Energy efficient and environmentally sound technologies for small and medium scale textile cluster

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Received 02 June 2009; accepted 21 October 2009

Continuous and sustained growth of small and medium scale units in Indian textile garment sector has resulted in increased CO₂ emission and effluent discharge. Analysis of processing units in Tirupur, India, has helped to identify some energy efficient and environmentally sound technology (E3ST) measures. This paper identifies potential for pollution reduction with selected E3STs.

Keywords: Energy efficiency, GHG emission mitigation, Resource conservation

Introduction
In late 60’s, number of garment industries in Tirupur (located 55 km east of Coimbatore, Tamilnadu, India) increased to 250 units, and very soon the city emerged as hosiery centre of India and present number of units is about 4000¹. Growth of wet processing industry (dyeing & bleaching) went up from 2 in 1941 to 750 in 2000². In Tirupur, there is tremendous growth, in the form of new units and expansion of existing units in knitwear industry. This industry is already providing employment for about 0.3 million people³. Untreated textile effluents that are released and disposed in open land and into aquifer result in increased concentration of total dissolved solids (TDS), sodium chloride (NaCl) and contamination of ground water⁴. Ground water up to 600 feet is saline and farmers have abandoned their farmland⁵. Specific water consumption (200-260 l/kg of finished product) is higher as compared to international standards⁶ (120-150 l/kg). Specific energy consumption is also high (2-4 times) due to inefficiency in processing⁷. Estimated wastewater generation from nine industrial clusters in Tirupur is around 100 million litres per day⁸ and about 56,492 tonnes of solid waste is produced each year⁹. Though most modern machineries are used for wet processing, majority of fabric dyeing is carried out in open winches, which require more water.

This study presents CO₂ (carbon dioxide) emission from Tirupur units (technology level, modern to obsolete) and identifies potential for pollution reduction with identified energy efficient and environmentally sound technology (E3ST) measures.

Methodology
In this study, 57 units (technology levels, modern to obsolete) were selected. Generally, modern technologies consume less water and steam when compared to obsolete technologies. Energy and environment audit studies were carried out in these identified sample units to find out specific CO₂ emission, specific energy consumption and specific water consumption. Under methodology for GHG emission estimation (Fig. 1), from specific CO₂ emission data of individual units, weighted CO₂ emission was calculated. This weighted average value was applied to extrapolate CO₂ emission for entire dyeing and bleaching sector of Tirupur based on production output. Indirect emission due to electricity consumption is also included in estimation. Formulas used for CO₂ emission from different energy sources use are given in Appendix 1.

Estimated annual CO₂ emission from Tirupur cluster is about one million tonne (Table 1, Fig. 2). Similarly, electricity, firewood and diesel consumption for Tirupur textile cluster were estimated from specific consumption data of electricity, firewood and HSD (Table 2). In all calculations, it was assumed that quantity of knitted fabric dyed is 90% and that of knitted fabric printed is 10%. In estimation, CO₂ emission from biomass fuel combustion

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was included but production from handloom sector was not included. CO emission from partial combustion has not been accounted. Also, emission from transport activities and CH$_4$ emission from biomass were not included.

Energy Efficient and Environmentally Sound Technology (E3ST) Options for Pollution Control

Some E3STs identified for Tirupur textile sector, in particular, to dyeing and bleaching sector were: i) Soft flow dyeing; ii) Use of indirect heating in open winches; iii) Control of excess air in boilers; iv) Use of fluidized bed combustion boiler; and v) Installation of temperature controller for processing machines. Potential of energy saving and pollution reduction in Tirupur garments industry with implementation of these identified E3STs were evaluated and estimated based on specific energy and water consumption data of identified E3STs.

Results

Soft Flow Dyeing

In conventional winch dyeing, fabric is circulated in a tub/chamber containing dye-solution. But in soft flow dyeing, both fabric and dye-solution circulates. A nozzle sprays dye-solution over circulating fabric and it is a highly economical machine for processing delicate and surface sensitive fabrics that require dyeing temperatures beyond boiling point. The process, which requires lesser speeds, can also be programmed thereby reducing power consumption. But, this machine consumes additional electricity even though there is considerable reduction in steam consumption per kg of fabric. Soft flow dyeing uses water quantity of 1/3 or 1/2 of that used in winch
This document discusses the benefits of soft flow dyeing in the textile industry, including energy and environmental savings. The technique requires less dyes, salts, and chemicals, resulting in lower pollution. The table below presents the techno-economic analysis of soft flow dyeing with E3ST:

