CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Test results of formulated products

The final recipe of EDA and PWA both the products were prepared 5 times in Zydex lab and testing was done in terms of physical appearance, pH, specific gravity, solid content, dispersion in water, viscosity, foaming test, AHS test, etc. The average results of samples were considered as the final results.

4.1.1 Physical appearance of the products

The physical appearance of EDA: It was a brownish-yellow viscous flowable liquid. This brownish colour was dependent on the enzyme used in EDA. Initially, a dark brown liquid amylase enzyme was used resulting in the brownish-yellow colour of the final EDA product.The actual colour of EDA and PWA are shown in Figure 4.1 & 4.2 respectively.

Figure 4.1 EDA in a glass beaker

Figure 4.2 PWA in a glass beaker

The physical appearance of PWA: It was white to creamish-white viscous flowable liquid. The colour is dependent on the physical appearance of polymer used in PWA. In this study, a creamish-white polymer was used which resulted in the creamish-white colour of the final PWA product.

4.1.2 pH of the products

pH of the products was measured in a pH meter. pH of both EDA and PWA products were between 6.5 - 7.5. In this formulation, no acidic or alkaline chemicals were used to increase the stability of the products.

4.1.3 Viscosity of the products

EDA is a combination formulation of amylase enzyme and polymer. Generally, enzyme has low viscosity like water but combination of polymer and emulsifier increases the viscosity of product. The viscosity of the products was measured by Brookfield viscometer. Product samples were put overnight for relaxation of the polymer at 30 ± 2˚C temperature and then viscosity was noted. Viscosity of EDA was 600-700 cPs and viscosity of PWA was 900-1000 cPs.

4.1.4 Specific gravity of the products

Specific gravity was checked by hydrometer at 30 ± 2˚C temperature. Both PWA & EDA have almost the same specific gravity which was in the range of 1.05 to 1.07.

4.1.5 Solid content of the products

The solid content of PWA was in the range of 95±1 %. The solid content of EDA was in the range of 77±1 %.

4.1.6 Dispersibility of products in Hard and Soft water

Both EDA and PWA products were easily dispersible in soft water at 1% concentration. Polymer-based products were hazy in appearance when diluted in water. Both the products were stable for an hour as per minimum requirements.

Both products took slightly higher time to completely disperse in hard water at room temperature at 1% concentration. Sequestering agents present in both products started to form complex and settle metals and iron particles present in hard water. The complex which formed tried to settle down in beaker but due to the haziness of both products in water, complexes were not properly visible in water. Figure 4.3 & 4.4 shows 1% EDA dispersion in soft and hard water and 1% PWA dispersion in soft and hard water respectively.

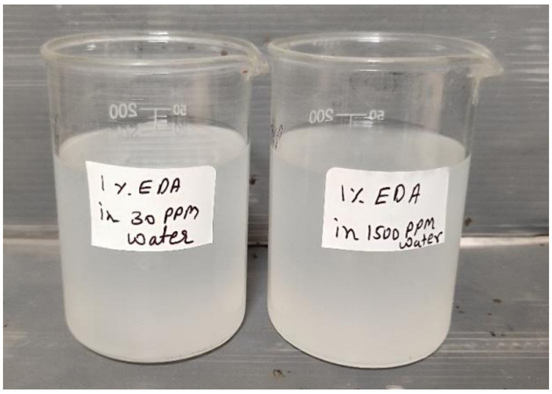

Figure 4.3 1% dispersion of EDA in soft and hard water

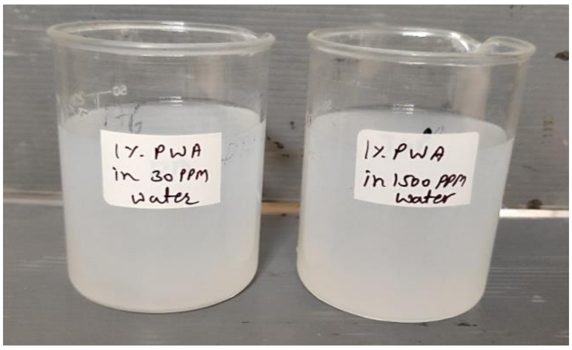

Figure 4.4 1% dispersion PWA in soft and hard water

4.1.7 Foaming behaviour of the products

Generally, foaming test is a simulation of churning of diluted pretreatment product in a machine. Jigger machine generates less foam compared to the soft flow machine. In soft flow machine, both fabric and liquor are circulating whereas in the jigger machine only fabric is circulating in open-width form.

Foam killing has two concepts namely antifoaming and defoaming. Antifoaming means foam generation is less and defoaming means rapid killing (settling) of generated foam. Anti-foam gives dewetting properties on pretreated fabric and that's why it is advisable to use a defoamer for defoaming action during the process. Here, I have used a silicone type of defoamer which kills foam very rapidly. Figure 4.5 & 4.6 shows the defoaming action starts after churning of PWA & EDA respectively.

In 100 ml 1% PWA solution, foam generation was approximately 25 ml and the settling of foam in 4-5 seconds. In 100ml 1% EDA solution, foam generation was approximately 50 ml and settling time is 7-8 seconds. Rapid defoaming actions were seen during industrial trials of cotton and viscose pre-treatment on actual machines. So, there was no need to add extra defoamer in the desizing and combined scouring–bleaching process.

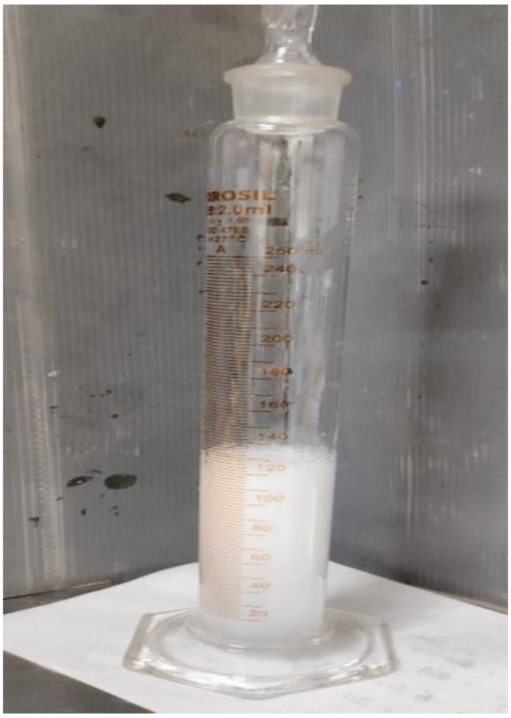

Figure 4.5 Check foaming test of 1% dispersion of PWA in water

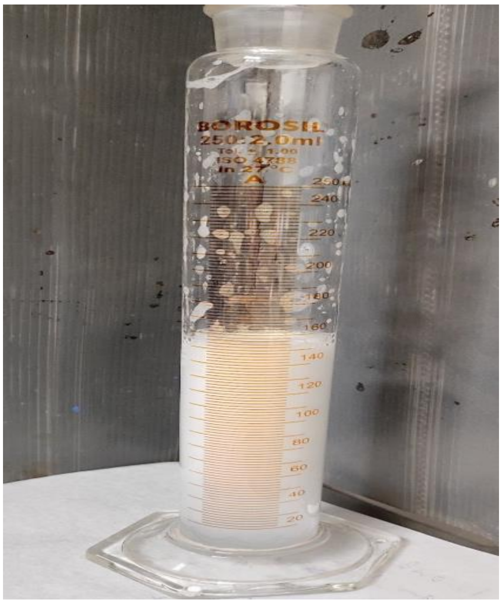

Figure 4.6 Check foaming test of 1% dispersion of EDA in water

4.1.8 Stability of the products tested by AHS test

A stability test of EDA was done at 40˚C for 1 month in the oven as the enzyme activation temperature was 50 ˚C. After 1 month, the sample was removed from the oven. The actual picture is presented in the figure 4.7. The product was checked in terms of its colour, condition and appearance. Results showed that no flocculation, no settling and no separation or coagulations were observed. The dispersibility in water was also found good. This one-month AHS test at 40˚C in the oven simulates that the product has minimum shelf life of 6 months. Samples were kept for 6 months at room temperature to reconfirm the results of the AHS study. The room temperature sample showed similar good results as were observed in AHS sample.

Figure 4.7 EDA in a glass bottle for 40˚C stability test

Figure 4.8 PWA in a glass bottle for 80˚C oven for stability test

The stability test of PWA was done at 80˚C for 8 days in the oven. After 8 days, the sample was removed from the oven. The actual picture is shown in the figure 4.8. The product was found in good condition i.e., colour and appearance. Results also showed that no flocculation, no settling, and no separation were observed. The dispersibility test in water was good.These eight days at 80˚C AHS simulates minimum shelf life of 1-year of the product. It was tested simultaneously for 1 year at room temperature to compare the results of the AHS study and similar good results were found.

4.1.9 Particle size distribution and Zeta potential

The particle size and size distribution of EDA and PWA were analyzed on the Malvern instrument. Figure 4.9 and 4.10. shows the intensity size distribution of EDA and PWA dispersed in water. The first peak of EDA at around 1558 nm arises from the dispersion.

The particle size and the size distribution graph as shown in the corresponding figure 4.9 for EDA, shows that the Z-average size of the dispersed particles is 2455 with Pdi value of 0.419. Two peaks for the size and size distribution in EDA solution is seen, indicats the solution is in polydisperse condition.

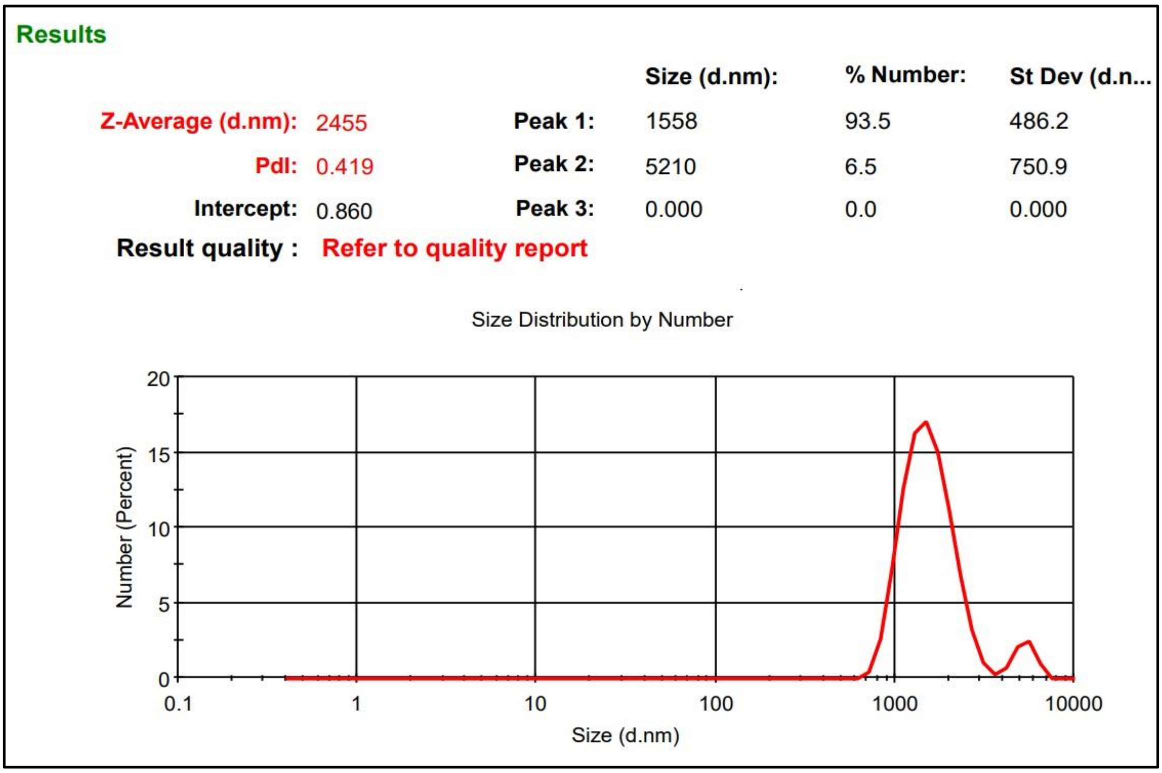

Figure 4.9 Particle size and size distribution of EDA

The particle size and the size distribution graph as shown in the corresponding figure 4.10 for PWA, shows that the Z-average size of the dispersed particles is 2607 with Pdi value of 0.362. This indicates that the size distribution is in very narrow range. The uniform size and narrow range of size distribution may responsible for the higher stability of the PWA product.

