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Annex 8

INDUSTRIAL POLLUTION REDUCTION PROGRAMME
DG/SRL/91/019

OPPORTUNITIES FOR WASTE MINIMISATION
IN THE TEXTILE PROCESSING INDUSTRY IN SRI LANKA

WASTE AUDIT

VEYANGODA TEXTILE MILLS LTD

CEYLON INSTITUTE OF SCIENTIFIC AND INDUSTRIAL RESEARCH
363, Bauddhaloka Mawatha, Colombo 7, SRI LANKA

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List of Abbreviations

COD	Chemical Oxygen Demand
°C	°Centigrade
h	hour
J	joule
°K	°Kelvin
km	kilometre
kg	kilogram
kWh	kilo Watt hour
l	litre
min	minute
m	meter
mg	milligram
N	Newton
Ref	Reference
s	second
y	year
w/w	weight/weight
M	Month
T	Tonnes
d	day
g	gram

SUMMARY

Veyangoda Textile Mills Ltd. is one of the largest mills in Sri Lanka, providing employment to about 2400 workers. It is situated in a rural area about 45 km away from Colombo. It produces mainly dyed and printed cotton fabric. At present the raw effluent is treated in a series of stabilisation ponds before release to the Attanagala Oya. The discharge of coloured water to this river, has resulted in many complaints and public displeasure.

With respect to housekeeping, data records, machinery maintenance etc. observations indicated that Veytex was very satisfactory. However the water balance and water consumption/kg fabric (275 l/kg) indicates an excessive use of water. This is probably due to its low cost & availability (pumping from the river). High boiler efficiency and low cost of steam generation, in comparision with other industries indicated efficient generation and utilisation. The water balance indicates that humidification, washing & printing are the highest water consumers. The COD balance indicates that though volume of waste water generated from de-sizing is very low, it is a significant contributor to COD. The rotary printer is the other significant contributor. As such, these have been given consideration in the generation and evaluation of Waste Minimisation options. 48 waste minimisation options were generated. The most important of these appear to be those that would help in reducing dye loss, so reducing colour in the effluent, and reduction of water consumption.

The cost of the sizing, de-sizing, bleaching and dyeing streams were seen to exceed the average cost of waste streams for this industry.

Conclusions of the cost benefit analysis carried out for the 10 options identified to be of high priority are tabulated below. The industry has however not been able to implement these options upto date due to labor problems.

Options	Investment (Rs)	Saving (Rs)	Pay back period(M)	Environmental benefits
1. Installation of ultrafiltration unit for sizing/desizing bath	14,864 x 10^3	2,122x10^3	84	20.5% reduction in organic load
2. Installation of temperature control unit for desizing plant	43,500	541,850	<1	0.5% reduction in organic load
3. Substitution of Acetic acid with Formic acid	Nil	225,540	NA	0.8% reduction in organic load
4. Use of counter current system in prewashing	15,000	779,893	<1	5% reduction in effluent volume, 2% in fuel consumption
5. Use of counter current system in postwashing	5,000	79,810	<1	1.5% reduction in effluent volume
6. Print paste recovery from blanket	10,000	1,212,540	<1	10% reduction in organic load, 4.5% in effluent volume
7. Reuse of return paste for dark shades	Nil	1,515,375	NA	-
8. Use of pressure guns for container washing and floor washing	5,000	8,700	20	0.2% reduction in effluent volume
9. Collection of paste from screens & squeezees	Nil	608,700	NA	6% reduction in organic load, 1.5 % in effluent volume
10.Neutralization of alkaline stream using flue gas	204,800	5,518,391	<1	reduction in acidic emissions, neutralisation of effluent

* reduction in fuel consumption results in reduction in atmospheric emissions
NA Not applicable

PART 1 - ENVIRONMENTAL STATUS

VEYANGODA TEXTILE MILLS (LTD)

1.0 Introduction

Veytex (Pvt) Ltd is a textile processing industry carrying out spinning, weaving, knitting, dyeing and printing of cotton, viscose, polyester and polyester viscose fabrics.

1.1	Organisational chart	: Annexure A - not provided by industry
1.2	Ownership	: Mr. Mukunthan (50%), Government (40%), Employees (10%)
1.3	Contact persons	: Mr. T.P. Phillip Chief Engineer, Mr. Wickramaratne, Processing Manager, Mr. Nayak, Dye Manager

2.0 Site details

2.1 Location Veyangoda (Annex B)

2.2 Physical Descriptions

(i)	Area	: $182{,}070\ m^2$
(ii)	Topography	: Flat land
(iii)	Factory layout	: Attached (Annex C)
(iv)	Sealed surface	: 40% of the site
(v)	Depth to groundwater	: 6 m
(vi)	Surface water bodies	: None
(vii)	Surface drainage channels	: All drains are connected to a main drain and then to the public drain

2.3 Current use

(i)	Processes	: Spinning, weaving, knitting, dyeing, and finishing
(ii)	Products	: Dyed and printed fabrics
(iii)	Raw materials	: Yarn
(iv)	Major chemicals	: Caustic soda, dyes, detergents, sizing and desizing agents, softners and pigments and other general chemicals
(v)	Energy source	: Furnace oil and electricity

2.4 Site drainage (type & discharge points)

(i)	Process effluent	: Through open drains to treatment lagoons
(ii)	Domestic waste water	: Through open drains to treatment lagoons
(iii)	Storm water	: Through open drains to public drains
(iv)	Toilet effluent	: Through pipe drain to septic tanks

3.0 Environmental Emissions

3.1 Atmospheric emissions	: Cotton dust from knitting machines, flue gas from boilers, exhaust from dryers and stentors.
3.2 Aqueous discharge points	: Effluents from bleaching and dyeing.
3.3 Solid waste	: Cotton dust, paper and empty chemical packaging materials

4.0 Site history and Neighbouring sites

4.1 History of the site

(i)	Start date	: 1961
(ii)	Former use	: Coconut estate

4.2 Current and former use of neighbouring sites

(i)	Northern	: Paddy field
(ii)	Southern	: Food Stores
(iii)	Western	: Residential
(iv)	Eastern	: Residential

4.3 Significant spills : None

5.0 Environmental Receptors

5.1 Abstraction points

(i)	Dug wells	: Two
(ii)	Tube wells	: None
(iii)	Surface water	: Attanagall Oya (a small river)

5.2 Sensitive neighbours within 2 km

(i)	Residence	: About 100
(ii)	Hospitals	: None
(iii)	Schools	: One
(iv)	Others	: Food Stores

5.3 Protected Natural Habitats : None

5.4 Water Bodies

(i)	Surface	: Attanagal Oya (a small river); 8 km away
(ii)	Sub-surface	: None

6.0 Solid Waste Issues

(i)	Type and disposal method	: Containers-sold; Cotton waste and polythene-incinerated

7.0 Environment Licence issues

7.1 Current status :

7.2 Current compliance issues :

PART 2 - WASTE AUDIT

1.0 General Information

WORKSHEET 1	
Name of the Company : VEYANGODA TEXTILE MILLS LTD.	
Waste Minimisation Team	
Name	**Designation**
1. Mr. H.N. Gunadasa	Manager, Environmental Technology/CISIR
2. Mrs. K.D.Attanayake	Senior Technical Officer/CISIR
3. Mrs. S. Wickramaratne	Research Officer/CISIR
4. Miss. S. De Costa	Research Officer/CISIR
5. Mr. R. Illankumaran	Research Officer/CISIR
6. Mr. K, Pavananthan	Research Officer/CISIR
7. Mr. T.P. Phillips	Chief Engineer/Veytex
8. Mr. Wickramaratne	Processing Manager/Veytex
9. Mr. Nayak	Dye Manager/Veytex
A. **Major Raw Materials Consumption**	
1) Fibre	
a) 100% cotton	¶2,075 Tons/y
b) Blend	¶109 Tons/y
2) Commissioned fabric	¶332 Tons/y
3) Chemicals	
a) Process chemicals	¶591,000 kg/y
b) Dyes	¶31,500 kg/y
B. **Energy Consumption**	
a) Electrical energy	14.66×10^6 kWh/y
b) Furnace Oil	3.98×10^6 l/y
C. **Water Consumption**	♪616,272 m^3/y

D. **Installed Capacity**	
Singeing & Desizing machine	75,000 m/d
Pre Washing & Bleaching machine	70,000 m/d
Cold Bleaching Range	30,000 m/d
Continuous Mercerization machine	65,000 m/d
Post Washing Range machine	65,000 m/d
Pad Dyeing machine	20,000 m/d
Rotary Printing machine	25,000 m/d
Flat Printing machine	6,000 m/d
Steaming machine	30,000 m/d
Drying range - Cylinder	65,000 m/d
Drying range - Float	85,000 m/d
New washing range	50,000 m/d
Old washing range	40,000 m/d
Stenter machine	70,000 m/d
ACTUAL PRODUCTION (August 95)	
Desizing machine	1,111,424 m
Pre-Washing, Bleaching,Post Washing machine	3,271,478 m
Cold Bleaching machine	482,390 m
Mercerization machine	1,240,487 m
Cold Pad Batch Dyeing machine	514,744 m
Flat Bed Printing machine	89,730 m
Rotary Printing machine	457,137 m
Cylinder drying machine	1,508,198 m
Float drying machine	2,290,577 m
Beam washing machine	190,580 m
Washing range machine	1,916,174 m
Stenter machine	1,480,457 m
E. Type of Effluent Treatment	Stabilization ponds
F. **Any Other Relevant Information :** Working days for August was 25 days. Production is carried out for 24 hours in 3 shifts. Total number of workers is about 2400.	

¶ Estimated from monthly figures

♪ Estimated according to the weir reading

2.0 Available information

Compared to most of the textile mills availability of information is quite satisfactory. Other required data were gathered by the study team, except energy related details and emission records, which were not available. Although an energy balance is necessary to attempt to conserve energy, this was not possible due to the absence of measuring equipment. However steam utilization for each process was theoretically estimated.

