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Annex 6

INDUSTRIAL POLLUTION REDUCTION PROGRAMME
DG/SRL/91/019

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

WASTE AUDIT

CEYLON SYNTHETICS TEXTILE MILLS LTD.

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

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SUMMARY

Ceylon Synthetic Textile Mills Ltd. is a medium scale textile processing industry providing employment to about 500 workers. The industry is located in a commercial area in Colombo. Their product range consists of printed and dyed synthetic fabrics. A physico-chemical treatment plant is available to treat the process effluent and the treated water is discharged to a nearby canal.

Theoretical steam utilization is 68% of total steam production. It is noted that the municipal water is used only for domestic purposes but the consumption figure per head is very high. Figure for water consumption/kg of fabric is 224 litres which is also considered high.

The water balance also indicates that the domestic consumption and undefined losses amount to the highest percentages out of the total consumption. Out of the process water consumption figures printing department and washing ranges are the highest water consumers. The COD table and waste and emission cost analysis indicate that desizing, printing and dyeing operations are the major contributors to the pollution load. Since printing is the highest contributor to both water consumption and pollution load these have been given high priority in the generation and evaluation of Waste Minimisation options. This also seems to be highest contributor to the waste stream cost.
56 waste minimisation options were identified and most of these originate in the printing department and implementation of these will bring down both the water consumption and the organic load in the waste stream. The results of the cost benefit analysis carried out for the 10 high priority options are presented in the table below. However the industry has not implemented these options due to the lack of interest of the management.

Option		Investment (Rs)	Savings (Rs)	Payback period (M)	Environmental benefits
1a.	Recovery of print paste from screens, squeezees containers (rotary printer)	Nil	96,235	NA	reduces organic load by 1.4%, effluent volume by 0.3%
1b.	Recovery of print paste from screens, squeezees containers (Flat bed printer)	Nil	30,965	NA	reduces organic load by 0.5%, effluent volume by 0.1%
2.	Installation of press button switches for jets	400	10,368	<1	--
3.	Lagging boiler feed water tank	67,080	23,516	34	reduces fuel by 0.6%
4a.	Installation of doctor blade for rotory printer blanket	10,000	236,091	<1	reduces organic load by 2.8% and effluent volume by 3%
4b.	Installation of doctor blade for flat bed printer blanket	10,000	29,848	4	reduces organic load by 2.4% and effluent volume by 0.7%
5.	Lagging of jets	103,740	63,832	19	reduces fuel by 1.3%
6.	Use of treated water to wash screens, squeezees, containers etc.	18,962	232,415	<1	reduces effluent volume by 9.6%
7.	Chemical substitution	Nil	295,608	NA	reduces organic load by 0.6%
8.	Reduce liquor ratio in jets from 1:8 to 1:7	Nil	92,579	NA	reduces effluent volume by 0.6%, fuel consumption by 0.79%
9.	Counter current rinsing in 4th & 5th baths in the saree washing range	500	3,332	2	reduces effluent volume by 0.1%
10.	Installation of temperature control system for 2nd bath and repair of 4th bath temperature control system in the washing range	46,250	35,182	16	reduces effluent volume by 0.7%

NA Not Applicable

List of Abbreviations

COD	Chemical Oxygen Demand
°C	°Centigrade
J	joule
K	kelvin
kJ	Kilo Joule
kg	kilogram
kWh	kilo Watt hour
l	litre
M	month
m	meter
min	minute
s	second
y	year
d	day
g	gram
PE	Polyester
PV	Polyester Viscose
PC	Polyester Cotton
HAc	Acetic acid
PVA	Poly Vinyl Acetate
hp	Horse power

PART 1 - ENVIRONMENTAL STATUS

CEYLON SYNTHETIC TEXTILE MILLS LTD

1.0 Introduction

Ceylon Synthetic Textile Mills Ltd is a textile processing industry carrying out weaving, mercerising, dyeing, and, printing of suiting, sarees, polyester cotton, polyester viscose and nylon fabric.

1.1 Organisational chart : Attached (Annex A)

1.2 Ownership : Mr. A.Y.S. Gnanam

1.3 Contact persons : Mr. Dhammika Liyanage, Processing Manager

2.0 Site details

2.1 Location : 752, Dr. Danister de Silva Mawatha, Colombo 9. (Annex B)

2.2 Physical Descriptions

(i) Area : 24,000 m^2

(ii) Topography : Flat land

(iii) Factory layout : Attached (Annex C)

(iv) Sealed surface : 70 % of the site

(v) Depth to groundwater : About 3 m

(vi) Surface water bodies : None

(vii) Surface drainage channels : Separate open drains for factory effluent & storm water

2.3 Current use

(i) Processes : Textile weaving, mercerising, dyeing, printing, and finishing

(ii) Products : Dyed and printed fabrics

(iii) Raw materials : 100 % polyester, viscose and nylon yarns

(iv) Major chemicals : Attached (Annex D)

(v) Energy source : Furnace oil and electricity

2.4 Site drainage (type & discharge points)

(i)	Process effluent	: Through open drains to treatment plant, to canal
(ii)	Domestic waste water	: Through open drains to public sewer
(iii)	Storm water	: To the road drain
(iv)	Toilet effluent	: Through pipe drains to public sewer

3.0 Environmental Emissions

3.1	Atmospheric emissions	: Flue gas from steam boilers, solvents from printing and curing machines and, exhaust from dryer and stentor.
3.2	Aqueous discharge points	: Effluents from bleaching, dyeing, printing, and washing
3.3	Solid waste	: Packaging materials, containers, fabric binding rope etc.,

4.0 Site history and Neighbouring sites

4.1 History of the site

(i)	Start date	:
(ii)	Former use	: Marshy land

4.2 Current and former use of neighbouring sites

(i)	Northern	: St. Anthony's Industries Ltd. - Hardware factory
(ii)	Southern	: Residential
(iii)	Western	: Base Line Road, a main road
(iv)	Eastern	: Marshy land

4.3 Significant spills : None

5.0 Environmental Receptors

5.1 Abstraction points

(i)	Dug wells	: None
(ii)	Tube wells	: 06 Numbers
(iii)	Surface water	: None

5.2 Sensitive neighbours within 2 km

(i) Residence : 10 m from factory southern boundary

(ii) Hospitals : none

(iii) Schools : 200 m from the Western boundary

(iv) Others :

5.3 Protected Natural Habitats : None

5.4 Water Bodies

(i) Surface : San Sebastian Canal

(ii) Sub-surface : None

6.0 Solid Waste Issues

(i) Type and disposal method : Plastic containers-sold; Garbage-to municipal solid waste

7.0 Environment Licence issues

7.1 Current status :

7.2 Current compliance issues : Effluent discharge and noise levels do not comply with CEA standards

PART 2 - WASTE AUDIT

1.0 General Information

WORK SHEET 1	
Name of the Company : Ceylon Synthetic Textiles 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. Ilangkumaran — Research Officer, CISIR 6. Mr. K. Pavananthan — Research Officer, CISIR 7. Mr Dhammika Liyanage — Processing Manager, CYNTEX	
A. Major Raw Materials Consumption (September 1995)	
a) Fabrics	260,449 m/M
b) Chemicals	
i) Process chemicals	9448 kg
ii) Dyes	888 kg
B. **Energy Consumption (September 1995)**	
a) Electrical	
Normal	131,480 kWh
Peak	22,400 kWh
Maximum demand KVA	727 kWh
b) Fuel for boilers (Steam boiler & Thermic boiler)	62,914 l
C. **Water Consumption**	125,076m^3 /y*

D. **Production**	
a) Installed capacity	
Jet 1	150 kg/Batch
Jet 2	150 kg/Batch
Jet 3	250 kg/Batch
Jet 4	350 kg/Batch
Jiggers (4 Nos)	180 kg/Batch
Jigger (4 Nos)	80 kg/Batch
Star Ager (steamer)	400 m/Batch
Flat Bed Printing machine	10 m/min
Rotary Printing machine	60 m/min
Stenters(5 chamber 2 machine, 4 chamber 1 machine)	35000 m/d
Weight Reduction Tanks	900 m/Batch
Washing Range (5 baths)	28 m/min
Mercerizing machine	20 m/min
Washing Range (4 baths)	400 m/min
Counter Current Washing Range (4 baths)	400 m/min
Singeing machine & De-sizing machine	50 m/min
Polymerizer	20 m/min

b) ACTUAL PRODUCTION (September 95)	
Dyeing & Finishing	
Polyester/Viscose suiting	13,228 m/M
Polyester/Cotton suiting	26,887 m/M
Polyester suiting	36,680 m/M
Polyester/Viscose (PV 65/35 dress fabric)	109,017 m/M
Polyester Saree	17,178 m/M
Nylon dress fabric	22,521 m/M
Cationic Suiting	14,457 m/M
Polyester/Viscose (PV 80/20 dress fabric)	20,481 m/M
Printing	
Polyester/Viscose (PV 65/35 dress fabric)	109,017 m/M
Polyester Saree	17,178 m/M
Polyester/Viscose (PV 80/20 dress fabric)	20,481 m/M
E. **Type of Effluent Treatment**	Physico Chemical
F. **Any other relevant information** : Working days for September was 25 and production is carried out for 16 hours. Total number of workers is 500.	

ASSUMPTIONS

* Water consumption per year was calculated from September 1995 monthly consumption given by the industry.

2.0 Available Information

Availability of information in the documented form is not satisfactory. However the required data and details for the preparation of the material balance etc were provided to the team on request. Measurement facilities are unavailable and the team had to rely on factory information for well water consumption etc. In the absence of measurement facilities and emission records, it was found to be difficult to make an energy balance.

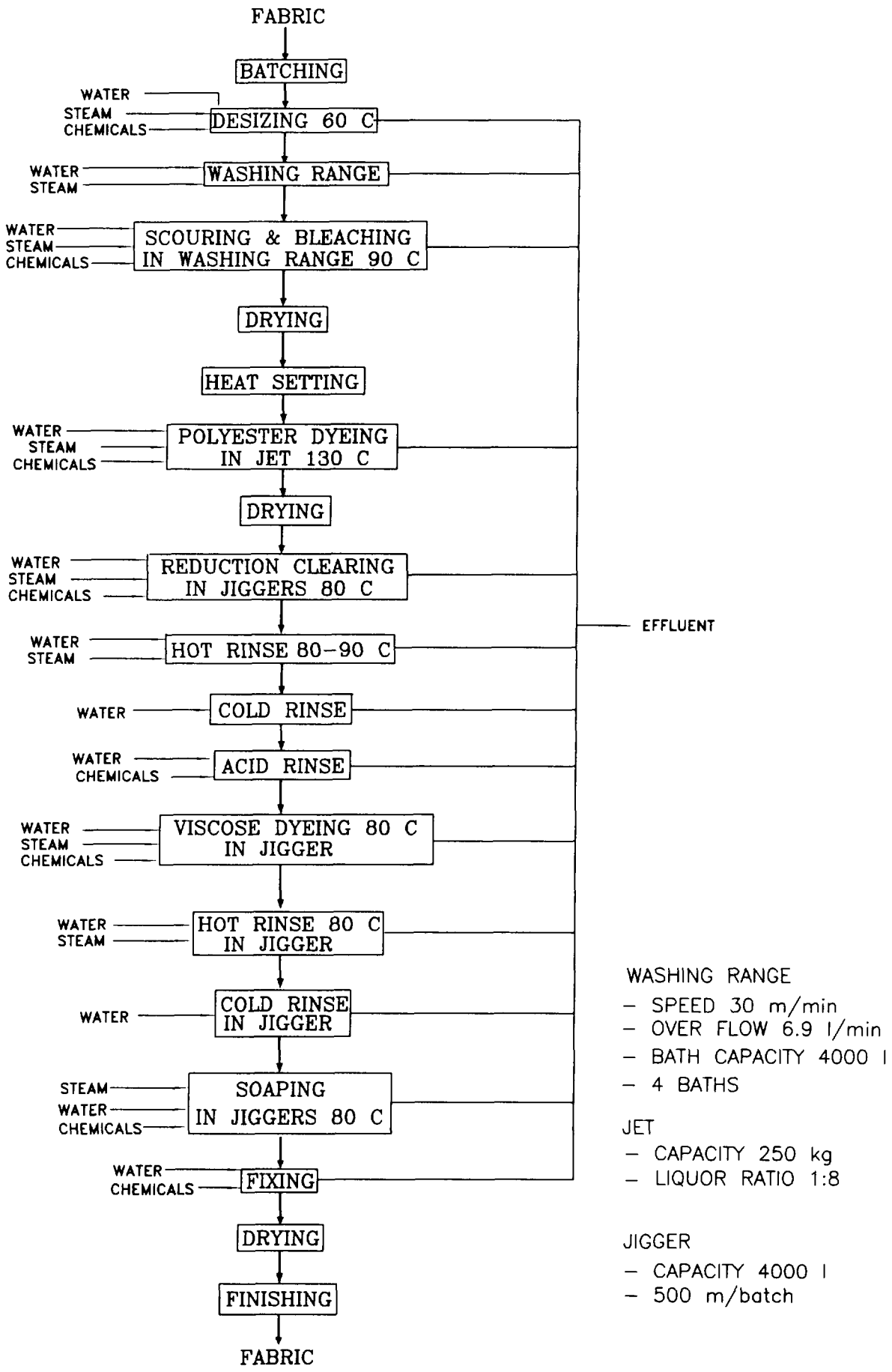
WORK SHEET 2		
Information	**Availability**	**Remarks**
Process flow diagram	Available	not satisfactory
Material Balance	Not available	Only monthly consumptions are available
Energy balance	Not available	
Water balance	Not available	Average water consumption is available
Plant layout	Available	Satisfactory
Waste analysis	Not available	
Emission records	Not available	
Production log sheets	Available	not used in any calculation
Maintenance log sheets	Not available	

3.0 Process Flow Diagrams

A number of varying processes are adopted in the processing of textiles of many varieties and the processing is carried out in different machines. Process flow diagrams depict these details along with process conditions, machine capacities and effluent generation etc.

