Bagasse Power for Meeting Challenges of Energy

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Abstract- Electricity is an important tool for development of any country. Electrical energy is the key factor for modern civilization. If per capita consumption of electrical energy is considered as an economic indicator of a nation; then we are far behind with just 1010 KWh which is among the lowest in the world. In India, the state of Maharashtra has achieved development in almost all sectors. While, it has also seen obstacles in the process of development due to load shedding in the past 15-20 years. The energy demand is increasing day-by-day and along with that the steep depletion of fossil fuels have created the immediate need to explore different alternative sources of energy and that too particularly from renewable energy sources. Hence, the need for Cogeneration is felt increasingly today in India because India is likely to face an energy shortage of 2.6 percent of 4208 MW in 2015-16. Maharashtra is the state which alone produces 21.87 per cent of the gross production of sugarcane. Maharashtra produces 82 million tones of the sugarcane by which about 17 MT of bagasse is produced. However, at present, only about 50 percent of total available bagasse is utilized for cogeneration in the sugar industries. In this paper, analysis of current scenario of bagasse based cogeneration in Maharashtra is done. Also, the estimation for potential of bagasse power is carried out if all the available bagasse is brought into cogeneration

Keywords— *Cogeneration; Bagasse; ; Cogeneration systems; Power generation*

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I. INTRODUCTION

Sugar industry has been traditionally practicing cogeneration by using bagasse as a fuel. Sugar industry can produce electricity and steam for their own requirements just by burning bagasse which is one of its by-products. It can also produce significant surplus electricity for sale to the grid using same quantity of bagasse. The sale of surplus power generated through optimum cogeneration makes a sugar mill to improve its viability, apart from adding to the power generation capacity of the country. The sugar mills can export power in the season and also in the off-season by using bagasse. The bagasse based electricity production is more easily adoptable and also it can be made applicable to the rural areas of the country. Electricity generated in the sugar mills through bagasse is found to be cheaper than that through the conventional fuels. The emission is also very low and hence it is beneficial to the environment as it reduces the greenhouse gases (GHGs) in the atmosphere. Therefore, Bagasse, a renewable resource, can play a major role in substituting fossil fuels. Sugar industry in India is the second largest agriculture based industry after textile. India is one of the largest consumers and producers of sugar in the world, standing at the second position for sugarcane production after Brazil. Sugar industry is an energy intensive industry as it requires both steam as well as electricity. Bagasse is the leftover of the sugarcane after crushing. If this bagasse is utilised for an extensive technology known as Cogeneration instead of burning it; then thousands of megawatts can be added to the electricity generation of the country. Hence, many of the sugar industries in India have been implementing cogeneration at their plant. However, to achieve the available potential of bagasse based cogeneration, more efficient boilers are needed to be installed. But due to various barriers arising in the heat economy measures, the surplus potential of bagasse based cogeneration of India is yet to be achieved.

II. COGENERATION: THE CONCEPT

Cogeneration is defined as the concurrent generation of process heat and motive power in an industry by sequential use of energy from a common fuel source and depending on the quantity of process heat required, it may be based upon the topping or bottoming cycle. In Bottoming cycle systems, heat is required for the process at high temperatures and hence heat is generated first and power is generated through a suitable Waste heat recovery system.

On the other hand, in the Topping cycle system, heat is required for the process at low temperatures and, therefore, Power generation is taken up first. All sugar mills employ this cycle for cogenerating power and heat.

III. CURRENT SCENARIO OF BAGASSE POWER IN MAHARASHTRA

In the state of Maharashtra, there are around 290 sugar mills. Among them total 105 mills have erected cogeneration plants of different capacities. Table I gives the statistics related to sugar factories in the state of Maharashtra.[5]

Table I. Statistics of Sugar Factories in Maharashtra

Particulars	Current Status
No. of Registered Cooperative factories	202
No. of Registered Private factories	88

