Modern Trends in Technology and relevant issues in cogeneration plants of Sugar Industry

Synopsis

Cogeneration in sugar industry to produce excess power and exported to the State Electricity Board grid has gained momentum and is the order of the day. The successful operation of four full fledged cogeneration plants in Tamil Nadu and a few more in other states have given the required confidence for the sugar industry to implement cogeneration plants. In fact, the profitability of a sugar plant is centered around the revenue from export of power. The encouragement being given by the central and state government for promoting the use of bio-mass / non-conventional, Eco-friendly energy further encourages the implementation of cogeneration plants in sugar industries. Today the catch word in the industry is to "to maximize the export of power".

Introduction

The bagasse based cogeneration plants generally consists of a high pressure boiler and a double extraction cum condensing turbine. The terminology high pressure has a floating value today as the power cycle parameters adopted are undergoing fast changes. Since, the first plant was installed with a capacity of 18.68 MW and was commissioned and stabilized in November 1995 there are a flurry of activities for preparation of Detailed Project Reports and implementation of Cogeneration programs. The Progressive minded changes in a State Electricity Board power purchase policies such as allowing certain percentage of pass through of power using conventional fuels is resulting in the increase of the Cogeneration Plant capacities. The increasing sizes offers options on selection of higher parameters for the power cycle which are in turn related to the capacities of the steam generators and turbo generators. The modern trends in technologies and the related issues are discussed in this paper.

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, even though 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 allowable percentage of the pass through using conventional fuels like oil / coal, 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.

Power Cycles

The Cogeneration scheme for any sugar plant is plant specific and there is no single scheme applicable for all the plants. A scheme applicable for a grass root plant will not fit into an existing operating plant wanting to go for Cogeneration. Even among operating plants, a plant going in for modernization or capacity up gradation can have an economical and power maximizing configuration, than the one where no capacity addition or modernization is planned. The modernization mentioned above includes, changing Mill drives from inefficient single stage steam turbines to Hydraulic/Electric drives, process improvements to reduce steam consumption by judicious vapor bleeding and usage of continuous pass etc., These steps make more steam available for power generation and improves vastly the viability of the Cogeneration Project. For a typical 5000 TCD plant with steam consumption 42% on cane the possible maximum steam generation will be around 148 TPH. By adopting difference cycle parameters the indicative figures of the maximum power generation possible are:

- 64 ata 480 Deg C - 27,400 kW
- 84 ata 510 Deg C - 29,200 kW
- 105 ata 515 Deg C - 31,680 kW.

The above data indicates that adopting 105 ata pressure cycle about 15.6% more power can be generated for the same sugar mill if it had adopted 64 ata power cycle. Thus, the selection of the power cycle and the cost competitiveness depends on the steam generation quantity of the boiler. By adopting multi stage feed water heating, high pressure deaerator and adopting new technologies for reducing moisture percentage in bagasse will contribute to the overall cycle efficiency increase. The major issues in adopting higher pressure cycles are the selection / availability of proven high capacity boilers and fuel handling / firing system. The availability of servicing facility and spares for imported high capacity turbo generators could also be a specific problem.

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. Travelling grate with pneumatic distributors are best suited for wide variations in the type of bio-mass fuel and additional use of conventional fuels such as coal / lignite / furnace oil. The availability of a reliable and well proven travelling grate of large size to suit 150 to 200 TPH indigenously is yet to be verified. The experience available with the various boiler manufacturers worldwide seem to have limitation on the boiler capacity matching with high pressure. Many references are available with boiler capacities in the range of 200 TPH but limited to low steam pressures. The operating experience / feed backs of the large size of grates have to be obtained before selecting boilers of high capacity.

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 vapor 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. For use of other fuels such as cane trash, cotton stalk etc., the collection of the fuels from the farms, bailing, de-bailing / chipping facilities have to be perfected. There are many imported equipment available for collection bailing and shredding of the bio-mass fuels. The dependability and performance of these machinery in the Indian Environment are yet to be verified.