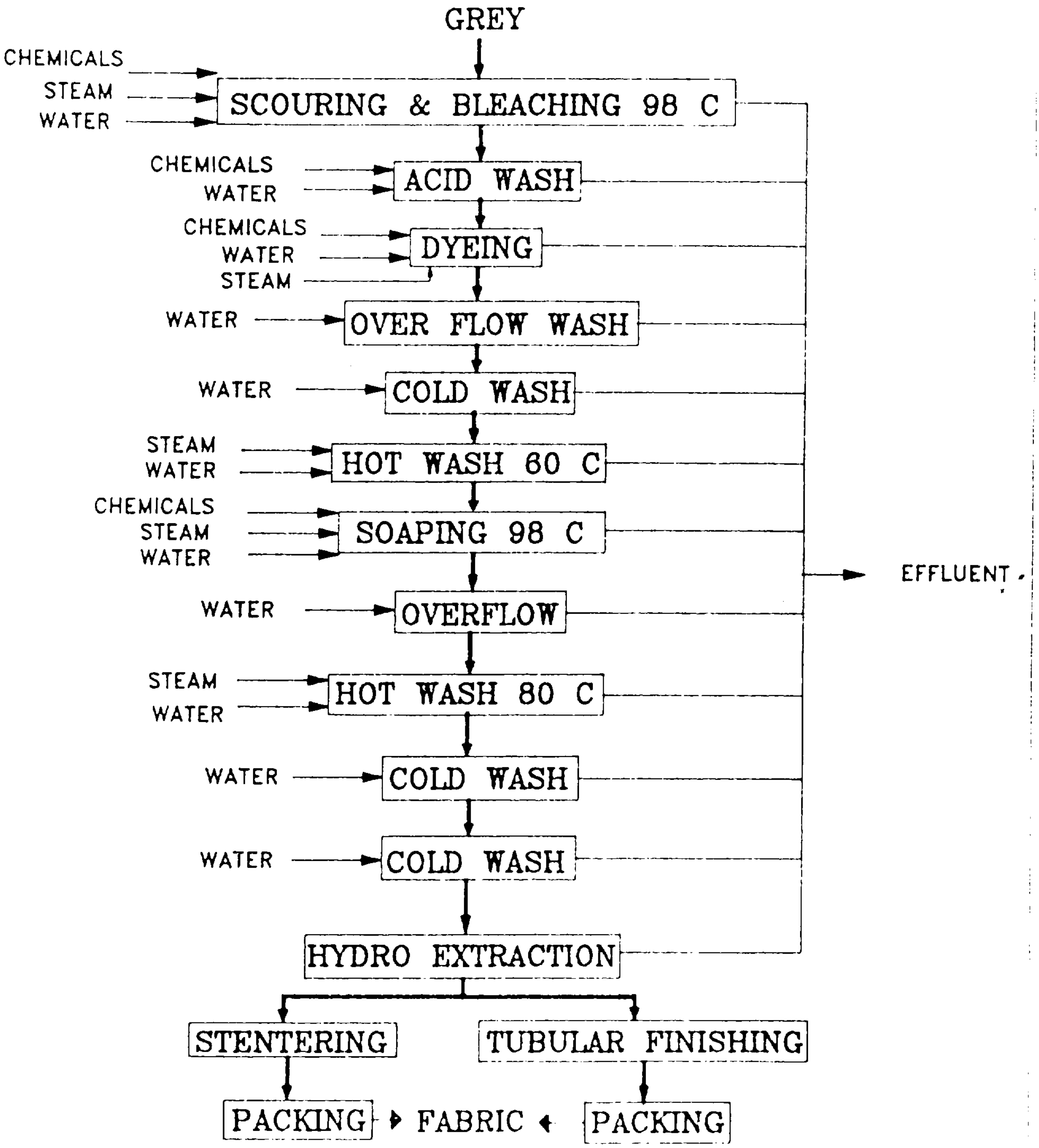
WORKSHEET 2		
Information	**Availability**	**Remarks**
Process flow diagram	Not available	
Material Balance	Not available	Monthly bulk consumption of each material is available
Energy balance	Not available	Monthly electricity bill is available
Water balance	Available	Processwise water usage with total effluent volume is available
Plant layout	Available	Satisfactory
Waste analysis	Available	only for water
Emission records	Not available	Facilities for measurements are not available
Production log sheets	Available	Satisfactory
Maintenance log sheets	Available	

3.0 Process Flow Diagrams

The main process flow diagram (Worksheet 3.1) indicates the sequence of operations and details of operations and further details of these operations are indicated in Worksheets 3.2 to 3.4 along with water flow rates and process details.

