Module 6: Understanding processes and assessing energy performance of textile and garment factories

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giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

FABRIC Asia

LU 6.1: Energy Performance in Textile Process

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At the end of this module you will be able to…

Assess and conduct energy balance of textile and garments processes

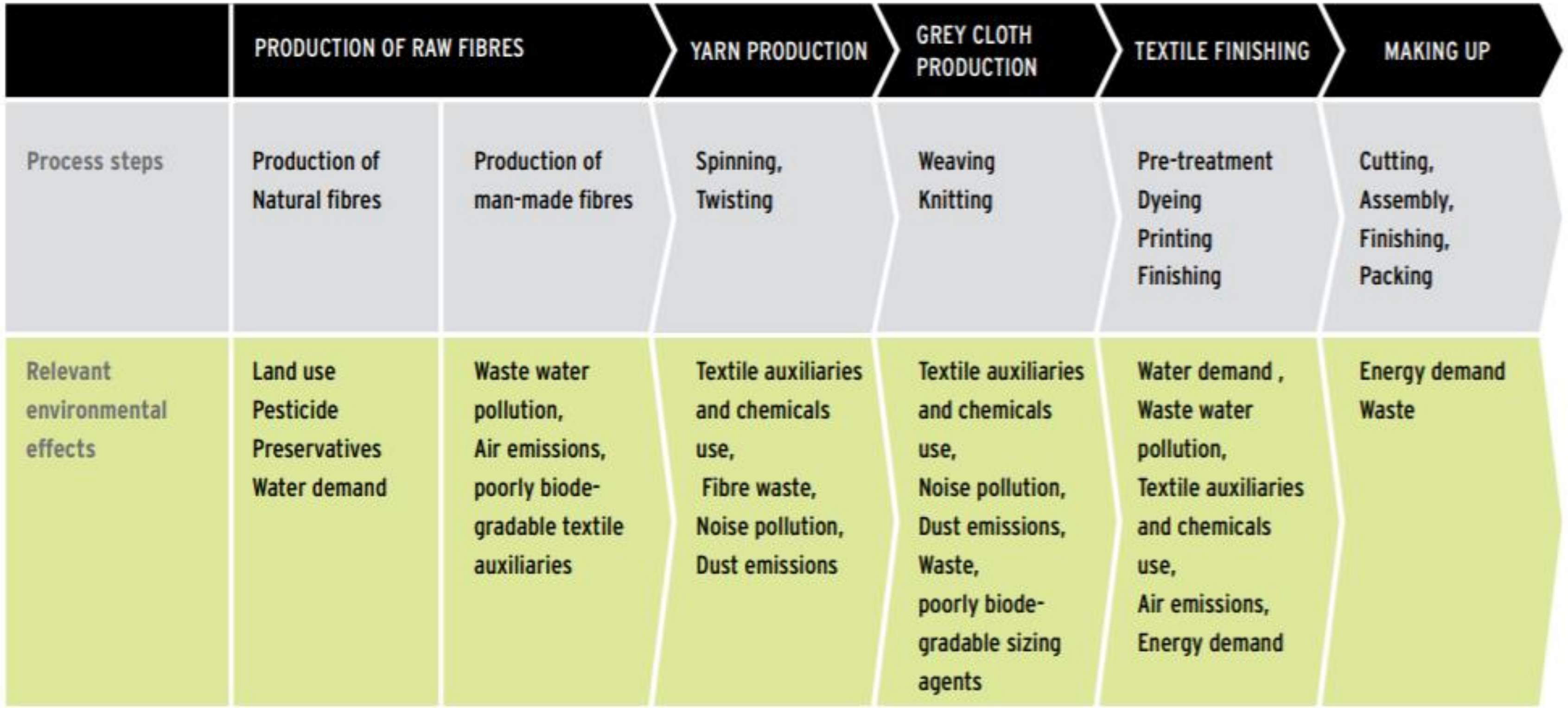
Resources

IFC Environmental, Health, and Safety Guidelines for Textile Manufacturing

Content

- Typical production and process flows in Spinning, Weaving, Dyeing, Finishing and Garment Making
- Input-output aspects
- Key performance benchmarks
- Energy balance of Textile and Garment processes
- EE Opportunities in processes

Textile Value Chain



	PRODUCTION OF RAW FIBRES		YARN PRODUCTION	GREY CLOTH PRODUCTION	TEXTILE FINISHING	MAKING UP
Process steps	Production of Natural fibres	Production of man-made fibres	Spinning, Twisting	Weaving Knitting	Pre-treatment Dyeing Printing Finishing	Cutting, Assembly, Finishing, Packing
Relevant environmental effects	Land use Pesticide Preservatives Water demand	Waste water pollution, Air emissions, poorly biodegradable textile auxiliaries	Textile auxiliaries and chemicals use, Fibre waste, Noise pollution, Dust emissions	Textile auxiliaries and chemicals use, Noise pollution, Dust emissions, Waste, poorly biodegradable sizing agents	Water demand , Waste water pollution, Textile auxiliaries and chemicals use, Air emissions, Energy demand	Energy demand Waste

Yarn manufacturing/ Spinning

YARN PRODUCTION

Spinning,
Twisting

Textile auxiliaries and chemicals use,
Fibre waste,
Noise pollution,
Dust emissions

Yarn Production

Group work

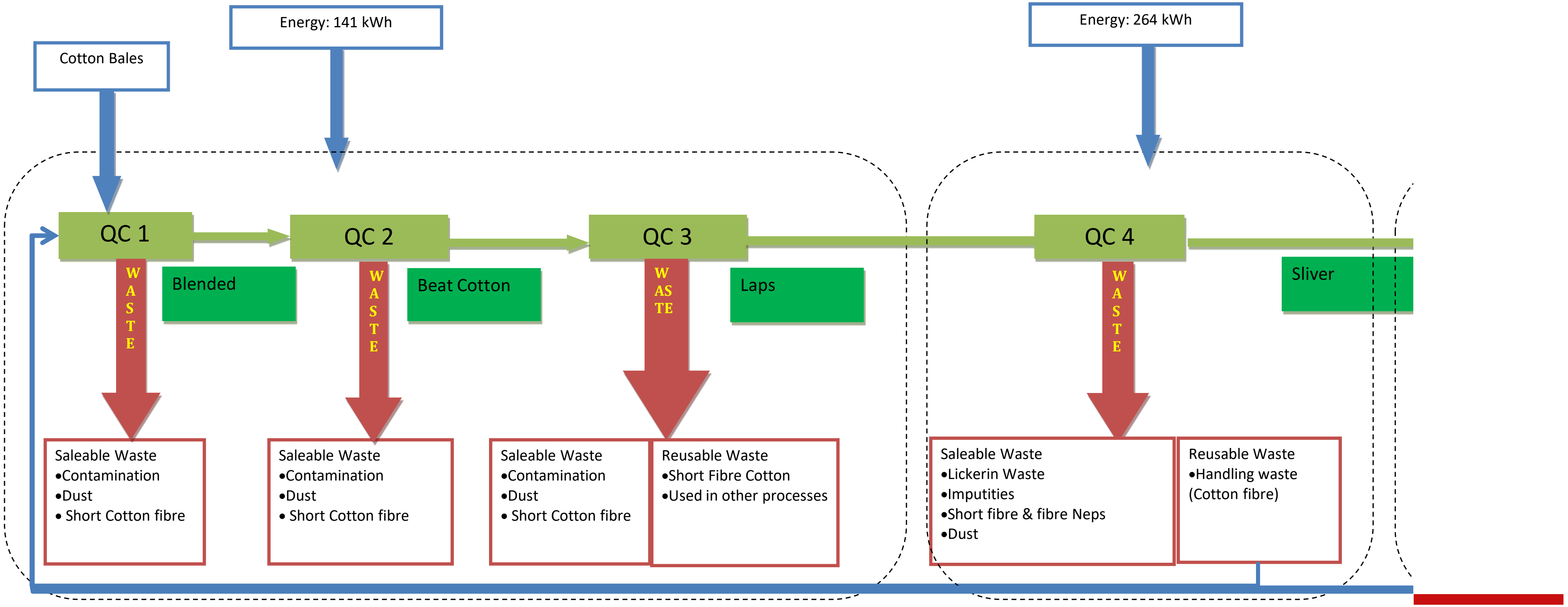
- In your groups, develop typical energy flows and losses in Yarn Production process using the I.P.O. diagram.
- Present your results on flip chart in Information Market format

- Time 15 min

Yarn Production (aka Spinning)

Example Material Flow Chart

QC 1	Mixing, Plucking, Blending
QC 2	Multimix, Beating
QC 3	Sorting, Beating, Scutcher
QC 4	Carding
QC 5	Breaker Drawing
QC 6	Finisher Drawing
QC 7	Simplex
QC 8	Ring
QC 9	Auto Cone



Cotton Bales

Energy: 141 kWh

Energy: 264 kWh

QC 1

QC 2

QC 3

QC 4

WASTE

Blended

Beat Cotton

Laps

Sliver

Saleable Waste
- Contamination
- Dust
- Short Cotton fibre

Saleable Waste
- Contamination
- Dust
- Short Cotton fibre

Saleable Waste
- Contamination
- Dust
- Short Cotton fibre

Reusable Waste
- Short Fibre Cotton
- Used in other processes

Saleable Waste
- Lickerin Waste
- Imputities
- Short fibre & fibre Neps
- Dust

Reusable Waste
- Handling waste (Cotton fibre)

Yarn Production (aka Spinning)

Example Material Flow Chart

QC 1	Mixing, Plucking, Blending
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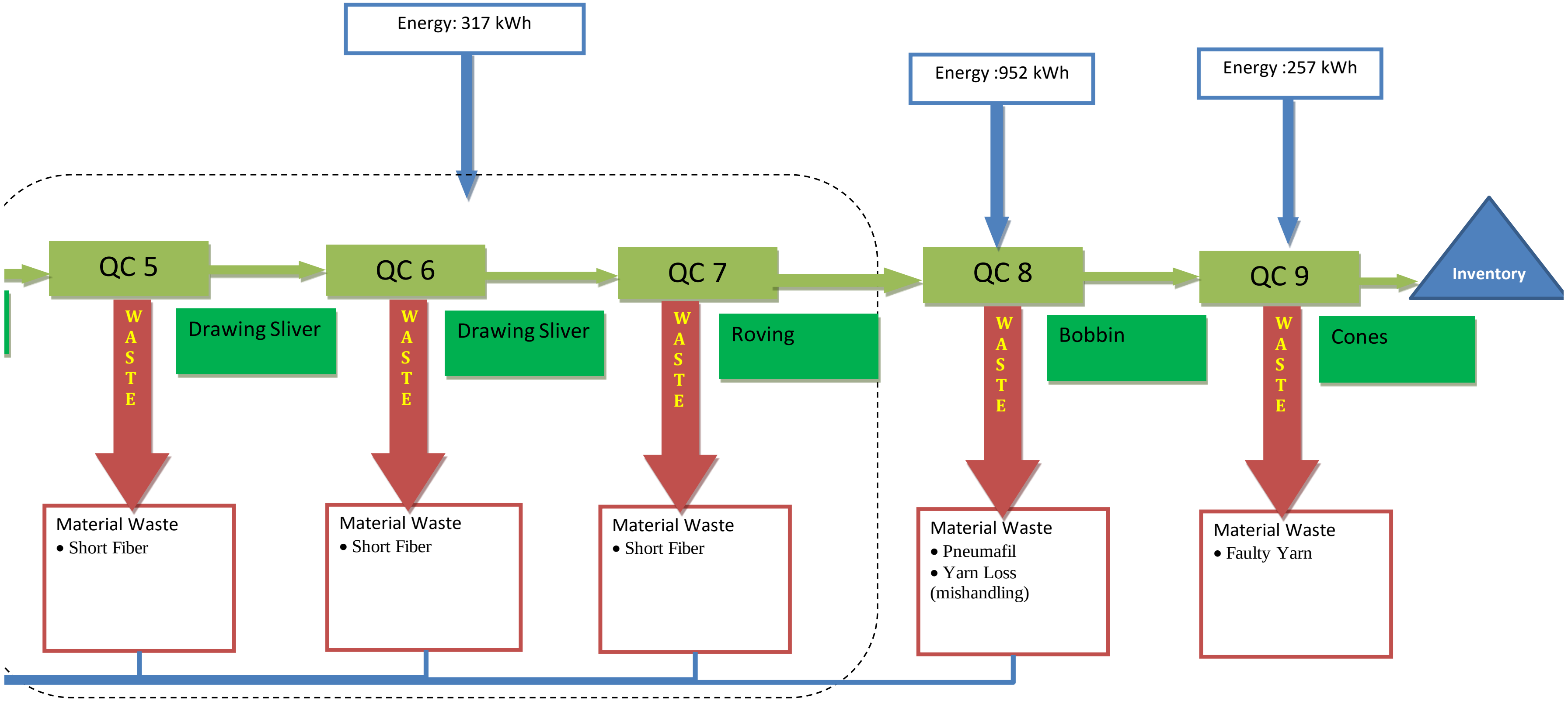


