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Annex 9

INDUSTRIAL POLLUTION REDUCTION PROGRAMME
DG/SRL/91/019

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

WASTE AUDIT

BAKSONS TEXTILES PVT LTD

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

TABLE OF CONTENTS

ANNEXURES

SUMMARY

Baksons Textiles (Pvt) Ltd.,is a medium scale textile processing industry situated in a industry dominated urban area of Colombo South. The Major environmental pollution issues from this factory are the disposal of highly alkaline textile effluent and emission of kerosene vapour from the textile printing section.

This industry consumes 110 l of water and 0.2 l of furnace oil for each kilogram of textile processed.

The organic load of the effluent discharged from the fabric cleaning processes of scouring, bleaching, mercerization (only for this industry mercerization is also considered as cleaning process because grey cloth mercerization is carried out) generate 23% of the total COD. 31% of total COD is generated from garment washing and the balance 46% of organic load is due to wastage of materials utilized in the processing.

The most expensive waste streams are cold pad dyeing, printing and mercerization. The waste streams from continuous wash, bleaching and normal wash also exceed the average value of waste stream cost. The high cost for cold pad dyeing is mainly due to the discharge of a low volume of concentrated effluent.

Sixty one waste minimization options were identified and cost benefit analysis done for 10 options identified to be of high priority by the industry. Conclusions from the cost benefit analysis are summarized in the Table. The industry was subsequently closed, and so was not able to implement these options.

Option	Investment	Operating cost/y	Savings/y	Pay back period in months	Environmental benefits
1) Reuse of waste caustic during handling	41,120/-	8,860/-	38,096/-	13	reduction in alkalinity of effluent
2) Recycle final rinse water for counter current and screen washing	47,962/-	14,932/-	49,226/-	11	reduction in effluent volume by 1.8%
3) Recycle counter current rinse water for washing screen	46, 962/-	14,722/-	24,533/-	28	reduction in effluent volume by 1%
4) Recycle of screen washings for preparation of caustic	195,000/-	47,430/-	1,686,090/-	2	reduction in alkalinity of effluent and volume of effluent by 0.4%
5) Installation of temp. control system for mercerizer	247,500/-	51,975/-	176,765/-	9	reduction of boiler fuel consumption by 8.3 %
6) Recovery of caustic	4,284,225/-	2,347,747/-	4,251,253/-	12	reduction of effluent by 1% and high reduction of alkalinity of effluent
7) Counter current rinsing in washing range	20,000/-	6,600/-	102,266/-	2	0.7% reduction of effluent volume, 1.4% of fuel consumption
8) Condensate recovery drum dryer	5,000/-	1,050/-	30,978/-	2	0.1% reduction of effluent volume, 0.5% of boiler fuel consumption
9) Recycling of hydro extraction water	16,000/-	4,740/-	7,260/-	26	0.3% reduction of effluent volume
10) Installation of doctor blade and print paste recovery	86,000/-	20,112	255,420/-	4	Effluent volume reduction by 1.6% and COD load reduced by 2%

* reduction of fuel consumption results in reduction of atmospheric emissions

Abbreviation List

COD	Chemical Oxygen Demand
J	joule
K	kelvin
kg	kilogram
kWh	kilo Watt hour
kW	kilo Watt
l	liter
M	month
m	meter
min	minute
mg	milligram
g	gram
s	second
T	ton
y	year
^{0}C	^{0}Centigrade
Ref	Reference
d	day
h	hour
hp	horse power

PART 1 - ENVIRONMENTAL STATUS

BAKSONS TEXTILES (PVT) LIMITED

1.0 Introduction

Baksons Textiles (Pvt) Ltd is a textile processing industry carrying out mercerising, dying and printing of cotton, polyester and polyester cotton fabrics, and garment washing

1.1 Organisational chart : Attached (Annex A)

1.2 Ownership : Mr. B.K. Bakshani

1.3 Contact persons : Messers. S.S. Vidhyanandan,Store keeper/Accounts Clerk, Lal Pieris, Administrative Manager. B.K. Bakshani, Managing Director, Mr. Lloyd Perera, Dyeing Manager.

2.0 Site details

2.1 Location : No. 11 Maligawa Road, Ratmalana (Annex B))

2.2 Physical Descriptions

(i) Area : ~ 4500 m^2

(ii) Topography : Flat land

(iii) Factory layout : Attached (Annex C)

(iv) Sealed surface : 100% of the site

(v) Depth to groundwater : 3 m

(vi) Surface water bodies : None

(vii) Surface drainage channels : All the drains are connected to one receiving sump and then to the public sewer system

2.3 Current use

(i) Processes : Mercerizing, dyeing, printing, garment washing and drying

(ii) Products : Dyed and printed fabrics and washed garments

(iii) Raw materials : Grey cloth, denim and non denim garments

(iv) Major chemicals : Caustic soda, dyes (direct, pigment, reactive, and sulfadyes), detergents, softners and pigments and other general chemicals (Annex D)

(v) Energy source : Furnace oil and electricity

2.4 Site drainage (type & discharge points)

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

3.0 Environmental Emissions

3.1 Atmospheric emissions	: Flue gas from boilers, solvents from printing and curing machines, exhaust from garment dryer and stentor.
3.2 Aqueous discharge points	: Effluents from mercerization, bleaching, dyeing, printing, and garment washing
3.3 Solid waste	: Paper, sacks, used nickel screens and empty chemical packaging materials

4.0 Site history and Neighbouring sites

4.1 History of the site

(i)	Start date	: Textile weaving from1986
(ii)	Former use	: Bare land

4.2 Current and former use of neighbouring sites

(i)	Northern	: Visaka garment and Ajantha Textiles-textile weaving factories
(ii)	Southern	: CIC (Colombo) Ltd.-Manufacture of PVA, Agrochemicals and Plastic items
(iii)	Western	: Sadaharitha Lanka-Metal fabrication (dry operation)
(iv)	Eastern	: Nelumpura Housing scheme

4.3 Significant spills : None

5.0 Environmental Receptors

5.1 Abstraction points

(i)	Dug wells	: One dug well but abandoned
(ii)	Tube wells	: None
(iii)	Surface water	: None

5.2 Sensitive neighbours within 2 km

(i) Residence : Mixed industrial & residential area

(ii) Hospitals : None

(iii) Schools : None

(iv) Others :

5.3 Protected Natural Habitats : Attidiya Bird Sanctuary - 3 km to the east (refer map)

5.4 Water Bodies

(i) Surface : Weras ganga, Bolgoda lake

(ii) Sub-surface : Residents in the neighbourhood use dug wells for domestic purposes and gardening

6.0 Solid Waste Issues

(i) Type and disposal method : Metal and plastic drums-sold; Gunny sacks-sold; Paper and polythene - garbage; Cotton waste from dryers-garbage; Fabric rejects and Offcuts-sold; Used nickel printing screens -

7.0 Environment Licence issues

7.1 Current status : EPL not issued due to high pH, BOD and COD - >10, 70-1600 mg/l and 230 -2400 mg/l respectively

7.2 Current compliance issues : Non-conformance of effluent discharge to standards; Complains from the neighbourhood regarding kerosene and soot emissions from the factory

PART 2 - WASTE AUDIT

1.0 General Information

WORKSHEET 1	
Name of the Company : Bakson Textiles (Pvt) ltd	
Waste Audit Team	
Name	**Designation**
1. Mr. H.N. Gunadasa,	Manager, Environmental Technology Group, CISIR
2. Mrs. K.D. Attanayake,	Senior Technical Officer, CISIR
3. Mrs. S.Wickramaratna,	Research Officer, CISIR
4. Miss. S.de Costa	Research Officer, CISIR
5. Mr. K. Pavanandan	Research Officer, CISIR
6. Mr. R. Ilangkumaran	Research Officer, CISIR
7. Mr. S. Vidhyanandan	Stockkeeper, Bakson Textiles (Pvt) ltd
8. Mr. Lal Pieris	Administrative Manager, Bakson Textiles (Pvt) ltd
9. Mr. Lioyd Perera	Dyeing Manager, Bakson Textiles (Pvt) ltd
A. **Major Raw Materials Consumption**	
i) RAW MATERIAL	
a) Fabric	--T*/y
ii) CHEMICAL	
a) Printing chemicals	46.8 T/y§
b) Garment washing chemicals	91.7 T/y§
c) Bleaching chemicals	274.1 T/y§
d) Printing dyes	10.2 T/y§
e) Fabric dyes	4.6 T/y§
f) Other chemicals	161.6 T/y§
B. **Energy Consumption**	
a) Electrical energy	1,281,540 kWh/y§
b) Fuel for boilers	270,000 l/y§

C.	**Water Consumption**	177,612 $m^3/y^{\S}$
D.	**Production**	
	i) **Installed Capacity**	
	Mercerizing	25-50 m/min
	Cold pad dyeing	45-50 m/min
	Washing range	70 m/min
	Stenter	80 m/min
	Jumbo jigger - 3 numbers	1000 kg/batch
	Small jiggers - 10 numbers	110 kg/batch
	Jet dyer - unit 1	100 kg/batch
	Jet dyer - unit 2	200 kg/batch
	Washing machines - 12 numbers	200 kg/batch
	Thies Dyer	70 kg/batch
	Drum drier	50 m/min
	Rotating screen printer	45 m/min
	ii) **ACTUAL PRODUCTION (September 1994)**	
	Mercerizing	650,000 m
	Cold pad dyeing	61,000 m
	Jigger or jet dyeing	15,000 m
	Bleaching	886,000 m
	Laundry	48,649 kg
	Printing	160,000 m
E.	**Type of Effluent Treatment**	No treatment
F.	**Any Other Relevant Information :** 25 Working days per month, the plant has 240 workers and this is a commission process industry with a daily average production capacity of 50,000 m fabrics as well as 10,000 garments.	

* Not provided by client.

§ Calculated using average monthly figures.

2.0 Available Information

Available information is very limited. No proper recording system available to quantify process wise production. Job card system is used to assign task to workers. Metering system also not available to determine important process parameters.

WORKSHEET 2		
Information	**Availability**	**Remarks**
Process flow diagram	Not available	
Material Balance	Not available	Only monthly consumption available
Energy balance	Not available	No provision to record
Water balance	Not available	Average monthly consumption available
Plant layout	Available	Not satisfactory
Waste analysis	Not Available	Not done
Emission records	Not available	Not done
Production log sheets	Available	Not satisfactory
Maintenance log sheets	Not available	

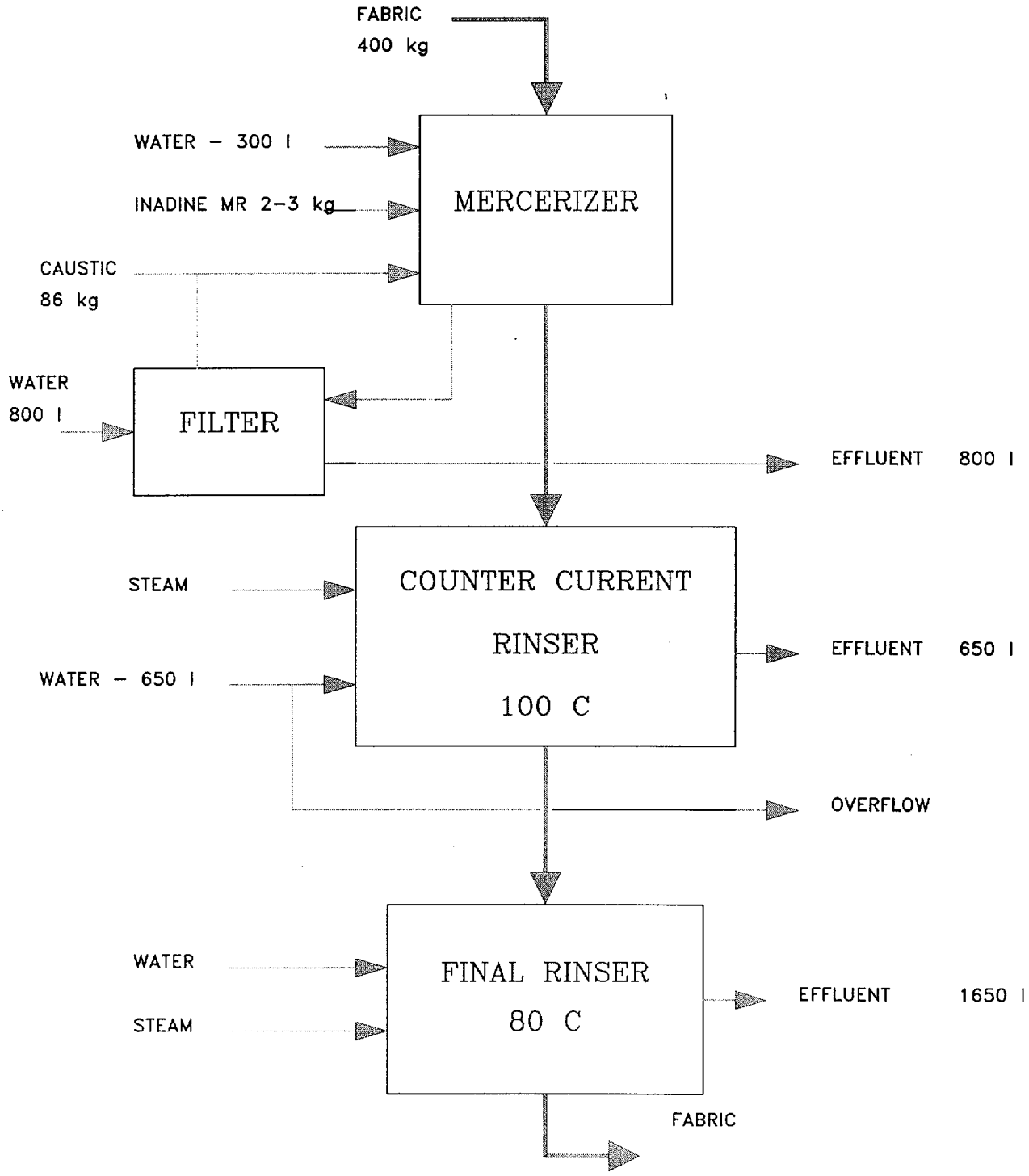
3.0 Process Flow Diagram

There are a number of production processes available for dyeing printing and laundering of fabrics and garments. The production process depends on type of material used and the type of product required. Worksheet 3.1 to 3.10 give the most commonly used production processes of this industry.

