Gaseous emission and air pollution

Promotion for Sustainability in the Textile and Garment Industry in Asia-FABRIC

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

FABRIC Asia

Gaseous emissions and air pollution

Contents

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Air emissions from textile processes

Air Emissions from Textile Processes

Process	Source	Pollutants
Energy production	Emissions from boiler	Nitrogen oxides (NOx), sulphur dioxides (SO_2) (SOx)
Drying and curing	Emission from high temperature ovens	Volatile organic compounds (VOCs)
Cotton handling activities	Emissions from preparation, carding, combing and fabrics manufacturing	Particulates
Sizing	Emission from using sizing compound (gums, PVA)	Nitrogen oxides, sulphur oxide, carbon monoxide
Bleaching	Emission from using chlorine compounds	Chlorine, chlorine dioxide
Dyeing	Disperse dyeing, carriers sulphur dyeing	Carriers
		H_2S
Printing	Screen printing, rotary printing	Hydrocarbons, ammonia
Finishing	Resin finishing, heat setting of synthetic fabrics	Formaldehyde
		Carriers - low molecular weight
		Polymers - lubricating oils
Chemical storage	Emissions from storage tanks for commodity and chemicals	VOCs
Wastewater treatment	Emissions from treatment tanks and vessels	VOCs, toxic emissions

Typical source of air emissions in textile and leather sector

Type of pollutants	Sources in textiles industry
Dust	Fiber (especially cotton) handling and storage
Air pollutants	Regenerated fibers (viscose) and synthetic polymers (nylon and acrylic fibers) production processes (of chemicals (e.g. release of carbon disulfide, hydrogen sulfide, hexamethylene diamine, and nitric acid).
Volatile organic Compounds (VOC) and oil mists	Organic solvents in activities such as printing processes, fabric cleaning, wool scouring and heat treatments Exhaust air from stenter frames and printing processes
Exhaust gases	Combustion sources for power generation (generator sets) and process heating (fired boilers), transport vehicles
Odors	Dyeing and other finishing processes (e.g. oils, solvent vapors, formaldehyde, sulfur compounds and ammonia

Options to Reduce Air Pollution

- Decreasing emissions of organic solvents by changing to water-based products.
- Using scrubbers to collect particulate matter.
- Optimizing boiler operations to reduce the emissions of nitrous and Sulphur oxides.
- Pre-screening chemicals using the material safety data sheets to ensure that chemicals are not toxic.
- Identifying sources of air pollution and quantifying emissions.
- Designing and manufacturing products that do not produce toxic or hazardous air pollutants.
- Avoiding fugitive air emissions from chemical spills through improved work.

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Good Housekeeping

- Equipment maintenance and operations audit
- Clean and maintain thermal treatment equipment (such as stenters) at regular intervals (at least once a year). Remove residue from the waste air channels and deposits from the burner air intake pipes.
- Minimisation/ optimisation of the chemical input
- Employ chemicals and auxiliary materials with good biodegradability/bio eliminability, low human and eco toxicity, low volatility and odour intensity
- Use vapour recovery systems (vapour return) when filling volatile compounds.

Yarn – Singeing as pre-treament before weaving

Singeing: the burning-off of loose fibers not firmly bound into the yarn and/or fabric structure.

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Air emissions from Singeing

The quality and quantity of air emissions in singeing depend strongly on:

- kind of substrate to be treated,
- position of burners (angle and distance to the textile; one-sided or double-sided singeing),
- kind of emission abatement installed.

Main air emissions are:

- dust from the fibres burned-off,
- organic-C from volatile substances on the substrate and/or crack-products and methane from incomplete combustion of burner gases,
- formaldehyde from burner gases.

