Analyzing Performance of Esterified Starch against Thin Boiling Starch for Warp Sizing Applications
Part I : Comparative Study of Two Starches as Size Binders

Parthiv R. Patel[1] Prof. A. I. Thakkar[2]
[1] M. E. Student, Department of Textile Technology
[2] Associate Professor, Department of Textile Technology
[1, 2] L. D. College of Engineering, Ahmedabad, Gujarat, India.

Abstract – Sizing imparts the strength and increases the abrasion resistance of warp yarn in a weave-shed. Various methods were established for characterizing size films and sized yarns to establish relationships that might be useful in predicting weaving performance. A variety of natural and synthetic binders were applied to cotton yarn in a laboratory sizing apparatus, equipments and other available sources.
There are two critical factors to evaluate size material performance are : Size must from a tough but flexible film to protect the yarn from stress , strain and rubbing actions , and there must be good adhesion between size and yarn. The flexibility i.e. extensibility is correlated with tensile properties of films. The degree of adhesion was evaluated by Lap-joint test in this study. Presence of starch percentage even after desizing was determined on Tegewa scales, important for environmental concerns [4, 7].

Keywords: Sizing, Esterified starch, Thin Boiling starch, Desizing, Cohesion, Viscosity

I. INTRODUCTION

Sizing is an important process affecting productivity of weaving process. Sizing imparts strength and improves abrasion resistance of warp yarn by coating a thin film of size ingredients so that it can withstand against several actions it is subjected to during weaving process i.e. cyclic strain, flexing abrasion at various loom parts and inter yarn friction. Selection of sizing chemicals (agent) is important because chemistry of sizing chemical with yarn decides in the degree of improvement in yarn strength. In modern times, weaving process has become highly sophisticated with loom speeds have increased ten-folds. The effectiveness of sizing depends not only on the adhesion between size and yarn but also on the film-forming properties of the size material, the properties of yarn themselves and machine variables. Even after sizing, size must be removed easily from the fabric after weaving without environmental and ecological damage. The selection of sizing ingredients is very critical and complex because the options available is in wide range[1,4,7].

Natural starch and its derivatives constitue nearly 75% of sizing agents used. Many attempts have been made to evaluate the variables that affect size performance without expensive full-scale sizing and weaving trials [4].
The purpose of this study is to explore the suitability of different experimental approach at R & D Laboratory level (Anil Ltd. ,Ahemdabad) for characterizing sizes and sized yarn properties. In context of this we have compared two chemically modified starches i.e. Esterified starch and Thin-Boiling starch, for their various properties.

II. MATERIALS AND METHODS

A. *Size Paste Preparation*

Esterified and Thin-Boiling starch powders were provided by the manufacturer (Anil Ltd. , Ahmedabad). 880 gms demineral water and 120 gms starch powder was taken in a vessel. The vessel with starch slurry was kept in boiling water bath $100^0C \pm 1^0$ C temperature for 30 minutes where the agitatior speed of 360 rpm used for thorough mixing. One after one both starch pastes were prepared.

B. *Size Film Preparation*

The size paste casted over methacrylate plates of 20cm(L) x 20cm(W) and 6mm thickness kept at room tempaerature for 8hrs and then in Stability Chamber at 40^0C and 75% R.H. for 1 hour. The sample were prepared to test the tensile strength on Instron.

C. *Size Film Tensile Strength test at different Relative Humidity (R.H.) Levels*

Six samples of esterified starch films 7" (L) x 1" (W) were prepared and three samples were conditioned at temperature 40^0C and 65% R.H. and remaining 3 at temperature 40^0C and 80% R.H. in Stability Chamber, kept for 1 hour. The samples were prepared to test the tensile strength on Instron Strength Tester under standard atmospheric condition , $20^0C \pm 2^0C$ temperature and 65%±2% R.H.