WORKSHEET 3.1

PROCESS FLOW DIAGRAM INDICATING WASTE STREAMS

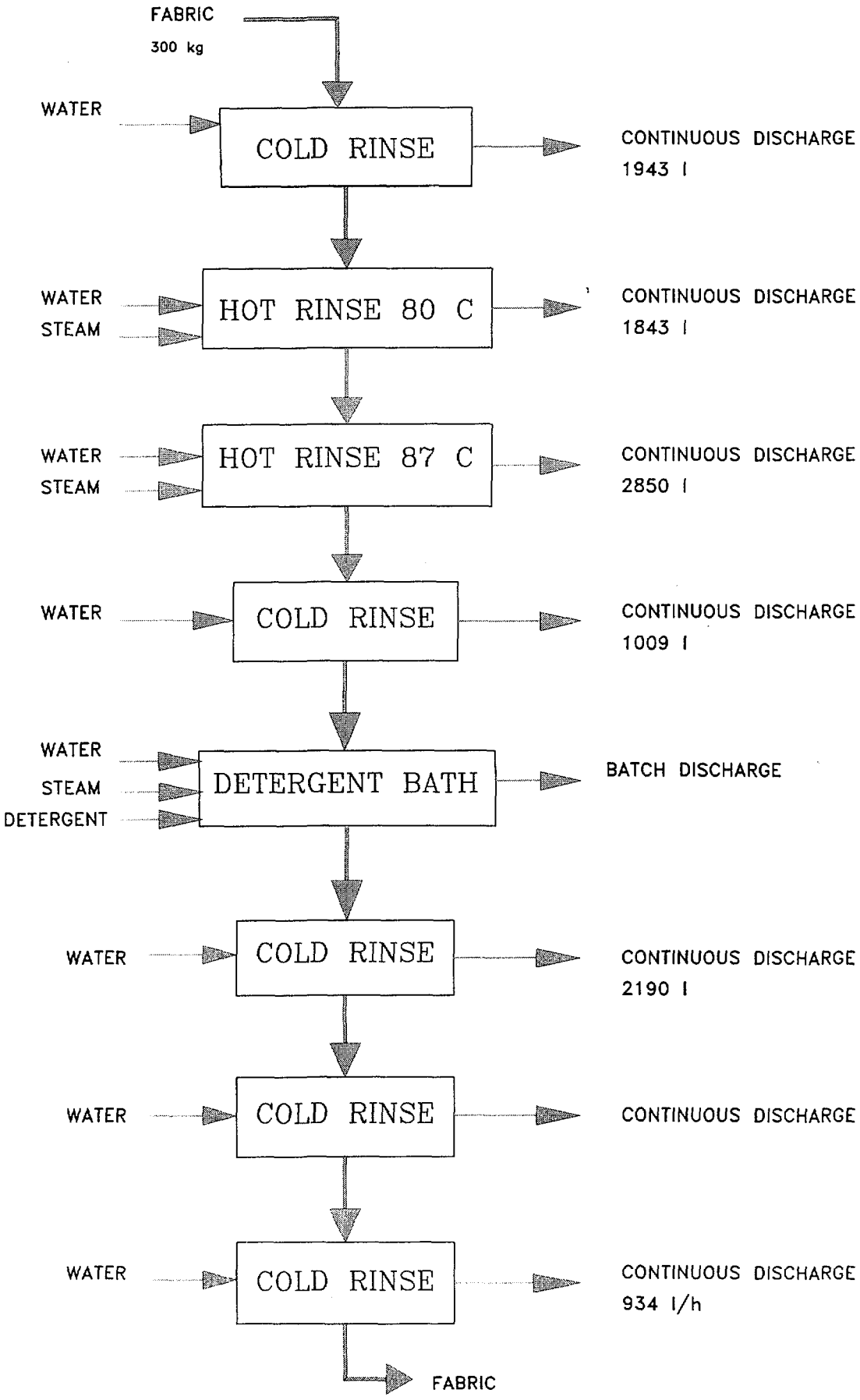
MERCERIZER – HOURLY BASIS



WORKSHEET 3.2

PROCESS FLOW DIAGRAM INDICATING WASTE STREAMS

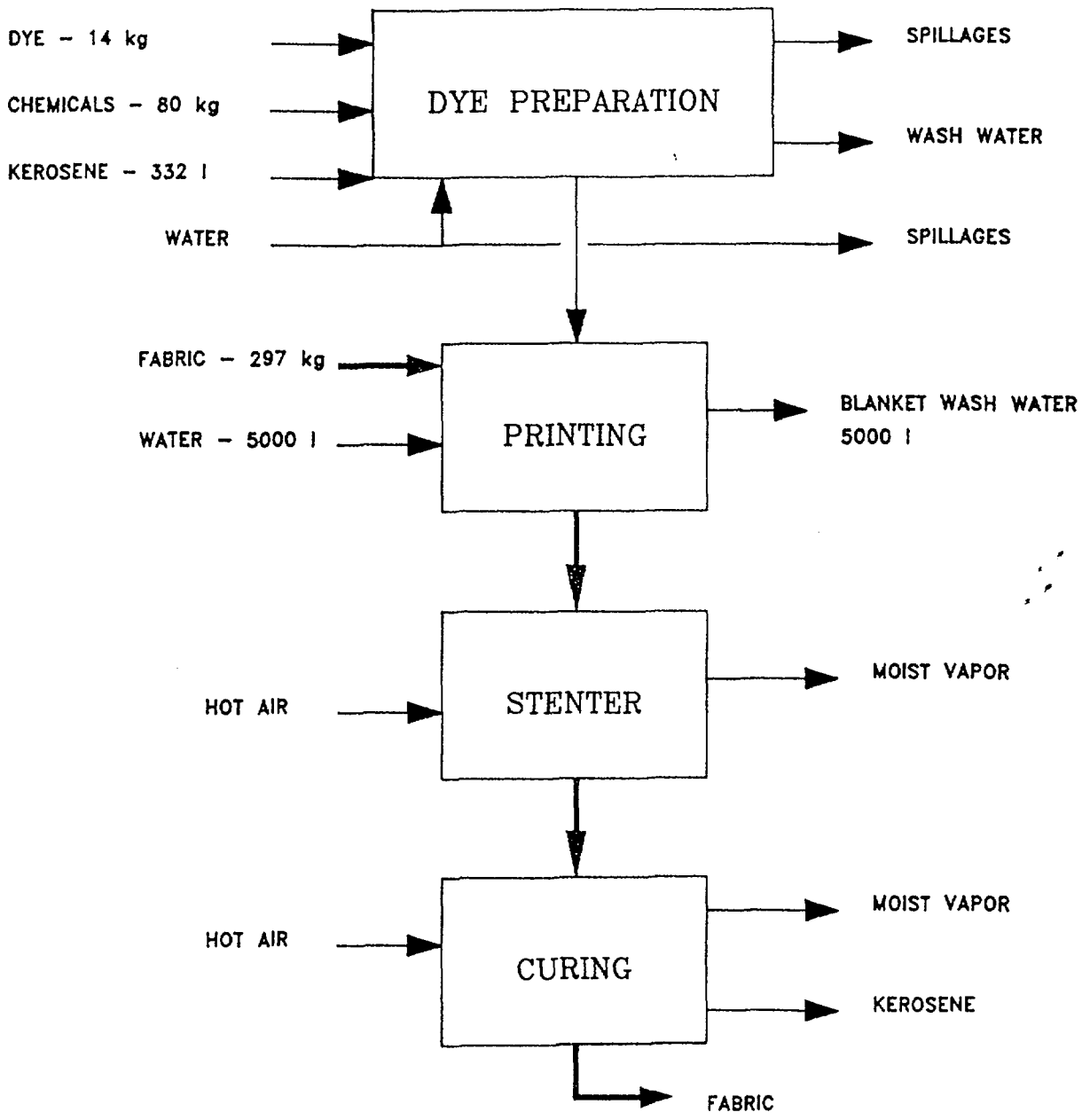
CONTINUOUS WASHING RANGE – HOURLY BASIS



WORKSHEET 3.3

PROCESS FLOW DIAGRAM INDICATING WASTE STREAMS

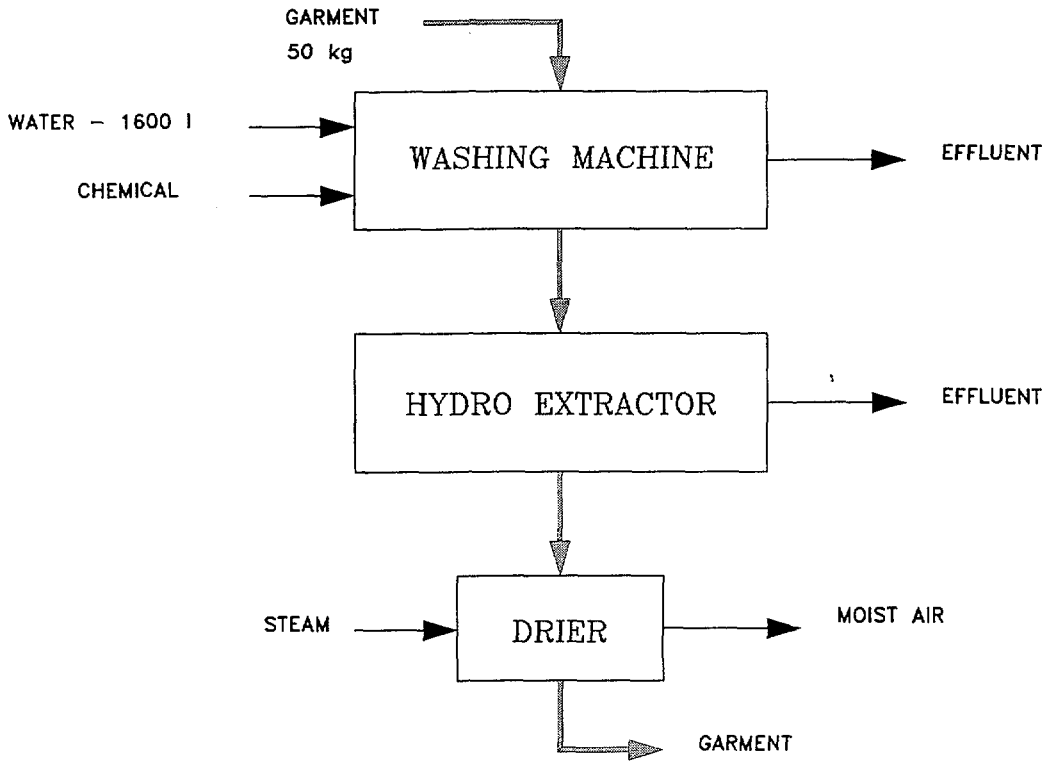
CONTINUOUS PRINTER – HOURLY BASIS



WORKSHEET 3.4

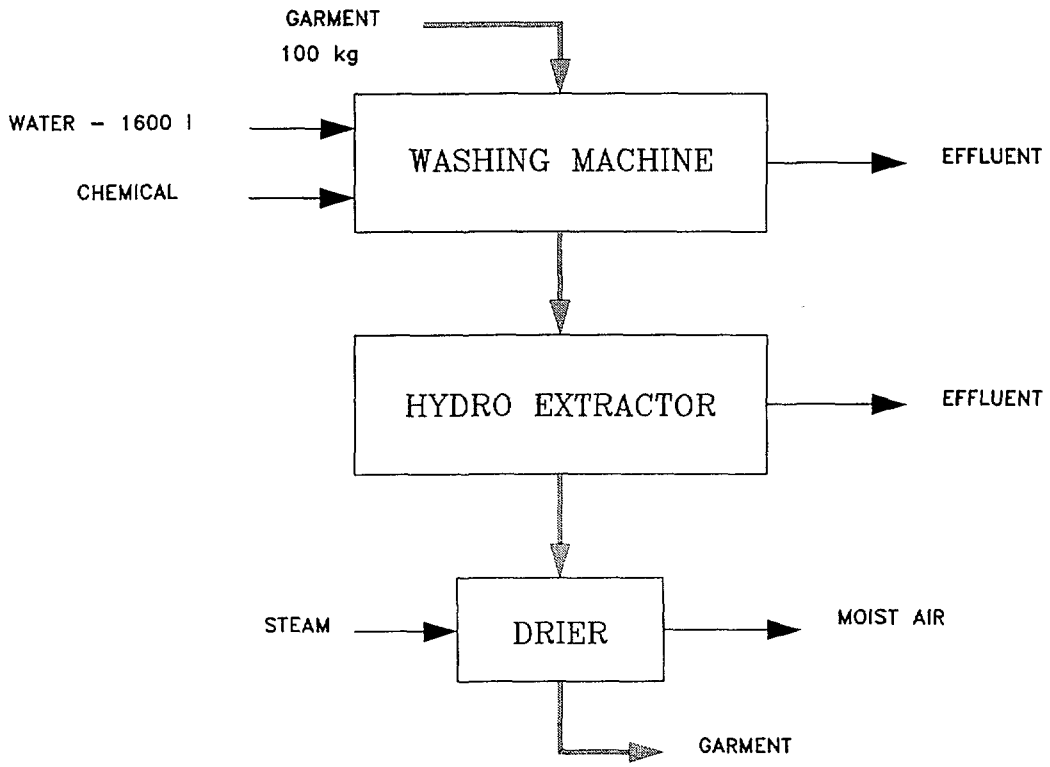
PROCESS FLOW DIAGRAM INDICATING WASTE STREAMS

LAUNDRY – NORMAL WASH (DENIMS) BATCH WISE