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Control Air Emissions – Local Exhaust Ventilation (LEV)

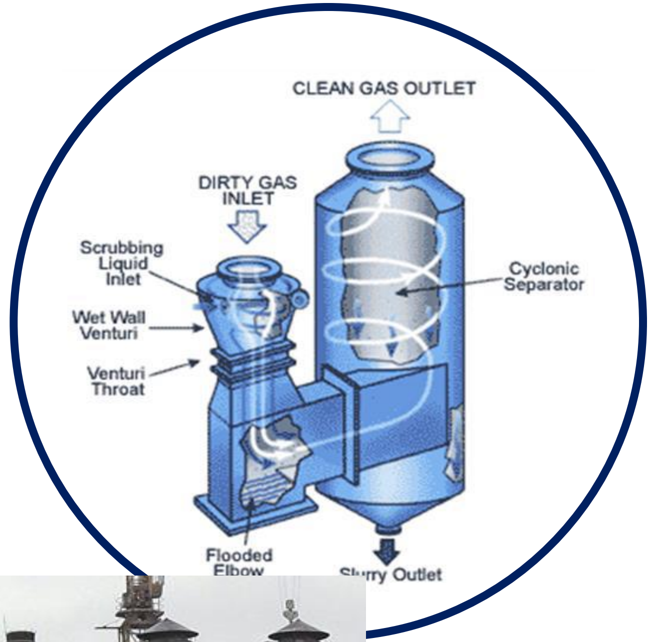
- Connect local exhaust ventilation (LEV) at the source of the emission. There should be a sufficient airflow to capture the dust or vapor before it disperses in the workplace. For dust, airflows greater than 1 m/s will generally be needed and for vapours, airflows greater than 0.5 m/s. The airflow should be measured at the origin of the dust or vapor with an anemometer. Provide an easy way of checking that the LEV is working such as a ribbon strip attached to the output side.

  Contain the source of dust or vapor as much as possible to stop it from spreading. Keep the hood as close as possible to the source of exposure

Control Air Emissions – Local Exhaust Ventilation (LEV)

- Don’t allow the workers to get in between the source of exposure and the LEV; otherwise they will be in the path of the contaminated air.
- Where possible, locate the work away from doors and windows to stop draughts from interfering with the LEV and spreading dust or vapours.
- Keep extraction ducts short and simple and avoid long sections of flexible duct.
- Discharge extracted air in a safe place away from doors, windows and air inlets. Be careful that extracted air does not affect your neighbours.

CONTROL AIR EMISSIONS



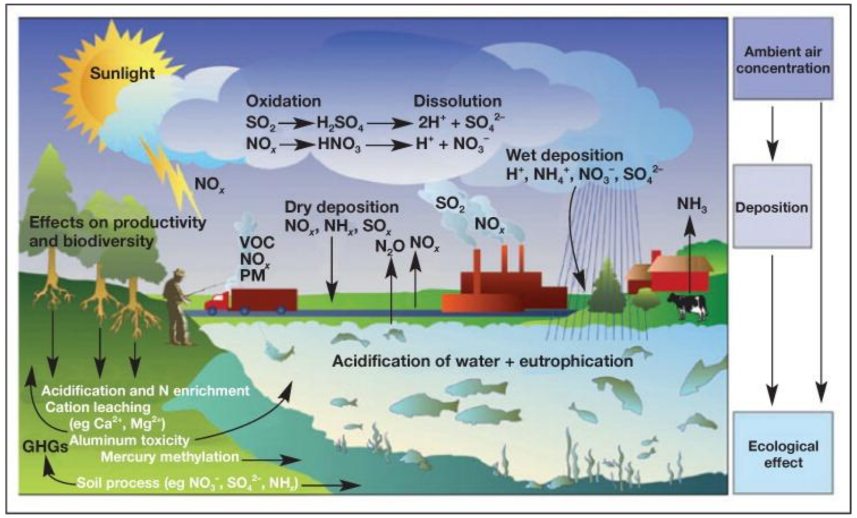
Source: GIZ CHS

The trapped contaminants are conveyed by ducts to a collector (cyclone, filter house, scrubbers or electrostatic precipitators) where they are removed before the air is discharged into the outside environment.

This is accomplished by a special exhaust System or by increasing the general ventilation.

For consideration:
Substitution of hazardous chemicals and process changes (see BATs) significantly reduce the need of such end-of-pipe treatment facilities.

Air emission abatement techniques



Description

The following off-gas abatement techniques can be used in textile finishing:

- oxidation techniques (thermal incineration, catalytic incineration)
- condensation techniques (e.g. heat exchangers)
- absorption techniques (e.g. wet scrubbers)
- particulates separation techniques (e.g. electrostatic precipitators, cyclones, fabric filters)
- adsorption techniques (e.g. activated carbon adsorption).

