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Potential of Waste Heat Recovery in Textile Industries

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ABSTRACT
Many developing countries, including India, look forward to developing strong integrated textile industries to add value to already-available raw materials. Textile industry is one of the largest industries, which consumes energy in the form of heat. Dyeing and finishing activities are, however, energy-intensive. In many cases, these depend on imported fossil fuels. By turning to heat recovery, significant cost savings can be achieved improving profitability and competitiveness. New technologies are required to recover some percentage of loss of energy. The techniques and technologies of heat recovery from boiler blow down, condensate and waste water are analyzed. Waste heat utilization in the textile industry is gaining vital importance in the Indian textile industry as international legislations are also to come into force in our country. This paper focuses on potential of heat recovery has brought significant cost reduction in textile dyeing and processes. The focus is on steam utilization in textile mills. The paper includes case studies from various textile dyeing plants in Tirupur area of TamilNadu.

Keywords – Boiler blow down, Condensate recovery, Steam utilization, Textile industry, Waste water.

I. INTRODUCTION

Textile process industries are those industries where the primary production processes are either continuous, or occur on a batch of materials that is indistinguishable. Textiles (dyeing and printing) are energy intensive industries. In the face of rising costs and increased competition, efficient utility management is a major focus area in these industries. One of the textile manufacturing clusters in India is located in Tirupur district of TamilNadu. Over 100 units of dyeing plants are integrated with textile processes. Steam is used as energy carrier for processing applications like dyeing and finishing in all textile industries. Hence boilers are the main fuel consumers in the textile industries in Tirupur area. Cost of fuel for generating Steam in the meantime continued to grow steeply, nearly offsetting the benefits of reductions achieved in other areas[1].

In this paper, the major heat recovery areas were found to be in boiler blow down, condensate and waste water that is drained after the dyeing process. A study conducted in textile sector Tirupur district of Tamil Nadu to generalize the direct impact of boiler blow down, condensate and waste water heat recovery on fuel consumption. As a part of study, energy and mass balance is performed on boiler and calculated the amount of energy can save through recovering the heat from boiler blow down, condensate recovery and waste water that is disposed to sewage. In all the industries, their main investment is in the steam production. As the industrial sector continues efforts to improve its energy efficiency, recovering waste heat losses provides an attractive opportunity for an emission free and less costly energy resource.

II. AREAS OF WASTE HEAT RECOVERY IN TEXTILE INDUSTRIES.

The main areas of waste heat recovery in textile dyeing are from boiler blow down flash steam, hot condensate flash steam and heat recovery from processed waste water.

III. BOILER BLOW DOWN HEAT RECOVERY

As water evaporates in the boiler steam drum, solids present in the feed water are left behind. The suspended solids form sludge or sediments in the boiler, which degrades heat transfer. Dissolved solids promote foaming and carryover of boiler water into the steam. To reduce the levels of suspended and total dissolved solids (TDS) to acceptable limits, water is periodically discharged or blown down from the boiler. Mud or bottom blow down is usually a manual procedure done for a few seconds on intervals of several hours. It is designed to remove suspended solids that settle out of the boiler water and form a heavy sludge. Surface or skimming blow down is designed to remove the dissolved solids that concentrate near the liquid surface. Surface blow down is often a continuous process[2].

Minimizing blow down rate can substantially reduce energy losses, as the temperature of the blown-down liquid is the same as that of the steam generated in the boiler. Minimizing blow down will also reduce makeup water and chemical treatment costs. Insufficient blow down may lead to carryover of boiler water into the steam, or the formation of deposits. Excessive blow down will waste energy, water, and chemicals.

It is necessary to control the level of concentration of the solids and this is achieved by the process of 'blowing down', where a certain volume of water is blown off and is automatically replaced by feed water - thus maintaining the optimum level of total dissolved solids (TDS) in the boiler water. Blow down is necessary to protect the surfaces of the heat exchanger in the boiler. However, blow down can be a significant source of heat loss, if improperly carried out.

3.1. Concept of flash steam

Flash steam is vapor or secondary steam formed from hot condensate discharged into a lower pressure area. It is caused by excessive boiling of the condensate which contains more heat than it can hold at the lower pressure. Flash steam occupies many times the volume of water from which it forms. For example, flash steam created by hot condensate flowing from 15 PSIG to an atmospheric pressure will have nearly 1,600 times the volume of the high pressure hot water[3].