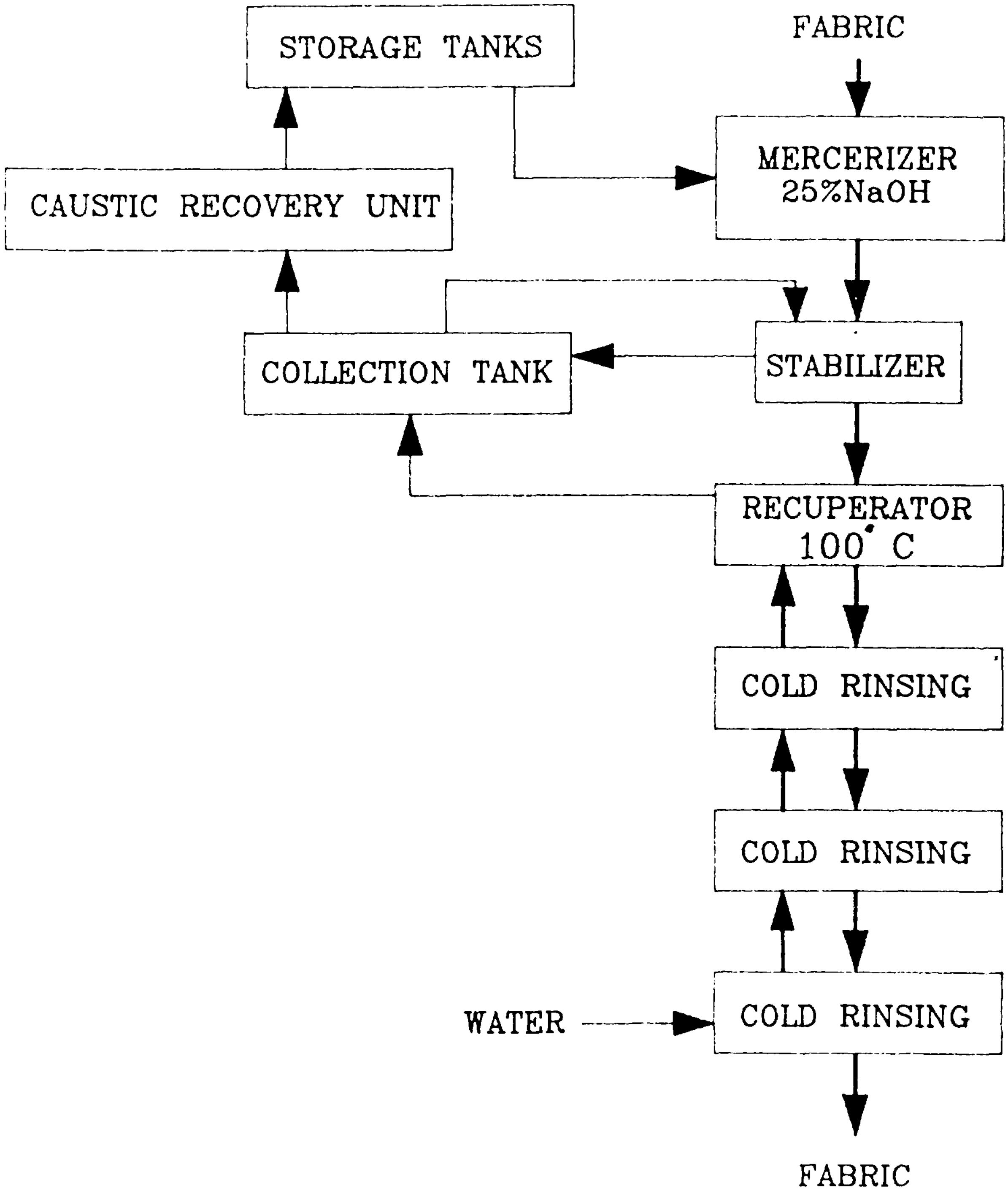
WORKSHEET 3.1

PROCESS FLOW DIAGRAM FOR 100% COTTON



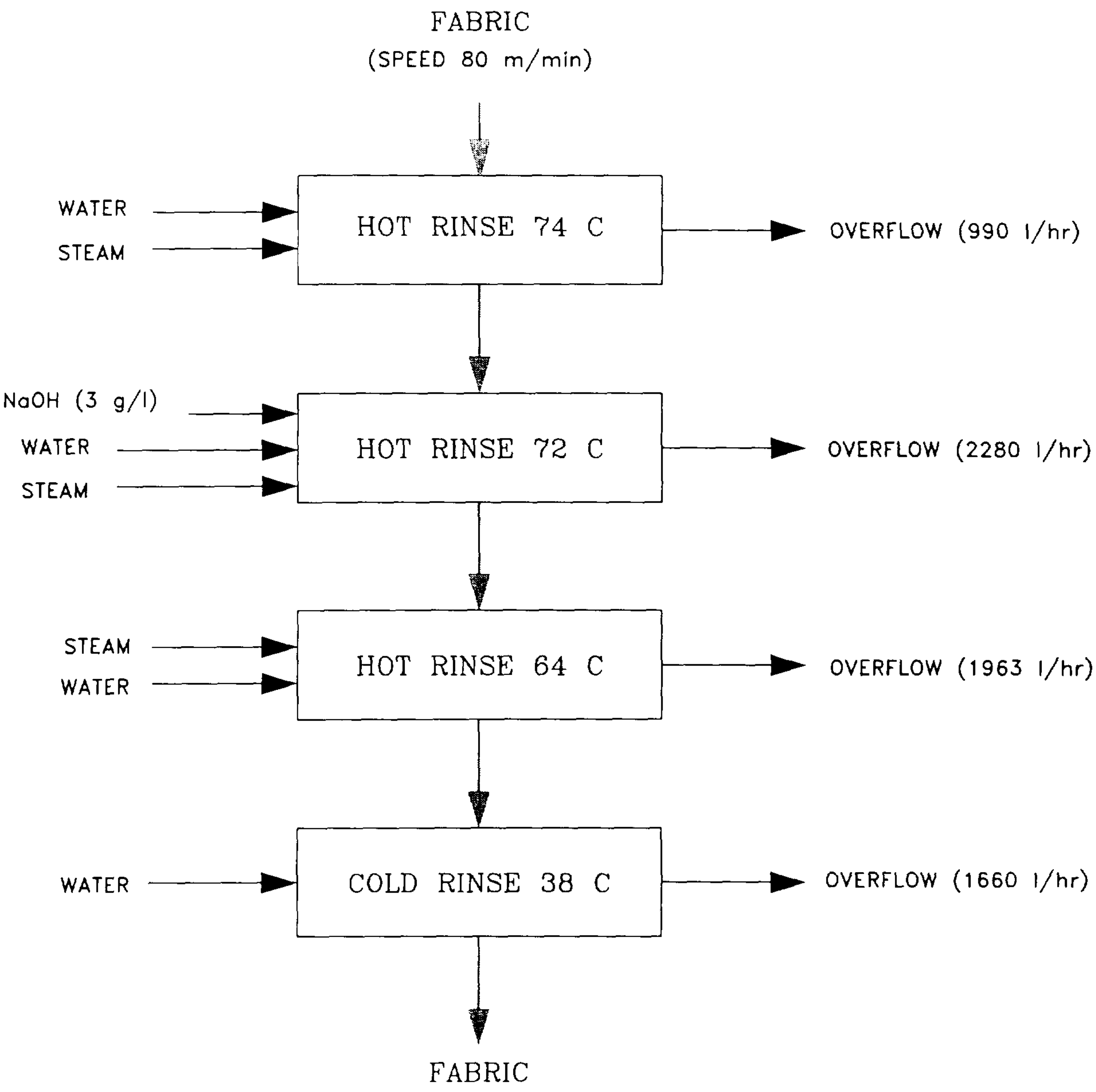
WORKSHEET 3.2

MERCERIZATION



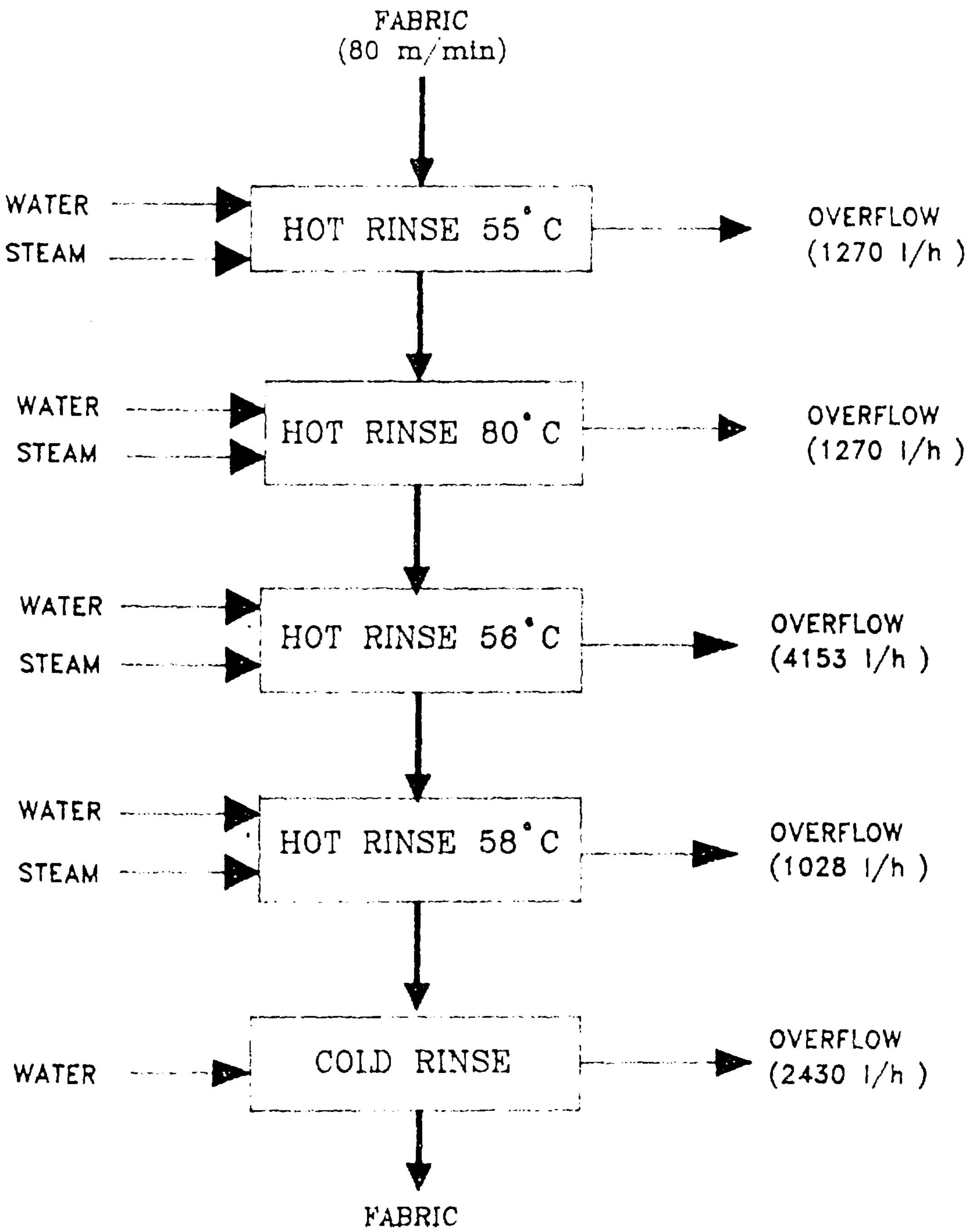
WORKSHEET 3.3

PREWASHING



WORKSHEET 3.4

POST WASHING



4.0 Housekeeping status

Although the general housekeeping status was found to be good, the lapses in housekeeping indicated in Worksheet 4.0 were observed during visits by the study team.

WORKSHEET 4.0 **General remarks related to housekeeping**	
Sections	**Lapses in housekeeping**
Sizing	* Leaks in sizing bath
Dye kitchen & printing equipment washing area	* Open water taps
Printing	* Continuous flow of blanket wash water when the machine is not functioning
Washing Ranges	* Uncontrolled flow of water * Leaking baths
Beam washing	* Beam washing for longer periods without supervision

5.0 Material Balance

The material balance has been carried out using actual monthly production figures for August 1995 given in Annexure E. The production involves a number of process variables such as density of fabric, dye & chemical recipes. The material input on weight basis may deviate from the actual input because the calculations are based on the average values.

Although this factory carries out dry processes such as carding, weaving and spinning as well, the material balance concentrates mainly on the wet processes as only the latter contribute to major economic losses and environmental problems.

WORK SHEET 5.0
MATERIAL BALANCE FOR THE MONTH OF AUGUST 1995

UNIT OPERATION	INPUT MATERIAL		OUTPUT MATERIAL		
			PRODUCT	WASTE	
	Name	Quantity (T)	Quantity (T)	Liquid (T)	Solid / Gaseous (T)
Sizing	Yarn	129.70	129.70	-	
	Water	25.00	12.50	12.5	
	Starch	4.50	3.74	0.66	0.10
	PVA	0.20	0.17	0.03	
	Gum	0.20	0.17	0.03	
	Tallow	0.30	0.25	0.05	
Desizing	Fabric	152.90	152.90 (96.56)		Nil
	Water	910.00		813.44	
	Steam	80.56	80.56	-	
	Enzyme	1.82		1.82	
	Detergent 1	1.22		1.22	
	Sizes(added on)	4.34	0.43	3.91	
Mercerization	Fabric	158.70 (100.00)	158.70 (100.00)		Nil
	Water	527.00	527.00		
	Caustic	11.70	2.90	8.8	
	Steam	31.38	31.38		
Pre Washing	Fabric	150.50 (94.50)	140.00 (88.00)	10.50	Nil
	Water	1560.00	-	1566.50	
	Steam	272.00	272.00		
	Caustic	4.70		4.70	

Hot Bleaching	Fabric	140.00 (88.00)	140.00 (88.00)		Nil
	Water	34.10		34.10	
	Steam	11.87		** 11.87	
	Hydrogen peroxide	2.60		*** 2.60	
	Sodium silicate	0.97		0.97	
	Detergent 1	0.49		0.49	
	Sequestering agent	0.08		0.08	
	Brightening agent	0.16		0.16	
	Caustic soda	0.81		0.81	
	Stabilizer 1	0.73		0.73	
Post Washing	Fabric	140.00 (88.00)	140.00 (88.00)		Nil
	Water	2296.00		2296.00	
	Steam	494.00	494.00		
Cold Bleaching	Fabric	62.00 (39.00)	62.00 (39.00)		Nil
	Water	60.00		60.00	
	Caustic Soda	3.30		3.30	
	Stabilizer 1	0.61		0.61	
	Detergent 1	0.24		0.24	
	Brightening agent	0.18		0.18	
	Sequestering agent	0.18		0.18	
	Hydrogen peroxide	1.21		1.21	
Cold Pad Dyeing	Fabric	66.00	66.00		Nil
	Water	(41.00)	(41.00)		
	Dyes	52.7		52.7	
		0.71	0.54	0.17	
Printing	Fabric	60.00	60.00		Nil
	Water	5888.00		5888.00	
	Binders & Resins	1.30	0.88	0.42	
	Dyes	0.80	0.56	0.24	
Drying	Fabric	486.00 (306.90)	481.00		*346.00
	Steam	415.00	415.00		
Beam washing	Fabric	24.00	24.00 (15.00)		Nil
	Water	1478.00		1463.00	
Continuous washing range (old)	Fabric	116.00 (73.20)	116.00 (73.20)		Nil
	Water	1408.00		1408.00	
Continuous washing range (new)	Fabric	129.00 (81.40)	129.00 (81.40)		Nil
	Water	8664.00		8664.00	

Total volume of the process effluent is estimated at 22,902 m^3 /month

Fabric weight given in table is with 7% moisture

** Direct steam heating is involved

*** Deactivated H_2O_2 discharged as water

* Released as vapor

( ) Moisture absorbed in the fabric

ASSUMPTIONS & CALCULATIONS

1) Moisture content of the fabrics on wet weight basis (analysed by CISIR)

Raw fibre	-	7%
After wet process	-	43%
After drying	-	6%

2) Average fabric weight (provided by industry)

80% of fabrics 110 g/m

20% of fabrics 200 g/m

3) Sizing recipe for 9144 m (10,000 yards) as provided by the industry

Starch	45 kg
Tallow	3 kg
Gum	2 kg
PVA	2 kg
Water	250 l

Losses of starch in solid form with the packing material is 2 %

The size bath is discharged once in two weeks and losses amount to 15% (estimated from COD data, given in Worksheet 7A).

Size remaining on the fabric after desizing is 3 g/kg of fabric (ref1)

4) 25 % (w/w) of the caustic is recovered using evaporators and recycled

5) Water utilized for desizing, sizing, bleaching, dyeing and mercerizing is estimated based on specific volumes. For other processes it is estimated from flow rates.

*	Desizing	6.4 l/min
**	Pre washing	114.5 l/min
**	Post washing	168.5 l/min
*	Cold pad dyeing	0.8 l/kg
*	Mercerization	1.7 l/m

** Measurements taken by audit team

* Obtained from thesis, University of Moratuwa, Srilanka (ref 2)

6) Print paste losses amount to 33% of usage. Breakdown is given below based on actual measurements done by the audit team.

Container losses	13.3%
Pump losses	4%
Squeezee losses	1%
Equipment wash	7%
Blanket wash	62%
Screen	12.7%
Total	100 %

7) Assumptions on fixation of dyes (ref 3)

Cibacron	80 %
Disperse	95 %
Sulfur	80 %
Direct	88 %
Reactive	60 %
Pigment	100 %

8) Dye losses

Quantity of dyes going out with the effluent = (Quantity of dyes/M) x (100 - %fixation)

	Consumption (kg/M)	In effluent (kg/M)
Direct dyes	24	2.8
Disperse dyes	2.5	0.12
Cibacron dyes	241	48.2
L.F reactive dyes	140	56
Sulfur dyes	302	60.4

9) Chemical consumption

Chemical utilization is calculated from recipes (Annexure F)

Quantity of Chemical = (Concentration of chemical according to the recipe) x (volume of water used)

It is assumed that the chemicals on the fabric after processing is negligible

10) Weight reduction of fabric on prewashing

Raw weight of fabric	= m_1 cotton
Weight after prewashing	=0.93 m_1 for cotton (Ref 4)

11) Moisture absorbed into wet fabric

Moisture content of raw fabric	$= 0.07m_l$
Moisture absorbed into wet fabric	=(total moisture in wet fabric - moisture content of raw fabric)
Dry weight of fabric after weight reduction	$=(0.93m_l) \times 0.93$
Total moisture in wet fabric after weight reduction	$=0.43 \times 0.93 \times (0.93m_l)/(1-0.43)$
Moisture content in raw fabric after weight reduction	$=0.07 \times 0.93 \times (0.93m_l)/(1-0.07)$
Moisture absorbed into fabric	$=0.59m_l$

12) Steam consumption

Steam consumption is calculated using heat requirement for each process to achieve required temperature and properties of boiler steam.