Energy: 317 kWh

Energy :952 kWh

Energy :257 kWh

QC 5

QC 6

QC 7

QC 8

QC 9

Inventory

Drawing Sliver

Drawing Sliver

Roving

Bobbin

Cones

WASTE

WASTE

WASTE

WASTE

WASTE

Material Waste
- Short Fiber

Material Waste
- Short Fiber

Material Waste
- Short Fiber

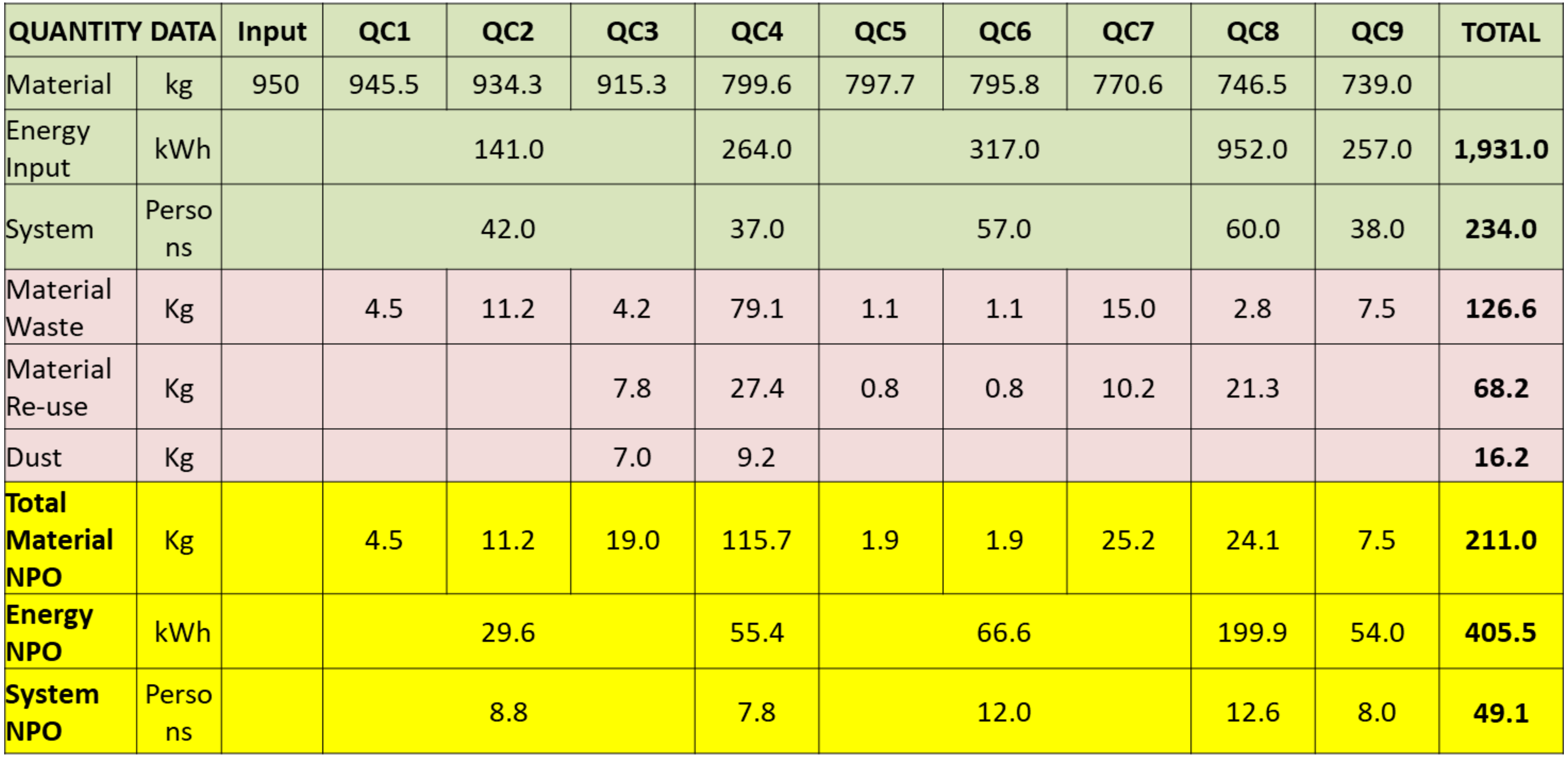
Material Waste
- Pneumafil
- Yarn Loss (mishandling)

Material Waste
- Faulty Yarn

Source: Material Flow Cost Accounting of a Spinning Mill by Espire Consult

Material Flow Cost Accounting - Spinning

Example Material Flow Chart

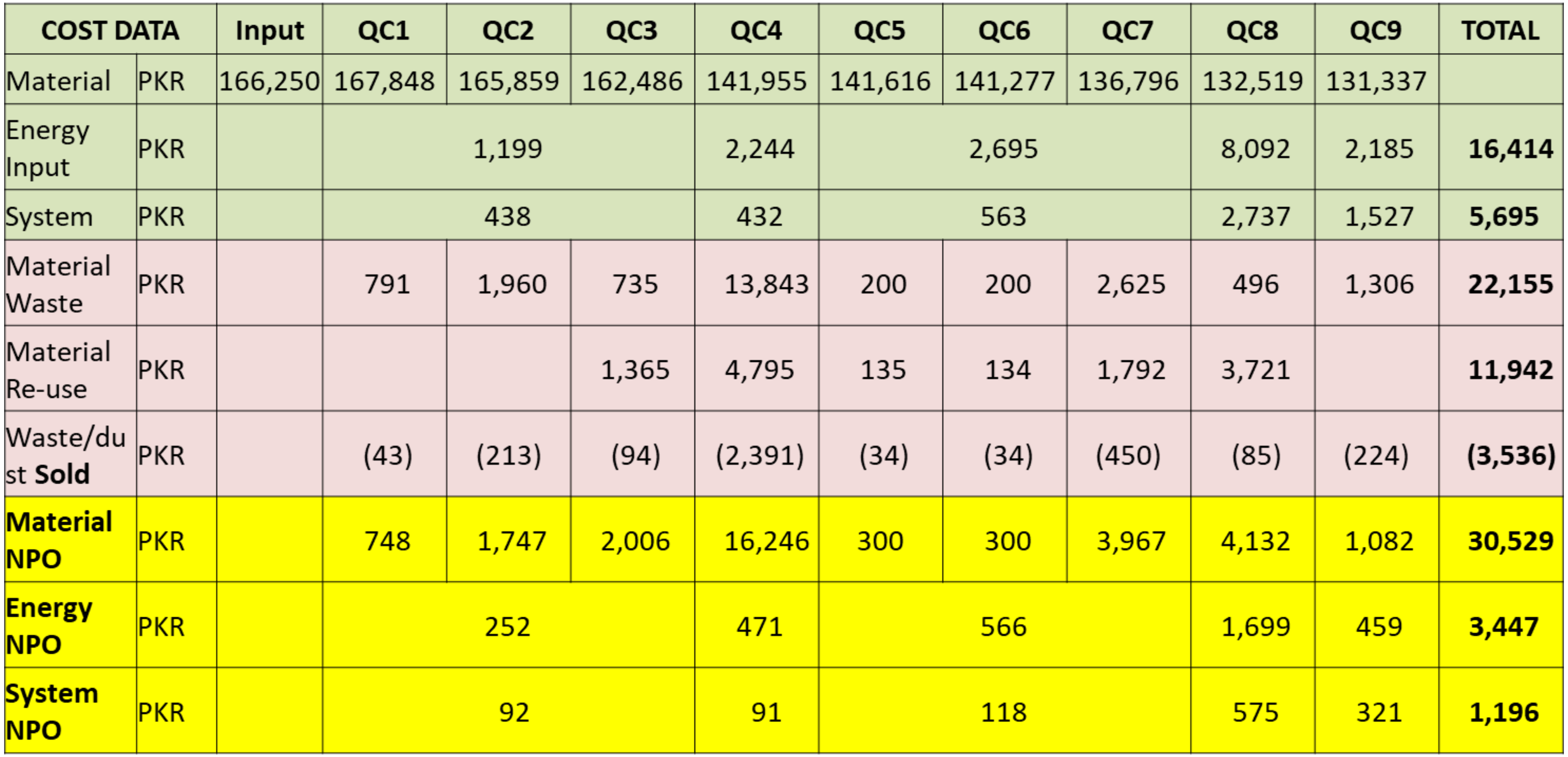


QUANTITY DATA		Input	QC1	QC2	QC3	QC4	QC5	QC6	QC7	QC8	QC9	TOTAL
Material	kg	950	945.5	934.3	915.3	799.6	797.7	795.8	770.6	746.5	739.0	
Energy Input	kWh		141.0			264.0	317.0			952.0	257.0	**1,931.0**
System	Persons		42.0			37.0	57.0			60.0	38.0	**234.0**
Material Waste	Kg		4.5	11.2	4.2	79.1	1.1	1.1	15.0	2.8	7.5	**126.6**
Material Re-use	Kg				7.8	27.4	0.8	0.8	10.2	21.3		**68.2**
Dust	Kg				7.0	9.2						**16.2**
Total Material NPO	Kg		4.5	11.2	19.0	115.7	1.9	1.9	25.2	24.1	7.5	**211.0**
Energy NPO	kWh		29.6			55.4	66.6			199.9	54.0	**405.5**
System NPO	Persons		8.8			7.8	12.0			12.6	8.0	**49.1**

Source: Material Flow Cost Accounting of a Spinning Mill by Espire Consult

Material Flow Cost Accounting - Spinning

Example Material Flow Cost Accounting



COST DATA		Input	QC1	QC2	QC3	QC4	QC5	QC6	QC7	QC8	QC9	TOTAL
Material	PKR	166,250	167,848	165,859	162,486	141,955	141,616	141,277	136,796	132,519	131,337	
Energy Input	PKR		1,199			2,244	2,695			8,092	2,185	**16,414**
System	PKR		438			432	563			2,737	1,527	**5,695**
Material Waste	PKR		791	1,960	735	13,843	200	200	2,625	496	1,306	**22,155**
Material Re-use	PKR				1,365	4,795	135	134	1,792	3,721		**11,942**
Waste/dust **Sold**	PKR		(43)	(213)	(94)	(2,391)	(34)	(34)	(450)	(85)	(224)	**(3,536)**
Material NPO	PKR		748	1,747	2,006	16,246	300	300	3,967	4,132	1,082	**30,529**
Energy NPO	PKR		252			471	566			1,699	459	**3,447**
System NPO	PKR		92			91	118			575	321	**1,196**

