Image: Depositphotos

Water efficiency in textile wet processing industries

Best practices on water saving in textile finishing industries

FABRIC Asia

german cooperation
DEUTSCHE ZUSAMMENARBEIT

Implemented by

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Imprint

As a federal enterprise, GIZ supports the German Government in achieving its objectives in the field of international cooperation for sustainable development.

Published by the
Deutsche Gesellschaft für
Internationale Zusammenarbeit (GIZ) GmbH

Registered offices
Bonn and Eschborn, Germany

Friedrich-Ebert-Allee 40
53113 Bonn, Germany
Phone: +49 228 44 60-0
Fax: +49 228 44 60-17 66

Dag-Hammarskjöld-Weg 1-5
65760 Eschborn
Phone: +49 61 96 79-0
Fax: +49 61 96 79-11 15
Email: info@giz.de
Internet: www.giz.de

Responsible
Asghar Majeed

Author/Editor etc.
Dr. – Ing. Harald Schönberger
Shafqat Ullah

Photo credits/Sources
Dr.-Ing. Harald Schönberger, Shafqat Ullah

Design
FLMH | Labor für Politik und Kommunikation

Place and date of publication
Lahore/Pakistan, July 2021

Preface

On behalf of the German Federal Ministry for Economic Cooperation and Development (BMZ), the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH implemented the project 'Water Efficiency in the Textile Industry (WETI)' in Pakistan during 2016-2018, to support wet processing industries to implement water efficiency measures. In total, 15 textile industries participated in the project in three batches and implemented various water efficiency measures and saved annually about 4 billion liter of processing water.

These measures are documented as 'Best practices' so that other textile industries of the region could get benefit of these water efficiency initiatives. Each measure is presented in a certain format to provide maximum information to the implementer for guiding and facilitating him to take decision for its implementation.

Following 15 industries participated in the WETI project whose data is being used in this document:

Batch-1	Batch-2	Batch-3
Kohinoor Mills Limited Lahore	Sarena Textile Industry Pvt. Ltd Lahore	Ittehad Textile Industries Pvt. Ltd Faisalabad
The Crescent Textile Mills Ltd Faisalabad	Klash Private Ltd Faisalabad	Rashid Textile Industries Pvt. Ltd Faisalabad
Noor Fatima Fabrics Pvt. Ltd Faisalabad	Samad Apparel Lahore	AZ Apparel Pvt. Ltd Fai salabad
Moderno Fabrics Lahore	Abdur Rahman Corporation Pvt. Ltd Faisalabad	MK Sons Pvt. Ltd Faisalabad
Kay and Emms Pvt. Ltd Faisalabad	Nishat Chunian Ltd Lahore	
	Samira Fabrics (Pvt) Ltd Faisalabad	

Table of Contents

List of Tables

List of Figures

1 Reuse of Reverse Osmosis (RO) Plant's Concentrate

Figure-1: Reverse osmosis plant for preparing water for wet finishing processes and boilers

Technical Description

In many cases, raw water, that is usually groundwater, contains high content of dissolved solids. The use of water of high dissolved solids for textile finishing leads to various problems such as quality issues in the fabric and relatively higher consumption of chemicals during wet processing. This water also cannot be used for steam boilers. Therefore, in most of the textile finishing industries, raw water of high dissolved solids is pretreated through reverse osmosis (RO) plant to minimize its total dissolved solids (TDS) and hardness in order to provide process water at required quality both for wet finishing processes and boiler feed water (See Figure-1).

As being a separation technology, the RO produces the so-called permeate, which is about 70% of the total raw water supplied to the RO plant, as well as the concentrate, which is highly concentrated with the salts with a percentage of 30% respectively. The concentrate is also called reject water. This reject water is often wasted.

The typical quality of RO reject water from one textile finishing industry is given as under:

pH	7.56
Total Hardness as $CaCO_3$ (mg/l)	1,475
Total Dissolved Solids-TDS (mg/l)	8,740
Total Iron (mg/l)	0.08

Note: The groundwater TDS of this industry is 3,190 mg/l and pressure at the RO plant is 230 psig or 15.86 barg (two stage RO plant)

Reject water is high in TDS contents which cannot be used for a wet finishing process but can be utilized for general purposes where high quality water is not required. It should be collected and used for general purposes as given below:

- At color kitchen for washing the floors and chemical drums
- Showering water at solid fuel fired boilers wet scrubbers
- Toilets
- Printing machine screens washing
- Showering water in the cooling rooms
- Vehicular washing
- Coal moisturizing for boilers
- Water injection at water ejectors of caustic recovery plant (CRP)
- Showering water at fluff scrubber at singeing machines.

RO reject water rate can also be decreased by increasing number of membranes (stages) of the RO plant.

Achieved Environmental Benefits

- Water conservation
- Groundwater protection
- Reduction in hydraulic load of wastewater treatment plant

Operational Data

Generally the reject water stream is about 150 to 1,100 m^3/day or 45,000 to 330,000 m^3/year, depending upon the size of the industry and consumption of the RO treated water in the processes. Mostly RO reject water is 30% of the total input to the RO plant but it can vary from industry to industry. The pressure at RO plant (two stage) is in the range of 230 psig to 250 psig as per the capacity of the plant. The value of this water is about USD 1,530 to 11,000/yr (PKR 0.23 to 1.65 million/yr).

Cross Media Effects

Salts accumulation can take place at places where this RO reject water is used due to its high salts contents. The places of use will require frequent cleaning and removal of adhered salts on the surfaces. This problem can be severe at places of high temperature due to water evaporation.

Reuse of RO reject water will also allow the industries to reduce their electricity consumption for groundwater extraction in the range of 9,000 to 66,000 kWh/yr. The anti-scale chemicals is used in the range of 2-5 mg/l in the RO plants.

Technical Considerations relevant to Applicability

This measure is applicable to all those industries where RO plants are installed and raw water is treated to get low salt content water. This measure does not require any major intervention in the process, no major infrastructure development and no technical human resource requirement. The RO reject water from the RO plant will be collected in an underground storage tank. This tank will be attached with pump and discharge pipeline. The discharge pipeline will be connected to multiple areas/sources with valves where this water is intended to be reused.

Economics

Capital cost for the underground tank, pump, pipeline and valves =
USD 2,000 – 6,660 (PKR. 300,000 -1,000,000)
Annual saving = USD 1,530 – 11,000 (PKR. 0.23 – 1.65 million)
Annual O&M cost = USD 660 – 4,660 (PKR. 100,000 – 700,000)
Simple payback period = 1 – 2.3 year

Additional benefit will be the reduction in hydraulic load and treatment cost of the wastewater treatment plant.

Driving Force for Implementation

- Financial benefits
- Resource conservation (water, electricity)
- Sustainability of textile business

Reference Industry

- The Crescent Textile Mills Limited, Sargodha Road, Faisalabad
- Rashid Textile Industries Pvt. Ltd, Sargodha Road, Faisalabad
- Ittehad Textile Industries Pvt. Ltd. Khurrianwala Industrial Estate, Faisalabad
- Sarena Textile Industry Pvt. Ltd, Sheikhupura Road, Lahore
- Abdur Rehman Corporation, Khurrianwala Road, Faisalabad

2 Reuse of Cooling Water from Singeing Machines

Figure-2: Cooling water wastage from singeing machine

Technical Description

In the woven fabric textile finishing industries, singeing is the first process step where greige fabric is passed through the singeing machine prior to wet pretreatment. Singeing operation is employed to destroy singes and tufts on the surface of the fabric, by its direct exposure to the flame, for a very short time. This process is required to improve the chemical uptake of the fabric, by preventing uneven impregnation.

Greige fabric is allowed to pass over the open flame of the burners through rollers where loose hairy fibers protruding from the surface of the fabric are burnt. Cooling water is continuously supplied at the inside of the rollers of the singeing machine to keep them cool which become hot by the direct exposure of the flame. This cooling water absorbs heat of the rollers and becomes warm at about 40-45oC temperature. This is a warm and clean water stream which is generally wasted from the singeing machines (See Figure-2).

This warm water stream can be collected and reused in any of the wet process machines (See Figure-3). Generally it is raw water. This water can be used at followings;

- Washing water in the process
- Showering water at wet scrubbers installed with steam boiler
- Showering water at wet scrubber installed with singeing machines

Figure-3: Singeing machine in operation with cooling water being collected in blue container and reused as showering water at singeing wet scrubber

Achieved Environmental Benefits

- Water conservation
- Reduction in thermal energy (warm water will require less steam for heating, in case if this water is used in the hot washes)
- Reduction in greenhouse gases
- Reduction in hydraulic load of wastewater treatment plant

Operational Data

Mostly raw water is used as cooling water in the singeing machines. Cooling water quantity varies from industry to industry. Generally its quantity is about 24 to 48 m3/day (8,400 – 16,800 m3/yr). Its value is USD 4,200 to USD 8400/yr (PKR 0.63 to 1.26 million/yr).

Cross Media Effects

No relevant cross media effect is known.

Technical Considerations relevant to Applicability

This measure is applicable to all the woven fabric textile finishing industries where greige fabric is singed before wet processing. This measure does not require any major intervention in the process, no major infrastructure development and no technical human resource requirement. The cooling water from the singeing machine will be collected in a small underground pit. This pit will be attached with small pump and discharge pipeline. The discharge pipeline will be connected to multiple machines/sources with valves where this water is intended to be reused. In case of water requirement to specific machine, the valve for that machine or source will be opened for the water supply.

Economics

Capital cost for the underground pit, small pump, pipeline and valves = USD 1000 – USD 2000 (PKR 150,000 – 300,000)
Annual saving = USD 4,200 - 8400 (PKR. 0.63 - 1.26 million)
Annual O&M cost = USD 1,630 – 3,360 (PKR 250,000 - 500,000)
Simple payback period = 5.0 months

Additional benefit will be the reduction in hydraulic load and treatment cost of wastewater treatment plant.