Bagasse Drying System

The bagasse from the mill contains 50% moisture. This moisture is evaporated in the furnace and is let out from the boiler at a temperature of about 160 Deg C without any useful contribution. This moisture restricts the efficiency of the boiler to around 70%. If this moisture is removed from the bagasse before it is fed into the boiler, the boiler size can be designed to be much smaller in dimensions for the same output or the capacity of the boiler can be increased in an already existing boiler. For every 5% reduction in moisture the boiler efficiency will go up by about 1%. This means that with the same quantity of bagasse available the capacity of the cogeneration plant can be increased. Various methods of drying have been tried. One among them is to tap off the flue gas from the boiler at a higher temperature and use it in a rotary bagasse drier. This method decreases the efficiency of the boiler due to tapping off of the gas at a higher temperature and has added disadvantages of pollution problem due to spreading of the dry pith in the bagasse. In this case, the bagasse is best dried in the furnace. If alternate heat source of surplus low pressure steam is available then it could be utilized in a rotary steam drier. This is a general practice for drying of de-pithed bagasse to about 5% moisture level in particle board plants. In these driers there is a rotating bundle of tubes through which the steam is passed and the bagasse moves on the outside of the tubes from one side of the bundle to the other. It is possible to reduce the moisture percentage in bagasse from 50% to 20%. The steam for the drying can be bled from the power turbine which will in turn improve the efficiency of the power cycle. The scheme for the system should be properly designed and optimized. In the operating experience available with steam driers have been more with de-pithed bagasse. The size / capacity of the driers also do not match with the required capacities for a Cogeneration Plant. Hence, more feed backs and operating experience on the working of the steam driers with un-depithed bagasse is to be studied before implementation.

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.

Conclusion

The maximization of power generation from bagasse based Cogeneration plant is the thrust factor in implementation of Cogeneration Plants in sugar industries. The basic design of the plant consists of the selection of power cycle parameters, the number of units and capacities of the boiler and turbo generator. The techno economical viability depends on the correct selection of the technology and adopting higher cycle parameters. The issues relating to the selection of the size, the number of units and the design of various other systems such as bagasse handling system, the water system etc., needs careful attention and a more in depth study of the feed backs and operating experience worldwide. There is no technological constraint in adopting high pressure cycles for the sugar plant Cogeneration systems.

ENERGY CONSUMPTION IN SUGAR MANUFACTURES:

Sugar is a highly energy oriented sector and consumes energy in all its forms viz. heat, mechanical and electrical. Steam consumption ranges from 45% to 60% depending upon technologies and the power consumption ranges from 20 units / tonne to 23 units per tonne in non cogen units and 28 units per tonne cane to 32 units per tonne cane in cogeneration units with electrical drives for mills and fibrisers. There is considerable loss of energy during the process of conversion from one form to the other and the right selection of the systems, technology, equipments etc. play a vital role in the overall energy conservation. Adoption of modern concepts like automation, V.F.D. drives, energy efficient motors, choosing of transmission gears, high efficiency pumps, correct sizing of all equipments, reducing energy losses due to leakages, radiation, friction and reduction in downtime etc. are the important aspects to be taken care of while aiming at energy conservation.

Therefore a detailed energy audit of all the systems in the factory is essential to identify the lacuna and effect improvements. Most often it is observed that the above aspects get overlooked leading to all-round inefficiencies and loss of energy and revenue.

In one of the energy audit exercises, it was estimated that opportunity existed for reducing more than 800 kW of power consumption in a 4000 TCD plant, the details of which are highlighted below.

The total power generated by both the TG sets was found to be 3831 kW. The break up of power consumption by different sections of the plant is shown in the pie chart annexed. As this includes the consumption of distillery and refinery units also, the consumption of sugar factory alone comes to 22.10 units / ton cane, which is a very high figure for a steam driven factory. The unitwise energy scenario is detailed in the following paragraphs.

01.The factory has two cane carriers with drives of 56 kW and 30 kW rating dyno drives. They were found to consume a power of 69 kW. With the introduction of VFD drives for both the carriers it was estimated that the power consumption will come down to 54 kW, a saving of 15 kW. In rupee terms the saving will be about Rs.1.80 lakhs per annum. Investment required will be about Rs.5 lakhs.

02. Strained Juice and weighed juice pumps are provided with pumps having 56 kW rating motors. The pumps are operated manually with almost 20% recirculation provision. The actual power consumption was found to be 38 kW and 48 kW respectively in these pumps. It was estimated that introduction of variable frequency drives with auto control valves will save about 9 kW of power in the strained juice pump. This will save energy equivalent of Rs.1.08 Lakhs per season. Investment required will be about Rs.2.5 lakhs.

03. By installing a mass flow meter for juice measurement, the weighed juice pump can be totally avoided saving about 40 kW of power equivalent to about Rs.4.8 lakhs per annum. Investment required will be about Rs. 6.0 lakhs

04. Sulphited juice pump was of 90 kW drive. Measured power consumption was 55 kW. By changing the drive to the required size with variable frequency drive provision, it is possible to save about 15 kW of power equivalent to about Rs.1.8 lakhs per annum. Approximate investment required will be about Rs. 4 lakhs

05. Bagacillo blower, air compressors and the vacuum pump for vacuum filter were all having V belt drives with a total installed power load of 285 kW, consuming about 167 kW of power totally. By converting them to efficient flat belt drives, it is possible to save 7% of power which will be equivalent to about 12 kW and Rs.1.44 lakhs per annum. The investment required for these changes will be about Rs.2.50 lakhs.