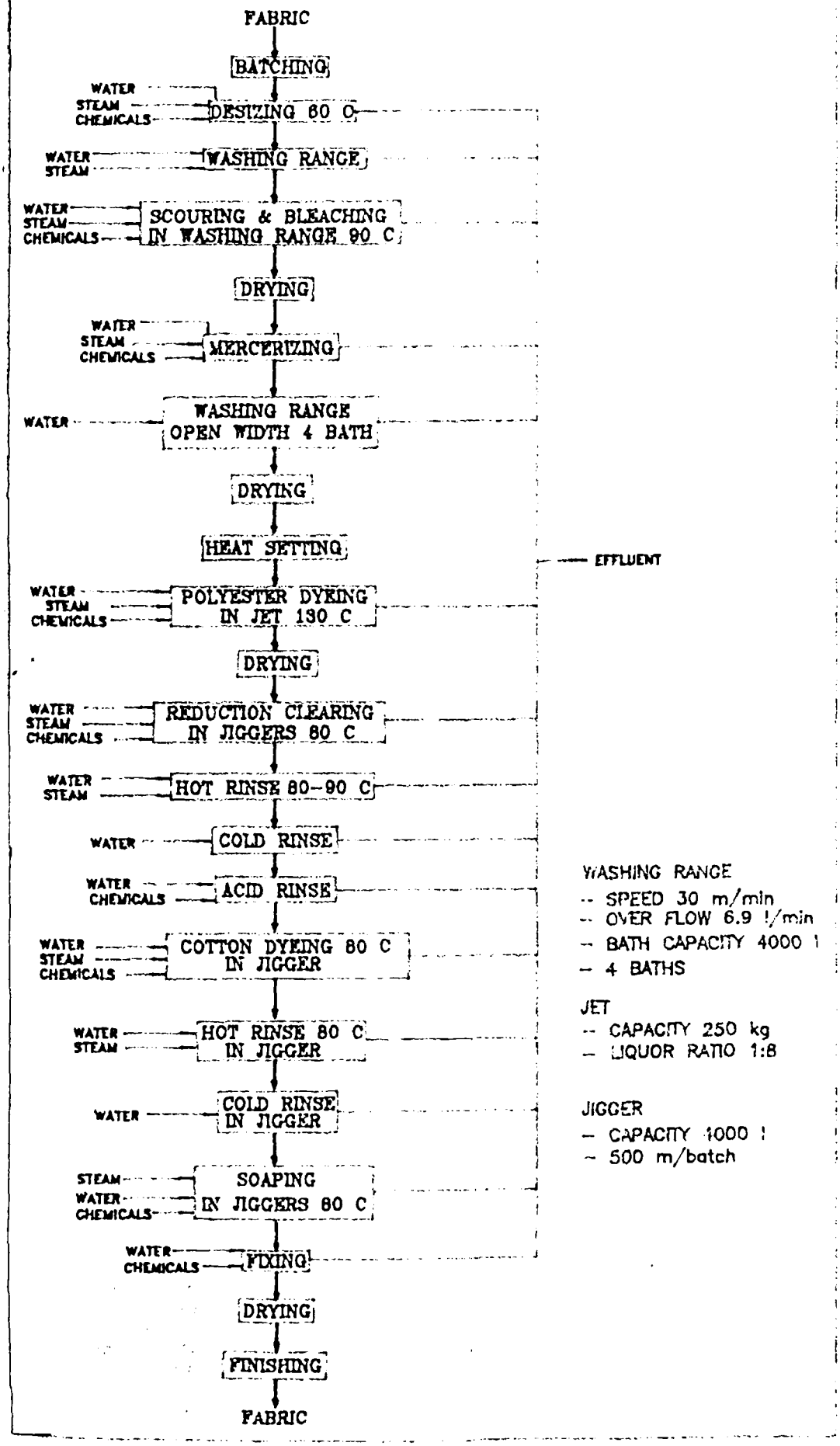
WORKSHEET 3.1

PROCESS FLOW DIAGRAM FOR POLYESTER/VISCOSE SUITING



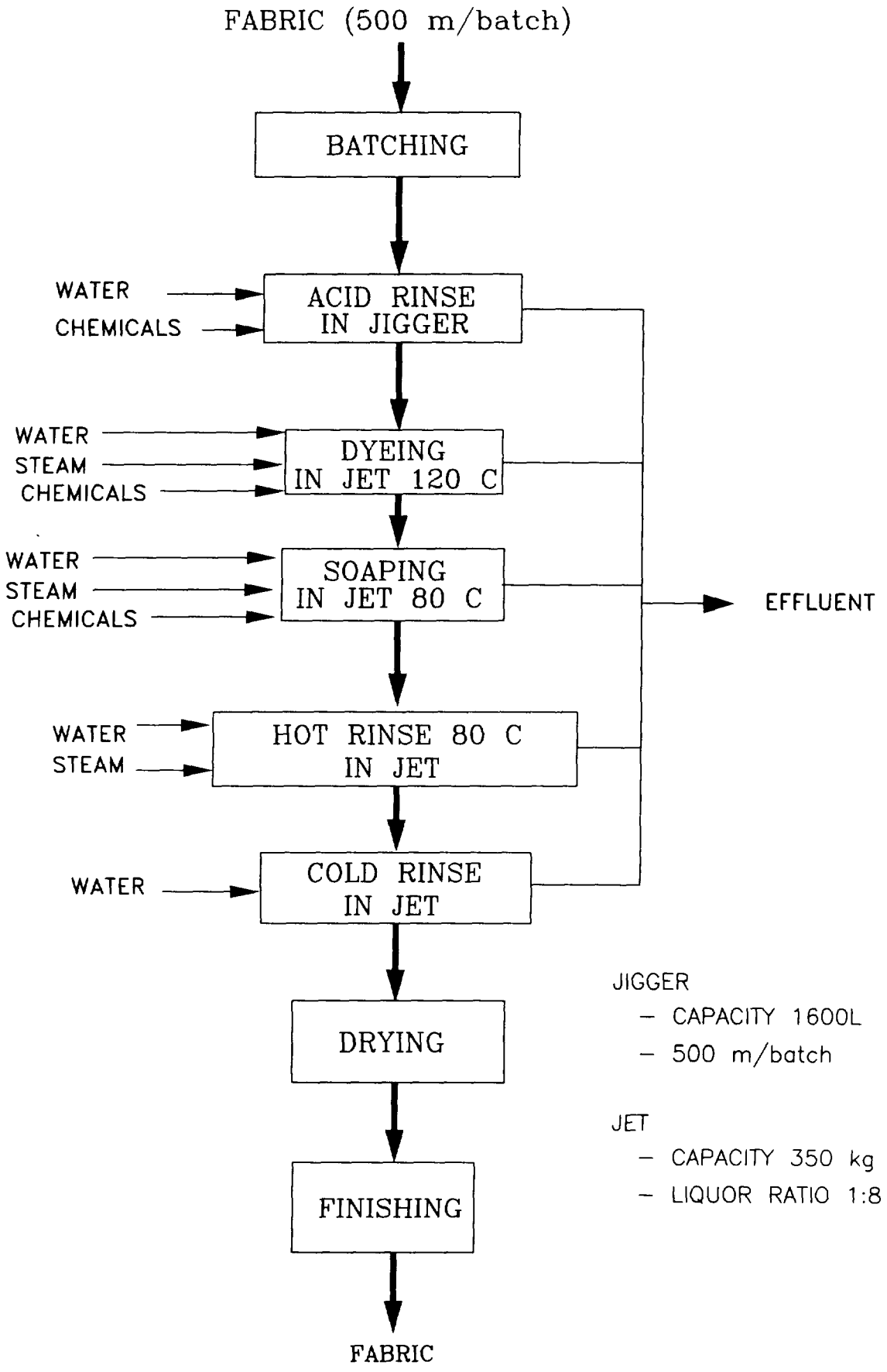
WORKSHEET 3.8

PROCESS FLOW DIAGRAM FOR POLYESTER/COTTON SUTING



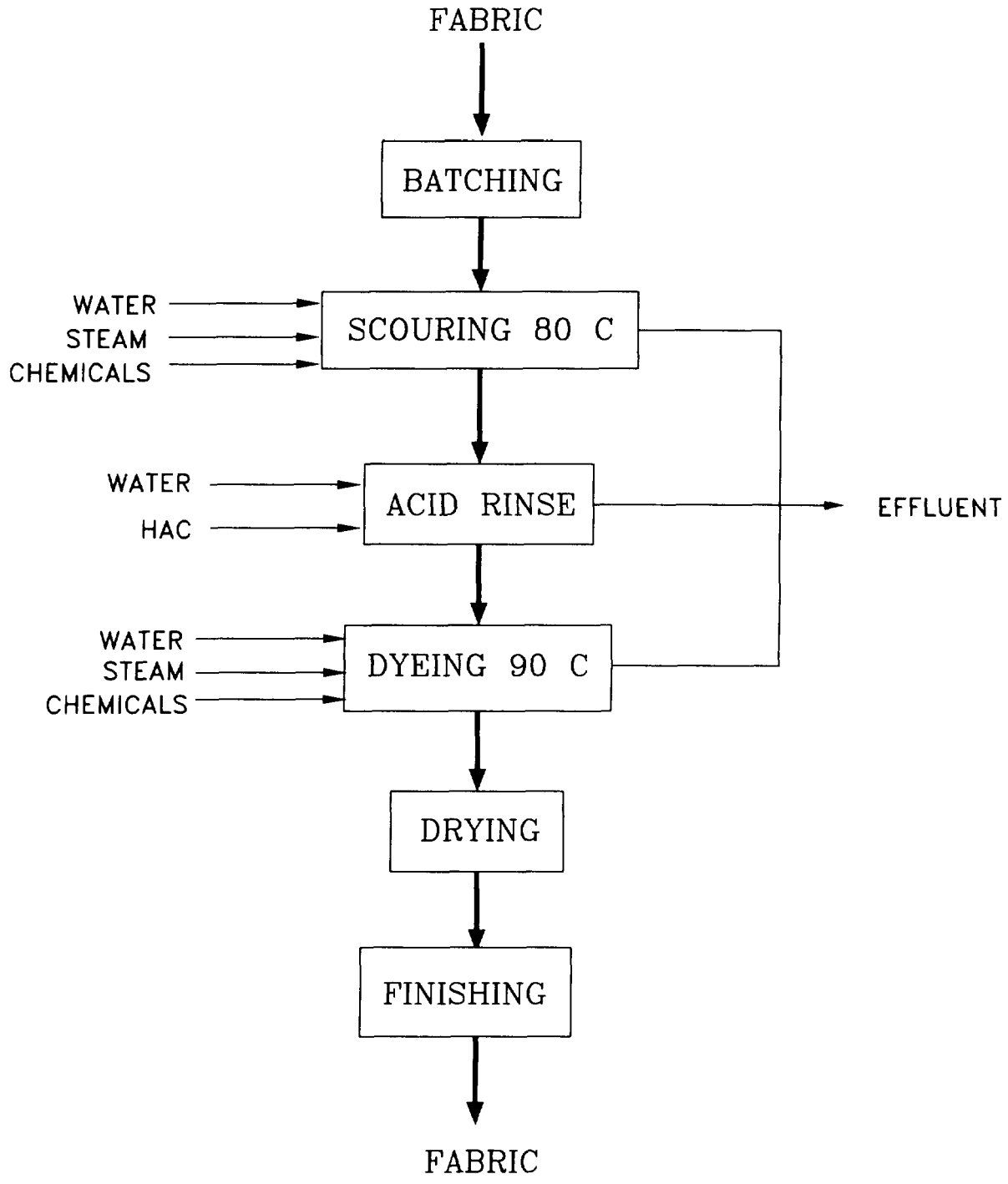
WORKSHEET 3.3

PROCESS FLOW DIAGRAM FOR CATIONIC SUITING



WORKSHEET 3.4

PROCESS FLOW DIAGRAM FOR NYLON DRESS



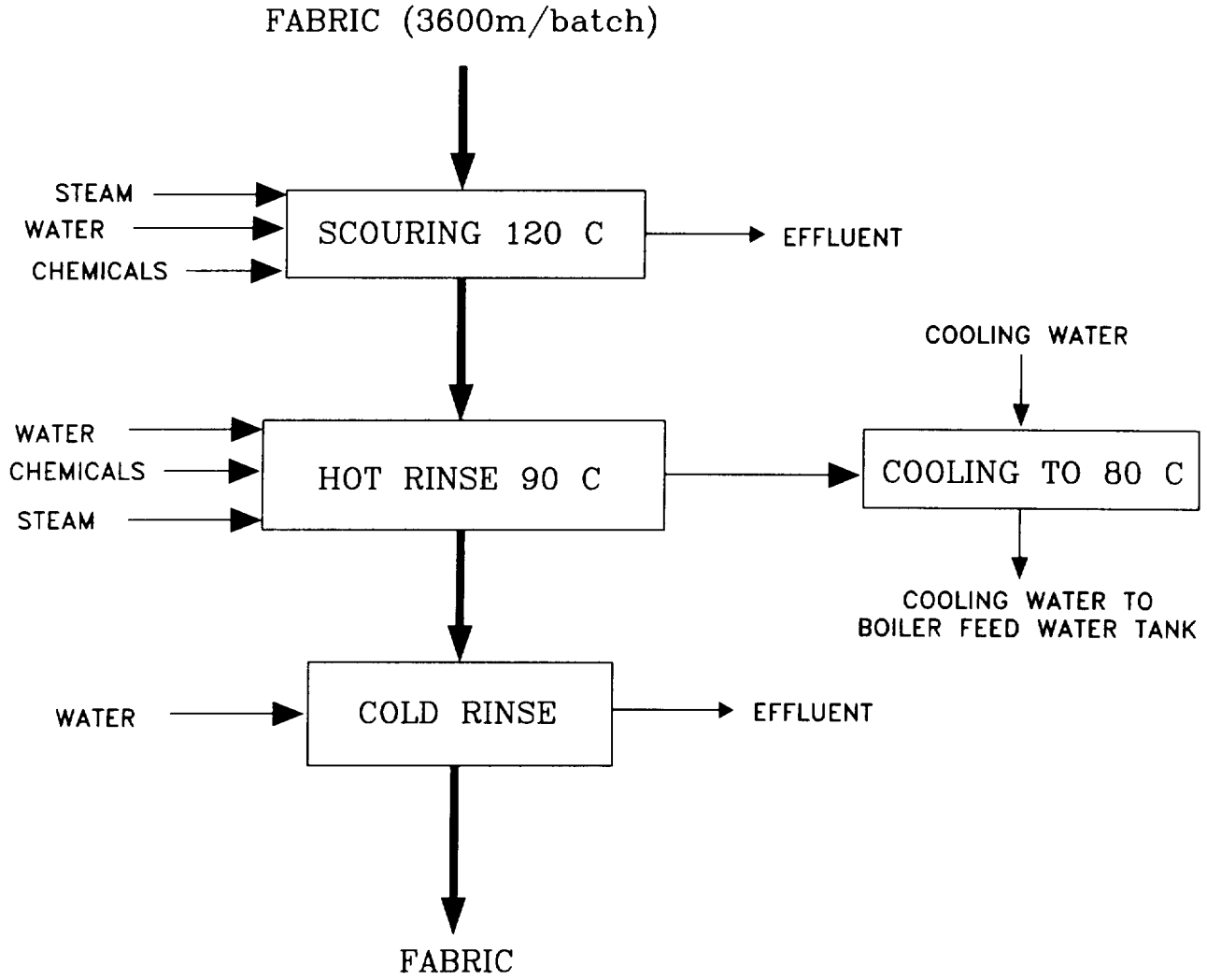
ALL THE OPERATIONS ARE CARRIED OUT IN JIGGER

- CAPACITY 2000 l
- 1000m (47 kg)/batch

WORKSHEET 3.5

DRUM WASHER

(100% POLYESTER SAREE)

