Bagasse Based Cogeneration

Synopsis

Cogeneration is not new to the cane sugar Industry. Eventhough sugar plants have been Cogenerating right from their inception, Cogeneration for surplus power generation has gained momentum in 1993. There are four full-fledged Cogeneration plants operating in Tamil Nadu, and a few plants have been commissioned in the other states as well. Quite a number of plants are in the various stages of implementation in various states. The successful operation of the plants in TamilNadu has created a lot of interest in Cogeneration and there has been a flurry of activities in the preparation of feasibility studies and project reports. A few of the technical aspects of the sugar plant Cogeneration systems are discussed. A discussion on the cycle parameters for the Cogeneration plants is also given.

Introduction

Bagasse based Cogeneration gained momentum in 1993, subsequent to the report submitted by the committee constituted by MNES. In TamilNadu, full-fledged Cogeneration plants have been commissioned in Four sugar plants. The first of these plants with the installed capacity of 18.68 MW, was commissioned and synchronized in November 1995, and the biggest of these plants with 30 MW capacity was commissioned in May 97. Operation of all these plants has stabilized. All the plants commissioned are based on 64 ata and 480´℃ cycle parameters. The 18.68 MW plant is designed with a 70 TPH boiler and a double extraction cum condensing turbine capable of generating 13.2 MW during season and 18.68 MW during the off-season operation. The 30 MW plant is designed with Two nos. of 70 TPH boilers and a double extraction condensing machine of 30 MW capacity capable of generating 24.5 MW during the season and 30 MW during the off-season operation. There has been a flurry of activities in the other states as well in the preparation of DPRs and implementation of Cogeneration programs.

Technical Aspects

Cogeneration based on Rankine Cycle is not new to the sugar industry, but however Cogeneration based on High pressure boilers and extraction condensing or straight condensing machines are definitely new to the industry. Cogeneration, by virtue of the fact that the excess power could be sold to the grid or to a third party for a price, puts a demand on the sugar industry for modernization, discipline and for energy conservation and this is new to the sugar industry. The following highlights a few of the technical aspects of the Cogeneration projects.

Basic design of the Cogeneration plant

This stage of Project is where the configuration of the Cogeneration plant gets finalized. What is important is that the configuration conceptualized is appropriate for the specific project. Basically the Cogeneration plant configuration is site specific, eventhough some amount of standardization could be made for the grass root plants. The Scheme should consider the available bagasse, the variations in the bagasse availability, the process steam requirements and the pressure levels. Considering the variations in the bagasse availability and the possible variations in the process steam consumption and the number of days of operation, may be it is better to down size the plant and ensure maximum plant load factors. The plant cycle should be optimized to give the best efficiency. The success of the Cogeneration plant depends on this "Basic Design " Phase. Plant Layout is part of the Basic design and is very important from the point of view of operability and maintainability of the plant. The plant and equipment should be so laid out that there is optimum routing of piping , cables and conveyors. Cooling tower location is very important from the point of view recirculation of plume, and also to prevent contamination of the cooling tower water with bagasse and ash. The switchyard layout should be such that the transmission lines could be run without difficulty and hindrance.

Steam generating system

The capability to design, manufacture and install steam generating systems of any capacity with any outlet steam parameters is available within the country. Bagasse being a fuel not amenable for perfect metering has given some problems with regard to the superheater steam temperatures. Higher temperatures during start-up and at load fluctuations have been experienced, but could be contained because of the desuperheating provided.

Some fine tuning is required in the areas of excess air control and unburnt carbon loss control. The operation of the cinder recovery systems provided is not satisfactory and the system provided need improvements.

Feed water quality control is an area needing attention and this is separately dealt under the water quality management.

In conventional bagasse fired boilers, the bagasse is fed into the boiler directly from the mill. The quantity of bagasse fed into the boiler is controlled manually by opening or closing a gate in the return bagasse carrier. This system cannot have an automatic combustion control. In order to implement an effective combustion control, storage bunkers above the feeders, or a continuous circulation of a large quantum of bagasse, say, about 50% of more bagasse, through a merry-go-round system is required.

