Cogeneration and energy conservation in paper-sugar complexes

Gehlawat J K *

ABSTRACT

Adequate measures for energy conservation through optimum designs, efficient plant operations and judicious integration of different process plants could result in substantial savings. Agro-based units like paper, sugar and allied industries are particularly suited to such integration. Energy from effluents and a recycle of resources through proper use of effluents may revolutionise the concept of agro-based industries Some constructive suggestions are presented in this paper for cogeneration and energy conservation through an integrated approach.

Introduction

Energy, in various forms, is an important input to process plants. Electric power supply and fuel for raising steam or for heating purposes are basic needs of any industrial activity. Generally, power in the form of electricity is purchased from an outside source. Periods of power cuts are not uncommon. These reflect adversely on production performance. Most plants do have their own steam raising units in the form of boilers fired by fuel oil, natural gas or coal. The concept of cogeneration, simultaneous of steam and power, may prove highly advantageous to agro industries as discussed elsewhere.

Adequate measures must be undertaken to conserve energy through optimal designs and efficient plant operations. It is estimated that better housekeeping and simple controls such as proper insulation of steam transfer lines, minimising loss through traps and optimal illumination at work places could result in savings of 10—15% in energy bills. Gehlawat (1) has recently drawn attention to the use of improved alternate technologies and a judicious integration of different process plants for energy conservation. Mahajani (2) has discussed basic thermodynamic and design aspects of cogeneration plants. It is noted that paper mills, particularly in combination with sugar mills are ideally suited for setting-up cogeneration facilities. The following presentation is directed to a discussion on agro-based units like paper-sugar-alcohol complexes.

Traditional sugar and paper industry

A study of the traditional sugar industry may be thought provoking. As discussed in greater details elsewhere, attempts to increase sugar recovery through second and third stages of crystallization clubbed with multiple evaporation efforts may be counter productive. The marginal increase in sugar recovery is a poor compensation for the excessive use of motive power and steam energy with enhanced maintenance and manpower costs. Hence, an optimum balance between energy expense and net gain must be attempted and corrective action should be taken wherever necessary.

It is commendable to note that several groups of industries are making sincere efforts to study and adopt measures for energy conservation. Paper industry offers interesting possibilities of using in house energy saving schemes as well as strategies for raw material inputs and suitable integrations with raw material producing units (3). Similarly, sugar industry, including units based on its by-products, offers an interesting possibility of large energy pavings through integration of different plants as discussed below.

Bagasse For Paper Production :

A number of recent reports (4-7) indicate bagasse to be an ideal raw material for paper manufacture. An

Department of Chemical Engineering
Indian Institute of Technology
Kanpur-208016, India

estimated 130 million tonnes of sugar cane may be crushed during the current season to produce about 45 million tonnes of mill-wet bagasse containing about 50% moisture. About 5.5 tonnes of mill-wet bagasse are required to produce one tonne of bleached pulp. Thus, about 7.5 million tonnes of paper may be produced if all the bagasse is made available to paper mills. This would be about 3.5 times the present consumption of paper in the country. However, the availability of bagasse for paper making is restricted mainly due to its principal use as a fuel for boilers in sugar mills. Only surplus bagasse can be spared for paper production. By improving the thermal efficiency of the bagasse fired boilers and by operating sugar mills at optimum production levels with consequent energy conservation, about 15% of bagasse may be saved and released for paper manufacture. Even if this surplus bagasse is fully utilized for paper production about 1.2 million tonnes of paper may be produced which would be about 50% of the presennt consumption.

Singh and Paul (4) have shown that, with the suggested Technology improvements for bagasse drying and balling facilities, a cluster of sugar mills could create a potential and dependable source for paper mills as ancillary units. Muralidharan (6) discussed the case study of Tamil Nadu News Print and Paper Limited who have entered into firm agreements with six sugar mills situated within a distance of 150 KM from the mill site. Another example is the setting up of a sugar mill by M/s. Ponni Sugars and Chemicals Ltd., adjacent to Seshasayee Paper Mills near Coimbatore. The paper mill supplies coal and provides other infrastructural facilities to the sugar mill to obtain the entire bagasse in exchange. Setty etal (7) have described the useful experience at Mandya National Paper Mills along with details on techno-economics of a paper mill based exclusively on bagasse.

Paper Mill as a Parallel Unit at a Sugar Mill

It becomes abundantly clear from the above discussion that bagasse is emerging to be an important raw material for paper production. With judicious efforts substantial amount of bagasse can be released for paper mills. It is for this reason that the Government of India have announced a 100% excise rebate on paper industry. Recently, Gehlawat (8, 9) recommended that it may be advisable to provide natural gas as fuel for sugar mills and save bagasse for paper production.