D. *Moisture Regain of Size Film*

Esterified starch film sample were placed in petri dish and weighted by Analytical Balance. The petri dish was kept in oven at temperature $110^0C \pm 2^0C$ for 1 hour , then in Desiccator for 15 minutes and Moisture Regain (%) was calculated by Weight-Loss method. The same method was applied for the Thin-Boiling starch film Moisture Regain (%).

E. *Film Solubility Test*

Plain water was taken in a beaker and 1" mark Esterified Starch film was dip in water. The stand was used to grip the film sample at room temperature ($28^0C \pm 2^0C$). The time was noted by stop watch to dissolve in water of Esterified Starch film.

F. *Viscosity Measurementby Rapid Visco Analyzer (RVA) equipment*

The RVA of Newport Scientific was used for the purpose 12% W/W Esterified and Thin-Boiling starch slurries were tested one by one on RVA. It records automatically the difference in viscosity units (centipoise) as the temperature changes. Initially the speed of agitator is set as 1000 rpm for slurry mixing for first 10 sec and then kept at 160 rpm for the entire test of 13 min. RVA takes only 5 min to reach at 95^0C. It records the change in viscosity units in centipoise (cP) as the temperature changes and graph is plotted on connected moniter.

G. *Lap Joint Test for Adhesion Power of Size Material (Paste)*

Six samples were cut to 5"(L) x 1"(W) from desized cotton fabric. They were arranged in a group of two. The two samples were bonded with adhesion of Esterfied Starch paste with 1" overlapping between the two samples at the edge. Thus resulting the total fabric sample length of 9". Then two more samples were prepared in a similar way. These three samples were placed in between the two methacrylate plates under the brick load of 4.5kg as for 30 min. Then they were kept for drying at room temperature for 24 hours.

In the similar way the samples for Thin-Boilong starch were prepared for adhesion power tensile test at Instron.

H. *Size Add-on(%) of Size Paste on Fabrics samples*

Two unsized fabric samples of 10"(L) x 4"(W) were taken one fabric sample was dipped in 12% W/W Esterified Starch paste, the size roll of 5kg. weight was applied for 1 stroke (squeezing) at room temperature and was dried for three hours. In the same way Thin-Boiling starch paste fabric sample was prepared.

I. *Desizing of Sized Fabric Samples*

Sized fabric samples of both type of starches were desized by Enzymatic treatment. (α-Amylase Enzyme 0.5ml/lit.of distilled water, sample weight= 3.5gms, so 175ml solution used).

The Esterified starch sized sample was given α-Amylase Enzymatic wash for 10 min and two plain water washes of each 5 min in Boiling water bath at 95^0C $\pm$ 2^0C. In similar way the Thin-Boiling starch fabric sample desizing was carried out.

J. *Presence of Starch percentage in Desired by TEGEWA Scales*

Tegewa Reagent was prepared by a standard method using Potassium Iodide (KI), Distilled water, Iodine and Ethanol.

Desized fabric sample of Esterified starch at room temperature was first diped in Tegewa Reagent for 30 sec and then in plain water for 1min.The change in colour of fabric sample matched on Tegewa scales which determines the presence of starch percentage. In the same way Thin-Boiling starch desized fabric was analysed on Tegewa Scales.

III. RESULTS AND DISCUSSIONS

A. *Effect of Size Film Preparation :*

The film of Esterified starch was peeled-off easily while the film of Thin boiling starch was found brittle and weak . Not only the the film was brittle but also the creation of 2"(L) x 1"(W) sample could not be achieved .

Thickness of films measured on electronic micrometer screw gauge were as follows :

- Esterified Starch = 0.087 millimeters
- Thin-boiling Starch = 0.045 millimeters

B. *Results of Size Film Tensile Strength test at different Relative Humidity (R.H.) Levels :*

Results at 65% R.H. and 80% R.H. of Esterified Starch (ES) film at 2" Gauge length of sample on Instron Tensile tester.