An effective bunker system for the storage of bagasse, which will store bagasse for the requirement of about 10 to 15 minutes for the boiler MCR, has been successfully tired and implemented. This system operates well for a bagasse that is well prepared and with 50% moisture.

Turbogenerator System

The experience has shown that the turbine for the Sugar plant Cogeneration application should be rugged and preferably with slow speed. Problems in maintaining the steam purity in the boilers affect the turbine with deposits on the blades. The major contaminant is silica that gets carried over as vapor as the operating pressure of the boiler increases. There had been some problems of vibration and failure of bearings. These were due to initial problems in the lube oil system, and these could be resolved by having proper pre-commissioning checks. There had been some problem of exhaust hood spray falling on the blades and causing vibration. This was mainly due to a misdirected spray nozzle in the exhaust hood.
However there is a specific problem with regard to the servicing and spares availability. There are a number of suppliers who can supply the machines, but other than One or Two, there is none that has set up an adequately staffed service network and stocks adequate spares. This could pose major problems, specifically after the warranty periods. Most of the suppliers, import the turbine steam path components, generators, AVRs and a few auxiliary equipment, and in such cases spares and servicing could pose serious problems.

Water Quality Management

This is one area that needs more attention. Extraction steam at low pressures is supplied to the sugar plant for processing. About 90% of the steam supplied to the sugar processing is returned as condensate to the steam generator feed water system, at a temperature of around 95 Deg.C. Generally there could be no contamination of this condensate. Sincere and disciplined efforts should be made to keep this condensate free from contamination. We are not recommending the usage of the vapour condensate for the feed water application as the quality of this condensate varies. Generally the pH is low, the TDS and silica are high and there could be traces of ammonia and organic compounds. We could use this with a lot of monitoring, but the repercussions could be serious if the monitoring system malfunctions or fails.
This aspect of water management needs some more study and a lot more of discipline.

Bagasse Handling

During the cane crushing season, the cogeneration plant receives the bagasse directly from the mill, and the surplus bagasse is taken to the bagasse storage yard. The bagasse thus saved could be used for the off-season operation of the Cogeneration plant, or could be used to run the Cogeneration plant on the cleaning days or when the mill is not running due to some other reasons. Under such occasions back feeding of the bagasse from the yard to the boiler is required. As the unit size becomes larger the quantum of bagasse to be backfed is so high. The feeding becomes non uniform, resulting in the overloading of the conveyors if the feeding is done improperly with bulldozers or pushers. To overcome the backfeeding difficulties stacker reclaimers have been designed, but only with limited success. Such systems are successfully in use in Mauritius and Reunion Island. We understand that large storage bins with automatic stacking and reclaiming facilities are in use in Australia, but we also understand that the cost of such systems are prohibitively high. Some operationally effective and also cost effective system of stacking and reclaiming is to be devised. If a good system is developed the best operating procedure will be to delink the Cogeneration plant operation from the mill operation, by taking all the bagasse to the storage yard and feed the boiler only through the reclaiming system.

Process side steam Economy

The success of Cogeneration depends on the quantum of power the plant is able to export. One important parameter that can contribute greatly to the success of Cogeneration is the process side steam economy. A program of modernizing the boiling house and pans and effecting steam economy should precede the implementation of Cogeneration. There is an urgent need to focus attention on this, as this could very well improve the Cogeneration plant viability.

Milling Section

Milling section in a sugar plant, where the juice is extracted from the cane, is the most important section of a sugar mill . This is where the bagasse is prepared as a fuel, and the moisture in the bagasse controlled to a value of around 50%. If there are problems with this section, the moisture content in the bagasse could go high and the bagasse will not be prepared well for handling and combustion.
Other points related to milling section are the use of optimum imbibition and the use of Electric or Hydraulic Drives for the mills.