Steam consumed = $(cp_f*m_f+cp_l*m_l)*(T_o - T_r)/h_f$
cp_f, cp_l; specific heat of fabric & liquid
m_f, m_l; mass of fabric & liquid
T_o, T_r; operating & room temperature T_r - 30 C
h_f ; Latent heat of steam :2000 kJ/kg
cp_f - 1.4
cp_l - 4.2 (Ref 5)

6.0 Total Water Balance

The water balance presented in Worksheet 6.0 has been carried out using water consumption figures for August 1995. It indicates the water consumption in individual processes both quantity and percentagewise, undefined losses and also water / product ratios used in the processes.

WORKSHEET 6.0 TOTAL WATER BALANCE (AUGUST 1995)				
Operation	**Estimated consumption m^3/M**	**Production T/M**	**Water/Production ratio**	**% consumption**
Sizing	*25	129	0.2	0.04
Desizing	910	158	6.4	2
Pre washing	**1,560	140	11.1	3
Hot bleaching	34	140	0.2	0.06
Post washing	**2,296	140	16.4	4
Cold pad dyeing	53	66	0.8	0.1
Cold bleaching	60	62	0.9	0.12
Mercerization	§527	159	3.8	1
Old washing range	**1,408	116	12.1	2.7
New washing range	**8,664	129	67.1	16.1
Beam washing	§1,478	24	114.3	2.9
Printing	**5,888	60	98	11.5
Stripping	*22			0.04
Canteen and Engineering	*810			1.5
Boiler	*2,624			5
Spinning	*4,253			8
Humidification	*9,213			18
Gardening	*151			0.3
Housing	*1,063			2
Others	*717			1.4
Total water consumption (calculated)	41,756			81.3
Actual water consumption	[illegible]51,356			
Unidentified losses	9600			18.7

.› Total water consumption figure provided by the industry according to the weir reading at the water treatment plant for August 1995
* Data provided by the industry
§ Obtained from thesis, University of Moratuwa (ref 2)
** Estimated from flow rate measurements
All the other figures according to the process recipes (Annexure F)

7.A COD Analysis Table

COD analysis was carried out for discharges from all operations on one day to obtain an understanding of the discharges that contribute the highest to the pollution load. Results are presented in Worksheet 7A. COD values are co-related with volume of water discharged from each operation. Flow rates of continuous operations are measured values during a particular time interval while water consumption figures in batch operations were estimated using production data for the particular day of sampling, machine speed etc.

The COD analysis was carried out by Central Environmental Authority (CEA) laboratory staff on 12.10.95.

WORKSHEET 7A							
STREAM	FLOW RATE l/min	DURATION min	WATER l/d	WATER %	COD mg/l	COD kg/d	COD %
Sizing	3		500	0.05	66000	33	2.73
Desizing			1250	0.13	131400	164	13.59
Prewashing 1	17	1440	23760	2.39	4500	107	8.86
Prewashing 2	38	1440	54720	5.50	1650	90	7.46
Prewashing 3	33	1440	47520	4.78	480	23	1.91
Prewashing 4	27	1440	38880	3.91	130	5	0.41
Post Washing 1	21	1440	30240	3.04	860	26	2.15
Post Washing 2	21	1440	30240	3.04	700	21	1.74
Post Washing 3	69	1440	99360	9.99	700	70	5.80
Post Washing 4	17	1440	24480	2.46	90	2	0.17
New Washing Range	300	1440	43200	4.34	250	108	8.95
Beam Washing of Prints	60	3000	180000	18.10	500	90	7.46
Rotary Blanket Wash	135	960	129600	13.03	1600	207	17.15
Rotary Pump	16	60	960	0.10	250	0	0.00
Rotary Screen	70	80	5600	0.56	2000	11	0.91
Rotary Screen Squeezee	100	130	13000	1.31	3400	44	3.65
Equipment Wash	33	80	26400	2.65	1000	26	2.15
Containers Wash	33	120	3960	0.40	4400	17	1.41

Flat Bed Blanket Wash	50	960	48000	4.83	250	12	0.99
Squeezee Wash	100	80	8000	0.80	3400	27	2.24
Stripping			800	0.08	800	1	0.08
Finishing Drain	15	5	75	0.01	8250	1	0.08
Boiler			97200	9.77	0	0	0.00
Old Washing Range (bath 1) (bath 2)	29 33	1400 1400	40600 46200	4.08 4.65	160 450	57 65	4.72 5.39
TOTAL			994545	100	233220	1207	100

Production in m/d	65000
Production in kg/d	8320
Water Consumption in l/m	15.3
Water Consumption in m^3/T Fabric	119.5
COD g/m	18.6
COD kg/T Fabric	145

Average COD of composite process effluent - 1214 mg/l (based on water consumption indicated in Worksheet 7A -994.6m^3/d)
Estimated process effluent volume - 22,375 m^3/M (from Worksheet 5.0)

Total effluent volume - 34,052 m^3/M (from Worksheet 6.0)
(In addition to the water consumption for processing, water consumption figures for canteen and engineering section and undefined losses included)
Based on the above figures average COD of the effluent is 797 mg/l

7.B WASTE AND EMISSIONS COST

Material consumption figures from the material and water balances (Worksheets 5.0 and 6.0) and COD analysis data presented in Worksheet 7A, were utilised to estimate the amount of waste generated from each unit operation. These quantities together with the costs are presented in Worksheet 7B. The cost estimation for effluent streams of material wasted for different unit operations enables an estimation of the total cost for the composite waste stream and also cost per unit volume of effluent. These values can be used in the cost comparison after implementation of waste minimization options.

WORKSHEET 7.B				
UNIT OPERATIONS	**COST COMPONENT**	**QUANTITY (T/M)**	**UNIT COST (Rs/kg)**	**TOTAL COST (x 1000Rs/M)**
SIZING	Chemicals*	5	36	180
	Water	25	0.01101	0.275
	COD removal**	1.6	30	49.5
	Total Cost Assigned to Waste Stream **Cost assigned per m³ effluent**			**229.7** **9.1**
DESIZING	Chemicals*	3	61	183
	Steam***	80	0.45	36
	Water	10	0.01101	10
	COD removal**	1.3	30	39
	Total Cost Assigned to Waste Stream **Cost assigned per m³ of effluent**			**259** **25.9**
PRE WASHING	Chemicals*	4.7	15	70.5
	Steam***	272	0.45	122.4
	Water	1560	0.01101	17.2
	COD removal**	2.1	30	63.8
	Total Cost Assigned to Waste Stream **Cost assigned per m³ of effluent**			**273.9** **0.17**
POST WASHING	Steam***	494	0.45	222.3
	Water	2296	0.01101	25.3
	COD removal**	1.6	30	48
	Total Cost Assigned to Waste Stream **Cost assigned per m³ of effluent**			**295.5** **0.13**

PRINTING	Chemicals*	0.4	85	34
	Water	5888	0.01101	64.7
	Pigment dye*	0.3	500	150
	COD removal**	8.6	30	258
	Total Cost Assigned to Waste Stream **Cost assigned per m^3 of effluent**			**506** **0.08**
DYEING	Water	52.7	0.01101	.58
	Dye*	0.2	1500	300
	COD removal**	0.44	30	13.4
	Total Cost Assigned to Waste Stream **Cost assigned per m^3 of effluent**			**314.4** **5.9**
BLEACHING	Water	94	0.01101	1
	Steam***	12	0.45	5.4
	Chemicals*	12	45	540
	COD removal**	7.5	30	225
	Total Cost Assigned to Waste Stream **Cost assigned per m^3 of effluent**			**771.4** **8.24**
BEAM WASHING	Water	1478	0.01101	16.2
	COD removal**	0.73	30	22.1
	Total Cost Assigned to Waste Stream **Cost assigned per m^3 of effluent**			**38.3** **0.025**
NEW WASHING RANGE	Water	8664	0.01101	95.3
	COD removal**	2.16	30	64.9
	Total Cost Assigned to Waste Stream **Cost assigned per m^3 of effluent**			**160.2** **0.018**
OLD WASHING RANGE	Water	1408	0.01101	15.4
	COD removal**	0.44	30	13.2
	Total Cost Assigned to Waste Stream **Cost assigned per m^3 of effluent**			**28.6** **0.02**
COMPOSITE EFFLUENT	**Total Cost Assigned to Waste Stream - Rs 2,877,000** **Total volume of waste stream - 21475.7 m^3** **Cost assigned per m^3 of effluent - Rs 133.9**			

* Unit cost of chemicals and dyes for all the processes was calculated based on the monthly chemical cost provided by the industry.

** Unit cost of disposal is calculated on the basis of COD of the effluent and both chemical and biological treatment costs have been taken into account (Annexure G)
For dyeing and bleaching the COD values are calculated based on chemical consumption due to lack of COD data for the effluent stream.

*** Details of steam cost calculation are given in Annexure H.
Utility costs and utility costs/kg fabric are given in Annexure I.

8.0 Waste Minimization options

Waste minimization options were identified for each process unit based on the observations of the team and rough calculations of material balances. These actions are presented in Worksheet 8.0. Actions necessary to quantify the relevant wastes and assess the costs and benefits of implementing the option and suitable waste reduction technologies for these options were also identified. The time required to implement the option and the cost also were noted, as it is these features, that would help in motivating the industry in its implementation/nonimplementation.

The priority for implementing the options was decided in discussion with the management of the industry.