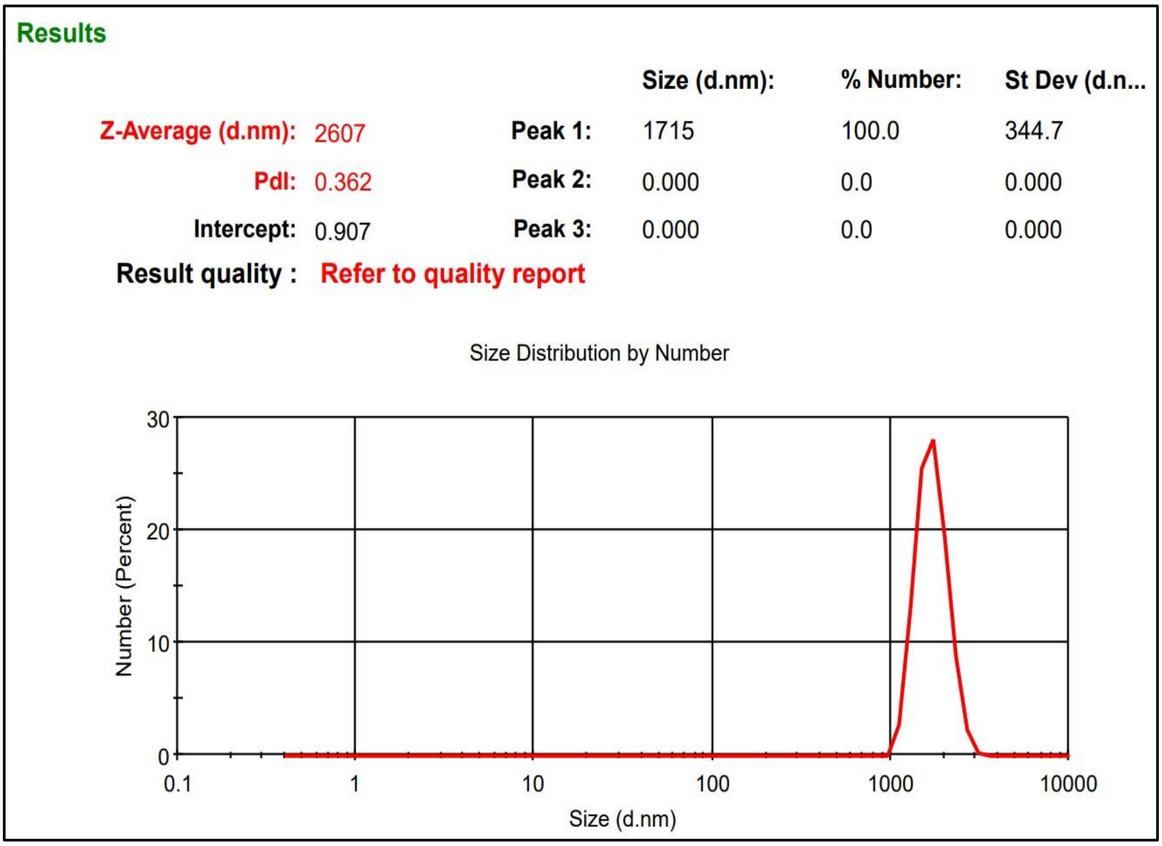

Figure 4.10 Particle size and size distributionof PWA

The following figures 4.11 and 4.12 for zeta potential and zeta deviation of PWA and EDA solutions shows that the Zeta Potential value for PWA is -8.18 mVand zeta deviation of the same is 2.63 mV. Similarly the Zeta Potential value for EDA is -9.45 mV and zeta deviation of the same is 3.16 Mv.

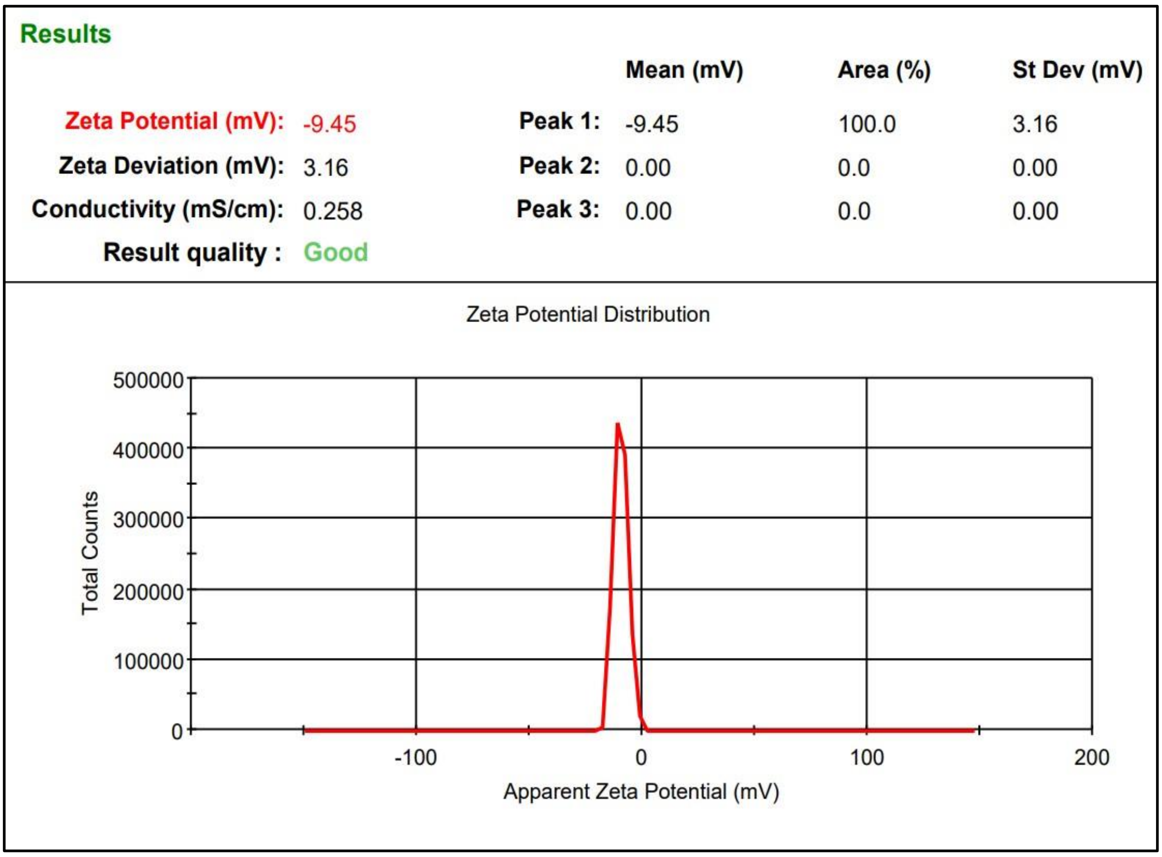

Figure 4.11 Zeta Potential and zeta deviation of EDA

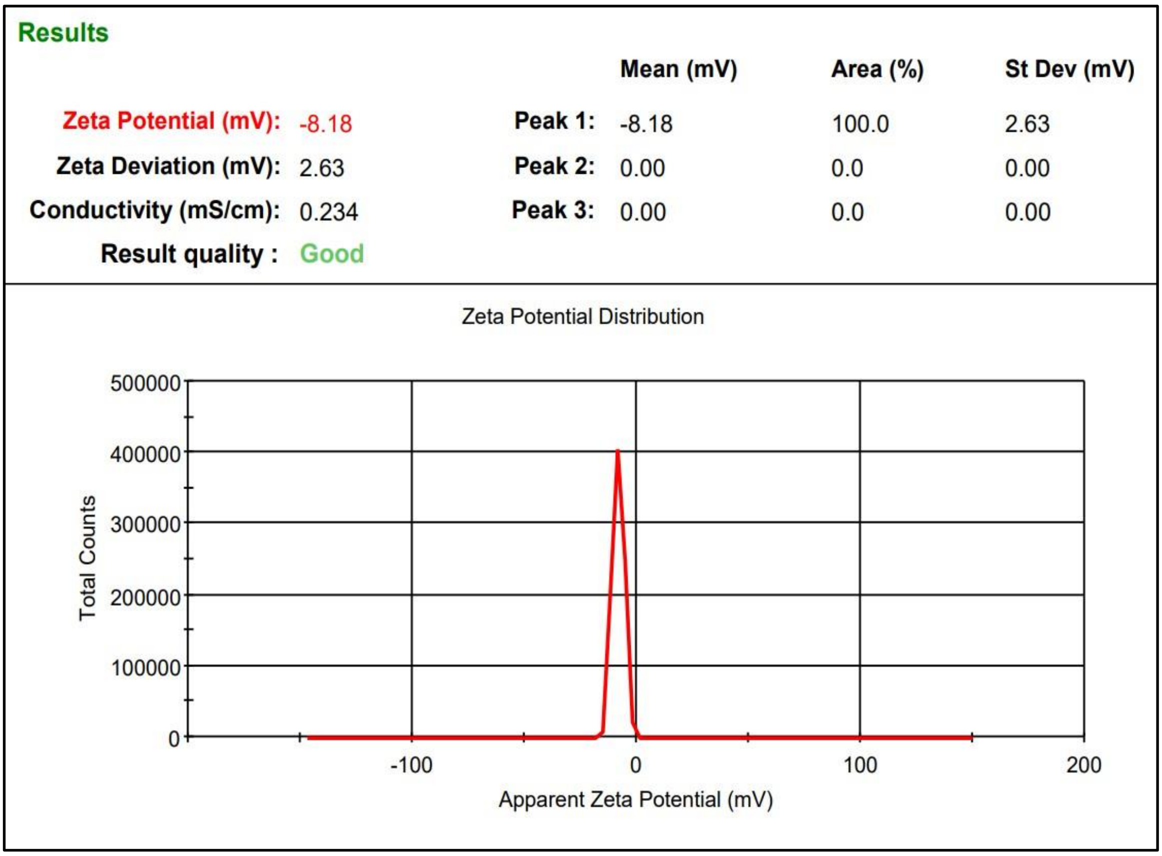

Figure 4.12 Zeta Potential and zeta deviation of PWA

4.1.10 Amylase activity in EDA

The lab evaluation of amylase enzyme and optimization study results shows the following.