Driving Force for Implementation

- Financial benefits
- Resource conservation
- Sustainability of textile business

Reference Industry

- The Crescent Textile Mills Limited, Sargodha Road, Faisalabad
- Sarena Textile Industry Pvt. Ltd, Sheikhupura Road, Lahore

3 Reuse of Water from Cooling Drums

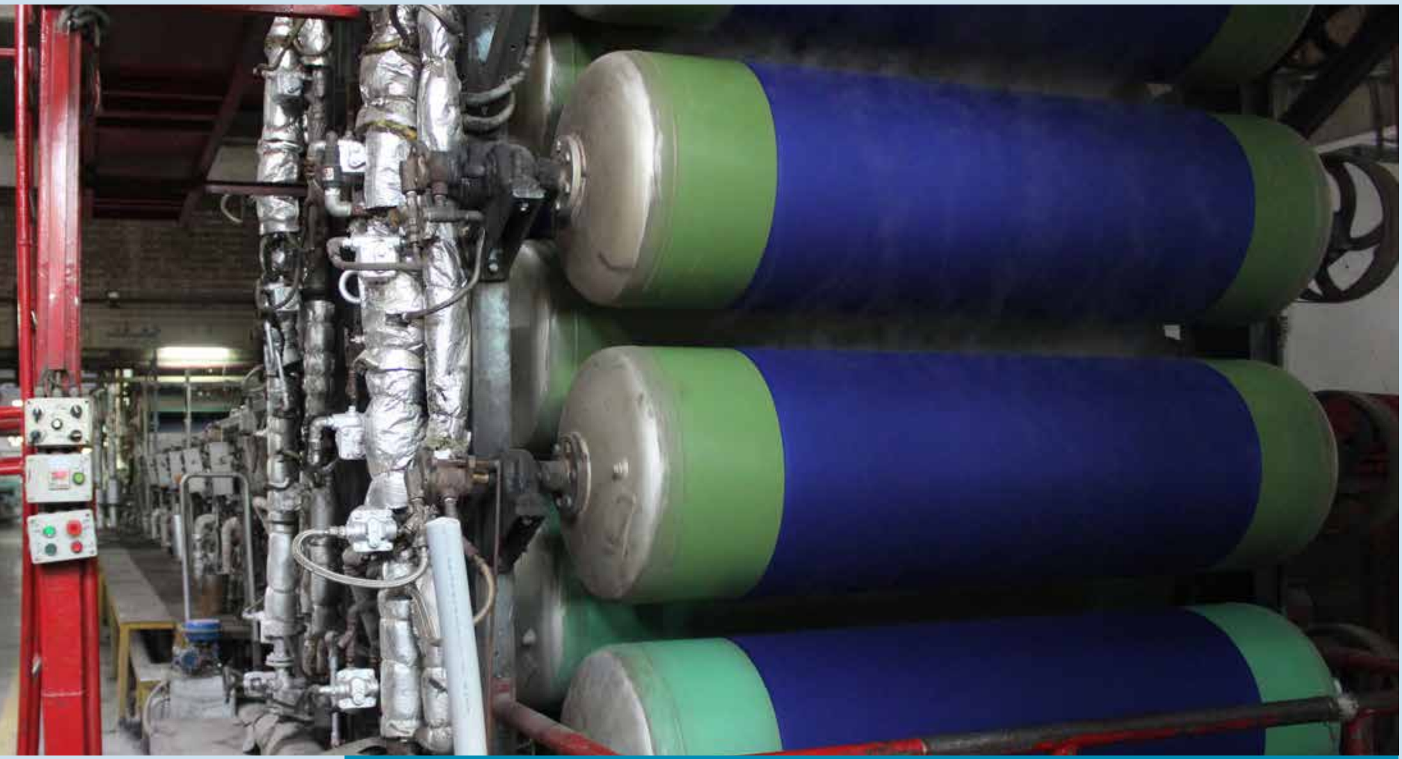


Figure-4: Drum dryer where the last drum is cooled with fresh water to reduce the temperature of the fabric

Technical Description

At most of the continuous woven fabric machines of the textile finishing industries, wet fabric is first dried at drum dryers and then cooled through cooling drums so that it could be handled easily. Figure-4 and Figure-5 show a drum dryer where the last drum is cooled with fresh water for reducing the fabric temperature. These cooling drums are provided with fresh water circulation inside. After getting heat of the hot fabric, this warm water is discharged as wastewater. This is a clean and warm water stream.

Generally cooling drums are attached with the following:

- Continuous pretreatment machines
- Mercerization machines
- Curing machines
- Pad steam dyeing machines
- Pad steam dyeing machines attached with Thermosole
- Stenters
- Pad dryers

This clean warm water can be collected in a storage tank and reused in the process. In some industries, this cooling water is not a raw water but a treated water (soft water or RO treated water) which is of a very good quality and very expensive.

Figure-5: Cooling drums attached with pad steam dyeing machine

Achieved Environmental Benefits

- Water conservation
- Reduction in thermal energy (warm water will require less steam for heating, in case if this water is used at hot washes)
- Reduction in greenhouse gases
- Reduction in hydraulic load of wastewater treatment plant

Operational Data

Cooling water quantity varies from industry to industry. Its quantity can be up to 482 m3/day or 168,700 m3/yr (large textile industry). The cost of this water is USD 56,000/yr (PKR 8.4 million/yr).

The implementation cost would be USD 23,330 (PKR 3.5 million) for underground water collection tank of 20 m3 capacity, piping and pumps.

Cross Media Effects

No relevant cross media effect is known.
Technical Considerations relevant to Applicability

This measure is applicable to all the woven fabric processing industries where hot fabric is cooled at cooling drums after drying. This measure does not require any major intervention in the process, no major infrastructure development and no technical human resource requirement. The cooling water from the cooling drums will be collected in an underground storage tank (preferably underground tank but over ground tank can also be used by constructing a small holding pit and pump).

Note: the cooling water supply in the cooling drums should be synchronized with the operation of the machines. The cooling water supply should be stopped when machine is stopped to avoid its unnecessary wastage in case of machine stoppage. In most of the cases, cooling water keeps on running and wasted even the machine is stopped due to various reasons (maintenance, change over etc.).

Economics

Capital cost = USD 23,330 (PKR 3.5 million)
Annual saving = USD 56,000 (PKR 8.4 million)
Annual O&M cost = USD 3,330 (PKR 500,000)
Simple payback period = 5 months

Additional benefit will be the reduction in hydraulic load and treatment cost of wastewater treatment plant

Driving Force for Implementation

- Financial benefits
- Resource conservation
- Sustainability of textile business

Reference Industry

This measure is relevant for all the woven fabric processing industries where cooling drums are used to cool the fabric.

4 Reuse of Vapor Condensate of Caustic Recovery Plant

Figure-6: Vapor condensate from CRP is collected at over ground tank and then supplied to the pretreatment machine for post bleaching washing

Technical Description

In some woven fabric textile finishing industries where mercerization process is carried out extensively, Caustic Recovery Plant (CRP) is installed to recover caustic soda from the mercerization process. The purpose of the CRP is to concentrate dilute caustic soda solution (weak lye) of 5 to 10 oBé concentration discharged from the mercerization machines into 20-25 oBé concentration by evaporating water from the weak lye through evaporators. The vapors from weak lye is condensed into hot water through condensers. This hot water is at a high temperature of about 60 to 80oC with alkaline pH. Generally this hot alkaline water is wasted in the industry.

This water can be collected and reused (See Figure-6) as:

- Washing water for post mercerization washes
- Pre and post washes of continuous textile pretreatment machines (desizing, scouring and bleaching)
- Dilution water for caustic soda solution from 50 oBé to 25 oBé.

Achieved Environmental Benefits

- Water conservation
- Reduction in thermal energy (hot water will require less steam for heating, in case if this water is used as hot washes)
- Reduction in greenhouse gases
- Reduction in hydraulic load of wastewater treatment plant

Operational Data

The quantity of this water varies from 30 to 75 m3/day or 9,000 to 22,500 m3/year. The value of this hot water is about USD 10,660 to USD 26,660/yr (PKR 1.6 to 4 million/ year).

Cross Media Effects

No relevant cross media effect is known.

Technical Considerations relevant to Applicability

This measure is applicable to all the woven fabric textile finishing industries where CRP is installed to concentrate dilute caustic soda solution from mercerization machine. This measure does not require any major intervention in the process, no major infrastructure development and no technical human resource requirement. The vapor condensate will be collected in an over ground or underground tank. This tank will be attached with small pump and discharge pipeline. The discharge pipeline will be connected to multiple machines/sources with valves where this water is intended to be reused. In case of water requirement to specific machine, the valve for that machine or source will be opened for the water supply. The storage tank and pipelines will be insulated to avoid convectional and radiation energy losses into the atmosphere.

Economics

Capital cost for the tank, pump, pipeline and valves = USD 2,000 – 3,330 (PKR 300,000 – 500,000)
Annual saving = USD 10,660 to 26,660 (PKR 1.6 to 4 million)
Annual O&M cost = USD 1,330 – 2,660 (PKR 200,000 - 400,000)
Simple payback period = 2 - 3 months

Additional benefit will be the reduction in hydraulic load and treatment cost of wastewater treatment plant.

Driving Force for Implementation

- Financial benefits
- Resource conservation
- Sustainability of textile business

Reference Industry

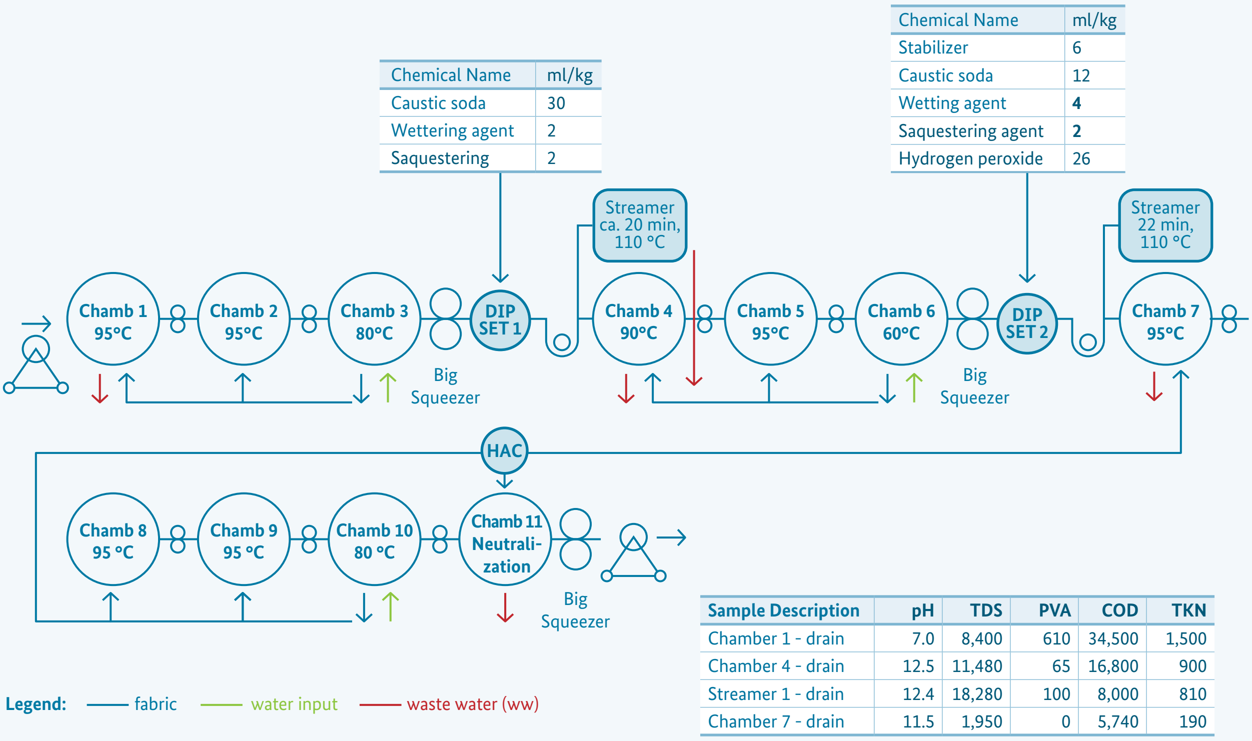
- Kohinoor Mills Limited Dyeing Division), Raiwind Manga Road, Lahore
- Sarena Textile Industry Pvt. Ltd, Sheikhupura Road, Lahore

5 Reuse of Post Scouring Washing Water as Desizing Washing Water in the Continuous Pretreatment Machines

Technical Description

Today, woven fabric made of cotton or cotton/polyester blends are usually continuously pre-treated. This pre-treatment consists of desizing, scouring and bleaching with associated washing operations, i.e. wash boxes each after desizing, scouring and bleaching. Further, depending on the desired quality, the fabric is also mercerized. Many industries already practice counter-current washing which means counter-current washing to wash out sizing agents, and to wash the fabric after scouring and bleaching. An example is given in the Figure-7. The consumption of water of this real plant is 16 l/kg whereas each of the three washing steps can be operated with 4 l/kg each, i.e. with a total water consumption of 12 l/kg in total (Textile BREF, 2003).