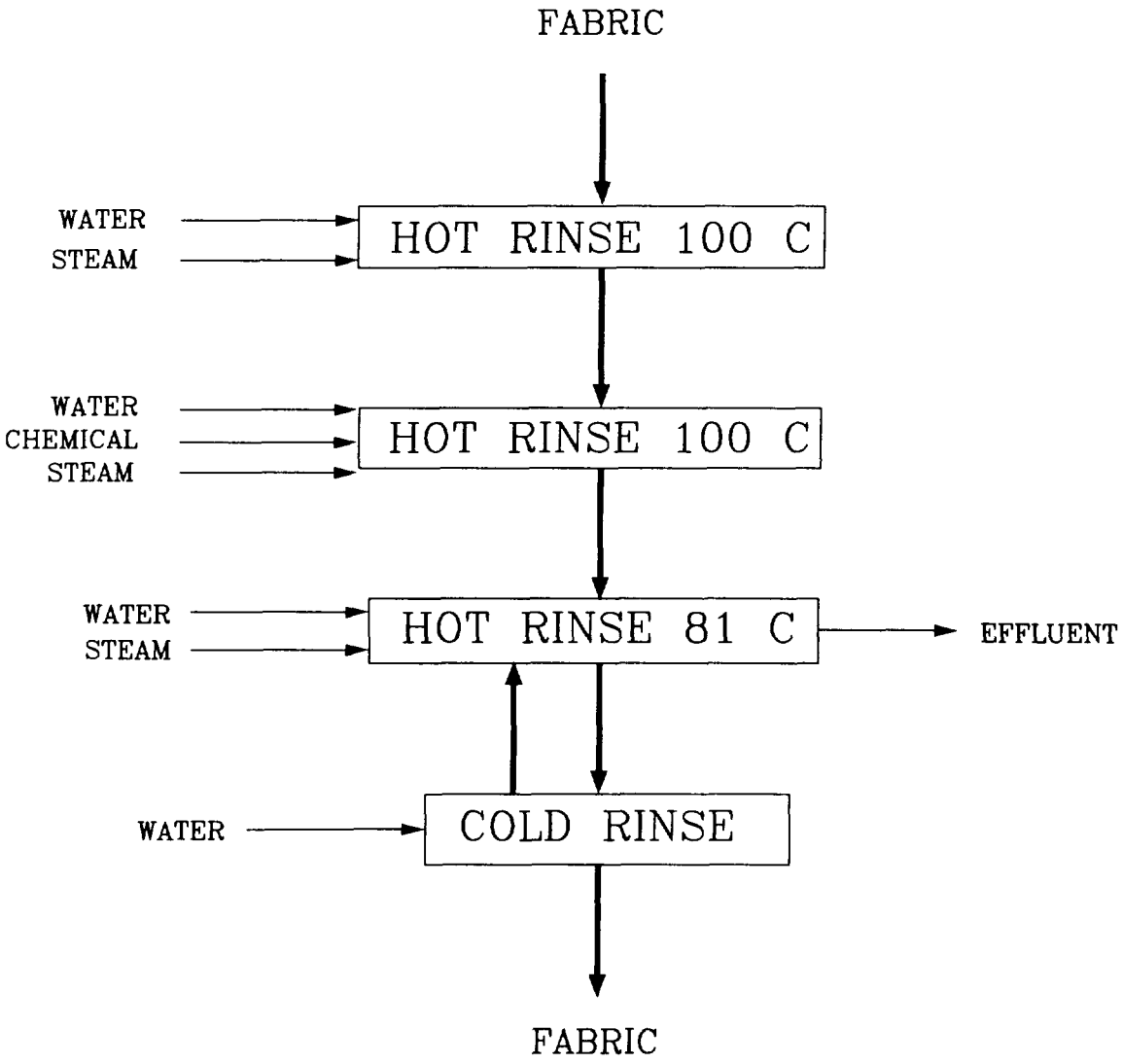


COOLING PROCESS IS NOT DONE FOR POLYESTER SAREE

WORKSHEET 3.6

COUNTER CURRENT WASHING

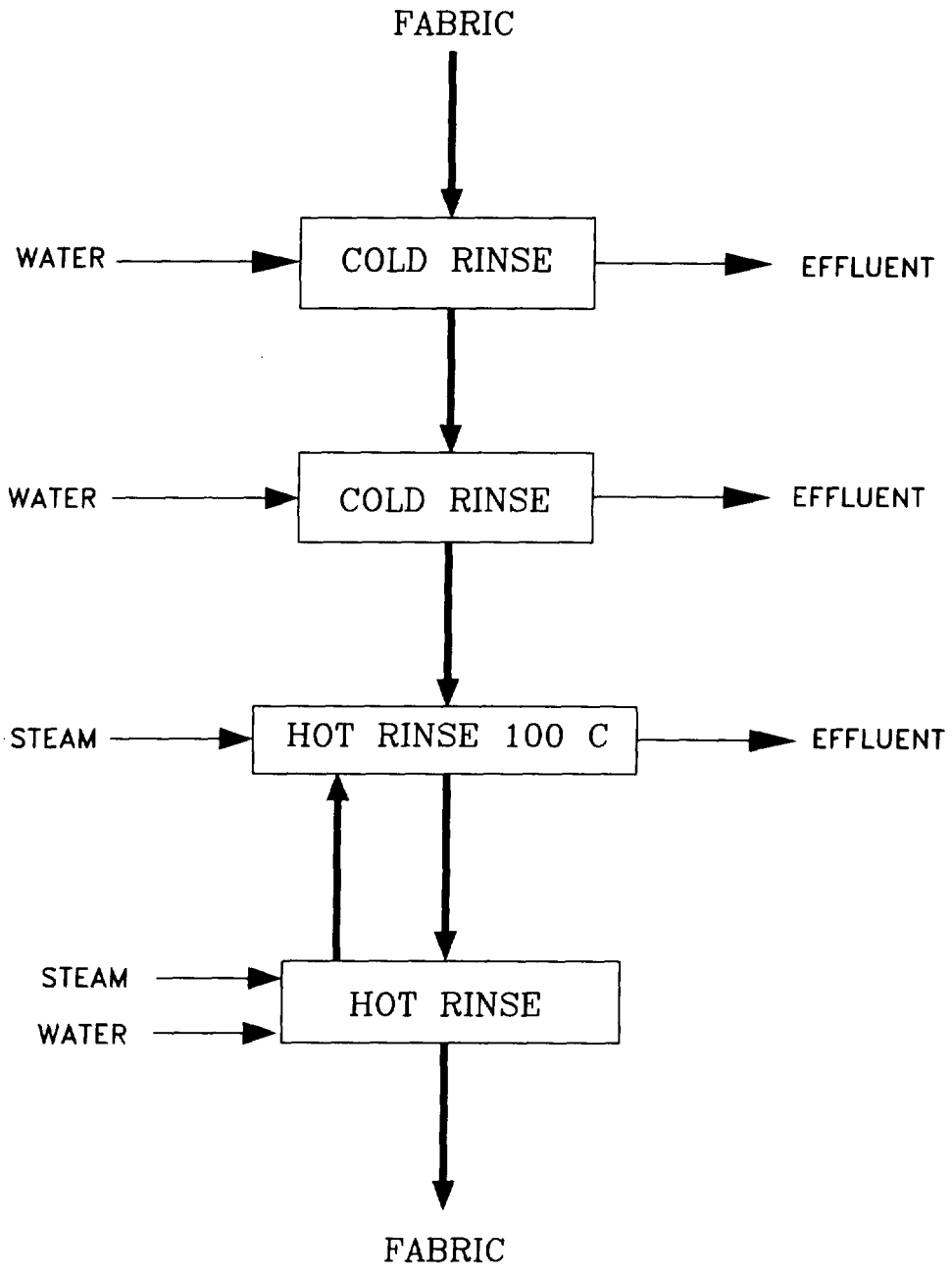
AFTER DESIZING



NOT USED IN SEPTEMBER 1995

WORKSHEET 3.7

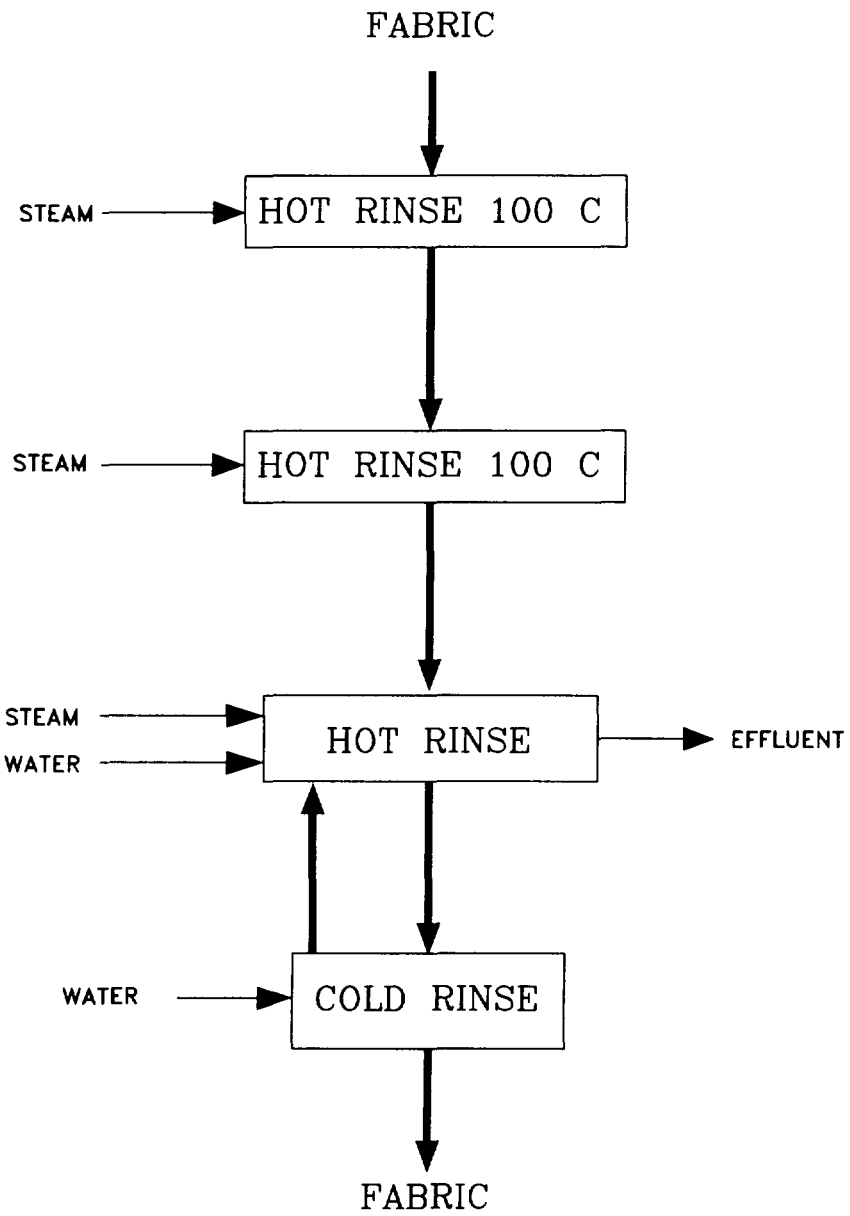
COUNTER CURRENT WASHING
AFTER BLEACHING



NOT USED IN SEPTEMBER 1995

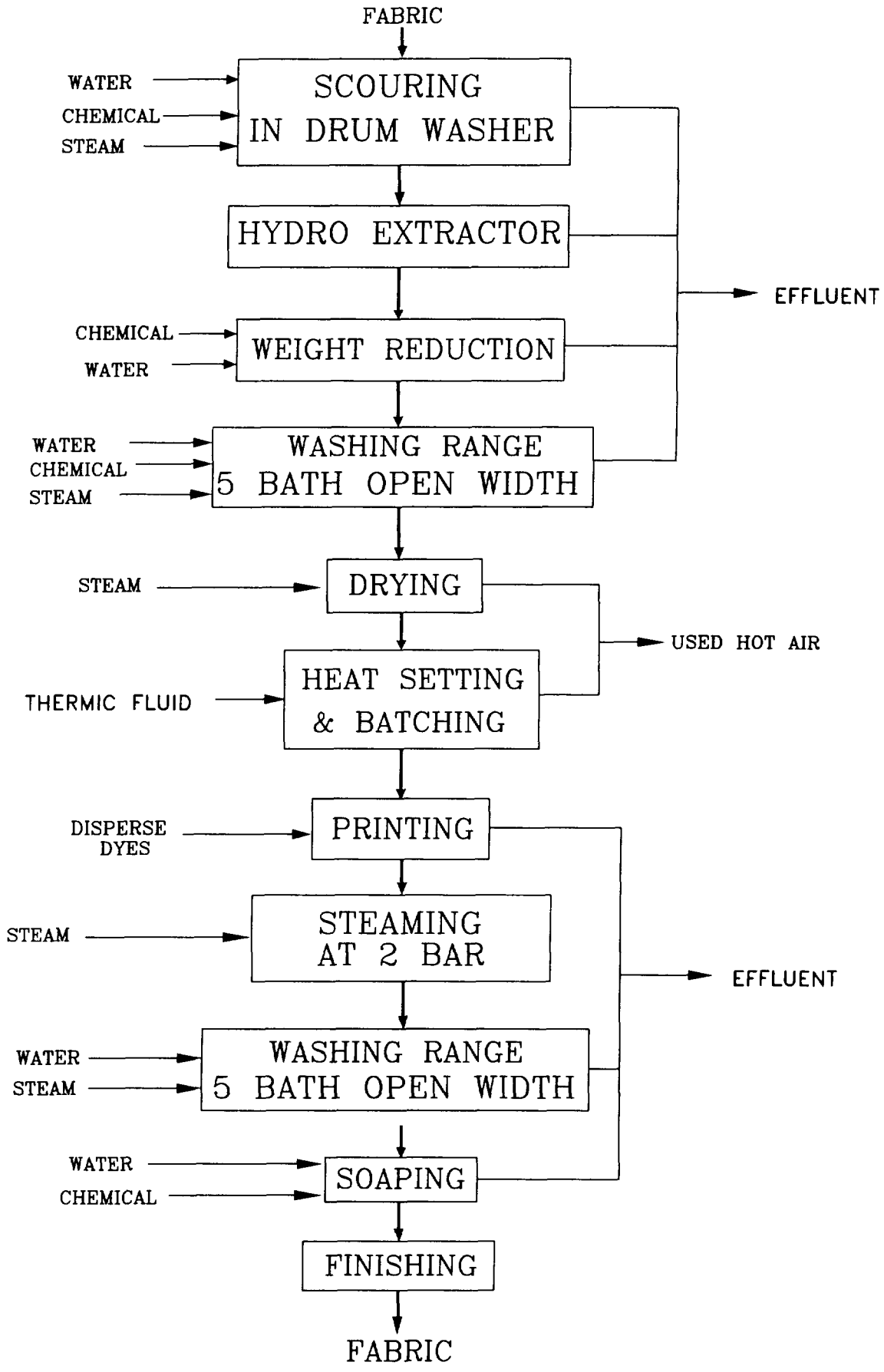
WORKSHEET 3.8

COUNTER CURRENT WASHING
AFTER SCOURING



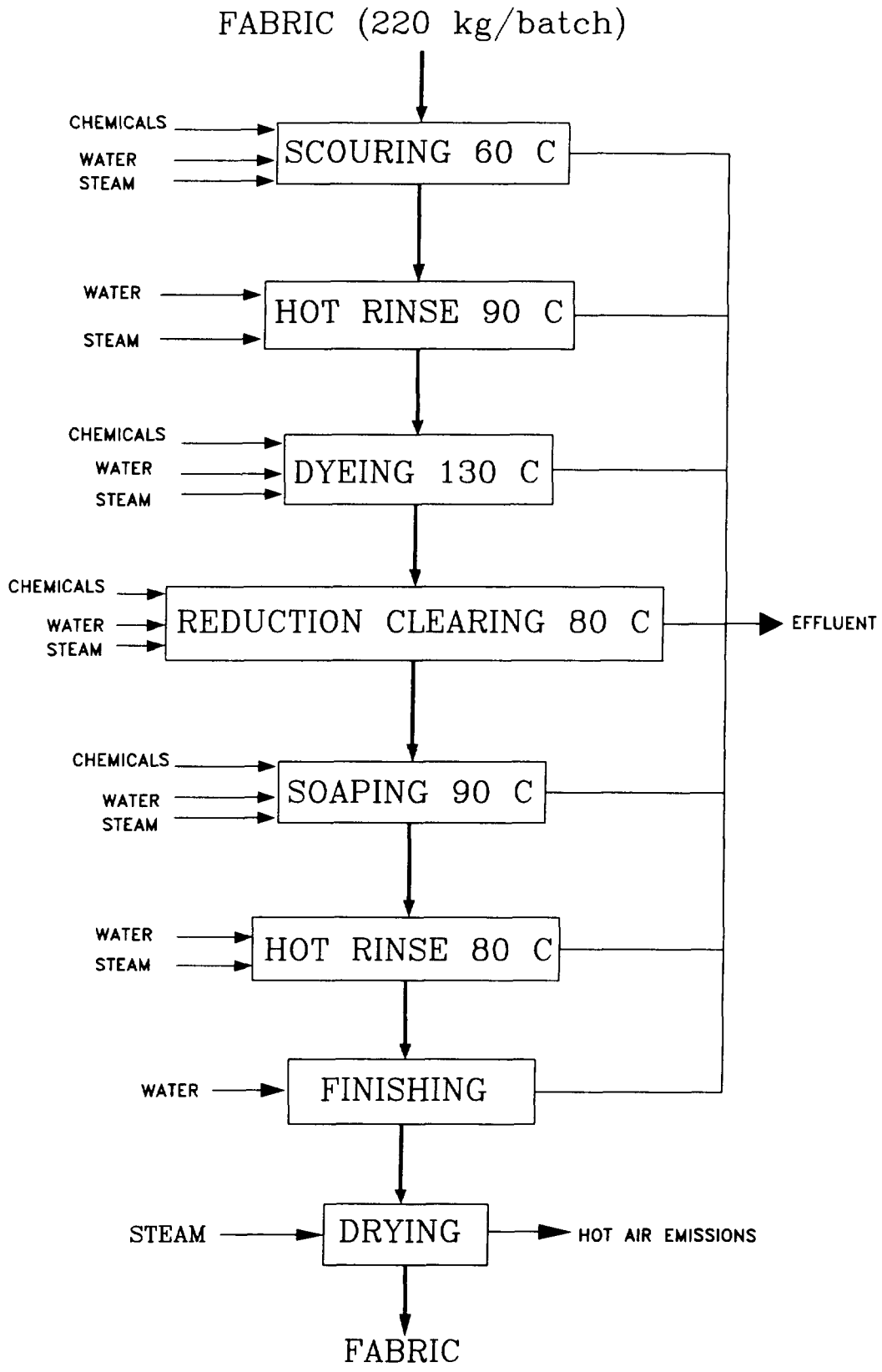
NOT USED IN SEPTEMBER 1995

PROCESS FLOW DIAGRAM
FOR 100% POLYESTER SAREE



WORKSHEET 3.10

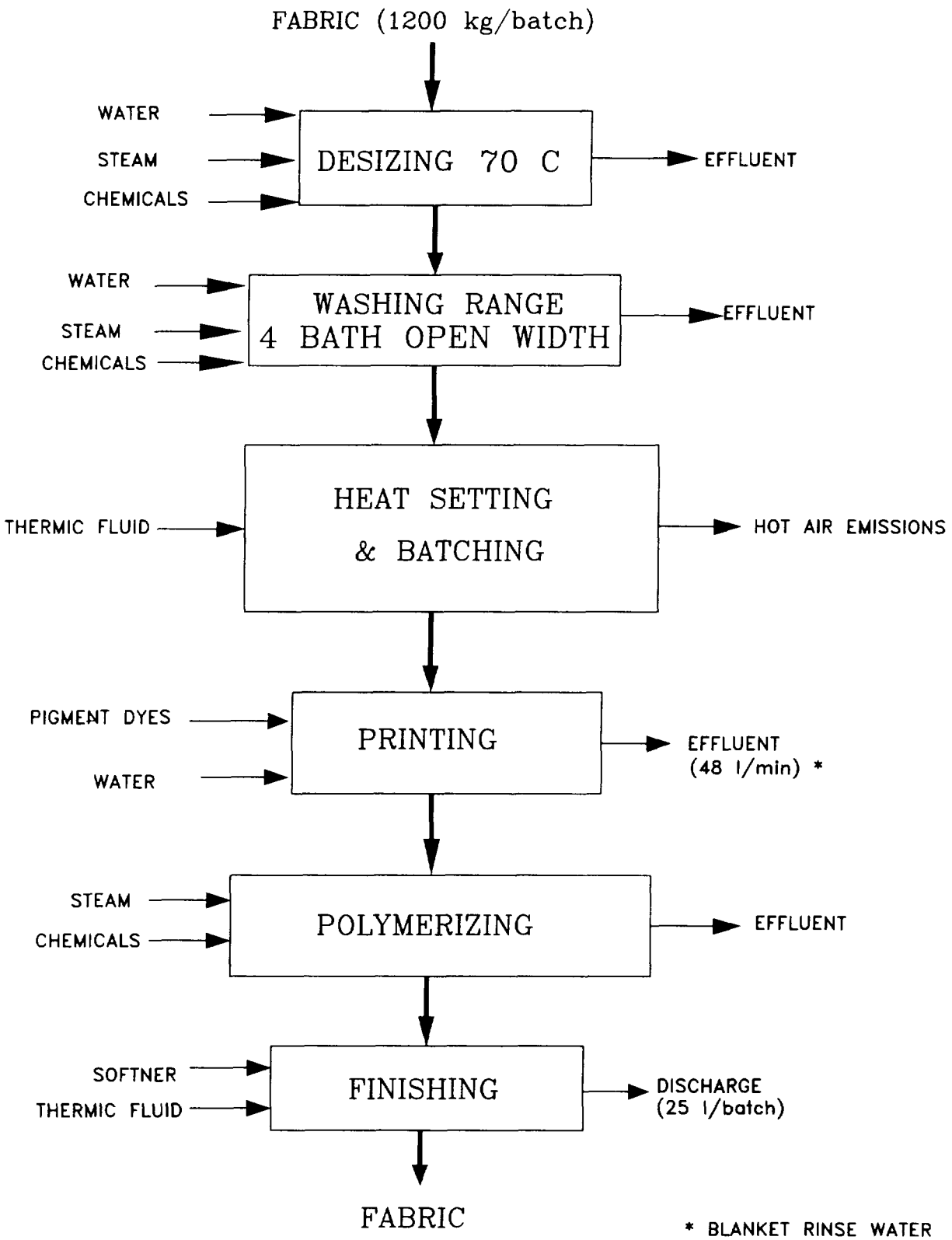
PROCESS FLOW DIAGRAM FOR 100% POLYESTER SUITING



ALL THE PROCESS ARE CARRIED OUT IN JET
- CAPACITY 350 kg
- LIQUOR RATIO 1:8

WORKSHEET 3.11

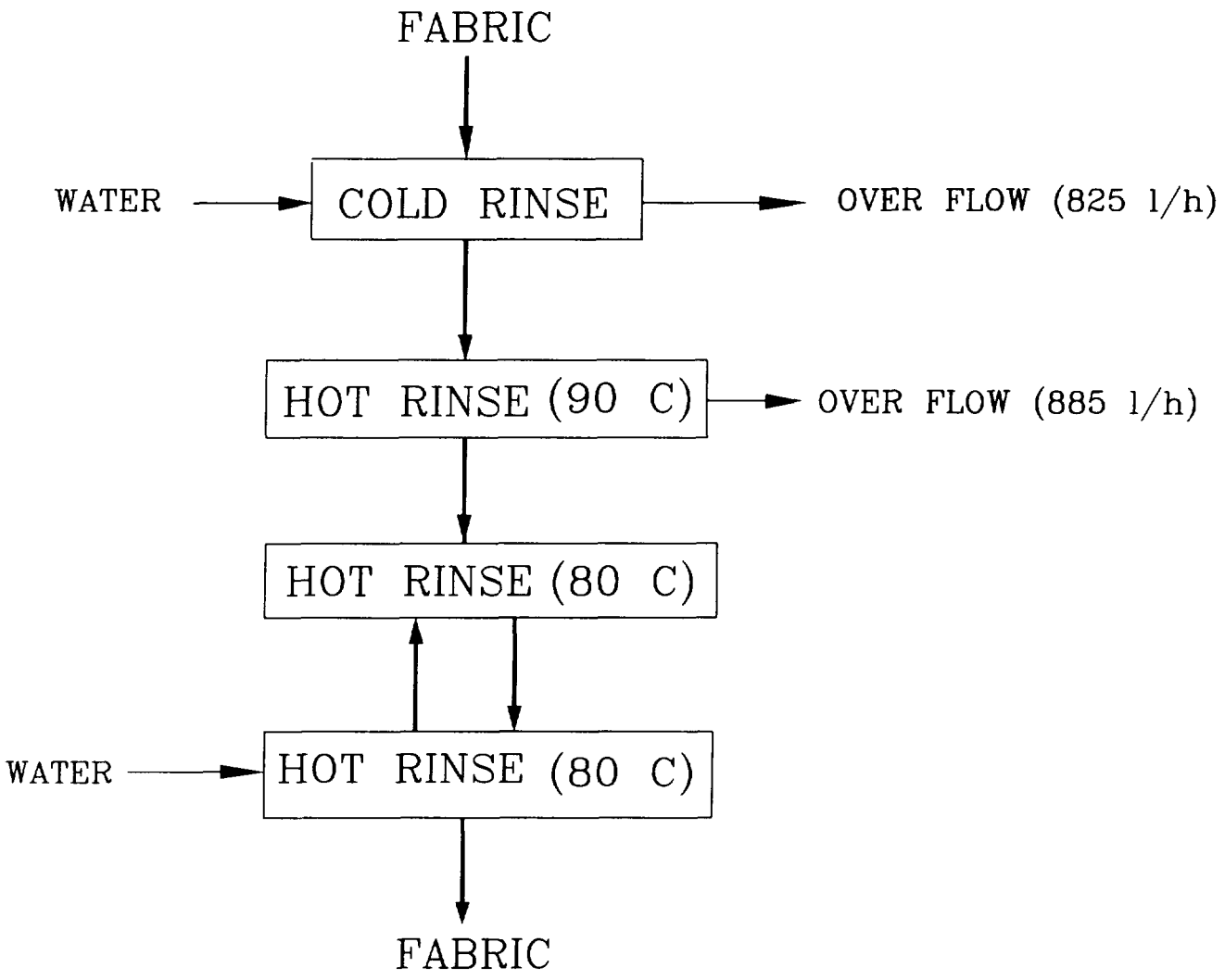
PROCESS FLOW DIAGRAM
FOR POLYESTER/VISCOSE DRESS FABRIC



* BLANKET RINSE WATER

WORKSHEET 3.12

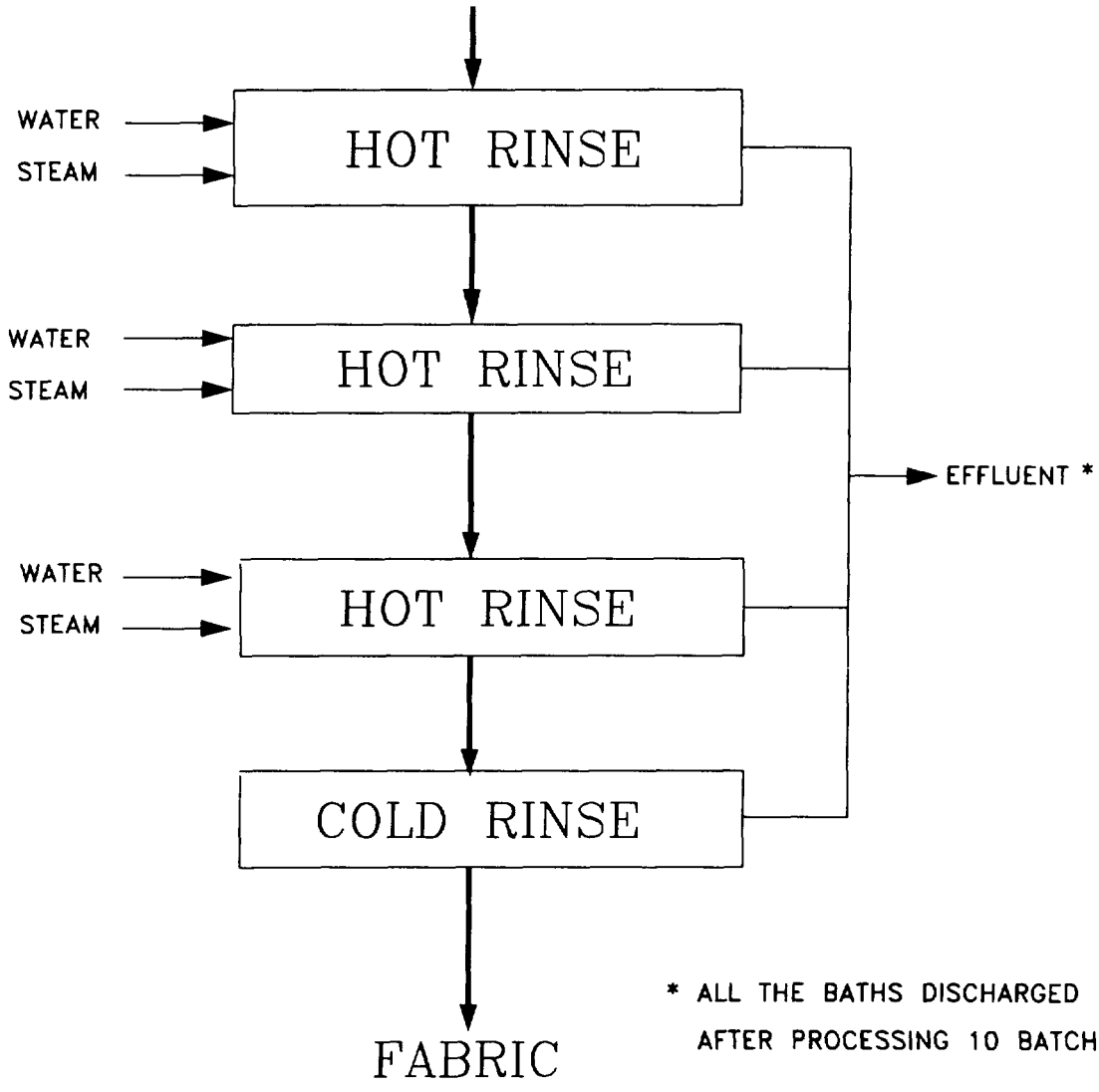
WASHING RANGE COUNTER CURRENT



NOT USED IN SEPTEMBER 1995

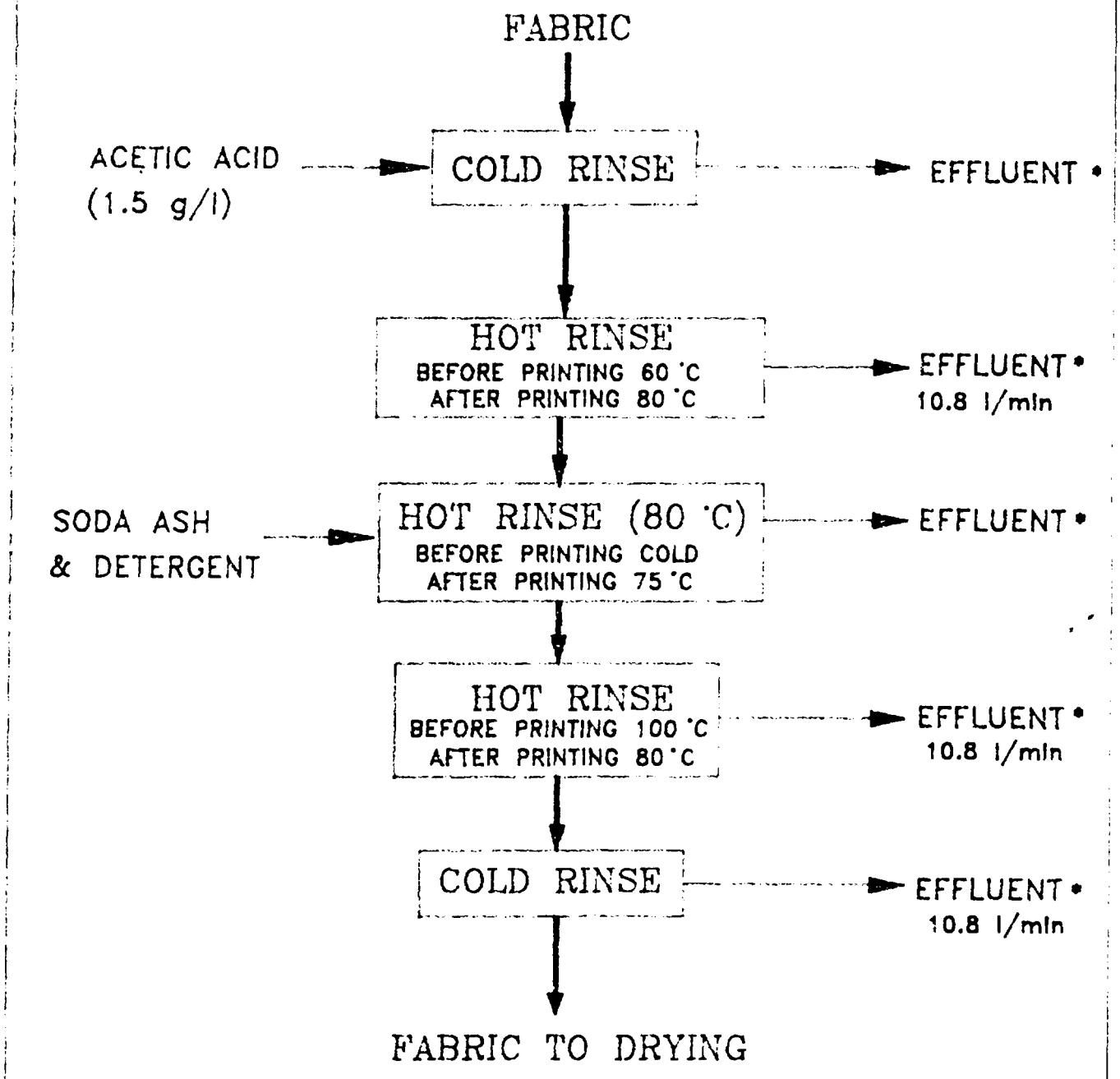
WORKSHEET 3.13

WASHING RANGE CO-CURRENT



WORKSHEET 3.14

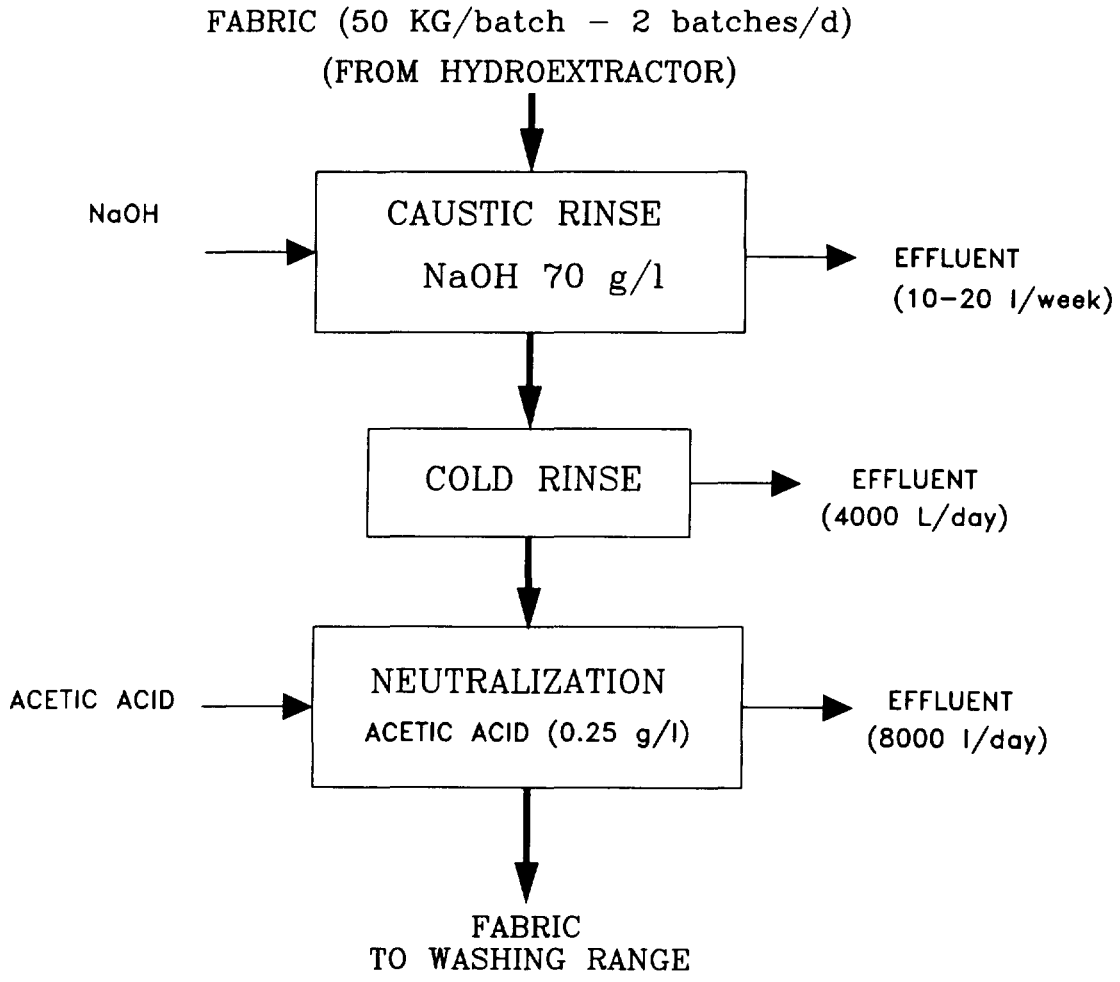
CONTINUOUS WASHING RANGE (OPEN WIDTH)



* ALL THE BATHS DISCHARGED AFTER PROCESSING 10 BATCHES

WORKSHEET 3.15

PROCESS FLOW DIAGRAM
WEIGHT REDUCTION(16%) FOR POLYESTER SAREES



4.0 Housekeeping Status

Housekeeping lapses identified by the Waste audit team in this plant result in economic losses but are not taken care of. Remedial measures needed need either little or no investment but the financial as well as environmental benefits will be significant.

WORKSHEET 4.0
General remarks related to housekeeping

Section	Lapses in housekeeping
Washing range	Improper use of steam and water (steam valves and water lines are kept open even when the plant is stopped during breakdown periods) Steam leaks in cold water baths resulting in higher temperatures
Printer	Wastage of print paste from barrels, screens, squeezees Open water hoses
Boiler	Unlagged and lengthy steam lines Unlagged boiler feed water tank which collects condensate

5.0 Material Balance

Material balance presented in Worksheet 5.0 was carried out using actual production and chemical consumption figures for the month of September 1995. Water and steam consumption figures have been estimated on liquor ratios and heat requirement to heat the water and the fabric (assumptions made and the calculations are indicated below the Worksheet).