- The pH at which the amylase enzyme has maximum activity was set as the optimum pH of the amylase. The optimum activity of amylase was observed in phosphate buffer at pH 5.5.
- The temperature at which the amylase enzyme has maximum activity was set as the optimum temperature of the amylase. The optimum activity of amylase was seen at pH 75°C temperature.
- The time at which the amylase enzyme shows maximum activity was set as the optimum time of the amylase. The optimum activity of amylase was seen at 45 minutes of incubation time.

4.2 Analysis of optimized parameters for the pretreatment of cotton woven, viscose woven and cotton knitted fabric

4.2.1 Analysis of optimized parameters for desizing process of cotton woven

Good desizing depends on different processing parameters which results in good tegawa rating. Graphs shown in Figure 4.13 to 4.17 point up that the best Tegawa rating (8-9 Tegawa) achieved by optimizing dosage of EDA, pH of desize bath, dwell time of process, temperature of desize bath and water qulity used to processing.

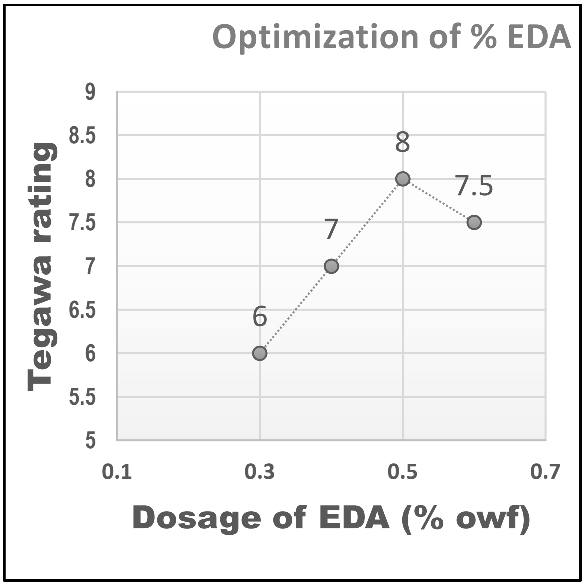

Figure 4.13 Optimization concentration of EDA in cotton woven desizing

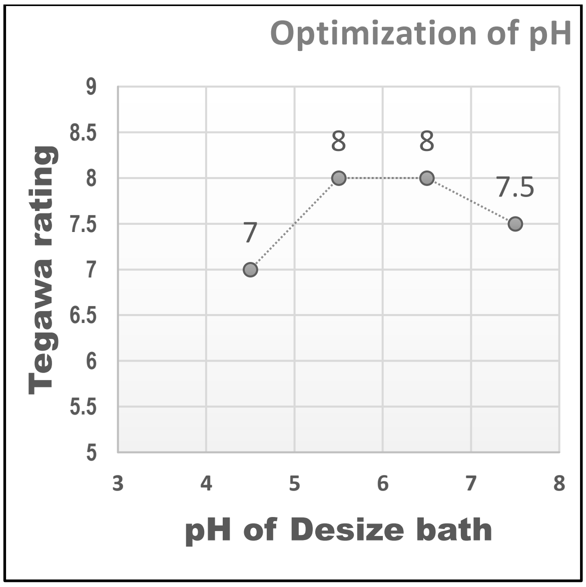

Figure 4.14 Optimization of pH in cotton woven desizing

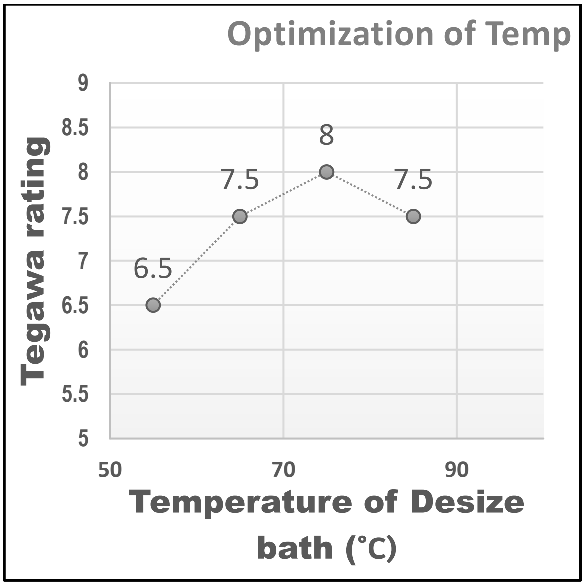

Figure 4.15 Optimization of bath Temperature in cotton woven desizing

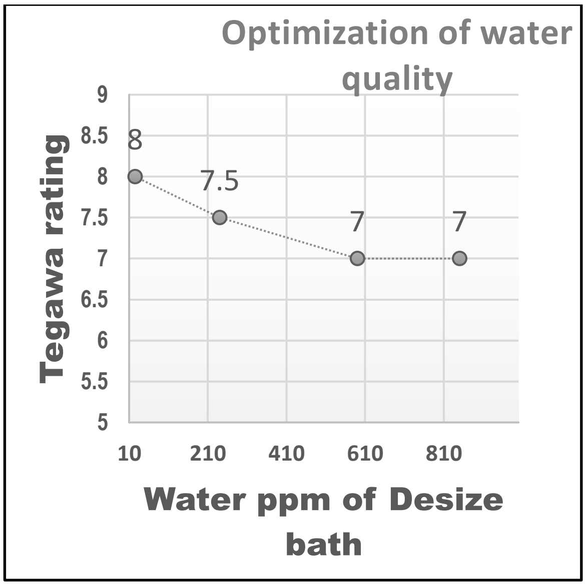

Figure 4.16 Optimization of quality of water in cotton woven Desizing

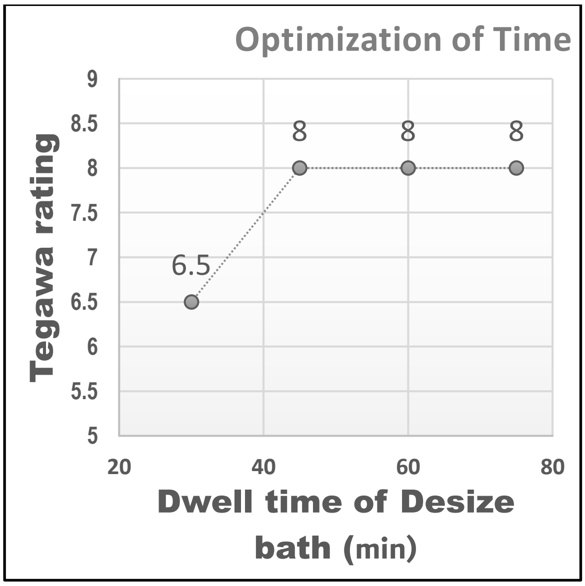

Figure 4.17 Optimization of dwell time in Cotton woven Desizing

4.2.2 Analysis of optimized parameters on combined scouring & bleaching process of cotton woven fabric

Good scouring and bleaching depends on different processing parameters which results in good absorbency (1-2 seconds). From the graphs shown below it can be seen that the best absorbency achieved by optimizing dosage of PWA, optimizing dosage of NaOH, dwell time of process, temperature of bath and water qulity used for processing.