Electrical Systems

As far as the technology for the design of the electrical systems for the Cogeneration plant, right from generation to EHV system and grid paralleling is concerned, enough experience is available. All the electrical equipment required for the Cogeneration plant, as well as its grid paralleling are available indigenously. The only problem faced by the Cogeneration plants is the stability of the grid.
There are unfounded fears in the minds of the plant operators with regard to the ability of the cogeneration plant to cope up with the tripping of the grid. If the protections are properly chosen and the equipment are properly specified, there is no reason why a cogeneration plant should trip with the grid and not go into island operation. To the extent possible efforts should be made to parallel the cogeneration plant at 110 kV level.

Controls & Instrumentation

Being the most important subject from the point of view of operation and maintenance of the cogeneration plant, this subject deserves a lot of attention. Distributed Control System

(DCS) is the order of the day. The technology for the planning and designing the complete controls & Instrumentation system for the cogeneration plants is available, but what is required is to create an awareness among sugar plant people about the importance of instrumentation in the operation and maintenance of the cogeneration plant.

Cycle Parameters For Cogeneration Plants

Historically the operating pressures for the boilers in a sugar plants have slowly gone up from 11.5 ata to 43 ata , and now to 67 ata. A large majority of the sugar plants that are built today have boilers with the operating pressure of around 43 ata, and with the superheater outlet temperature varying between 400 Deg. C to 440 Deg.C. Out of these, there are a few installations that are designed with Cogeneration also. Quite a few boilers that have been installed, in sugar plants for Cogeneration applications in the last four to five years have been designed with an operating pressure of 67 ata and with the superheater outlet temperature of 485 Deg.C.

A substantial majority of the operating sugar plants, still have boilers operating at 11 ata or 14 ata or 21 ata, and in an industry where such low pressure boilers are common, 43 ata or 67 ata is looked upon as high pressures. Even among 43 ata and 67 ata systems, 43 ata system has gained popularity as more units with 43 ata pressure is operating and more are getting added to the population. As the 67 ata systems are getting established and more number of units are being ordered and installed, there area objections from the old school that 67 ata is a high pressure system and is not suitable for the Indian sugar Industry. Such arguments and Objections are mostly because of the lack of experience with such pressure systems. It is a fact that, elsewhere in the world, there are bagasse based Cogeneration plants, operating alongside the sugar plants, that are designed and operating with even 110 ata pressure, and there is no reason why such systems can not operate in our sugar plants.

Our country has built a lot of superthermal power plants where the operating cycles are based on even 185 ata pressure, and those plants designed and built by Indian engineers and operated by Indian engineers are running successfully. To power engineers, the 67 ata and even 85 ata cycles are still medium pressure cycles and not high pressure cycles.

In a sugar plant environment, the opposition to the introduction of higher or medium pressure systems are mainly due to the lack of experience. However, masquerading the fact that the opposition is mainly from the lack of experience, the common arguments put forth are, the lack of skill for the operators in a sugar plant, the requirement of stringent feed water quality, the difficulties in grid interfacing etc.. The following addresses a few of the generally prevalent misconceptions in the industry with regard to the so called high pressure cycles. There is nothing wrong with 44 ata or 64 ata and even with 85 ata for sugar industry application. The decision to choose a particular cycle should be purely based on techno-economic criteria and not on personal bias and bogies.

The following give some of the specific apprehensions with regard to the 64 ata cycle.

1. High Investment and running cost :

"The cost of equipment for identical output from boilers and TG sets for 64 ata system undergo a quantum jump as compared to the 44 ata system. Also in the 64 ata system, the steam temperatures will be around 500 Deg.C, thus necessitating the use of alloy steels in all steam handling stations and considerably increasing the costs for all these equipment. The total cost addition is about 35 - 40 %."

The above observation made generally is clearly a misconception and is not correct. For two plants consuming the same quantum of the fuel, the plant based on 64 ata cycle gives more power than the one based on 44 ata cycle. This difference is about 16%. This difference is, only when comparing the high efficiency machines, for both 64 ata and 44 ata cycles. When compared with the configuration involving a group of low efficiency machines, this difference could go up to 20 % to 22 %. The areas where higher costs are involved, consequent to the change in the cycle pressure and temperature, are the boilers, turbines and the piping. There is no difference for the other systems and sub-systems of the plant. The incremental cost involved, is calculated and projected subsequently, and that definitely cannot be called as quantum jump in the cost.

