Jr. of Industrial Pollution Control 24 (1)(2008) pp 1-8

AIR POLLUTION REDUCTION POTENTIAL OF KNITWEAR INDUSTRY IN TIRUPUR

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Key words : Boiler, CO_2 emission, Excess air, Fuel oil, Firewood, Thermic fluid heater.

ABSTRACT

In a knitwear industry, wet processing consumes significant amount of thermal energy, which is generated by burning fuels in boilers or in thermic fluid heaters and there is a significant amount of CO_2 which causes atmospheric pollution. In addition to CO_2, SO_2, CO and oxides of NO_2 contribute to the air pollution to a limited extent. In Tirupur, there are about 800 processing units, which consume both thermal energy and electrical power. Thermal energy is generated in the form of steam in boilers, which burn solid fuels for getting the required heat. The total estimates of CO_2 pollution is about 0.8 million tonnes. This paper focuses on reducing the CO_2 emission in the knitwear industry of Tirupur. For this purpose, sample energy audit study was conducted in selected units and results of the audit study in analyzed in this paper and evaluated for reduction in pollution level.

INTRODUCTION

Air pollution is caused in knitwear industry due to burning of fuels in equipments like boilers, thermic fluid heaters and DG sets. Boilers are used to generate stream at certain pressure and temperature. The steam is used indirectly or directly in the processing equipments like textile dyeing machines, winches and driers. It is worthwhile to examine the specific options for reducing the CO_2 in each of these individual equipments. Similarly the thermic fluid heater, fuel oil or firewood is burnt to heat the thermic fluid, which is again circulated in equipments like hot air stenters. DG sets are used to generate electricity whenever there is a powercut and the burning of diesel generates emission like CO_2, CO and oxides of nitrogen. Further, the consumption of electricity in different equipments like pumps, fans, compressors do generate emission but these emissions are at power plant itself and as such these emissions not considered for localized emission estimation.

The amount of firewood used in Tirupur is about 440 kilotonnes per year which in turn produces about 0.65 million tonnes of CO_2. In addition, thermic fluid heater which uses furnace oil for heating thermic fluid and DG sets using diesel produces additional CO2 to an extent of 0.15 million tonnes.

In addition to CO_2 emissions, about 860.9 tonnes of SO_2, 334.3 tonnes of NO_x, 30175 tonnes of CO, and 428 tonnes of black carbon are produced. However these are very low amount in relation to CO_2. Hence ways to reduce CO_2 emissions are considered.
In order to reduce emission, it is necessary to make a study of energy efficiency of these energy equipments that will go a long way in establishing the source of CO_2 emissions and identifying the control measures.

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Table 1. Boiler Efficiency at different units.

Unit	Fuel used	Feed Water Temp.(°C)	Excess air (%)		Flue Gas Temp. (°C)		CO_2 in flue gas (%)	Direct Boiler efficiency (%)	Indirect Boiler efficiency (%)
			Actual	Ideal	Actual	Ideal			
1	Firewood	31	400	100	139	120	3.72	27.5	30.57
2	Firewood	95	128	100	205	120	16.78	54.7	50.24
3	Firewood	70	331	100	140	120	5.5	41.9	43.81
4	Furnace Oil	78	114	20	168	120	13.75	68.0	70.2
5	Firewood	38	303	100	170	120	7.0	23.2	26.49
6	Firewood	70	505	100	160	120	4.0	29.7	30.10
7	Firewood	70	177	100	300	120	12.0	20.2	20.39

The major equipments causing CO_2 emission are (1) Boilers, (2) Thermic fluid heaters and (3) DG sets.

By reducing CO_2, it is possible to reduce other emissions. In addition to gaseous pollutants, solid pollutants like particulate matter will escape with the exhaust gases. This particulate matter have to be removed by using proper particulate removal system like fabric filter, cyclone separator, etc.

Energy efficiency evalution in boilers and improvements

Boiler efficiency is defined as follows:

$$\text{Boiler efficiency} = \frac{\text{Amount of thermal energy absorbed by steam}}{\text{Amount of thermal energy supplied by fuel}}$$

$$\eta\ (\%) \quad \frac{m_s\,(h_s - h_{fw}) \times 100}{m_f \times GCV_f}$$

Evaluation of the efficiency can be done by either by direct method or indirect method. In using the above formulae, it is essential to account for wetness of stream.