In the continuous pretreatment machine, the scouring wash water can be reused as desizing washing water by directing discharge pipeline of scouring section wash water into the supply line of desizing wash boxes (See Figure-8). For desizing washing, high quality water is generally not required and scouring wash water can be a good option for such type of washing.



Chemical Name	ml/kg
Caustic soda	30
Wettering agent	2
Saquestering	2

Chemical Name	ml/kg
Stabilizer	6
Caustic soda	12
Wetting agent	**4**
Saquestering agent	**2**
Hydrogen peroxide	26

Sample Description	pH	TDS	PVA	COD	TKN
Chamber 1 - drain	7.0	8,400	610	34,500	1,500
Chamber 4 - drain	12.5	11,480	65	16,800	900
Streamer 1 - drain	12.4	18,280	100	8,000	810
Chamber 7 - drain	11.5	1,950	0	5,740	190

Note: Water inputs and wastewater outputs are indicated with blue and red arrows respectively; the chemicals input is also mentioned as well as the analysis of individual wastewater streams

Figure-7: Scheme of a real continuous pre-treatment machine (line) consisting of desizing, scouring and bleaching with counter current washing

Figure-8: Three counter-currently operated washing boxes for desizing as part of a continuous pre-treatment machine (line)

Achieved Environmental Benefits

- Water conservation
- Thermal energy conservation (reduction in steam for heating the washing water)
- Reduction in greenhouse gases (reduction in fuel due to reduced steam demand)
- Reduction in hydraulic load of wastewater treatment plant

Operational Data

The influence of pH and fluff content should be checked for the use of scouring washing water for desizing washes. In case of fluff issue, the scouring washes should be passed through the screens prior to feeding into desizing wash boxes. The scouring wash water supply should be directly to the desizing wash boxes while bypassing the heat exchanger.

The implementation of this option will significantly reduce water and steam consumption in the pretreatment machine. The water in the range of 100 to 170 m3/d (34,000 – 51,000 m3/yr) can be reduced. Its value is USD 55,000/yr (PKR 8.25 million/yr). The potential of savings can vary from industry to industry. However, potential is significant due to reduction in thermal energy which has substantial cost.

Technical Considerations relevant to Applicability

This measure is applicable to all those woven fabric processing industries where continuous pretreatment machines are used for desizing, scouring and bleaching. This measure does not require any major intervention in the process, no major infrastructure development and no technical human resource requirement. Only the discharge pipeline of the post scouring washing (or post bleaching washing) water will be directed towards the inlet of desizing washing water.

Note: In some industries, so called solomatic bleaching is carried out (scouring and bleaching in one step i.e. only one impregnation and one steamer). In this case, post solomatic washing water can also be used for desizing washing.

The implementation cost will be Rs. 400,000 for the collection sump, pipelines and small pump (if required).

Economics

Capital cost = USD 2,660 (PKR 400,000)
Annual saving = USD 55,000 (PKR 8.25 million)
Annual O&M cost = USD 3,660 (PKR 550,000)
Simple payback period = < 1 month

Additional benefit will be the reduction in hydraulic load and treatment cost of wastewater treatment plant.

Driving Force for Implementation

- Financial benefits
- Resource conservation
- Sustainability of textile business

Reference Industry

- Kohinoor Mills Limited, Raiwind Manga Road, Lahore
- Sarena Industries & Embroidery Mills (Pvt) Ltd, Sheikhupura Road, Lahore

Reference Literature

European Commission (2003), Reference Document on Best Available Techniques for the Textiles Industry,
https://eippcb.jrc.ec.europa.eu/sites/default/files/2019-11/txt_bref_0703.pdf

6 Reuse of Ammonia Chiller Condenser Water

Figure-9: View of an ammonia chiller

Technical Description

Cold caustic soda solution is used at some of the mercerization processes in the textile finishing industries. The caustic soda solution is cooled through ammonia chiller (See Figure-9). Cooling water is used at ammonia chiller's condenser to condense ammonia gas. This cooling water is a clean water stream which is usually wasted. This water can be collected and reused in the process.

Achieved Environmental Benefits

- Water conservation
- Reduction in hydraulic load of wastewater treatment plant

Operational Data

The data of only one industry is available. The quantity of the cooling water used in this industry is about 400 m3/day or 120,000 m3/yr for one mercerization plant. The value of this cooling water is about USD 4,000/yr (PKR 600,000/yr).

Cross Media Effects

No relevant cross media effect is known.

Technical Considerations relevant to Applicability

This measure is applicable to all woven fabric textile finishing industries where cold caustic soda solution is used in the mercerization process which is cooled through the ammonia chiller. This measure requires storage tank, pump and pipeline.

Economics

Capital cost = USD 2,660 (PKR400,000) (for storage tank, pump and pipelines)
Annual saving = USD 4,000 (PKR 600,000)
Annual O&M cost = USD 2,000 (PKR 300,000)
Simple payback period = 1.3 year

Additional benefit will be the reduction in hydraulic load and treatment cost of wastewater treatment plant.

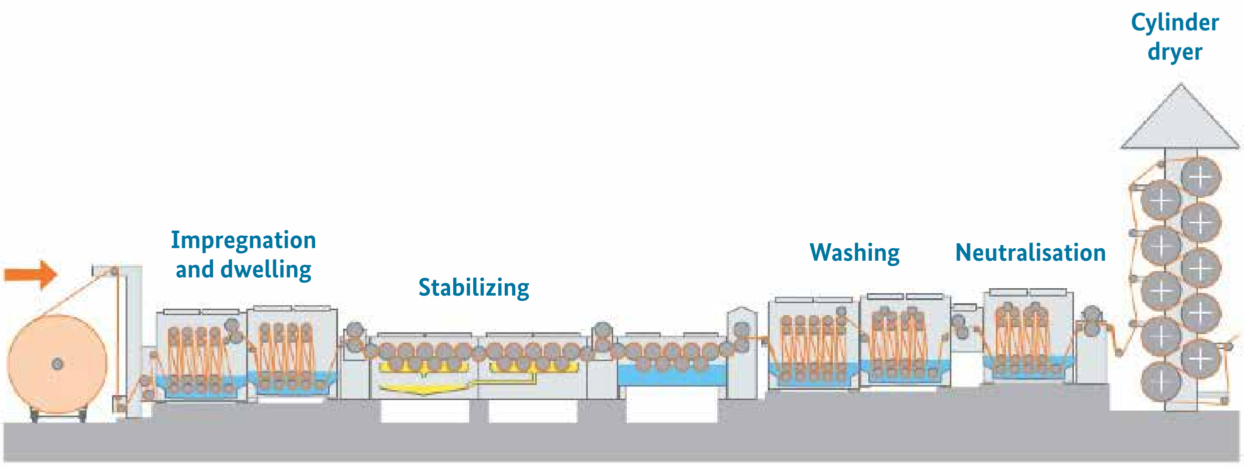
Driving Force for Implementation

- Financial benefits
- Resource conservation
- Sustainability of textile business

Reference Industry

Ittehad Textile Industries Pvt. Ltd, Khurrianwala Road, Faisalabad

7 Reuse of Post Mercerization Washes



Source: based on Benninger AG – Mercerizing Solutions; https://www.benningergroup.com/fileadmin/user_upload/downloads/textile_finishing/only_en/mercerizing_en.pdf)

Figure-10: Example for amercerization process

Technical Description

Mercerization process is carried out for cotton woven fabric, not necessarily but depending on the final product quality. Mercerization is applied to improve properties such as fiber strength, shrink- age resistance, luster, and dye affinity/up-take. In this process, fabric is treated with caustic soda (NaOH) solution of high concentration under tension (Figure-10 and Figure-11). Caustic soda reacts with the cellulose, swells it and imparts above properties.

In the mercerization machines, fabric is first allowed to dip into the caustic soda solution of the required concentration (generally 22 to 28 oBé), provided certain residence time for reaction between fabric and caustic soda and then finally washed to remove unreacted caustic soda from the fabric. The first and/or second wash box water contains substantial amount of caustic soda (6 to 7 oBé) which is collected and reused and also sent to the Caustic Recovery Plant (CRP) for concentrating it and reusing in the mercerization process. After the first and/or second wash box, further hot washes, at a tempera- ture of 80oC to 90oC are applied in three to four wash boxes to remove traces of caustic soda from the fabric. The discharged washing water is alkaline and contains very low concentration of caustic soda. This water can be collected in the storage tank and reused as washing water for desizing wash, post scouring wash or post bleaching wash, generally in the continuous pretreatment machine. In this way not only water but also energy will be saved.

Note: Generally textile finishing industries receive caustic soda of 50% oBé and dilute it to 22 to 28 oBé by adding water in it. Instead of using fresh water, the discharged washing water of mercerization machine can also be used for dilution purpose which will not only reduce water consumption but also the caustic soda consumption.

Figure-11: Example for mercerization machine for cotton woven fabric

Achieved Environmental Benefits

- Water conservation
- Reduction in hydraulic load of wastewater treatment plant

Operational Data

The data of only one industry is available. The quantity of the cooling water used in this industry is about 400 m3/day or 120,000 m3/yr for one mercerization plant. The value of this cooling water is about USD 4,000/yr (PKR 600,000/yr).

Cross Media Effects

No relevant cross media effect is known.

Technical Considerations relevant to Applicability

This measure is applicable to all woven fabric textile finishing industries where cold caustic soda solution is used in the mercerization process which is cooled through the ammonia chiller. This measure requires storage tank, pump and pipeline.

Economics

Capital cost = USD 2,660 (PKR400,000) (for storage tank, pump and pipelines)
Annual saving = USD 4,000 (PKR 600,000)
Annual O&M cost = USD 2,000 (PKR 300,000)
Simple payback period = 1.3 year

Additional benefit will be the reduction in hydraulic load and treatment cost of wastewater treatment plant.