Quiz!

What is the required airflow to capture the dust or vapor with a Local Exhaust Ventilation before it disperses in the workplace?

- 3 m/sec
- 1 m/sec
- 0,1 m/sec

Stack gas emissions from power generation and boilers

Stack gas emissions from boilers

The main sources of air pollution from textile production are boilers, and diesel generators which generate gaseous pollutants as suspended particular matter (SPM), sulphur di-oxid gas and oxide of nitrogen gas.

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Emissions from volatile chemicals

VOC Air Emissions

a) calculated as total carbon

b) As the 30-minute mean for stack emission:

- 2 mg/Nm3 for VOCs classified as carcinogenic or mutagenic with mass flow greater than or equal to 10 g/hour;
- 20 mg/Nm3 for discharges of halogenated VOCs with a mass flow equal or greater than 100 g/hour;
- 50 mg/Nm3 for waste gases from drying for large installations (solvent consumption >15 t/a);
- 75 mg/Nm^3 for coating application processes for large installations (solvent consumption >15 t/a);
- 100mg/Nm^3 for small installations

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Treatment of Exhaust Air

- Treatment of exhaust air from the textile industry ä Combination of condensation and scrubbing followed by electrostatic precipitation (ESP) or the use of thermal combustion with energy recovery in textile processes with relevant quantities of exhaust air emissions (e.g. thermosol processes, finishing, coating, printing).

- In the tailoring process formaldehyde is often used in the sewing and ironing stages, with halogenated and nonhalogenated solvents used in stain removal. Formaldehyde is carcinogenic and can lead to allergic reactions. The maximum allowable workplace concentration (MAC) may not exceed 0.5 ml/m3 (ppm) or 0.6 mg/m3. You can strongly reduce or even avoid formaldehyde emissions by using formaldehyde-free or low-formaldehyde curing agents in your processes.

BATs for Finishing

- Use of recipes optimised with regard to lower emissions in air
- Replacement of halogen organic solvents (e.g. in stain removal and subsequent cleaning)..