If the pressure is increased both the boiling point and the heat content at boiling go up. Conversely, if the pressure of the boiling water is reduced, the water must reduce its temperature and heat content to those corresponding to the lower pressure. This means that a certain amount of heat must be released, and this excess heat will be absorbed in the form of latent heat, causing part of the water to flash into steam[3].

$$\%Flash = \frac{h_f@high\ pressure - h_f@low\ pressure \times 100}{hfg\ @\ low\ pressure} \qquad (1)$$

Where h_f@high pressure is pressure at which the boiler operates, h_f@lower pressure is the pressure at which the boiler blown takes place, i.e. at atmospheric pressure and h_{fg}@lower pressure is the latent heat in the atmospheric pressure.

Heat content in the flash steam from Boiler blow down and condensate can be recovered back to pre heat the boiler feed water and Flash steam produced due to excess boiler blow down also can reduced fuel consumption rate.

The blow down performed on a boiler when it's under working; hence the blow down water is at boiler temperature and pressure. It contains large quantity of energy. For a particular amount of blow down water to reach that temperature boiler has to supply certain amount of fuel. Hence in all respect the blow down is fuel wastage[4]. But for efficient operation of boiler it's necessary.

Table 3.1 Fuel wastage in Industries

Industry	Blow down rate(kg/day)	Amount of Fuel wasted(kg/day)
G.K.M PROCESS	4848	147.37
JAI KNIT	1680	51.07
M.S DYEING	5724	147
MICRO KNIT	2862	76.43
P.R.N PROCESS	2016	61.28
PEACOCK	2520	49.28
RAAGAM	4320	115.37
SUGAN	1872	41.63
T.B.S DYEING	5040	98.56
VARSHAN	1800	47.23

From the audit conducted in 10 textile processing unit it is observed that nearly 3% of total fuel consumption is wasted through blow down. i.e., nearly a 850Kg of fuel (wood) is wasted as blow down, which is equivalent to a price value of 3000rs/day. In actual blow down losses may includes the makeup water cost and its treatment cost.

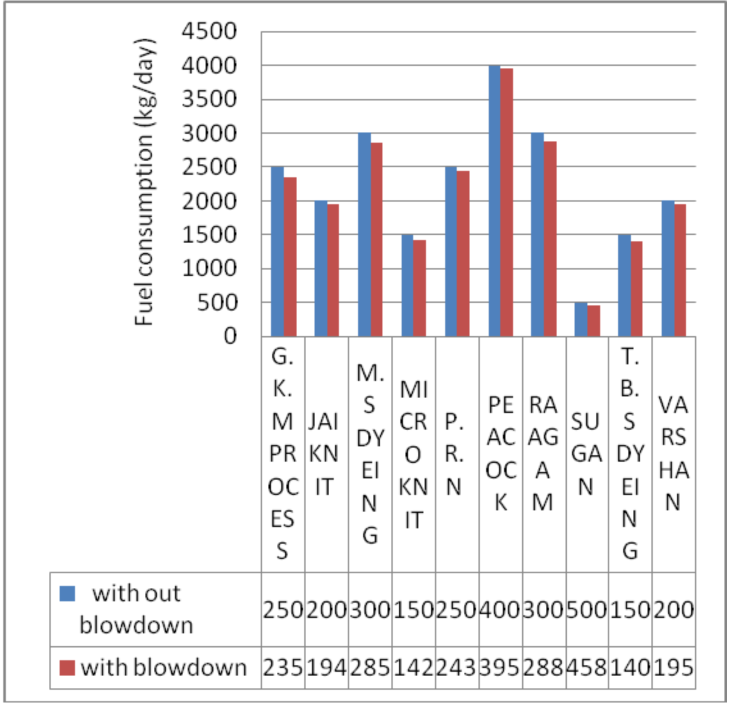

Figure 3.1 Variations in fuel consumption with blow down recovery.

It is found that Flash steam recovery from the boiler blow down also increases the efficiency of the boiler up to 2%. Heat recovery is used frequently to reduce energy losses that result from boiler water blow down.