Driving Force for Implementation

- Financial benefits
- Resource conservation
- Sustainability of textile business

Reference Industry

Ittehad Textile Industries Pvt. Ltd, Khurrianwala Road, Faisalabad

8 Reuse of Cooling Water of Dyeing Machines

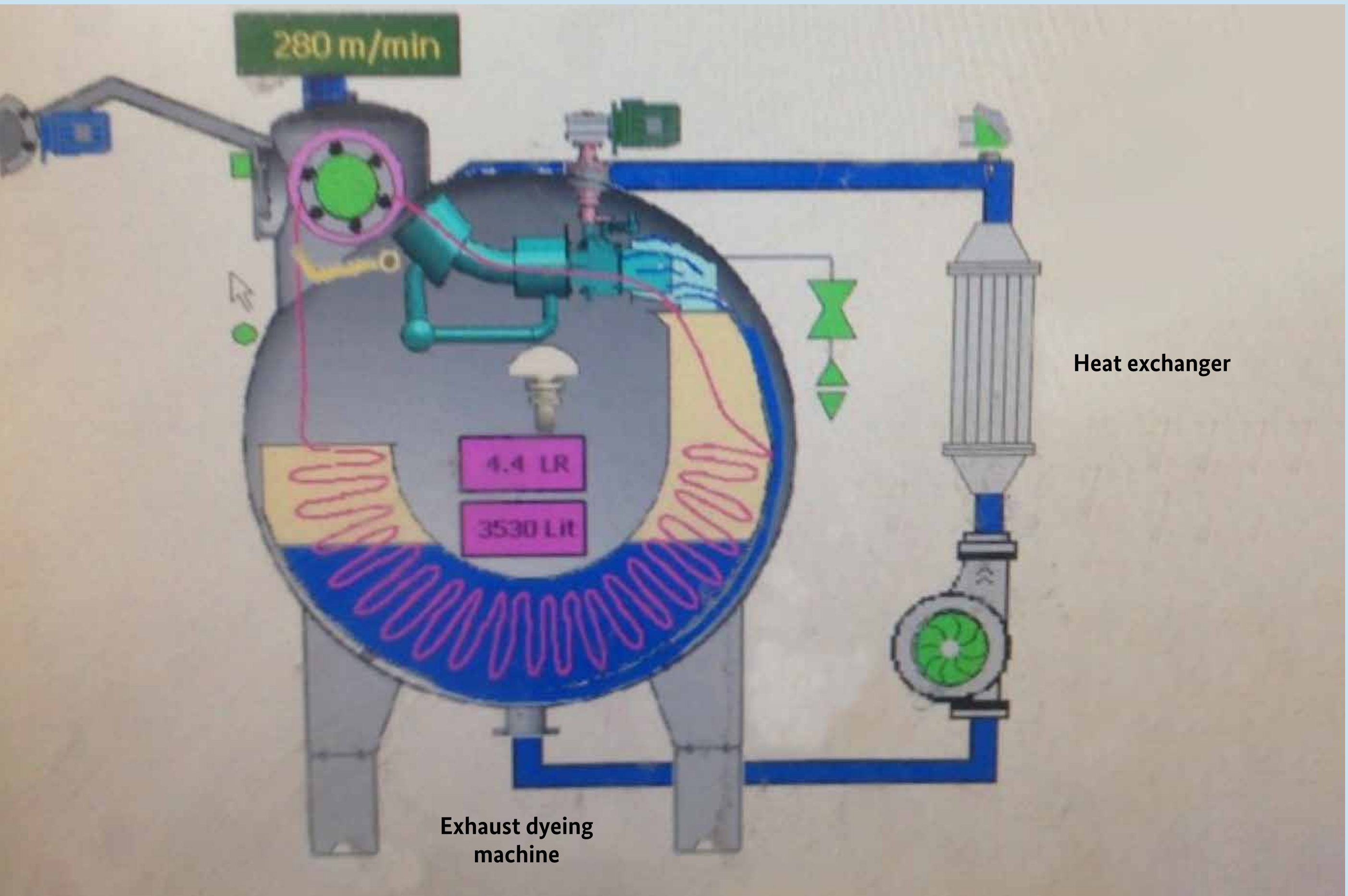


Figure-12: Exhaust dyeing machine with integrated heat exchanger to heat or to cool the circulating dyeing liquid

Technical Description

In the knitted fabric textile finishing industries, dyeing of the either pure polyester fabric or polyester part of the polyester-cotton blended fabric is carried out at higher temperature of about 130°C in the dyeing machines. After completion of the dyeing process, the temperature of the dye bath is reduced to about 80°C by circulating the hot bath through heat exchanger (attached with the dyeing machi-ne- See Figure-12). Fresh water is circulated in the heat exchanger to cool down the hot bath. The hot dye bath transfers its heat to the fresh water which gets warm. This continuous warm cooling water stream from the heat exchanger is wasted in the drain. This is a warm and clean water stream at a temperature of 50 to 60°C.

This warm and clean water can be stored and reused in the process. For reuse, the cooling water discharge line of all the dyeing machines (See Figure-13) will be connected to the new pipeline from where the cooling water will be transferred to the storage tank through small covered collection pit. The small pit will be connected to the hot water storage tank through pump. For reusing this warm water again in the dyeing machines, the water supply will be through already installed hot water supply pipeline. Whenever hot water is required in the process, the hot water valve will be opened and machine will be filled with the warm or hot water. In this way water heating time and energy will be saved.

Figure-13: View of the dyeing machine

Achieved Environmental Benefits

- Water conservation
- Reduction in thermal energy (hot water will require less steam for heating hen used as hot process water)
- Reduction in greenhouse gases
- Reduction in hydraulic load of wastewater treatment plant

Operational Data

The quantity of cooling water varies from industry to industry, depending upon the quantity of polyester dyed fabric production and number of dyeing machines installed. Its quantity can be in the range of 57 to 179 m3/day (19,380 - 53,700 m3/yr). The value of this warm water stream in monetary terms is USD 9,330 to 39,730/yr (PKR 1.4 to 5.96 million/yr).

The implementation cost would be USD 5,330 to 8,000 (PKR 0.8 to 1.2 million) for storage tank, pipes, valves and pump.

Cross Media Effects

No relevant cross media effect is known.

Technical Considerations relevant to Applicability

This measure is applicable to all the knitted fabric textile finishing industries where polyester (PES 100 % and blended polyester) dyeing is carried out. This measure does not require any intervention in the process, no major infrastructure development and no technical human resource requirement. The cooling water will be collected in the storage tank and pumped to the dyeing machines.

Economics

Capital cost = USD 5,330 – 8,000 (PKR 0.8 - 1.2 million)
Annual saving = USD 9,330 to 39,730 (PKR 1.4 to 5.96 million)
Annual O&M cost = USD 2,660 – 4,000 (PKR 400,000 – 600,000)
Simple payback period = 3 to 10 months

Additional benefit will be the reduction in hydraulic load and treatment cost of waste-water treatment plant.

Driving Force for Implementation

- Financial benefits
- Resource conservation
- Sustainability of textile business

Reference Industry

- Moderno Fabrics, Raiwind, Lahore
- Kay and Emms Private Limited, Faisalabad
- Klash Private Limited, Faisalabad

9 Reuse of Cooling Water from Different Sources

Figure-14: Cooling water discharge from the therm oil heater pump

Technical Description

There are many equipment in the textile finishing industries where cooling water is applied. The purpose of supplying cooling water in these equipment is to keep them cool, to minimize undesired reactions (e.g. of reactive dyestuffs) or to prevent damaging of their moving and rotating parts. This cooling water is not in direct contact with any media and remains uncontaminated. Only its temperature is increased. Generally, this warm water stream is ultimately discharged as wastewater. Cooling water is used at following locations/machines:

- Coal based boiler induced fan
- Coal feeding gate of steam boilers
- Coal feeding gate of therm oil heaters
- Thermosole padder's hydraulic pump
- Therm oil pumps at therm oil heaters (See Figure-14 as an example)
- Ager therm oil pump
- Calender cooling water
- Comfort cooling water
- Gas based therm oil pump cooling water
- Padders of continuous dyeing machines
- Cooling for water of high-temperature exhaust dyeing machines (loose material, yarn, knitwear or woven fabric made of polyester or polyester blends) – see technique-8

The non-contaminated water can be collected and reused in the process wherever convenient for the industry.

Achieved Environmental Benefits

- Water conservation
- Reduction in thermal energy
- Reduction in hydraulic load of wastewater treatment plant

Operational Data

The quantity of cooling water varies from industry to industry, depending upon the number of sources where cooling water is applied. Its quantity can be in the range of 100 to 160 m3/day (32,300 – 51,680 m3/year). The value of this warm water is about USD 12,933 to 21,000/yr (PKR 1.94 to 3.15 million/year).

The implementation cost will vary from industry to industry, depending upon its quantity and point of use. The implementation cost will be USD 4,000 to 8,000 (PKR 0.6 to 1.2 million) for storage tank, pipes, valves and pump.

Cross Media Effects

No relevant cross media effect is known.

Technical Considerations relevant to Applicability

This measure is applicable to all types of the textile finishing industries where cooling water is applied in different equipment. This measure does not require any intervention in the process, no major infrastructure development and no technical human resource requirement. The cooling water will be collected in the storage tank and pumped to the process wherever required.

Economics

Capital cost = USD 4,000 to 8,000 (PKR 0.6 to 1.2 million)
Annual saving = USD 12,933 to 21,000 (PKR 1.94 to 3.15 million)
Annual O&M cost = USD 2,000 to 3,330 (PKR 300,000 to 500,000)
Simple payback period = 4 to 5 months

Additional benefit will be the reduction in hydraulic load and treatment cost of wastewater treatment plant.

Driving Force for Implementation

- Financial benefits
- Resource conservation
- Sustainability of textile business

Reference Industry

All textile finishing industries

10 Reuse of Water Lock Water from Steamers

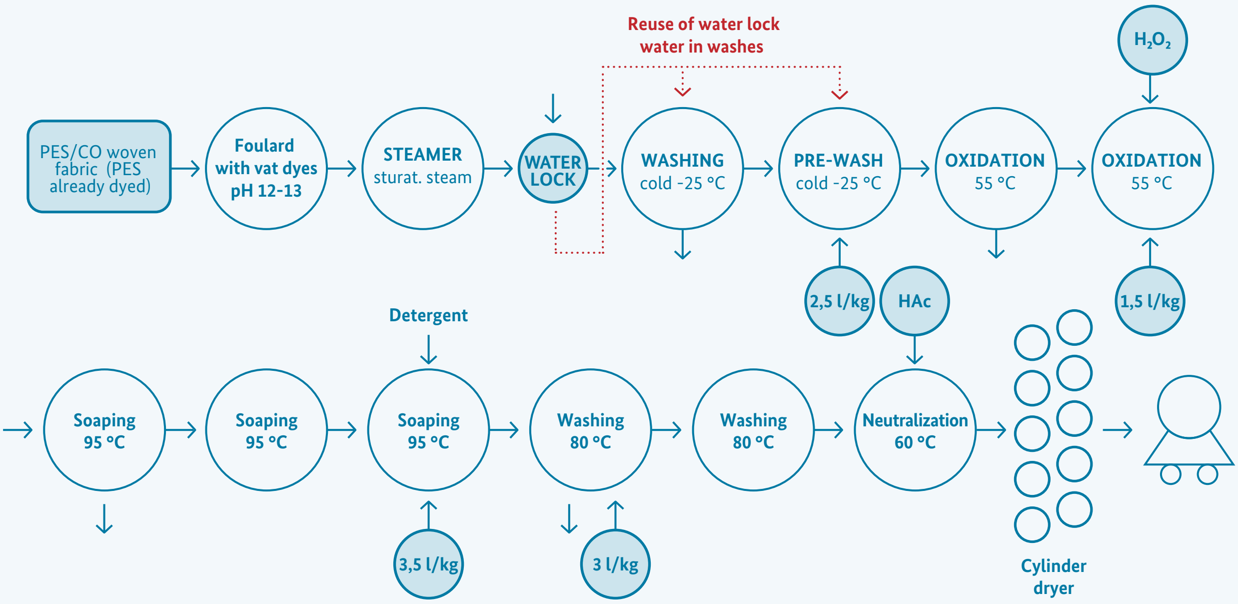


Figure-15: Continuous dyeing process with vat dyes with water input and output at the water lock for the steamer after impregnation with vat dyes

Technical Description

In woven fabric textile finishing industry, continuous pretreatment and pad steam dyeing machines are used for pretreatment (desizing, scouring, bleaching) and dyeing of the fabric respectively. These machines are equipped with steamers (generally at the top) for heating the fabric and giving reaction time for the completion of the process (scouring/bleaching/dyeing). The pretreatment machine where scouring and bleaching process is carried out separately, there are two steamers (one after the scouring impregnator and other after the bleaching impregnator) and for the pretreatment machine where scouring and bleaching process is carried out simultaneously in the same impregnator, there is only one steamer.