The only piping that is to be fabricated out of alloy steel is the main steam piping. It may be noted that the piping to be used for main steam line even for 430 Deg.C steam temperature is low alloy steel. The current practice in the power industry, if the steam temperature go above 400 Deg.C, is to use low alloy steels, on account of graphitization, creep etc.

2.Boiler Water Management

"The use of 64 ata steam generation system would warrant strict maintenance of water quality, both feed water and boiler water to within limits for proper operation of the boiler and avoiding scale formation in turbogenerators"

The above observation is made generally comparing the 44 ata and 64 ata cycles. It is true that the water management needs more attention, in either of the cases and more so as the pressures increases. The recommendations given by standard institutions, renowned boiler manufacturers etc., do not change with every ata increase in pressure. The recommendations are generally for a range of pressures. Some classify the pressures as low pressure, medium pressure and high pressure, and others give pressure ranges like 10 to 20 ata, 21 to 40 ata, 41 to 60 ata etc.

The following give a few of the recommendations with regard to the feed and boiler water

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The following give a few of the recommendations with regard to the feed and boiler water:
a) BHEL's recommendations :
Recommendation of Feed water:

Pressure	41 to 60 ata	61 to 100 ata
Hardness, ppm	Nil	Nil
pH	8.8 to 9.2	8.8 to 9.2
Oxygen, ppm	0.01	0.005
Total Iron, ppm	0.01	0.01
Total Copper	0.01	0.01
SiO_2, ppm	0.1	0.02
Residual Hydrazene,ppm	0.02 to 0.04	0.01 to 0.02

It may be seen from the above, the important difference as given by BHEL is only in the silica level in the feed water. A good DM plant will give the required silica level in the feed water.

Recommendation for Boiler water :

Pressure	41 to 60 ata	61 to 100 ata
TDS	150	100
pH	9.8 to 10.2	9 to 10
Silica, ppm	15 to 25	5 to 20

It may be seen from the above there are differences in the TDS and the silica levels. This can be easily maintained with appropriate blowdown and maintaining the feed water quality levels.

b) Recommendation of B&W as given in "Steam" Book:
Recommended Limits in Boiler Feed water

Drum Pressure	Below 600 psi	600 to 1000 psi	1000 to 2000 psi	above 2000 psi
Total Solids, ppm	----	----	0.15	0.05
Iron, ppm	0.1	0.05	0.01	0.01
Copper, ppm	0.05	0.03	0.005	0.002
Oxygen, ppm	0.007	0.007	0.007	0.007
pH	8 to 9.5	8 to 9.5	8.5 to 9.5	8.8 to 9.5
Total Hardness as CaCo3,ppm	0	0	0	0

It may be seen from the above table that there is no differentiation with regard to the (42 ata and 64 ata cycles from B&W's point of view. The 42 ata cycle will call for a boiler drum operating pressure of atleast 48 ata (682.7 psi), and 64 ata cycle will call for a boiler operating pressure of atleast 70 ata (995.6 psi), and both fall under 600 to 1000 psi range.

c) The book on "Water Treatment" by Mr.F.Belan (Mir Publishers Moscow) recommends the same feed water quality for the range of pressures from 4.0 Mpa to 10.0 Mpa, i.e roughly from 40 ata to 100 ata. This book gives the Russian practices for the water quality standards.

With the above it may be seen that there are differences between the 42 ata and 64 ata requirements, but those differences are very minor and it should be possible to take care of them during the plant operations. With only the exhaust condensate and DM Water used as boiler feed water, there will be no problem. Vapour condensate if monitored could be used. Heat recovery from vapour condensate to DM water is possible. DM Plant operation is not very costly. The cost of DM Water, for normal raw water quantity is about Rs.15/Cu.M for normal raw water quality.