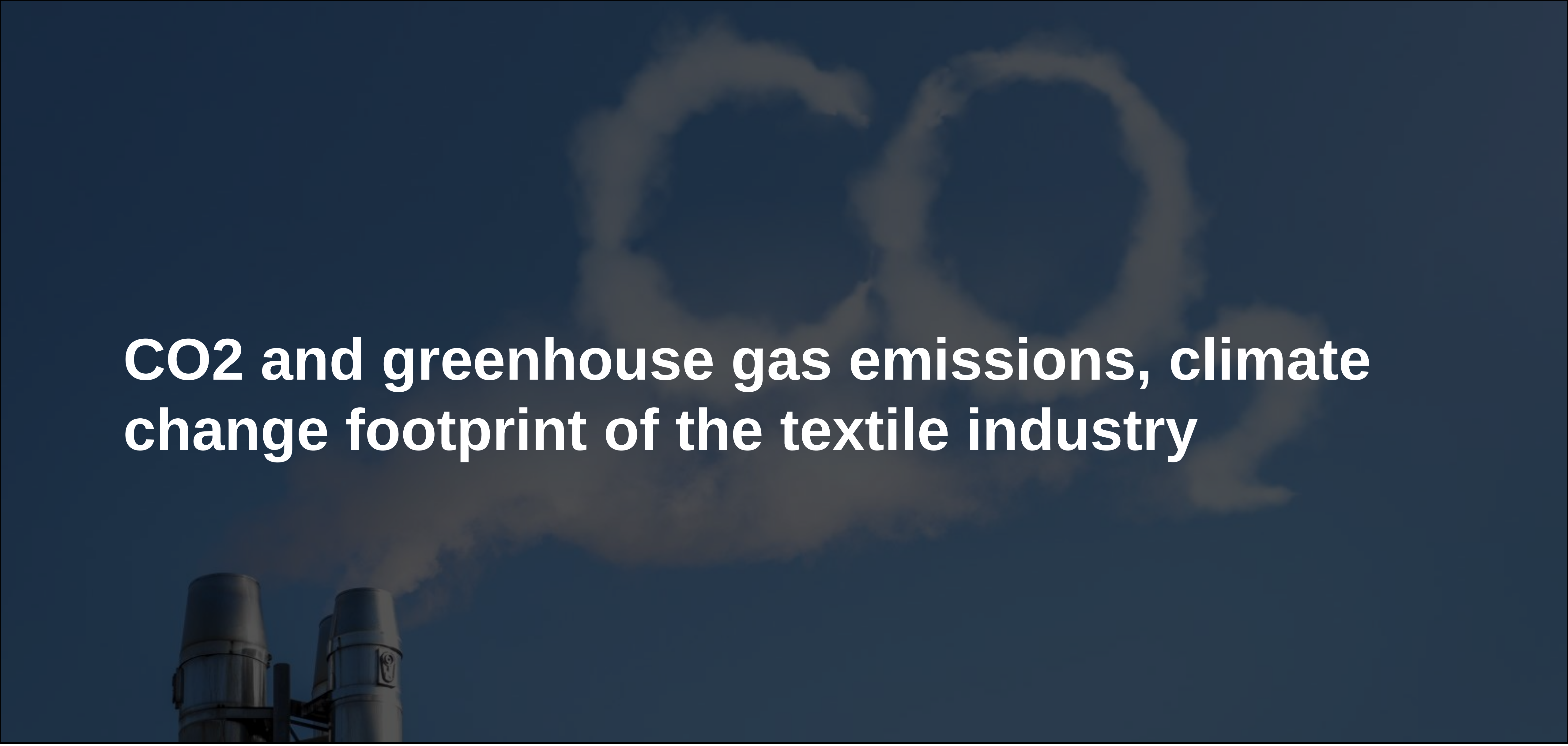
BAT's for Dyeing

- Polyester and polyester blends dyed with disperse dyes
- Use of polyester fibres that can be dyed without carriers: 1st priority. (4.6.2)
- Dyeing under high temperature conditions without the use of carriers: 2nd priority

BAT's for Printing

- Reactive printing
- Substitution or reduction of urea volumes: Single-stage process with controlled humidifying. (4.7.1)
- Pigment printing
- Use of optimised, low-emission printing pastes:
- Low-emission thickener,
- APEO-free and with a high degree of bioeliminability,
- reduced ammonia content. (4.7.3)

CO2 and greenhouse gas emissions, climate change footprint of the textile industry



Climate impact

About 80% of the total climate change impact of textiles occurs in the production phase. A further 3% occurs in distribution and retail, 14% in the use phase (washing, drying and ironing), and 3% during end of life (collection, sorting, recycling, incineration and disposal) (ECOS, 2021; Östlund et al., 2020).

Climate impact

Textiles made from natural fibres, such as cotton, generally have the lowest climate impact. Those made from synthetic fibres (especially nylon and acrylic) generally have a higher climate impact because of their fossil fuel origin and the energy consumed during production (ETC/WMGE, 2021b; Beton et al., 2014).

Climate impact

The textile industry pumps **between 1.22 and 2.93 billion metric tons of carbon dioxide** into the atmosphere every year. The result is that, by some estimates, the life cycle of textiles (including laundering) accounts for 6.7% of all global greenhouse gas emissions.

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Heat setting, dimension stabilization by thermal treatment

Heat-setting, Thermofixation

Preparation agents and spinning oils, are applied to fibres in various steps of the process, from the manufacture of the fibre itself (for synthetic fibres only) to the formation of the yarn.

These organic substances are removed during pre-treatment at the finishing mill either through wet processing (washing) or through dry processing (heat-setting). In the former case they contribute to the increase of the organic load of the final water effluent, in the latter case they become airborne.

Heat-setting, Thermofixation

Typical operations before colouring are washing and thermofixing (heat-setting)

Thermofixation is also another important operation in synthetic fibres pre-treatment. Its position within the process can be different, depending on the make-up and the fibre. As a result the following possible sequences are possible:

1. thermofixation – washing – dyeing
2. washing – thermofixation – dyeing
3. washing - dyeing - thermofixation.