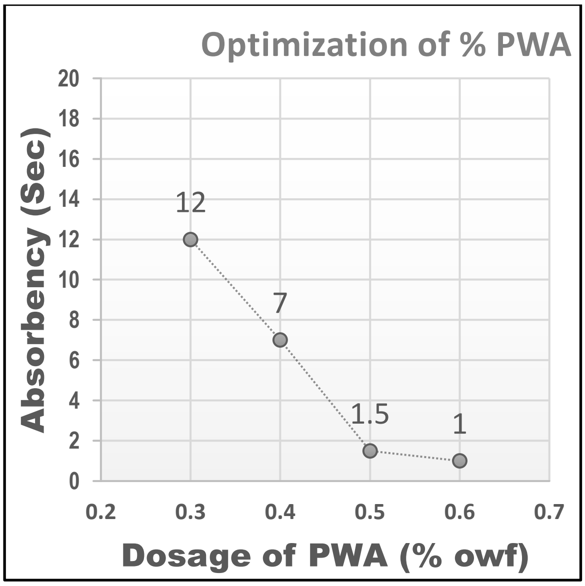

Figure 4.18 Optimization conc of PWA in cotton woven Scouring & bleaching

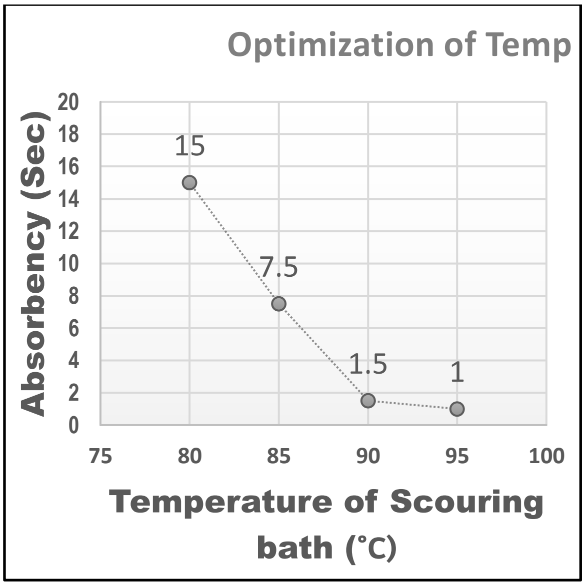

Figure 4.19 Optimization of bath Temp in cotton woven scouring & blg

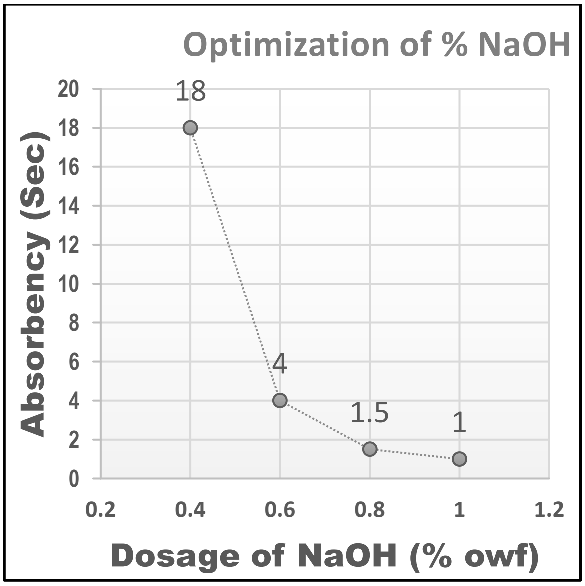

Figure 4.20 Optimization of conc of NaOH in cotton woven Scouring and bleaching

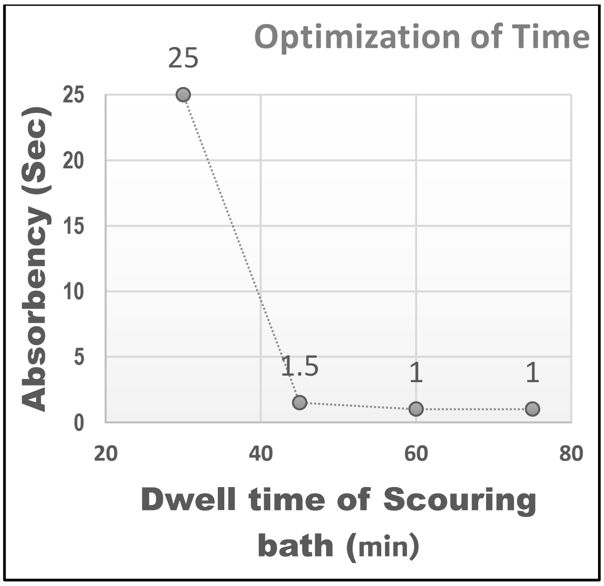

Figure 4.21 Optimization of dwell time in cotton woven Scouring and bleaching

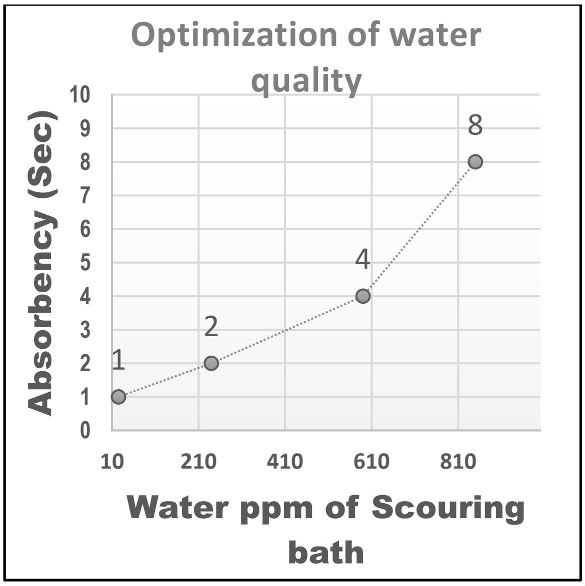

Figure 4.22 Optimization of quality of water in Cotton woven Scouring and bleaching

4.2.3 Analysis of optimized parameters for desizing process of viscose woven

Generally, desizing process carried out for viscose rayon pretreatment only. So, good desizing depends on different processing parameters which results in good tegawa rating (8-9 Tegawa). The best Tegawa rating achieved by optimizing dosage of EDA, pH of desize bath, dwell time of process, temperature of desize bath and water qulity used for the processing. The optimized results are given in the following Figures 4.23 to 4.27.

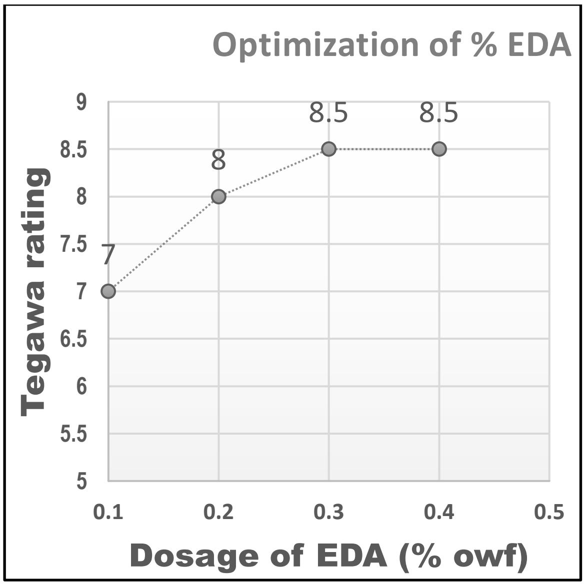

Figure 4.23 Optimization concentration of EDA in viscose woven desizing

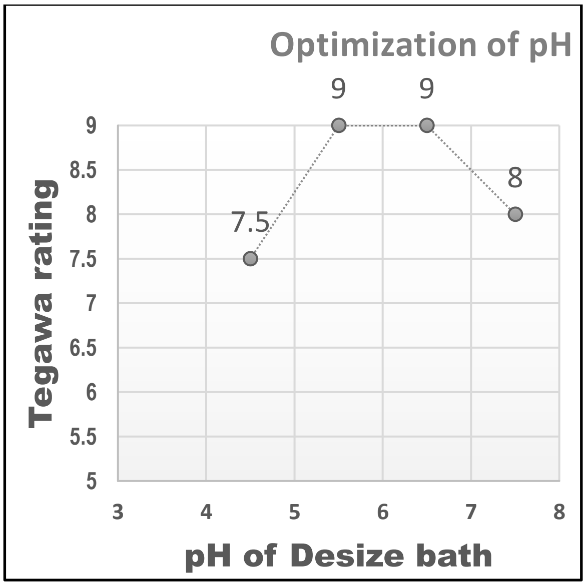

Figure 4.24 Optimization of pH in viscose woven desizing

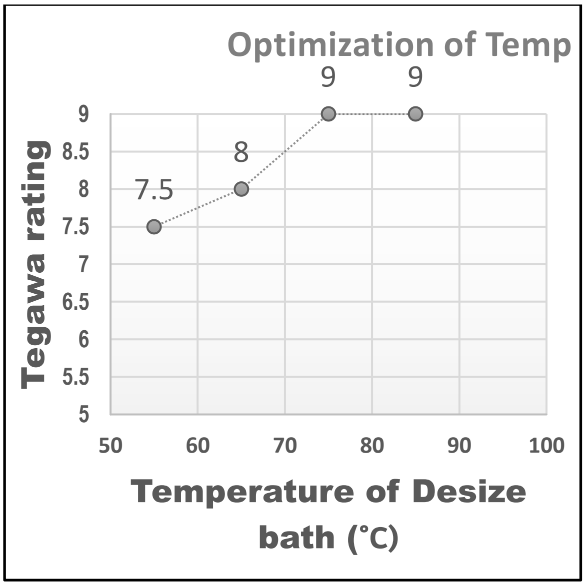

Figure 4.25 Optimization of bath Temperature in viscose woven Desizing

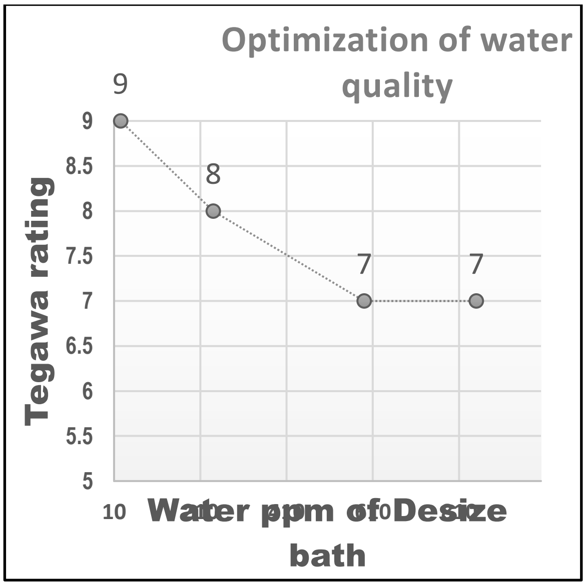

Figure 4.26 Optimization of quality of water in viscose woven desizing

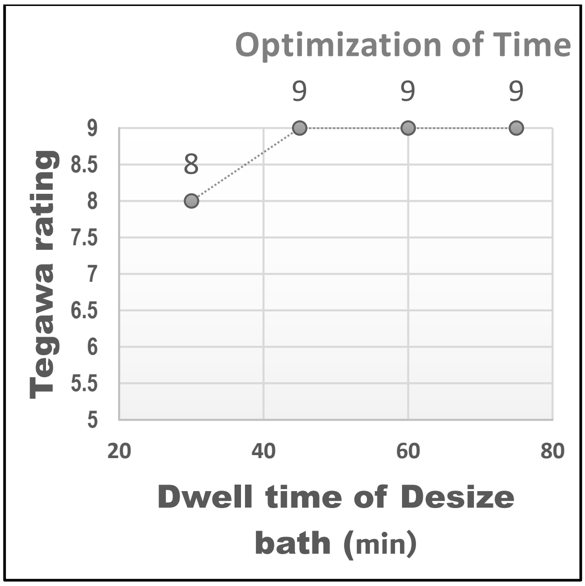

Figure 4.27 Optimization of dwell time in viscose woven desizing

4.2.4 Analysis of optimized parameters on combined Scouring & bleaching process of cotton knitted fabric

Efficacy of scouring and bleaching of cotton knitted depends on different processing parameters which results in good absorbency (1-2 seconds). Graphs shown in Figures 4.28 to 4.32. The best absorbency achieved by optimizing dosage of PWA, optimizing dosage of NaOH, dwell time of process,temperature of bath and the quality of water used for processing.

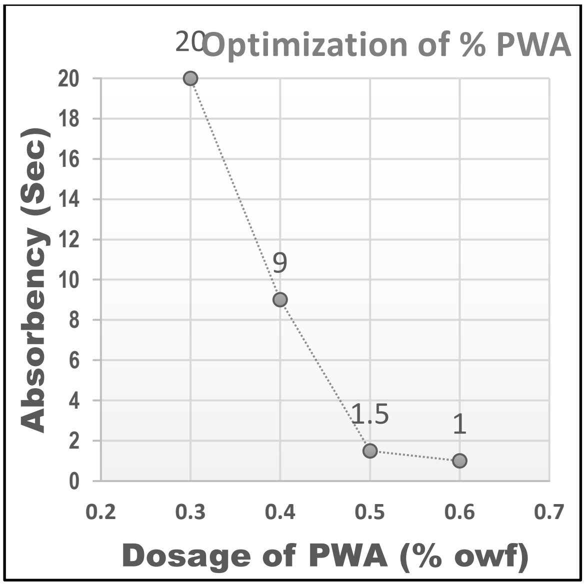

Figure 4.28 Optimization concentration of PWA in cotton knitted scouring & bleaching

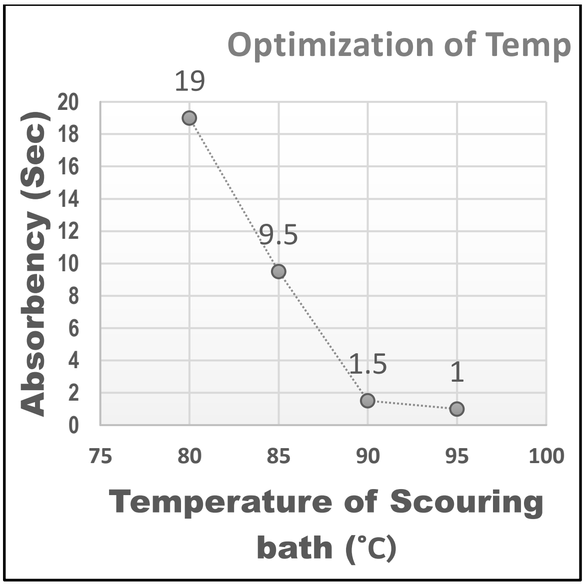

Figure 4.29 Optimization of bath Temperature in cotton knitted scouring & bleaching