There is continuous supply and wastage of fresh water at fabric exit point of the steamer. This water is supplied to maintain a water lock so that the steam vapors could not escape from the steamer along with fabric into the atmosphere (loss of steam and increase of humidity of the environment) (See Figure-15 as an example). This is relatively a clean water stream which can be collected and reused at the wash boxes of the same machine.

Achieved Environmental Benefits

- Water conservation
- Reduction in hydraulic load of wastewater treatment plant

Operational Data

The quantity of water lock water will vary from industry to industry depending upon the type of the pretreatment machine employed, and production of the bleached and dyed fabric. Its quantity is in the range of 90 to 115 m3/day (29,070 - 37,145 m3/year). Its value is USD 3,860 to 4,930 (PKR 580,000 to 740,000 /year).

The implementation cost will be nominal as the discharge point of this water lock water will be directly connected to the wash boxes of the same machine.

Cross Media Effects

No relevant cross media effect is known.

Technical Considerations relevant to Applicability

This measure is applicable to all the woven fabric finishing industries where continuous pretreatment and pad steam dyeing machines are installed. This measure does not require any intervention in the process, no major infrastructure development and no technical human resource requirement. The water lock water will be directly diverted to the wash boxes of the same machine.

Note: In principle, there are two types of dyestuffs applied for continuous dyeing cotton or cotton/polyester woven fabric at pad steam dyeing machines: reactive and vat dyes. For dark shade reactive dyed fabric, this water lock water is generally contaminated with dyes whereas for vat dyed fabric, this water is relatively clean; the same is true for light shades with reactive dyes. In case if water is contaminated due to dark shade reactive dyes, it should be discarded.

Economics

Capital cost = Nominal
Annual saving = USD 3,860 to 4,930 (PKR 580,000 - 740,000)
Annual O&M cost = Nil
Simple payback period = Few days

Additional benefit will be the reduction in hydraulic load and treatment cost of wastewater treatment plant.

Driving Force for Implementation

- Financial benefits
- Resource conservation
- Sustainability of textile business

Reference Industry

All the woven fabric textile finishing industries where pretreatment and pad steam dyeing machines are installed.

11 Installation of Automatic Water Shut Off Valves at Rotary and Flatbed Printing Machines' Blanket Washing Water

Figure-16: View of blanket washing water from rotary printing machine

Technical Description

Rotary and flatbed printing machines are employed for the continuous printing of woven fabric. The printer table blanket is washed with forced water jets (See Figure-16), by means of two or three rows of multiple nozzles, placed underneath the table in cross direction, to remove the stains adhered to the blanket during printing operation. Generally, the blanket washing water at the printing machines is kept on running and wasted during machine stoppage (due to maintenance or change over). This water wastage can be avoided by installing automatic water shut off valve at the printing machines. Whenever printing machine is stopped, the

Achieved Environmental Benefits

- Water conservation
- Reduction in hydraulic load of wastewater treatment plant

Operational Data

The quantity of blanket washing water will vary from industry to industry, depending upon number of printing machines, frequency and duration of stoppage due to maintenance or change over. Its quantity is in the range of 50 to 90 m3/d (16,150 - 29,070 m3/yr). Its value is about USD 1,600 to 2,930/yr (PKR 240,000 to 440,000/year).

The implementation cost will be USD 660 to 1,330 (PKR 100,000/machine).

Cross Media Effects

No relevant cross media effect is known.

Technical Considerations relevant to Applicability

This measure is applicable to all the woven fabric textile finishing industries where continuous rotary and flatbed printing machines are employed for printing purpose. This measure does not require any intervention in the process, no major infrastructure development and no technical human resource requirement. The blanket washing water supply will be stopped whenever the machine is stopped. This supply will be synchronized with the operation of the printing machine.

Economics

Capital cost = USD 660 to 1,330 (PKR 100,000 to 200,000)
Annual saving = USD 1,600 to 2,930 (PKR 240,000 to 440,000)
Annual O&M cost = USD 330 to 660 (PKR 50,000 to 100,000)
Simple payback period = 6 to 7 months

Additional benefit will be the reduction in hydraulic load and treatment cost of wastewater treatment plant.

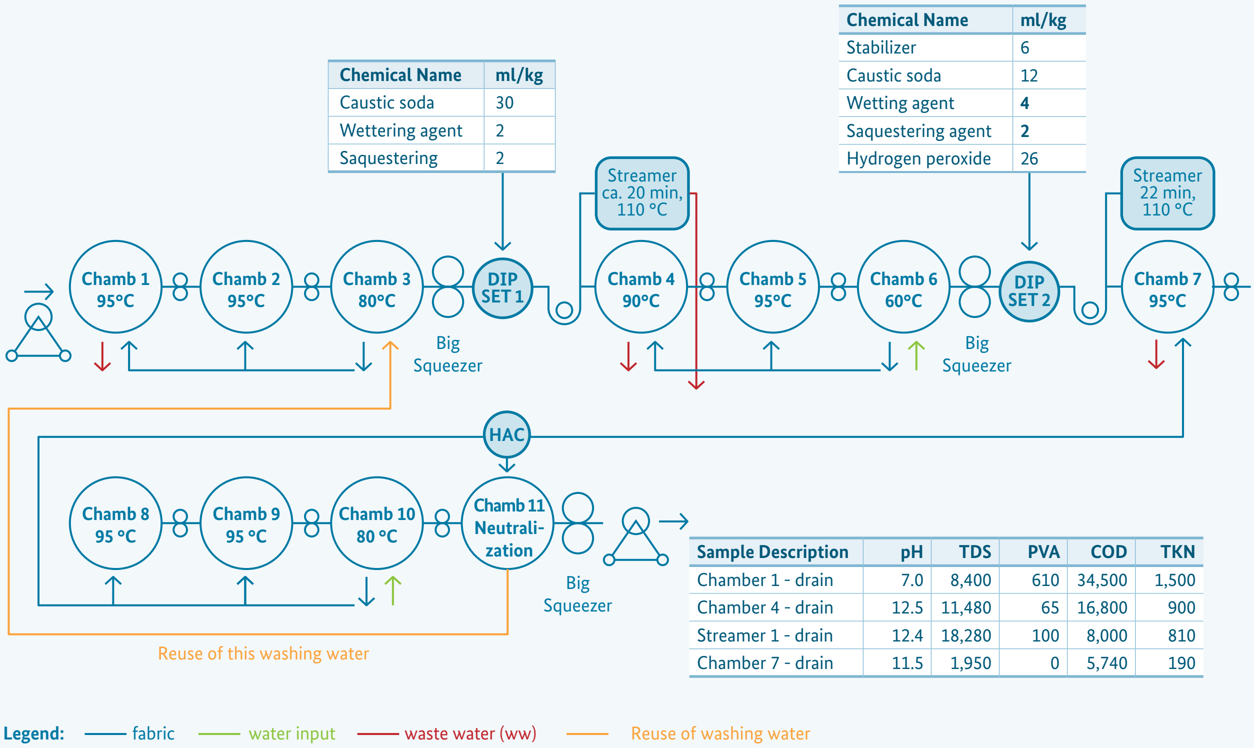
Driving Force for Implementation

- Financial benefits
- Resource conservation
- Sustainability of textile business

Reference Industry

- MK Sons Pvt. Ltd, Khurrianwala Road, Faisalabad
- Ittehad Textile Industries Pvt. Ltd, Khurrianwala Road, Faisalabad
- Sarena Textile Industry Pvt. Ltd, Sheikhupra Road, Lahore

12 Reuse of Post Neutralization Washes as Pre Washes at Pretreatment Machine



Chemical Name	ml/kg
Caustic soda	30
Wettering agent	2
Saquestering	2

Chemical Name	ml/kg
Stabilizer	6
Caustic soda	12
Wetting agent	4
Saquestering agent	2
Hydrogen peroxide	26

Sample Description	pH	TDS	PVA	COD	TKN
Chamber 1 - drain	7.0	8,400	610	34,500	1,500
Chamber 4 - drain	12.5	11,480	65	16,800	900
Streamer 1 - drain	12.4	18,280	100	8,000	810
Chamber 7 - drain	11.5	1,950	0	5,740	190

Figure-17: Reuse of washing water after neutralization for the desizing washing process

Technical Description

In woven fabric textile finishing industries, continuous pretreatment machines are employed to perform desizing washes, scouring and post scouring washes, bleaching and post bleaching washes and subsequent neutralization of the alkaline fabric with acid. In this machine, there are three sections of wash boxes: washes for desizing, post scouring washes and post bleaching washes. After post bleaching washes, fabric is treated with acid for neutralization of the fabric and then washed in the post neutralization wash boxes at about 60oC temperature. The post neutralization wash water can be reused as pre-wash water by directing discharge pipeline of neutralization section wash water into the supply line of pre-wash boxes (See Figure-17). For pre-washing, high quality water is generally not required and neutralization wash water can be a good option for such type of washing.

Achieved Environmental Benefits

- Water conservation
- Reduction in thermal energy (hot water will not require less steam for heating)
- Reduction in greenhouse gases
- Reduction in hydraulic load of wastewater treatment plant

Operational Data

The typical quality of pre wash and post neutralization wash water of one industry is given below:

Parameters	Pre Wash Water	Post Neutralization Wash Water
pH	8.17	7.29
Total Hardness as CaCO3 (mg/l)	880	840
Total Dissolved Solids-TDS (mg/l)	5,682	6,696

The quantity of post neutralization wash water will vary from industry to industry, depending upon operational frequency of the pretreatment machine and quantity of fabric bleached and neutralized. The water is in the range of 50 to 82 m3/d (12,500 to 20,500 m3/yr) which can be reduced in the pretreatment machine. Its value is USD 9,200 to 15,130/yr (PKR 1.38 to 2.27 million/yr).

The implementation of this option will reduce water and steam consumption in the pretreatment machine.

Cross Media Effects

No relevant cross media effect is known.