WORK SHEET 5
MATERIAL BALANCE FOR THE MONTH OF SEPTEMBER 1995

UNIT OPERATION	INPUT MATERIALS		OUTPUT MATERIALS		
			PRODUCT	WASTE STREAM	
	Name	Quantity (kg)	Quantity (kg)	Liquid (m^3)	Solid /gas (kg)
WEIGHT REDUCTION (16%)	Fabric	1125	945	180	
		(217)	(596)		NIL
	Water	80080		79774	
	NaOH	0.28		0.28	
	HAC ‡	10		10	
SCOURING	Fabric	26732	25663	1069	
		(9120)	(16208)		
	Water	269000		280278	NIL
	Steam	23300	✡ 4934		
	Soda Ash	1111		1111	
	H_2O_2	484.5		484.5	
	Non ionic detergent	535		535	
	Hydro sulphite ‡	91		91	
	Other Chemicals	407		407	
WASHING RANGE	Fabric	30310	30310		
		(19144)	(19144)		
	Water	548353		839680	NIL
	Steam	291327			
	Soda Ash	24		24	
	HAC ‡	7		7	
	Detergent	12		12	
REDUCTION CLEARING	Fabric	23723	23723		
		(6227)	(14892)		NIL
	Water	110984		105822	
	Steam	11399	✡ 7896		
	NaOH	170		170	
	Hydro sulphite ‡	113		113	

PRINTING	Fabric	16485	16485		
	Water	1430209		1430209	
	Disperse dyes	254	181	73	
	White Khadi Paste	200	150	50	
	Pigments	22.6	16.95	5.65	
	Vinyl sulphone dyes	74.1	33.35	40.75	
	Kerosene	1100			1100
COLD WASH	Fabric	19108	19108		
		(12068)	(12068)		NIL
	Water	109600		109600	
HOT WASH	Fabric	28967	28967		
		(18295)	(18295)		NIL
	Water	271520		277700	
	Steam	25279	✡ 19099		
	HAC ‡	12		12	
DYEING	Fabric	29166	29166		
		(18421)	(18421)		NIL
	Water - Jets	232400		232400	
	- Jiggers	76400		85207	
	Steam	54055	✡ 45248		
	HAC ‡	121		121	
	Amino sulphite	168		168	
	Levelling agent	139		139	
	Dispersing agent	243		243	
	Anticreasing agent	271		271	
	Other Chemicals	2615		2615	
	Sulfur dyes	73	58.4	14.6	
	Cationic dyes	41	38.95	2.05	
	Disperse dyes	140	137.2	2.8	
	Whitening Agent	43.4	41.23	2.17	
	Vinyl sulphone dyes	40	24	16	
SOAPING	Fabric	27886	27886		
		(17612)	(17612)		
	Water	144922		148453	NIL
	Steam	15757	✡ 12266		
	Soda Ash	78		78	
	Detergent	121		121	
DESIZING	Fabric	29981	29981		
			(18935)		
	Water	63300		49408	
	Steam	5043			
	Enzyme	112		112	
	Wetting Agent	22		22	
	Non ionic detergent	6		6	

ACID WASH	Fabric	19308	19308		NIL
		(12194)	(12194)		
	Water	124800		124800	
	HAC ‡	31		31	
FIXING	Fabric	13863	13863		NIL
		(8756)	(8756)		
	Water	32400		32400	
	Fixing Agent	N/A			
*** STEAMING**	Fabric	762	762		
	Steam	41		41	NIL

( ) % Moisture associated with fabric

✡ Condensates that are reused as boiler feed water.

♀ Chemicals to be substituted

- Substitute Formic acid for HAC.
- Substitute Thiourea dioxide based product (e.g Reduction HF) for Sodium hydrosulfite

ASSUMPTIONS

* Only the steam requirement for heating the fabric was taken into account but the steam consumption for heating up the steel vessel could be significant

Weight reduction for Polyester sarees - 16%

100% of the chemicals used are assumed to be going with waste water.

Polymerization of Polyester/Viscose dress fabric was not considered due to insufficient data.

Finishing of Polyester saree fabric, Polyester suiting, Polyester/Viscose and Nylon dress fabric was not considered due to unavailability of data on chemicals used.

Chemical and dye consumptions in dyeing of Nylon dress fabric was not taken into account due to unavailability of data, only the water and steam consumptions were taken into account.

Mecerisation process was not considered due to insufficient data and less frequency of operation.

Process sequence for both polyester/viscose dress fabric PV02 and PV07 were considered as same.

Both municipal and well water are used in the mill and to estimate well water consumption following data is used.

Number of working hours - 16/d, Number of working days - 25/M
Pumping rate - 20,000 l/h

Actual water consumption is based on the daily average consumption figure provided by the industry.

Moisture content of fabrics

- 7% before wet processes
- 43% after wet processes
- 43% before Hydro Extractor
- 22% after Hydro Extractor

Process *	Type of fabric	Moisture of fabric entering the Process *
Weight reduction	PE sarees	22% after hydro extractor
Scouring	Polyester sarees, Polyester suiting, Nylon dress fabric	7% raw fabric
	PC and PV suiting	43% after washing stage
Reduction clearing	PE suiting	43% after dyeing stage
	PV and PC Suiting	7% after drying stage
Acid wash	Cationic suiting	7% raw fabric
	Nylon dress fabric	43% after scouring stage
	PV and PC Suiting	43%

% Losses and Fixation of dyes and chemicals

Printing

	% Fixation	% Losses §
Pigment Dyes	100%	25%
White Khadi Paste	100%	25%
Disperse Dyes	95%	25%
Vinyl Sulphone Dyes	60%	25%

Dyeing

Sulfur Dyes	80%	-
Cationic Dyes	95%	-
Disperse Dyes	98%	-
Whitening Agents	95%	-
Vinyl Sulphone Dyes	60%	-

§ % losses (average) with the containers, screens etc. is assumed as 25% but in actual practice these losses could be much higher.

100% of the chemicals used are assumed to be going with waste water.

Details of printing operations

Printer type	Blanket wash water Flow rate (l/min)	Average speed (m/min)	Batch size (m)	Type of fabric printed
Flat bed	48	10	1000	PE sarees
Rotary	43	60	2000	Dress fabric

Item washed	Flat bed (l/unit)	Rotary (l/unit)
Container	43	968
Equipment	119	119
Screen	79	417.6
Squeezees	70	647
Pump	--	1598
Total	311	3108
Number of batches printed	17	65

Water usage for containers, equipments, screens and squeezee washings were estimated using following formula.

Water usage (l/M) = Duration of washing (min) x Flow rate of water (l/min)xNumber of batches/M x Number of colour changes

For both machines it was assumed that 5 colour changes take place per batch.

Use of Washing Ranges

Both washing ranges used in the month of September 1995 involve direct steam heating.

Open width 5 bath Washing Range (Worksheet 3.14) is used for washing of PE sarees before and after printing stage. Process conditions for both stages along with overflow rates from 2nd and 4th baths are indicated in the flow diagram. 1st and 3rd baths are static and all the baths are discharged after processing 10 batches. Volume of each bath is 4000 l.

	Batch size (m)	Machine speed (m/min)
Washing before printing -	1800	28
Washing after printing -	1500	28

4 bath Washing range indicated in Worksheet 3.13 is used for PC, PV suiting and PV dress fabric -

1st, 2nd and 3rd baths are static and after processing 10 batches all the baths are discharged. Bath volume is 4000 l each.

4th bath over flow rate - 6.9 l/min

Temperatures for operation are as follows :

	PC & PV suiting	PV dress fabric
Temperature - 1st bath	95°C	90°C
- 2nd bath	95°C	80°C
- 3rd bath	80°C	80°C
- 4th bath	Cold	Cold
Batch size	500 m/b	1000 m/b
Machine speed	30 m/min	30 m/min

Operations 1,2 & 3 depicted in Worksheets 3.6, 3.7 & 3.8 respectively have not been carried out in September 1995.

Desizing bath details :

Capacity	-	1000 l
Batch size for PV & PC	-	500 m
Batch size for PV dress fabric	-	1000 m

Two 500 m batches are processed per day and 600 l/d of the bath volume is discharged.

During desizing there will be some sizing material removed from the fabric which is not included in the waste stream

Steaming process for PE Sarees

Steaming process is done only for Polyester sarees.

Period	-	20 min
Temperature	-	115°C (at - 2 bar)

6.0 TOTAL WATER BALANCE

Water consumption for each unit operation presented in the material balance are given in the Worksheet below along with other water consumptions such as boiler water. All the assumptions made and the figures for cooling water etc are according to the information recieved from the industry.

WORKSHEET 6.0				
Operation	**Total estimated consumption (l/M)**	**Total product (kg/M)**	**Water/Product Ratio**	**% Consumption**
Scouring	269000	26732	10	2.58
Weight reduction	80080	945	84.7	0.77
Washing range	548353	30310	18.1	5.26
Printing	1430209	16485	86.8	13.72
Hot rinses	271520	28967	9.4	2.61
Cold rinses	109600	19108	5.7	1.06
Reduction clearing	110984	23723	4.7	1.06
Dyeing	308800	29166	10.6	2.96
Fixing	32400	14441	2.2	0.31
Soaping	144922	27886	5.2	1.39
Desizing	63300	29981	2.1	0.61
Acid rinses	124800	19308	6.5	1.19
Cooling water (estimated)	222407			2.13
Boiler (raw water)	311850			2.99
Domestic (municipal)	2923000			28.04
Total (estimated)	6951225			66.69
Actual (municipal & well)	10423000			
Undefined consumption	3471775			33.31

ASSUMPTIONS

Total boiler water consumption was calculated from the consumption of fuel for September 1995 (59400 l). 50% of the boiler water requirement is considered as raw water supply and the balance 50% is condensate (89443 l according to the material balance) and cooling water.

Furnace oil consumption for steam boiler	=	59,400 l/M
Boiler efficiency	=	70%
Total boiler water consumption	=	59,400(l/M) x 40500(kJ/l) x 0.7/2700(kJ/kg)
	=	623,700 l/M
Raw(fresh) water consumption (50%)	=	311,850 l/M
Condensate and cooling water consumption (50%)	=	311,850 l/M
Condensate volume(from material balance)	=	89,443 l/M
Therefore cooling water consumption	=	222,407 l/M

Municipal water is used for domestic purposes only.

Estimation of well water is based on following assumptions

Working hours 15 h/d
Working days 25 d/M
Pumping rate 20,000 l/h

Well water volume = 20,000(l/h) x 15(h/d) x 25(d/M)
= 7,500,000 l/M

Actual water consumption = well water + domestic water
= 7,500,000 + 2,923,000 l/M
= 10,423,000 l/M

7A. COD Analysis

COD analysis of effluent discharges from different machines was carried out on two days and these results are presented in Worksheets 7A.1 and 7A.2 respectively. COD values are corelated with the volumes of effluent discharged per batch. The percentage contribution of each waste stream is also indicated in the last column.

WORKSHEET 7A.1

STREAM	WATER l/min	DURATION (min)	WATER l/d	COD mg/l	COD kg/d	COD %	WATER %
Reduction clearing							
First rinse			800	435	Neg	2	5
Hot rinse			800	335	Neg	1	5
Cold rinse			800	215	Neg	1	5
HAC rinse			800	506	Neg	2	5
Counter Current Washing Range (After Scouring)							
Fourth bath overflow	14	9	129	125	Neg	Neg	1
Third bath overflow	15	9	139	724	Neg	Neg	1
Drum Washing							
Cold rinse 1			4000	1210	5	21	24
Chemical rinse			2000	2010	4	18	12
Cold rinse 2			2000	152	Neg	1	12
Jigger dyeing							
Dye bath			200	16500	3	15	1
Dye cold wash			400	8250	3	15	2
Chem. Wash			1600	480	1	3	10
Flat bed printing							
Blanket wash	49	44	2169	410	1	4	13
Screen wash	15	27	398	6250	2	11	2
Squeezee wash	15	24	353	2350	1	4	2
Barrel wash	15	15	218	1600	Neg	2	1
TOTAL			16805	41552	22	100	100

Neg - Negligible

WORKSHEET 7A.2							
STREAM	WATER l/min	DURATION min	WATER l/d	WATER %	COD mg/l	COD kg/d	COD %
Rotary Printing (washings)							
Blanket	180.0	240.0	43200	36	1170	50.54	42
Rotary Screens	69.6	18.0	1253	1	1200	1.50	1
Rotary Squeezees	49.8	13.0	647	1	4000	2.60	2
Rotary Pumps	66.6	72.0	4795	4	1500	7.20	6
Equipment	27.0	4.4	119	Neg	13900	1.65	Neg
Containers	16.8	57.6	968	1	1600	1.55	1
Continuous washing range (saree)							
Bath 1	10.75	188	2021	2	92	0.19	0
Bath 2	10.75	188	2021	2	27	0.05	0
Bath 3 (Detergent)	10.75	188	2021	2	355	0.72	1
Bath 4	10.75	188	2021	2	85	0.17	0
Bath 5	10.75	188	2021	2	34	0.07	0
Dyeing of suiting (batch) (1800 l *3)							
Jet washing of fabric			5400	4	652	3.52	3
Jet scouring			5400	4	1165	6.29	5
Jet Hot rinse			5400	4	189	1.02	1
Jet acid rinse			5400	4	230	1.24	1
Jet dye water			5400	4	1025	5.54	5
Jet hot rinse			5400	4	5650	30.51	25
Jet reduction clearing			5400	4	400	2.16	2
Jet hot rinse			5400	4	220	1.19	1
Jet Soaping			5400	4	440	2.38	2
Jet hot rinse			5400	4	140	1	1
Jet washing			5400	4	100	1	1
TOTAL			120487	100		121.4	100
Production figures indicate that for							
Printing - 3 batch changes were carried out in a total of 4 hours							
Dyeing - 3 batches were carried out							
Washing range - operated for 188 minutes							

Neg - Negligible

Printing production was 1240 m carried out as one batch.

For Reduction clearing, Jigger and Drum washing production was assumed to be one batch.

Average COD of the composite process effluent - 1045 mg/l (based on COD and water consumption figures in Worksheet 7.A)

Total effluent volume - 3795 m^3 (from Worksheet 5.0)

Volume of effluent stream including undefined losses - 7268 m^3

Therefore COD of the effluent stream - 545 mg/l

COD analysis was carried out by the laboratory staff of the Central Environmental Authority (CEA) on 16.10.95 and 18.10.95.

7B. WASTE AND EMISSION COST

Material consumption figures from the material balance and COD analysis data were made use of to estimate the amount and the cost of waste generated in each process step. These values are presented in the Worksheet below.

WORK SHEET 7.B				
UNIT OPERATIONS	**COST COMPONENT**	**QUANTITY (kg/M)**	**UNIT COST (Rs/1000Kg)**	**TOTAL COST (Rs/m³)**
REDUCTION CLEARING	$NaHSO_4$ ✡	113	99,000	11,187.00
	Chemicals	170	35,000	5,950.00
	Steam	11399	800	9,119.20
	Water	105822	20	2,116.44
	COD Removal	46	30,000	1,380.00
	Total Cost Assigned to Waste Stream			**29,752.64**
	Cost assigned per m³ effluent (105.8 m³)			**281.22**
SOAPING	Chemicals	199	138,000	27,462.00
	Steam	15757	800	12,605.60
	Water	148453	20	2,969.00
	COD Removal	65.4	30,000	1,962.00
	Total Cost Assigned to Waste Stream			**44,998.60**
	Cost assigned per m³ effluent (148.4 m³)			**303.00**
PRINTING	Disperse dyes	73	875,000	63,875.00
	Pigments	5.65	280,000	1,582.00
	White Khadi paste	50	210,000	10,500.00
	Vinyl sulphone dyes	40.75	900,000	36,675.00
	Water	1430209	20	28,604.18
	COD Removal	1838	30,000	55,140.00
	Total Cost Assigned to Waste Stream			**196,376.18**
	Cost assigned per m³ effluent (1430.2 m³)			**137.31**
DYEING *	HAC ✡ - Jets	104.8	85,000	8,908.00
	- Jiggers	16.2	85,000	1,377.00

	Chemicals - Jets - jiggers	875 2561	144,000 144,000	126,000.00 368,784.00
	Dyes	38	840,000	31,920.00
	Water - Jets - Jiggers	232400 85207	20 20	4,648.00 1,704.00
	Steam	54055	800	43,244.00
	COD Removal - Jets - Jiggers	 238.2 1406	 30,000 30,000	 7,146.00 42,180.00
	Total Cost Assigned to Waste Stream **Cost assigned per m^3 effluent (317.5 m^3)**			**635,911.00** **2,002.24**
SCOURING	$NaHSO_4$ ✡	91	99,000	9,009.00
	Chemicals	2537	188,000	476,956.00
	Steam	23,300	800	18,640.00
	Water	280278	20	5,605.50
	COD Removal	333	30,000	9,990.00
	Total Cost Assigned to Waste Stream **Cost assigned per m^3 effluent (280.3 m^3)**			**520,200.50** **1,855.80**
HOT WASHING	HAC ✡	12	85,000	1,020.00
	Steam	25279	800	20,223.20
	Water	277700	20	5,554.00
	COD Removal	409	30,000	12,270.00
	Total Cost Assigned to Waste Stream **Cost assigned per m^3 effluent (277.7 m^3)**			**39,067.20** **140.68**
COLD WASHING	Water	109600	20	2,192.00
	COD Removal	131	30,000	3,930.00
	Total Cost Assigned to Waste Stream **Cost assigned per m^3 effluent (109.6 m^3)**			**6,122.00** **55.86**
WASHING RANGE	HAC ✡	7	85,000	595.00
	Chemicals	36	88,000	3,168.00
	Steam	291327	800	233,061.60
	Water	839680	20	16,793.60
	COD Removal	0.14	30,000	4.20

	Total Cost Assigned to Waste Stream **Cost assigned per m^3 effluent (839.68 m^3)**			**253,622.40** **302.05**
ACID WASH	HAC ✡	31	85,000	2,635.00
	Water	124800	20	2,496.00
	COD Removal	30	30,000	900.00
	Total Cost Assigned to Waste Stream **Cost assigned per m^3 effluent (124.8 m^3)**			**6,031.00** **48.33**
DESIZING	Chemicals	140	427,000	59,780.00
	Steam	5043	800	4,034.40
	Water	49408	20	988.16
	COD Removal	8317	30,000	249,510.00
	Total Cost Assigned to Waste Stream **Cost assigned per m^3 effluent (49.4 m^3)**			**314,312.56** **6,362.60**
COMPOSITE EFFLUENT	**Total Cost Assigned to Waste Stream** **Total waste stream (3684 m^3)** **Cost assigned per m^3 effluent**			**2,046,394.00** **555.50**

✡ Replaceable Chemicals

Assumptions

Desizing COD load in a similar industry used (0.131 kg/l).