Source: Material Flow Cost Accounting of a Spinning Mill by Espire Consult

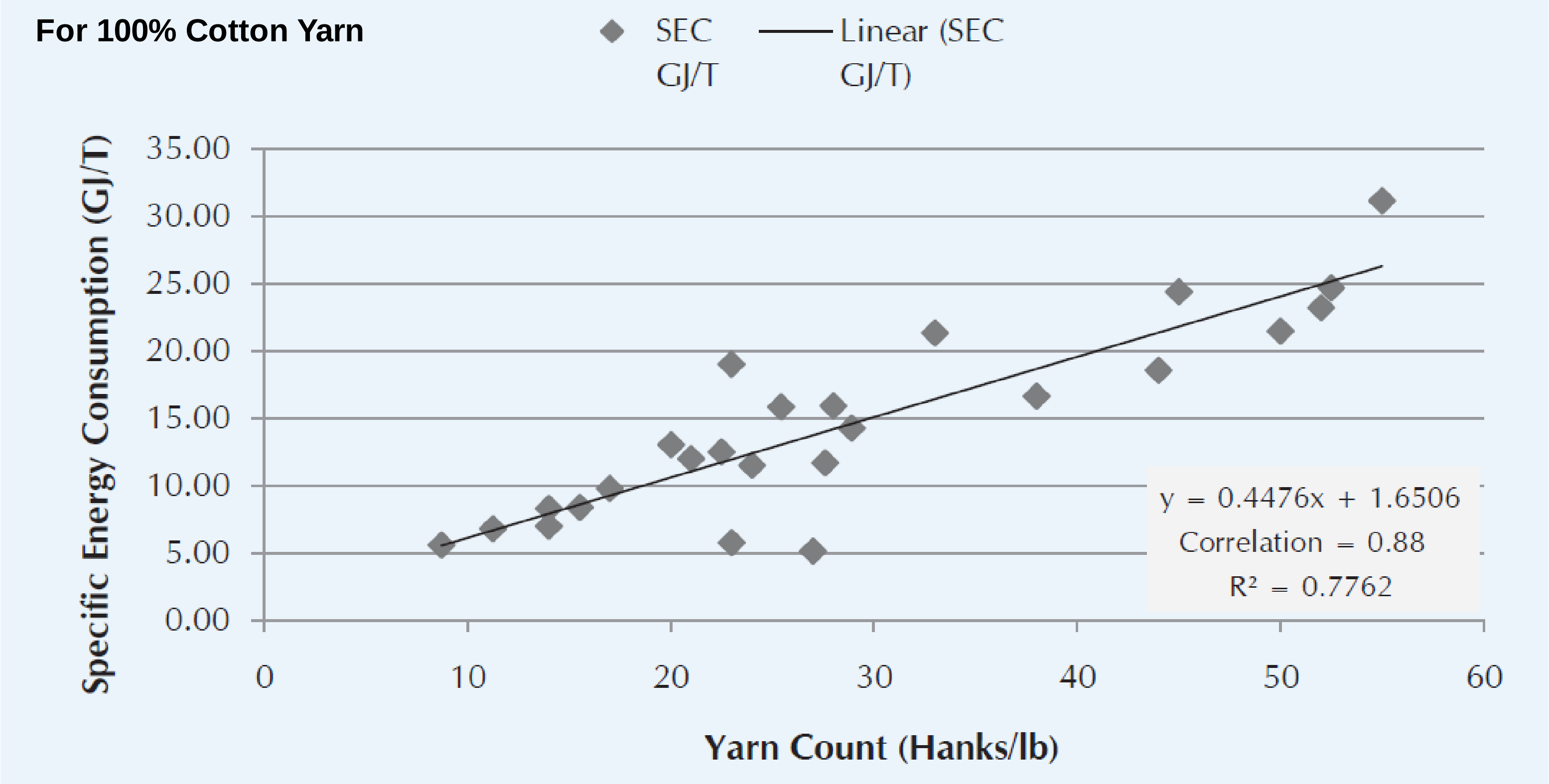
Material Flow Cost Accounting - Spinning

Example Material Flow Cost Accounting

Cost		Material	Energy	System	Disposal	Total
Product	PKR	131,337	12,967	4,499		**148,803**
	%	79%	79%	79%		**72%**
NPOs	PKR	34,097	3,447	1,196	20,331	**59,071**
	%	21%	21%	21%	100%	**28%**

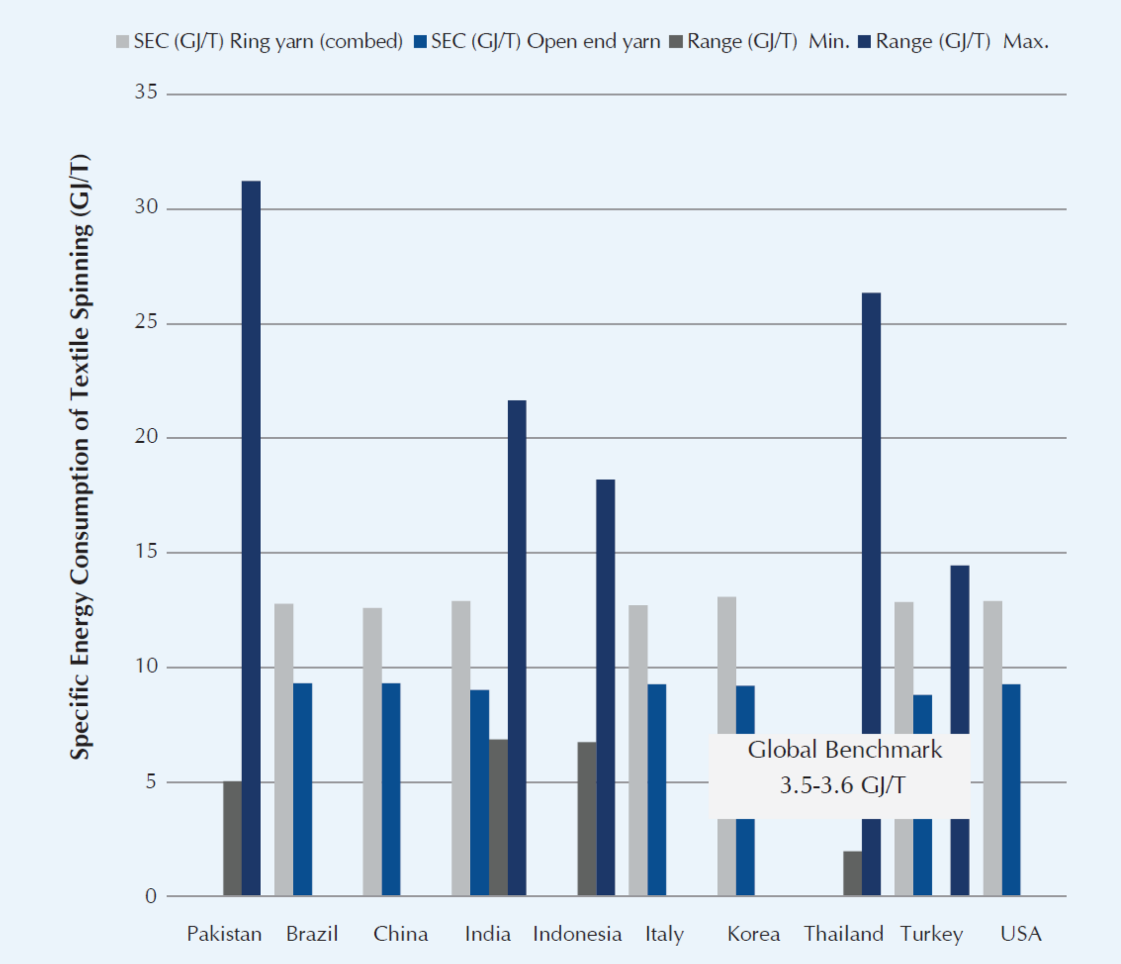
Source: Material Flow Cost Accounting of a Spinning Mill by Espire Consult

Spinning Energy Benchmarking - Pakistan



Source: UNIDO Sectoral Analysis on Renewable Energy and Energy Efficiency in Pakistan (2019)

Spinning Energy Consumption Ranges

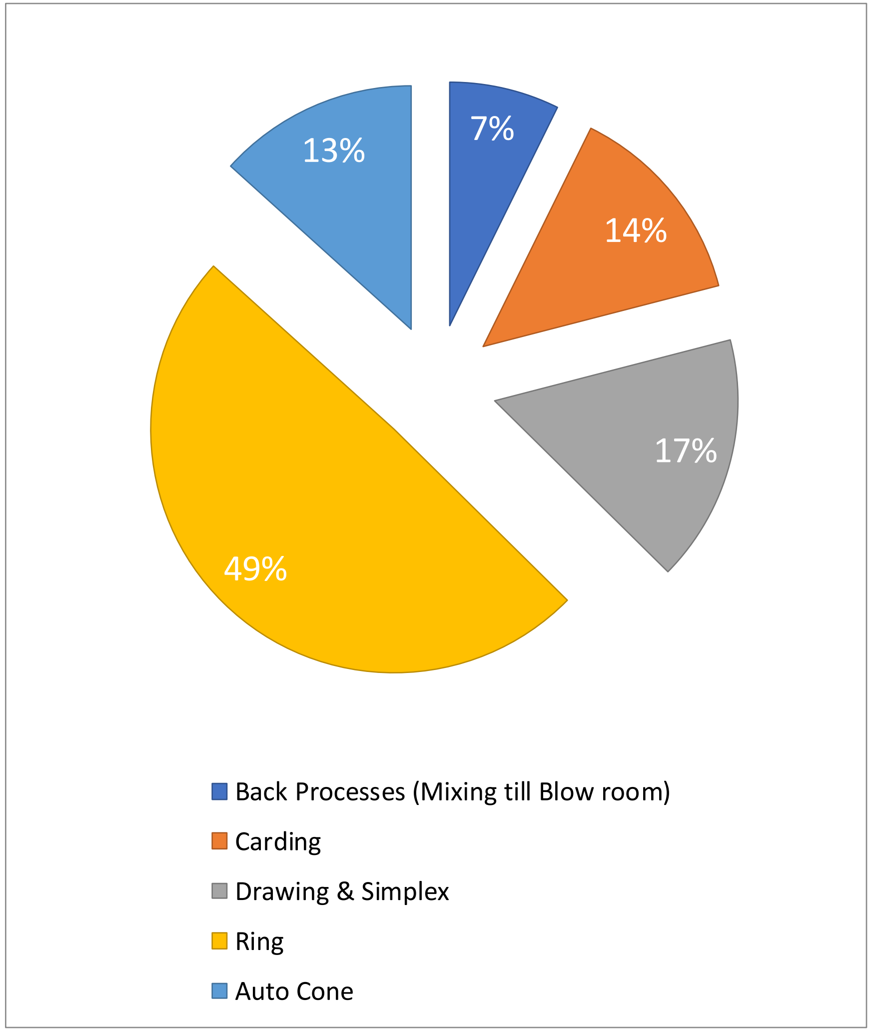


Source: UNIDO Sectoral Analysis on Renewable Energy and Energy Efficiency in Pakistan (2019)

Energy Balance of a Spinning Process

Example Energy Balance

- Main Energy type: Electrical Power
- Major utility: Compressed Air and Humidification Plant
- Largest consumer of energy : Ring Frames



Source: Material Flow Cost Accounting of a Spinning Mill by Espire Consult

Yarn Production

Energy Performance Improvement Options

- Compressed air system
    - ✓ Demand side Pressure optimization
    - ✓ Leakage reduction
- Ventilation and Humidification Plant
    - 3-5% positive pressure between supply and exhaust air
    - Automated controls of humidification system
        - ✓ Optimization of Supply and Return Fans e.g. FRP Fans, Air Changes..
        - ✓ Optimization of Showering System e.g. Fogging System, Humidity feedback control…
- Machinery
    - ✓ Automation & synchronization of transportation fans in blow room
    - ✓ Avoiding fluff accommodation in machines to reduce friction and yarn breakages (especially Ring frames and Auto Cone)
    - ✓ Automation of machine speed according to yarn tension and loading in Ring frames

Textile Weaving

GREY CLOTH PRODUCTION

Weaving
Knitting

Textile auxiliaries and chemicals use,
Noise pollution,
Dust emissions,
Waste,
poorly biodegradable sizing agents

Weaving

Group work

- In your groups, develop typical energy flows and losses in Weaving process using the I.P.O. diagram.
- Present your results on flip chart in Information Market format

- Time 15 min

Weaving

- **Common Methods**
  - Power Looms
  - Water Jet Looms (mostly synthetic fibre)
  - Air jet Looms
  - Rapier Looms