PROCESS FLOW DIAGRAM INDICATING WASTE STREAMS

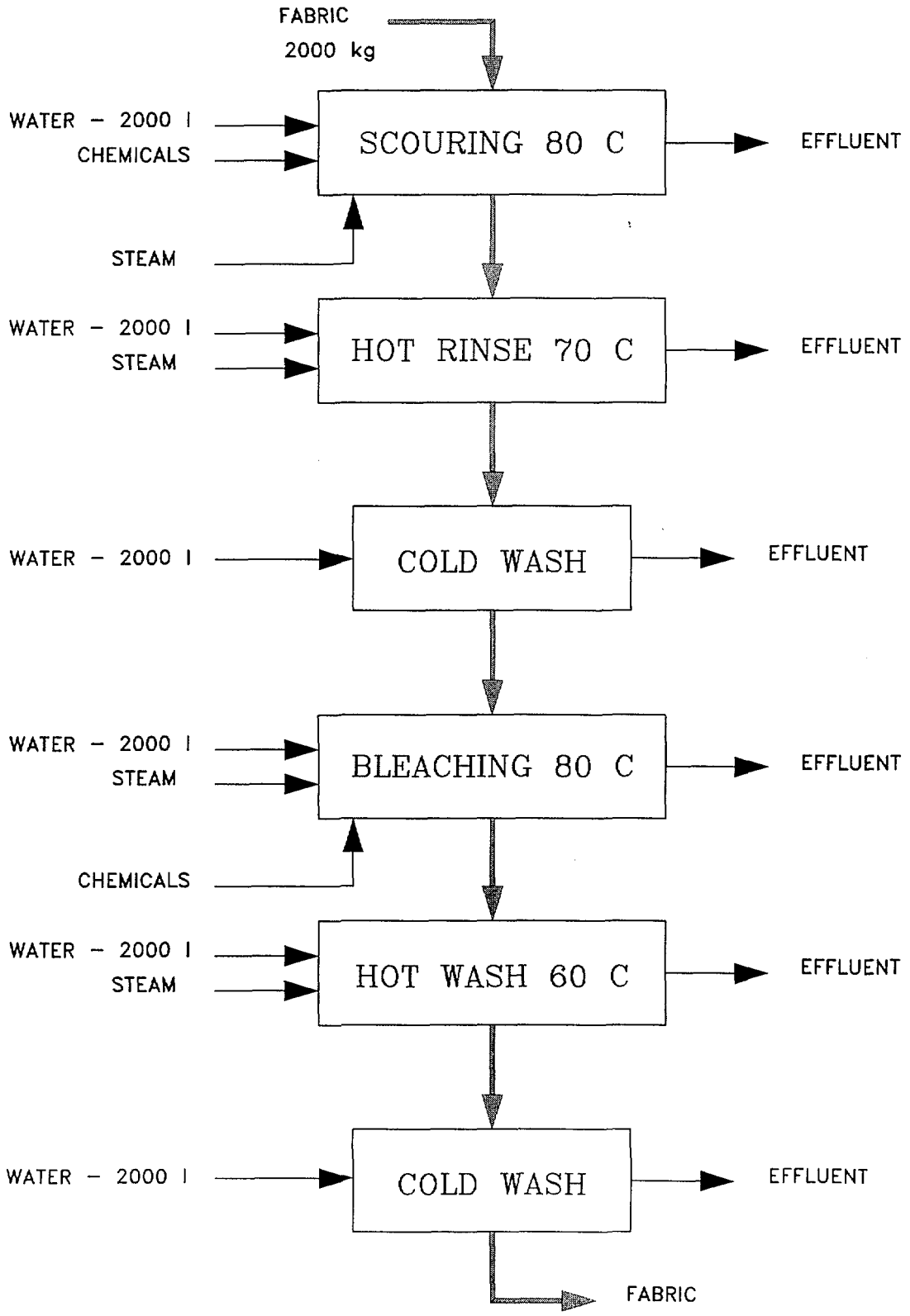
LAUNDRY – GARMENT WASH (WITHOUT DENIMS) BATCH WISE



WORKSHEET 3.5

PROCESS FLOW DIAGRAM INDICATING WASTE STREAMS

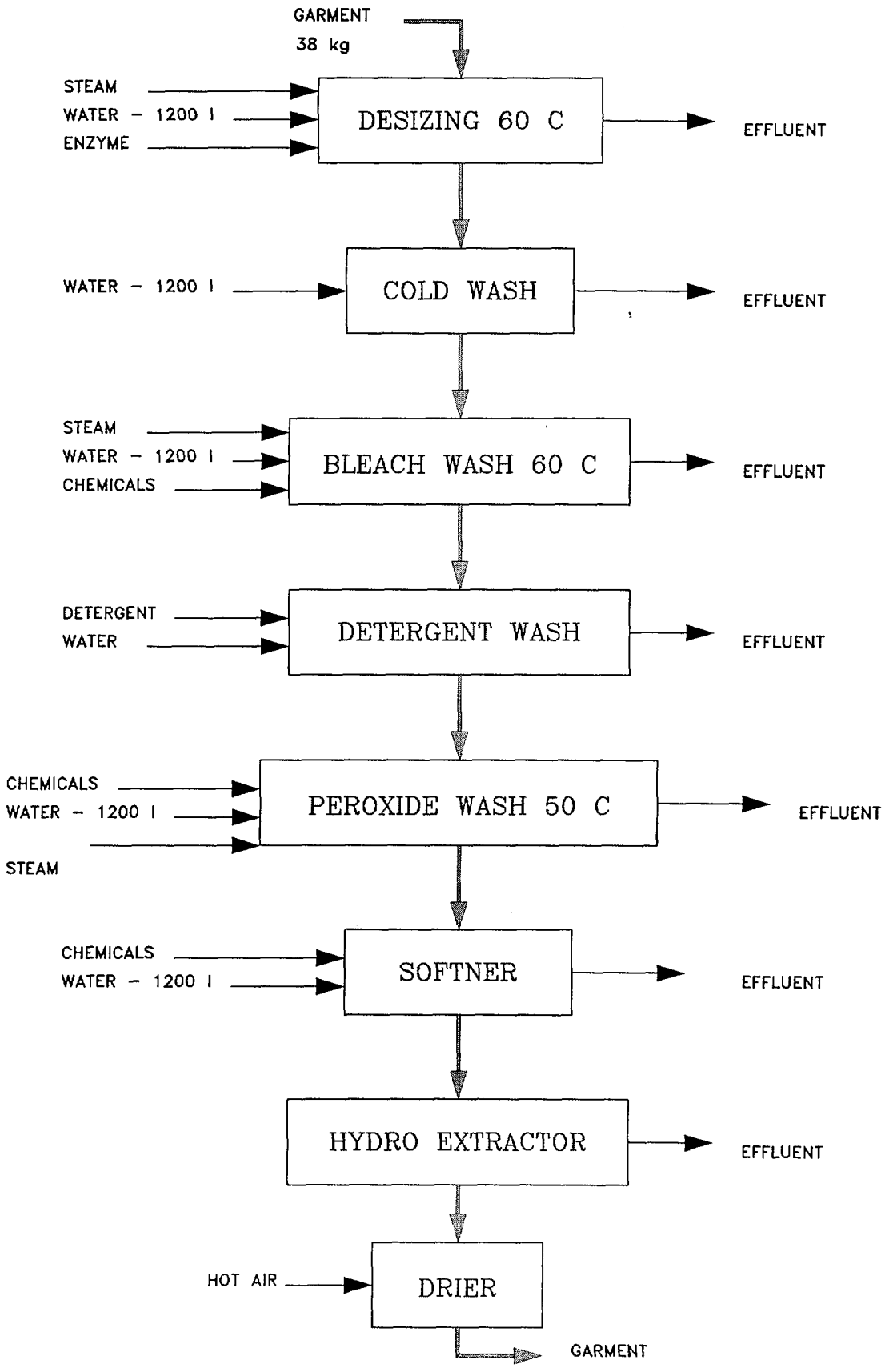
BLEACHING (JUMBO JIGGEERS) – BATCH WISE



WORKSHEET 3.6

PROCESS FLOW DIAGRAM INDICATING WASTE STREAMS

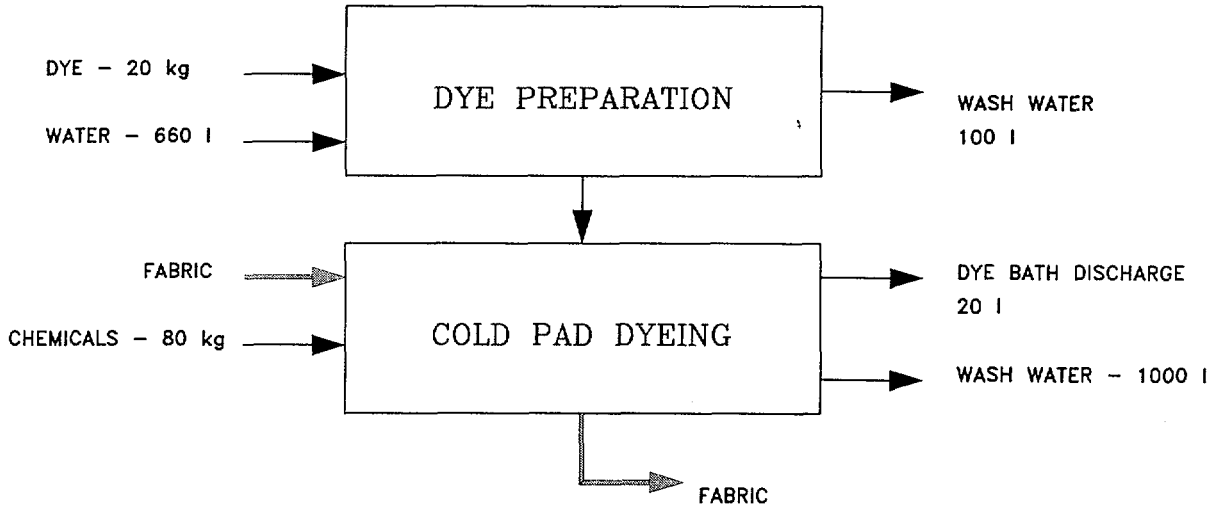
LAUNDRY – BLEACH WASH/ICE WASH (BATCH WISE)



WORKSHEET 3.7

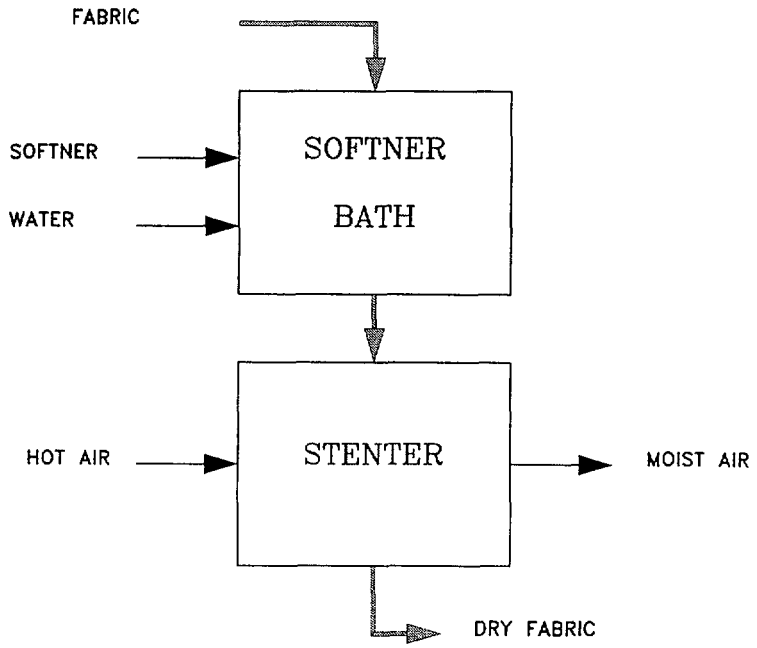
PROCESS FLOW DIAGRAM INDICATING WASTE STREAMS

COLD PAD DYEING – BATCH WISE (450 kg/batch)