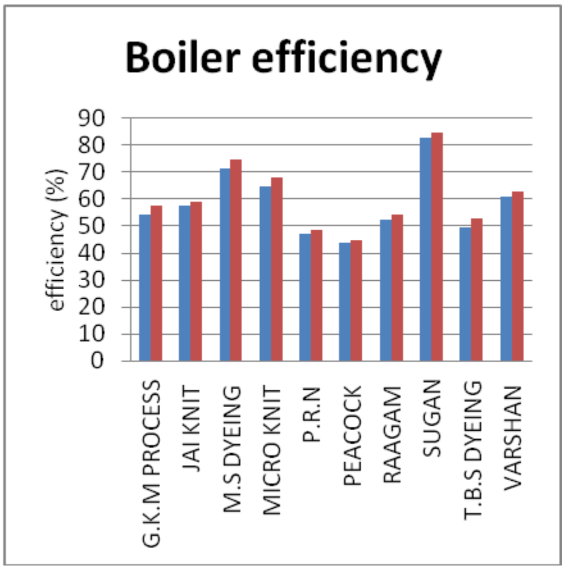

Figure 3.2 Changes in the boiler efficiencies.

It is found that boiler efficiency has significantly improved after flash stem recovered from the boiler blow down. Installation of heat recovery equipment is valuable only when energy from the flash tank or the blow down water can be recovered and utilized. In flash recovery system, the blow down water is directly supplied to a flash vessel which is at atmospheric pressure. Due to the change in enthalpies of water at boiler pressure and atmospheric pressure nearly 13% of blow down water is converted into flash steam. This steam is directly supplied to the feed water tank hence the temperature of feed water is raised due to high enthalpy value of steam. The flash steam contains nearly 49% of energy contained in the blow down water.

Table 3.2Fuel savings by blow down recovery.

Industry	**Savings in Fuel**		**Monitory savings (Rs/annum)**
	(Kg/day)	(Tons/ annum)	
G.K.M PROCESS	147.38	39	1,29,000
JAI KNIT	51.07	12.8	44800
M.S DYEING	147	36.7	129000
MICRO KNIT	76.43	19	66500
P.R.N PROCESS	61.28	15.3	53500
PEACOCK	49.28	12.3	43000
RAAGAM	115.37	29	101500
SUGAN	41.63	10.4	36400
T.B.S DYEING	98.56	24.6	86100
VARSHAN	47.23	11.8	41300

From the analysis carried out in industries its found that 3% of fuel can be saved through flash stem from the blow down.

With every 6% rise in the temperature of feed water it is observed that a 1% reduction in the wood consumption. Reduction in wood consumption means that the increased efficiency of boiler. From the analytical comparison between the system with heat recovery and without heat recovery, it is observed that the efficiency of boiler if nearly 3% rise.

IV. CONDENSATE HEAT RECOVERY

Steam contains two types of energy: latent and sensible. When steam is supplied to a process application (heat exchanger, coil, etc.) the steam vapor releases the latent energy to the process fluid and condenses to a liquid condensate. The condensate retains the sensible energy the steam had. The condensate can have as much as 16% of the total energy in the steam vapor, depending on the pressure[5].

One of highest return on investments is to return condensate to the boiler. As fuel costs continue to rise, it's imperative to focus on recovering condensate in every industrial steam operation. Returning hot condensate to the boiler makes sense for several reasons. As more condensate is returned, less make-up water is required, saving fuel, makeup water, and chemicals and treatment costs. Less condensate discharged into a sewer system reduces disposal costs. Return of high purity condensate also reduces energy losses due to boiler blow down.

2.2.1 Flash steam recovery

Condensate is discharged through traps from a higher to a lower pressure. As a result of this drop in pressure, some of the condensate will then re-evaporate into 'flash steam. The flash steam generated can contain up to half of the total energy of the condensate, hence flash steam recovery is an essential part of an energy efficient system[5].

$$\% \text{ flash steam} = (SH-SL)/H*100 \qquad (2)$$

Where SH = Sensible heat in the condensate at the higher pressure before discharge, SL = Sensible heat in the condensate at the lower pressure to which discharge takes place and H = Latent heat in the steam at the lower pressure to which the condensate has been discharged.

In the industries, it is found that the hot condensate is discharges to sewage without recovering its energy. The amount of condensate and flash steam produced in each industry is given in table.