Photo credit: M. Salman Butt, Espire Consult

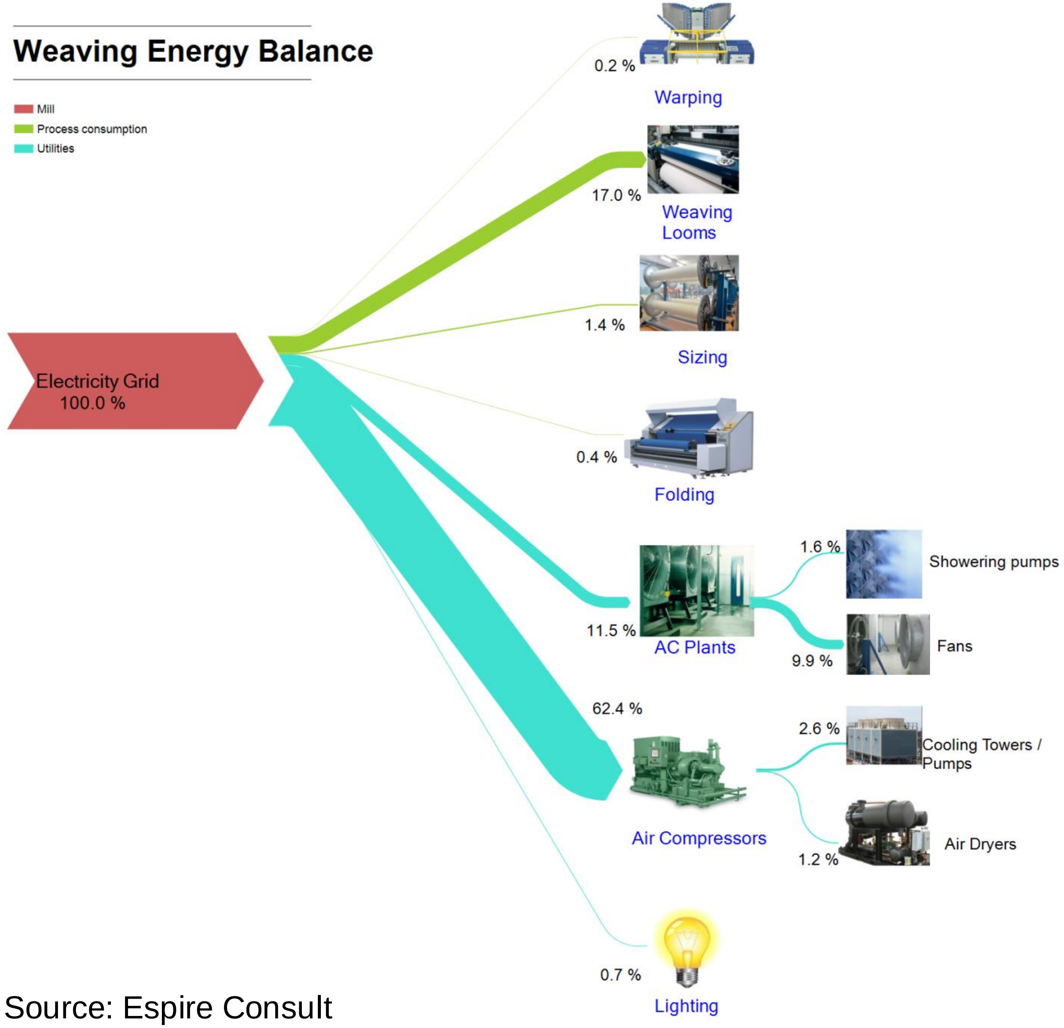
- **Air Jet Loom Application**

  Suitable for
  - plain and textured fabrics
  - fine high density fabrics
  - High speed bulk production

- **Rapier Loom Application**

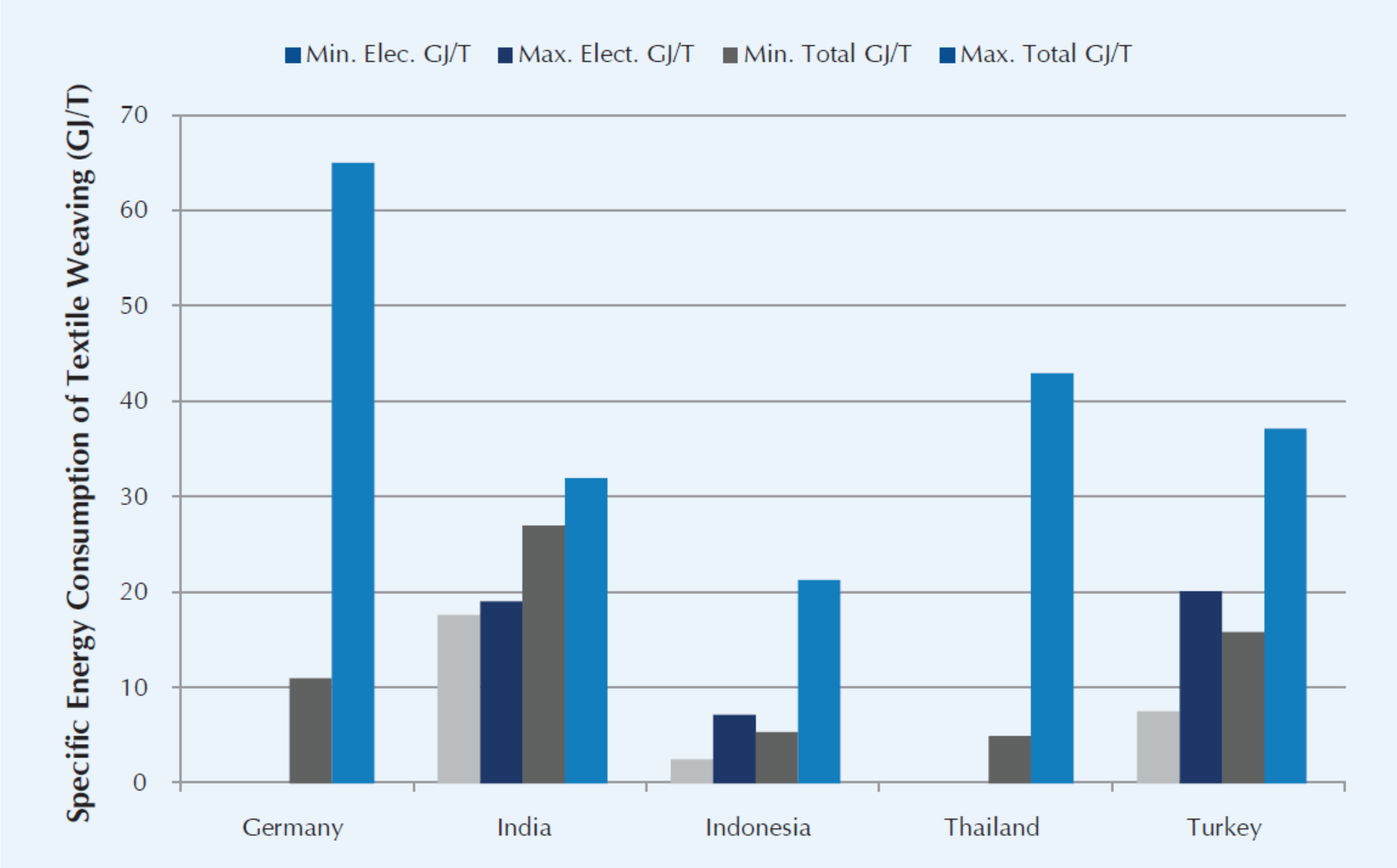
  Suitable for
  - multi-color weft fabrics
  - yarn-dyed fabric
  - double-layered velvet fabrics
  - terry fabrics
  - decorative fabrics
  - Much slower than air jet loom
  - Moderate energy consumption

Energy Balance – Example (Weaving)



Source: Espire Consult

Weaving Energy Consumption Ranges



Source: UNIDO Sectoral Analysis on Renewable Energy and Energy Efficiency in Pakistan (2019)

Energy Efficiency Options in Air Jet Looms

- Control Air Leakages in looms
    - ✓ Leakages up to 15-20% of total air demand have been observed
- Optimize compressed air pressure according to yarn count
    - ✓ Mostly, higher air pressure is provided to cover for pressure loss due to leakages; hence inducing more leakages
- Automate the air conditioning parameters based on real-time temperature, and humidity
    - ✓ Don’t forget to adjust air changes according to number of machines operating in the area; and temperature and humidity conditions
- Maintain Air Balance among Supply and Return air
    - ✓ Maintaining positive displacement (~3-5%) facilitates fluff removal from air, reducing fluff accumulation in the looms hence maintaining energy performance
- Production Planning
    - ✓ Improve machine up-time to improve energy performance

Common Air Leakages in Air Jet Looms
Relay Valve
Tuck Inn
Suction Mouth
Pre-winder
Internal PVC Link Pipes

Textile Wet processing

TEXTILE FINISHING

Pre-treatment
Dyeing
Printing
Finishing

Water demand ,
Waste water pollution,
Textile auxiliaries and chemicals use,
Air emissions,
Energy demand

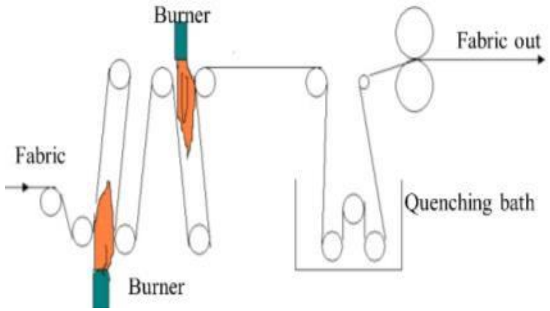
Fabric Wet Processing and Finishing

Pre-treatment	Dyeing & Printing	Finishing
Shearing	**Dyeing**	**Stenter**
Combing	**Printing**	**Water proofing**
Singeing, Desizing		**Wrinkle free treatment**
Scouring and Bleaching or Solomatic Bleaching		**Softening treatment**
Washing		**Flame retardancy treatment**
Mercerising, Drying		**Odour resistance treatment**
Stenter		**Oleophobic treatment**
Shrinking		**Biocide treatment**
		Coating

A-Fabric Pre-treatment (Open Width)

- Singeing-Desizing
- Batching
- Post Desizing Wash
- Scouring
- Bleaching
- Washing
- Drying
- Mercerizing (If cotton dyeing is required)

Singeing



Methods

- Direct Flame application on fabric
- Passing fabric over a Heated Copper Plates/rollers

Energy Efficiency Options

- Controlling flame size and fabric roll speed
- Variable Flame Width
- Improve burner efficiency
- Recover and reuse cooling water

Parameter	**O2**	**CO**	**NOx**	**NO**	**NO2**	**CO2**	**SO2**	**Flue Temp.**
	%	**ppm**	**ppm**	**ppm**	**ppm**	**%**	**ppm**	**◦C**
Standard (PEQs)		**649**	**195**				**603**	
New Singeing Machine	**19.22**	**145**	1.2	0	1.2	**0.99**	0	139

De-sizing

If Singeing is done, De-sizing is conducted in the Singeing Quenching batch

Methods vary according to size applied

- Enzymatic (Process control!; for starched based sizes)
- Oxidative (usually for different types of textiles, applying hydrogen peroxides, caustic soda) – Rarely used
- Use of acids (sulfuric or hydrochloric acid)
- Washing out with hot water and wash soda

Energy Efficiency Options

- Waste water heat recovery
- Improving Insulation of Hot Water Baths
- Optimizing process using pH, temperature and speed with automation

Bleaching

Common methods

- Hydrogen peroxide (H2O2)
- Sodium hypochlorite (chlorine bleaching lye, NaClO)
- Sodium chlorite (NaClO2)
- Sulphur dioxide (SO2)

Energy Efficiency Options:

- Waste water heat recovery (~6m payback)
- Improved heat exchanger material (e.g. Stainless Steel) allowing longer life and reduced corrosion; hence improving heat exchanger efficiency

Mercerising

Refining process with the aim of improving tensile strength, dimensional stability and improved absorbency for consequent dyeing

Methods

- Sodium hydroxide bath with heat treatment under tension or without tension, then neutralization with an acid plus washing
- Ammonia (very rare)

Energy Efficiency Options

- Optimizing steam in-take of Drying Rollers
    - vendors claim ~14% steam saving but its not verifiable; companies have experienced improvement in process quality and control
- Waste water heat recovery
- Caustic Recovery (shown on next slide)
- Reusing Mercerising wastewater in scouring