3 Technological Constraints in Design and Operation.

There is no technological constraint in the design and operation of the 64 Ata cycle. As seen earlier there are much higher pressure systems that are designed, built and operated in India, and a 64 ata Cogeneration system can never pose any technological constraint.

Another statement used quite often is that the "fluctuations in sugar mill operation due to various internal and external reasons can considerably increase the net running cost". There is no validity in this statement as the plant designed with knowledgeable and experienced engineers will automatically take care of the above.

4 Operation needs skilled Man Power

It is so with any new better technology. When the mill (a typical 5000 TCD capacity) is investing about Rs.70.0 to 75.0 crores on the Cogeneration Plant, it is worth identifying appropriate skilled man power and train them for the operation and maintenance. It is worth mentioning here that the Cogeneration plants commissioned so far with 64 ata cycle have been operating with most of the staff drawn from the sugar mill. What is important is that the operators and engineers should be properly trained. It should also be noted that there is no difference in the no.of persons required for operating 44 ata cycle & 67 ata cycle.

5. "The 67 ata boilers are under trial stage as far as the Indian sugar industry is concerned."

It is true that the 64 ata cycles were introduced only four or five years back in the Indian sugar Industry, but they are well past the trial period. The Cogeneration plants designed with 67 ata boilers and turbogenerators are operating very well for the past few years. The 67 ata cycles and still higher pressure cycles are widely being used in other countries, even for sugar plant Cogeneration applications. Technology has no territorial bar, and whatever technology works elsewhere in the world should work the same or better in the Indian scenario also.

The technology of designing manufacturing and operating such boilers and still higher pressure boilers and power plants are available within the country for decades. Like any new technology, the introduction of such high pressure systems in any industry calls for skilled and trained operators and some discipline in the operation of the plant. When a vast skilled and trained pool of manpower is available with in the country, it is difficult to understand why the sugar industry should be denied the advantage of a new modern technology.

6. "Silica Carry over and consequent damages"

It is a fact that the vapourous carry over of silica increases with the increase in the boiler operating pressures. It is not that the carry over is zero at 46 ata and it becomes a serious problem only if the pressure goes to 67 ata. It is to be noted that there are boilers with above 200 ata pressures operating in the country.

At 67 ata the carry over is slightly more than that at 46 ata. Once the silica level in the feed water and boiler water is controlled there is no problem of unacceptable carry over in the steam going to the turbine. With the recommendation of using the Exhaust condensate and DM water for the boiler feed, the silica carry over no longer poses a major problem in the operation.(The vapour condensate could also be used with careful monitoring or atleast the heat in the vapour condensate could be utilized for heating the incoming DM water).

Comparison of Parameter	44 ata and 64 ata44 ata cycle	Cycles for A Project: 64 ata Cycle
Fuel consumed	63.3 TPH of Bagasse per Hour & 100 S.Cu.m per Hour of Bio-Gas	63.3 TPH of Bagasse per Hour & 1100 S.Cu.m per Hour of Bio-Gas
Gross Power Generation	24000 kW	28000 kW
Exportable Power	15445 kW	19220 kW
Exportable Units per Year	81.73	101.71
Total Project Cost (Rs.Lakhs)	7265.47	7634.88
Internal Rate of Return (%)	27.44	34.11
Net Present Value (Rs.Lakhs)	3004.24	5119.10
Project Schedule	20 Months	20 months

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Conclusion

The bagasse based surplus power Cogeneration is not entirely a new technology. The successful operation of the plants that have been commissioned and operating prove that bagasse based Cogeneration could play a substantial role in bridging the ever widening gap between the electricity supply and demand. There are a few technical, issues that need to be addressed to for the successful implementation and operation of these projects. Adapting to, and operating the high pressure boilers and extraction condensing turbogenerators, and HT and EHV systems need trained manpower and certain discipline. The 64 ata 480 Deg.C cycle is definitely advantageous compared to the 44 ata cycles. There is no technological constraint in adopting high pressure cycles for the sugar plant Cogeneration systems.

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