Technical Considerations relevant to Applicability

This measure is applicable to all the woven fabric processing industries where open width continuous pretreatment machines are employed. This measure does not require any intervention in the process, no major infrastructure development and no technical human resource requirement. The post neutralization washing water will be directed to the pre wash boxes of the machine (See Figure-17).

The implementation cost will be USD 1,330 to 2,660 (PKR 200,000 to 400,000) for the collection sump, pipelines and small pump (if required).

Economics

Capital cost = USD 1,330 to 2,660 (PKR 200,000 to 400,000)
Annual saving = USD 9,200 to 15,130 (PKR 1.38 to 2.27 million)
Annual O&M cost = USD 660 to 1,330 (PKR 100,000 to 200,000)
Simple payback period = 2 to 3 months

Additional benefit will be the reduction in hydraulic load and treatment cost of wastewater treatment plant.

Driving Force for Implementation

- Financial benefits
- Resource conservation
- Sustainability of textile business

Reference Industry

This measure is applicable to all the woven fabric textile finishing industries where open width continuous pretreatment machines are employed.

13 Water Management through Water Monitoring

Figure-18: Water flow meter installed at boiler feed water supply line

Technical Description

Water is the most important resource of the textile finishing industries. All the wet processes are based on water. Water consumption is directly or indirectly related with energy and chemicals consumption and wastewater hydraulic load. Excess water consumption increases thermal and electrical energy and chemical consumption in the processes. Water management is very important in the textile finishing industry to reduce resource consumption and sustain textile processes. Water management will only be possible if water consumption in the processes is measured, monitored and controlled. Mostly water consumption in the textile finishing industry is not measured, monitored and managed due to its availability in abundance, particularly where fresh water costs are low. Often, the management and workers do not realize the importance of water and associated resource wastage due to its inappropriate use in the process.

Water measurement is very important for water management by installing water flow meters at main water turbines, different wet process sections, process machines and utilities (See Figure-18). After water measurement, its analysis and benchmarking is important to assess the status of water consumption in the industry and to know whether its consumption is optimum or consuming huge amount of water as compared with other similar industries. Establishing water consumption benchmarking i.e. liter of water consumed per kilogram of finished fabric, and its improvement by taking water conservation measures will improve water management in the industry.

Achieved Environmental Benefits

- Water conservation
- Reduction in hydraulic load of wastewater treatment plant

Operational Data

Water monitoring facilitates production floor professionals to control water consumption at machines. There is one example of the industry that reduced about 25% of its water consumption for continuous pretreatment machine just by monitoring daily water consumption and then optimizing without any other intervention in the machine.

Table-1 below shows a real example for compiling machine-specific water consumption monitoring data of continuous wet processing machines. As it is a real example of a textile finishing industry in Pakistan, some figures are missing but it can be easily seen that the washing processes for continuous pre-treatment (continuous pre-treatment lines and mercerization plants) is low, i.e. water-efficient whereas the specific consumption for the continuous washing machine is high. As a benchmark, the figures from the technique on counter-current washing can be taken (See Technique-14). The monitoring of steam and electricity is carried out similarly. The daily determination of the specific water (and energy) consumption allows the identification of deviation of standard operating conditions and thus, immediate action can be taken.

Table-1: Real example for monitoring the water consumption for different continuous wet processing of cotton and cotton/polyester woven fabric

Date of month	Continuous pre-treatment line 1 (desizing, scouring and bleaching)			Continuous pre-treatment line 2 (desizing, scouring and bleaching)			Mercerisation plant 1			Mercerisation plant 2			Pad steam line			Continuous washing machine		
	[m/d]	[m³/d]	[L/kg]	[m/d]	[m³/d]	[L/kg]	[m/d]	[m³/d]	[L/kg]	[m/d]	[m³/d]	[L/kg]	[m/d]	[m³/d]	[L/kg]	[m/d]	[m³/d]	[L/kg]
1	137700	349	7.2	152000	557	10.5	62800	188	8.6	40900	310	21.7	100300	583	16.6	40500	549	42
2	117900	729	8.7	162000	987	11.5	63800	283	12.3	65300	684	13.6	56600	413	20.9	41900	1044	71.2
3	121200			83000			2100			78800								
4	130500	344.5		112900	376		50000	102		72400	300	11.9	56300	434	22	25800	323	35.7
5	118500	304		146500	570		46900	223		47000	289	17.6	51600	456	25.3	28900	366	36.2
6	121000	365		112600	502		44500	154		66900	274	11.7	24700	240	27.3	14700	167	32.5
7	139850	405	8.3	157100	553	10.1	61600	162	7.5	44400	284	18.3	63400	475	21.4	31900	428	38.3
8	126000	1411	8.3	124700	1857	10.3	51200	522	8.9	70700	866	12.6	51700	1233	21	40100	1273	32.5
9	145900			138200			31200			76500			67700			36700		
10	93300			85000			26000			0			0			0		
11	120600			165300			59400			48500			48100			35000		
12	136700	328	6.7	131500	496	10.8	57200	177	8.9	33700	179	17.2	66100	575	24.9	44600	464	29.7
13	35400	2062		180000	1988		44000	557		61100	1439	16	62900	2685	25	34700	2213	27.7
14	139200			139000			58700			74500			60700			57100		
15	128800			151200			54200			79200			74000			49100		
16	139500			115500			27400			42500			60100			46300		
17	101400			0									49000			41600		
18	124000	329.5	7.6	104400	442		47300	152	9.2	40200	246		34700	408	33.6	46600	239	14.7
19	118300	327	7.9	164000	524	9.1	56500	149	7.5	87500	340	11.1	70000	512	20.9	39500	288	20.8
20	139100	257.5	5.3	140600	498	10.1	57600	157	7.8	73000	275	10.8	67600	474	20	45600	377	23.6
21	117400	331	8.1	140200	512	10.4	58100	162	8	57200	246	12.3	42400	392	24.4	39800	329	23.6
22	117900	290.5		121700	552		51900	161		69300	341	14.1	63800	507	22.7	32000	401	35.9
23	5600	207		114600	1105		36300	95		52800	596	14.1	33800	960	8.1	27600	324	30.6
24				130500						67800			0			2800		
25	109500	284		128000	453		25100	109		85300	310	10.4	49800	214	12.3	38000	435	32.7
26	68700	176	7.3	131300	444	9.7	28400	113	11.4	39800	171	12.3	27200	144	15.1	28200	240	24.3
27	126000	596.5	6.1	142500	948	9.1	58300	292	8	63200	537	13.3	53100	849	19.1	56300	854	25
28	152000			154500			45900			52500			71000			41500		
29	121000	293	6.9	107400	426	11.3	25100	109	12.4	62600	241	11	45800	291	18.1	64600	449	19.9
30	137500	334.5	7	119000	509.5	12.2	40300	114	8.1	42800	226	15.1	37600	418	31.8	68000	373	15.7
total	3390450	9724		3855200	14299.5		1271800	3981		1696400	8154		1490000	12263		1099400	11136	

Table-2 below shows another example from another textile finishing industry where, in addition to water, the absolute and specific consumption is given for steam and electricity (power). Here, the specific consumption is referred to one meter and not to one kilogram of fabric.

Table-2: Monitoring data for water, steam and electricity consumption of two continuous woven fabric wet processing machines

Data of Bleaching Plants

DATE	PRODUCTION (Meters)			Goller										
				Total Mtr.	Steam			Power			Water			Energy Cost/Mtr (Rs)
	Scour	Solo Bleach	Bleach/ Mer.		Kgs.	Kgs/Mtr	Rs./Mtr	KWh	Watt/Mtr	Rs/Mtr	Liters	Ltrs/Mtr	Rs./Mtr	
1. Oct	3445	70668	19008	93121	71000	0,76	1,10		0,0	0,00	378000	4,1	0,020	1,12
2. Oct	20725	74209		94934	66000	0,70	1,00	157	1,7	0,02	350000	3,7	0,018	1,03
3. Oct		67728	2500	70228	65000	0,93	1,33	169	2,4	0,03	330000	4,7	0,023	1,38
4. Oct		47475	20535	68010	63000	0,93	1,33	175	2,6	0,03	384000	5,6	0,028	1,39
5. Oct		63108		63108	51000	0,81	1,16	147	2,3	0,02	250000	4,0	0,020	1,21
6. Oct		88891		88891	76000	0,85	1,23	189	2,1	0,02	291000	3,3	0,016	1,27
7. Oct		58417		58417	44000	0,75	1,08	146	2,5	0,03	200000	3,4	0,017	1,13
8. Oct		83900		83900	65000	0,77	1,11	185	2,2	0,02	248000	3,0	0,015	1,15
9. Oct		55357		55357	52000	0,94	1,35	139	2,5	0,03	224000	4,0	0,020	1,40
10. Oct	14889	72659		87548	69000	0,79	1,13	199	2,3	0,02	350000	4,0	0,020	1,18
11. Oct		92193		92193	73000	0,79	1,14	199	2,2	0,02	245000	2,7	0,013	1,17
12. Oct		98608		98608	75000	0,76	1,09	208	2,1	0,02	350000	3,5	0,018	1,13
13. Oct		70659		70659	61000	0,86	1,24	165	2,3	0,02	358000	5,1	0,025	1,29
14. Oct		69122	3384	72506	69000	0,95	1,37	169	2,3	0,02	368000	5,1	0,025	1,42
15. Oct		93217		93217	76000	0,82	1,17	220	2,4	0,02	392000	4,2	0,021	1,22
16. Oct		92266		92266	73000	0,79	1,14	200	2,2	0,02	393000	4,3	0,021	1,18
17. Oct		90621		90621	73000	0,81	1,16	188	2,1	0,02	384000	4,2	0,021	1,20
18. Oct		75147		75147	65000	0,86	1,24	171	2,3	0,02	371000	4,9	0,025	1,29
19. Oct	29563	63067		92630	72000	0,78	1,12	189	2,0	0,02	351000	3,8	0,019	1,16
20. Oct	9670	74909		84579	68000	0,80	1,16	188	2,2	0,02	415000	4,9	0,025	1,20
21. Oct		78615		78615	69000	0,88	1,26	190	2,4	0,03	377000	4,8	0,024	1,31
22. Oct		90856		90856	71000	0,78	1,12	191	2,1	0,02	378000	4,2	0,021	1,17
23. Oct		76946		76946	55000	0,71	1,03	166	2,2	0,02	354000	4,6	0,023	1,07
24. Oct		88696		88696	66000	0,74	1,07	183	2,1	0,02	353000	4,0	0,020	1,11
25. Oct		83986		83986	66000	0,79	1,13	180	2,1	0,02	374000	4,5	0,022	1,17
26. Oct		80890		80890	70000	0,87	1,24	189	2,3	0,02	367000	4,5	0,023	1,29
27. Oct		69246		69246	60000	0,87	1,25	156	2,3	0,02	339000	4,9	0,024	1,29
28. Oct		76959		76959	61000	0,79	1,14	182	2,4	0,02	354000	4,6	0,023	1,19
29. Oct	4830	74408		79238	66000	0,83	1,20	167	2,1	0,02	320000	4,0	0,020	1,24
30. Oct		89654		89654	72000	0,80	1,15	193	2,2	0,02	340000	3,8	0,019	1,20
31. Oct		77008		77008	67000	0,87	1,25	175	2,3	0,02	290000	3,8	0,019	1,29
Total	83122	2389485	45427	2518034	2050000	25,38819	36,48	5375	67,0	0,70	10478000	130,1	0,650	37,84
Average	13853,66667	77080,16129	11356,75	81226,90323	66129,03226	0,814	1,17	179,16667	2,2	0,02	338000	4,16	0,021	1,21