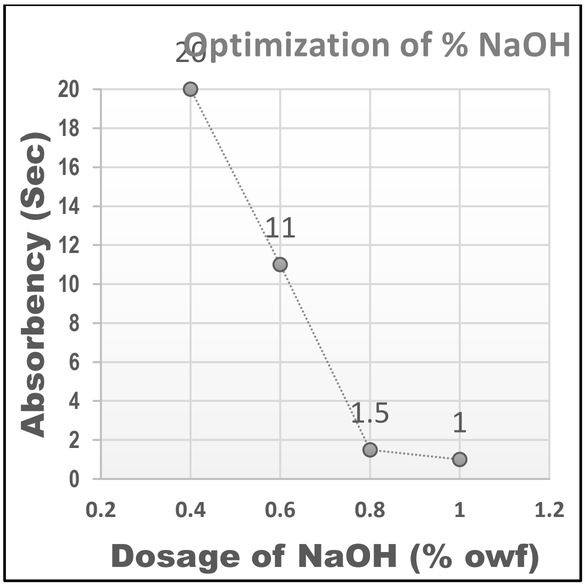

Figure 4.30 Optimization of conc of NaOH in cotton knitted scouring and bleaching

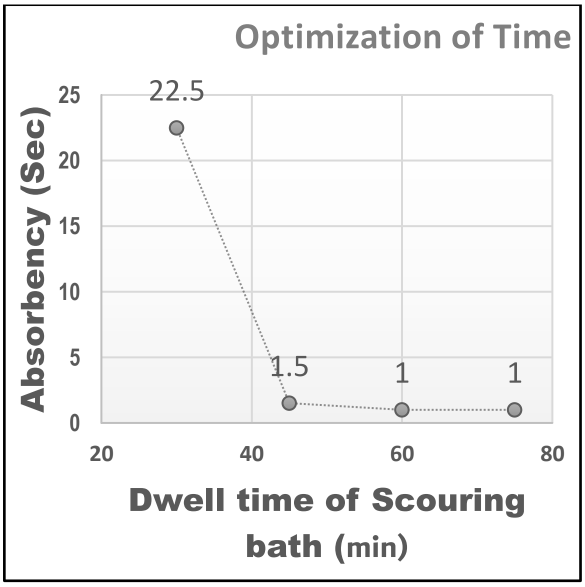

Figure 4.31 Optimization of dwell time in cotton knitted Scouring and bleaching

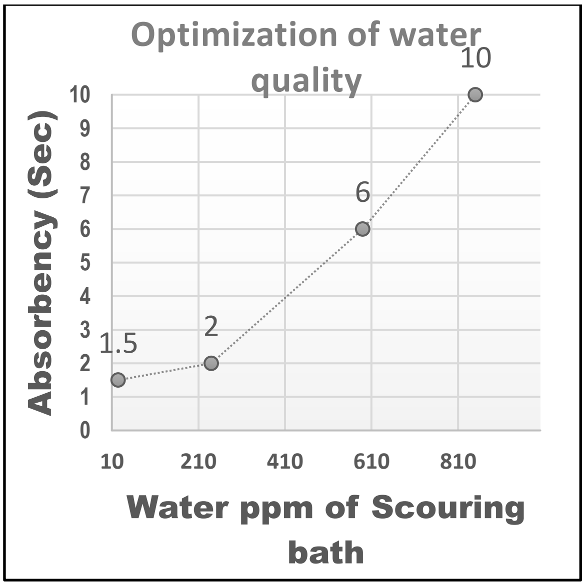

Figure 4.32 Optimization of quality of water in cotton knitted Scouring and bleaching

4.3 Result and Discussion of pretreated fabric testing methods

4.3.1 Weight loss of fabrics

GSM of grey and dry fabric after desizing wash of 100% cotton & 100% viscose-rayon woven fabric were taken. The calculated weight loss of 100% cotton woven fabric in the current pretreatment process was 3.48 % whereas in the modified process was 3%. As per the calculation of % weight loss, 100% viscose fabric in the current pretreatment process was 5.25% where as in the modified process was 3.5%. The results show that size add-ons of approximately 7-9% in sizing were removed in desizing and maybe some fiber loss was observed in the case of 100% Viscose rayon. In cotton, 100% size removal is not possible but approx. 90% size removal and maybe a small amount of fiber loss observed.

4.3.2 Tegawa rating

Table 4.1 Tegawa rating of cotton and viscose woven pretreated fabric

Sr. No.	Fabrics	Current process	Modified process
1	Cotton woven	6-7	7
2	Viscose woven	8-9	8-9

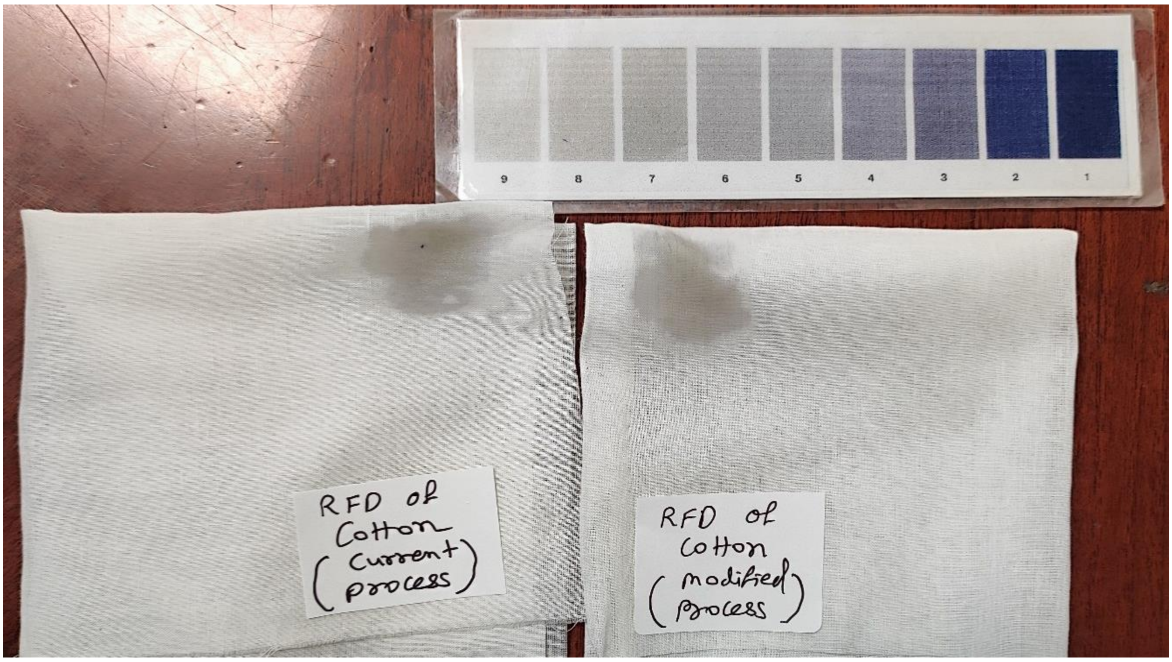

Figure 4.33 Tegawa stain on currently processed and modified processed 100% cotton woven fabric.

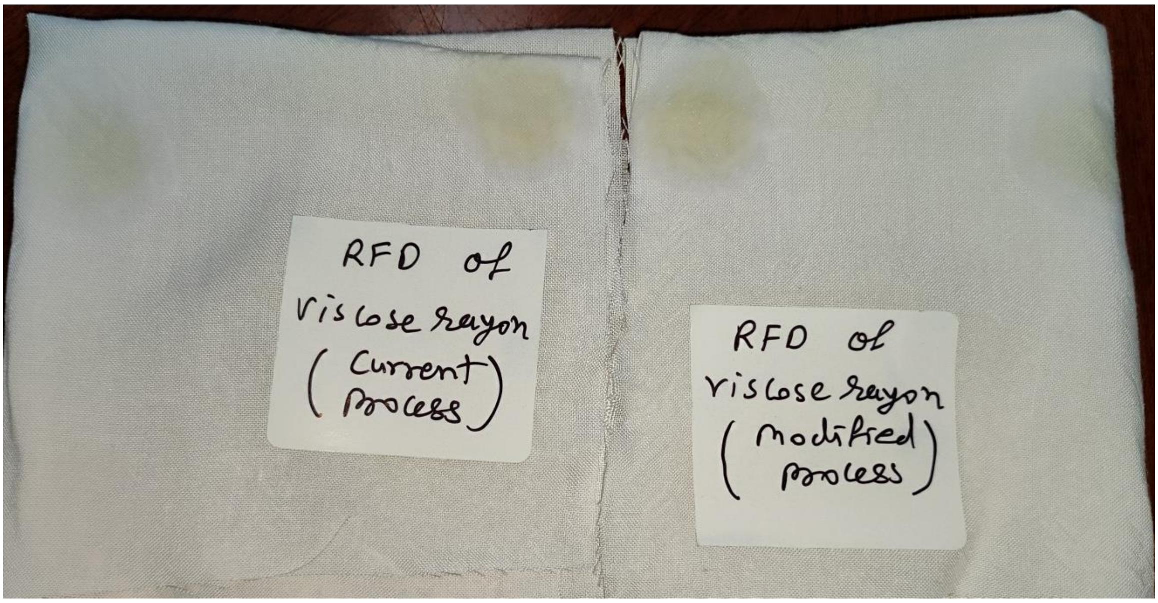

Figure 4.34 Tegawa stain on currently processed and modified processed 100% viscose woven fabric.

4.3.3 Absorbency of fabrics

Absorbency of all six fabrics of both pretreatment processes namely 100% cotton woven, 100% viscose-rayon woven, and 100% cotton knitted were carried out for 10 times each. The average of all readings was noted down. All the fabrics showed excellent absorbency. 100% cotton woven and 100% viscose-rayon woven fabrics had instant 1-2 seconds absorbency whereas 100% cotton knitted fabric had absorbancy of 2-3 seconds.

4.3.4 Sinking time

The sinking time of all six fabrics namely 100% cotton woven, 100% viscose-rayon woven and 100% cotton knitted were performed 10 times each. The average of all readings was noted down. All the fabrics showed excellent sinking behaviour with instant sinking time of 2-3 seconds.

4.3.5 Whiteness and Yellowness Index

The fabrics were analyzed in terms of any change in appearance using CCM. The results in terms of whiteness and yellowness index are given in Table 4.2. Results shows that there is only a negligible change in the whiteness and yellowness index of all three fabrics after both types of current and modified pretreatment.