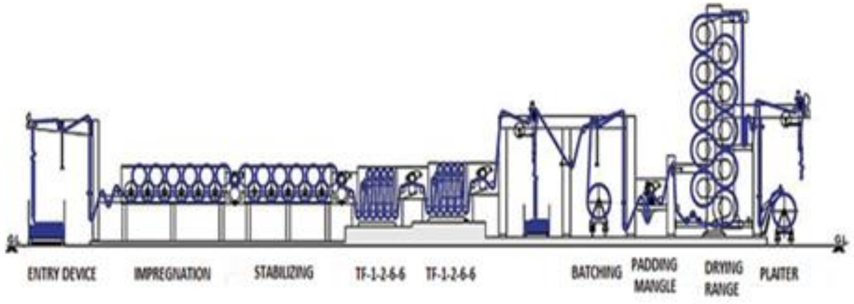
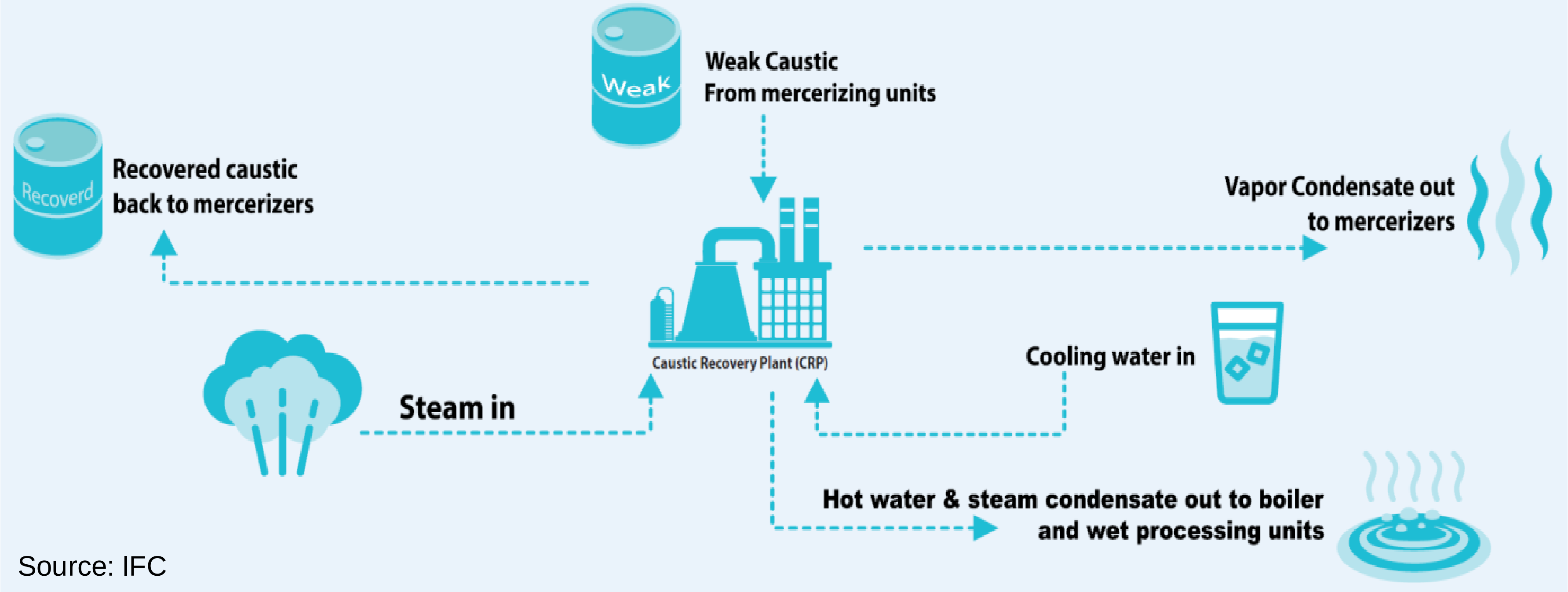


Photo Source: textiletoday.com.bd

Recovering NPOs – Caustic Recovery Plant

- NaOH is re-used in Mercerising (24 – 30 Baume)
- H_2SO_4 consumption is reduced at Effluent Treatment
- Hot water available to feed into the processes – saving steam
- Return on Investment ~ 3 years



Source: IFC

B- Dyeing

Group work

- In your groups, develop typical energy flows and losses in Dyeing process using the I.P.O. diagram.
- Present your results on flip chart in Information Market format

- Time 15 min

Dyeing approaches

- **Material dyed**
  - Twine
  - Yarn
  - Knitted / woven fabric
  - Garment
- **Process**
  - Batch
  - Continuous

- **Dyeing techniques**
  - Gel dyeing (in the production of artificial fibres)
  - Pigment dyeing (with binder)
  - Diffusion dyeing
  - Exhaust dyeing
  - Ozone dyeing
    - ✓ Ozone can be used on indigo or black sulfur fabrics.
    - ✓ Use of ozone requires up-front investment in the ozone machine and the generators, along with safety training for workers.

Fabric Dyeing

- **Cellulosic Fabric Dyeing (Cotton, Viscose, lyocell, linen, hemp etc.)**
  - ✓ Reactive Dyes
  - ✓ Temperature Required around 65 deg C for which machines work at atmospheric pressure

- **Synthetic Fabric / Blended (Polyester, PC, Nylon etc.)**
  - ✓ Disperse Dyes
  - ✓ Temperature Required Above 100 deg C for which machines work above atmospheric pressure

Fabric Dyeing

- **Batch/Discontinuous**
  - ✓ Open Width form Dyeing
    Open Jiggers and Pressure Jiggers, Beam,
  - ✓ Rope form Dyeing
    - ○ Jets, Winches, Soft flow machines / HT machines (Knitted fabric)
- **Semi Continuous**
  - ✓ Pad Batch / Cold Pad Batch (CPB)
    - ○ (For Cellulosic Materials and alternative to reactive dyeing)
  - ✓ Pad Jig
  - ✓ Pad Roll
- **Continuous**
  - ✓ Chemical Steam Pad
  - ✓ Pad Dry Steam (PDS)
  - ✓ Pad Dry Pad Steam (PDPS)
  - ✓ Pad Dry Cure (PDC)
  - ✓ Pad Thermosol Dyeing

Dyeing – Basic steps

Step 1

- Colouring agents (mostly powder form, dye) dissolved in "dye liquor" according to a given recipe
- Dyestuffs diffuse from "liquor" to the substrate

Step 2

- Dyestuff accumulates on the surface of the yarn/fabric => question of the affinity of the dyestuff to the fibre

Step 3

- Penetration of the fibre with the dye (slower than surface accumulation) => prerequisite given for hydrophilic fibres (micropores); in the case of hydrophobic fibres => heating necessary (often over 100 degrees)
- Addition of salts to overcome electrostatic surface barriers

Step 4

- Fixation of dyestuffs (heat, auxiliaries)

Benchmarks to look out for in dyeing

Liquor ratio

- Dye bath = solvent (usually water) as well as all dissolved, emulsified or dispersed components contained therein such as dyes, pigments, chemicals and auxiliaries.
- Liquor ratio (LR) = Ratio of quantity of fabrics to dyebath liquor (kg to kg or kg to liters)
- Mostly referred to in batch-dyeing
- Aim => To achieve low liquor ratios

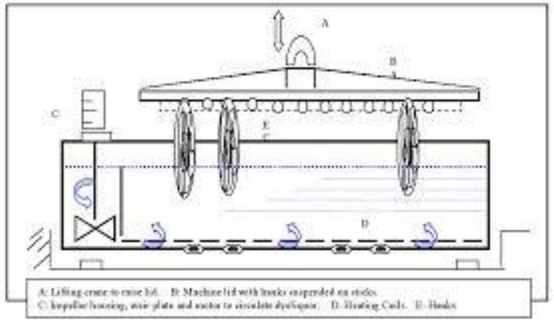
For example: 200 kg fabrics, 1400 ltr dyebath

=> LR 1:7

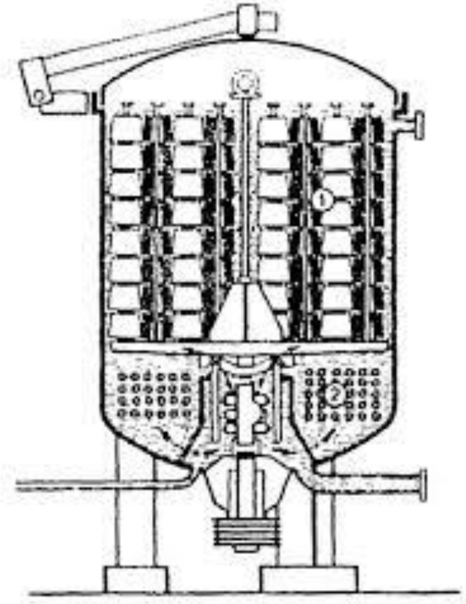
Fixation rate

- Percentage of dye used that remains on the material to be dyed.
- Different extraction rates depending on dye and process