The indirect method calculates the heat losses occurring in the equipments and the efficiency is calculated as follows :

$$\eta_{\text{Indirect}}\ \% = 100 \text{ - heat losses (\%)}$$

The various factors which affect heat losses include hot flue gas, burning of H_2, moisture in the air, radiation, blow down, ash, unburnt carbon, and out of this losses due to hot flue gas loss, moisture heat loss, blow down loss, unburnt carbon losses are controllable losses and has to be controlled in order to obtain higher efficiency. These losses can be kept minimum by proper excess air control, proper water and fuel pretreatment and better preparation of fuel.

In study carried out in the processing units at Tirupur, it was found that boilers are operating at very low efficiency. These are conformed by both direct and indirect methods. The evaluation is shown in Table 1.

Low boiler efficiency indicates that more fuel is burnt and more fuel leads to more air pollutants like CO_2, CO etc. The following measures can be adopted to reduce the CO_2 emissions from boilers.

1. Replacement of boiler with energy efficient boilers
2. Excess air control
3. Better fuels
4. Efficient methods of water treatment
5. Efficient use of steam

Firewood is the most widely used fuel in these units. For example 1 kg of firewood produces 1.2 - 1.3 kg of CO_2. The low boiler efficiency is due to poor operating practices and controls, use of old and inefficient boilers and poor maintenance. In fact these boilers are nowadays have become outdated and the original design efficiency itself is around 45-50%. The operating efficiencies are much lower than the design efficiencies as shown in the Table 1 given above.

Replacement of boiler

Therefore it is necessary to consider replacing these boilers with high efficiency boilers like fluidized bed boilers, package boilers etc. These boilers operate in the efficiency range of 70- 80%. Therefore using these boilers, it is possible to increase the efficiency by 20 - 30%, which in turn will reduce fuel consumption by 20-30%. The CO_2 reduction due to efficient use of boiler is given in Table 2.

Table 2. Replacement of boiler

		CO_2 reduction		
Present Fuel	Replaced by	Present emission	Expected emission	% Reduction
Firewood	Coal fired fluidized bed boiler	650 tonnes	500 tonnes	25

Table 3. Fuel replacement

S. No.	Present Fuel	Replaced By	CO_2 (ktonnes)		CO_2 Reduction %
			Present	Future	
1.	Firewood	Leco	650	520	20
2.	Firewood	Coal	650	210	50

Table 4. Efficiency of thermic fluid heaters

Parameters Fuel	Unit - 1 Furnace Oil	Unit - 2 Furnace Oil
Efficiency (%)	55.9	68.5
Actual CO_2 (%)	14	14
Ideal CO_2 (%)	14	14
Flue gas temperature(°C)	226	326

Table 5. Reduction in CO_2 in thermic fluid heater

Unit No.	Present Efficiency (%)	Achievable Efficiency (%)	Reduction in CO_2 (%)
1	56	75	19
2	68.5	75	6.5

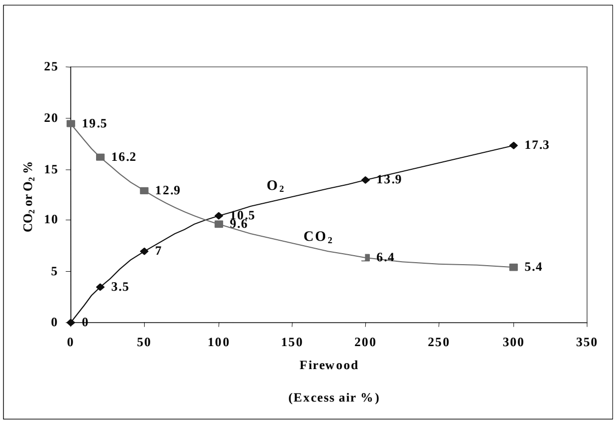

Fig. 1 Excess Aair vs CO_2 and O_2 for firewood.

2. Excess air control

Another critical factor that is responsible for low efficiency is high excess air that is provided for combustion of firewood. Normally for any solid fuel about 50-80% excess air can be supplied as a general practice. Any thing more than that leads to more losses and consequently boiler efficiency comes down. Therefore for the same heat output, more fuel is burnt and it is necessary to keep the excess air at desired minimum level. The excess air supplied can be derived from the percentage of CO_2 in the flue gas. The CO_2 percentage can be measured by using flue gas analyser. The excess air provided in these boilers widely varies from 100 to 300%. Thus it is essential to control the excess air to the required minimum.