Sample No.	Sample	Max.Load (N)	Load at break (Std) (N)	Elongation (%)	Tensile Strength (kgf/cm^2)
1	ES film 65%	106.48	106.48	1.67	108.58
2	ES film 65%	115.15	115.15	2.53	117.42
3	ES film 65%	81.46	81.46	0.87	83.07
Avg.		**101.03**	**101.03**	**1.69**	**103.02**

ES = Esterified Starch

Table 1: Results of ES film 65% R.H.

Sample No.	Sample	Max.Load (N)	Load at break (Std) (N)	Elongation (%)	Tensile Strength (kgf/cm^2)
1	ES film 80%	107.72	90.44	3.00	92.23
2	ES film 80%	118.76	118.76	4.07	121.10
3	ES film 80%	128.39	123.72	4.20	126.16
Avg.		**118.29**	**110.97**	**3.76**	**113.16**

ES = Esterified Starch

Table 2: Results of ES film 80% R.H.

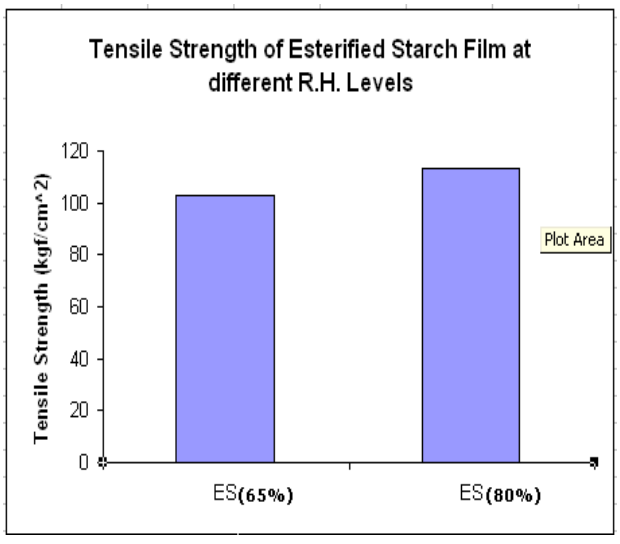


Fig 1. Tensile Strength of ES film at different R.H. levels

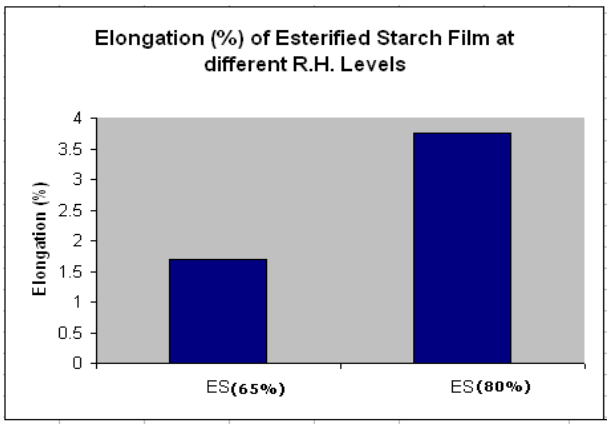


Fig 2. Elongation(%) of ES film at different R.H. levels

The tensile strength , breaking strength and elongation were found higher in the 80% R.H. Esterified starch film than 65% RH conditioned film sample .

The thin boiling starch film formed was brittle and weak hence the test was not possible .

C. *Results of Size film Moisture Regain*

Moisture regain(%) by weight-loss method of both starches found were almost similar as shown under by table and graph .