WORKSHEET 8.0								
Process Unit	**Unit operation**	**Waste Minimisation (WM) Options**	**Actions to assess WM options**	**Category**	**Effect**	**Timing**	**Priority**	**Cost**
Weaving shed	Humidification	1. Reduce humidification in weaving shed	- Carry out trials at different levels of humidification - Estimate water savings/day	RC	WM ES	MT	4	L
	Humidification	2. Employ alternative methods to reduce cost of humidification in weaving shed eg: Installation of fabric type air washers Recirculation of air Roof cooling	- Estimate capital & maintenance costs & cost benefit	RC	WM ES	MT		M
Sizing bath	Sizing	3. Addition of glycerine to the size bath	- Carry out trials and determine the quantity of glycerine required - Estimate cost and compare with humidification savings	RC MC	WM ES	ST	5	L
	Sizing	4. Collection of residual starch from the bags (Washing device)	- Estimate quantity of starch wasted - Estimate savings in cost of starch and treatment cost - Estimate cost of modification to cooker	RC	WM PR ES	ST		L
	Sizing	5. Minimise the amount of spilt starch going into the effluent by - Provision of a vacuum cleaner to collect spillage or - Remove starch on floor with scoops	- Estimate cost of vacuum cleaner - Estimate cost of savings in treatment - Educate workers	RC HK	WM PR ES	MT		L
	Sizing	6. Eliminate the use of toxic chemicals	- Check the presence of PCP in starch	MC	PR	ST	6	M
	Purchasing	7. Importing the starch in IBCs (Intermediate Bulk Containers)	- Compare the costs involved and the savings - Estimate cost of fuel to burn bags in the incinerator	RC	WM PR ES	MT		L

CR - Chemical Reduction
EM - Equipment Modification
ES - Energy Savings
HK - Housekeeping
H - High cost
IC - Inventory Control
L - Low Cost
LT - Long term
M - Medium cost
MC - Material Change
MT - Medium Term
PC - Process Control
PCP - Penta Chloro Phenol
PR - Pollution Reduction
PVA - Poly Vinyl Acetate
QI - Quality Improvement
RC - Resource Conservation
RR - Resource Recovery
SI - Safety Improvement
ST - Short term
TC - Technology Change
WM - Waste Minimisation
1-10 - Increasing priority

Process Unit	Unit operation	Waste Minimisation (WM) Options		Actions to assess WM Options	Category	Effect	Timing	Priority	Cost
Sizing bath	Sizing	8.	Repair leaks in the size bath	- Estimate savings by reducing size loss & treatment costs	RC	WM PR			L
	Sizing	9	Reduce concentration of size chemicals in size bath	- Carry out trials - Estimate savings in treatment costs	RC	WM PR ES			L
	Sizing	10.	Reduce size add on from 10% to 8-9%	- Carry out trials	RC	WM			M
	Sizing	11	Store and re-use size baths instead of draining, when there is a change in production.	- Study storage possibility and estimate savings - Estimate savings in treatment costs	RC	WM PR ES	ST	6	L
	Sizing	12.	Replace starch with PVA	- Estimate cost of using PVA - Compare cost of desizing for starch with cost for PVA - Estimate savings in reducing desizing washes, and reduction in treatment costs by eliminating starch	MC	WM PR ES	LT	5	l
	Sizing	13.	Installation of a PVA recovery plant	- Estimate cost of installation of PVA recovery plant - Estimate savings in treatment and chemical costs by recovery	EM	WM PR	LT	5	H
Desizing bath	Desizing	14.	Reduce concentration of enzyme & wetting agent in desizing bath	- Carry out trials	RC	WM CR	LT	5	L
	Desizing	15.	Optimise temp in desizing bath by installing a temperature control unit	- Estimate cost of temperature control unit - Check % degradation of enzymes at high temperature - Savings in cost of enzymes and treatment	PC	WM ES	LT	6	M

Process unit	Unit operation	Waste Minimisation (WM) Options	Actions to assess WM Options	Category	Effect	Timing	Priority	Cost
Pre washing	Pre washing	16. Counter current washing in the prewashing step	- Determine COD values & flow rates - Determine the flow rate in counter current rinsing - Estimate water savings	RC	WM ES	LT	6	M
	Pre washing	17. Control pH of fabric in the prewashing step (optimum pH-10.2-10.5)	- Control of NaOH addition in prewashing step - Improve washing efficiency by agitation or jet spraying	PC	WM PR CR	MT	3	L
	Pre washing	18. Control overflow with time switches	- Estimate present water usage - Estimate savings after installation of time switches	PC	WM	MT		M
Bleaching	Bleaching	19. Check the efficiency of sodium silicate as peroxide stabiliser	- Check the Mg content in raw water	RC	WM CR	MT		L
	Bleaching	20. Installation of a pH meter in bleach bath	- Estimate cost of installation	PC	WM CR QI	MT		M
	Batching / Post washing	21. Collection of drippings containing H_2O_2 from the batching & 1[st] stage in post washing & utilisation for preparation of bleaching bath	- Estimate volume of water that can be saved and the strength of H_2O_2 - Estimate H_2O_2 & water savings	RC	WM CR	ST		L
Post washing	Post washing	22. Counter current rinsing in the post washing step	- Determine the flow rates from each each bath & COD value - Determine water consumption in Counter Current rinsing	RC	WM	MT	4	M
	Post washing	23. Control overflow with time switches	- Estimate present water usage - Estimate savings after installation of time switches	PC	WM	MT		M

Process Unit	Unit Operation	Waste Minimisation (WM) options	Actions to assess WM Options	Category	Effect	Timing	Priority	Cost
Mercerizer	Mercerizing	24. Increase efficiency of mercerizer	- Carry out a material balance	RC	WM ES	MT	3	L
Washing ranges	Washing	25. Reduce flow rate in the washing range (old)	- Check the flow rate & COD value	RC	WM	MT	4	L
	Washing	26. Change 1st & 2nd overflow washes to counter current washes in new washing range	- Measure flow rates & COD values in each washing step - Carry out trials for each step	RC	WM	MT	4	M
	Washing	27. Reduce number of washing steps in new washing range	- Estimate present water & energy consumption	RC	WM	MT	4	L
Beam washing	Washing	28 Carry out beam washing after one rinse in the washing range	- Discuss with management	RC	WM ES	MT	4	L
	Washing	29 Recycle beam wash water in the washing range	- Compare cost of necessary collection tank, water piping etc. with savings in water	RC	WM ES	LT	2	M
	Washing	30. Control beam washing time	- Strict supervision	RC	WM ES	ST	2	L

Process Unit	Unit Operation		Waste minimisation (WM) Options	Actions to assess WM options	Category	Effect	Timing	Priority	Cost
Printing	Printing	31	Collection of print paste from screens into Print feed barrels Flat bed - scrape out, rotary - tilt into barrel	- Estimate the amount of print paste wasted - Estimate cost of waste paste	RC	WM PR	ST	8	L
	Printing	32.	Use of acrylic adhesive instead of PVA on rotary printer blanket	- Quantify recoverable print paste - Carryout cost benefit with pollution reduction	MC	PR WM			M
	Printing	33.	Installation of doctor blades on the blankets	- Estimate cost of installation - Estimate amount of print paste recovery - Estimate water savings	EM	WM PR	MT	9	L
	Printing	34.	Reuse of returns for dark shades	- Quantify returns	RC	WM PR	MT	9	L
	Printing	35.	Minimise printing down time and stop water flow when not in use	- Estimate breakdown periods - Estimate water wastage	RC	WM ES	LT	2	L
	Printing	36.	Use print wash water for washing spilt PVA below rotary printer	- Compare savings in water with cost of necessary piping	RC	WM ES	ST	3	L
	Printing	37.	Construct diptanks for screens to be immersed in before washing with water	- Estimate cost of construction of tank - Educate workers	RC	WM			L
Drying	Drying	38.	Dewatering the fabric before drying by using better padding mangles	- Estimate pickup with new & used Padding mangles - Compare energy savings	EM	WM ES	LT	2	M
	Drying	39.	Dewatering the fabric using vacuum slit (VS) device	- Cost of installation of VS - Check moisture content with & without VS - Compare energy savings	EM	WM ES	LT	2	H

Process Unit	Unit Operation	Waste Minimisation (WM) Options	Actions to assess WM options	Category	Effect	Timing	Priority	Cost
Drying	Drying	40. Control overdrying of fabric and install moisture meters	- Determine moisture content of fabrics after drying - Estimate cost of installation of moisture meters - Estimate energy savings	RC	WM ES	LT	2	M
General	Washing	41. Use of pressure guns for container washing, floor washing etc.	- Estimate cost of installation of pressure guns	RC	WM ES	MT	6	L
	Purchasing	42. Selection of less toxic chemicals eg: screen stripping solutions	- Obtain Material Safety data sheets	MC	PR	LT	3	M
	Waste disposal	43. Segregation of colour effluent from alkaline effluent	- Estimate volume of two streams - Estimate cost of segregating the two streams and identify advantages in treatment	RC	ES WM	MT	4	M
	Waste disposal	44. Neutralising the alkaline effluent with flue gas	- Carry out trials - Calculate savings in treatment	RC	PR CR	ST	4	M
	Waste disposal	45. Use of cotton waste (recycling) instead of burning eg: biogas generation	- Identify possible uses of the cotton waste - Estimate benefits	RR	WM	LT	3	L
	Purchasing	46. Reduce damages in commissioned fabric	- Carry out analysis of commissioned fabric for iron content - Identify the source of contamination	HK	WM ES PR	ST	3	L

Process Unit	Unit Operation	Waste Minimisation (WM) Options	Actions to assess WM options	Category	Effect	Timing	Priority	Cost
General	Maintenance	47. Routine equipment inspection to repair leaks from taps etc.			WM	ST	3	L
	Purchasing	48. Substitution of process chemicals with more environmental friendly and efficient chemicals Eg. substitution of silicate peroxide stabilisers with non-silicate stabilisers Substitution of acetic acid with formic acid	- Check the Mg content of process waste water - Carry out cost benefit analysis	MC	CR	LT	5	M

9 . COST BENEFIT ANALYSIS

Cost benefit analysis was carried out for the 10 options identified to be of the high priority in discussion with the management of the industry. Worksheets 9A.1 to 9A.10 indicate the investment cost, operating cost, savings and the payback period. Details of calculations are presented below the respective Worksheet.

WORK SHEET 9 .1			
Installation of ultra filtration (UF) unit for sizing/desizing bath (option no 13 in worksheet 8.0)			
Investment	**(x1000) Rs**	**Saving**	**(x1000)Rs/y**
Membranes	2,469	Chemicals	7,031
Modular housing	3,294	Treatment cost	1,993
Equipment cost	9,101	**Total**	**9,024**
Total	**14,864**	**Net saving**	**2,122**
Annual operating cost	**Rs/y**	**Pay back**	84 Months
Interest(21%)	3,121		
Power cost (1.5kWh/45m^2)	849		
Labour cost (1012/m^2)	247		
Maintenance (759/m^2)	185		
Cleaning (759/m^2)	185		
Ancillary power cost (5kWh/m^3 permeate)	228		
Membrane replacement cost	823		
Make up PVA	5,508		
Total operating cost	**11,146**		

Cloth production(sizing & desizing)	= 1.2 x 10^6 m/M
Average cloth weight	= 200g/m
PVA add - on during sizing	= 15 kg/1000 m cloth
Size box PVA concentration	= 90g/l
Size losses	= 15%
Desizing water usage	= 4 l/kg
Production time	= 600 h/M
Sizing PVA requirement	= (1.2 x 10^6)(10^{-3})(15)
	= 18,000 kg/M
PVA losses (15%)	= 2700 kg/M
PVA make-up requirement	= 2700 kg/M
PVA in effluent	= 15,300 kg/M
Desizing effluent volume	= (1.2 x 10^6)(0.2)(4/1000)
	= 960 m^3/M
PVA concentration of effluent	= (15,300/960) g/l
	= 15.9 g/l
Reclaimed size concentration	
Concentrate required	= 960(15.9/76.5)
	= 199.5 m^3/M
Permeate required	=(960 - 199.5)m^3/M
	= 760.5 m^3/M
	= 1.267 m^3/h

Thus the specifications of the required Ultra filteration unit are
Process capacity - 960 m^3/M of effluent at 15.9 g/l PVA .
Concentration to - 76.5 g/l PVA.
The permeate production is 760.5 m^3/M.
Average permeate flux for these conditions is about 5.2 l/m^2h (Fig. 1).
8 inches module and inlet flowrate of 22.75 m^3/h .

