00 Recovery of Caustic Soda from Mercerization Process

Technical Description

Mercerization process is carried out for cotton woven fabric to improve fabric quality. This process is not necessarily performed on all the fabric but it mainly depends on the final product quality. Mercerization is applied to improve fabric properties such as fiber strength, shrinkage resistance, luster, and dye affinity/up-take. In this process, fabric is treated with caustic soda (NaOH) solution of high concentration under tension. Caustic soda reacts with the cellulose, swells it and imparts above properties. About 175 – 300 g NaOH/kg fabric is applied in the mercerization process.

In the mercerization process, fabric is first allowed to dip into the saturator of caustic soda solution of the required concentration (generally 22 to 28 ^{o}Bé or 16% to 22% by weight NaOH or 189 g/l to 274 g/l of NaOH). After passing through this saturator, fabric is squeezed and enters into the stabilizing zone where reaction time is provided. The concentration of caustic soda in the stabilizer is maintained at 5 -7 ^{o}Bé (4-5% by weight NaOH or 42 g/l to 53 g/l of NaOH). Fabric is stretched in the stretching frames and passed through the second stabilizing zone where fabric is treated with caustic soda of 4-5 ^{o}Bé (3-4% by weight NaOH or 31 g/l to 42 g/l of NaOH). Fabric is squeezed and then washed in the wash boxes, neutralized with acid and dried at drying drums.

The first and second washing water from the wash boxes, after stabilization zones, contain substantial amount of caustic soda (5 to 7 ^{o}Bé). The showering water at stabilization zones comes from these two washes. The showering water from stabilization zones is collected at underneath storage tank. Overflow water from this tank at concentration of 5-7 ^{o}Bé is transferred to the Caustic Recovery Plant (CRP), called 'weak lye' for concentrating it to about 40 ^{o}Bé (35% by weight NaOH or 484 g/l of NaOH), called 'strong lye' and reusing in the mercerization process.

In those industries where CRP is not installed, the over flow caustic solution of 5-7 ^{o}Bé concentration is discharged as wastewater which contributes in alkalinity and solids in the wastewater.

Achieved Environmental Benefits

- Water conservation *(water evaporated at 70^{o}C temperature from dilute caustic soda solution and hot water at 65^{o}C temperature from condenser is reused in the process)*
- Reduction in thermal energy *(hot evaporated water from dilute caustic soda solution and condenser is reused as hot washing water in the process allowing reduction in steam consumption)*
- Reduction in greenhouse gases *(steam reduction will allow reduction in fossil fuel combustion)*
- Reduction in hydraulic load of wastewater treatment plant

- Reduction in solids and alkalinity of wastewater
- Reduction in acids consumed to neutralize alkalinity of wastewater

Operational Data

The design capacity of the standard CRP is 5 m^3/h (5 t/h) in terms of weak lye feed rate. The larger and smaller plants are also available (depending upon the quantum of mercerization carried out in the industry) but generally standard plants are installed in most of the industries. These plants are available in locally manufactured (Pakistan) and also imported from different countries (e.g. Germany, India).

Components

The major components of the plant includes screening and filtration unit for removing fluff and other suspended contaminants from the weak lye (01), weak lye preheaters of shell and tube type (03), evaporators of rising film type (04), condenser of shell and tube type (01), vacuum pump (01), weak lye storage tank (01), strong lye storage tank (01), sedimentation tank (01), and pumps (05).

The electric power, water and steam requirement for CRP is 10 kW, 15 m^3/h and 1,000 – 1,200 kg/h respectively.

Function

The function of CRP is to concentrate the waste stream of mercerization washes and stabilization section (dilute stream i.e. weak lye) through evaporation so that it can be used again in the mercerization process.

The dilute stream (weak lye) is first passed through screens and filters to remove fluff and suspended particles and then collected in the storage tank. Weak lye is then preheated in the preheaters. Hot vapor condensate from the evaporators are used in the preheaters to preheat the CRP feed.