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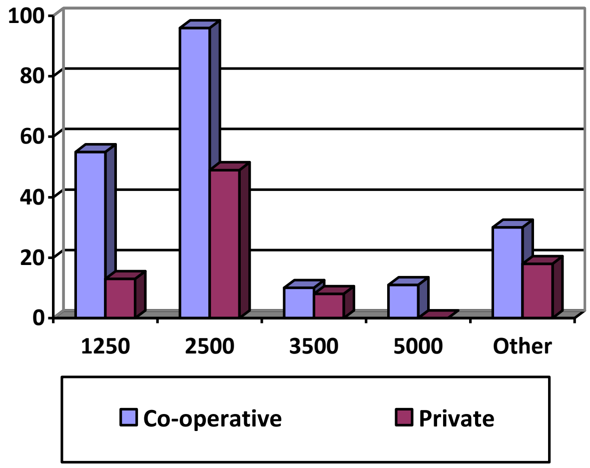
No. of factories in operation (Cooperative & Private)	240
No. of Cooperative factories having Cogeneration	56
No. of Private factories having Cogeneration	49
Average Capacity (TCD)	2500
Sugar Produced (lack Tonnes)	82
Total Installed Electricity generation capacity (MW)	1619.7

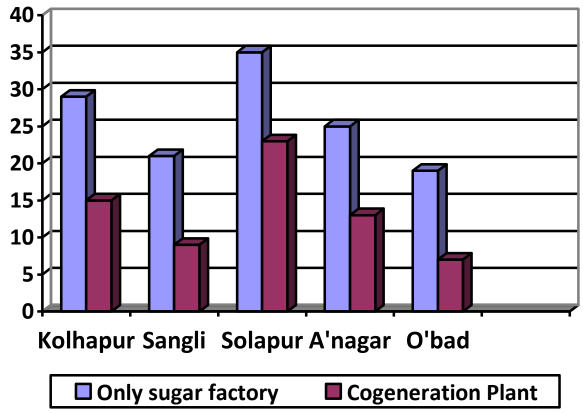
B . TCD wise distribution of sugar factories in Maharashtra

There are total 240 sugar factories which are in working condition. About 50 percent of them are having per day crushing capacity of 2500 TCD. The maximum capacity observed in both co-operative and private factories is 7500. The following graph gives the capacity wise distribution of sugar factories in Maharashtra. The x-axis represents various TCD capacities while y-axis represents number of mills of respective capacity.



B . District wise distribution of sugar factories in Maharashtra

Among total 35 districts of Maharashtra, sugar factories are located mainly at Kolhapur, Sangli, Solapur, Ahmednagar as sugar production is highly concentrated in these districts. In the following graph, the x-axis represents major districts having sugar factories while y-axis represents number of factories in respective district.



Cogeneration Systems

Now-a-days, in the modern cogeneration plants, advanced cogeneration systems are employed by employing high pressure boilers and condensing cum extraction turbines. These sugar mills have been able to export power in the season as well as in the off-season by using bagasse. High technology has made these sugar mills efficient by improving the economic viability of the mills in terms of higher production of units of electricity per unit of bagasse. The ratio of heat to electricity generated varies depending on the type of arrangement. The steam-electric power plant with the extraction-condensing turbine is widely used because it can be arranged to give a wide range of ratios to suit the processing requirements of the sugar factory. The boilers generally range from 35 to 150 ton of steam per hour, at pressures varying from 15 to 82 bar and temperatures ranging from 300◦C to 525◦C [9].

Traditionally, cogeneration was adopted as a means of incinerating bagasse in a useful way by generating steam in boilers for process heating and electricity generation. This was regarded as an intelligent way of converting waste into useful energy. Production efficiency and process optimization for energy production were not taken into account. The two major parameters which needs to be considered while optimizing energy production at a sugar factory are-

1. The steam to bagasse ratio (Rsb).

Rsb is a measure of the yield of steam per unit weight of bagasse, thus representing the efficiency of steam production. Operating parameters which influences Rsb are-

(1) moisture and fiber content of bagasse; (2) excess air ratio; (3) flue gas temperature; (4) furnace temperature and boiler pressure.

