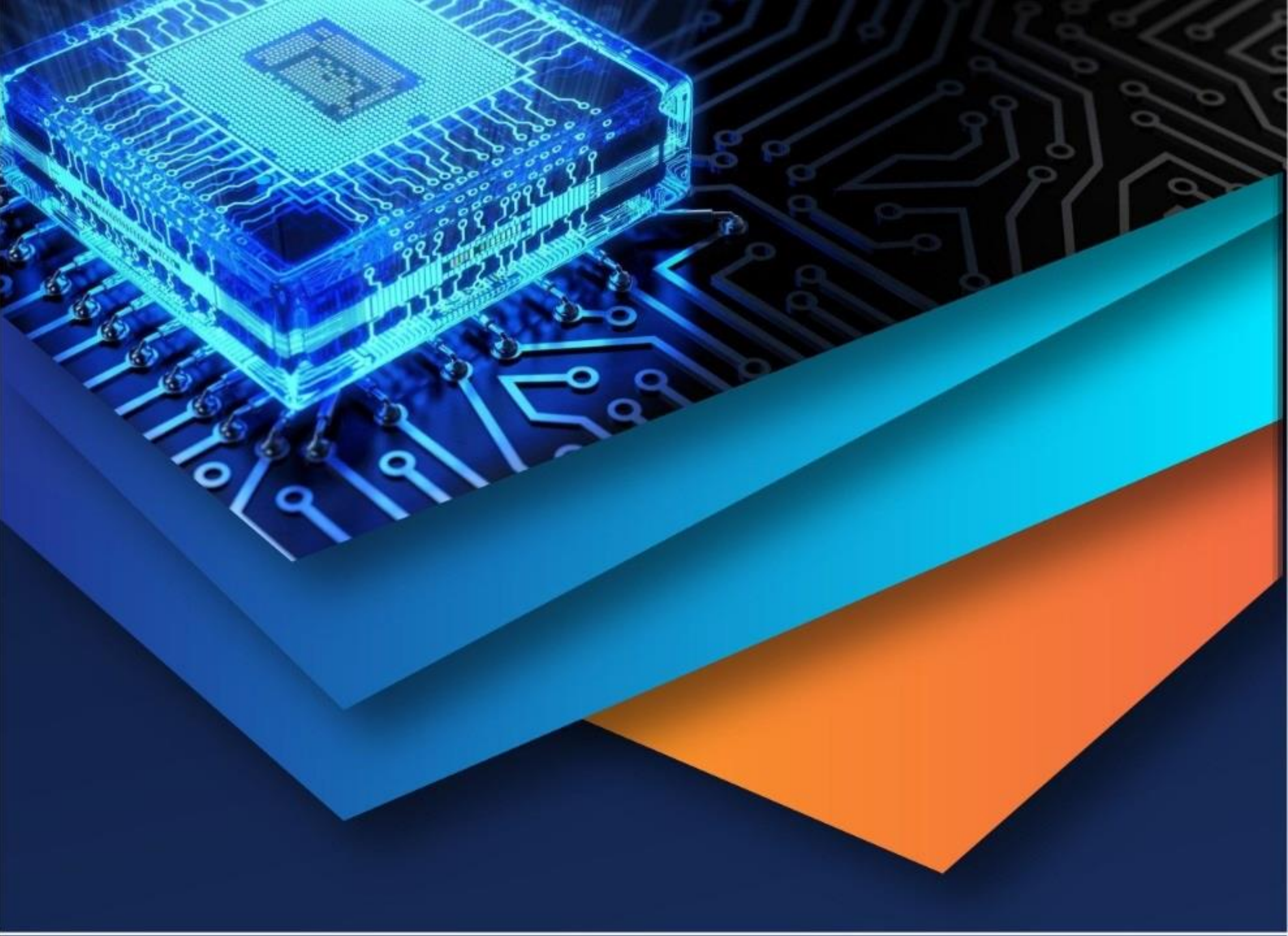
©IJRASET 2015: All Rights are Reserved

for silk fabric. The findings of this section confirm that fibre constitution has a profound role in deciding suitable cleaning treatments for aged fabrics.

REFERENCES

[1] Balazsy, A. T. & Eastop, D., *Chemical Principles of Textiles Conservation*, Butterworth Heinemann, 2002.
[2] Barton, G. & Weik, S., 1, ' Ultrasonic Cleaning of Ethnographic Featherwork In Aqueous Solutions', *Studies in Conservation*, Vol. 31, No. 3, pg.125-132, 1986.
[3] Bhat, M. K., 'Cellulases and Related Enzymes in Biotechnology', *Biotechnology Advances*, Vol. 18, pg. 355-383, 2000.
[4] Cardamone, J. M., 'Historic Textiles and Paper', *In Historic Textiles, Papers and Polymers in Museums*, ACS Symposium Series; American Chemical Society; Washington D.C., pg. 2-7, 2007.
[5] Chikkodi, S. V., Khan S., Mehta R. D., 'Effects of Biofinishing on Cotton/Wool Blended Fabrics', *Textile Research Journal*, Vol. 65, No. 10, pg. 564-569, 1995.
[6] Dallas, D. B., *Tools and Manufacturing Engineers Handbook*, 3rd Edn, McGraw-Hill, pg. 24.81-24.86, 1976**.**
[7] Doshi, R. & Shelke, V., 'Enzymes in Textile Industry- An Environment Friendly Approach', *Indian Journal of Fibre & Textile Research*, Vol. 26, pg. 202-205, 2001.
[8] Naithani, H. K. & Kharbade, B. V., 'An Overview on the Considerations of Cleaning of Historic Textiles', *Conservation of Cultural Property in India*, Vol. XVIII-XX, pg. 35-39, 1985-87.
[9] Sethi, Sabina, 'Ultrasonic Cleaning of Highly Soiled Apparel', Unpublished PhD work submitted to University of Delhi, Delhi, 2012.
[10] *AATCC Test Method 61-2007, 'Colorfastness to Laundering: Accelerated'*, AATCC Technical Manual, pg. 86-90, 2008.
[11] *AATCC Test Method 26-1994, 'Ageing of Sulfur-Dyed Textiles: Accelerated'*, AATCC Technical Manual, Vol.70, pg. 80-81, 1995.
[12] *AATCC Test Method 158-1995, 'Dimensional Changes on Drycleaning in Perchloroethylene: Machine Method'*, AATCC Technical Manual, pg. 272-274, 2000.

©IJRASET 2015: All Rights are Reserved



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Call : 08813907089 (24*7 Support on Whatsapp)