Table 4.2 Whiteness and yellowness index of fabrics after current and modified pretreatment

Sr.No.	Fabric	Pretreatment	Whiteness Index	Yellowness index
1	Cotton woven	Current	60.05	10.60
		Modified	59.18	9.97
2	Viscose woven	Current	57.66	12.79
		Modified	59.86	11.85
3	Cotton knitted	Current	62.02	8.07
		Modified	60.51	9.91

4.3.6 Core pH of fabrics

The core pH of fabric depends on the alkali present in the core, which was not neutralized properly during the neutralization process. Generally, the core pH of fabric is more alkaline when more alkali is used in the pretreatment process followed by washing & neutralization is not done enough. Cotton woven and knitted fabrics showed more alkaline core pH because NaOH was used but viscose was near to neutral pH where no alkali was used. The current pretreatment process had used almost double the dosage of alkali compared to the modified process which shows that higher core pH in the current processed compared to the modified processed fabric as per table 4.3

Table 4.3 Core pH of fabrics after current and modified pretreatment

Sr.No.	Fabric	Pretreatment	Core pH of the fabric
1	Cotton woven	Current	8.45
		Modified	8.02
2	Viscose woven	Current	7.40
		Modified	7.55
3	Cotton knitted	Current	8.61
		Modified	8.21

4.3.7 Dyeing of pretreated fabrics and their colour strength

Dyeing was done by reactive dyeing on all three types of fabric and colour strength was measured on a spectrophotometer. Here, current pretreatment dyed fabric has been taken as standard and modified pretreatment is taken as a sample for evaluation.

Table 4.4 Colour strength of current and modified pretreated fabrics

Pre treatment	Spectrophotometer reading							
	L	a	b	DL	Da	Db	DE	% Strength
Bottle green dyed cotton woven fabric								
Current	31.16	-16.72	-7.70	-	-	-	-	100
Modified	31.08	-16.15	-6.81	-0.08D	0.57R	0.89Y	1.06	99.42
Turquoise blue dyed viscose woven fabric								
Current	44.42	-35.77	-15.49	-	-	-	-	100
Modified	45.12	-36.66	-16.66	0.70L	-0.89G	-1.17B	1.63	99.13
Purple-dyed cotton knitted fabric								
Current	35.59	19.74	-9.19	-	-	-	-	100
Modified	35.77	21.13	-8.81	0.18L	1.39R	0.38Y	1.46	99.22

It can be seen from the results shown in the above table that there is no significant change in colour strength values of dyed samples after current and modified pretreatments irrespective of the type of fabric or dye used for the colouration of textiles.

4.3.8 Tensile strength of fabrics

The results for tensile strength (dry) and elongation at break of current as well as modified pretreatment are given in Table 4.5 and their effect is graphically represented in Figure 4.35 & 4.36.

Table 4.5 Tensile strength of current and modified pretreated fabrics

Sr.No.	Fabric	Pretreatment	Lengthwise/ Widthwise	Load (kgf)	Percentage Strain
1	Cotton woven	Current	Warp	18.57	19.35
			Weft	11.28	5.14
		Modified	Warp	19.15	19.85
			Weft	11.55	5.25
2	Viscose woven	Current	Warp	23.16	8.92
			Weft	19.50	8.42
		Modified	Warp	24.50	9.47
			Weft	22.85	9.10
3	Cotton knitted	Current	Course	38.44	81.44
			Wale	22.74	78.44
		Modified	Course	40.05	83.08
			Wale	22.50	79.89

From the results, it can be visualized that the modified treatment marginally improves the tensile strength of all the fabrics most probably due to the lower concentration of auxiliaries and lower washing cycle. It is clear from the corresponding figures that the modified treatment leads to a slight improvement in the tensile strength as well as elongation at break. The improvement in the tensile and elongation of fabric attributed due to the lesser washing cycle was done in a modified process which led to lesser thermal energy usage and lesser abrasion on the cellulose chain. However, the change in improvement in values of TS and % strain varies (Figure 4.35 & 4.36) for cotton woven to viscose woven to the cotton knitted fabric. Such differences in the values of tensile strengths in warp and weft direction could be associated with variations in the class of fiber.

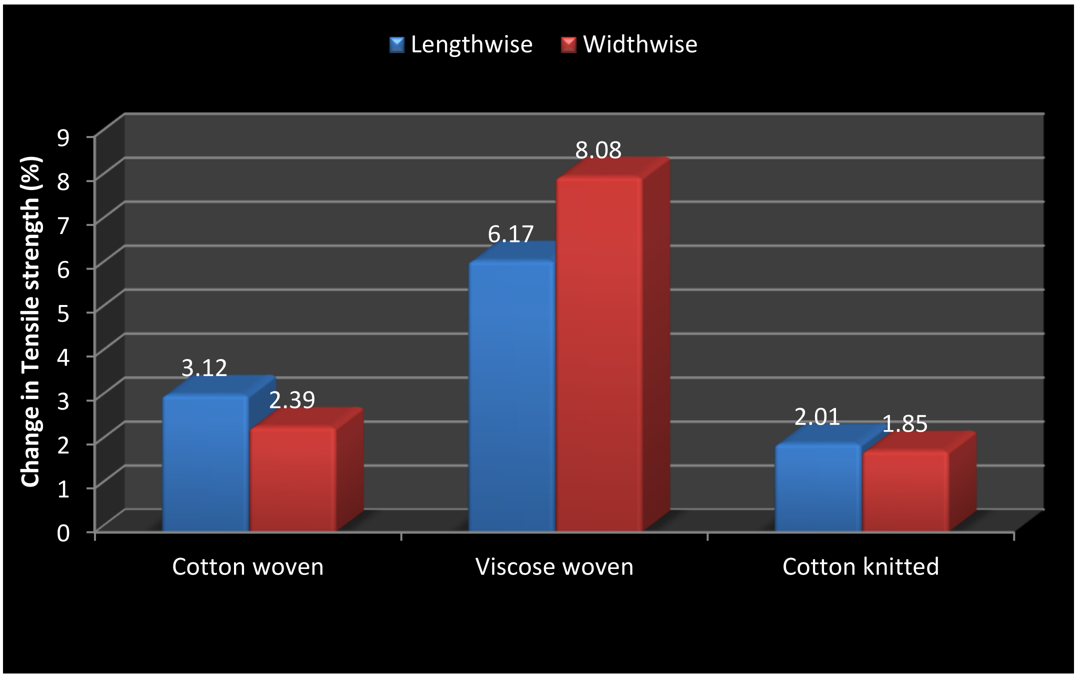

Figure 4.35 Effect of modified pretreatment on tensile strength of fabrics

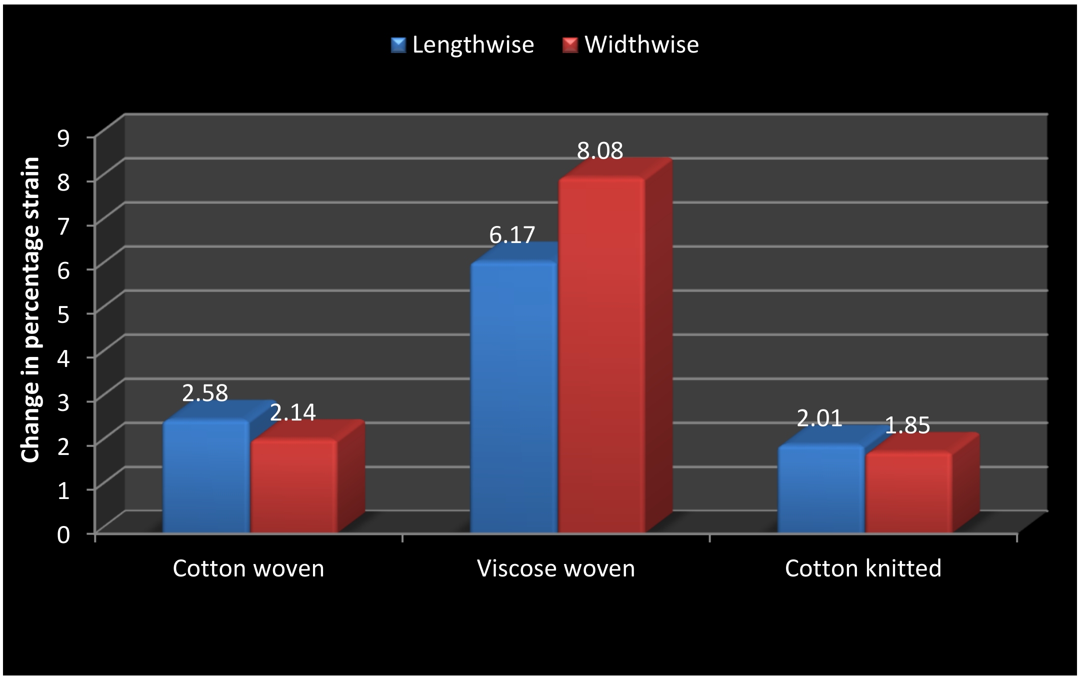

Figure 4.36 Effect of modified pretreatment on percentage strain of fabrics

4.3.9 Tear strength of fabrics

Table 4.6 Tearing strength of current and modified pretreated fabrics

Fabric	Pretreatment	Lengthwise/ Widthwise	Avg. Pointer reading	Tear strength (gms)
Cotton woven	Current	Warp	65.6	4198
		Weft	49.2	3148
	Modified	Warp	69.5	4448
		Weft	49.8	3187
Viscose woven	Current	Warp	80	5120
		Weft	66.1	4230
	Modified	Warp	84.4	5402
		Weft	69.5	4448
Cotton knitted	Current	Course	55	3520
		Wale	40	2560
	Modified	Course	59.1	3782
		Wale	40.8	2611

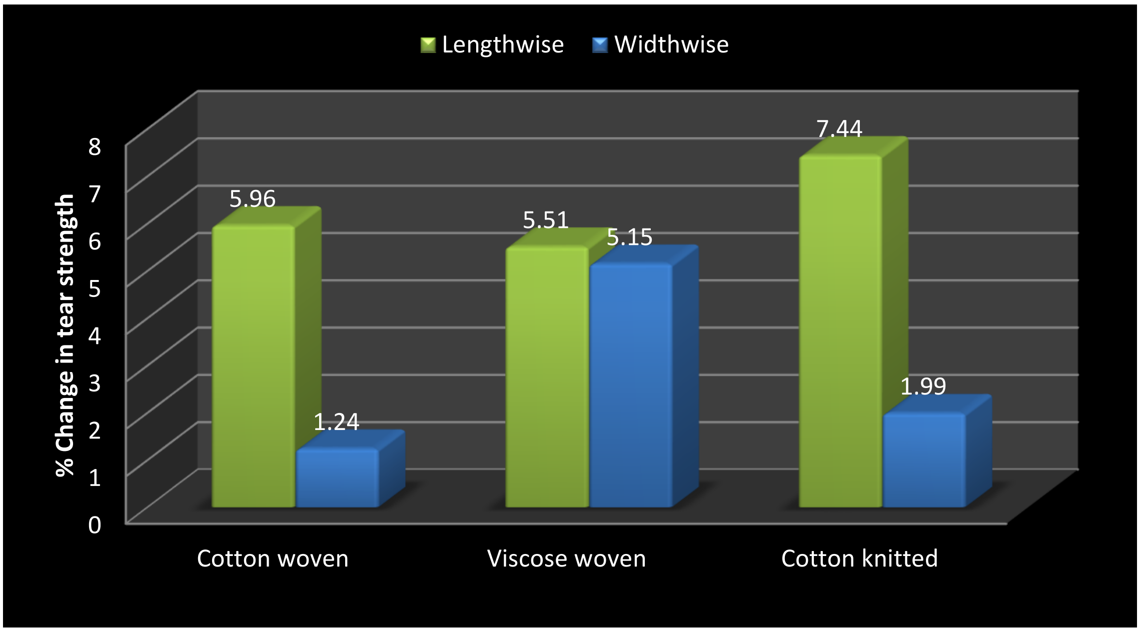

Figure 4.37 Effect of modified pretreatment on tearing strength of fabrics

The average force required to continue a tongue-type tear in a fabric is determined by measuring the work done in tearing it through a fixed distance. The tearing strength of fabric samples in both warp and weft ways was calculated by multiplying the pointer reading by weight. The results in average pointer reading and tear strength are given in Table 4.6. The change percentage of tear strength due to the modified pretreatment was shown in Figure 4.37. It can be seen from the results that the cotton woven and cotton knitted samples pretreated with the modified process showed an increase in tear strength compared to current process samples in the warp as well as in weft way by 6-7% to 1-2% respectively. The tear strength was found to increase in the case of viscose woven fabric by 5-5.5% compared to the current process pretreated sample.