Table-2: Monitoring data for water, steam and electricity consumption of two continuous woven fabric wet processing machines (continued)

Data of Bleaching Plants

DATE	PRODUCTION (Meters)			Babcock										
				Total Mtr.	Steam			Power			Water			Energy Cost/Mtr (Rs)
	Scour	Solo Bleach	Bleach/ Mer.		Kgs.	Kg/Mtr	Rs./Mtr	KWh	Watt/Mtr	Rs/Mtr	Liters	Ltrs/Mtr	Rs./Mtr	
1. Oct	63820		37565	101385	42000	0,414	0,60		0,00	0,00	158000	1,6	0,008	0,60
2. Oct	5440	12300	29650	47390	49000	1,034	1,49	255	5,38	0,06	165000	3,5	0,017	1,56
3. Oct	60018		1500	61518	40000	0,650	0,93	288	4,68	0,05	146000	2,4	0,012	1,00
4. Oct	47512	6703	36870	91085	50000	0,549	0,79	314	3,45	0,04	230000	2,5	0,013	0,84
5. Oct	31685		45047	76732	55000	0,717	1,03	295	3,84	0,04	200000	2,6	0,013	1,08
6. Oct	54334	13720	24833	92887	46000	0,495	0,71	302	3,25	0,03	218000	2,3	0,012	0,76
7. Oct			3000	3000	6000	2,000	2,87	164	54,67	0,57	59000	19,7	0,098	3,55
8. Oct	69155		25573	94728	46000	0,486	0,70	291	3,07	0,03	152000	1,6	0,008	0,74
9. Oct			46468	46468	34000	0,732	1,05	276	5,94	0,06	143000	3,1	0,015	1,13
10. Oct	41330		4302	45632	42000	0,920	1,32	259	5,68	0,06	159000	3,5	0,017	1,40
11. Oct	18570	25623	43966	88159	47000	0,533	0,77	291	3,30	0,03	132000	1,5	0,007	0,81
12. Oct	17802	21990	42083	81875	49000	0,598	0,86	305	3,73	0,04	140000	1,7	0,009	0,91
13. Oct	2098	35558	27815	65471	33000	0,504	0,72	299	4,57	0,05	141000	2,2	0,011	0,78
14. Oct	42018	13602	6710	62330	46000	0,738	1,06	305	4,89	0,05	131000	2,1	0,011	1,12
15. Oct	36590	32401	22750	91741	59000	0,643	0,92	345	3,76	0,04	167000	1,8	0,009	0,97
16. Oct	40991	27407	47385	115783	46000	0,397	0,57	350	3,02	0,03	149000	1,3	0,006	0,61
17. Oct	7125	14220	12564	33909	52000	1,534	2,20	306	9,02	0,09	133000	3,9	0,020	2,32
18. Oct	47665	9598	38142	95405	37000	0,388	0,56	323	3,39	0,04	140000	1,5	0,007	0,60
19. Oct		44325		44325	45000	1,015	1,46	301	6,79	0,07	83000	1,9	0,009	1,54
20. Oct	42476	22147	3335	67958	45000	0,662	0,95	362	5,33	0,06	108000	1,6	0,008	1,02
21. Oct	35375	8636	57108	101119	43000	0,425	0,61	329	3,25	0,03	90000	0,9	0,004	0,65
22. Oct		41821	22126	63947	51000	0,798	1,15	309	4,83	0,05	88000	1,4	0,007	1,20
23. Oct	55243	5660	20822	81725	40000	0,489	0,70	295	3,61	0,04	117000	1,4	0,007	0,75
24. Oct	29982	5500	53738	89220	41000	0,460	0,66	318	3,56	0,04	116000	1,3	0,007	0,70
25. Oct	30950	60118	11535	102603	52000	0,507	0,73	306	2,98	0,03		0,0	0,000	0,76
26. Oct	21095	4150	56029	81274	39000	0,480	0,69	293	3,61	0,04		0,0	0,000	0,73
27. Oct		63232	40311	103543	72000	0,695	1,00	314	3,03	0,03		0,0	0,000	1,03
28. Oct	72666		30313	102979	37000	0,359	0,52	336	3,26	0,03	180000	1,7	0,009	0,56
29. Oct	17011	19948	24559	61518	43000	0,699	1,00	308	5,01	0,05	150000	2,4	0,012	1,07
30. Oct	28112	4387	54170	86669	47000	0,542	0,78	324	3,74	0,04	155000	1,8	0,009	0,83
31. Oct			35796	35796	40000	1,117	1,61	299	8,35	0,09	130000	3,6	0,018	1,71
Total	919063	493046	906065	2318174	1374000	21,58169	31,01	9062	183,00	1,92	3980000	76,8	0,384	33,32
Average	36762,52	22411,18182	30202,16667	74779,80645	44322,58065	0,59	0,85	302,06667	4,04	0,04	142142,85714	1,90	0,009	0,90

Cross Media Effects

No relevant cross media effect is known.

Technical Considerations relevant to Applicability

This measure is applicable to all the textile finishing industries. The water flow meters should be selected carefully. Most of the times, the water flow meters malfunction due to water quality issues. The electromagnetic type water flow meters are preferred due to their durability whereas the impeller type flow meters malfunction due to clogging and scaling. The electromagnetic type flow meters are expensive than impeller type. The price of the flow meter depends upon its type and size.

Economics

The direct calculation of the benefits from the implementation of water flow meters is not possible. However, the monitoring is usually associated with significant savings of water and energy, especially directly after the implementation of water meters.

Driving Force for Implementation

- Financial benefits
- Resource conservation
- Sustainability of textile business

Reference Industry

- Kohinoor Mills Limited, Raiwind Manga Road, Lahore
- The Crescent Textile Mills Limited, Sargodha Road, Faisalabad
- Nishat Chunian, Raiwind, Lahore
- Abdur Rehman Corporation, Khurrianwala Road, Faisalabad
- Sarena Textile Industry Pvt. Ltd, Sheikhupura Road, Lahore
- Klash Private Limited, Faisalabad

14 Counter-current Washing in Wash Boxes (Compartments)

Figure-19: Wash boxes of continuous pre-treatment machine for woven fabric in counter-current washing mode

Technical Description

In the woven fabric textile finishing industries, fabric is washed in number of wash boxes in the continuous machines. Generally the wash boxes of the machine vary from two to eight. Following are the continuous machines where fabric is washed in wash boxes:

- Pre-treatment (washing for desizing, scouring, bleaching)
- Mercerization
- Washing after pad steam dyeing
- Soaper machine (soaping and washing after printing)
- Washing machines for washing of fabric after cold pad batch dyeing or fabric printed with reactive or vat dyestuffs

The latest machines are designed on counter-current washing mode in which all the wash boxes are interconnected, and washing water of one wash box is used in the other wash box (See Figure-19). In the counter-current washing mode, water and energy consumption is reduced substantially. The locally manufactured machines are often not designed on counter-current washing mode where each wash box is operated independently with supply of water in the wash box which is heated through steam and then wasted as overflow water. There is substantial amount of water and energy consumption in such type of arrangement. Counter-current washing is based upon the principle that the dirty fabric is in contact with dirty water and clean fabric is in contact with clean water because the fabric and water move counter-currently.

In some cases, even though machine is provided with counter-current washing arrangement but operators disconnect this arrangement and operate machine without counter-current sequence due to their own ease of operation.

It is resource efficient way to operate machines on counter-current washing mode to save water and energy. In the counter-current washing mode, the hot washing water of one box is transferred to other wash box and so on. In this way, water and energy of one wash box is utilized in the adjoining wash box.

Achieved Environmental Benefits

- Water conservation
- Reduction in thermal energy (hot water will require less steam for heating)
- Reduction in greenhouse gases
- Reduction in hydraulic load of wastewater treatment plant

Operational Data

The quantity of water and energy reduction will vary from industry to industry depending upon number of wash boxes, flow rate of water supply, temperature of washing water and operational frequency of the machine. In Table-3 below, specific water consumption figures for different continuous washing processes are compiled which can be achieved in practice by applying counter-current washing, efficient washing boxes and machine-specific daily monitoring of water consumption.

	Specific water consumption [L/kg]	
Processes for woven fabric if not otherwise indicated	**Total**	**of which hot water**
Pretreatment processes		
Washing for desizing	3 - 4	3 - 4
Washing after demineralizing	2 - 3	2 - 3
Washing after scouring	4 - 5	4 - 5
Washing after bleaching	4 - 5	4 - 5
Washing after cold bleaching	4 - 6	4 - 6
Washing after mercerisation		
- Washing to remove NaOH	4 - 5 (hot)	4 - 5
- Neutralisation without drying	1 - 2 (cold)	n/a
- Neutralisation and drying	1 - 2 (warm)	< 1
Washing after dyeing		
Reactive dyestuffs 0-5 g/l	8 - 10	4 - 5
Reactive dyestuffs 5.1-20 g/l	10 - 12	5 - 7
Reactive dyestuffs 21- 50 g/l	12 - 14	7 - 10
Reactive dyestuffs > 50 g/l	14 - 20	10 - 14
Vat dyestuffs	8 - 12	3 - 7
Sulphur dyestuffs	18 - 20	8 - 10
Naphtol dyestuffs	12 - 16	4 - 8
Washing after printing		
Reactive dyestuffs	15 - 20	12 - 16
Vat dyestuffs	12 - 16	4 - 8
Naphtol dyestuffs	14 - 18	6 - 10
Disperse dyestuffs	12 - 16	4 - 8

Concerning "Washing after dyeing", the concentration g/L refers to the dyestuff concentration of the padding liquor

Source: Schönberger, H.; Schäfer, T., Best Available Techniques in Textile Industry, UBA-Texte 14/03,

https://www.umweltbundesamt.de/sites/default/files/medien/publikation/long/2274.pdf

all figures up-dated in November 2020

Cross Media Effects

No relevant cross media effect is known.

Technical Considerations relevant to Applicability

In case if the wash boxes of the machine are already placed in such a way that gradient exists for water flow from one box to other, then, the only thing will be to connect these boxes with each other. In case where wash boxes of the machine are placed at a same floor level and there is no such gradient, the machine's boxes will have to be relocated to create gradient for flow.

Economics

Capital cost = USD 13,330 (PKR 2 million)
Annual saving = USD 191,260 (PKR 28.69 million)
Annual O&M cost = zero
Simple payback period = 1 month

Additional benefit will be the reduction in hydraulic load and treatment cost of wastewater treatment plant,

Driving Force for Implementation

- Financial benefits
- Resource conservation
- Sustainability of textile business

Reference Industry

This option is relevant for all the woven fabric textile finishing industries where continuous washing of fabric is carried out in different machines as mentioned above.

