Co-generation and Developments in the Utility Areas of Pulp and Paper Industry

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ABSTRACT

The economics of cogeneration in the Mill have ben reported. Comparsion of efficiency between the conventional and after having cogeneration has been made. The various factors affecting cogeneration plant efficiency are indicated. The steps for the energy saving and efficiency improvement are highlighted.

INTRODUCTION

Paper industry are an energy intensive industry. Steam and Power is required in large quantity for completing the paper making process. A lot of infrastructure has to be put at the back end of Pulp Mill and Paper machine to ensure regular steam and Power supply. Pulp and Paper Industry is the 6th largest industrial consumer of energy in our Country.

Presently our per capita consumption of paper is 3.7 kg/year against Asian average of 20 kg and US average of 320 kg. India with 16% of world population accounts barely 1% of world paper consumption. With increase in literacy rate and rise in living standard of people paper consumption in India is bound to rise.

In India an average mill uses 30% more energy to produce an equivalent amount of pulp and paper relative to a mill in Sweden or in United States. So a lot has to be done in energy conservation area to keep our mills economically viable and Environmentally friendly.

Why Co-generation ?

Paper Industry in general uses steam at 8 to 10 kg/cm^2 for cooking of wood in digesters for making pulp and 3 kg/cm^2 steam on drying cylinders of paper machines for drying of paper. Besides this steam is also used in Chemical Recovery plant. Almost all the heating applications are met through steam only. Total energy cost accounts for nearly 30% of the cost of production.

This means that steam is an indispensiable energy media in paper Industry. Power is also required for running paper machines and Pulp Mill. Since both steam and power are essentially required, Co-generation is the answer. Being process industry, uninterrupted power supply is must for getting optimized production. Even single Power tripping for 5 minutes results in nearly 30 minutes. Unreliable Power supply almost in every state calls for inplant generation of Power as a part of Process.

Co-generation Principle

Co-generation is the generation of steam and power simultaneously. Instead of generating steam pressure required by process it is generated at higher pressure and desired steam pressure for process is reached by expanding this high pressure steam in Turbine and getting power as byproduct. High pressure steam is passed through steam Turbine for generating the power. Part of steam is extracted at desired pressure and this is sent to process for cooking of pulp and drying of paper. During the expansion of steam in Turbine it generates power, which is called byproduct power. A condenser is also generally installed to take care of fluctuations in process steam demand.

Some mills install back pressure Turbine but in this case there is considerable loss due to venting of steam if the steam consumption reduces and electrical load remains the same. High pressure Extraction Turbine with condenser is a more viable

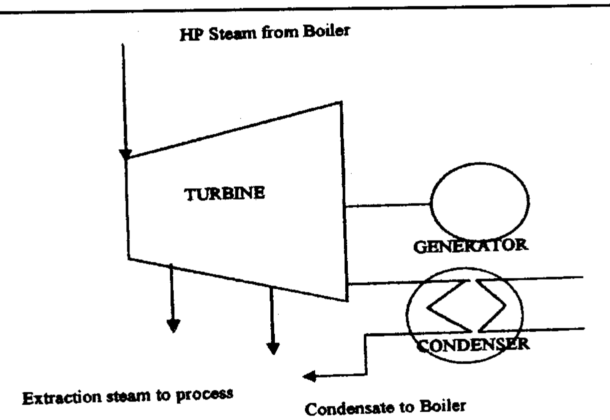

Fig. 1

option to reduce heat losses and recover condensate.

Economics of Co-generation

In India Mills consume average power of 1150 Kw and 10 tonne of steam for producing 1 tonne of paper. Let us work out the energy cost for plant with co-generation and without co-generation.

Non Co-generation Plant

This plant has installed boiler, which generat steam at 10 kg/cm² pressure for making pulp. Part of the steam is supplied to paper machine and Recovery Plant through Pressure Reducing Valve (PRV). There is no Turbine installed and Power for running of Plant is taken from Grid.

(a) Power Cost

Present Grid Power Cost	= Rs. 4.20/Kwh
Power cost per tonne of Paper	= Rs. 4,830

(b) Steam Cost

Let us consider that coal is used as fuel in the boiler.