<table>
<thead>
<tr>
<th>Category</th>
<th>Before installation of E3ST</th>
<th>After installation of E3ST</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy consumption</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrical energy, million kWh/y</td>
<td>175.76</td>
<td>202.28</td>
</tr>
<tr>
<td>Firewood, million kg/y</td>
<td>660.28</td>
<td>501.81</td>
</tr>
<tr>
<td>Pollution</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO₂, million t/y (Direct and indirect)</td>
<td>1.000</td>
<td>0.835</td>
</tr>
<tr>
<td>Effluent, million l/y</td>
<td>30600</td>
<td>17870</td>
</tr>
<tr>
<td>Economical benefits of E3ST</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy saving</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Firewood, 158.47 million kg @ Rs 2.50 kg</td>
<td>Rs 396.17 million</td>
<td></td>
</tr>
<tr>
<td>Water saving</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water, 12729.6 million l @ Rs 35/1000 l</td>
<td>Rs 445.54 million</td>
<td></td>
</tr>
<tr>
<td>Effluent treatment, 12729.6 million l @ Rs 0.05/l</td>
<td>Rs 636.48 million</td>
<td></td>
</tr>
<tr>
<td>Additional cost</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrical energy, 26.52 million kWh @ Rs 4.5/kWh</td>
<td>Rs 119.34 million</td>
<td></td>
</tr>
<tr>
<td>Total saving</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total investment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pay-back period</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Use of Indirect Heating in Open Winches

Generally, steam pressure used in winches is high in relation to the temperature required for processes. Actual temperature required in winches varies from 60-90°C. For this, a steam pressure (1-1.2 kg/cm²) is sufficient. Any excess pressure will lead to the escape of live steam in winches. In winches, 30% of steam is normally utilised and the remaining 70% escapes as live steam. Energy,
Control of Excess Air in Boilers

At present, excess air level is as high as 300%. Excess air level should be reduced to around 50% for efficient performance of boiler in most cases. CO$_2$% should be monitored and kept around 50% by proper control of FD & ID fans. By reducing excess air, it is possible to save considerable quantity of fuel (Table 4).

Use of Fluidized Bed Combustion (FBC) Boiler

FBC boiler will have efficiency in the order of 75%. Combustion in this boiler is well controlled and hence heat content of fuel is utilised to maximum extent. These boilers can be used with wide range of agro fuels and fuels with high ash content. Heat flux and intensity is very high and size of boiler is drastically reduced due to high heat transfer coefficient. Energy, environment and cost benefits of this technology for entire garment industry of Tirupur are given in Table 4.

Installation of Temperature Controller for Processing Machines

Temperatures of dye and other hot baths are more than required level. This results in additional heat input. By applying E3ST, steam consumption will reduce by 5-10% (Table 4).

Conclusions

It is possible to reduce pollution load considerably by adoption of E3ST measures in textile units of Tirupur and substantial saving in energy, water and chemical can be achieved. If combination of these five technologies were adopted in all factories in Tirupur, there will be fair amount of CO$_2$ reduction (0.563-0.567 million tonnes/y) and saving of firewood (482.83-497.05 million kg/y). Water usage will come down by 12729.6 million litres per year. This will help deforestation and protection of ground water level and also substantial cost reduction.

Acknowledgement

Authors thank management of PSG College of Technology for providing all necessary facility and support.

Appendix 1

A. CO$_2$ Emission from electricity use (Indirect emission)

\[
\text{Total Carbon dioxide emission} = \frac{\text{No. of kWh consumed} \times \text{EF}_{\text{Country}}}{\eta_{\text{transmission/distribution}}}
\]
Electricity Emission Factor (EF) for India is 0.0008 t CO$_2$/kWh

$\eta_{\text{transmission/distribution}}$ value for India is 0.75

B. CO$_2$ Emission from high speed diesel use

Total Carbon dioxide emission = Fuel consumed X Net Calorific Value of fuel (NCV$_{\text{fuel}}$) X Carbon dioxide Emission factor (CEF)) X (fraction oxidized ($f_o$))

From IPCC Reference manual Table 1.2, pp 1.18: NCV$_{\text{Diesel}}$ = 43 Terajoules / Gg
From IPCC Reference manual Table 1.4, pp 1.23: CEF= 74100 kg CO$_2$/TJ
From IPCC Reference manual Table 1.4, pp 1.23: $f_o$ = 1

C. CO$_2$ Emission from firewood use

Total Carbon dioxide emission = Fuel consumed X NCV$_{\text{fuel}}$ X Carbon dioxide Emission factor(CEF)) X (fraction oxidized ($f_o$))

From Ultimate analysis: NCV$_{\text{Firewood}}$ = 10.5 Terajoules / kilotonne
From IPCC Reference manual, Table 1.4, pp 1.24: CEF= 112000 kg CO$_2$/TJ
From IPCC Reference manual Table 1.4, pp 1.24: $f_o$ = 1

References
1. Adapted from information brochure on Tirupur, Tirupur Exporters Association, 2002.