PROCESS FLOW DIAGRAM INDICATING WASTE STREAMS

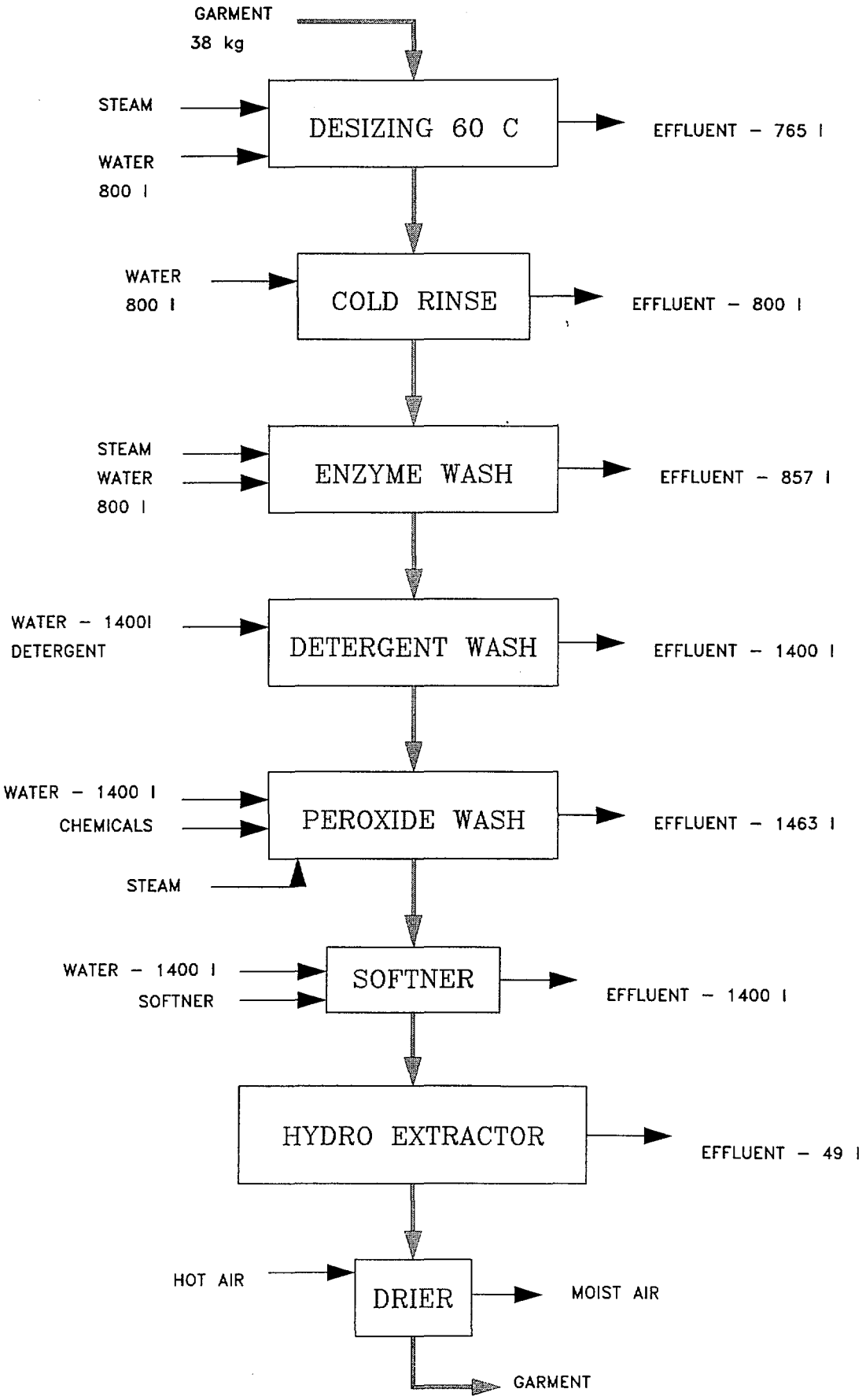
STENTER



WORKSHEET 3.8

PROCESS FLOW DIAGRAM INDICATING WASTE STREAMS

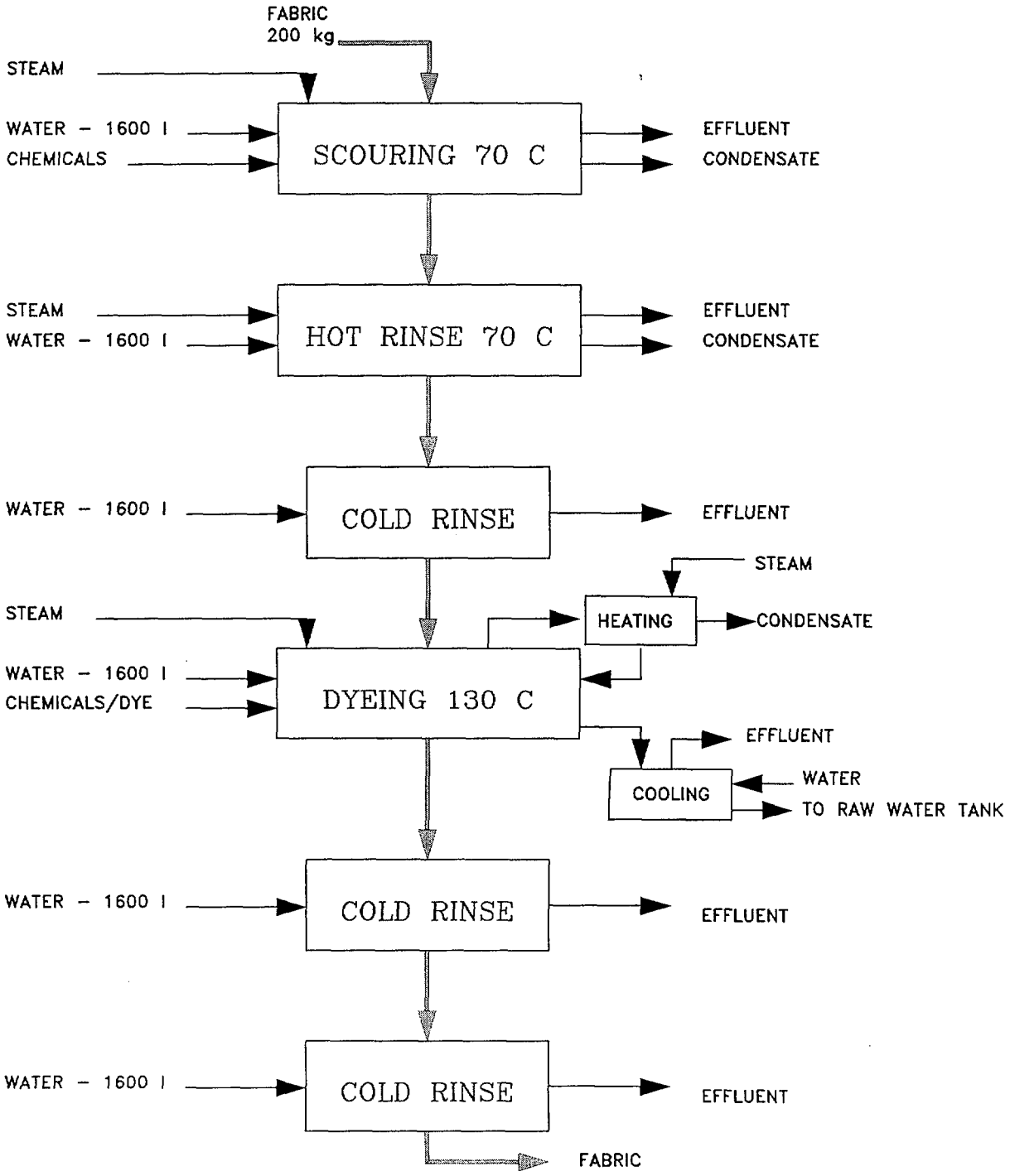
LAUNDRY – ENZYME WASH (BATCH WISE)



WORKSHEET 3.9

JET DYEING – 100% POLYESTER

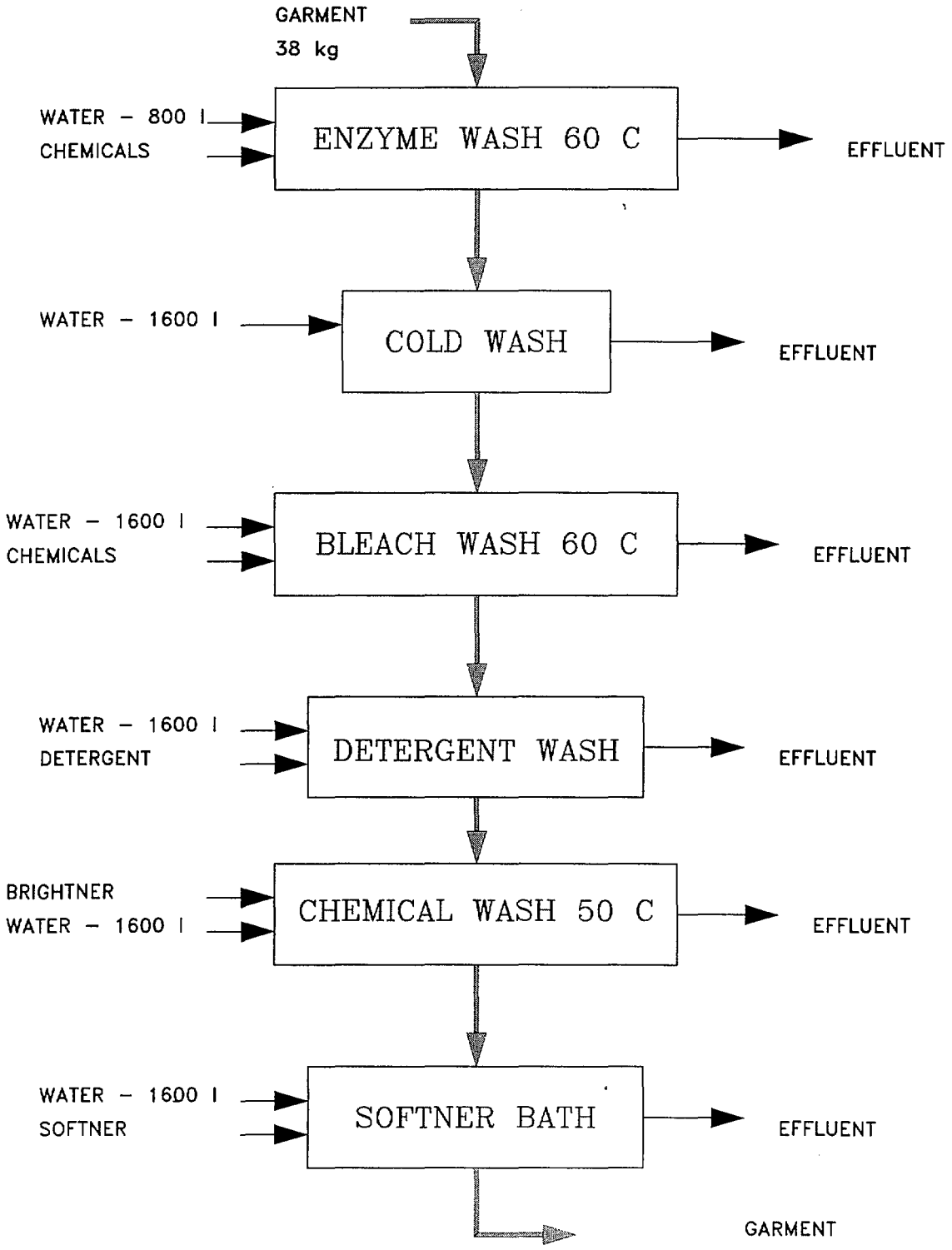
BATCHWISE

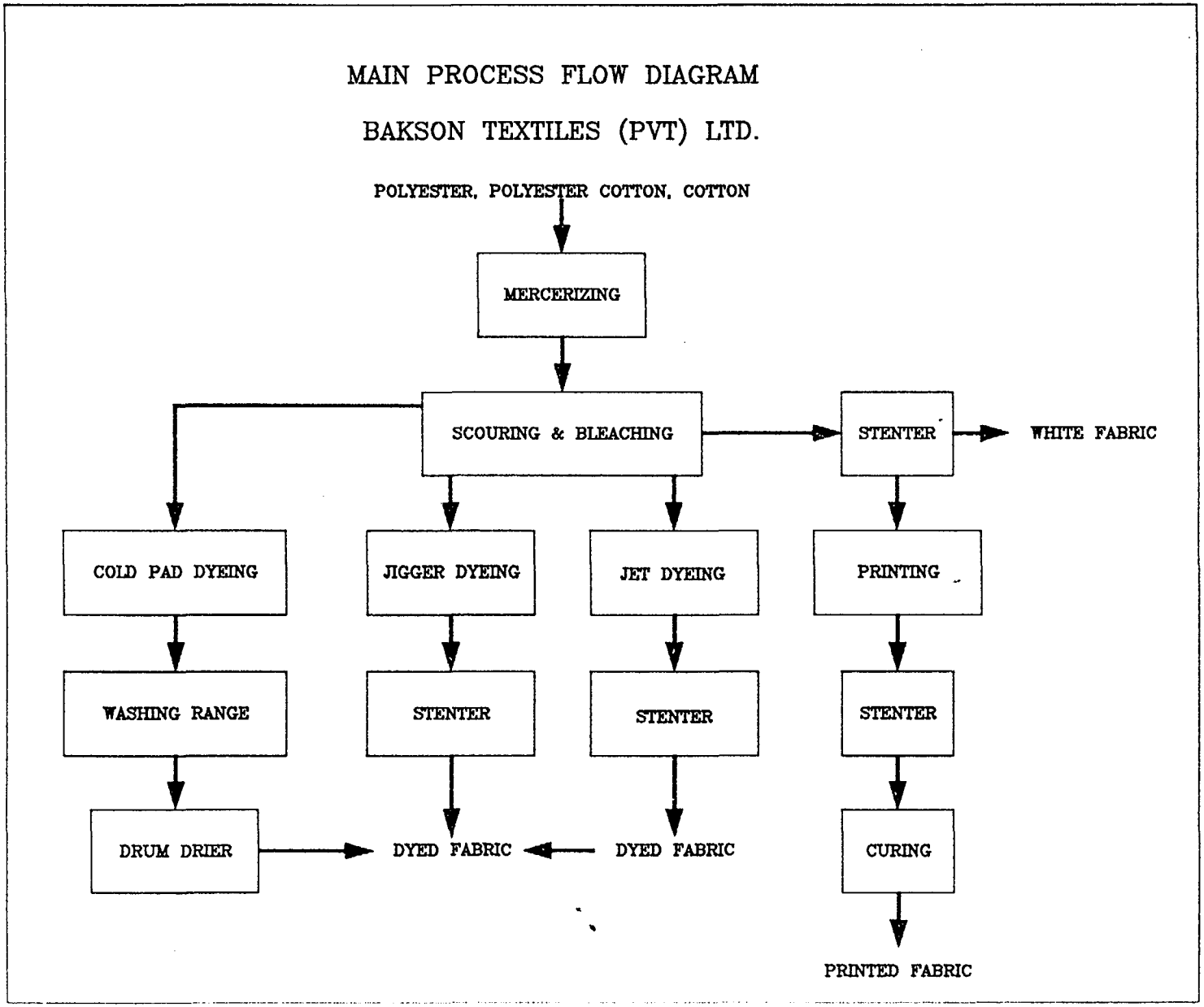


WORKSHEET 3.10

PROCESS FLOW DIAGRAM INDICATING WASTE STREAMS

LAUNDRY – STONE BLEACH (BATCH WISE)




MAIN PROCESS FLOW DIAGRAM
BAKSON TEXTILES (PVT) LTD.
POLYESTER, POLYESTER COTTON, COTTON
MERCERIZING
SCOURING & BLEACHING
STENTER
WHITE FABRIC
COLD PAD DYEING
JIGGER DYEING
JET DYEING
PRINTING
WASHING RANGE
STENTER
STENTER
STENTER
DRUM DRIER
DYED FABRIC
DYED FABRIC
CURING
PRINTED FABRIC

4.0 Housekeeping Status

The waste audit team identified several housekeeping lapses, which will affect the production output and these are described in Worksheet 4. Some of the losses caused by lapses in housekeeping cannot be quantified financially. However they would result in decreased productivity due to discomfort of the workers.

WORKSHEET 4
GENERAL REMARKS RELATED TO HOUSEKEEPING

Sections	Lapses in Housekeeping
MERCERIZER	Water overflow from raw water tank of counter current washing due to improper adjustment of flow rate.
DRUM DRIER	Steam leakages due to unattendence of small repairs.
WASHING RANGE	Improper use of steam (steam valves are kept open even when the plant is stopped for short periods).
COLD PAD DYEING	Open water valves when washing is over.
PRINTER	Spillage of dye/chemical solutions. Open water hoses. Increase of ambient temperature due to heat dissipated from dryer.
BOILER	Fuel leaks in joints.
Dyeing and Laundering	Open water hoses. Warm working environment due to hot discharge and heat dissipated from dryers.

5.0 Material Balance

Material balance carried out using actual material consumption of September 1994(Annexure E) and calculated water and steam consumptions based on liquor ratio for batch operations and measured flow rate for continuous operations.

WORK SHEET 5
MATERIAL BALANCE FOR THE MONTH OF SEPTEMBER 1994.