If white fabrics are to be produced, bleaching of the fabric may be necessary after thermofixation.

Possible sources of air emissions arising during heat-setting of grey fabrics

Fibre	Impurities/by-products on the fabric	Pollutants in air emissions
Man-made fibres in general	Preparation agents	Mineral oils, fatty acid esters and their by-products and/or thermal decomposition compounds
Natural fibres in general	Preparation agents	See above
PU (elastane)	Fibre solvent Preparation agents	Dimethylacetamide Silicones
Aromatic polyamides	Fibre solvent	Dimethylacetamide
PAC	Fibre solvent	Dimethylformamide, Dimethylacetamide
PA 6	Monomer	Epsilon-Caprolactam

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Stentors, final finishing by impregnation and subsequent thermal fixation

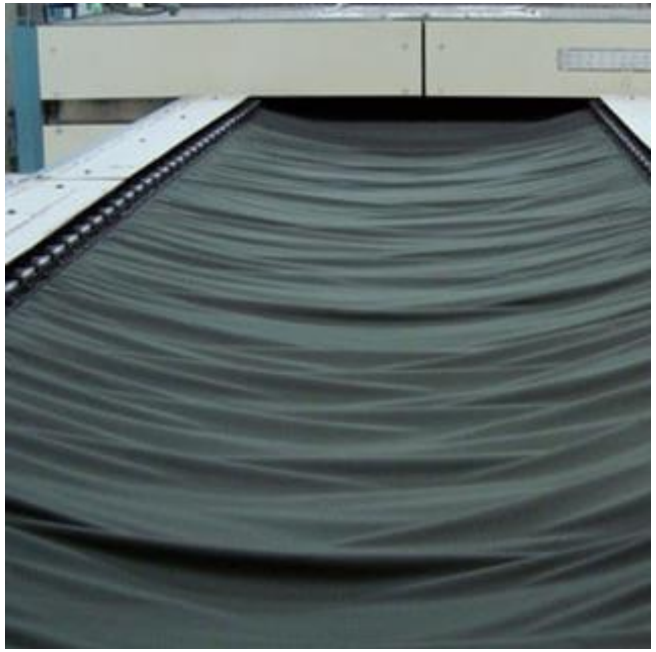
Emissions associated with continuous finishing processes

In the drying and curing operation air emissions are produced due to the volatility of the active substances themselves as well as that of their constituents (e.g. monomers, oligomers, impurities and decomposition by-products). Furthermore air emissions (sometimes accompanied by odours) are associated with the residues of preparations and fabric carry-over from upstream processes (for example, polychlorinated dioxins/furans may arise from the thermal treatment of textiles that have been previously treated with chlorinated carriers or perchloroethylene).

The emission loads depend on the drying or curing temperature, the quantity of volatile substances in the finishing liquor, the substrate and the potential reagents in the formulation.

Another important factor to consider regarding air emissions is that the directly heated (methane, propane, butane) stenters themselves may produce relevant emissions (non-combusted organic compounds, CO, NOx, formaldehyde).

Stenter

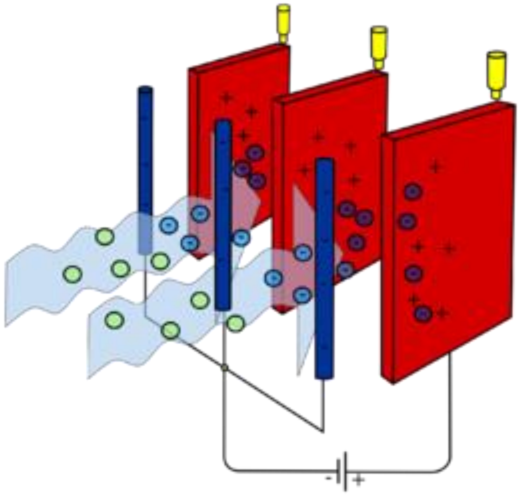


This machine is used for full drying of the fabric. The fabric is conveyed through the machine in open width. A hot current of air is blown across the fabric thereby producing evaporation of the water.

Stenters are mainly used in textile finishing for heat-setting, drying, thermosol processes and finishing. It can be roughly estimated that, in fabric finishing, each textile substrate is treated on average 2.5 times in a stenter.