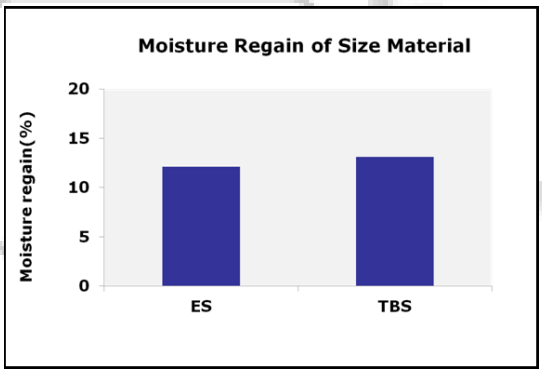


Fig 3. Moisture Regain of Sized Material (TBS-Thin Boiling Starch)

Sample Film	Sample Wt. (gms)	Petri dish+ Sample Wt. (gms.)	Petri dish+ Oven dried sample Wt.(gms.)	Moisture Regain(%)
Esterified starch	1.32	86.99	86.83	12.12
Thin boiling	0.9	86.59	86.47	13.13

Table 3: Results of Sized film Moisture Regain (%) – Weight Loss Method

D. *Results of Film Solubility Test*

Esterified starch film sample took 3 min. Time to dissolve in water while the test of solubility was not possible for thin boiling starch film due to unavailability of 2"(L) x 1"(W) sample.

E. *Results of Viscosity Measurement by RVA Equipment*

The final viscosity (cP) of 12% w/w Esterified starch paste was 112 while the final viscosity of 12% w/w thin-boiling paste was 9 on RVA (Rapid Visco Analyzer) equipment .

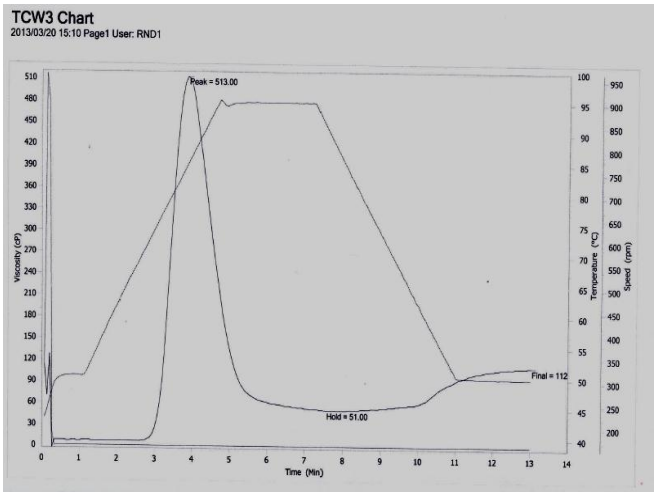


Fig 4. RVA Viscograph of 12% w/w Esterified Starch paste

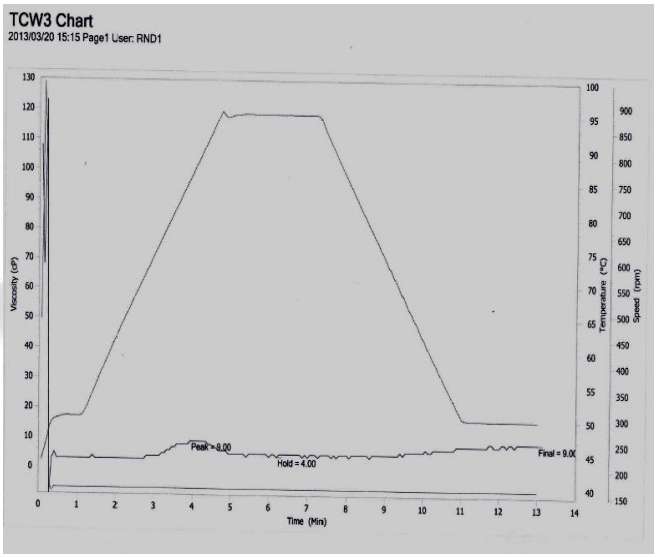


Fig 5. RVA Viscograph – 12% w/w Thin boiling starch paste.