Table 4.1 Amount of condensate formed

Industry	**Total steam production (kg/day)**	**Amount of condensate formed (kg/day)**	**Amount of flash steam recovered (kg/day)**
G.K.M PROCESS	2145.6	2072	210.41
JAI KNIT	1992	1760	178.74
M.S DYEING	4282.8	3267	236.88
MICRO KNIT	2138	1615	219.32
P.R.N PROCESS	1984	1813	184.07
PEACOCK	3744	2697	289.76
RAAGAM	2904	2401	243.79
SUGAN	938.4	634	58.12
T.B.S DYEING	1480	1133	121.85
VARSHAN	2200	1872	171.69

From the audit conducted in 10 textile processing unit it is observed that nearly 2% of total fuel consumption is wasted through condensate drainage. i.e., nearly a 400kg fuel is wasted per day, which can be saved thorough proper condensate recovery method.

Table 4.2Fuel savings by Condensate flash steam recovery.

Industry	**Savings in Fuel**		**Monitory savings (Rs/annum)**
	(Kg/day)	(Tons/ annum)	
G.K.M PROCESS	42.02	10.5	36750
JAI KNIT	35.7	9	31500
M.S DYEING	47.31	11.8	41300
MICRO KNIT	43.80	11	38500
P.R.N PROCESS	36.76	9.2	32200
PEACOCK	57.87	14.5	50750
RAAGAM	48.69	12.2	42700
SUGAN	11.6	2.9	10150
T.B.S DYEING	24.33	6	21000
VARSHAN	36.57	9.2	32200

As per the study conducted, the textile industry inTirupur-TamilNadu has been consumed about 96.3 T of wood per annum for steam generation. Through condensate and flash steam recovery, the potential reductions in fuel consumption reduce and also raise the temperature of feed water to 80-90^0. The impact of heat recovery on boiler fuel consumption in textile plant is shown fig 4.1.

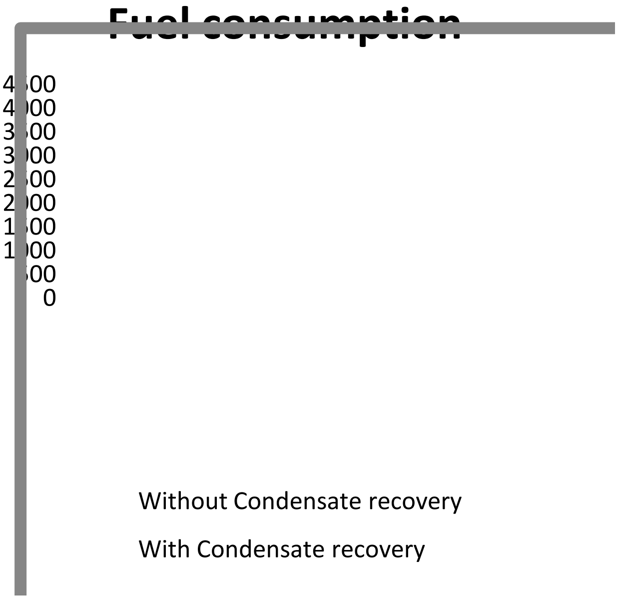

Figure 4.1 Impact on fuel consumption

Based on detailed studies carried in industries, some of the boilers were found to be inefficient and the efficiencies were found to be range of 40 to 80%. 0n recovering the flash steam from condensate remarkably enhances the boiler efficiency by 1%[6] .

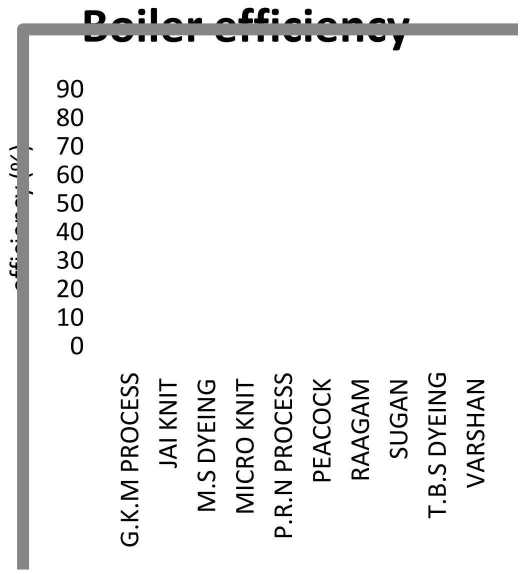

Figure 4.2 Changes in the boiler efficiencies.