Weight reduction and Fixing processes were not included due to lack of COD values for their effluents.

8.0 Waste Minimisation Options

Even though the material and water balances are useful in quantification, most of the waste minimization options were identified through observations made by the waste audit team and information provided by the industry during visits to the industry. The options identified are presented in Worksheet 8.0 along with actions needed to determine feasibility (eg: carrying out trials) or assess the costs and benefits. Since it is mainly the cost that motivates the industry for implemetation a rating has been given on the cost along with priority and time required for implementation.

WORKSHEET 8.0								
Process Unit	Unit operation	Waste Minimisation (WM) Options	Actions to assess WM options	Category	Effect	Priority	Timing	Cost
DESIZING	Desizing	1. Control the temperature in the hot wash for PVA desizing	- Check the operating temperature - estimate energy savings by desizing at 60°C	PC	ES WM	4	MT	M
	Desizing	2. Reduce the number of discharges	- Check the volume & frequency of discharges - Estimate COD of discharges - Production planning to reduce discharges - Estimate cost of treatment	RC	ES WM PR	3	MT	L
SAREE WASHING RANGE	Washing	3. Counter current (c/c) rinsing in 4th & 5th baths	- Check COD values of discharges for possibility of c/c rinsing - Determine flow rates - Estimate water savings	RC	WM	6	MT	M
	Washing	4. Reduce down time	- Proper & regular maintenence of drying units	RC	WM ES		ST	L
	Washing	5. Repair temperature control device in the 4th bath & install one for detergent bath	- Determine the temperature for each bath - Check the optimum temperatures for each bath - Estimate cost of installation of temp. control units & energy savings	PC	WM ES	6	MT	M
	Washing	6. Stop water & steam when the fabric is not running	- Strict supervision	RC	WM ES		ST	L

CR - Chemical Reduction
EM - Equipment Modification
ES - Energy Savings
H - High cost
HK - Housekeeping
IC - Inventory Control
L - Low Cost
LT - Long Term
M - Medium Cost
MC - Material Change
MT - Medium Term
PC - Process Control
PR - Pollution Reduction
QI - Quality Improvement
RC - Resource Conservation
RR - Resource Recovery
ST - Short term
SI - Safety Improvement
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	Priority	Timing	Cost
SAREE WASHING RANGE	Washing	7. Repair steam leaks in the 2nd bath	- Check the temperature of the bath - Estimate energy savings	RC	WM ES		ST	L
STENTER	Washing	8. Determine the necessity for two stages of drying	- Discuss with the factory management & expert	RC	WM ES			L
	Drying	9. Install vacuum slit (VS) device for stenter	- Estimate cost of installation - Check moisture content with & without VS - Compare energy savings	EM	WM ES	3	LT	H
	Drying	10. Control overdrying of fabric	- Check the moisture content of fabric after drying - Estimate cost of installation of moisture meter & energy savings possiblewith this	RC	ES WM			M
	Drying	11. Omit final cooling of fabric in stenter	- Check the moisture removal efficiency of stenter with & without final cooling - Discuss with factory management regarding effects on fabric	RC	ES WM			L
	Drying	12. Check the efficiency of stenter	- Carry out energy audit on stenter	RC	WM ES		LT	M
JUMBO RANGE (SCOURING)	Scouring	13. Optimise caustic use	- Check the concentration of caustic bath regularly during the process	RC	WM CR		ST	L
DESHRINKING MACHINE	Deshrinking	14. Collection of cooling water	- Quantify the volume & check temperature - Estimate energy savings	RC	WM ES	6	ST	M

Process Unit	Unit operation	Waste Minimisation (WM) Options	Actions to assess WM options	Category	Effect	Priority	Timing	Cost
BOILER	All operations	15. Check the efficiency of boiler	- Carry out efficiency study	RC	WM ES	5	LT	M
	All operations	16. Lag the steam lines & valve units	- Estimate exposed surfaces & heat losses - Estimate cost of lagging	RC	WM ES	6	MT	M
	All operations	17. Lag condensate & cooling water return pipes to boiler feed tank	- Monitor the temperature of recovered water - Estimate energy savings & cost of lagging	RC	WM ES	6	MT	M
	All operations	18. Lag Boiler feed water tank	- Estimate surface area & temperature	RC	ES		MT	M
ROTARY PRINTER		19. Reuse return print paste	- Quantify the amounts & water use for washing - Use for dark shades & do cost benefit analysis		WM PS	6	ST	L
	Printing	20. Install a doctor blade for blanket	- Quantify the print paste recovery - Estimate COD & volume of blanket wash water - Estimate cost of installation of doctor blade	RR	WM PR	6	MT	L
	Printing	21. Recovery of print paste from screens, squeezees	- Quantify print paste wastages & water use - Estimate COD of washings - Carry out cost benefit analysis of paste reuse for dark shades	RR	WM PR	6	MT	L
	Printing	22. Reduce blanket wash water flow rate	- Carry out trials - Check the COD of discharges	RC	WM EE	5		L
	Printing	23. Recirculate blanket wash water	- Carry out trials - Check the COD of discharges	RR	WM ES	5		L
	Printing	24. Segregation of printing effluent for separate treatment & reuse for equipment washing after simple treatment	- Estimate cost for segregation & treatment unit - Estimate water savings	RR	WM ES	5		M

Process Unit	Unit operation	Waste Minimisation (WM) Option		Actions to assess WM options	Category	Effect	Priority	Timing	Cost
ROTARY PRINTER	Printing	25.	Use of treated waste water to wash screens & other equipment	- Carryout trials - Estimate water savings	RR	WM	5		L
	Printing	26.	Construct dip tanks for screens to be immersed in before washing with water	- Estimate cost of construction of tanks & water savings	RC	WM PR			L
FLAT BED PRINTER	Printing	27.	Reuse return print paste	- Quantify the amounts & water use for washing - Use for dark shades & do cost benefit	RR	WM PR CR			L
	Printing	28.	Install a doctor blade for blanket	- Quantify volume of print paste recovery - Estimate COD & volume of blanket wash water - Use for dark shades & do cost benefit	RR	WM PR CR	6		L
	Printing	29.	Recovery of print paste from screens, squeezees	- Quantify the print paste & water use - Estimate COD of washings - Reuse print paste for dark shades	RR	WM PR CR	6		L
	Printing	30.	Reduce flow rate of blanket wash	- Check COD of dischrge - Carry out trials	RC	WM	5		L
	Printing	31.	Reduce % losses of print paste from screens, containers & squeezees (presently 80% losses)	- Estimate % losses - Discuss with factory management regarding improvement of existing methods & equipment modification	RC EM	WM PR CR	7		L

Process Unit	Unit operation	Waste Minimisation (WM) Option	Actions to assess WM options	Category	Effect	Priority	Timing	Cost
JIGGERS	All operations	32. Provide covers	- Estimate heat losses with and without covers & cost benefit	RC	WM ES	6		L
	All operations	33. Recycling of hot rinses	- Check the CODvalues of rinse discharges - Quantify volumes - Estimate energy & water savings	RR	WM ES	1		L
	All operations	34. Install a heat recovery unit	- Estimate cost of installation & energy savings	RR	WM ES	3		H
	All operations	35. Install temperature control unit	- Estimate cost of installation - Estimate energy & chemical savings	PC	WM ES	6		M
JETS	All operations	36. Install heat recovery unit (HRU)	- Check the temperature of discharge - Estimate cost of installation of HRU - Estimate energy savings	RR	ES WM			H
	All operations	37. Check the possibility of recycling rinse water	- Determine COD of discharges	RR	ES WM			L
	All operations	38. Lagging the jets	- Estimate surface areas & temperature - Estimate energy savings	RC	WM ES	6		M
	Dyeing	39. Employ Rapid Inverse Dyeing	- Carry out trials - Compare savings in chemicals, water, energy & time with cost of chemicals	TC	ES WM CR	5		M
	All operations	40. Install push button switches for view glass lights	- Calculate energy losses - Estimate cost of installation of switches - Check the running time & estimate cost benefit	EM	WM ES	6		L
	All operations	41. Eliminate dispersing agent in medium & dark shades	- Carry out trials & estimate cost benefit	MC	WM CR PR			L

Process Unit	Unit operation	Waste MInimisation (W.M) Option		Actions to assess WM options	Category	Effect	Priority	Timing	Cost
JETS	Dyeing	42.	Reduce the liquor ratio in jets	- Carry out trials increasing the load	RC	ES WM			L
	All operations	43.	Replace high polluting chemicals with environmentally friendly ones with less cost eg: Replace Acetic acid with Formic acid, Na_2S with Hydrol, Sodium Hydrosulfite with Thiourea dioxide based product	- Carry out trials with cost benefit analysis	MC	WM PR CR			M
	All operations	44.	Optimise chemical consumption	- Carry out trials with reduced amounts of chemicals & do cost benefit	RC	WM CR			L
STEAMING UNIT	Steaming	45.	Lag the unit	- Determine surface area & temperature - Estimate heat losses & cost of lagging	RC	WM ES			M
	Steaming	46.	Carry out steaming at 30 psi instead of 22 psi	- Carry out trials	RC	WM QI	7	MT	M
	Steaming	47.	Install temperature control unit	- Check the operating temperature - Estimate energy losses	PC	WM ES	7	MT	M
	Steaming	48.	Use bookends method to fold the fabric	- Carryout trials to determine the increase in loading capacity - Estimate time & energy savings	TC	WM		ST	L
COUNTER CURRENT WASHING RANGE	Washing	49.	Optimise chemical use in the baths for washing after desizing & scouring	- Discuss with the industry & expert	RC	WM PR CR		ST	L

Process Unit	Unit operation	Waste MInimisation (W M) Options		Actions to assess WM options	Category	Effect	Priority	Timing	Cost
COUNTER CURRENT WASHING RANGE	Washing	50.	Adjust overflow outlet in the baths for counter current system between first two baths & last two	- Estimate water consumption in the present system - Estimate water & energy savings in the cc system with modifications to overflow outlet	RC	WM		ST	L
	Washing	51.	Install temperature control units	- Check the optimum temperature - Check the temperature in the baths - Estimate cost of installation of temp control unit with energy losses	PC	WM ES		MT	M
	Washing	52.	Repair steam leaks in the 4th bath (cold)	- Check the temp. of the bath - Estimate energy savings	RC	WM ES		ST	L
DRUM WASHER	Washing	53.	Recycle the rinsing baths	- Check the COD of rinses	RR	WM ES		MT	L
	Washing	54.	Discharge of cooling water to boiler feed tank through a pipeline instead of open drain	- Quantify the volume & temperature - Estimate energy losses in the open drain	RC	WM ES		MT	L
DRUM DRYER	Drying	55.	Avoid overdrying of fabric	- Determine moisture content of fabric after drying - Estimate cost of installation of moisture meter & energy savings	RC	WM ES		ST	L
	Drying	56.	Improve efficiency of drying	- Repair dimostat to allow speed control of fabric	RC	ES WM		MT	L
	Drying	57.	Install a padding mangle of correct width to match with drums to allow drying of 2 lines of fabric	- Discuss with factory management regarding using 2 lines of cloth & estimate cost benefit	RC	WM ES		MT	M

9.0 COST BENEFIT ANALYSIS

Detailed cost benefit analysis was carried out for the ten high priority options identified and Worksheets 9.1 to 9.10 indicate the investment and operating costs and the savings and the payback period. Data and assumptions used are presented below each Worksheet.

WORKSHEET 9.1(a)			
Recovery of print paste (70%) from Screens, Squeezees, Containers (Rotary Printing) (option 21 in Worksheet 8.0)			
	Rs	**Savings**	**Rs/y**
Investment	Nil		
		Paste	16,157.00
		Treatment cost	64,631.00
		Water	15,447.00
		TOTAL	**96,235.00**
	Rs	**Net saving**	**96,235.00**
Annual operating cost	Nil	=(savings - annual operating cost)	
		Pay back period = (Investment/Net saving) x 12 = Not Applicable	

Assumptions

Average 5 colors/batch
Print Paste value Rs 7.50/kg
100% of the print paste that is wasted with the effluent can be recovered from Rotary printing section
Recovered print paste can be used for Dark shades
Treatment Cost Rs 30/kg of waste (including both Chemical and Biological treatment) and treatment cost savings 100%
1 kg Paste = 1 kg COD

The volume of waste and organic load was estimated based on the COD figures as follows:

	Water (l/M)	COD (g/l)	COD x Water (kg/M)
R.Screens	40262	1.17	47.11
R.Squeezee	20717	4.0	82.87
Containers	30966	1.6	49.55
Total	91945		179.53

Paste saving = 179.53 x (Rs 7.50) x 12
(This contributes to 1.4% of the total COD)

Treatment cost saving = 179.53 x (Rs 30) x 12

Water saving = 91945 x 0.70 x 12 l/y
(0.3% of total water consumption)

= Rs 15,447 /y

Note:- During the study it was found that at times as much as 70% of the total print paste prepared is wasted with the container washings etc. The COD reduction caused by the paste saving could therefore be even higher than the above estimate. COD values cannot be considered as representative as homogenous samples could not be obtained since the paste goes out in clumps.

WORKSHEET 9.1(b)			
Recovery of print paste (80%) from Screens, Squeezees, Containers (Flat Bed Printer) (option 21 in Worksheet 8.0)			
	Rs	**Savings**	**Rs/y**
Investment	Nil	Paste	5,566.00
		Treatment cost	22,266.00
		Water	3,133.00
		TOTAL	**30,965.00**
	Rs	**Net saving**	**30,965.00**
Annual operating cost	Nil	=(savings - annual operating	cost)
		Pay back period =(Investment/Net saving) x 12 = Not Applicable	

Assumptions same as for Rotary printer

	COD (g/l)	water (g/l)	COD x Water (g/l)
Screens	6.25	6715	42
Squeezees	2.35	5950	14
Containers	1.6	3655	5.85
Total		16320	61.85 **(0.5% of total COD)**

Paste saving = 61.85 x (Rs 7.5) x 12

Treatment cost saving = 61.85 x (Rs 30) x 12

Water saving = 16320 x 0.8 x 12 l/y **(0.1% of total water consumption)**

= Rs 3133 /y

WORKSHEET 9.2			
Installation of press button switches for Jets (4 Numbers) (option 40 in Worksheet 8.0)			
Investment	**Rs**	**Saving**	**Rs/y**
Push buttons	400.00	Electricity	10,368.00
		Net saving	**10,368.00** =(saving - annual operating cost)
	Rs		
Annual operating cost	Nil	**Pay back period** =(Investment/Net savings) x 12 = **<1** Month	

Cost of push buttons = Rs 100/unit (from local market)

Electricity savings = 4 x .12(kW) x 16(h) x 25(d) x 4.5 (Rs/kWh) x 12
= Rs 10368/year

WORKSHEET 9.3			
Lagging Boiler feed water tank (option 18 in Worksheet 8.0)			
Investment	**Rs**	**Saving**	**Rs/y**
Lagging Cost	67,080	Steam	37,603
		Net saving =(saving - annual operating cost)	**23,516**
Annual operating cost	**Rs**		
Interest (21%)	14,087	**Pay back period** =(Investment/Net savings) x 12 = 34 Months	

Surface area of feed water tank (A) = 43 m^2

Surface temperature = 80°c
Temperature after lagging = 40°C

Heat transfer coefficient = 4.27 W/m^2K (Ref 2)
Number of working hours/d = 16
Number of working days/M = 25

Heat loss = 43 x 4.27 x 40 x 16 x 25 x $3600/10^3$
= 10,575,936 kJ/M
Enthalpy of steam = 2700 kJ/kg

Steam savings (Rs 0.8/kg) = 3917 kg/M **(0.6% reduction in boiler fuel)**
= Rs 37,603/y
Total cost of lagging (Rs 1560/m^2) = Rs 67,080 (from local market)

WORKSHEET 9.4(a)			
Installation of a doctor Blade for the Rotary printer blanket (option 20 in Worksheet 8.0)			
Investment	**Rs**		
Doctor Blade (including installation)	10,000.00	**Saving**	**Rs/y**
		Print Paste (80%)	32,722.00
TOTAL	**10,000.00**	Treatment Cost	130,889.00
		Water	74,580.00
		Total	**238,191.00**
Annual operating cost	**Rs**		
		Net saving	**236,091.00**
Interest (21%)	2,100.00	=(saving - annual operating cost)	
		Pay back period =(Investment/Net saving)x12 = <1 Months	