Membrane area required	= 244 m^2 (1267/5.2)
Number of 8 inch modules (15 m^2 each)	= 16
Number of module housing units for 3 membrane elements per housing	= 5

For the cost benefit analysis, the following capital costs have been used

1) Membrane cost	= 10,120/m^2
2) Modular cost	= 13,500/m^2
3) Equipment cost	= 112,000(membrane area)$^{0.8}$

Monthly consumption of sizes & desizing chemicals are from material balance (Worksheet 5.0)

Chemicals	**Amount(kg)**	**Unit price (Rs)**	**Total price (Rs)**
Starch	4500	26	117,000
PVA	200	170	34,000
Enzyme	1823	303	552,360
Cottoclarin KD	1215	240	291,600
Gum	200	100	20,000
Tallow	300	100	30,000
Total	**8238**		**1044,000**

Monthly consumption (kg) of sizes and chemicals after modification

PVA	2700	170	459,000

Chemical saving	= 1044,960 - 459,000
	= 585,960
Treatment saving by COD load reduction	= 5538 kg/month (18.4% of total COD load)
	= 166,140 Rs/ month

* All Technical data utilised are from Ref 1.

WORK SHEET 9 .2

Installation of Temperature control unit for desizing plant (option 15 in worksheet 8.0)

Investment	**Rs**	**Saving**	**Rs/y**
Temperature control unit	43,500	Enzyme	487,220
		Steam	15,525
		Treatment cost	48,240
		Total	**550,985**
Annual operating cost	**Rs/y**	**Net saving**	**541,850**
Interest	9,135		
		Pay back	**<1 month**

Current bath temperature	= 85° C
Enzyme activity at 85° C	= 2000 units
Optimum bath temperature	= 75° C
Optimum temperature activity	= 2300 unit
Enzyme consumption (August 95)	= 1023 kg/M
Therefore enzyme saving by controlling temperature at 75° C	= 1023(1-2000/2300) kg/M
	= 134 kg/M
Unit price of enzyme	= 303 Rs/kg
Saving	= 303 x 134 Rs/M
	= 40,600 Rs/M
COD loading reduction (i.e 0.5% reduction of total COD)	= 134 kg COD/M
Treatment cost per COD kg	= Rs 30
Treatment saving	= (134 x 30)
	= 4,020 Rs/M
Steam saving by temperature reduction from 85° C to 75° C	= 207 l oil/M
	= 1293 Rs /M

Veytex is using Rapidase L - 40 (α amylase) as enzyme.
Optimum temperature is 60 - 70° C .
Optimum pH 5 - 7 (ref4)
These conditions may vary with water quality

WORK SHEET 9 .3			
Chemical substitution : Acetic acid with Formic acid (option 48 in worksheet 8.0)			
Investment	**Rs**	**Saving**	**Rs/y**
	Nil	Chemical	144,540
		Treatment cost	81,000
		Net saving	**225,540**
Annual operating cost	**Rs/y**		
	Nil	**Pay back**	
			Not applicable

Monthly acetic acid consumption = 261 kg
Formic acid consumption after substitution = 130 kg/M

COD load of acetic acid = 1.04 kg/kg
COD reduction after
sustitution (83%) (ref5) = 261 x 1.04 x 0.83 kg/M
= 225 kg/M (i.e 0.8% of total COD load)
Treatment cost saving = 30 x 225
= 6,750 Rs/M

Unit prices of Acetic acid and Formic acid are Rs.85 and Rs.78 per kg

Chemical saving = (261 x 85-130 x 78)
= 12,045 Rs/M

WORK SHEET 9 .4			
Use of counter current system in prewashing (option 16 in worksheet 8.0)			
Investment	**Rs**	**Saving**	**Rs/y**
Modification (pipe lines)	15,000	Steam	497,664
		Water	285,379
		Total	**783,043**
Annual operating cost	**Rs/y**	**Net saving**	**779,893**
Interest	3,150		
		Pay back	**<1 month**

Bath	Water flow (l/min)		Average steam flow(l/min)	
	Before	**After***	**Before**	**After***
1	16.5	16.5	1.79	1.79
2	38	5	3.3	0.89
3	33	6	2.43	2.28
4	27	27	-	-

After* - After implementing counter current system

(Flow diagram in worksheet 3.3)

Unit cost of water	= Rs 11.01/m^3
Unit cost of steam	= Rs 0.4/kg
Water saving	= 60(l/min) x 60 x 24 x 300 (d)
	= 285,379 Rs/y
Steam saving	= 2.56(kg/min) x 60 x 24 x 300 (d)
	= 1,105,920 kg/y
	= Rs 497,664 /y

Total water saving will be 5% of the total water consumption

WORK SHEET 9 .5			
Counter current system in postwashing (option 22 in worksheet 8.0)			
Investment	**Rs**	**Saving**	**Rs/y**
Modification (pipe lines)	5,000	Water	80,860
		Total	**80,860**
		Net saving	**79,810**
Annual operating cost	**Rs/y**		
Interest	1050		
		Pay back	**<1 Month**

Bath	**Water flow rate(l/min)**	
	Before	After*
3	69	52
4	17	17

(Flow diagram in Worksheet 3.4)
After* after implementing counter current system

Water saving = 17(l/min) x 60 x 24 x 300 x 11.01/1000 Rs/month

Total water saving is 1.5 % of total water consumption

WORK SHEET 9 .6			
Print paste recovery from blanket (option 33 in worksheet 8.0)			
Investment	**Rs**	**Saving**	**Rs/y**
Doctor blade	10,000	Treatment cost	972,000
		Water	242,550
		Net saving	**1212,450**
Annual operating cost	**Rs/y**		
	Nil	**Pay back**	**<1 Month**

	Water flow rate (l/min)		**Paste on blanket (g/min) (in terms of COD)**		**COD value of rinse water (g/l)**
	Before	After*	Before	After*	
Rotary blanket	135	27	216	43.2	1.6
Flat blanket	50	10	12.5	2.5	0.25

Average production in rotary blanket	= 25,000 m/day
Rotary blanket speed	= 40 m/min
Rotary blanket running time	= (25000 m/day)/(40 m/min)
	= 625 min/ day
Average production in flat blanket	= 6000 m/day
Flat blanket speed	= 40 m/min
Flat blanket running time	= (6000 m/day)/(40 m/min)
	= 150 min
Water saving/day	= (135 - 27) x 625 + (50 - 10) x 150
	= 73.5 m^3 /d (4.5% of total water consumption)
Treatment cost saving	= (216 x 625+12.5 x 150)0.8/1000 kg COD
(10 % reduction in COD load)	= 109.5 kg x 30 Rs/kg
	= 3285 Rs/day

After* -

It is assumed that installation of doctor blades will remove 80 % of the paste remained on the blanket and the water flow rate can be reduced to this value to maintain the same COD load in the effluent.

eg Rotary blanket

Water flow rate after installation of doctor blade = (43.2/1.6) l/min

= 27 l/min

WORK SHEET 9 .7			
Reuse of return paste for dark shades (option 34 in worksheet 8.0)			
Investment	**Rs** Nil	**Saving** Paste **Net saving**	**Rs/y** 1,515,375 **1,515,375**
Annual operating cost	**Rs/y** **Nil**	**Pay back**	**Not applicable**

Average return stock = 570 kg/d
Screen & squeezee = 65 kg/d
Doctor blade = 109 kg/d
Container = 72 kg/d
Total quantity = 815 kg/d

Assuming only 25% is being reused for dark shades and the price of the return paste is Rs.7.50/kg (price of the fresh paste is 15 Rs/kg)

Amount wasted = 427.5 kg/d
Savings = Rs. 1,515,375/y

WORK SHEET 9.8			
Use of pressure guns for container washing & floor washing (option 41 in worksheet 8.0)			
Investment	**Rs**	**Saving**	**Rs/y**
Pressure gun	5000	Water	8,700
		Net saving	8,700
		Pay back	**20 months**
Annual operating cost	**Rs/y**		
	Nil		

Flow rate of water for container washing = 33 l/min
Time duration = 200 min/day
By using gun 40% of the water can be saved(ref5)
Water saving = 33 x 200 x 0.4 l/ day
(This is 0.2% of total water consumption)
Annual saving = Rs 8700

WORK SHEET 9 .9			
Collection of paste from screens & squeezees into paste feed container (option 31 in worksheet 8.0)			
Investment	**Rs**	**Saving**	**Rs/y**
	Nil	Treatment cost	578,700
		Water	78,000
		Total	**656,700**
		Net saving	**608,700**
Annual operating cost	**Rs/y**		
Labour	48,000		
		Pay back	**Not applicable**

	Paste remaining (kg/day)	Water flow rate (l/day)
Flat bed screens	1.5	3000
Flat bed squeezees	0.8	8000
Rotary screens	75	5600
Rotary squeezees	3	13,000

Assuming 80 % of the paste can be collected manually

Total paste that can be collected = (1.5+0.8+75+3)0.8
= 64.3 kg / d

Let the COD loading of paste = 1 (kg/kg)

Treatment cost saving = 64.3 kg COD
= 64.3 x 30 Rs/d

Wash water saving = (3000+8000+5600+13000)0.8
= 23.68 m^3 x 11.01
= 260 Rs/d

WORKSHEET 9.10			
Neutralization of alkaline stream using flue gas (option 44 in worksheet 8.0)			
Investment	**Rs/y**	**Saving**	**Rs/y**
Neutralizing plant	204,800	Chemical HCl	6,036,000
	Rs/y	**Net saving** (Saving - operating cost)	**5,518,391**
Annual operating cost		**Payback period**	
Depreciation(10%)	20,480	=(Investment/Net Saving)12	
Maintenance(3%)	6,144		<1 Month
Interest(21%)	43,000		
Electricity	447,985		
Total	**517,609**		

pH of the effluent = 12
Effluent flow rate = 407.50 m^3/d
Neutralizing chemical = 486.46 kmol (H^+) (ref 6)
Molecular weight of HCl = 36.5 kg/kmol
Weight of HCl = 17,755.9 kg HCl
Price of HCl = 37 Rs/kg

Saving = Rs. 503,000 /M

Effluent flow rate = 407.5 m^3/d
Operating hours = 24
Design capacity of plant = 17 m^3/h
Electricity power of plant = 17 kW (ref 6)
Electric power cost = 17 x 24 x 3.36 x 300 Rs
= 447,985 Rs/y

Capital cost of plant
with capacity of 17 m^3/h = 204,800 Rs (ref 6)

In Veytex alkaline effluent is segregated (consists of streams from scouring, bleaching and washing).
Caustic soda is the main contributor to the alkaline nature of the effluent and monthly consumption is 14,900 kg.

Capital cost is estimated using sixth - tenth - factor rule

Cost of equip.a = Cost of equip.b { capacity .equip.a / capacity . equip.b}$^{0.6}$ (ref 7)

10.0 Conclusions :

General housekeeping and record keeping for such a large mill is quite satisfactory. All the lapses in housekeeping indicated in Worksheet 4.0 are related to water and these losses are being neglected by the workers since they consider water as a freely available source.

According to the total water balance (Worksheet 6.0), highest percentage water consumption figures have been obtained for a non effluent generation operation viz. humidification. Out of the wet processes, washing in the new washing range and printing are the highest water consuming processes. In the new washing range, printed fabric is further rinsed after beam washing. This operation can be carried out efficiently if better process control measures such as controlling of flow rates, adopting a counter current system etc. are implemented. Same comment can be made regarding the pre and post washing processes.