It is clear that, flash steam recovery from hot condensate enhanced boiler efficiency and it will in turn reduce the fuel consumption rate.

The return of condensate represents huge potential for energy savings in the boiler house. Condensate has high heat content and approximately 1% less fuel is required for every 6°C temperature rise in the feed tank. The more the condensate recovery, the lesser will the condensate that is discharged into a sewer system be and the lower will the blow down be. This will reduce the sewer disposal costs.

V. HEAT RECOVERY FROM WASTE WATER

Batch or non-continuous processing is common in textile dyeing plants. Thus, a large volume of wastewater is available intermittently from several machines at different locations in the plant. If wastewater can neither be re-used nor can its heat be recovered locally, the feasibility of installing a centralized heat recovery system should be investigated[7].

Equipment such as washing-, mercerizing- and bleaching-machines often operate continuously for long hours, requiring a large volume of hot water and produce an equal volume of hot waste water simultaneously. A characteristic feature of some technology is the incorporation of heat exchangers on such textile machines with the purpose of heating up the incoming cold-water stream with hot wastewater leaving the machine.

In the industries that study has done, the amount waste/processed water is simply dumped to sewage. If it is properly utilized for preheating the boiler feed water or dyeing purpose, it can save energy as well as water.

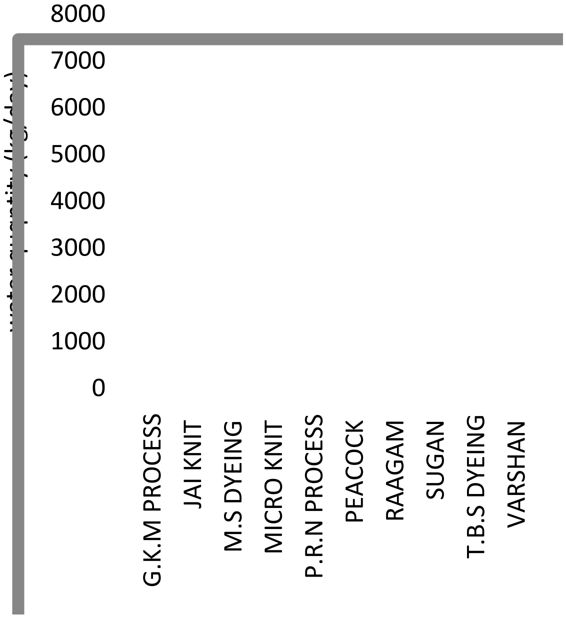

Figure 5.1 Amount of waste water.

Hot wastewater, produced in textile dyeing plats, can be a significant source of heat energy. In many instances, this valuable resource is discharged to wastewater treatment facilities without employing the heat it acquired during processing. The waste water quantity has been calculated by the equation,

$$Q = m_{water} C_p \Delta t \qquad (3)$$

Where Q is the quantity of energy absorbed in kcals, m_{water} is the amount of waste water (in kg) , C_p is the specific heat of water in(kcals/kg ^{0}C) and Δt is the temperature rise of the substance (in ^{0}C).

Most of the heat contained in the wastewater stream can be reclaimed and utilized, while providing significant cost reductions with attractive payback periods. Through utilization of proper wastewater heat recovery system, reclaimed heat from the wastewater discharge can preheat incoming process water; thereby saving fuel costs, while enhancing the environment through the removal of thermal pollution.

VI. CONCLUSION

Evaluating the feasibility of waste heat recovery requires characterizing the waste heat source and the stream to which the heat will be transferred. Important waste stream parameters that must be determined include: heat quantity, heat temperature/quality, composition, minimum allowed temperature, and• operating schedules, availability, and other logistics. These parameters allow for analysis of the quality and quantity of the stream and also provide insight into possible materials/design limitations.

By implementing the waste heat recovery methods we can conserve the energy in the textile industries. The improvements in the boiler blow down, condensate recovery, feed water management and waste water recovery will minimize the energy losses and improve the performance of the thermal systems in textile industries.

As the industrial sector continues efforts to improve its energy efficiency, recovering waste heat losses provides an attractive opportunity for an emission free and less costly energy resource.

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