Alternately if all these are provided with VFD drives by rationalising the power of the drives, it is possible to save about 25 kW of power equivalent to Rs.3.0 lakhs. Investment required will be about Rs. 10 lakhs. The vacuum pump for vacuum filter is of very high capacity with a drive of 240 kW motor. The actual power consumed was only 95 kW and with the right type of pump and drive the power consumption for this will come down by 20 kW saving about Rs.2.4 lakhs per annum and investment will be about 7 lakhs

06.There are 27 drives of crystallisers, magma minglers, molasses pumps and mechanical circulators for pans with a total installed load of 516 kW, which consume less than 25% of the installed loads and of these 16 consume even less than 15% of the installed capacities. Since the efficiency of motors drops drastically when they are operated at less than 40% load, sizing them correctly becomes necessary. Besides providing them with right size drives, if the gears are changed to planetary type, it is possible to save a minimum 50 kW of power equivalent to an additional revenue of about Rs.6 lakhs per annum. Incorporating of these changes may cost around Rs.40 lakhs. It is also possible to operate them either on permanent star mode or with DSCM (Delta Star Control Module) depending upon conditions which will give about 10% power saving (i.e.) about 7 kW. Total investment for these may be about Rs.1 lakh only and saving of power equivalent to Rs.0.84 lakhs per annum.

07.The condensers, interjection water, air ejection and spray cooling system was found to consume about 18.97% of factory s total load of 3831 kW. Counter current rain and shower condensers has been installed for vacuum creation in evaporator and pans. The installed power is 1187.5 kW and the actual consumption is measured as 949.9 kW. It is found from calculations that the water consumption is more than 200% of the theoretical requirement. The head of injection and spray pumps are 22m and 15m respectively. Since the location of spray pond is at the backyard of the boilers, blow down water from all the boilers and the slurry from the fly ash collection pits is finding easy access into the spray pond adding unwanted heat load and solid load to the spray pond water. Since the spray pond is covered from three sides by buildings, natural draft and ventilation required for good cooling is also getting affected. All these factors have made this system a most inefficient one resulting in colossal waste of energy. By changing the condensers with efficient single entry multijets and relocating the spray pond in better ventilated location and redesigning the entire system with automation it is possible to restrict the total power consumption of this system to about 450 kW, saving about 400 kW of power and an additional revenue of about Rs.48 lakhs per annum. The investment required will be about 300 lakhs since it involves relocation of spray pond. Otherwise it would be less by Rs.100 lakhs making the proposal quite attractive. But in the interest of future viability this becomes unavoidable and perhaps a price to be paid for some earlier lapses.

08.The factory has 2 A-range centrifugals, fully automatic recycling type of 1.2 T capacity / charge each with D.C. thyristor controlled drives and 4 semiautomatic self discharging machines of 0.6 T capacity / charge each with A.C. pole changing drives. The self discharging machines are very old and due for replacement and cures 0.743 T of A-massecuite per kWH. The fully automatic machines cures 1.028 T of A-massecuite per kWH. The sugar from the fully automatic machines are also found to have better quality as well as keeping quality. Therefore the old machines if replaced with the fully automatic new machines with D.C. drives, there will be a saving of about 13 kW of power and total elimination of kick loads. The saving will be equivalent to about Rs.1.56 lakhs per annum. Though the new machines may cost around Rs.60 lakhs, the investment may be considered only as a replacement and not as a fresh investment.

09.The fibriser and mills are provided with turbine drives with a total capacity of 2950 kW, with a steam consumption of 23.63% on cane. The actual specific steam consumption of all the turbines works out to 13.3 which appears to be quite high. The same quantity of steam from modern 87 ata boilers and TG sets can produce about 6900 kW of power, i.e. extra 3950 kW of power which can be exported, fetching an additional revenue of Rs.470 lakhs.

The conversion of fibriser drive into electric drive and all the mill drives into DC drives will require an investment of about 600 lakhs which will be paid back in less than 2 years.

10.All the boilers are quite old ranging from 10 to 25 years and out of the four boilers, furnaces in three boilers have been changed from horse shoe to dumping grate with an increase of generation capacity by 5 tons in each. Wet scrubbers are provided for 2 of the boilers. Due to space constraint both the wet scrubbers are located far away from the boiler. A booster ID fan is provided along with wet scrubber in addition to the regular ID fan. The ID fan is of 180 kW and the booster fan is of 200 kW. Single higher capacity ID fan of improved design may be provided which will consume only 191 kW of power. The power saving will be 149 kW for one boiler and 125 kW for another boiler making to a total of 274 kW. This will be equivalent to about Rs.32.8 lakhs of additional revenue. The investment required for this will be about Rs 46 lakhs, with a payback of less than 2 years.