Batch Dyeing



Hank dyeing, LR
1:12 – 1:25

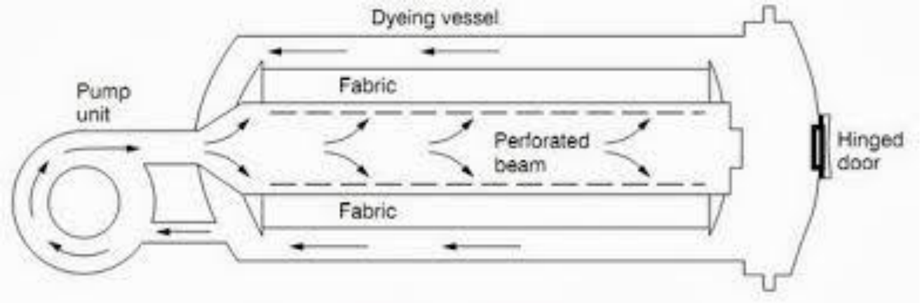


1 Yarn on package
2 Heating system (steam)

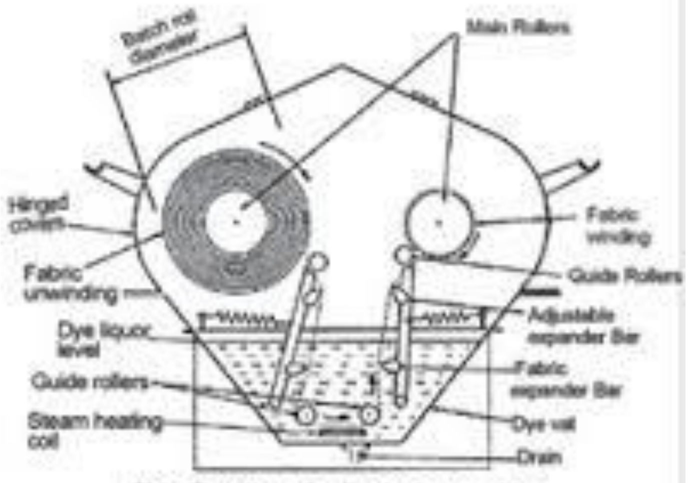
bobbin dyeing 1:8 – 1:15

Package Dyeing – Knitware

Jig Dyeing
LR 1:3 – 1:6

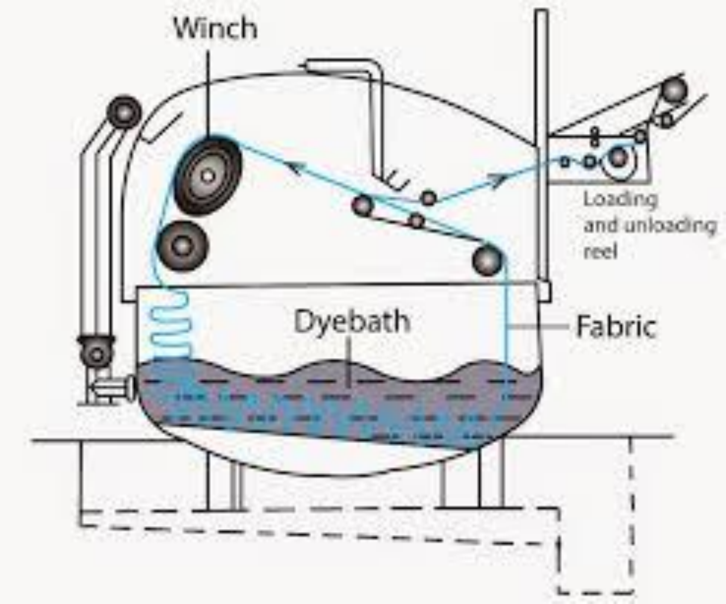


Beam dyeing)
LR 1:8 - 1:10



Side Elevation of a Jig dyeing machine

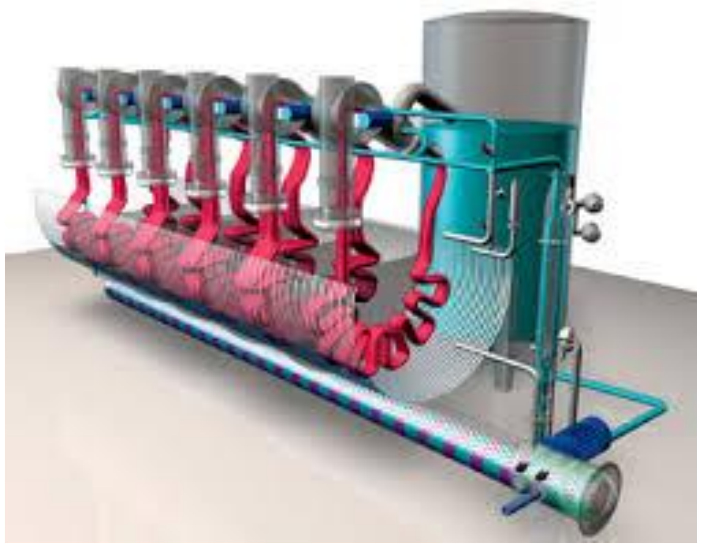
„Winch“ dyeing

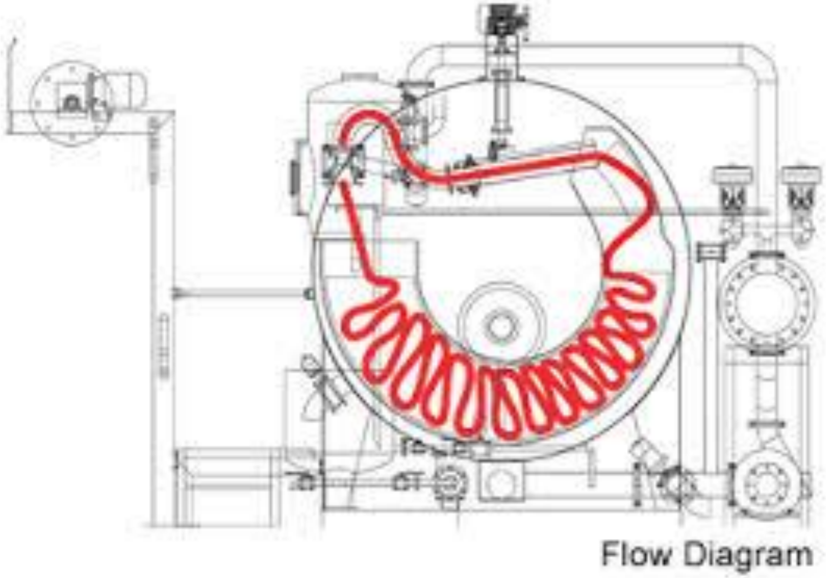


LR 1:15 - 1:40

„Jet“ Dyeing machines

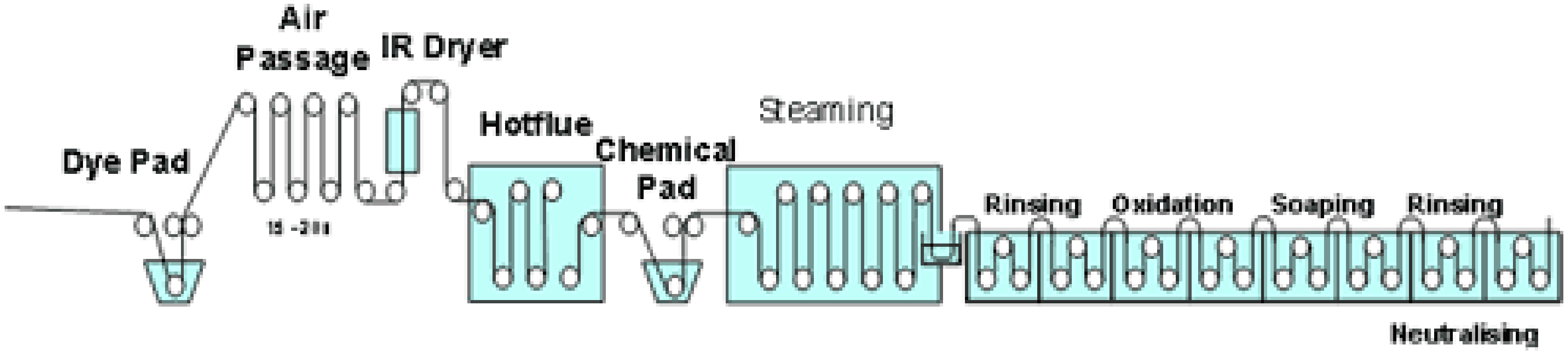
Also callsed SoftFlow Machines





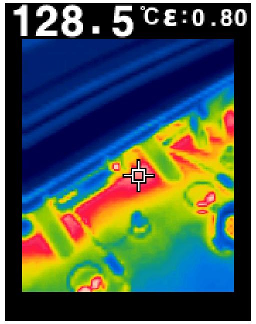
LR 1:4 - 1:10

Feed-through dying maschines



Energy Efficiency Options in Dyeing

- Using low TDS water for dyeing and post dyeing operations helps reducing
    - ✓ Dyes, chemicals and auxilliary consumption
    - ✓ Process time
    - ✓ Liquor Ratio
- Improved heat exchanger material (e.g. Stainless Steel) allowing longer life and reduced corrosion; hence improving heat exchanger efficiency
- Low Liquor Ratio and use of high fixation dyes helps reducing
    - ✓ Steam consumption
    - ✓ Water pumping cost
    - ✓ Process time → electrical energy
- Improve insulation of machine
- Wastewater heat recovery
    - ✓ Additionally, an insulated hot water storage tank might also be needed if hot water is to be used in process
- Cooling water recovery and reuse



Switching to Cold Pad Batch (CPB) instead of conventional reactive dyeing

- It is not possible to switch to cold pad batch dyeing for every reactive dyeing setup (High precision and control required)
- However, the associated benefits encourage the textile mills to put in more efforts
  - ✓Up to 50% energy consumption reduction
  - ✓Up to 50% water consumption reduction and reduced wastewater
  - ✓No use of salt, reducing the pollution load of generated wastewater
  - ✓The fabric don’t undergo abrasion so dyed fabrics have smoother surface

Question

What are the Energy benefits of reducing liquor ratio and improving fixation in dyeing?

C- Printing

Group work

- In your groups, develop typical energy flows and losses in Printing process using the I.P.O. diagram.
- Present your results on flip chart in Information Market format

- Time 15 min

Fabric Printing

- In industry 03 types of machines are used for printing the fabric
  - Rotary Printing
  - Flat bed / Panel Printing
  - Digital Printing

Fabric Printing

- **Normally fabric is printed through two methods**

  - ✓ Pigment Printing: Surface Printing where design is fixed with the help of binders and fixers. Curing is done through dry heat in curing chambers above 100 ^{o}C (depending upon the colour recipe)
  - ✓ Reactive Printing: The colour design is attached to fabric as a result of chemical reaction. Curing is done in a high temperature (close to 100 ^{o}C) moist environment. This type of fabric requires washing after printing.

Energy Efficiency Options in Printing

- **The Curing chamber is the main area of interest in which air is heated either through direct natural gas firing or indirect air hot thermal oil**
  - ✓ Automation of curing chambers through linking fans and fuel firing with exhaust moisture and temperature of each chamber
  - ✓ Heat Recovery from exhaust flue gases
  - ✓ Insulation of curing chambers

D- Finishing

- **In Textiles two types of Finishing Processes are used**
  - ✓ Chemical Finishing in Stenter Machines: Either direct firing of natural gas or indirect heating through Thermal Oil
  - ✓ Mechanical Finishing: Mostly steam is used for indirect heating at following machines
    - ▪ Calendars
    - ▪ Comfort
    - ▪ Sanforizer

D- Finishing

- **In Textiles two types of Finishing Processes are used**
  - ✓ Chemical Finishing in Stenter Machines: Either direct firing of natural gas or indirect heating through Thermal Oil
  - ✓ Mechanical Finishing: Mostly steam is used for indirect heating at following machines
    - ▪ Calendars
    - ▪ Comfort
    - ▪ Sanforizer

Stenter

Group work

- In your groups, develop typical energy flows and losses in a Stenter using the I.P.O. diagram.
- Present your results on flip chart in Information Market format

- Time 15 min

Stenter

Energy Efficiency Options:

- Modulation of Thermal Oil Heater/ Gas Burners according to temperature requirement in Stenter
  - oil temperature of +50C is required)
- Automation of stenter exhaust according to required temperature, **moisture** and feed rate of fabric
  - requires installing VFD on ID/FD Fan, and fabric moisture sensors
  - Other Benefit: Results in improved quality by reducing shade variation
- Exhaust air waste heat recovery system
  - Requires an efficient filter before the waste heat recovery system
  - CAUTION: install proper control systems to avoid fire in the filter

Photo Source: Sekkeli, Mustafa & Kececioglu, Fatih. (2012). SCADA based an energy saving approach to operation of stenter machine in a textile plant using waste heat recovery system. Tekstil ve Konfeksiyon. 03. 248-257.

Example Calculations

Parameters	Unit	Values
Calculation for 1 stenter		
Exhaust Air flow	kg/s	2.45
Stenter exhaust temperature T1	^{o}C	160
Target exhaust temperature T2	^{o}C	100
Temperature Reduction dT	^{o}C	60
Operational hours	Hours/year	7,200
Specific Heat of Air	kJ/kg-C	1
Available energy	kJ/h	[redacted]
Recoverable energy (@70% efficiency)	GJ/y	[redacted]
Coal saving per stenter	Tonne/y	[redacted]
Financial Saving per stenter	USD/y	[redacted]
Investment per stenter	USD	[redacted]
Payback period	months	[redacted]
GHG emission reduction per stenter	TonneCO2/y	[redacted]

Calorific Value of Coal	23.36	GJ/tonne
Emission factor of Coal	0.089	tCO2/GJ
Coal price	0.125	USD/kg

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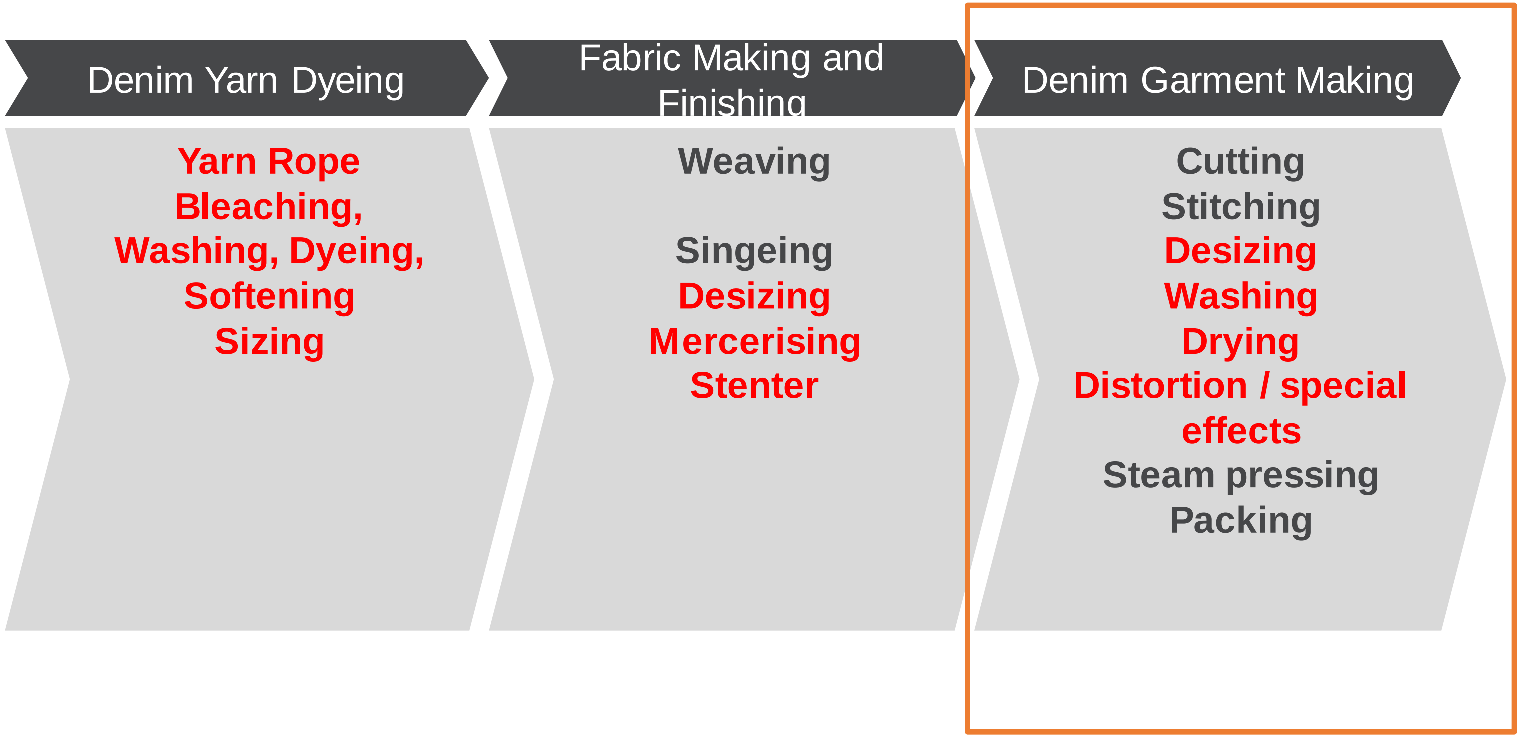
Temperature Reduction dT	^{o}C	60
Operational hours	Hours/year	7,200
Specific Heat of Air	kJ/kg-C	1
Available energy	kJ/h	529,200
Recoverable energy (@70% efficiency)	GJ/y	2,667
Coal saving per stenter	Tonne/y	143
Financial Saving per stenter	USD/y	17,838
Investment per stenter	USD	25,000
Payback period	months	17
GHG emission reduction per stenter	TonneCO2/y	298