15 Heat Recovery from Hot Wastewater

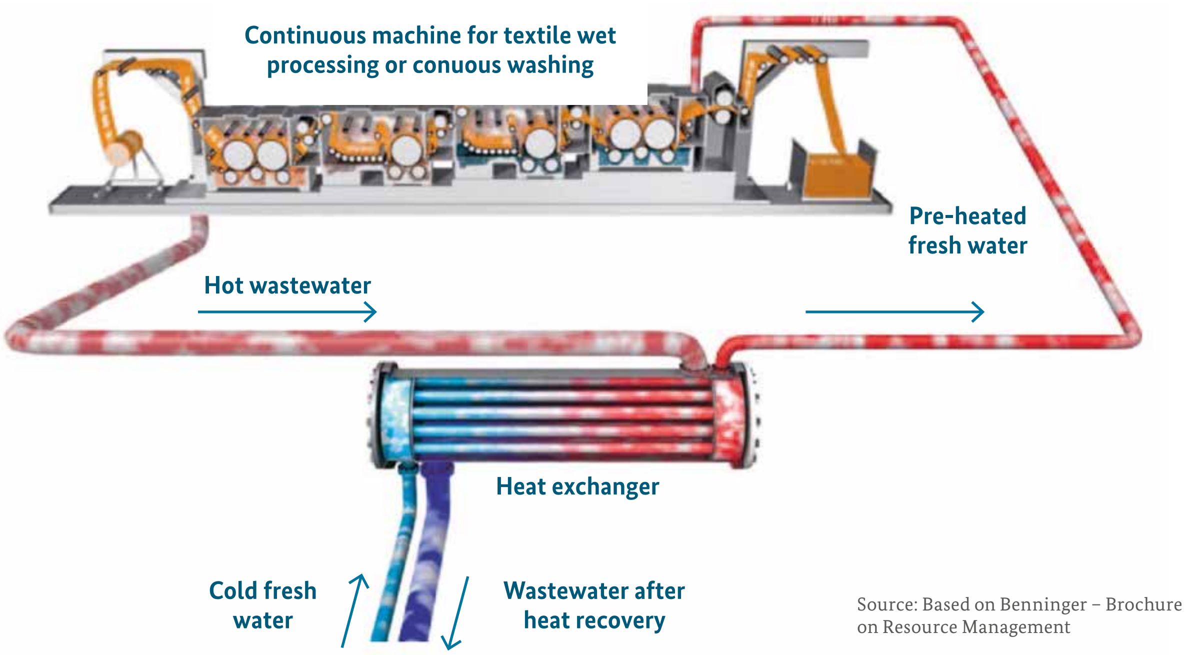


Figure-20: Scheme for the recovery of heat from wastewater directly at the machine

Technical Description

Extensive hot washes are carried out in the textile finishing industries to wash impurities, undesired chemicals and unfixed dyes and pigments. Hot wastewater from these washes contain substantial amount of thermal energy which costs millions of rupees per year.

These wastewater streams are discharged at a temperature of 60-95oC from various processes, given as under:

- Desizing washing water
- Scouring and bleaching washing water
- Mercerization hot washing water
- Dyeing hot washing water discharge
- Continuous washing of cold pad batch-dyed fabric or fabric printed with reactive dyestuffs or vat dyes
- Hot washing water discharge from exhaust dyeing
- Washing water from soapers

Thermal energy from the wastewater streams can be recovered. It is not practicable to recover energy from all the wastewater streams but there are few streams from where energy can be recovered effectively. Major factors for evaluating the viability and effectiveness of heat transfer are the temperature and the flow of the stream under consideration.

Thermal energy of the hot washes can be recovered by installing plate type or shell and tube type heat exchanger (shell and tube heat exchangers are a bit less efficient compared to plate type heat exchangers but need much less maintenance). For the implementation of this option, hot washes are first collected in a small covered storage tank. It is then pumped into the heat exchanger while passing through the strainer, in the tube side, whereas fresh water, which will be heated and used as hot water in the process, flows in the shell side (in case of shell and tube type heat exchanger). The fresh water is heated and used in the washings. Under such arrangement, less quantity of steam will be required to heat up the washing water up to the required temperature as it is already hot.

Also hot wastewater from the machine can be directly fed into the heat exchanger while passing through the strainer instead of first collecting in the storage tank and then pumped to the heat exchanger.

Figure-20 above shows the scheme for recovering heat from hot wastewater directly at the machine. This is most efficient as the temperature difference between fresh water and wastewater is maximum.

Figure-21 below show two examples for recovering heat from wastewater directly at the machine.

Figure-21: Shell and tube heat exchanger directly installed at continuous pre-treatment machines (two different machines)

In case of retrofitting existing textile finishing industries with heat recovery from wastewater, due to limited space or other circumstances, heat recovery can be carried out for composite wastewater. This is a compromise as the temperature difference between fresh water and composite wastewater is much less. The Figure-22 & 23 below show for heat recovery from composite textile wastewater.

- a central plate heat exchanger with prior sieve as plate heat exchangers can get quickly clogged by fibers
- central disc heat exchanger

On the left hand side the plate heat exchanger, and on the right hand side the sieve to remove course fibers

Figure-22: Plate heat exchanger for heat recovery from composite textile wastewater

Figure-23: Disc heat exchanger for heat recovery from composite textile wastewater

Note: There are five disc heat exchangers in parallel for about 3500 m3/d wastewater

Achieved Environmental Benefits

- Reduction in thermal energy (preheated process water will require less steam for heating)
- Reduction in greenhouse gases (reduction in fuel consumption due to less steam demand in the process)
- Reduction in wastewater temperature which will enhance efficiency of the wastewater treatment plant

Operational Data

The energy contents of hot wastewater will vary from industry to industry. It depends upon the quantity and temperature of the wastewater. For typical industry, the value of the energy of the hot wastewater from pretreatment machine, is USD 86,660/yr (PKR 13 million/yr). About 70% of this energy can be recovered by installing heat exchanger. The energy of the value of USD 60,000/yr (PKR 9 million/yr) can be saved.

Before exchanger, well-designed fibers/fluff removal device will be installed to protect the exchanger against clogging and mal-functioning. Tube and shell heat exchangers need much less maintenance as they clog much more slowly whereas plate heat exchangers tend to clog rapidly.
Cross Media Effects

No relevant cross media effect is known.

Technical Considerations relevant to Applicability

This measure is applicable to all the textile finishing industries where hot washes are carried out. This measure does not require any major intervention in the process, no major infrastructure development and no technical human resource requirement. The hot wastewater discharge pipeline will be connected to the tube side of the heat exchanger via rotary filter or strainer (for shell and tube heat exchanger). The filter will be important to remove fluff coming with the wastewater. Daily cleaning of filter will be essential for effective operation of the heat exchanger. The fresh water line will be connected to the shell side of the exchanger. The outlet of the fresh hot water can be connected to different machines or to hot water storage tank for use at different places.

The implementation cost will be USD 10,000 (PKR 1.5 million) for the heat exchanger, pump and pipelines.

Economics

Capital cost = USD 10,000 (PKR 1.5 million)
Annual saving = USD 60,000 (PKR 9 million)
Annual O&M cost = USD 4,000 (PKR 600,000)
Simple payback period = 2 month

Driving Force for Implementation

- Financial benefits
- Resource conservation

Reference Industry

- Kohinoor Mills Limited, Raiwind Manga Road, Lahore
- Abdur Rehman Corporation, Khurrianwala Road, Faisalabad
- Nishat Chunian, Raiwind Manga Road, Lahore
- Sarena Textile Industry Pvt. Ltd, Sheikhupura Road, Lahore

16 Pre-treatment and Dyeing of Cotton Knitwear in Exhaust Dyeing Machines with a very Short Process Sequence and Low Liquor Ratio

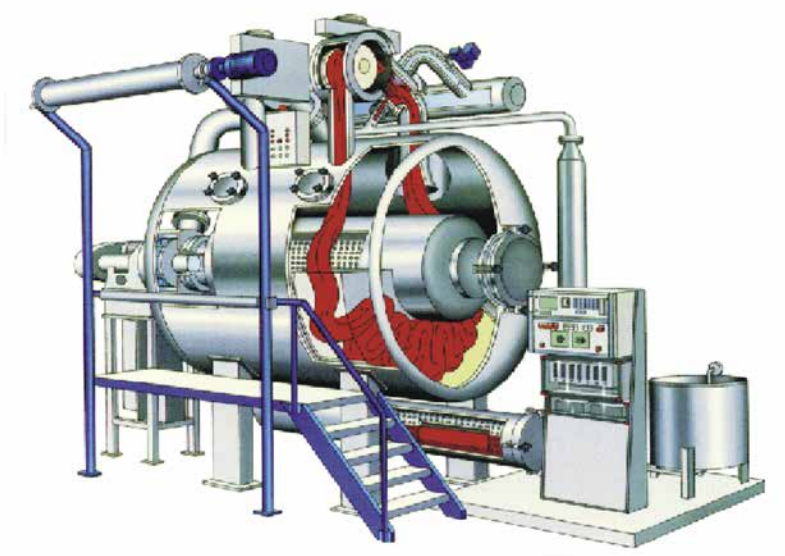


Figure-24: Scheme of an exhaust dyeing machine operated at low liquor ratio

Technical Description

In the past, the number of baths for finishing cotton knitwear in exhaust dyeing machines was considerable such as 3-4 for pre-treatment and up to 8 or 9 baths for the complete dyeing process. For more than 10 years, exhaust dyeing machines for cotton knitwear are available (see Figure-24) which are operated at low liquor ratio (LR: 3 -5 l/kg).

More recent, the number of baths could be drastically reduced down to 4 – 6 baths by means of following operating conditions:

- Pre-treatment - no discharge of the pre-treatment bath but directly dosing of dyestuffs (with prior cationic treatment) or discharge of one bath before dyeing
- After pre-treatment and dyeing – first drain
- Soaping at 60°C (commonly at boiling temperature) – second drain
- 2 rinsing baths (for few specific dyestuffs 3 rinsing baths)

Achieved Environmental Benefits

- Water conservation
- Reduction in greenhouse gases
- Reduction in hydraulic load of wastewater treatment plant

Operational Data

The very short sequence of processes (minimized number of baths) requires effective chemicals to disperse all the impurities. So far, specific information on these new chemical products is not available yet.

Cross Media Effects

Probably more chemicals have to be applied to minimize the number of baths but information on that is still limited. It is also not known whether the additional chemicals are easily or heavily or even non-biodegradable.

Technical Considerations relevant to Applicability

This measure is applicable to all the pre-treatment and dyeing of cotton and cotton/polyester knitwear in exhaust dyeing machines.

The specific operating conditions are not known yet. The same is true for dyestuffs with low fixations rates (especially phthalocyanine reactive dyes) or for dyestuffs which are more difficult to dye such as many reactive red dyes.

Economics

So far, there is no detailed information available on the economic aspects. Certainly, there will be a big advantage due to saving time, water and energy.

Driving Force for Implementation

- Financial benefits
- Resource conservation
- Sustainability of textile business

Reference Industry

Various companies in Bangladesh.