Unit Operation	Input Material		Output		
			Product	Waste Stream	
	Name	Qty (kg)	Qty (kg)	Liquid (kg)	Solid/ gas (kg)
Mercerization	Fabric	71,500	71,500		
			(45,000)		Nil
	Caustic	15,600	14	15,586	
	Water	549,000		554,000	
	Steam	50,731			
Printing	Fabric	17,600	17,600		
			(760)		
	Chemicals	4,700		4,700	
	Dyes	800		40	19,700
	Kerosene	19,700			
	Water	296,000		296,000	
Continuous Washing range	Fabric	6,710	6,710		Nil
			(4,200)		
	Steam	11,000			
	Water	233,000		239,800	
Bleaching Small jiggers	Fabric	9,900	9,310	490	
			(5918)		
	Steam	9,270			
	Water	144,000		147,292	Nil
	NaOH	100		100	
	$NaSiO_3$	288		288	
	H_2O_2	378		378	
	Uvitex CID	39		39	
	NaCl	126		126	
	Thinovadine Ju	49		49	

Bleaching Jumbo jiggers (88 batches)	Fabric	87,660	83,277 (53,472)	4,383	
	Steam	73,9200			Nil
	Water	1,056,000		1,076,445	
	NaOH	2,552		2,552	
	$NaSiO_3$	3,472		3,472	
	H_2O_2	2,217		2,217	
	NaCl	1,624		1,624	
	Thinovadine Ju	161		161	
Cold Pad dyeing	Fabric	6,710	6,710 (4,227)		
	Chemicals	1,200		1,200	Nil
	Dyes	300	270	30	
	Water	26,500		22,273	
Bleach wash /Ice wash (305 batches)	Garment	11,600	11,600 (10,440)		
	Steam	63,440			Nil
	Water	2,196,000		2,236,440	
	Pimaze Al	552		552	
	Pisoft 195	552		552	
	H_2O_2	442		442	
	Other chemicals	663		663	
Stone Bleach (345 batches)	Garment	13,100	13,100 (11,790)		
	Steam	79,000			
	Water	3,036,000		3,103,210	
	Pimaze Al	655		655	
	Pisoft 195	655		655	Nil
	HAC	52		52	
	Other chemicals	883		883	
Normal wash (80 batches)	Garment	4,000	4,000 (3,600)		Nil
	Water	128,000		124,400	
	Chemicals	200		200	

Garment wash (28 batches)	Garment	2,800	2,800 2,520		Nil
	Water	44,800		42,280	
	Chemicals	100		100	
Enzyme wash (177 batches)	Garment	6,700	6,700 (6,030)		
	Steam	26,066			Nil
	Water	1,168,200		1,188,236	
	Pimaze Al	335		335	
	Pisoft 195	335		335	
	CH_3COOH	26		26	
	H_2O_2	325		325	
	Other chemicals	587		587	
Jet dyeing (9 batches)	Fabric	1,650	4,500 (1040)		
	Steam	5,108		♀ 5,108	
	Water	86,400		85,360	
	NaOH	36		36	Nil
	$NaSiO_3$	14		14	
	H_2O_2	22		22	
	Thinovadine	44		44	
	Ju	97		97	
	Na2CO3	272		272	
	Dye				

Total volume of process effluent = 7895 m^3/M
Steam consumption = 318 T/M
♀ The recyclable steam condensate discharged into drain.
() Moisture accompanied with fabric.

ASSUMPTIONS

1. Fabric undergoes 5% weight reduction in dry basis during the scouring and bleaching process.
2. Moisture content of the fabric in weight basis (wet) given in annexure J.

CALCULATIONS

1. Moisture absorbed into fabric
   Let M - Weight of the fabric with 7% moisture
   M_d- Dry weight of the fabric= 0.93M

Moisture absorbed after wet process(43%) = (0.43 x 0.93M/0.57 - 0.07M)
= 0.63M

2. Similarly moisture absorbed into garment after Hydroextractor
= (0.51 x 0.93M/0.49 - 0.07M)
=0.9M

3. Chemical consumptions were calculated according to the recipe.

Recipes are given in annexure F.

4. Steam consumption is calculated using heat requirement for each process to achieve required temperature and properties of steam.
Steam consumed $=(cp_f \times m_f + cp_l \times m_l)(T_o - T_r)/h_f$
cp_f, cp_l are specific heat of fabric and water respectively (ref3)
m_f, m_l are weight of fabric and water respectively
T_o, T_r are operating temperature and room temperature(30^0C) respectively
h_f is heat released from steam condensation =2000 kJ/kg

Heat absorbed by machines and other losses are neglected.

6.0 TOTAL WATER BALANCE

A breakdown for water consumption for each unit operation was calculated on theoretical basis and is presented in Worksheet 6. This enabled the determination of the high water consumption activities and unidentified consumption in monthly basis.

WORKSHEET 6 WATER BALANCE FOR SEPTEMBER 1994				
Operation	**Total Estimated Consumption (m^3)**	**Total Product (T/month)**	**Water/Production Ratio**	**% Consumption**
Mercerization	☼ 549	71.5	7.7	3.7
Printing	§ 296	17.6	16.8	2.0
Washing range	233	6.7	34.8	1.6
Bleaching	1200	97.5	12.3	8.1
Cold Pad dyeing	27	6.7	4	0.2
Bleach/Ice wash	2196	11.6	189	14.8
Stone bleach	3036	13.1	231.8	20.4
Normal wash	128	4	32	0.9
Garment wash	45	2.8	16	0.3
Enzyme wash	1168	6.7	174.3	7.9
Jet dyeing	86	1.65	52.8	0.6
Domestic	♀ 1336			8.9
Total water consumed (estimated)	10540			69.3
Actual water consumed	14870			100.0
Undefined water consumption	4570			30.7

Actual water consumption for the month of September 1994 was 14,870 m^3.

☼ Water use for caustic preparation, floor washing after caustic preparation and overflow from the counter current rinse water tank was not taken into account.

§ Only the water used for washing the blanket was taken into account. Water used for dye preparation, screen, equipment and floor washing was not considered.

♀ Domestic water consumption was calculated was calculated on the basis of 200 l per person since the workers are used to have baths in the factory.

It was not possible to measure boiler water consumption even though steam consumption in most of the processes other than dryers have been taken into account.

The 30% unidentified water consumption may be attributed to floor washing, boiler water, leakage and additional rinses etc.

Jet cooling water is recycled.

7.0 COD Analysis

COD analysis were carried out for effluent discharge from each machines operated in one day to identify the discharges that contribute the highest to the pollution load.

Average COD of process effluent = 2635 mg/l
Average COD based on the factory total effluent = 1588 mg/l

WORKSHEET 7.0

Date of sampling :11.10.95

Stream	Water l/m	Duration min	Water l/d	Water %	COD mg/l	COD kg/d	COD %
Mercerizer							
Screen washing	13	600	7800	18.6	5900	46.02	8.1
Final rinse	28	600	16800	40.2	6600	110.88	19.4
Counter current rinse	11	600	6600	15.0	10350	68.31	12.0
Dyeing							
Cold pad bath 6	55	6 batches	330	0.8	8500	2.805	0.5
Washing bath & tank	16	3 x 6	288	0.7	2900	0.835	0.2
Cooling water	1.5	360	540	1.3	0.00	0.00	0.0
Printer							
Blanket	83	79	6557	15.7	5000	32.78	5.8
Screen	294	2	588	1.4	26400	15.52	2.7
Pump wash	90	17	1530	3.7	165000	252.45	44.3
Squeeze	50	16	800	1.9	50900	40.77	7.1
TOTAL			41833	100		570.37	100

7B. WASTE AND EMISSIONS COST

Material consumption figures from the material and water balances and COD analysis data were utilized to estimate the amount of waste generated from each unit operation and its cost.

WORK SHEET 7B				
UNIT OPERATION	**COST COMPONENT**	**QUANTITY (kg/M)**	**UNIT COST (Rs/1000kg)**	**TOTAL COST (Rs/M)**
Mercerisation	Chemicals	15,600	31,000	483,600.00
	Water	549,000	20	10,980.00
	Steam	50,231	1500	75,346.50
	COD Removal	3,963	30,000	118,890.00
	Total cost assigned to waste stream **Cost assigned per m^3 of effluent (549 m^3)**			**688,816.50** **1,254.67**
Printing	Dyes	40	683,000	27,320.00
	Chemicals	4700	56,000	263,200.00
	Water	296,000	20	5,920.00
	COD Removal	10,667.6	30,000	320,128.00
	Total cost assigned to waste stream **Cost assigned per m^3 of effluent (296 m^3)**			**616,468.00** **2,082.66**
Continuous wash	Chemicals	2061	62,000	127,782.00
	Steam	11,000	1,500	16,500.00
	Water	233,000	20	4,660.00
	COD Removal	136	30,000	4,080.00
	Total cost assigned to waste stream **Cost assigned per m^3 of effluent (233 m^3)**			**153,022.00** **656.75**
Bleach wash/Ice wash	Chemicals	2209	266,000	587,594.00
	Water	2,196,000	20	443,920.00
	Steam	63,440	1,500	95,160.00
	COD Removal	2,504	30,000	75,120.00
	Total cost assigned to waste stream **Cost assigned per m^3 of effluent (2196 m^3)**			**801,794.00** **365.10**
Bleaching (Small jigger)	Chemicals	1,151	55,000	63,305.00
	Water	144,000	20	2,880.00

	Steam	9,270	1,500	13,905.00
	COD Removal	168	30,000	5,040.00
	Total cost assigned to waste stream **Cost assigned per m^3 of effluent (144 m^3)**			**85,130.00** **591.20**
Cold pad dyeing	Water	26,500	20	530.00
	Chemicals	1,200	56,000	67,200.00
	Dyes	30	683,000	20,490.00
	COD Removal	42	30,000	1,260.00
	Total cost assigned to waste stream **Cost assigned per m^3 of effluent (26.5 m^3)**			**88,950.00** **3,357.00**
Bleaching (Jumbo jigger)	Water	1,056,000	20	21,120.00
	Chemicals	10,098	43,000	434,214.00
	Steam	73,920	1,500	110,880.00
	COD Removal	1,230	30,000	36,900.00
	Total cost assigned to waste stream **Cost assigned per m^3 of effluent (1056 m^3)**			**603,114.00** **571.00**
Stone bleach	Water	3,036,000	20	60,720.00
	Steam	79,000	1,500	118,500.00
	Chemicals	2,245	332,000	745,340.00
	COD Removal	3,377.50	30,000	101,325.00
	Total cost assigned to waste stream **Cost assigned per m^3 of effluent (3036 m^3)**			**1,025,885.00** **337.90**
Normal wash	Chemicals	200	453,000	90,600.00
	Water	128,000	20	2,560.00
	COD Removal	1.61	30,000	48.30
	Total cost assigned to waste stream **Cost assigned per m^3 of effluent (128 m^3)**			**93208.30** **728.20**
Enzyme wash	Chemicals	1,608	64,000	102,912.00
	Water	1,168,200	20	23,364.00
	Steam	26,066	1,500	39,099.00
	COD Removal	1,299	30,000	38,970.00
	Total cost assigned to waste stream **Cost assigned per m^3 of effluent (1168.2 m^3)**			**204,345.00** **174.90**

Jet dyeing	Chemicals	485	58,000	28,130.00
	Water	86,400	20	1,728.00
	Steam	5,108	1,500	7,662.00
	COD Removal	136	30,000	4,080.00
	Total cost assigned to waste stream **Cost assigned per m^3 of effluent (86.4 m^3)**			**41,600.00** **481.50**
Garment wash	Chemicals	100	56,000	5,600.00
	Water	44,800	20	896.00
	COD Removal	97	30,000	2,910.00
	Total cost assigned to waste stream **Cost assigned per m^3 of effluent (44.8 m^3)**			**9,406.00** **210.00**
Composite Effluent	**Total cost assigned to waste stream** **Total volume of(8963.9 m^3)** **Cost assigned per m^3 of effluent**			**4,411,738.80** **492.17**

Unit cost of disposal based on the COD of the effluent which includes both chemical and biological treatment costs (Details are given in Annexure H).

Steam cost was given by the industry (Annexure G).

Utility costs and utility costs per kg fabric are given in Annexure I.

8.0 Waste minimisation options

Waste minimisation options were identified by the waste audit team based mainly on observations made during visits to the industry. Losses identified from the material balances helped in identifying some of the options. The options identified together with details are presented in Worksheet 8.

Actions were identified for each options, which would help in assessing the costs and benefits of implementing the option. It is anticipated that these actions would help the industrialist subsequently in determining the suitability of implementation. 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 that would be given for implementing each option was determined in discussion with the management of the industry.

WORKSHEET 8.0								
Process unit	Unit operation	Waste Minimisation (WM) option	Actions to assess WM options	Category	Effect	Priority	Timing	Cost
MERCERIZER	Mercerising	1 : Containing the barrel opening area and collection of spillage	- Estimate caustic spillage and water usage - Estimate cost of construction of a tank, bunding the area and pump - Estimate labour savings, treatment cost savings and cost benefit	RC	WM QI PR	7	ST	L
	Mercerising	2 : Use of final rinse water for counter current rinsing and screen washing	- Estimate water use for screen washing and counter current rinsing - Estimate cost of construction of a tank & pump - Estimate water and energy savings	RR	WM PR ES	7	MT	M
	Mercerising	3.1 Use of counter current rinse water for screen washing	- Estimate water use for screen washing - Estimate cost of construction of collection tank & pump	RR	WM PR	7	MT	M
	Mercerising	3.2: Recycling of screen washings for caustic preparation (with the implementation of 3.1)	- Estimate water use for caustic preparation - Estimate NaOH strength of screen washing - Estimate cost of construction of collection tank, pump & filtration system	RR	WM PR	6	MT	M

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) option	Actions to assess WM options	Category	Effect	Priority	Timing	Cost
MERCERIZER	Mercerising	4 : Preventing the counter current rinse water tank overflow	- Estimate volume of water lost - Estimate cost of installing a level control	RC	WM		ST	M
	Mercerising	5 : Automatic temperature control device in baths	- Measure maximum variations in temperature - Check the optimum temperature - Estimate cost of temperature control unit and energy savings	PC	ES	7	MT	M
	Mercerising	6 : Indirect steam heating for baths	- Estimate cost of installation of a system with steam trap & cover plate - Estimate total steam consumption - Estimate cost of construction of condensate recovery tank	RC	WM ES	3	LT	M
	Mercerising	7.1 Recovery of caustic (after using final rinse water for counter current rinsing and screen washing)	- Estimate cost of construction of 2 tanks, pumps, filter presses & evaporator system - Estimate cost of construction of caustic tanks, Pump, overhead tank - Estimate cost of installation of cooling coil for storage tank - Estimate operational cost and savings	PR	WM PR	6	MT	H
	Mercerising	7.2 Recovery of caustic after using counter current rinse water for screen washing	- Same as above	RR	WM PR	6	MT	H