4.3.10 Feel of the pretreated fabrics

These were done qualitatively by hand feel. All the fabrics of the current pretreated process and modified pretreated process were evaluated by ten persons in the Zydex lab & Surat industry. Out of these ten persons, eight persons agreed on that good feel of modified pretreatment processed fabric compared to current pretreatment processed fabric. The two persons said that no difference in the feel of fabrics in both type of processes. Modified pretreatment processed 100% viscose-rayon woven fabric showed a softer, more bulky and bouncy feel compared to the fabric processed with the current process employed by the industry.

4.4 Result and Discussion of effluent testing of current v/s modified pre-treatment process

Table 4.7 Approximate quantity of effluent generated after pretreatment of cotton and viscose process

Sr.No.	Fabrics	Quantity of fabric (kg)	Machine used for pretreatment	Effluent generated in liters	
				Current process	Modified process
1	Cotton woven	200	Jigger	4200	3000
2	Viscose woven	250	Soft flow	5000	3000
3	Cotton knitted	250	Soft flow	5000	4000

The effluent generated in the current and modified pretreatment process of three types of fabric was measured in industry. Here table 4.7 shows the amount of effluent generated in all processes.

Washing effluent parameters like BOD, COD, and TDS for current and modified process samples were evaluated by standard methods and reported in Table 4.7.

Table 4.8 Pretreatment effluent testing of cotton woven fabric by current and modified process

Sr. No.	Effluent testing parameters	Current process	Modified process
1	TDS (in PPM)	14500	9580
2	BOD for 3 days	3680	3792
3	COD	18255	14622
4	pH	8.55	7.50

Table 4.9 Pretreatment effluent testing of viscose woven fabric by current and modified process

Sr. No.	Effluent testing parameters	Current process	Modified process
1	TDS (in PPM)	952	1177
2	BOD for 3 days	3020	3193
3	COD	12520	11856
4	pH	7.75	7.59

Table 4.10 Pretreatment effluent testing of cotton knitted fabric by current and modified process

Sr. No.	Effluent testing parameters	Current process	Modified process
1	TDS (in PPM)	17500	14900
2	BOD for 3 days	3325	3218
3	COD	16525	12953
4	pH	9.23	8.58

Today, biodegradable products are used all over the world, and significant research is being done to create new synthetic processes that will enhance their application qualities. However, increasing the amount of alkalis might have serious negative environmental effects on the effluent. Table 4.8 to 4.10 makes it evident that, in contrast to the current washing effluent of the sample with higher alkali, the washing effluent with the proposed treatment does not increase the BOD, COD, TDS, or pH. It is acceptable to assume that polymer can safely deliver high durability of the intended textile functionalities based on the lower values of TDS.

4.5 Comparison of the existing process's chemical, water, steam and time consumption with the modified process

4.5.1 Comparison of pretreatment for cotton woven fabrics

- Quantity: 2239 meters
- Machine: Jigger
- Avg. GSM: 77
- Width: 45.66 inches.
- GLM = GSM*Width of fabric in meter: 77*1.16: 89.32
- Quantity: GLM* Total meters: 0.089*2239: 200Kg

***Total chemical expenditures*:**

Table 4.11 Calculating the cost of chemicals for pretreating cotton fabric

Auxiliaries/ Chemical used	Chemical Price (Rs./kg)	Dosage of product (%owf)		Cost of Chemical (Rs/kg of fabric)		
		Current process	Modified process	Current process	Modified process	Saving
Sequestering agent	80	0.2	-	0.16	-	0.16
Acetic acid	55	0.3	0.3	0.165	0.165	-
Defoamer	100	0.2	-	0.20	-	0.20
Amylase Enzyme	100	0.8	-	0.80	-	0.80
EDA	300	-	0.5	-	1.50	-1.50
Sequestering agent	80	0.2	-	0.16	-	0.16
Wetting agent	150	0.5	-	0.75	-	0.75
PWA	250	-	0.5	-	1.25	-1.25
Defoamer	100	0.2	-	0.20	-	0.20
NaOH	38	2	0.8	0.76	0.304	0.456
Peroxide	35	3	3	1.05	1.05	-

Peroxide stabilizer	80	1	1	0.80	0.80	-
Acetic acid	55	0.6	0.4	0.33	0.22	0.11
Total				**5.38**	**5.29**	**0.09**

- Chemical cost in current process = 5.38 Rs./Kg of fabric
- Chemical cost in Modified process = 5.29 Rs./Kg of fabric
- Total chemical cost saving = **0.09Rs./Kg of fabric**

***Total water required*:**

Table 4.12 Calculation of water savings for pretreatment of cotton woven fabrics

Sr. No.	Process Sequence	M:L:R	Water in litres / kg of fabric		
			Current process	Modified process	Saving
1	Prewash	1:3	3	-	3
2	Desizing	1:3	3	3	-
3	Hot wash	1:3	3	-	3
4	Scouring& Bleaching	1:3	3	3	-
5	Hot wash	1:3	3	3	-
6	Hot wash	1:3	3	3	-
7	Cold wash& Neutralizing	1:3	3	3	-
	Total		**21**	**15**	**6**

- Water required/kg of the fabric in current process = 21liters
- Water required/kg of the fabric in Modified process = 15liters
- Total water required in current process = (21*200) = 4200liters
- Total water required in Modified process = (15*200) = 3000 liters
- Total water saving = (6*200) = **1200 liters**.

***Total steam required*:**

Table 4.13 Calculating steam savings for treating cotton woven fabric

Sr. No.	Process Sequence	Steam in kg/ kg of fabric		
		Current process	Modified process	Saving
1	Prewash	0.5	-	0.5
2	Desizing	1.1	1.1	-
3	Hot wash	0.5	-	0.5
4	Scouring & Bleaching	1.7	1.4	0.3
5	Hot wash	0.8	0.5	0.3
6	Hot wash	0.8	0.5	0.3
7	Cold wash & Neutralizing	-	-	-
	Total	**5.4**	**3.5**	**1.9**

- Total steam required in current process = (5.4*200) = 1080kg
- Total steam required in Modified process = (3.5*200) = 700kg
- Total steam saving = (1.9*200) = **380kg**

Total time required:

Table 4.14 Calculating time savings for pretreating cotton woven fabrics

Sr. no.	Process Sequence	Time(min.)		
		Current process	Modified process	Saving
1	Added water	8	-	8
2	Raised the temp. (for prewash)	5	-	5
3	Fabric loadedin current process and Circulation/ Dwell time	40	-	40
4	Drained liquor	2	-	2
5	Filledthewater (for desizing)	8	8	-
6	Fabric loaded in modified process and Circulation/ Dwell time	40	40	-
7	Raised the temp.	6	7	-1
8	Circulation/ Dwell time	120	120	-

9	Drained & filled the water(for hot wash)	10	-	10
10	Raised the temp.	8	-	8
11	Circulation/ Dwell time	40	-	40
12	Drained and filled the water (for scouring & bleaching)	10	10	-
13	Raised the temp.	4	4	-
14	Circulation/ Dwell time	40	40	-
15	Raised the temp.	7	6	1
16	Circulation/ Dwell time	160	120	40
17	Drained and filled the water (for hot wash-1)	10	10	-
18	Raised the temp.	11	10	1
19	Circulation/ Dwell time	80	40	40
20	Drained and filled the water (for hot wash-2)	10	10	-
21	Raised the temp.	11	10	1
22	Circulation/ Dwell time	80	40	40
23	Drained and filled the water (for cold wash)	10	10	-
24	Cold wash	40	40	-
25	Neutralization	40	40	-
26	Drained liquor	2	2	-
27	Unloaded the fabric	20	20	-
	Total time	**822**	**587**	**235**

- Total time required to complete pretreatment cycle in current process = 13 hours and 42 minutes
- Total time required to complete pretreatment cycle in modified process = 9 hours and 47 minutes
- Total time saving = **3 hours and 55 minutes**

4.5.2 Comparison of pretreatment for viscose woven fabric

- Quantity: 1925 meters
- Machine: Soft flow
- Avg. GSM: 108
- Width: 47.33 inches.