A guideline for firewood combustion on CO_2 Vs excess air is shown in Fig. 1.

3. Use of alternate fuels

By using fuels like Leco which is available easily, it is possible to achieve a better steam- fuel evaporation ratio in boiler. These results in lesser use of fuel and reduction in CO_2.1 kg of leco produces 2.5 kg CO_2 and 1 kg of firewood can be replaced by 0.4 kg of leco. The economy of this fuel replacement is given in Table 3.

4. Efficient treatment of water

At present water quality supplied to the boiler is poor and use of this water leads to scale formation on the heat transfer surfaces and high wetness in steam was observed. This affects the heat transfer in the dyeing processes. Therefore efficient treatment of water can lead to better heat transfer efficiency and higher operating efficiency in boilers.

5. Better utilisation of steam

Efficient steam utilization techniques like use of indirect steam instead of direct steam, use of low pressure steam for low temperature requirements, better insulation of steam pipes, recovery of waste heat from condensate can result in larger savings in steam. Use of efficient dyeing equipments like jet dyeing can lead to reduction in steam. This reduces the fuel consumption and also CO_2 emissions.

Energy efficiency and air pollution in thermic fluid heater

Thermic fluid heaters are used to heat air to higher temperatures, which is required in dryers. The thermic fluid is heated from 250°C to 350°C, and hot thermic fluid is circulated in hot air heaters. The return colder thermic fluid is again heated in the heater. Fuel oil or firewood is used in heater. Heater efficiency is calculated using following equation.

$$\text{Heater efficiency} = \frac{\text{Heat taken by thermic fluid}}{\text{Heat supplied by fuel}}$$

$$\eta_{\text{heater}}(\%) = \frac{m_t \times C_{pt} \times (T_{to} - T_{ti}) \times 100}{m_f \times GCV_f}$$

This Table 4 indicates that heaters are operating at much lower efficiency level and the specific fuel oil consumption is high. Proper operating and maintenance can lead to increase in operating efficiency. Operating at part-load leads to decrease in efficiency. Additionally excess air control is also important since this will maintain the efficiency at the desired level. The present excess air level is high. Therefore control of CO_2 in flue gas can lead to excess air being maintained at a desirable level of 20%. 1kg of fuel oil produces 3.08 kg of CO_2. Better insulation of hot thermic fluid lines and avoiding leakage in lines, better fuel oil preparation can also lead to saving of fuel oil which in turn reduces CO_2 emission. The reduction in CO_2 due to increased efficiency of thermic fluid heater is given in the Table 5.

Use of dg sets and pollution control

Presently DG sets are used for meeting the power demand of the units during powercuts. The efficiency of the DG sets can be determined by calculating the ratio of the power generated units to diesel consumed. Normally a ratio of 3.5 is desirable for an efficient DG set. In order to achieve this, it is necessary to load the DG sets appropriately and control the excess air ratio so that proper and efficient combustion is achieved. Thus it is possible to save diesel and reduce CO_2 emissions effectively. By increasing the efficiency of DG sets and thermic fluid heaters, it is possible to save about 15% (i.e.) 22.5 kilotonnes of CO_2.

CONCLUSION

The air pollutants emission namely CO_2 and others can be effectively controlled by improving the energy efficiency of the thermal equipment like boilers, thermic fluid heaters and DG sets. From the study it is efficient that it is possible to reduce the GHG emissions by about 20% by achieving higher energy efficiency of these systems. By reducing electricity consumption, we can also decrease GHG emission from central power plants.

ACKNOWLEDGEMENT

The authors wish to express thanks to M/s Ecosmart, Mumbai and Textile Committee and various textile associations at Tirupur for providing us an necessary data for evaluation purposes.

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ABBREVIATIONS & NOTATIONS

GCV - Gross calorific value, kJ/kg

DG – Diesel Generators

C_{pt} - Specific heat capacity of thermic fluid, kJ/kg

h_{fw} - Enthalpy of feed water, kJ/kg

h_s - Enthalpy of steam generated at the given pressure and temperature, kJ/kg

m_f - Mass flow rate of fuel oil, kg/hr

m_s - Rate of steam generation, kg/hr

m_t - Mass flow rate of thermic fluid, kg/hr

T_{to} - Outlet thermic fluid temperature, °C

T_{ti} - Inlet thermic fluid temperature,°C

h_{heater} – Efficiency of Heater