* Desizing and scouring processes should be carried out for the grey cloth prior to mercerizing. Recovery of caustic from mercerizer effluent is possible only if the above is implemented as the impurities in the mercerizer effluent from the grey cloth will hinder the caustic recovery.
Desizing & scouring could be carried out in jigger

Process unit	Unit operation	Waste Minimisation (WM) Options	Actions to assess WM Options	Category	Effect	Priority	Timing	Cost
MERCERIZER	Mercerising	8 : Selling the effluent containing caustic to an outside party	- Estimate quantity & strength - Check possibility of selling	RR	WM PR	2	LT	L
	Mercerizing	9 : Omitting the final rinsing step from the process	- Estimate water use in final rinser - Estimate water & energy savings	RC	WM ES	4	MT	L
	Mercerising	10: Reducing heat wastage	- Estimate cost of lagging counter current rinser bath - Estimate heat losses & cost of installing a steam flow meter	RC	WM ES	4	MT	M
	Mercerising	11: Planned use of machine avoiding frequent start up	- Estimate water use in counter current & final rinser & energy required for initial heating - Check the frequency of start up - Estimate cost of automation of the plant	RC	WM ES	4	ST	L
WASHING RANGE	Washing	12 : Counter current rinsing in the first four baths & the last three	- Estimate cost of one pump - Estimate water & energy savings	RC	WM ES	7	MT	M
	Washing	13: Indirect steam heating of baths	- Estimate cost of installation of a system with a steam trap & cover plate - Estimate steam consumption - Estimate cost of construction of condensate collection tank	RC	WM	5	LT	M
	Washing	14: Stopping the water flow when the machine is not running	- Check the interruption time & frequency - Estimate cost of automation of pumps - Estimate cost of installation of common water & steam valves	RC	WM ES		MT	M
	Washing	15: Reduction of volume of water	- Carryout trials to determine optimum flow rate - Estimate cost of installation of flow meter	RC	WM ES	4	LT	M

Process unit	Unit operation	Waste Minimisation (WM) Options	Actions to assess WM Option	Category	Effect	Priority	Timing	Cost
CONTINUOUS PRINTER	Printing	16 : Installation of doctor blades on the blankets & recycling blanket wash water	- Estimate cost of installation - Quantify print paste recovery - Estimate water savings	RR	WM PR	7	MT	L
	Printing	17 : Collection of print paste from screens into print feed barrels before washing	- Estimate the quantity getting into the waste stream - Check the possibility of using them for dark shades	RR	WM PR	6	MT	L
	Printing	18 : Construct dip tanks for screens to be immersed in before washing with water	- Estimate cost of construction of tank - Educate workers	RC	WM	5	ST	L
	Printing	19 : Installation of self closing valves for raw water hose pipes & use of pressure guns for container & floor washing	- Estimate water wastage - Estimate cost of installation of self closing valves or pressure jets	RC	WM	6	ST	L
	Printing	20 : Avoiding overfilling of containers used for dye preparation	- Supervision of the procedure	RC	WM PR		ST	L
	Printing	21 : Use synthetic thickener instead of kerosene	- Get expert opinion - Estimate expenses involved & emission treatment costs	MC	PR	5	LT	M
	Printing	22 : Disposal of printing screens	- Estimate the number of discarded screens per annum - Check the possibility of reusing or selling for recycling	RR	WM	5	MT	L

Process unit	Unit operation	Waste Minimisation (WM) Option	Actions to assess WM Options	Category	Effect	Priority	Timing	Cost
CONTINUOUS PRINTER	Printing	23 : Use of return paste for dark shades	- Estimate quantity - Check the possibility of using them for dark shades	RR	WM PR	5	MT	L
	Drying	24 : Improvement of drying efficiency in the dryer	- Measure ambient air humidity - Cost estimate for installing an air inlet from outside the factory	RC	WM ES	4	LT	L
	Drying	25 : Minimising heat losses in the dryer	- Estimate heat losses - Estimate cost of insulating the entire unit	RC	ES	5	MT	M
	Drying	26 : Optimising the air flow rate in the dryer	- Estimate present air flow & compare with design values - Cost benefit analysis	RC	WM	5	MT	M
LAUNDRY	Garment washing	27 : Use of machine at the maximum operating capacity	- Estimate present capacity utilization - Identify reasons for under capacity utilization - Production planning	RC	WM	4	MT	L

Process unit	Unit operation	Waste Minimisation (WM) option	Actions to assess WM options	Category	Effect	Priority	Timing	Cost
LAUNDRY	Garment washing	28 : Optiimise the chemical use	- Prepare a list of chemicals & consumption for different washing procedures - Optimise use of chemicals	RC	WM PR	5	MT	L
	Garment washing	29 : Reduction of hydro extractor running time	- Check the present hydro extractor running time & efficieny of extraction - Carry out trials & estimate energy savings	RC	WM ES	4	MT	L
	Garment washing	30 : Recycling of water from hydro extractor	- Estimate the volume - Estimate the cost of construction of collection tank	RR	WM	5	MT	M
DRUM DRYER	Drying	31 : Collection of condensate for recycling	- Estimate volume & temperature of condensate - Estimate energy recovery - Estimate cost of construction of a collection tank	RR	ES WM	7	ST	M
	Drying	32 : Avoid overdrying of fabric	- Estimate moisture content of dried fabric & temperature - Control drying to maintain the moisture content at 8%	RC	ES WM	5	LT	L
GARMENT DRYER	Drying	33 : Collection of condensate	- Estimate quantity & temperature - Cost of investment	RR	ES WM	6	MT	M
	Drying	34 : Avoid overdrying of fabric	- Estimate moisture content of dried fabric & temperature - Control drying to maintain the moisture content at 8%	RC	ES WM	5	MT	L

Process unit	Unit operation	Waste Minimisation (WM) Option	Actions to assess WM options	Category	Effect	Priority	Timing	Cost
JIGGERS	All operations	35 : Use of direct heating for rapid heating and indirect heating to maintain temperature	- Estimate cost of installation & volume and temperature of condensate - Estimate energy recovery	RC	WM ES	5	MT	M
	All operations	36 : Collection and recycling of hot rinses	- Estimate volume of water that can be recycled & water and energy savings - Estimate cost of construction of a collection tank	RR	WM ES	3	LT	M
	All operations	37 : Temperature control	- Measure maximum variations in temperature - Check the optimum temp - Estimate cost of temp control unit - Estimate energy savings	PC	ES	6	MT	M
	All operations	38 : Recycling of some of the rinses	- Carryout COD analysis of the rinses - Estimate the volume that can be recycled	RR	WM ES	3	LT	L
	Bleaching	39 : Improve handling practices of hydrogen Peroxide	- Use separate containers for caustic soda & Hydrogen Peroxide to avoid peroxide decomposition	RC	WM PR CR	5	ST	L
	Bleaching	40 : Optimize the bleaching recipe	- Carry out trials with 10-15% lesser concentrations of H_2O_2	RC	WM CR	4	MT	L
	Bleaching	41 : Check the efficiency of sodium silicate as peroxide stabiliser	- Check the Mg content in raw water	MC	WM CR	4	MT	L
	Bleaching	42 : Monitor pH in bleaching bath	- Estimate cost of pH meter	PC	QI WM	4	ST	M

Process unit	Unit operation	Waste Minimisation (WM) option	Actions to assess WM Options	Category	Effect	Priority	Timing	Cost
JET DYER	All operations	43 : Heat recovery from condensate	- Determine volume & temperature of condensate - Estimate cost of construction of a collection tank	RR	WM ES	6	MT	M
	All operations	44 : Use of cooling water for processing	- Check the cooling water temperature & volume - Estimate cost of construction of a collection tank	RR	WM ES	6	ST	M
	All operations	45 : Counter current rinsing system	- Identification & quantification of recyclable rinses - Estimate cost of collection & recycling	RR	WM	3	LT	M
	Dyeing	46 : Computer colour matching	- Estimate the present cost of colour matching - Estimate capital & operational cost of computer aided colour matching system	PC	QI	2	LT	H
COLD PAD DYEING	Dyeing	47 : Installation of self closing valves for raw water hose pipes	- Estimate raw water losses - Estimate cost of installation of self closing valves	RC	ES WM	5	ST	L
	Dyeing	48 : Recycling of hydraulic pump cooling water	- Quantify the volume	RR	WM	5	ST	L
COLD PAD BLEACHING	Bleaching	49 : Cold pad bleaching	- Get expert opinion on process introduction - Estimate cost benefit	TC	ES WM	4	LT	M

BOILER	All operations	50 :	Containing the spillages during furnace oil unloading	- Bunding the area around the furnace oil tank	RC	ES	3	ST	L
	All operations	51 :	Optimisation of fuel combustion efficiency and boiler efficiency	- Determine present combustion efficiency & heat loss - Optimisation of air flow & fuel atomisation - Estimate cost of introducing an economiser or air preheater	RC	ES WM	6	MT	M
	All operations	52 :	Construction of a hot water tank	- Estimate total volume of factory condensate - Estimate cost of construction of a tank & heat insulation	RC	WM ES PR	6	MT	M

Process unit	Unit operation	Waste Minimisation (WM) option	Actions to assess WM Options	Category	Effect	Priority	Timing	Cost
	All operations	53 : Heat insulation of all steam and hot water pipes	- Estimate cost	RC	ES	5	M	M
	All operations	54 : Improvement of water quality	- Analysis of boiler feed & boiler water - Estimate chemical consumption - Check blow down frequency - Estimate heat losses due to scale formation - Water quality improvement & cost benefit analysis	PC	WS WM	4	M	M
STENTER	Finishing	55 : Improvement of drying efficiency	- Measure ambient air humidity - Cost estimation for installing a system to get air from outside - Get expert opinion	RC	ES	3	M	M
	Finishing	56 : Heat insulation of the machine	- Estimate heat losses & cost benefit in lagging	RC	ES	5	M	M
GENERAL	Effluent treatment	57 : Neutralising the alkaline effluent with flue gas	- Carry out trials - Calculate savings in treatment costs	RC	PR CR	6	L	M
	Effluent treatment	58 : Segregation of the colour effluent from alkaline effluent	- Estimate volumes of two streams - Estimate cost of segregation & identify advantages in treatment	RC	ES WM	5	M	M

	All operations	59 : Substitute present chemicals with more environmentally friendly ones eg: Chromic acid, Sodium silicate		MC	PR		L	M

9.0 COST BENEFIT ANALYSIS

Cost benefit analysis was carried out for the 10 waste minimisation options given the highest priority by the management (from worksheet 8). The investment, savings and pay back period for each option is presented in a worksheet, while relevant details for each calculation are presented below the respective worksheet.

WORK SHEET 9.1			
Containing the barrel opening area and collection of caustic spillage (option 1 in worksheet 8).			
Investment	**Rs**	**Saving**	**Rs/y**
Civil work	29,120	Caustic soda	4,536
Pump	10,000	Treatment cost	4,620
Piping	2,000	Labor	37,800
Total	**41,120**	**Total**	**49,956**
Annual operating cost	**Rs**	**Net saving**	**38,096**
		=(saving - annual operating cost)	
Interest(21%)	8,635		
Pump operating cost	225	**Pay back period**	
Total	**8,860**	=(Investment/Net saving)x12	
		= 13 Months	

Chemical Saving

Caustic spillage	= 200g/barrel (assumed)
Number of barrel	= 63/M
Caustic spillage	=12.6 kg/M (lower OH^- alkalinity in effluent)
Caustic saving	=12.6(kg)x30(Rs/kg)x12(M)
	=Rs 4,536/y

Treatment cost saving

$2\ NaOH + H_2SO_4 \rightarrow Na_2SO_4 + H_2O$

80 98

H_2SO_4 needed	=15.4 kg/M
Cost saving	=15.4X25(Rs/kg)x12(M)
	=Rs 4,620/y

Labor cost saving

Barrel handling 6 laborers	
Labor hours consumed	=42 h/M (2h/3 barrels, 63 barrels)
Total Labor hours saving	=126 h/M
	=Rs 37,800/y (Rs 25/h)

Civil work

Existing tank size 2m x 1m x 1.5m(depth)

Excavation cost(1.5m x 2m x 2m)	=Rs 1,120
Concrete walls (Rs 17,500/m^3)	=Rs 26,250
Platform(2m x 2m area, Rs 437/m^2)	=Rs 1,750
Total	=Rs 29,120
Pump cost (1 hp, domestic)	=Rs 10,000
Piping cost	=Rs 2,000

WORK SHEET 9.2			
Use of final rinse water for counter current rinsing and screen washing (option 2 in worksheet 8)			
Investment	**Rs**	**Saving**	**Rs/y**
Collection tank	10,962	Steam	1,278
Pumps(2)	30,000		
Piping & valves	7,000	Water	62,880
Total	**47,962**	**Total**	**64,158**
Annual operating cost	**Rs**	**Net saving** =(saving - annual operating cost)	**49,226**
Interest (21%)	10,072	**Pay back period**	
Pumping operation	4,860	=(Investment/Net saving)*12	
Total	**14,932**	= 11 Months	

Construction of collection tank ($1m^3$)

Excavation cost(1.5mx1.5mx1.5m)	=Rs 742
Tank construction	=Rs 10,220

Cost of pumps(1hp, 3phase, 2 numbers, 1 standby)	=Rs 30,000
Pumping operational cost (1650 l/h, 135kWh)	=Rs 405/M
Cost of piping & valves	=Rs 7,000

Water saving =262(m^3/M)x20(Rs/m^3)x12(M) (i.e 1.8% of total water)
=Rs 62,880

Steam saving =95kgX75%/M
=71(kg)x1.5(Rs/kg)x12(M)
=Rs 1,278/y

WORK SHEET 9.3			
Use of counter current rinse water for screen washing (option 3.1 in worksheet 8)			
Investment	**Rs**	**Saving**	**Rs/y**
Collection tank	10,962	Water	34,800
Pumps, piping & valves	36,000	**Net saving** =(saving - annual operating cost)	**24,533**
Total	**46,962**	**Pay back period** =(Investment/Net saving)x12 = 28 Months	
Annual operating cost	**Rs**		
Interest (21%)	9,862		
Pumping operational cost	4,860		
Total	**14,722**		