The preheated weak lye enters into the first evaporator. The lower part of the evaporator assembly is the evaporator (where solution is heated and water vapors are formed) and the upper part acts as separator (where water vapors are separated from the solution). Steam, at a pressure of 40 - 60 psig, is supplied in the tubes, fitted in the evaporator part, which gives off its heat to the feed water. Water is evaporated from the feed water and solution is concentrated to some degree. This concentrated solution is then fed to the second evaporator. The water vapors from the first evaporators are used as steam in the second evaporator. Similarly the solution and the water vapors travel from the second to third and to fourth evaporator in sequence. When solution is discharged from the fourth evaporator, it is concentrated to the required degree. The water vapors emitting from the fourth evaporator are transferred to the condenser where these vapors are condensed into the hot clean water. A vacuum of about 11.6 psig is created in the system. Some part of these vapors, before entering into the condenser, is passed through the preheaters to preheat the incoming feed. Vapor condensate from the condenser is directly used in the process. The fresh water used in the condenser to condense the vapors is also used as hot water in the process. The hot concentrated solution (strong lye) is stored in the strong lye storage tank and transferred to the sedimentation tank. The sludge settled at the bottom hopper of the sedimentation tank is drained in the storm water drain and concentrated solution is pumped to the mercerization machine for use.

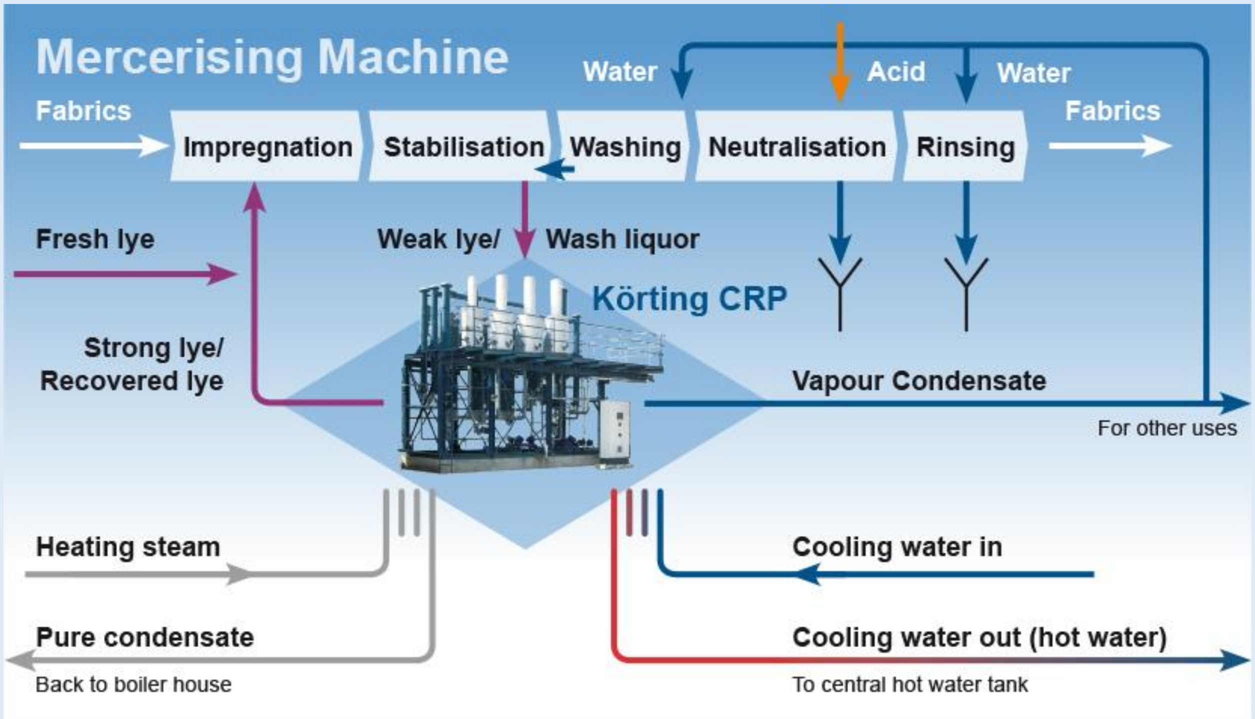

Figure: Caustic Recovery Plant (4 Stages)
Source: Körting Hannover GmbH

Following data can be used to determine the feasibility of the CRP:

Daily production of mercerized fabric (Basis: 12 h/d)	30,000 – 40,000 meter/day *(Fabric weight: 2.0 – 2.5 meter/kg)* 80,000 – 150,000 meter/day *(Fabric weight: 7 – 10 meter/kg)*
Weak lye production (5 -7 ^{o}Bé or 4-5% by weight NaOH or 42 g/l to 53 g/l of NaOH)	3 – 4 kg/kg mercerized fabric
Strong lye production (40 ^{o}Bé or 35% by weight NaOH or 484 g/l of NaOH)	400 – 500 g/kg mercerized fabric
Caustic soda recovery (100%)	140 -200 g/kg mercerized fabric
Vapor condensate generation (70^{o}C)	2.5 – 3.5 kg/kg mercerized fabric

Note: Above figures of mercerized fabric production give an idea that at what production rate the CRP of 5t/h capacity will be feasible (payback from 0.8 to 1.85 year). However, for smaller production rates, smaller plants are also available which will give the same payback.

About 60 – 80% of the caustic soda consumed in the mercerization process can be recovered through CRP and reused in the mercerization process.

The vapor condensate (70^oC) is a good source of hot water (slightly alkaline) which can be used as washing water in the mercerization and pretreatment machine (desizing, scouring and bleaching washes). Also hot water (65^oC) from condenser is a good source of hot water which can be used in the process as well. Steam condensate should also be recovered and used as boiler feed water in the boiler.

Cross Media Effects

Contribution of CO_2 emission due to fossil fuel combustion for steam production for CRP. Generation of solid waste in the form of fluff and solids from screens and filters.

Technical Considerations relevant to Applicability

This measure is applicable to all the woven fabric processing industries where open width continuous mercerization of cotton fabric are employed (mostly white fabric). In case of denim fabric mercerization, the weak lye will first undergo bleaching treatment with H_2O_2 to remove its blue color prior to feeding in CRP.

This measure does not require any intervention in the process. CRP requires land of about 100 m^2 area. The plant operator will require training for operating the plant from the technology vendor initially. All the utilities (electricity, water and steam) are already available in the textile industry.

The screening and filtration of the weak lye is very important to avoid choking of the plant, interrupted operation and high O&M cost. For denim industry weak lye (in case of blue color), bleaching of weak lye will be carried out. Also minor bleaching is also carried out for other weak lye to improve brightness of the recovered strong lye.

The capital cost of CRP will be USD 220,000 (Rs. 50 million) for local plant and about USD 438,000 (Rs. 100 million) for imported plant (Germany).

In calculating the feasibility of CRP, the monetary value of the production of hot vapor condensate, hot water and reduction in acid for wastewater neutralization should also be considered along with caustic soda recovery.

Economics

Capital cost = USD 220,000 (Rs. 50 million) local plant
Annual saving = USD 263,000 to 329,000 (Rs. 60 to 75 million)
(Caustic soda and hot vapor condensate)
Annual O&M cost = USD 57,000 (Rs. 13 million)
(Electricity, steam, water and labor)
Simple payback period = 0.8 to 1.06 year

Basis: 200 days/year x 12 hour/day

Driving Force for Implementation

- Financial benefits
- Resource conservation (caustic soda, acid, water and energy)
- Wastewater pollution control
- Sustainability of textile business

Reference Industry

There are many textile finishing industries in Pakistan which have installed CRP and successfully operating (above 50).