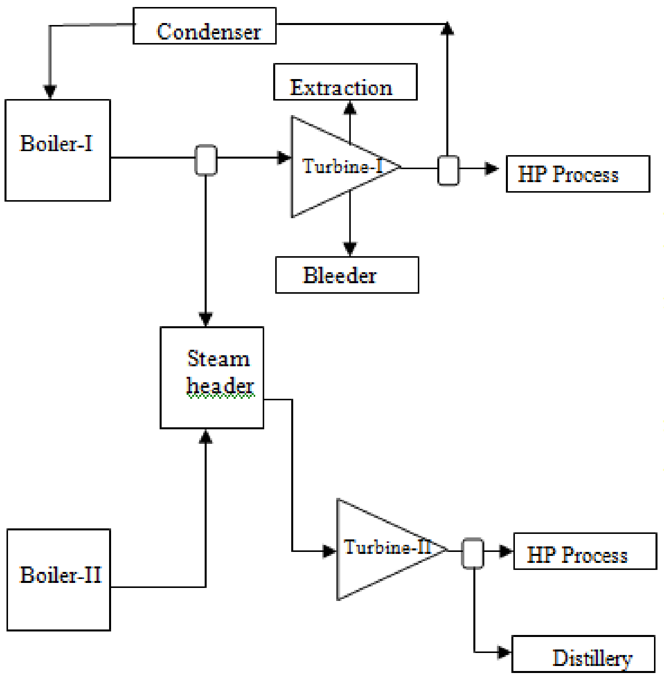
2. The specific steam consumption (SSC).

SSC is a measure of weight of steam required per unit of cane being processed. It is a measure of the efficiency of steam utilization for the manufacture of raw sugar. High efficiencies of steam generation (high Rsb) and low process steam utilization (low SSC) would demand the use of equipments such as high-pressure boilers, boiler feed water treatment plants, condensing turbines and modifications of the process steam cycles[2]. Over the time, The boiler and turbine are transformed to high efficiency units by changing the steam condition that is increasing the temperature to between 440◦C and 460◦C and the pressure to between 45 and 60 bar and by using extraction/ condensing steam turbines[10].

IV. CASE STUDY

A Typical Cogeneration plant in the state of Maharashtra is considered for estimation purpose. The details of the plant are given below:

A. *Cogeneration process flow diagram*



B . Ratings of the machines present at the factory

There are two boilers and two turbines at the proposed factory. The per day crushing capacity is 5000 TCD and the electricity generation capacity through cogeneration is 32 MW. The ratings of the various equipments are as follows:

1. Boiler-I
Type- spreader stoker travelling grate water tube boiler
Capacity- 140 TPH
Working Temperature- 510°C
Working Pressure- 72 kg/cm2

2. Boiler-II
Type- spreader stoker travelling grate water tube boiler
Capacity- 30 TPH
Working Temperature- 510°C
Working Pressure- 67 kg/cm2

3. Turbine-I
Type- Condensing cum Bleed cum extraction
Capacity- 20 MW
Steam Input- 90 Metric Tones
Steam Output-
a).Extraction- 36 MT at 1.5 kg/cm2
b).Condensation- 40 MT at 0.9 kg/cm2
c).HP Process- 5 MT at 7 kg/cm2
d).Bleed(Distillery)- 9 MT at 9 kg/cm2

4. Turbine-II
Type- Back-Pressure cum Bleed Type
Capacity- 12 MW
Steam Input- 80 MT
Steam Output-
a).Distillery- 10 MT at 6.5 kg/cm2
b).Process- 70 MT

VI. POWER FOR MAHARASHTRA

As observed from Table I, Among 240 working sugar factories in the state of Maharashtra, only about factories have erected Cogeneration plant at their premises. Hence, the bagasse potential from remaining factories remains unused. If this bagasse is brought into use by employing it into cogeneration process at the factories where cogeneration plant is in operation; then surplus generation of electricity can be carried out. The estimation of bagasse based power potential is done below:

1. Bagasse power generation from co-operative sugar industries having no cogeneration:
a).No. of co-operative sugar factories in Maharashtra- 202
b).No. of co-operative sugar factories having no cogeneration- 146
c).TCD available from these factories- 305650 Tones
d).Per Hour Crushing capacity(TPH)- 13893.18 TPH
(Per day working hours- 22 Hrs.)
e).Bagasse Percentage in Sugarcane- 25%
f).Total available bagasse- 3890 TPH
g).Now, from 1 tonne of bagasse, 2.35 tones of steam is generated. Hence, steam that can be generated from available bagasse- 3890* 2.35=9141.5 TPH
h).Now, steam required for process- 40% of TPH sugarcane available- 40% of 13893.18= 5557.27 TPH
i). At standard temperature and pressure back pressure turbine requires 6.1 TPH of steam for the generation of 1MW of electricity. Hence, power generated by BP turbine-
5557.27/6.1=911 MW
j).Now, steam available for condensation turbine-
9141.5-5557.27= 3584.23 TPH
k). At standard temperature and pressure back pressure turbine requires 4 TPH steam for the generation of 1MW of electricity. Hence, power generated by condensation turbine-
3584.23/4= 896 MW
l).Hence, total power that can be generated is-
911+896=180 7 MW

2. Bagasse power generation from private sugar industries having no cogeneration:
a).No. of private sugar factories in Maharashtra- 88

b).No. of private sugar factories having no cogeneration- 39
c).TCD available from these factories- 77200 Tones
d).Per Hour Crushing capacity(TPH)- 3509 TPH
(Per day working hours- 22 Hrs.)
e).Bagasse Percentage in Sugarcane- 25%
f).Total available bagasse- 982.54 TPH
g).Now, from 1 tonne of bagasse, 2.35 tones of steam is generated. Hence, steam that can be generated from available bagasse- 982.54*2.35 TPH= 2309 TPH
h).Now, steam required for process-
40% of 3509= 1403.6 TPH
i).Power generated by BP turbine-
1403.6/6.1=230 MW
j).Now, steam available for condensation turbine-
2309-1403.6= 905.4 TPH
k).Power generated by condensation turbine-
905.4/4= 226.35MW
l).Hence, total power that can be generated is-
230+226.35= 456.35 MW

3. Total electricity generation from unutilized bagasse available in co-operative and private factories can be estimated as 1807+456.35= 2263.35 MW.

VII. Analysis

Generally, In the state of Maharashtra, sugar factories stay active for around 5 months(from November to March). In the remaining period factories are not in the operation. The proposed sugar factory is having cogeneration plant of 32 MW. However due to insufficient bagasse, only about 26 MW electricity is generated. That means the boilers are not run with their full capability.

If during off-season, bagasse from other factories having no cogeneration is brought at the proposed factory then 32 MW of electricity can be generated which can be further supplied to the respective power grid as no electricity is required during off-season of the factory. Whereas, the amount of electricity that can be supplied during active period of the factory is about (26-6.022) 19.978 MW. If during on-season also if surplus bagasse is arranged from other factories then plant can be run for the total capacity of cogeneration i.e 32 MW and hence the power to be exported is (32-6.022) 25.978 MW.

Moreover, as explained above if the all available bagasse in the state is brought into cogeneration, then about 2263.35 MW of surplus electricity can be produced. Hence, total electricity generation capacity by cogeneration in the sugar mills can be increased from 1619.7 MW to (1619.7+2263.35) 3883.05 MW which is enough considerable.

Now, the transport expenses for bringing the bagasse from other factories is needed to consider. The price of sugar in the world market makes it necessary to keep production costs very low in order to ensure some profit margin, and it is therefore essential to optimize the transport of sugar cane to the factories.

CONCLUSION

In view of the economic advantages as well as the conservation potential, there is an urgent need to encourage cogeneration in individual industries.

The power produced through cogeneration substitutes the conventional thermal alternative and reduces greenhouse gas emissions. High efficiency bagasse based cogeneration can be perceived as an attractive technology both in terms of its potential to produce carbon neutral electricity as well as its economic benefits to the sugar sector. In the present scenario, where fossil fuel prices are shooting up and there is a shortage and non-availability of coal, cogeneration appears to be a promising development.

The analysis carried out suggests that the sugar industries in the state of Maharashtra can be proven to be the leading industrial sector as far as generation of electricity through cogeneration is concerned. If the total available bagasse is brought into cogeneration, then approximately 3880 MW of electricity can be generated some part of which can be exported to the grid. By applying suitable optimization techniques, the transportation routes can be optimized so that minimum cost of transport can be obtained. The steps towards total utilization of available bagasse will help for sure to reduce the demand-supply gap that the Maharashtra is facing.

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