Regarding the beam washing, it can be said that the period of washing is not being regulated carefully, resulting in heavy water losses.

Mercerization is being carried out with 25% Caustic and as indicated in the flow diagram (Worksheet 3.2) the rinse water also is being recycled with the spent caustic and concentrated to 25% in evaporators. According to data received from the industry the recovery of caustic is 23% and monthly consumption is 14.9 Tonnes. Therefore it will be appropriate to carry out a separate material balance on the mercerization.

Based on the COD balance for different processes (Worksheet 7A), the average COD of the composite effluent has been estimated. Utilising this figure and the values obtained from water and material balances (Worksheets 5.0 and 6.0) the COD of the total effluent is estimated at 797 mg/l. These COD figures will be useful for the cost comparison after implementation of the waste minimisation options.

Waste and emission costs (Worksheet 7B) indicate the value of material wasted in each effluent stream. These values too will be useful for comparison after implementation of options.

A total of 48 waste minimization options were identified by the study team. These are based on observations and inquires made by the team during their visits to the industry. The categories of these options are as follows:-
Resource conservation (3), Material changes (6), Housekeeping (2), Equipment modification (4), Process Control (5), Resource Recovery (1).
Cost wise categorisation of the options indicated that most of the options are low cost (Low cost 28, Medium cost 18 and High cost 2).

Ten waste minimisation options were selected as high priority in consultation with the industry management. Cost benefit analysis was carried out for these options. For three options, it was seen that no investment was required and for four options the investment ranges from Rs. 5000 - 15000/-. For four options the payback period is less than one month and out of those, three are low cost options. For one option the investment is medium but the pay back is less than one month. Therefore at least 7 options (3 with no investment and 3 low and medium cost options) can be implemented very easily by the industry. However after the completion of this study, the industry has faced manylabor problems, which has prevented their implementation.

11.0 References

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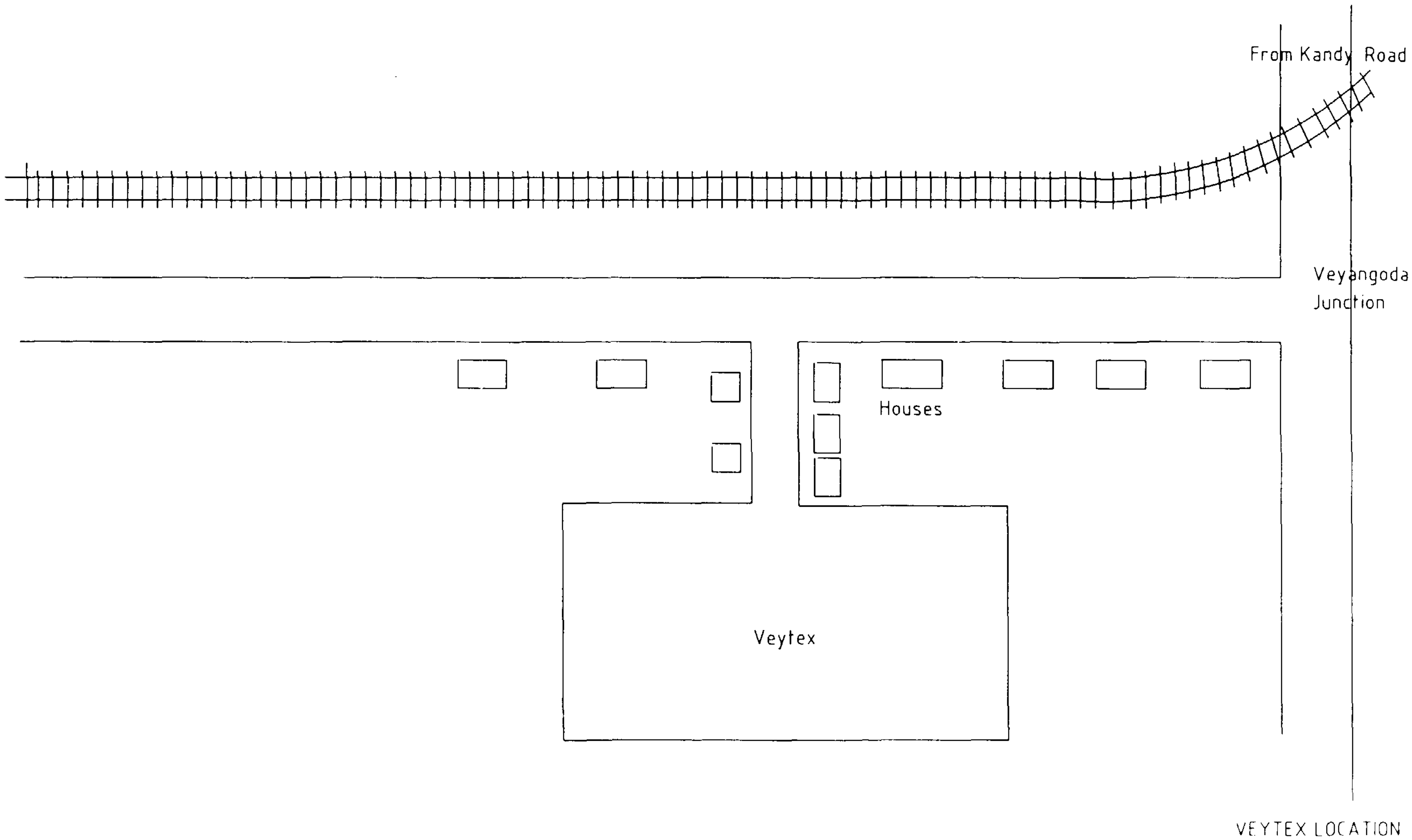
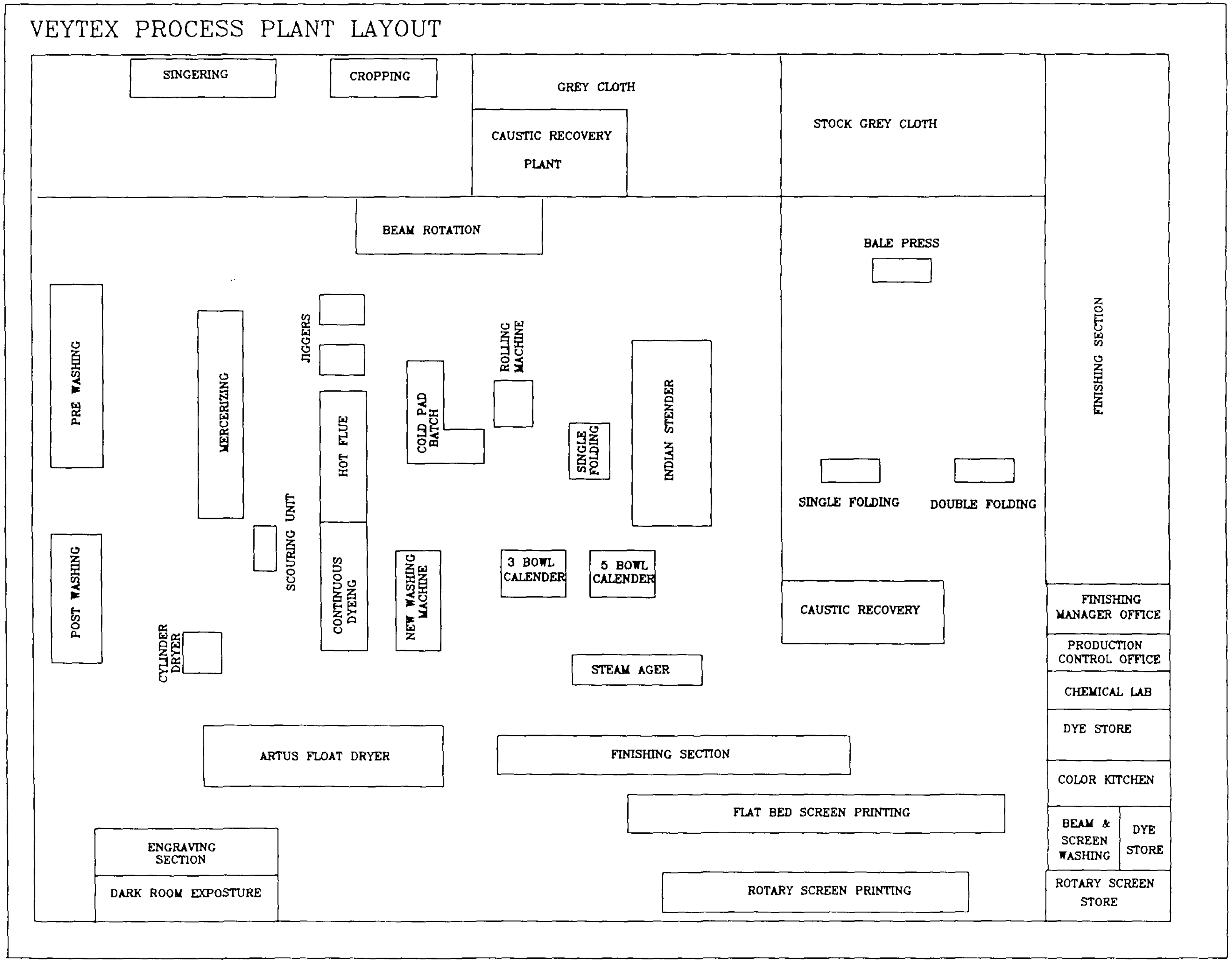
   pg 169, 205

ANNEXURE B


From Kandy Road
Veyangoda
Junction
Houses
Veytex
VEYTEX LOCATION

ANNEXURE C


VEYTEX PROCESS PLANT LAYOUT
SINGERING
CROPPING
GREY CLOTH
CAUSTIC RECOVERY PLANT
STOCK GREY CLOTH
BEAM ROTATION
BALE PRESS
FINISHING SECTION
PRE WASHING
MERCERIZING
JIGGERS
HOT FLUE
COLD PAD BATCH
ROLLING MACHINE
SINGLE FOLDING
INDIAN STENDER
SINGLE FOLDING
DOUBLE FOLDING
SCOURING UNIT
CONTINUOUS DYEING
NEW WASHING MACHINE
3 BOWL CALENDER
5 BOWL CALENDER
CAUSTIC RECOVERY
FINISHING MANAGER OFFICE
POST WASHING
CYLINDER DRYER
STEAM AGER
PRODUCTION CONTROL OFFICE
CHEMICAL LAB
DYE STORE
ARTUS FLOAT DRYER
FINISHING SECTION
COLOR KITCHEN
FLAT BED SCREEN PRINTING
BEAM & SCREEN WASHING
DYE STORE
ENGRAVING SECTION
DARK ROOM EXPOSTURE
ROTARY SCREEN PRINTING
ROTARY SCREEN STORE