Calorific value of coal	= 5500 kcal/kg
Landed cost of coal	= Rs. 2800/MT
Boiler Efficiency	=72% (Assumed)
Enthalpy of steam at 10 kg/cm² and 250°C is 700 kcal/kg	
Coal consumption per tonne of steam	= 0.1767 tonne
Steam cost per tonne	= Rs. 495
Steam cost per tonne of Paper	= Rs. 4950
Total Energy cost/tonne	**= Rs. 9780**

Co-generation Plant

Now consider that the same plant is equipped with High Pressure Boiler and Steam Turbine having double extraction for supplying process steam to Paper Machines, Digester and Recovery etc. Condenser is also installed to take care of fluctuations in Extraction demand. Some mills install Back pressure Turbine also. In that condition byproduct Power comes absolutely free but during any fluctuations in steam demand, part of steam has to be vented out to maintain power generation. Venting of steam to atmosphere is the total loss of energy.

In case of condensing Turbine, some cost for Power Generation is involved. This is due to the reasons that some minimum quantity of steam has to be passed through condenser for Power generation only but still the generation cost is lesser than the Grid Power Cost.

(a) Power Cost

$$\text{Energy spent for Power Generation} = \frac{\text{Energy input to Turbine - (Energy in 1}^{st}\text{ Ext.+Energy in 2}^{nd}\text{ Ext.+Energy in Condensate)}}{\text{Power Generation in the same time}}$$

(Typical Example of Turbine Operating at 46 kg/cm² and 400°C)

Enthalpy of steam	= 764 kcal/kg
Energy spent for Power Generation	= 2903 kcal/kg

This is equivalent to 3.8 tonne of steam of 764 kcal/kg enthalpy

Coal GCV	= 5500 kcal/kg
Coal Cost	= Rs. 2800 kcal/kg
Boiler Eficiency	= 72% Assumed
Coal consumption/tonne to steam	= 0.193 Tonne
Steam Cost per Tonne	= Rs. 540
Power Generation Cost/MW	= Rs. 2052
Power Cost per tonne of Paper	= Rs. 2360

(a) Steam Cost

Steam consumed for producing 1 tonne of Paper =10tonne

Therefore steam cost per tonne of Paper = Rs. 5400

Total energy cost/tonne of paper = Rs. 7760

Difference in Energy cost for Non Co-Generation and Co-Generation Plant

= Rs. 9780-7760

= Rs. 2020/tonne of Paper

For a mill with 100 tonne capacity extra expenses per year.

= Rs. 2020 x 100 x 365

= Rs. 737 lakhs

From the above comparison it is clear that for running the plant efficiently Co-generation is must. Installation of Co-generation plant requires capital cost but it is paid off by way of more profit and greater Plant availability. For running the Turbines efficiently DM water quality has to be maintained.

Efficiency Comparision of Conventional and Co-generation Plant

(a) In conventional Power Plant (Like Thermal Power Plant) High pressure steam generated in boilers is only used for power generation. These are large Power Plants of 50 to 500 MW capacities. All the steam is passed through Turbine and condensed in the condenser. For efficiency improvement only small quantity of steam is required for feed water heating. Steam is condensed in condenser as low temperature vapour and condensate is again supplied to Boiler for steam generation. Heat of steam vapours is taken by Circulating water of condenser and this heat is given in atmoshphere through cooling towers. In conventional power Plant almost 70% of heat of steam is lost as latent heat of vapours. Turbine efficiency is 22% only.

(b) Co-generation Plant

In co-generation plant part of steam after generating some power is extracted and is used in process. This steam is returned to Power Plant in form of condensate and is again fed to the boiler for generating steam.

Since part of steam is extracted during its travel the quantity of steam flowing to condenser decreases resulting in higher Turbine efficiency.

Factors affecting Co-generation plant efficiency

For Units with back pressure Turbine Power generation and Extraction steam demand must be balanced. More power generation will result in venting loss and less Power generation than steam demand will result in meeting steam demand through PRV resulting in loss of Co-generation.

For Units with Extraction cum condensing Turbine any variation in Process steam is taken care by condenser. When the extraction steam demand reduces due to any reason more steam flows through the condenser keeping the Power generation same. This results in improved condensate Recovery. By adjusting extraction loads and providing minimum steam flow through condenser Plant efficiency can be maximized.