- GLM = GSM*Width of fabric in meter: 108*1.20: 129.83
- Quantity: GLM* Total meters: 0.130*1925: 250Kg

***Total chemical cost involved*:**

Table 4.15 Calculating the cost of chemicals for pretreatment of viscose rayon woven

Auxiliaries/ Chemical used	Chemical Price (Rs./kg)	Dosage of product (%owf)		Cost of Chemical (Rs/kg of fabric)		
		Current process	Modified process	Current process	Modified process	Saving
Sequestering agent	80	0.2	-	0.16	-	0.16
Wetting agent	150	0.4	-	0.60	-	0.60
Defoamer	100	0.2	-	0.20	-	0.20
Acetic acid	55	0.3	0.3	0.165	0.165	-
Amylase Enzyme	100	0.5	-	0.50	-	0.50
EDA	300	-	0.3	-	0.90	-0.90
Total				**1.63**	**1.07**	**0.56**

- Chemical cost in current process =1.63Rs./Kg of fabric
- Chemical cost in Modified process =1.07Rs./Kg of fabric
- Total chemical cost saving = **0.56Rs./Kg of fabric**

***Total water required*:**

Table 4.16 Calculating water savings for pretreatment of viscose woven fabrics

Sr. No.	Process Sequence	M:L:R	Water in kg/ kg of fabric		
			Current process	Modified process	Saving
1	Prewash	1:4	4	-	4
2	Desizing	1:4	4	4	-
3	Hot wash	1:4	4	4	-
4	Hot wash	1:4	4	-	4
5	Cold wash	1:4	4	4	-
	Total		**20**	**12**	**8**

- Water required/kg of the fabric in current process = 20litres

- Water required/kg of the fabric in Modified process = 12litres
- Total water required in current process = (20*250) = 5000litres
- Total water required in Modified process = (12*250) = 3000litres
- Total water saving = (8*250) = **2000 litres.**

***Total steam required*:**

Table 4.17 Steam saving calculation for viscose woven pretreatment

Sr. No.	Process Sequence	Steam in kg/ kg of fabric		
		Current process	**Modified process**	**Saving**
1	Prewash	0.50	-	0.50
2	Desizing	1.25	1.02	0.23
3	Hot wash	0.50	0.50	-
4	Hot wash	0.50	-	0.50
5	Cold wash	-	-	-
	Total	**2.75**	**1.52**	**1.23**

- Total steam required in current process = (2.75*250) = 687.5kg
- Total steam required in Modified process = (1.52*250) = 380kg
- Total steam saving = (1.23*250) = **307.5kg**

***Total time required*:**

Table 4.18 Calculating time savings for pretreatment of viscose woven fabrics

Sr. no.	Process Sequence	Time(min.)		
		Current process	**Modified process**	**Saving**
1	Fabricloaded&filledwater (for prewash)	15	-	15
2	Raised the temp.	7	-	7
3	Circulation/ Dwell time	10	-	10
4	Drained liquor	3	-	3
5	Fabric loaded in modified process and filledthewater (for desizing)	10	15	-5
6	Raised the temp.	15	12	3
7	Circulation/ Dwell time	60	45	15

8	Drained and filled the water (for hot wash 1)	13	13	-
9	Raised the temp.	17	15	2
10	Hot wash	10	10	-
11	Drained and filled the water (for hot wash 2)	13	-	13
12	Raised the temp	17	-	17
13	Hot wash	10	-	10
14	Drained and filled the water (for cold wash)	13	13	-
15	Cold wash & Neutralization	10	10	-
16	Drained liquor	3	3	-
17	Unloaded the fabric	15	15	-
	Total time	**241**	**151**	**90**

- Total time required to complete pretreatment cycle in current process = 4 hours and 1 minute
- Total time required to complete pretreatment cycle in modified process = 2 hours and 31 minutes
- Total time saving = **1 hour and 30 minutes**

4.5.3 Comparison of pretreatment for cotton knitted fabric

- Quantity: 1174 meters
- Machine: Soft flow
- Avg. GSM: 150
- Width: 55.9 inches.
- GLM = GSM*Width of fabric in meter: 150*1.42: 213
- Quantity: GLM* Total meters: 0.213*1174: 250Kg

Total chemical cost involved:

Table 4.19 Calculating the cost of chemicals for pretreating knit cotton

Auxiliaries/ Chemical used	Chemical Price (Rs./kg)	Dosage of product (%owf)		Cost of Chemical (Rs/kg of fabric)		
		Current process	Modified process	Current process	Modified process	Saving
Sequestering agent	80	0.2	-	0.16	-	0.16

Wetting agent	150	1	-	1.50	-	1.50
PWA	250	-	0.5	-	1.25	-1.25
Defoamer	100	0.2	-	0.20	-	0.20
NaOH	38	2	0.8	0.76	0.304	0.456
Peroxide	35	3	3	1.05	1.05	-
Peroxide stabilizer	80	1	1	0.80	0.80	-
Acetic acid	55	0.8	0.6	0.44	0.33	0.11
Total				**4.91**	**3.73**	**1.18**

- Chemical cost in current process =4.91Rs./Kg of fabric
- Chemical cost in Modified process =3.73Rs./Kg of fabric
- Total chemical cost saving = **1.18Rs./Kg of fabric**

***Total water required*:**

Table 4.20 Calculation of water savings for pretreatment of cotton knits

Sr. No.	Process Sequence	M:L:R	Water in kg/ kg of fabric		
			Current process	Modified process	Saving
1	Prewash	1:4	4	-	4
2	Scouring & Bleaching	1:4	4	4	-
3	Hot wash	1:4	4	4	-
4	Hot wash	1:4	4	4	-
5	Cold wash & Neutralizing	1:4	4	4	-
	Total		**20**	**16**	**4**

- Water required/kg of the fabric in current process = 20litres
- Water required/kg of the fabric in Modified process = 16litres
- Total water required in current process = (20*250) = 5000litres
- Total water required in Modified process = (16*250) = 4000lires
- Total water saving = (4*250) = **1000 litres**.

***Total steam required*:**

Table 4.21 Calculating steam savings for pretreatment of cotton knits

Sr. No.	Process Sequence	Steam in kg/ kg of fabric		
		Current process	Modified process	Saving
1	Prewash	0.50	-	0.50
2	Scouring & Bleaching	1.40	1.17	0.23
3	Hot wash	0.50	0.50	-
4	Hot wash	0.50	0.50	-
5	Cold wash & Neutralizing	-	-	-
	Total	**2.90**	**2.17**	**0.73**

- Total steam required in current process = (2.9*250) = 725kg
- Total steam required in Modified process = (2.17*250) = 542.5kg
- Total steam saving = (0.73*250) = **182.5kg**

***Total time required*:**

Table 4.22 Calculating time savings for pretreatment of cotton knits

Sr. No.	Process Sequence	Time(min.)		
		Current process	Modified process	Saving
1	Fabric loaded & filled water (for prewash)	10	-	10
2	Raised the temp.	8	-	8
3	Circulation/ Dwell time	10	-	10
4	Drained liquor	2	-	2
5	Fabric loaded in modified process & filled the water (for scouring)	8	10	-2
6	Raised the temp.	7	7	-
7	Circulation/ Dwell time	10	10	-
8	Raised the temp	12	10	2
9	Circulation/ Dwell time	60	45	15

10	Drained and filled the water (for hot wash 1)	10	10	-
11	Raised the temp.	11	10	1
12	Hot wash	10	10	-
13	Drained and filled the water (for hot wash 2)	10	10	-
14	Raised the temp.	11	10	1
15	Hot wash	10	10	-
16	Drained and filled the water (for cold wash)	10	10	-
17	Cold wash & Neutralization	20	20	-
18	Drained liquor	2	2	-
19	Unloaded the fabric	10	10	-
	Total time	**231**	**184**	**47**

- Total time required to complete pretreatment cycle in current process = 3 hours and 51 minutes
- Total time required to complete pretreatment cycle in modified process = 3 hours and 4 minutes
- Total time saving = **47 minutes**

4.6 The economics of the current method against the modified procedure

4.6.1 Economics comparison of Cotton woven pretreatment

***Chemical cost*:**

- Total chemical cost in current process = (5.38*200) = 1076 Rs./ Batch
- Total chemical cost in Modified process = (5.29*200) = 1058 Rs./ Batch
- **Total chemical cost saving = (0.09*200) = 18 Rs./ Batch**
- **2% chemical cost saving in modified process**

***Water cost*:**

- Cost of water = 20 Rs./1000 kg
- Save cost of water = (1200/1000)*20 = Rs 24
- **Save cost of water/kg of the fabric = (24/200) =Rs 0.12**

***Steam Cost*:**

- Cost of steam = 1.30 Rs/kg
- Total steam saves = (1.9*200) = 380kg

- Total steam cost saves = (380*1.30) = Rs. 494
- **Save cost of steam/kg of the fabric = (494/200) = Rs 2.47**

***Time Saving*:**

- Production of pretreatment in current process = 24 hours/13 hours and 42 min = 1.75 batches/ day
- Production of pretreatment in modified process = 24 hours/9 hours and 47 min = 2.45 batches/ day
- **Production was 40% higher in modified process.**

4.6.2 Economics comparison of Viscose woven pretreatment

Chemical cost

- Total chemical cost in current process = (1.63*250) = 407.5Rs./ Batch
- Total chemical cost in Modified process = (1.07*250) = 267.5Rs./ Batch
- **Total chemical cost saving = (0.56*250) = 140Rs./ Batch**
- **34% chemical cost saving in modified process**

***Water cost*:**

- Cost of water = 20 Rs/1000 litres
- Save cost of water = (2000/1000) *20 = Rs 40
- **Save cost of water/ kg of the fabric = (40/250) =Rs 0.16**

***Steam Cost*:**

- Cost of steam = 1.30 Rs/ kg
- Total steam saves = (1.23*250) = 307.5kg
- Total steam cost saves = (307.5*1.30) = Rs. 399.75
- **Save cost of steam/ kg of the fabric = (399.75/250) = Rs 1.60**

***Time Saving*:**

- Production of pretreatment in current process = 24 hours/4 hours and 1 min = 5.98 batches/ day
- Production of pretreatment in modified process = 24 hours/2 hours and 31 min = 9.54 batches/ day
- **Production was 60% higher in modified process.**

4.6.3 Economics comparison of Cotton knitted pretreatment

***Chemical cost*:**

- Total chemical cost in current process = (4.91*250) = 1227.5Rs./ Batch
- Total chemical cost in Modified process = (3.73*250) = 932.5Rs./ Batch
- **Total chemical cost saving = (1.18*250) = 295Rs./ Batch**
- **24% chemical cost saving in modified process**

***Water cost*:**

- Cost of water = 20 Rs/1000 litres
- Save cost of water = (1000/1000) *20 = Rs 20
- **Save cost of water/ kg of the fabric = (20/250) =Rs 0.08**

***Steam Cost*:**

- Cost of steam = 1.30 Rs/ kg
- Total steam saves = (0.73*250) = 182.5kg
- Total steam cost saves = (182.5*1.30) = Rs. 237.25
- **Save cost of steam/ kg of the fabric = (237.25/250) = Rs 0.95**

***Time Saving*:**

- Production of pretreatment in current process = 24 hours/3 hours and 51 min = 6.23 batches / day
- Production of pretreatment in modified process = 24 hours/3 hours and 4 min = 7.83 batches / day
- **Production was 25% higher in modified process.**

4.7 Cost-saving comparison

The cost was involved for Current and modified pretreatment process of 100% cotton woven, 100% Viscose rayon woven and 100% cotton knitted fabrics seen in Table 4.23. These cost was divided in four major parts i.e. chemical cost, water cost, steam cost and time saving.

From the data given in above table 4.23, it can be seen that the new modified pretreatment process not only save the cost per batch but also give higher production compared to the current process for the same pretreatment employed by the industry.

Highest production i.e. almost 60 % increase can be achived by the new modified preparatory method in case of pretreatment of viscose rayon woven fabric. In case of cotton woven and cotton knitted fabric the increase in production is 40 % and 25 % respectively.

Table 4.23 Total saving with the modified pretreatment process

Sr. No.	Different Cost	Total saving in Cotton woven	Total saving in Viscose woven	Total saving in Cotton knitted
		Cost Saving		
1	Chemical cost (Rs./ Batch)	18	140	295
2	Water cost (Rs./ Batch)	24	40	20
3	Steam cost (Rs./ Batch)	494	400	237
	Total (Rs./Batch)	**536**	**580**	**552**
		Time Saving		
4	**Time saving**	**40% higher production**	**60% higher production**	**25% higher production**