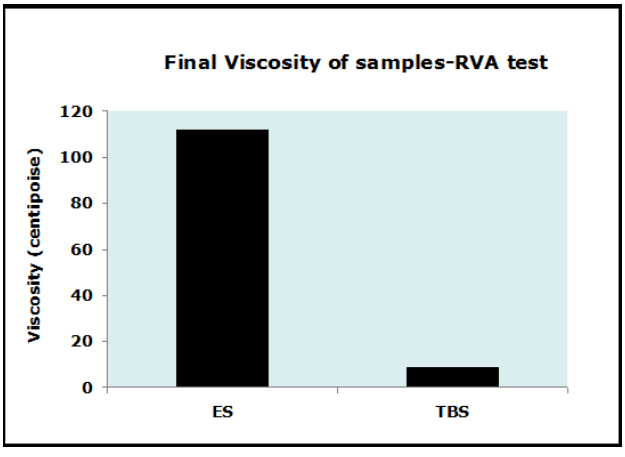


Fig 6. Final Viscosity of ES and TBS by RVA Test

The final viscosity (cP) was 92% weaker of Thin boiling starch paste than Esterified starch paste , so the film of Thin boiling starch was formed brittle and weak .

F. *Results of Lap Joint Test for Adhesion Power of Size Material (Paste) :*

– Gauge length of samples=2" for testing on Instron

Sr No.	Fabric Sample	Max. Load (N)	Load at Break (Std.) (N)	Elongation(%)	Tensile Strength (kgf/cm^2)
1	ES	109.90	95.03	9.47	96.90
2	ES	111.38	111.38	8.02	113.58
3	ES	102.38	92.49	10.13	94.31
Avg.		**107.89**	**99.63**	**9.21**	**101.60**

Table 4: Lap Joint Test Results for ES sample

– Gauge length of samples=2" for testing on Instron

Sr No.	Fabric Sample	Max. Load (N)	Load at Break (Std.) (N)	Elongation(%)	Tensile Strength (kgf/cm^2)
1	TBS	64.57	60.32	9.60	61.51
2	TBS	68.72	63.48	9.05	64.72
3	TBS	72.90	66.64	8.53	67.96
Avg.		**68.73**	**63.48**	**9.06**	**64.73**

Table 5: Lap Joint Test Results for TBS sample

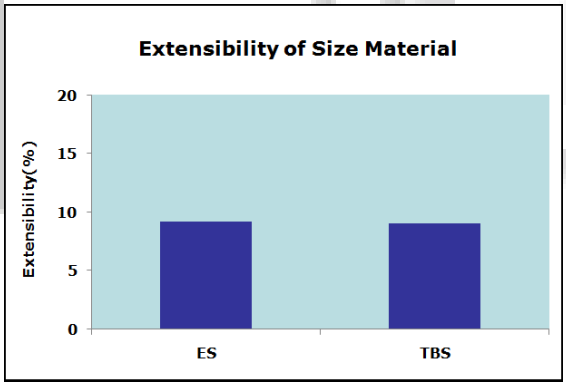


Fig 7. Extensibility of ES and TBS size material samples.