Calorific Value of Coal	23.36	GJ/tonne
Emission factor of Coal	0.089	tCO2/GJ
Coal price	0.125	USD/kg

Garment Making



Denim Yarn Dyeing

Yarn Rope
Bleaching,
Washing, Dyeing,
Softening
Sizing

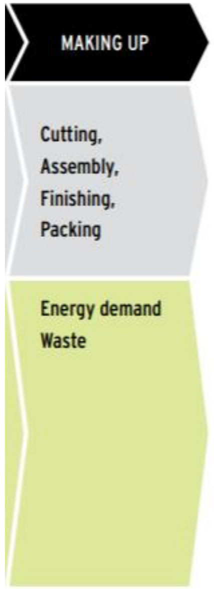
Fabric Making and Finishing

Weaving

Singeing
Desizing
Mercerising
Stenter

Denim Garment Making

Cutting
Stitching
Desizing
Washing
Drying
Distortion / special effects
Steam pressing
Packing

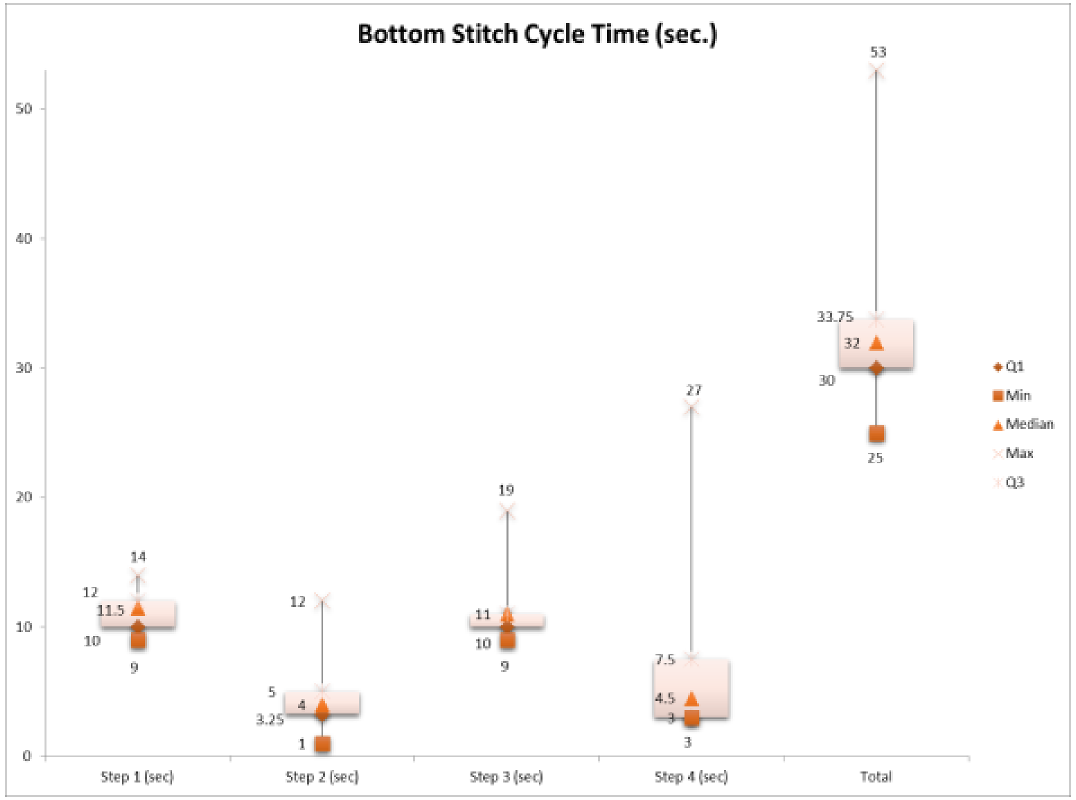


Cut to Pack (Garments)

- This segment shapes up the final product ready for dispatch. It includes following areas;
  - ✓ Pattern Making
  - ✓ Cutting
  - ✓ Stitching
  - ✓ Packing
- Cut to Pack Units are human resource intensive so utilities like lighting, ventilation, thermal comfort, drinking water etc. are required to maintained and can be inspected accordingly.

Stitching Process Optimization

- Installing Servo Motors brings return on investment typically within One year
- Additionally, 8-10% variation in process times is usually observed; possible savings include;
  - ✓ Electricity
  - ✓ Compressed air
  - ✓ Process time, resulting in higher productivity



Source: Box plot of a stitching process by Espire Consult

Stitching Process Optimization

- Installing Servo Motors brings return on investment typically within two year
- On-load time is 60% of the Cycle Time (normally this value is lower which would increase saving potential)
- Calculate annual energy saving (assume annual operation 7200 hrs)

Motor Type	**Loading**	**Load (kW)**
Clutch Motor	On-load	0.638
	Off-load	0.2332
Servo Motor	On-load	0.528
	Off-load	0.0242
Sample measurements of stitching machine power consumption		

Energy Saving = On-load 475 kWh + offload 602 kWh = Total 1,077 kWh

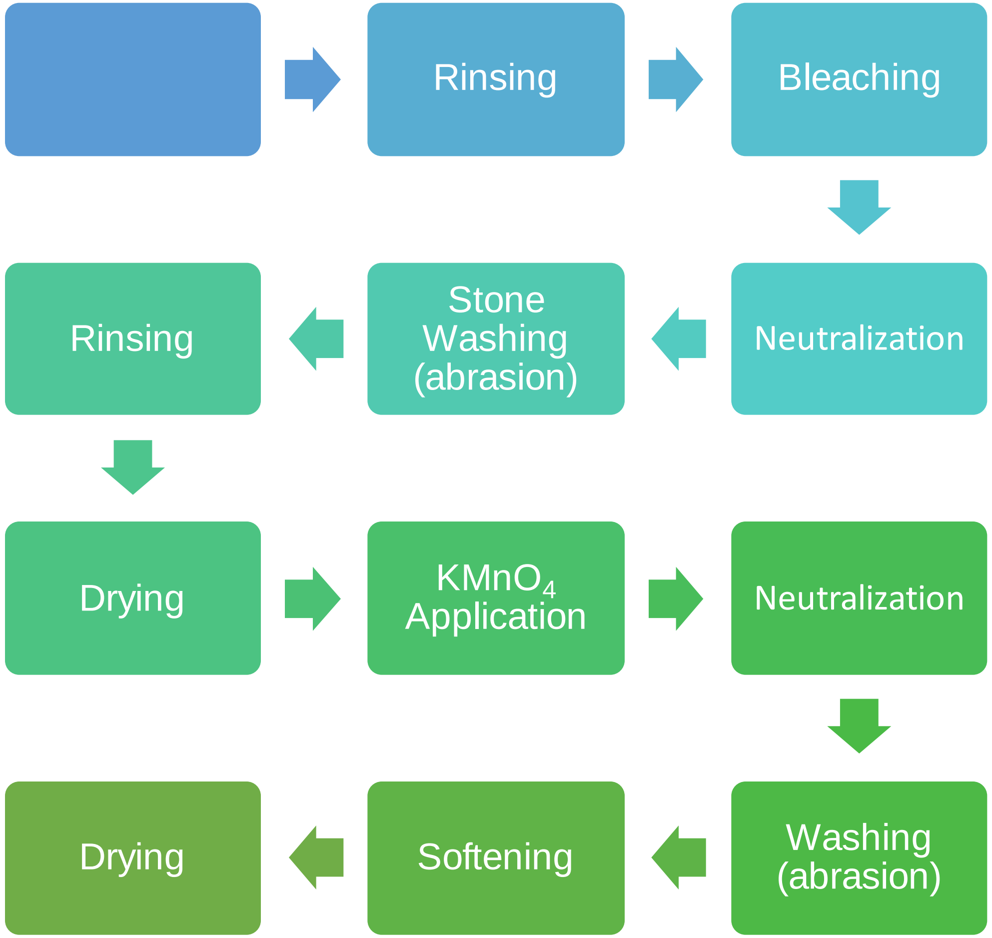
Garment Washing

Group work

- In your groups, develop typical energy flows and losses in Garment Washing process using the I.P.O. diagram.
- Present your results on flip chart in Information Market format

- Time 15 min

Denim Garment Washing



Rinsing

Bleaching

Neutralization

Stone Washing (abrasion)

Rinsing

Drying

$KMnO_4$ Application

Neutralization

Washing (abrasion)

Softening

Drying

Denim Production – Washing

Mechanical processes

- Rinse wash
- Water jet fading
- Stone wash
- Whiskering
- Microsanding including sandblasting
- Mechanical abrasion
- Laser treatment

Chemical processes

- Acid wash, ice or snow wash
- Hydrogen peroxide wash or bleach washing
- Enzyme wash
- Ozone fading
- Spray techniques
- Overdyeing and tinting

Levi Strauss & Co. Water<Less™ Program

Low Liquor Ratio in Stone Wash

- Water savings counted: ½ Stone Wash bath
- Average water savings: 2.4 liters / jean
- Energy Saving: Steam used for ½ Stone Wash bath
- Frequency of use: Moderate
- Critical issues
  - ✓ Back staining may occur if this technique is not properly applied.
  - ✓ Low liquor ratio stonewash can be difficult in a belly washer machine.
  - ✓ It is not recommended to use a liquor ratio below 3:1.
  - ✓ Advances in enzyme and dispersant chemistry make this technique possible

Levi Strauss & Co. Water<Less™ Program

Combine desize and stonewash / enzyme wash

Traditional	Proposed
Desizing	Desizing + Stone
↓	↓
Rinsing	Rinsing
↓	
Washing (Stone)	
↓	
Rinsing	

- Water savings counted: Two total baths, a de-size and a rinse
- Average water savings: 11.8 liters / jean
- Energy Saving: Electricity and Steam used for 2 baths
- Frequency of use: High
- Method
  - ✓ When a stonewash or enzyme wash follows a desize bath in a finish formula, it traditionally requires four baths: a desize bath, a rinse, a stonewash or enzyme bath, and another rinse. Combining the desize step with the stonewash/enzyme wash followed by a rinse reduces the process to a total of two baths.
- Critical Issues
  - ✓ Not recommended for fabrics that bleeds a lot.
  - ✓ An extra dispersant in the bath may be required to avoid back staining.