1 kg Paste = 1 kg COD

Blanket wash COD	=	1.17 g/l
Water use	=	388440 l/M (based on period of operation for September 1995 -32h)
Print paste savings(80%)	=	1.17 x 388.44 x 0.8 x 12
	=	4363 kg/y **(2.8% of total COD)**
	=	Rs 32,722/y
Treatment cost savings	=	1.17 x 388.44 x 0.8 x 12 x Rs 30
	=	Rs 130889/y
Water savings	=	388440 x 0.8 x 12 l/M
	=	3729 m^3/M **(3% of total water consumption)**
	=	Rs 74,580/y
Cost of Doctor blade (including installation)	=	Rs 10,000

WORKSHEET 9.4(b)			
Installation of a doctor blade for Flat Bed printer blanket (option 28 in Worksheet 8.0)			
Investment	**Rs**	**Savings**	**Rs/y**
Doctor Blade (including installation)	10000.00	Print paste Treatment cost Water	2,777.00 11,108.00 18,063.00
		TOTAL	**31,948.00**
Annual operating cost	**Rs/Y**	**Net savings** =(savings - annual operating cost)	**29,848.00**
Interest (21%)	2,100.00	**Pay back period** =(Investment/Net saving) x 12 = 4 Months	

1 kg Print paste = 1 kg COD

COD of blanket wash water = 0.41 g/l
Water consumption = 94080 l/M

Print paste savings(80%) = 0.41 x 940.8 x 0.8 x 12 x Rs 7.50
= 3703 kg/y **(2.4% of total COD)**
= Rs 2777/y

Treatment cost savings = 0.41 x 940.8 x 0.8 x 12 x Rs 30
= Rs 11108/y

Water savings = 94080 x 0.8 x 12 l/y
= 903 m^3/y **(0.7% of total water consumption)**
= Rs 18,063

WORKSHEET 9.5			
Lagging of Jets (4 Numbers) (option 38 in Worksheet 8.0)			
Investment	**Rs**	**Saving**	**Rs/y**
Lagging cost	103,740.00	Steam	85,617.00
		TOTAL	**85,617.00**
Annual operating cost	**Rs**	**Net savings** =(savings- annual operating cost)	**63,832.00**
Interest (21%)	21,785.00		
		Pay back period =(Investment/Net saving) x 12 = 19 Months	

Surface temperature (measured) = 126°C
Average surface temperature = 95°C
Total surface area of Jets = 66.5m^2
Temperature diference = 55°C

Heat transfer coefficent = 4.572 W/m^{2o}K (Ref 2)

Heat loss = 66.5(m^2) x 4.572(W/m2o K) x 55(°C) x operating time(s)
Operating time = 400 h/M

Therefore heat loss = 24,079,810 kJ/M **(1.3% of total fuel consumption)**

Enthalpy of steam = 2,700 kJ/kg

Steam saving = 107,021 kg/y
= Rs 85,617 /y

Lagging cost = 66.5(m^2) x 1560(Rs/m^2)(from local market)
= Rs 103,740

WORKSHEET 9.6			
Use of treated water to wash screens, squeezees, containers, pumps and equipment in the printing section (option 25 in Worksheet 8.0)			
Investment	**Rs**	**Savings**	**Rs/y**
Pump	8,000.00	Water	239,075.00
Collection tank	10,962	**TOTAL**	**239,075.00**
Annual operating cost	**Rs/y**	**Net savings** =(savings- annual operating cost)	**232,415.00**
Pumping cost (Electricity)	4,980.00		
Interest (21%)	1,680.00	**Pay back period** =(Investment/Net saving) x 12 = <1 Month	
Total	**6,660.00**		

Water consumption in the printing section for washing of individual units is indicated in page for both printers
Total Water consumption in both sections for washing of these are 1,245,185 l/M
It is assumed that 80% of this requirement be obtained from treated water and only final washing be carried out with fresh water

Water saving = 996,145 l/M **(9.6% of total water consumption)**
= Rs 239,075 /y

Cost of pump (1 hp, 40 l/min) = Rs 8000.00

Cost of collection tank (1m^3 capacity) = Rs 10,962.00

WORKSHEET 9.7			
Chemical substitutions (option 43 in Worksheet 8.0)			
	Rs	**Savings**	**Rs/y**
Investment	Nil	Chemical savings	266,010.00
		Treatment saving	29,592.00
		TOTAL	**295,608.00**
	Rs/y	**Net saving**	**295,608.00**
Annual operating cost	Nil	=(savings - annual operating cost)	
		Pay back period =(Investment/Net savings) x 12 = Not applicable	

Chemical savings (Rs) = (chemical consumption x price - substitute chemical consumption x price)

Treatment cost saving = Percentage reduction in COD x Rs 30/kg or (percentage chemical consumption x COD - percentage substitute chemical consumption x COD) x Rs 30/kg

Oxalic acid can be replaced by HCl (chemical savings only)

Chemical saving = 26.95kg/M x Rs 90 - 26.95kg/M x Rs 25
= Rs 1,752/M

Sodium Hydrosulphite can be replaced by Thiourea dioxide (Dioxyn HF)

Chemical saving = 293kg/M x Rs99 - 293/6 Kg/m x Rs 190
= Rs 19,728/M

Treatment cost savings (85%) = 293kg/M x 0.33 x 0.85 (Ref 5)
= 82 kg/M **(0.6% of total COD)**
= Rs 2,466/M

Sodium sulphite by Hydrol (chemical savings only)

Chemical savings = 137.5kg/M x Rs45 - 137.5kg/M x Rs 40
= Rs 688/M

Total Chemical savings = Rs 266,010/y

Total Treatment cost savings = Rs 29,592/y

WORKSHEET 9.8			
Reduce liquor ratio in Jets (From 1:8 To 1:7 except for dyeing) (option 42 in Worksheet 8.0)			
	Rs	**Saving**	**Rs/y**
Investment	Nil	Steam	47,069.00
		Water	15,018.00
		Chemical	30,492.00
		TOTAL	**92,579.00**
	Rs		
Annual operating cost	Nil	**Net saving** =(savings- annual operating cost)	**92,579.00**
		Pay back period =(Investment/Net savings) x 12 = Not applicable	

Savings if liquor ratio is reduced from 1:8 to 1:7

Polyester suiting

Water savings = 49,526 kg/M
Steam savings = 4,043 kg/M
Chemical savings = 29.5 kg/M

Cationic suiting (soaping and washing)

Water savings	=	13,050 kg/M
Steam savings	=	860 kg/M
Chemicals savings	=	3.6 kg/M

Total Savings

Water	=	Rs 15,018/y	**(0.6% reduction in total water consumption)**
Steam	=	Rs 47,069/y	**(0.7% reduction in total fuel consumption)**
Chemicals	=	Rs 30,492/y	

Note: If it is possible to carryout dyeing step too at a lower liquor ratio (1:7) the savings will be as follows.

Polyester/Cotton (Polyester dyeing)

Water savings	=	Rs 2,333/y
Steam savings	=	Rs 18,660/y
Chemical savings	=	Rs 43,605/y

Polyester/Viscose (Polyester dyeing)

Water savings	=	Rs 1,166/y
Steam savings	=	Rs 9,330/y
Chemical savings	=	Rs 21,735/y

Cationic suiting

Water savings	=	Rs 1,044/y
Steam savings	=	Rs 7,469/y
Chemical savings	=	Rs 25,867/y

Polyester suiting

Water savings	=	Rs 2,429/y
Steam savings	=	Rs 18,838/y
Chemical savings	=	Rs 62,208/y

Total savings from dyeing at liqour ratio 1:7

Water	=	Rs 6,972/y
Steam	=	Rs 46,828/y
Chemicals	=	Rs 139,590/y

WORKSHEET 9.9			
Counter current rinsing in 4th and 5th bath for Sarees in the washing range (option 3 in Worksheet 8.0)			
Investment	**Rs**	**Savings**	**Rs/y**
Piping (Including construction)	500.00	Water	3,332.00
		Net savings =(savings - annual operating cost)	**3,332.00**
Annual operating cost	**Rs** Nil	**Pay back period** =(Investment/Net saving) x 12 = 2 Months	

Overflow rate from 4th and 5th bath	=	10.8 l/min
Speed of the machine	=	28m/min
Batch size	=	1800m/batch
Number of batches per month	=	10
Therefore Water flow from each bath	=	694 l/batch

Saree washing is done in the washing range before and after printing of the fabric

Water Savings	=	694 x 10 x 2 x 12 x 0.02
	=	166 m^3/y **(0.1% of total water consumption)**
	=	Rs 3,332/y
Cost of piping (including material and fabrication)	=	Rs 500

Note: In the month of September 1995 the production figure for PE Sarees is low (17,178m - 945kg)

WORKSHEET 9.10			
Installation of a temperature control system for 2nd bath and repair 4th bath temperature control system in the Saree washing range (option 5 in Worksheet 8.0)			
Investment	**Rs**	**Savings**	**Rs/y**
Temp/ control system	41,250.00	Steam	44,895
Repair cost	5,000.00	**Net savings** =(savings - annual operating cost)	**35,182**
TOTAL	**46,250.00**	**Pay back period** =(Investment/Net savings) x 12 = 16 Months	
Annual operating cost	**Rs**		
Interest (21%)	9,713.00		

Steam pressure - 60 psi

Cost of temperature control unit = Rs. 41250 (in 1990 $750, Ref 3)

	*	**
2nd bath	80	60
3rd	75	75
4th	83	80

* Measured values of temperature in the baths °C
** Optimum temperatures °C

Fabric speed	=	28 m/min
Fabric weight	=	907 kg (17,708 m)
Volume/bath	=	4000 l
Overflow rate	=	10.8 l/min

Volumetric flow	=	66,258 l
Specific heat of fabric	=	1.4 kJ/kg

All the baths are discharged after processing 10 batches.

Steam savings in 2nd bath	=	(907.2 x 1.4 + (4000 x 10 + 66258) x 4.2) x (current temperature - optimum temperature)/2200
	=	4068 kg/M
Steam saving	=	(4000 x 10 + 66258) x 4.2 x 3/2200
	=	608.5 kg/M
Total steam saving	=	4776 kg/M
	=	Rs 44,895 /y

10.0 CONCLUSIONS

This medium scale textile processing industry is engaged in processing several types of fabrics and for certain fabric types processing steps are carried out in 2 or 3 different types of machines. These variations along with process conditions are depicted in Worksheets 3.1 to 3.15.

It is believed that significant savings on raw materials and utilities (steam and water) could be achieved by adhering to proper housekeeping practices highlighted in Worksheet 3.0.

Availability of data is very limited and some of the figures eg. well water consumption figure obtained from the industry sources cannot be considered very reliable. Further measurements therefore are required to obtain better estimates by installing flow meters etc.

The material balance was prepared for the month of September 1995 (production figures in annexure E). The material balance was prepared for individual process steps for different fabrics including estimates of steam, water and chemical inputs and the outputs. These figures were found to be useful in the preparation of water balance and calculation of emission costs.

According to the water balance, % domestic consumption is very high for a total number of 500 workers. Reasons for this is not clear. Out of the process water consumption figures, printing department and washing ranges consume high percentages of water. Only the mercerization process carried out for PC suiting material was not considered due to lack of data even though the undefined loss is 33%. Chemical losses associated with the mercerizer cannot be very high since the industry is equipped with evaporators for the recovery of caustic.

Waste and emission costs prepared depicts the values assigned to each waste stream in terms of Water, Steam and Chemicals. These figures will be useful for cost comparison once some of the options such as chemical substitution, water usage reduction are implemented.

A total of 56 options were identified by the Waste audit team and 34 of these are considered low investment. Nineteen will involve medium investment and only three need high investment. Majority of these options are of the Resource Conservation category (31). Others are Resource Recovery (14), Process Control (5), Equipment Modification (3), Technology Change (2) and Material Change (2).

Three of the ten high priority options identified do not involve any investment and the savings are significant. Three options are in the low investment range (Rs. 400 - Rs. 10,000). and their pay back period ranges from less than one month to four months. Only four of the options involve high investment, and of these also, one option has a pay back of less than one month, and the others are 16, 19 and 34 months. Therefore it was expected that at least 7 options out of the ten will be implemented by the industry. However upto date, the industry has not showed an interest in implementation of these options, which is probably related to the problems being faced by the industry.

11.0 References

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3 PETERS & TIMMERHAMS
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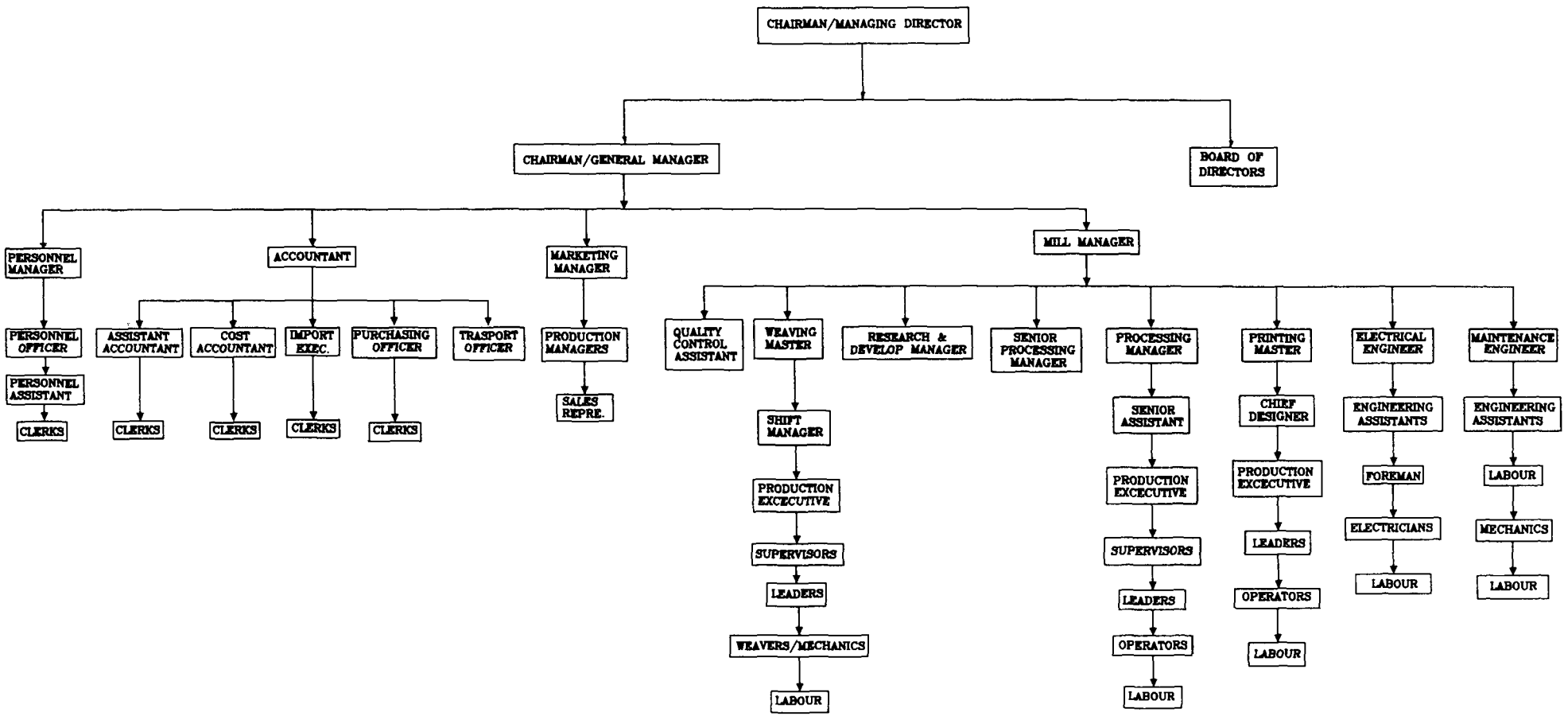
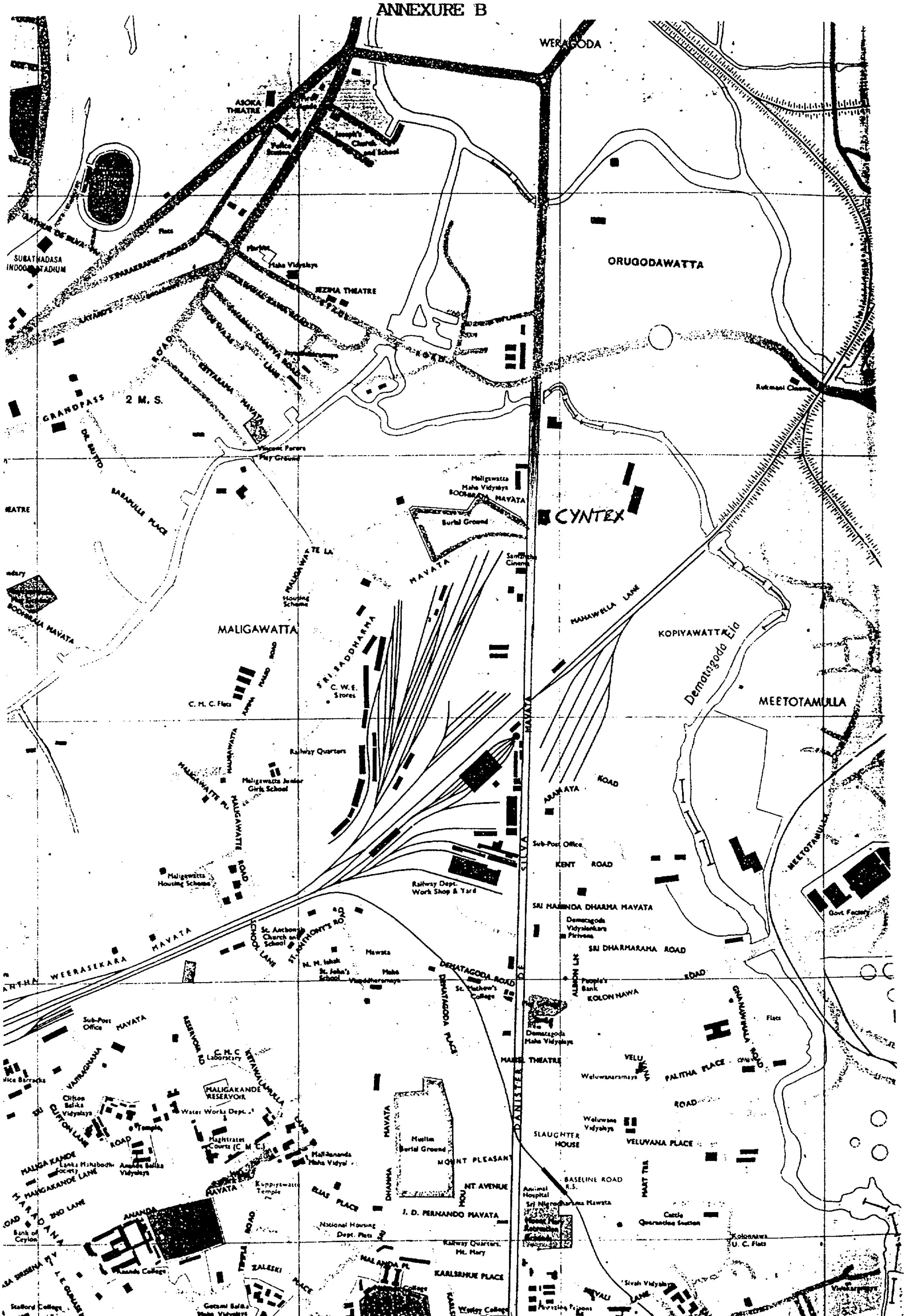
ANNEXURE A