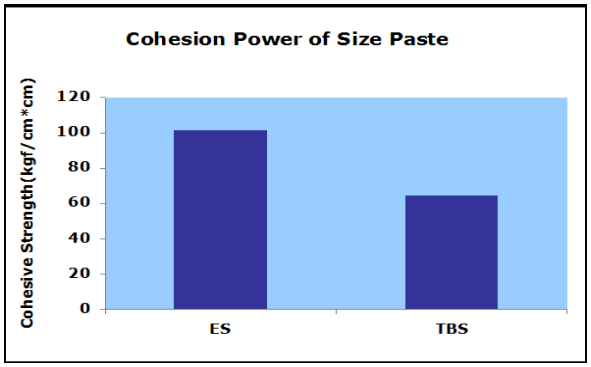


Fig 8. Cohesion Power of Size Paste Samples

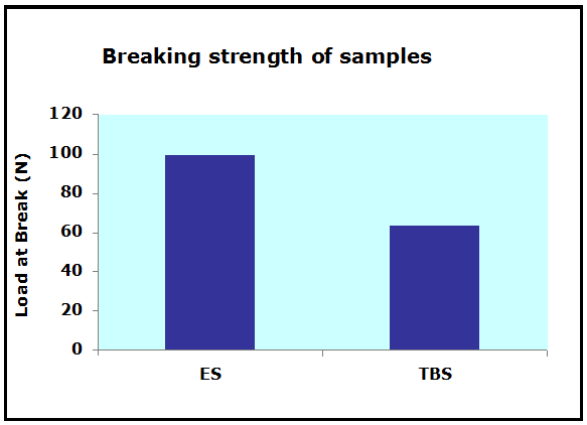


Fig 9. Breaking strength of samples on Instron

The cohesion power and breaking strength was found superior around 35% higher of Esterified starch sample than Thin Boiling one while extensibility of both the samples were found almost similar.

G. *Results of Size Add-on(%) of Size Paste on Fabrics samples:*

– Fabric sample specification = 10"(L)x4"(W)

Starch Name	Unsized Fabric Weight (gms.)	Sized Fabric Weight (gms.)	Add-on(%)
Esterified	3.57	4.29	20.16
Thin Boiling	3.55	4.25	20.28

Table 6: Size Add-on (%) of samples.

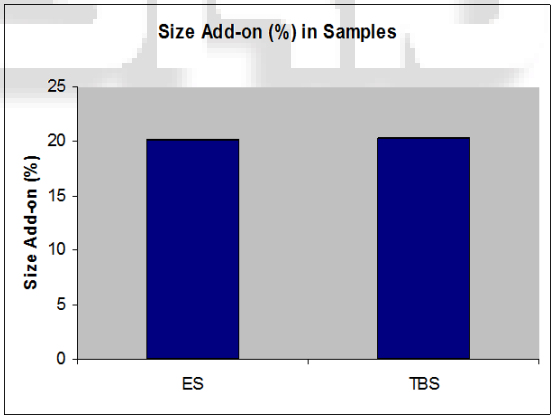


Fig 10. Comparison of Sized Add-on(%) of samples

The size add-on(%) on fabric samples sized with Esterified and Thin boiling starches were found similar as shown in above table and graph .

H. *Results of Desizing of Sized Fabric Samples:*

The Desizing of Esterified and Thin boiling starch sized fabric samples[10"(L)x4"(W)] were prepared and made them ready for Tegewa scale testing . Desizing was carried through enzymatic treatment.

I. *Results for Presence of Starch Percentage in Desized Fabric by TEGEWA Scales*

After desizing fabric samples one with Esterified and other with Thin boiling starch were compared by Tegewa scaled method

Desized fabric sample	Tegewa Scale	Presence of starch in (%)
Esterified	6	0.125 %
Thin boiling	4	0.35 %

Table 7:Results of Desized fabric samples on Tegewa Scales.

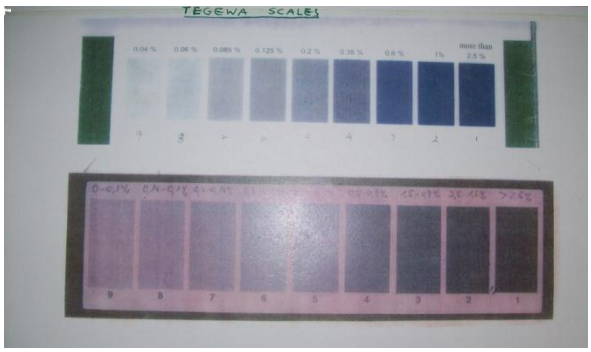
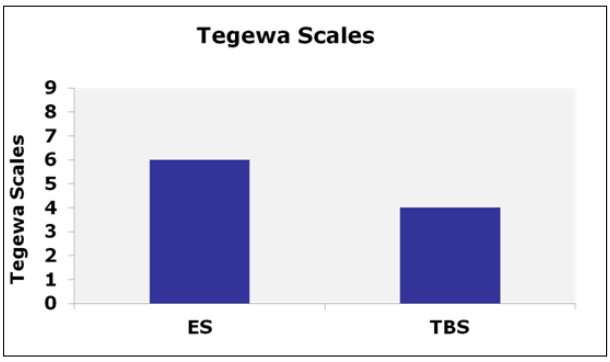