Water saving =145m^3/M (about 1% of total water)
=Rs 34,800/y

Cost of collection tank (1m3) =Rs 10,962

Cost of pumps, Valves(5) and pipes =Rs 36,000

Pumping cost (Electricity) =Rs 4860/y

WORK SHEET 9.4			
Recycling of screen washing for caustic preparation ,with the implementation of option 3.1 (option 3.2 in worksheet 8)			
Investment	**Rs**	**Saving**	**Rs/y**
Collection tank	22,000	Water	14,880
Pumps(3)	40,000	Caustic	1,718,640
Piping & valves	8,000		
Filter press	125,000	**Total**	**1,733,520**
Total	**195,000**	**Net saving** =(saving - annual operating cost)	**1,686,090**
Annual operating cost	**Rs**	**Pay back period** =(Investment/Net saving)*12 = 2 Months	
Interest (21%)	40,950		
Electricity(pumping)	6,480		
Total	**47,430**		

Monthly NaOH consumption =15,590 Kg
Water requirement for 25% =62 m^3/M (0.4% of total water)
Caustic strength in effluent =77kg/m^3
Caustic recovery =4774 kg/M
Caustic saving =4774x30(Rs/kg)x12
=Rs 1,718,640/y

Water saving =62x20(Rs/m^3)
=Rs 14,880/y

Investment
Cost of collection tank (1m^3) =Rs 22,000
Cost of pumps(3 numbers) =Rs 40,000
Cost of piping & Valves =Rs 8,000

Operational cost (electricity)
Pump(47kWh) =Rs 1,620/y
Pump(135kWh) =Rs 4,860/y

WORK SHEET 9.5			
Automatic temperature control device for baths (option 5 in worksheet 8)			
Investment	**Rs**	**Saving**	**Rs/y**
Temperature control unit(6)	247,500	Steam	402,192
TOTAL	**247,500**	**Total**	**402,192**
Annual operating cost	**Rs/y**	**Net saving** =(saving - annual operating cost)	**176,765**
Interest (21%)	51,975	**Pay back period** =(Investment/Net saving)x12 = 9 Months	

Cost of temperature control unit(including installation cost) = Rs 41,250
Number of units required =6

Steam savings =22,344 kg/M (8.3% reduction of boiler fuel)
=Rs 402,192/y

WORK SHEET 9.6			
Recovery of Caustic (Counter current rinse water after recycling for screen washing) (option 7.2 in worksheet 8)			
Investment	**Rs**	**Saving**	**Rs/y**
Counter current rinse water collection tank	11,000	Caustic	3,247,200
Pumps(7), Pipes & Valves(including Installation)	187,000	Treatment cost	3,312,000
Civil work	86,225	Water	34,800
Filter press(2)	250,000		
Triple effect evaporator	3,500,000		
Condensate tank(steel)	100,000	**TOTAL**	**6,594,000**
Caustic collection tank	50,000		
Over head collection tank	100,000		
		Net saving =(saving - annual operating cost)	**4,251,253**
Total	**4,284,225**		
Annual operating cost	**Rs**	**Pay back period** =(Investment/Net saving)x12 = 12 Months	
Interest (21%)	899,687		
Electricity(pumping)	43,560		
Labor(2 skilled laborer)	180,000		
Maintenance cost(3%)			
Filter press	7,500		
Evaporator	105,000		
Depreciation(10%)	375,000		
Steam	732,000		
Total	**2,342,747**		

Investment cost

Counter current rinse water collection tank =Rs 11,000
2 pumps including valves and piping =Rs 36,000

Collection tank for screen washing($10m^3$, 2mx2mx2.5m, 700l/h)
Excavation cost(2.5mx2.5mx3m) =Rs 3,975
Concrete work (4.7m3) =Rs 82,250

Total civil work =Rs 86,225

Two pumps including valves =Rs 36,000

Triple effect evaporator =Rs 3,500,000
(Including steam lines, condensate lines etc)

Condensate tank(heat insulated, capacity 3.5m^3 steel)=Rs 100,000
Two pumps(including insulated piping etc) =Rs 100,000

Caustic collection tank(steel 2 m^3) =Rs 50,000
Pump =Rs 15,000

Overhead collection tank (including cooling coils 2m^3)=Rs 100,000

Operational cost

Electricity(pumping) =Rs 43,560/y

Steam cost
Two kg of water can be evaporated by using 1 kg of steam

Evaporation =483 l/h

Therefore steam requirement =240 kg/h

Steam cost =Rs 732,000/y

Two skilled labourers =Rs 180,000/y

Savings

Caustic saving =Rs 270,600/M (lower alkalinity of effluent)

Treatment cost(Neutralization) =Rs 276,000/M

Water saving (Rs20/Kg) =145m3/M (1% of total water)
=Rs 34,800/y

WORK SHEET 9.7			
Counter current rinsing in the 1st four baths and last three baths (option 12 in worksheet 8)			
Investment	**Rs**	**Saving**	**Rs/y**
Pumps(including fittings)	20,000	Water	24,000
		Steam	85,266
		TOTAL	**109,266**
Annual operating cost	**Rs**	**Net saving** =(saving - annual operating cost)	**102,666**
Interest (21%)	4,200		
Electricity	2,400	**Pay back period** =(Investment/Net saving)x12 = 2 Months	
Total	**6,600**		

Savings

Water saving(Rs 20/kg) = 100 m^3/M (0.7% of total water consumption)
=Rs 24,000/y

Steam saving(Rs 1.5/kg) = 4737 kg/M (1.4% of total fuel consumption)
=Rs 85,266/y

Investment

Pumps(four pumps, 1 standby, 1 hp, 3/4 kWh) (including fittings) =Rs 20,000

Variable cost

Electricity (63 kWh/M) =Rs 2,400/y

WORK SHEET 9.8			
Collection of condensate (from Drum dryer) for recycling (option 31 in worksheet 8)			
Investment	**Rs**	**Saving**	**Rs/y**
Pipes	5,000	Steam	31,848
		TOTAL	**31,848**
	Rs	**Net saving** =(saving - annual operating cost)	**30,798**
Annual operating cost			
Interest (21%)	1,050	**Pay back period** =(Investment/Net saving)x12 = 2 Month (or 170,000 m drying)	

Investment
Extension of condensate pipe to the mercerizer condensate collection tank =Rs 5,000
(including lagging and installation)

Savings
Steam condensate =155 kg/h (0.1% of water consumption)
=155x4.2x60 kJ/h
=39060(kJ/h)/2500(kJ/kg)
Steam =15.6 kg/h (0.5% of total boiler fuel)

Operating hours per month(assumed) =100 h

WORK SHEET 9.9			
Recycling of water from Hydroextractor (option 30 in worksheet 8)			
Investment	**Rs**	**Saving**	**Rs/y**
Collection tank	11,000	Water	12,000
Pump	5,000		
		TOTAL	**12,000**
Total	**16,000**		
		Net saving =(saving - annual operating cost)	**7,260**
Annual operating cost	**Rs**		
Interest(21%)	3,360	**Pay back period** =(Investment/Net saving)x12 =26 Months	
Electricity	1,380		
Total	**4,740**		

Investment

Collection tank (1 m^3) =Rs 11,000
Pump (1000l/h) =Rs 5,000

Operating cost(Electricity) =Rs 1,380/y

Water saving (per month)

Normal wash	=5 m^3
Garment wash (without denim)	=3.7m^3
Enzyme wash	=8.6m^3
Bleach wash/Ice wash	=15m^3
Stone bleach	=17m^3
Total	=49.3m^3

Total water saving =50m^3/M (0.3% of total water consumption)
=Rs 12,000/y

WORK SHEET 9.10			
Installation of doctor blades on the blankets & recycling blanket wash water (option 16 in worksheet 8)			
Investment	**Rs**	**Saving**	**Rs/y**
Doctor blade	10,000	Water	56,832
Collection tank	40,000	Treatment cost	174,960
Pumps(Including valves etc)	36,000	Print paste	43,740
Total	**86,000**	**TOTAL**	**275,532**
Annual operating cost	**Rs**	**Net saving** =(saving - annual operating cost)	**255,420**
Interest(21%)	18,060		
Electricity	2,052	**Pay back period** =(Investment/Net saving)x12 = 4 Months	
Total	**20,112**		

Investment

Doctor blade	=Rs 10,000
Collection tank (2 m^3)	=Rs 40,000
Pumps(2 numbers, 1hp, 45kWh) (Including valves and piping etc)	=Rs 36,000

Operating cost

Electricity	=57 kWh/M
	=Rs 2,052/y

Savings

(i) Water

Water consumption before scraping	=296 m^3/M
80% reduction of water	=296 x 0.8 m^3/M
	=236.8 m^3/M (i.e 1.6% of total water)
	=236.8(m^3/M) x 20(Rs/m^3) x 12(M)
	= Rs 56,832/y

(ii) Treatment cost saving

COD reduction	$=27.6x10^{-3}$(kg COD/kg fabric)x17600 (kg/M)
	=486 kg COD/M (i.e 2.05 % reduction of total COD)
	= 486(kg) x 30 (Rs/kg) x 12(M)
	=Rs 174,960 /y

(iii) Print paste recovery

Recovered paste can be reused for dark shades, and cost of print paste is about Rs 7.5 per kg

Total paste saving	= 486(kg) x 7.5(Rs/kg) x 12(M)
	= Rs 43,740/y
Total saving	**= Rs 274,532/y**

10.0 Conclusions

General housekeeping lapses were observed which have a significant affect on productivity. The general atmosphere in this industry also shows a lack of motivation among the workers to take initiative and responsibility about their jobs.

Inspection of the processes carried out in the industry suggested very obvious waste minimisation options that should be implemented for eg. Termination of grey cloth mercerisation and switching to scoured cloth mercerisation will enable the installation and operation of a caustic recovery plant for the mercerisation waste water, so reducing alkali consumption significantly.

Use of appropriate synthetic thickeners, instead of kerosene based solvents will provide an economical solution to the prevailing nuisance and health hazards caused by the emission of kerosene vapours during curing and drying.

Material wastages (identified in the balances) could be controlled by the requirement for maintaining daily manufacturing sheets including material consumption and factory downtime analysis.

Calculated steam consumption excluding the losses and steam production indicates and unacceptable high boiler efficiency. It is difficult to accept this high value, and it is thought that this value is due to recording of incorrect values for actual fuel consumption.

The recovery of condensate and lagging of hot surfaces, optimisation of water consumption in jiggers and garment washing machines are several options for improvement of economy i n steam production.

A total of 61 Waste Minimisation options were identified by the team and of these it is estimated that 24 require low investment, 34 require medium investment and 3 require high investment. The majority of the options are Resource Conservation (33) and Resource Recovery (19), while the others are Process Control (5), Material Change (3) and Technology Change (1).

The industry was not able to implement these options, as it was closed shortly after the study was carried out.

11.0 References

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3 PETERS & TIMMERHAMS
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4 R.H PETERS (1967)
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5 CHITTARANJAN DESAI (October, 1995)
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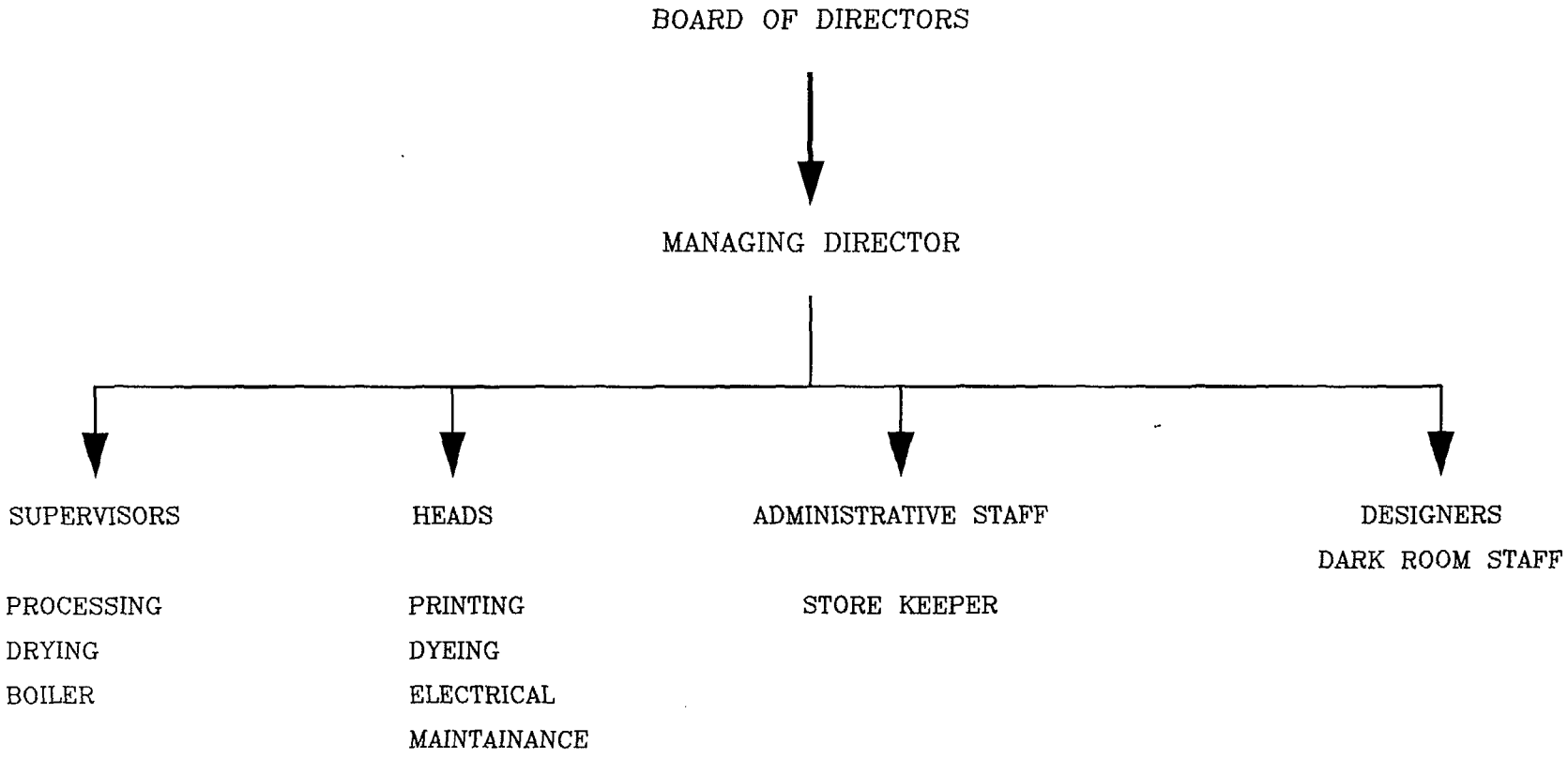
ANNEXURE A

ORGANIZATIONAL CHART

BAKSON TEXTILES (PVT) LTD.