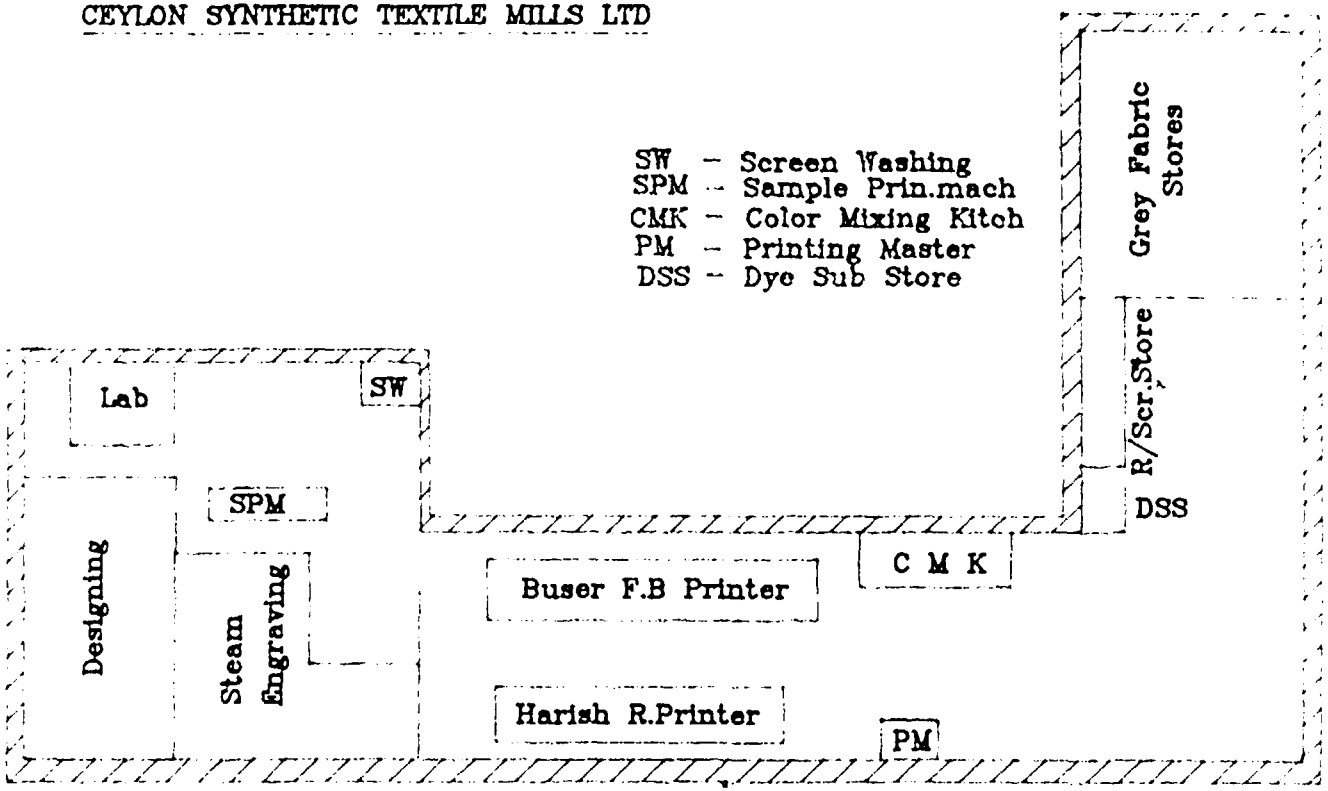
ORGANIZATIONAL CHART – CEYLON SYNTHETIC TEXTILE MILLS



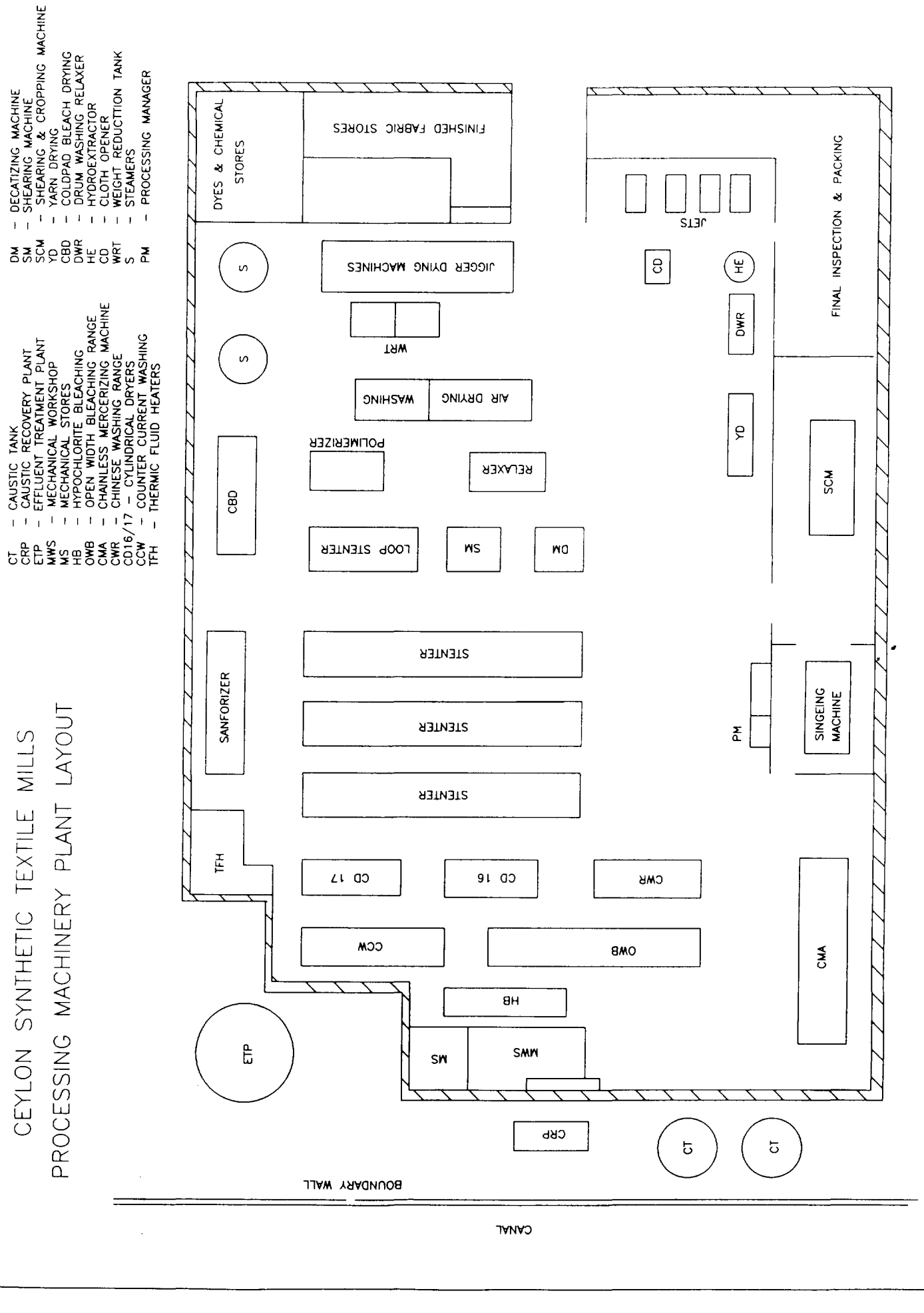

WERAGODA
ASOKA THEATRE
SUBATHADASA INDOOR STADIUM
ORUGODAWATTA
JEZIMA THEATRE
GRANDPASS
2 M. S.
Rukmani Cinema
CYNTEX
Burial Ground
MALIGAWATTA
SRI SADDHARMA
C. W. E. Stores
C. M. C. Flats
Railway Quarters
Maligawatta Junior Girls School
Maligawatta Housing Scheme
MAHAWELLA LANE
KOPIYAWATTA
Dematagoda Ela
MEETOTAMULLA
Railway Dept. Work Shop & Yard
Sub-Post Office
KENT ROAD
SRI MAHINDA DHARMA MAVATA
SRI DHARMARAMA ROAD
Govt Factory
WEERASEKARA MAVATA
DEMATAGODA ROAD
KOLONNAWA
Dematagoda Maha Vidyalaya
MARDEL THEATRE
PALITHA PLACE
MALIGAKANDE RESERVOIR
Water Works Dept.
Muslim Burial Ground
MOUNT PLEASANT
SLAUGHTER HOUSE
VELUVANA PLACE
BASELINE ROAD
Animal Hospital
Cattle Quarantine Section
ANANDA
Ananda College
ZALESKI PLACE
KARLSRHUE PLACE
Wesley College
Stafford College

ANNEXURE C

LAYOUT OF THE PROCESSING DEPARTMENT – 1ST FLOOR
CEYLON SYNTHETIC TEXTILE MILLS LTD



ANNEXURE C
PLANT LAYOUT – GROUND FLOOR



ANNEXURE D

LIST OF MAJOR CHEMICALS & DYES

Chemicals	Quantity kg/M
Desizing agent	136.00
Anti-creasing agent	274.70
Antifoaming agent	18.90
Spot cleaning agent	0.50
Levelling agent	27.95
Antiprecipitating agent	43.50
Detergents	73.50
Carriers	7.80
Wetting agents	23.20
Peroxide neutralizer	8.00
Dispersing agents	200.30
Organic stabilizer for H_2O_2	22.50
Cationic fixing agent	41.00
Silicon softener	50.50
Amino Silicon softener	161.40
Resin	105.30
Cationic softeners (300%)	181.70
Polyethylene emulsion	26.35
Softening agents	111.10
Thermoplast adhesive	50.00
Acetic acid	308.00
Ammonium sulphate	215.00
Caustic soda	839.00
Common salt	1406.00
Citric acid	25.00
Diamonium hydrogen phosphate	25.00
Hydrogen peroxide	88.50
Oxalic acid	26.95
Soda ash	710.00
Sodium hydrosulphite	92.60
Sodium sulphate	214.50
Sodium sulphide	137.50
Sodium silicate	100.00
Tri-sodium phosphate	40.20
Tri-chloro ethylene	3.00
Urea	250.00
Binder for pigment printing	500.00
CMC	75.00
Sodium alginate	100.00
Synthetic thickener	100.00
Keroseine	1100.00

Acid dyes	2.148
Cationic dyes	40.73
Disperse dyes	394.00
Pigment dyes	34.80
Pigment dyes (white)	200.00
Reactive dyes	205.40
Whitening agents(F.W.A)	39.30
Tinting agents	15.00

ANNEXURE E

RECIPES

Polyester saree fabric

Scouring	g/l
Soda ash	2
Hydrosulphite	1
Non ionic detergent	1
Weight reduction(16%)	
Caustic soda	15kg/900m
HAC	1kg/900m
Washing	
HAC	1.5
Soda ash	3
Detergent	1.5

Polyester suiting

Scouring	
Soda ash	1.5
Hydrosulphite	1
Non ionic detergent	1
Spot cleaning agent	0.25
Hot wash	
HAC	0.15
Dyeing	
HAC	0.5
Ammonium sulphate	1
Levelling agent	1
Dispersing agent	1-2
Anti-creasing agent	1.5
Sequestering agent	0.15
Anti-foaming agent	0.1
Reduction clearing	
Caustic soda	1
Hydrosulphite	0.5
Soaping	
Soda ash	1
Detergent	0.5

Polyester/Cotton, Polyester/Viscose suiting

Desizing	
Enzyme	4
Wetting agent	1
Scouring	
H_2O_2	5
Stabilizer	2
Soda ash	10
Detergent	5
Wetting agent	2
Dyeing (Polyester component)	
Dispersing agent	1
Levelling agent	0.5
Ammonium sulphate	0.75
HAC	0.4
Anticreasing agent	1.25
Water softener	0.15
Defoamer	0.1
Reduction clearing	
Caustic soda	1.25
Sodium Hydrosulphite	1
Dyeing(Cotton/Viscose component)	
Common salt	50-70
Soda ash	15-20
Mild oxidizing agent	1
Water softener	0.2
HAC	0.5
Soaping	
Detergent	2
Fixing	
Fixing agent	not given
Finishing	
Softner	25
Resin	10
Polyethylene emulsion	2

Cationic Suiting

Dyeing

Antiprecipitator	1.25
Glaubers salt	3.5
HAC	0.5
Water softener	0.15
Defoamer	0.1

Soaping and washing

Detergent	0.5

Finishing

Softner	25

Polyester/Viscose Dress Fabric

Desizing

Enzyme	4
Non-ionic detergent	1

Polymerizing

Chemicals not given

Finishing

Cationic softener	80
Silicon softener	5
Amino Silicon softner	2-15

Nylon Dress Fabric

Insufficient data

ANNEXURE F

ESTIMATION OF THE STEAM COST

Average Steam cost = Rs 800/1000kg of steam (GIVEN BY THE INDUSTRY)

ANNEXURE G

Total production of September 1995

Polyester Saree fabric (Printed)	=	17,178m (945kg)
Polyester/Viscose Dress Fabric(PV 002)(Printed)	=	109,017m (13,082kg)
Polyester/Viscose Dress Fabric(PV 007)(Printed)	=	20,481m (2,458kg)
Polyester suiting	=	36,680m (10,270kg)
Polyester/Viscose suiting	=	13,228m (4,762kg)
Polyester/Cotton suiting	=	26,887m (9,679kg)
Cationic suiting	=	14,457m (4,337kg)
Nylon Dress Fabric	=	22,521m (1,076kg)

ANNEXURE H

ESTIMATION OF EFFLUENT DISPOSAL COST IN THE BASIS OF COD REMOVAL

Assumptions

a) Capacity of plant = 200 m^3/d
b) Typical COD of textile effluent after equalization = 800 mg/l

Chemical consumption

Coagulant	-	Alum (400 mg/l)	=	80 kg/d
Flocculant Polymer (2 mg/l on dry solid basis)			=	400 g/d
Neutralizer	-	Lime (120 mg/l)	=	24 kg/d

Cost

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

Electricity

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(0.5kW)	=	18 kWh
RBC (1.5 kW)	=	36 kwh
Secondary clarifier scraper(0.75 kW)	=	18 kWh
Total power	=	145.7 kWh
Electricity cost (Rs 5/kWh)	=	726
Labor cost (24 labor hours per day) Total cost of labor including EPF, ETF, and annual overtime	=	Rs 25/h
Labour cost	=	Rs 600/d
Sludge handling cost	=	Rs 150/d
Total operational cost	=	Rs 3726/d
COD removal per day	=	200 x (800-250) x 10^{-3} kg/d
	=	110 kg/d
Cost for COD removal	=	3276/110
	=	Rs 29.78/kg
	=	Rs 30/ kg

ANNEXURE I

UTILITY COSTS

UTILITY	UNIT COST (Rs)	COST Rs/kg of fabric
WATER	20 /m^3	4.47
STEAM	0.8 / kg	4.65 §
ELECTRICITY	4.5 / kWh	15.5
FUEL OIL	6 / l	7.95
TREATMENT COST	30 / kg COD	8.25 ♀

♀ Treatment cost per kg of fabric is calculated from total effluent treatment cost (Rs 384,412/M ,from waste emission cost table) and total production (46609 kg/M) in September 1995.

§ Unit cost of steam per kg of fabric was calculated from the calculated steam consumption and production figures (426201 kg and 46609 kg respectively) in September 1995.