ANNEXURE D

MAJOR CHEMICALS

		Consumption for August 1995
i)	Manitex (Alginate)	1200
ii)	PVA	880
iii)	Acetic Acid	261
iv)	NaOH flakes	1700
v)	NaOH Solid	13,200
vi)	Na_2SiO_3	4700
vii)	$NaHCO_3$	1536
viii)	Na_2CO_3	190
ix)	H_2O_2	4740
x)	Di Ammonium Phosphate	18
xi)	Invatex (Sequestering Agent)	480
xii)	Lutexal HP (Thickener)	72
xiii)	Cottoclarin KD	1000
xv)	Repidol PS	427
xvi)	Dipol	242
xvii)	Tino clorite CB (Bleaching/stabilising)	90
xviii)	Tino clorite ON (Bleaching/stabilising)	326
xix)	Emulsifier VA	184
xx)	Lusyntan SE (H_2O_2 stabiliser)	379
xxi)	Hydro	90
xxii)	Maize starch	1861
xxiii)	Binder	1711
xxiv)	Urea	6740
xxv)	Fixer	247
xxvi)	Tinofix ECO	1072
xxvii)	Pregasol (Stripping agent)	
xxviii)	R31 NTS	
xxviv)	Enzyme	
xxx)	Dyes	

ANNEXURE E

MACHINE WISE PRODUCTION FOR AUGUST 1995

Process	Production (m)	Production (T)
Sizing	914,400	129.7
Desizing	1,111,424	158
Pre washing	1,090,492	140
Hot bleaching	1,090,492	140
Post washing	1,090,492	140
Cold bleaching	482,390	62
Mercerization	1,240,487	159
Cold pad dyeing	514,744	66
Printing	546,867	60
Drying	3,798,775	486
New washing range	1,007,474	129
Old washing range	908,700	116
Stenter	1,480,457	189
Curing	721,604	92
Beam washing	190,580	24.3

ANNEXURE F
RECIPES

Desizing

2 g/l. Rapidase L-40 or
5 g/l. X-Size
2 g/l. Cottoclarine KD

B.F. & M.B.F. Light material (Hot-Bleach)

72 g/l. Hydrogen Peroxide
36 g/l. Sodium Silicate
24 g/l. Stabilizer HPC
or
12 g/l. Tinoclorite
18 g/l. Cottoclarine KD
10 g/l. Rapidol PS
30 g/l. Caustic Soda (50° TW)
6 g/l Uvitex RSB
or
6 g/l Sun-White
3 g/l Invatex SA

B.F. & M.B.F. Heavy material (Hot-Bleach)

96 g/l. Hydrogen Peroxide
36 g/l Sodium Silicate
24 g/l Stabilizer HPC
or
12 g/l Tinoclorite
18 g/l Cottoclarine KD
10 g/l. Rapidol PS
30 g/l. Caustic Soda 50°TW
6 g/l Uvitex RSB
or
6 g/l Sun-White
3 g/l Invatex SA

B.M.P. and B.M.D. - (Hot-Bleach)

96 g/l Hydrogen Peroxide
36 g/l Sodium Silicate
24 g/l Stabilizer HPC
or
12 g/l Tinoclorite
18 g/l Cottoclarine KD
10 g/l. Rapidol PS
30 g/l. Caustic Soda (50°TW)
3 g/l Invatex SA
6 g/l Uvitex RSB or
4 g/l Sun-White

Viscose Rayon B.C.F. (Cold Bleach)

55 g/l. Caustic Soda (Flakes)
10 g/l. Tinoclorite
4 g/l. Cottoclarine KD
3 g/l Uvitex RSB or
3 g/l Sun-White
3 g/l Invatex SA
20 g/l Hydrogen Peroxide

Viscose Rayon B.C.D. (Cold Bleach)

40 g/l. Caustic Soda (Flakes)
10 g/l. Tinoclorite
4 g/l. Cottoclarine KD
3 g/l Invatex SA
10 g/l Hydrogen Peroxide

After the Cold bleach (Viscose Rayon BCD goods) it is necessary to Causticize with the following recipe.
8 TW Caustic Soda)
4 g/l Invatex SA) Cold

Viscose Rayon B.C.P.

55 g/l. Caustic Soda (Flakes)
10 g/l. Tinoclorite OB
4 g/l. Cottoclarine KD
3 g/l Uvitex RSB or Sun-White
3 g/l Invatex SA
10 g/l Hydrogen Peroxide

Normal Cold-Bleach Recipe

32 g/l. Hydrogen Peroxide
12 g/l. Sodium Silicate
18 g/l. Stabilizer HPC
or
6 g/l. Tinoclorite
2 g/l. Cottoclarine KD
5.5 g/l Invatex SA
3 g/l Uvitex RSB or Sun-White

Hot - Scour

8 TW Caustic Soda
2 g/l. Cottoclarine KD

Annexure G

ESTIMATION OF EFFLUENT TREATMENT COST ON THE BASIS OF COD REMOVAL

Assumptions

a) Capacity of plant	- 200 m^3/day
b) Typical COD of textile effluent after equalization	- 800 mg/l
c) Chemical consumption	
Coagulant, Alum (400 mg/l)	- 80 kg/day
Flocculant, Polymer (2 mg/l on dry solid basis)	- 400 g/day
Neutralizer, Lime (120 mg/l)	- 24 kg/day

Chemical Costs

Alum (Rs 16/kg)	=	1280
Polymer (Rs 1000/kg)	=	400
Lime (Rs 5/kg)	=	120
Total Chemical cost	=	**Rs. 1800/d**

Electricity cost

Feed pump (1 kW)	=	24 kWh
Chemical preparation(0.25x3)	=	18 kWh
Dosing pump (0.1x3)	=	7.2 kWh
Flash mixer (0.5 kW)	=	12 kWh
Clarifier scraper(0.75kW)	=	18 kWh
Sewage pump (0.5 kW)	=	12 kWh
RBC (1.5 kW)	=	36 kWh
Secondary clarifier scraper(0.75 kW)	=	18 kWh
Total power requirement/d	=	145.7 kWh
Electricity cost (Rs 5/kWh)	=	**Rs. 726/d**

Labour cost for the operation of the treatment plant (24 labour hours per day)

Total cost of labor including EPF, ETF, and annual overtime	=	Rs 25/h
Labor cost	=	**Rs 600/d**
Sludge handling cost	=	**Rs 150/d**
TOTAL OPERATIONAL COST	=	**Rs 3276/d**
COD removal required per day	=	$200(800-250)10^{-3}$ kg/d
	=	110 kg/d
Cost for removal	=	3276/110
of 1 kg COD	=	30 Rs. approx.

ANNEXURE H

ESTIMATION OF THE STEAM COST
(BASIS ONE MONTH)

Fuel oil cost	=	385,000(l) x 6.25(Rs/l)
	=	Rs. 2406,250
Electricity power cost	=	100(kW/hr)(23*28) x 3.66(Rs/kWh)
	=	Rs. 235,704
Water cost	=	6237(M^3) x 11.01(Rs/M^3)
	=	Rs. 34,350
Boiler water treatment cost	=	Rs. 10,000
Labour cost	=	Rs. 100,000

Water used is estimated using boiler efficiency (80%)

Fuel used	=	385,000 l
Heat content	=	40,500 kJ/l
Steam produced	=	(385,000 x 40,500 x 0.8)/2000
	=	6237,000 kg
Total cost	=	Rs. 2,786,303
Total steam produced	=	**6237,000 kg**
Unit steam cost	=	**0.4135 Rs/kg**

ANNEXURE I

UTILITY COST

UTILITY	UNIT COST (Rs)	COST/kg FABRIC (Rs)
WATER	11.01 /m^3	3.03
STEAM	0.45 / kg	13.08
ELECTRICITY	3.66 / kWh	26.31
FUEL OIL	6.25 / l	12.21
TREATMENT COST	30 / kg COD	5.01

Process flow diagram for ultafiltration unit.

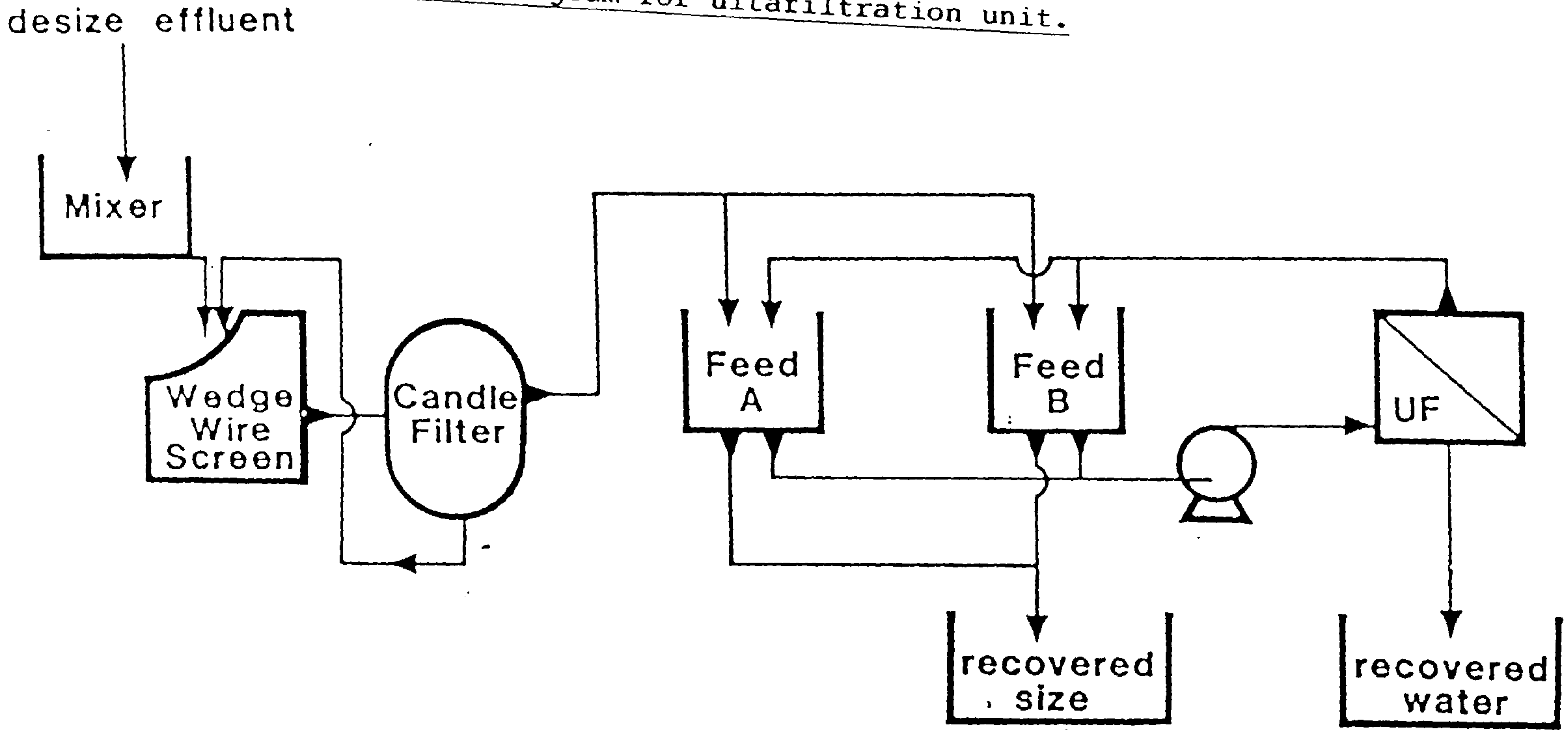


Figure 1