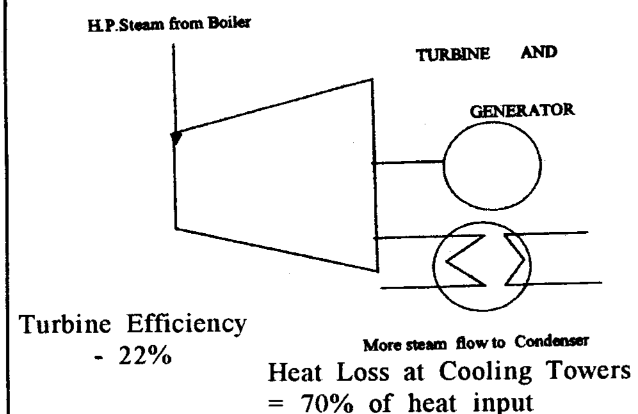

Fig. 2

Steam pressure plays very important role in maximizing the plant output. As there is limitation on low pressure side i.e. condenser part, more we increase the pressure of power generation per tonne of steam, flow through Turbine increases more. Due to this lesser steam has to be passed through the Turbine for generating same amount of power. Heat utilized for power generation increases from 13% to 23% if we increase pressure from 15kg. /cm² to 85kg/cm². This is a huge jump in efficiency but it requires higher more capital cost.

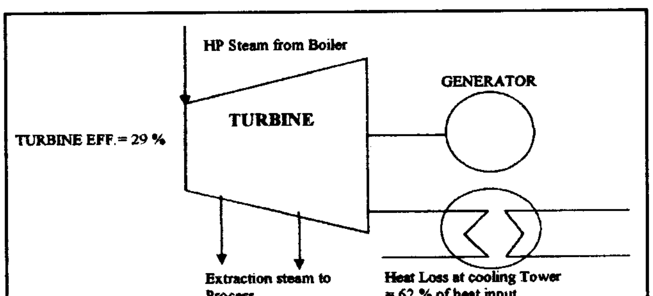

Fig. 3 Thus we can see that by adopting co-generation Turbine Efficiency has increased from 22% to 29%.

Boilers should be operated at designed pressures only. As said earlier increase, in steam pressure decreases steam rate. For every 2.4 kg/cm² decrease in steam pressure steam rate increases by 1%.

Condenser plays an important part in plant efficiency. Steam rate decreases by 5% if the vacuum is improved from 28" to 29" of Hg.

By installing feed water heaters before economizer and taking steam from Turbine extraction for heating feed water, more HP steam can be generated reducing flow to condenser. By this way cycle efficiency can be improved. Every 6°C increase in feed water temperature, results in 1% fuel saving.

$$\text{Fuel Saving} = \frac{H_3 - H_2}{H_1 - H_2}$$

Where H_3 = Temperature of Feed water at Heater Outlet

H_0 = Temperature of Feed water at Heater inlet

H_1 = Enthalpy of steam at Boiler outlet

Energy saving and efficiency improvement steps in Co-generation plant

Boiler, Turbine and Process together are the improtant elements of co-generation plant. By carefully observing the running parameters efficiency can be improved. Some of Efficiency improvement tips are:-

1. Optimization of excess air is must to reduce dry flue gas loss. Optimum excess air level for best efficiency occurs when sum of loss due to incomplete combustion and loss due to heat in flue gas is minimum. for every 15% reduction in excess air efficiency increases by 1%.
2. If the temperature of flue gas leaving the stack increases by 220°C efficiency loss is 1%. To reduce the flue gas temperature heat transfer surface of Boiler must be kept clean. Boiler should be checked for any external or internal deposits during inspection shut.
3. Increase in Feed water inlet temperature to boiler by 6°C reduces fuel consumption by 1%.
4. Presence of CO in flue gas increases loss due to incomplete. combustion. 0.2% of CO is equivalent to 1% of fuel cost. Forced draft air should be increased to supply complete air for complete combustion.
5. Boiler should be operated as close at their designed rating as possible Overall efficiency falls rapidly

if the boiler is operated below 50% of rated load.

6. Flash steam generated by discharging condensate from high pressure to low pressure is a valuable source of energy and should be utilized effectively. This may include the following areas:-
   (a) CBD of boilers
   (b) Condensate from indirect heating stations like air preheaters, dryer cylinders, digesters etc.
   (c) Condensate discharged from Traps

Flash steam generated can be calculated by following relationship:-

$$\text{Flash generated} = \frac{S_H - S_L}{H}$$

Where S_H = Sensible heat in condensate at high pressure

S_L = Sensible heat in condensate at low pressure

H = Total heat in steam at low pressure.

CONCLUSION

Co-generation imporves plant efficiency considerably. If the unit is having its own Power generating source it must be of Backpressure/Extraction cum condensing type. Power from Grid and straight condensing Turbines are costly because efficiencies are low. For extraction cum condensing Turbine minimum flow should be maintained through condenser to get maximum cycle efficiency. It is imperative to install feed water heaters to get more High Pressure steam and increase plant efficiency amd High pressure boilers (above 40 kg/cm^2) for getting more by product power. Backpressure Turbines should be run preferably in synchronized operation with grid.