While the stenter operation volatile components of finishing chemicals are evaporated and released as emissions.

Electrostatic precipitation in combination with heat exchangers I



Electrostatic precipitation in combination with heat exchangers or scrubbers is successfully applied in the treatment of fumes emitted from the stenters where the fabric is submitted to thermofixation.

The combination of electrostatic precipitation with heat exchangers (dry electrofiltration) is particularly advantageous when this operation is carried out as a first treatment step before washing. The oils and preparation agents present on the grey fabric evaporate and give rise to a dense smoke also associated with odour emissions.

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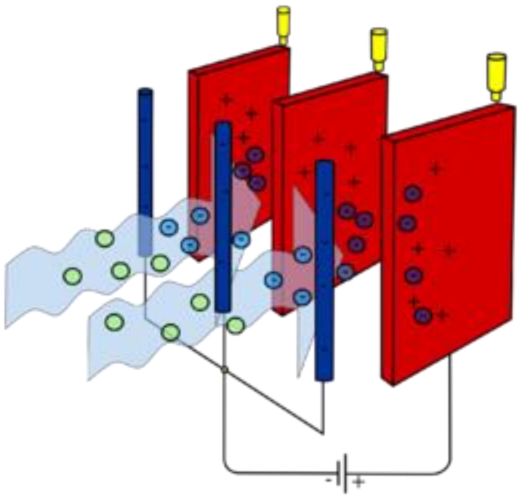
Electrostatic precipitation in combination with heat exchangers I



This off-gas can be treated in four steps:

1. mechanical filtration
2. cooling and condensation (the suspended condensable compounds are separated in the form of oily droplets and thermal energy is recovered)
3. ionisation/ electrofiltration
4. collection of the condensates and separation of the oily phase from the aqueous phase in a static decanter.

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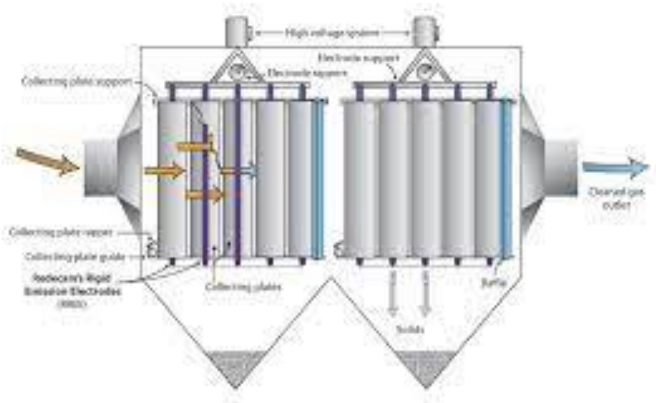
Quiz!

Which technology can remove the emissions of volatile components of finishing chemicals evaporated and released while stenter operation from the off gas?

- a) activated sludge process
- b) Electrostatic precipitation
- c) reverse osmosis

Electrostatic precipitation in combination with heat exchangers II



One of the advantages of this dry electrofiltration system is that the oily condensates (mineral oils, silicone oils, etc.) are collected separately and thus recovered instead of being transferred to the water effluent (e.g. via a scrubber).

Energy recovery is another advantage of this technique. Recovered energy (35 – 40 % of the supplied amount) can be used to preheat the fresh air supplied to the stenter or to heat up process water.

Thermosol process

This process is specific for dyeing with disperse dyestuffs polyester or cotton/polyester blends.

- The process includes the following steps:
- impregnation in the dyeing liquor
- pre-drying in an infrared oven drying in hot-flue
- passage through a stenter frame for thermal fixation at 200 ºC of the disperse dyes to the PES (sublimation)
- The process provoke a continuous emission to air.

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Minimisation of energy consumption at the stenters

Minimisation of energy consumption at the stenters:	Energy saving of up to %
Use of mechanical dehydration to reduce moisture content of the textile to be dried	**15%**
optimisation of air flow at the stenters	**57%**
installation of heat recovery systems	**70%**
insulation of thermal treatment units	**20%**
regular maintenance of the burners in the case of directly heated thermal treatment units.	

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