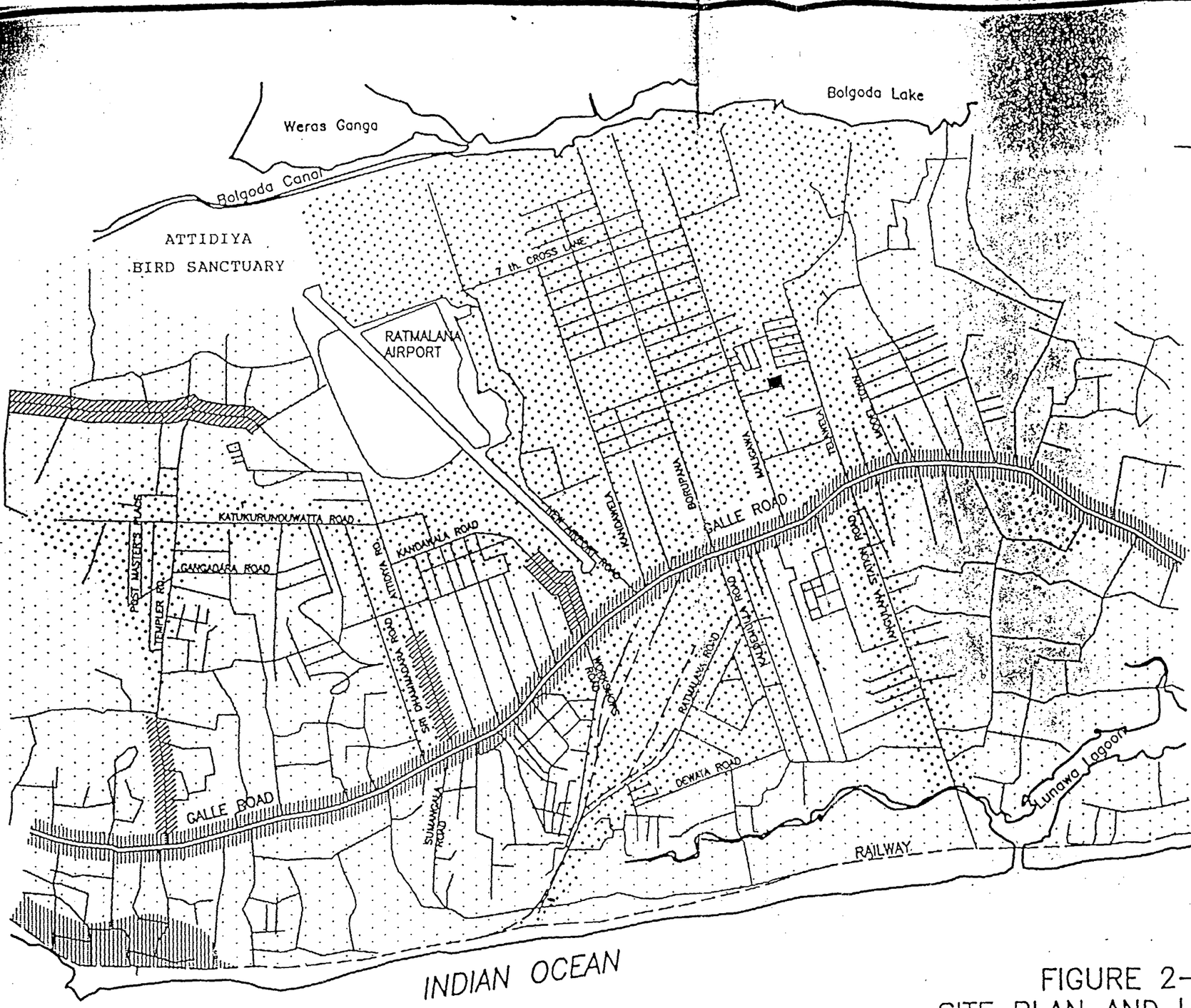


FIGURE 2–2
SITE PLAN AND LAND USE

SCALE: 1:20000

ASSOCIATED ENGINEERING

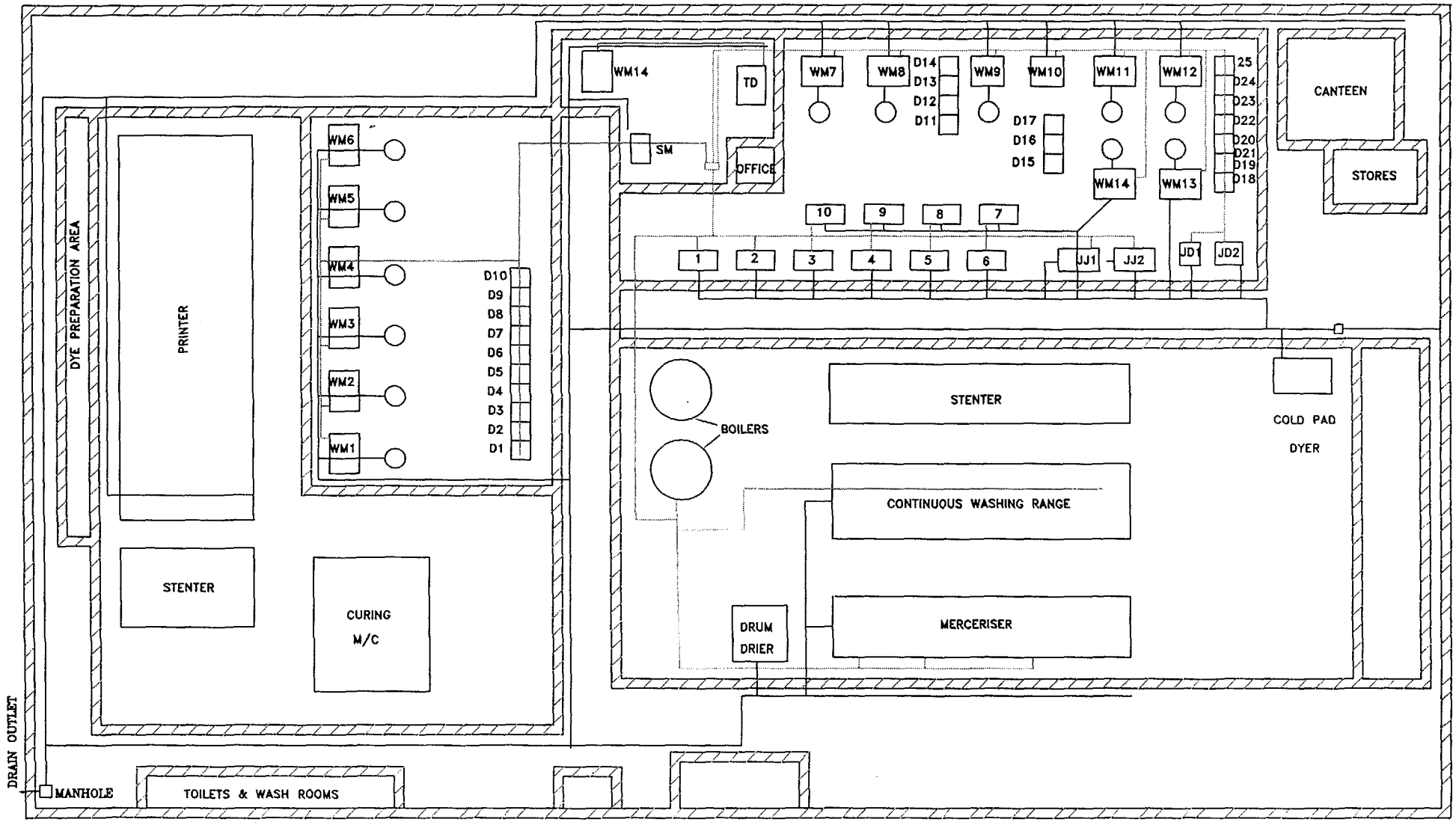
ANNEXURE C

TITLE : FACTORY LAYOUT PLAN

1	–	10	–	SMALL JIGGERS
WM1	–	WM14	–	WASHING MACHINES
D1	–	D25	–	DRIERS
TD			–	THIES DYER
SM			–	SAMPLE MACHINE
JJ			–	JUMBO JIGGERS
JD			–	JET DYERS

STEAM LINES

EFFLUENT DRAINS



Annexure D

LIST OF MAJOR CHEMICALS AND DYES
(For September 1995)

DYES

DESCRIPTION	QUANTITY kg/month
Cibacron Blue FGF	1.344
Cibacron Blue FR	3.327
Colour Chem Black FBRK	200.00
Colour Chem Blue FFRN	50.00
Colour Chem Green FB	50.00
Colour Chem Golden yellow FRM	50.00
Colour Chem Navy Blue FBR	25.00
Colour Chem Orange FB	50.00
Colour Chem Red FGR	50.00
Colour Chem Turquise Blue FBN	25.00
Colour Chem Violet FFR	25.00
Colour Chem Yellow F20	25.00
Cibacron Navy FG	1.816
Cibacron Red FB	18.266
Cibacron Scarlet F3G	30.607
Cibacron Yellow F3R	13.454
Cibacron Yellow F4G	22.088
Drimarene Golden Yellow K2R	1.275
Drimarene Turquise Blue K2B	42.13
Levafix Black EB	37.97
Levafix Turquise Blue EBA	11.342
Remozol Golden Yellow RNL	1.179
Remazol RED RB	6.741
Sulphole Black QC	125.00

CHEMICALS

DESCRIPTION	QUANTITY kg/month
Acetic Acid	90.00
Becksol 2K	600.00
Bluton K2D	100.00
Bio Wash L	100.00

Bleaching powder	50.00
Colour Chem Binder 684	2500.00
Calcium Hypo Chlorite	150.00
Caustic soda	19615.00
Calatac VB	400.00
Di Ammonium Phosphate	300.00
Hydrogen Peroxide	2310.00
Irgalon St	50.00
Pisoft 195	365.00
Pimaze Al	300.00
Ryudye W Binder S420	25.00
Salt	500.00
Soda Ash	250.00
Sodium Silicate	2860.00
Sodium Sulphide Flake	25.00
Tinovadine JU HC	210.00
Texfix M	150.00
Urea	1200.00
Uvitex CID	150.00

PRINTING UPKEEP

DESCRIPTION	**QUANTITY kg/month**
Araldite Gum	2.000
Chromic acid flakes	17.000
Nickel Screen 80 Mesh	6.000
Nickel Screen 80 Mesh Large	3.000
RS25a Daylight Film	20.000
RS 61 Sensitizer	1.000
RS 63 Photo Emulsion	5.000
Uland Flim	1.000

BOILER UPKEEP

DESCRIPTION	**QUANTITY kg/month**
Nalco-19	35.000

Annexure E

Production data (September 1994)

Mercerizing	= 650,000 m (71,500 kg)
Cold pad dyeing	= 61,000 m (6,710 kg)
Jigger/Jet dyeing	= 15,000 m (1,650 kg)
Bleaching	= 886,000 m (97,460 kg)
Laundry	= 48,649 kg
Printing	= 160,000 m (17,600 kg)

Total production (Bleaching and Laundry) = 146,109 kg

Annexure F

Process recipes

Jiggers

100kg/batch

Scouring

NaOH	2.5kg (38^0Be)
$NaSio_3$	2.5 kg
H_2O_2	3 kg
Ju	0.5 kg

Bleaching

NaOH	400 g (38^0Be)
$NaSio_3$	400 g
H_2O_2	800 g
NaCl	1250 g
Uvitex CID	400 g

Jet dyeing

100kg/batch

100% Polyester

Soda ash	2.4 kg
Thinovadine Ju	1-0.5 kg
Dyes	2.5 kg

Polyester/Cotton

NaOH	4 kg
$NaSio_3$	3.2 kg
H_2O_2	4.8 kg
Thinovadine Ju	0.8 kg
Dyes	2.5 -0.5 kg

Small Jiggers (Unmercerized)

32 kg/batch

Desizing

Pimaze Al	1 kg
Thinovadine Ju	0.5 kg

Scouring/Bleaching

NaOH	2.9 kg
$NaSio_3$	2.9 kg
H_2O_2	3.8 kg
Thinovadine Ju	0.5 kg
Uvitex CID	0.5 kg
NaCl	1.2 kg

Stone/Bleach

(38 kg/batch)

Pimaze Al	1.9 kg
Thinovadine Ju	2 kg
Piscon 80	475 g
HAC	150 g
Pisoft 195	1.9 kg

Dyeing
100kg/Batch

Dyes	2.5-0.5 kg
Soda ash	8-2.5 kg
NaCl	30-10 kg
Thinovadine Ju	1-0.6 kg
Pisoft 195	3 kg

Bleach wash/Ice wash

42 kg/Batch

Pimaze Al	2 kg
Thinovadine Ju	1 kg
Ca Hyperchloride	1.4 kg
Pisoft 195	2 kg
H^2O^2	1.6 kg

Enzyme/Stone wash

38kg/Batch

Pimaze Al	1.9 kg
Thinovadine Ju	0.95 kg
Ca Hyperchloride	1.9 kg
Pisoft 195	1.9 kg
H^2O^2	1.9 kg
Pican 80	0.475 kg
Hac	0.15 kg

Normal wash

100kg/Batch(without denim)

Pisoft 195	5 kg

50kg/Batch(denim)

Pisoft 195	3 kg

Annexure G

ESTIMATION OF THE STEAM COST

Average Steam cost **=Rs 1500/1000kg of steam (GIVEN BY THE INDUSTRY)**

Annexure H

ESTIMATION OF EFFLUENT DISPOSAL COST IN THE BASIS OF COD REMOVAL

Assumption	
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
Flocculent Polymer (2 mg/l in 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
Labor cost	=Rs 600/d
Sludge handling cost	=Rs 150/d
Total operational cost	=Rs 3726/d
COD removal per day	=200x(800-250)x10^{-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 FABRIC
WATER	33.4 /m^3	3.35
STEAM	1.5 / kg	3.27 ♀
ELECTRICITY	4.98 / kWh	3.64
FUEL OIL	6.43 / l	1.11
TREATMENT COST ✡	30 / kg COD	4.91 §

✡ Treatment unit cost (Rs 30/kg) include Chemical and biological treatment cost. (Detail calculation is in the annexure H).

§ Treatment cost per kg of fabric was calculated using total cod removal cost (from waste emission cost Rs 717,801) and total production (146,109 kg) in September 1994.

♀ Steam cost per kg of fabric was calculated using total steam consumption(from material balance 318,535 kg) and total production (146,109 kg) in September 1994.