Levi Strauss & Co. Water<Less™ Program

Remove de-size step

- Water savings counted: One de-size bath
- Average water savings: 5.9 liters / jean
- Energy Saving: Electricity and Steam used for One de-size and One Rinsing bath
- Frequency of use: High
- Critical issues
    - ✓ Possible if Water Soluble Sizing material is used in Denim Mill – needs encouragement from the Brands / Buyers
    - ✓ In the case of a heavy weight fabric or a fabric that is sensitive to abrasion, a rinse step might still be necessary
    - ✓ Challenges with shrinkage may arise

Levi Strauss & Co. Water<Less™ Program

Increasing Ozone Concentration

- Water savings counted: A bleach bath and a generic neutralization bath
- Average water savings: 12 liters / jean
- Energy Saving: Electricity and Steam used for One bleach and One Neutralization bath
- Frequency of use: Moderate
- Method
  - ✓ Higher concentrations of ozone achieve more pronounced lightening effects, effectively replacing many uses for wet bleach baths.
  - ✓ Lightening a garment with a wet bleaching agent typically requires three wet baths: a bleach bath, a neutralize bath, and a rinse bath. If ozone use comes in the middle of a finish formula, it saves all three baths.
  - ✓ If ozone use is the first step in a formula, it only saves two baths because the garments need to be wet before being loaded into the machine.
- Critical Issues
  - ✓ Ozone can be used on indigo or black sulfur fabrics only.
  - ✓ Use of ozone requires up-front investment in the ozone machine and the generators, along with safety training for workers

Levi Strauss & Co. Water<Less™ Program

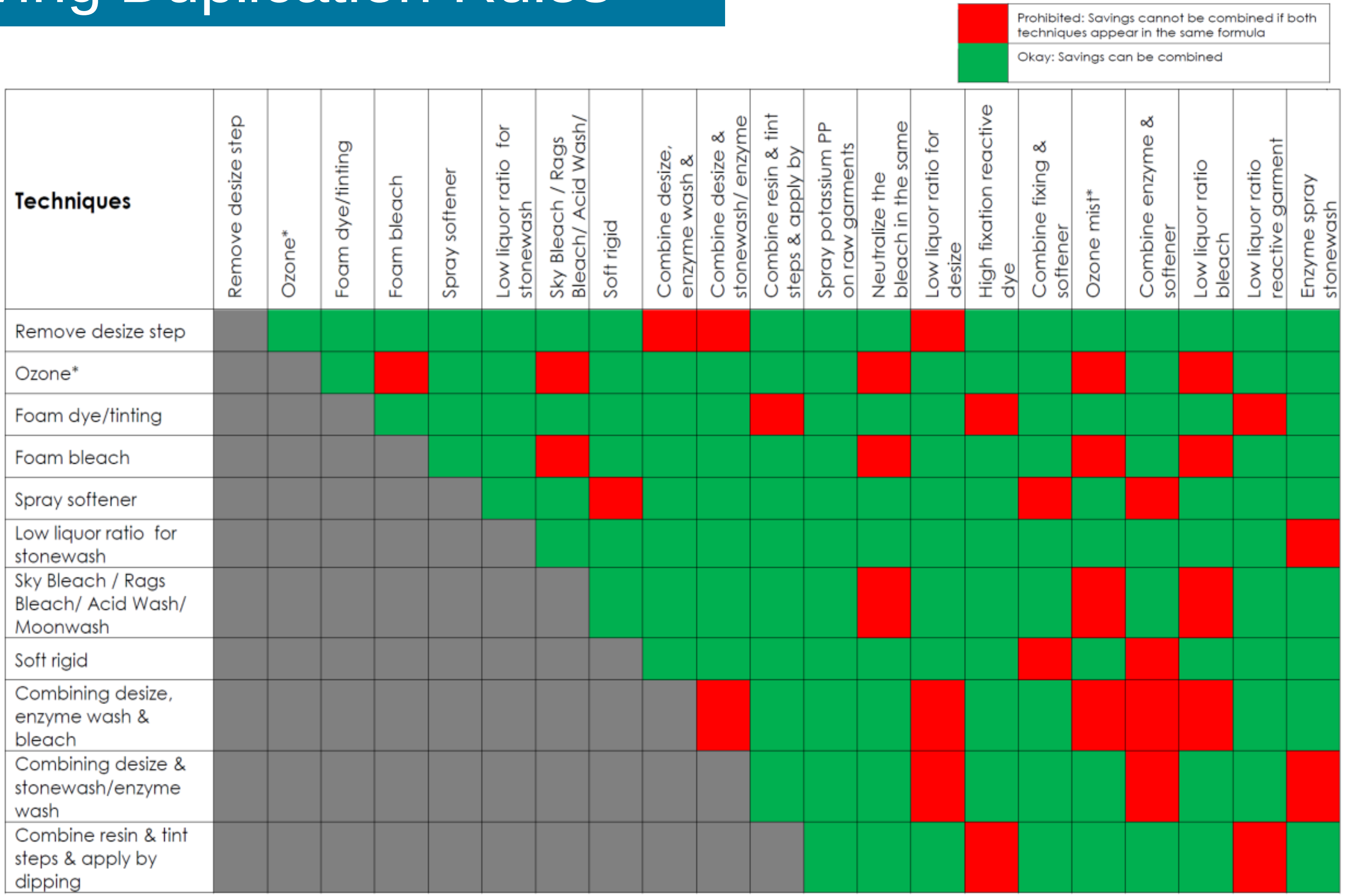
Spray potassium permanganate on raw garments

- Water savings counted: One neutralization bath
- Average water savings: 5.8 liters / jean
- Energy Saving: Electricity and Steam used for One Neutralization bath and One Drying Cycle
- Frequency of use: High
- Method
    - ✓ Applying the spray at the beginning of the finish formula – before the garments ever get wet – allows the neutralization agent to be added to the first existing wet bath.
    - ✓ The neutralization bath is removed, and the rinse that follows neutralization is also **potentially** removed.
- Critical Issues
    - ✓ This technique works best with dark finishes
    - ✓ Be aware of potential back staining

Drying Process

- Modulate steam pressure according to process temperature requirement i.e. Shade, fabric weight, batch size etc. to optimise steam use
- Majority companies don’t even install Steam Pressure Reducing Valves with dryers and all dryers are provided same pressure
- Assess possibility of recirculating the machine exhaust air
- This would require installing a fluff collector Jute bag (like used in Carding Machine filters in Spinning industry) and adding 30~40% fresh air
- May result in better heat exchange as well as reduction in process time and Steam consumption

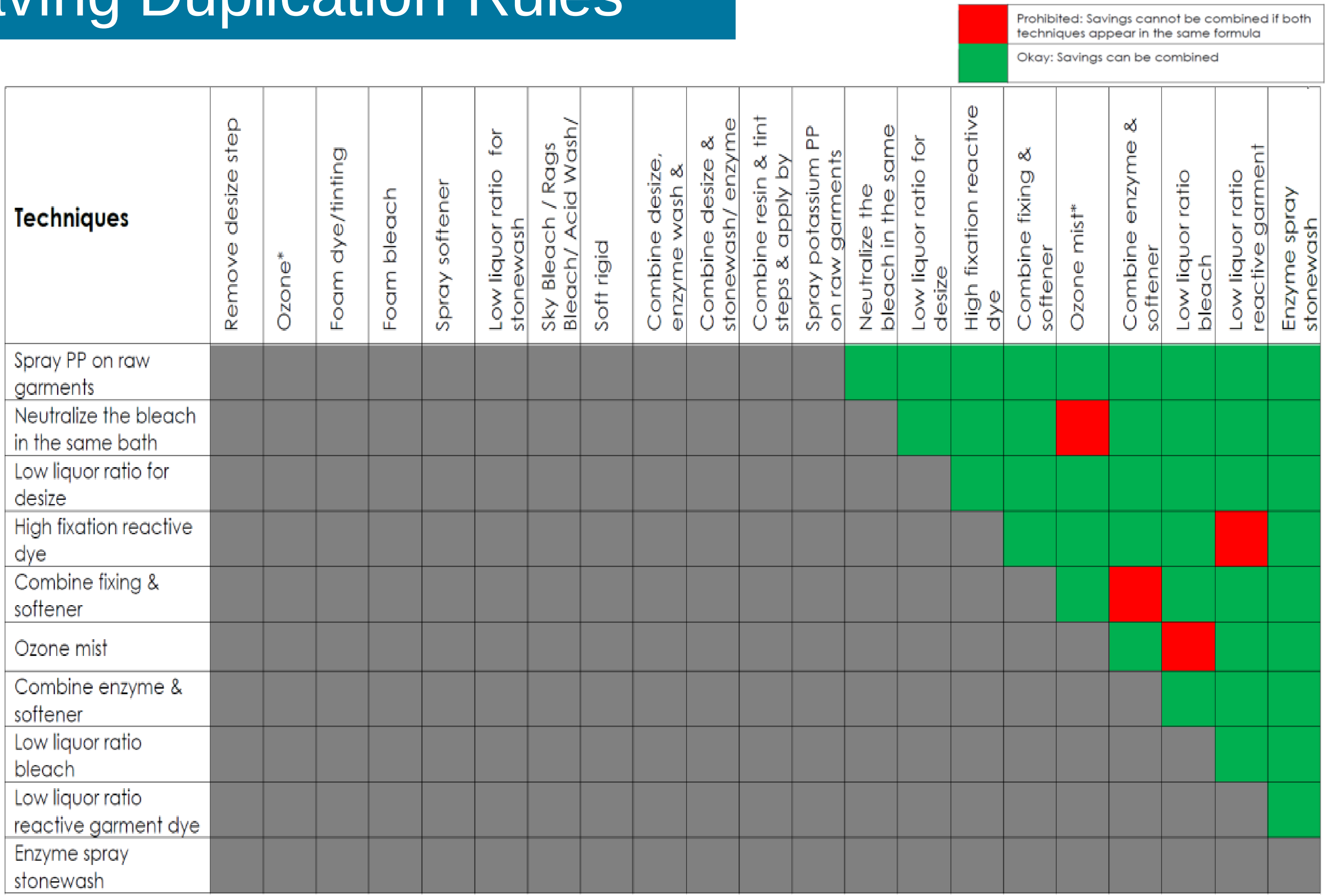
Water Saving Duplication Rules



🟥 Prohibited: Savings cannot be combined if both techniques appear in the same formula
🟩 Okay: Savings can be combined

Techniques	Remove desize step	Ozone*	Foam dye/tinting	Foam bleach	Spray softener	Low liquor ratio for stonewash	Sky Bleach / Rags Bleach/ Acid Wash/	Soft rigid	Combine desize, enzyme wash &	Combine desize & stonewash/ enzyme	Combine resin & tint steps & apply by	Spray potassium PP on raw garments	Neutralize the bleach in the same	Low liquor ratio for desize	High fixation reactive dye	Combine fixing & softener	Ozone mist*	Combine enzyme & softener	Low liquor ratio bleach	Low liquor ratio reactive garment	Enzyme spray stonewash
Remove desize step		🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟥	🟥	🟩	🟩	🟩	🟥	🟩	🟩	🟩	🟩	🟩	🟩	🟩
Ozone*			🟩	🟥	🟩	🟩	🟥	🟩	🟩	🟩	🟩	🟩	🟥	🟩	🟩	🟩	🟥	🟩	🟥	🟩	🟩
Foam dye/tinting				🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟥	🟩	🟩	🟩	🟥	🟩	🟩	🟩	🟩	🟥	🟩
Foam bleach					🟩	🟩	🟥	🟩	🟩	🟩	🟩	🟩	🟥	🟩	🟩	🟩	🟥	🟩	🟥	🟩	🟩
Spray softener						🟩	🟩	🟥	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟥	🟩	🟥	🟩	🟩	🟩
Low liquor ratio for stonewash							🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟥
Sky Bleach / Rags Bleach/ Acid Wash/ Moonwash								🟩	🟩	🟩	🟩	🟩	🟥	🟩	🟩	🟩	🟥	🟩	🟥	🟩	🟩
Soft rigid									🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟥	🟩	🟥	🟩	🟩	🟩
Combining desize, enzyme wash & bleach										🟥	🟩	🟩	🟩	🟥	🟩	🟩	🟥	🟥	🟥	🟩	🟩
Combining desize & stonewash/enzyme wash											🟩	🟩	🟩	🟥	🟩	🟩	🟩	🟥	🟩	🟩	🟥
Combine resin & tint steps & apply by dipping												🟩	🟩	🟩	🟥	🟩	🟩	🟩	🟩	🟥	🟩

Water Saving Duplication Rules



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Spray PP on raw garments													🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
Neutralize the bleach in the same bath														🟩	🟩	🟩	🟥	🟩	🟩	🟩	🟩
Low liquor ratio for desize															🟩	🟩	🟩	🟩	🟩	🟩	🟩
High fixation reactive dye																🟩	🟩	🟩	🟩	🟥	🟩
Combine fixing & softener																	🟩	🟥	🟩	🟩	🟩
Ozone mist																		🟩	🟥	🟩	🟩
Combine enzyme & softener																			🟩	🟩	🟩
Low liquor ratio bleach																				🟩	🟩
Low liquor ratio reactive garment dye																					🟩
Enzyme spray stonewash																					

Blow Cleaning in Distortion

- Install high pressure electric blower with custom nozzle instead of using compressed air
- Reference calculations
  - ✓ 03 pipes of 4mm internal diameter at each workstation
  - ✓ Air consumption = 94 m3/h per workstation
  - ✓ Cost saving per work-station = ~6,000 USD/y
  - ✓ Investment for a high pressure electric blower = 500 USD
  - ✓ Return on Investment = Immediate

Key takeaways

- Often energy practitioners and consultants avoid assessing manufacturing processes in detail when conducting energy assessments, whereas most significant and sustainable energy savings are found in the manufacturing processes
- When assessing any process, first step is to develop an Input-Process-Output diagram or an energy balance of that process. This reveals many facts about the nature and manner of energy use and thus opens new avenues for energy saving

Key takeaways

- Identify which manufacturing process are significant energy uses (SEUs) and develop their Input-Process-Output diagrams with quantification of energy balance
- Identify which variables significantly affect energy performance of these processes
- Calculate cost impact of the energy NPOs / wastes
- Select improvement measures to reduce energy NPOs and calculate their financial payback

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