Fig 10. Standard Tegewa Scale



Tegewa Scale	1	2	3	4	5	6	7	8	9
Starch in %	2.5	1	0.6	**0.35**	0.2	**0.125**	0.085	0.06	0.04

Fig 11. Tegewa Scale Results of ES and TBS samples.

We assessed that the change of colour of both starch desized samples and matched them on Tegewa scale as shown in the above figure. The presence of starch in Esterified desized fabric sample was found 0.125% (Tegewa scale -6) while in Thin boiling desized fabric sample , it was 0.35% (Tegewa scale-4)

IV. CONCLUSIONS

The film forming property of Esterified starch paste film was found more suitable than that of Thin boiling starch paste film which was brittle and weak. The above results was further supported by RVA test . In the range of humidities normally experienced in the weaving room , 65% to 85%, Esterified starch exhibit good film and bond strength . Abrasion resistance is reduced because of smoother film and increased flexibility. The cohesive and breaking strength was found much better than Thin boiling starch resulted from Lap Joint Test . Comparative presence of starch percentage after desizing was lower in Esterified starch sample than Thin boiling starch sample on Tegewa scale . Thus it indicates that the amount of effluents coming out from Esterified starch desized fabric is less as compared to Thin boiling starch desized fabric . Due to less presence of starch in Esterified desized fabric , more uniformity can be achieved in Dyeing process .

ACKNOWLEDGMENT

The authors thank the management of L.D. College of Engineering , Ahmedabad for providing the necessary facilities to undertake the above work. The authors are also pleased to acknowledge the co-operation and guidance of Mr. Harish Tekchandani (GM ,Product Development) of Anil Ltd. . The authors would even like to thank Mr. Jigneshbhai Oza , Mr. Hardik Shah and team of R&D department , Anil Ltd . for their support to carry-out this research-based project-work .

REFERENCES

[1] Evaluation of weavability of sized cotton warps by Maatung, Ladhar and Sakli, *AUTEX Res.J.*,Vol.8, No.4, Dec.2007

[2] Weavability of core-spun dref yarns by Dr.B.K.Behera & V.K.Joshi ,*Indian Jou. of Fibre & Textile Research*, Vol.32,March2007Heechan Cho, Dalyoung Oh, Kwanho Kim, A Study on removal characteristics of heavy metals from aqueous solution by fly ash, J. of Hazard. Mater. B127, pp 187–195, 2005.

[3] Effect of sizing on weavability of DREF yarns by Dr.B.K.Behera&V.K.Joshi *AUTEX Res.J.*,Vol.6,Sept.2006 Microporous Mesoporous Mater, 96, pp 157–167, 2006.

[4] Physiochemical properties of sized yarn Part-I by Slauson, Miller & Rebufeld ,*Textile R.J.*,Oct.1984.

[5] Faasen N.J. amd Harten K.V. , "The Effect of Sizing on the Weavability of Cotton Yarns" , *J.Text. Inst.* , 57,7,1966, T269 .

[6] Malhotra, V.P., and Ranganathan, S.R., A Useful Basis for Screening the Performance of Textile Sized Materials through Studies on Film Strength – Elongation Properties ,*Textile Res. J.* 35,290-291(1965)

[7] Textile Sizing : Goswami,Anandjiwala & Hall

[8] Modified Starches: Properties and Uses by O.B.Wurzburg, CRC Press,Inc.