The report of the Energy Committee (10) observes that bagasse and agricultural residues as raw materials have advantages of comparatively low consumption of chemicals for cooking and bleaching and lower energy needs. Thus, from energy conservation and other cost savings view-point, it is desirable to put-up a paper mill at the existing or a new sugar mill. Mysore Paper Mills, Bhadravati, have taken a lead in this direction by setting up a sugar mill of their own to obtain bagasse for the existing paper mill.

Co-Generation in Paper and Sugar Mills

The concept of Co-generation, that is, simultaneous generation of steam and power is becoming popular among most modern process plants. Mahajani (2) has recently discussed the basic design and thermodynamic aspects involved in the settingup of cogeneration units in process industries. Co-generation is well suited for sugar industry. Verma and Khattar (11) have discussed the economics of cogeneration in sugar industry. It is pointed out that a medium sized 2500 MT per day cane crushing capacity mill could generate about 7-8 MW surplus power which may be supplied to other consumers in the neigh-bourhood. Thus, one may be surprised to note that sugar industry can add over 3000 MW surplus power to the national grid by using high pressure modern boilers based on bagasse.

The chemical recovery plant and/or biogas units by the use of black liquor from a paper mill provide enough scope for captive power generation. A paper-sugar mill combination is ideally suited for cogeneration (12). Thus, setting-up of a paper plant at a sugar mill or vice-versa may be recommended as parallel units and for cogeneration facilities to generate surplus power.

Paper-Sugar-Alcohol-Complex

Photosynthesis is one of the most efficient natural process for the conversion of abundant solar energy into biomass. In this respect, sugar cane plant holds a unique position in the family of all annual crops. This is the only crop which is endowed with one of the highest solar energy conversion efficiency for biomass and can be rightly named as a vast store-house of fibre, food, fuel, fertilizer and chemicals. One hectare of land can annually produce about 10 tonnes of valuable fibre for paper, 10 tonnes of food products

including sugar, a kilo-litre of alcohol and 2 tonnes of fertilizers, provided this raw material is processed in a more efficient manner. Sugar cane has been traditionally processed for recovery of crystallized sugar. The use of membrane technology for juice clarification-cum-concentration may prove highly energy efficient (13,14). Tradi tionally the emphasis on recovering the last trace of this product has been so intense that expenditure of energy did not appear to be a primary consideration right from the first stage of juice extraction at sugar mills upto the last stage of molasses discharge. This inherent shortcoming of conventional processing technology with over-emphasis on sucrose extraction has been realized only recently (15). With an integrated sugar mill and a distillery unit, the proportion of sugar and alcohol can be altered as and when desired. High purity primary juice can thus be used for sugar extraction and low purity secondary juice and molasses obtained from any appropriate stage can be utilized for producing alcohol. This scheme enables minimum energy inputs, generation of substantial surplus begasse and additional valuable energy source in the form of ethyl alcohol. Spent wash of the distillery along with municipal waste of workers colony and mill effluents can further be used for the generation of biogas which can be utilized for meeting energy needs to suit local conditions. This alternative to the conventional sugarcane technology requires minimum of steam and power consumption. Brazil has taken a lead in this direction (15). A combination of sugar mill and paper unit with a distillery would mean considerable energy savings and related other commercial benefits.

Combined Units Have Cost Advantages

Unremunerative prices offered to the farmer has made sugarcane cultivation unattractive. Consequently, the area under cane production has tended to remain stagnant for the past about two decades. Often sugar mills are unable to obtain adequate supplies of cane for crushing. This affects their performance adversely. Most of the sugar mills are under great financial constraints on account of poor supplies of cane and other controls on the sale of their products. It is a vicious circle and the only remedy in sight for the industry appears to be to diversify and to set-up parallel units as suggested above. Thus, combination of a sugar-paper and alcohol units may prove to be highly advantageous. At such a complex, bagasse will be used for paper production and molasses will be captively consumed for alcohol production. Under Government controls, molasses is sold at highly low unremunerative Prices. Thus, setting-up of the proposed sugar-paper-alcohol complexes has become imperative. The technical and economic performance of the integrated combined units will be highly impressive. With co-generation facilities, surplus power may be produced. This could be supplied to the farmers and other units in the command area to ensure uninterrupted power supply. Further, the effluent water, after suitable treatment (extraction of biogas for example) may be used for irrigation purpose. This will enable farmer to produce more sugar cane in the command area which is the main raw material for these complexes. It will prove to be an excellent example of resource generation from effluent streams (16). In this way it will be possible to offer remunerative prices to the farmers for cane supplies and to motivate them to increase the cane production.

Multipurpose Agro-Based Complexes

Cellulose and sugarcane are biomass obtained through photosynthesis. They belong to the family of Polysaccharides. Hydrolysis of cellulosic materials like bagasse under certain conditions results in the formation of furfural (17) and fermentable sugars (18-20). The production of a large number of products from bagasse, from molasses and hydrol (mother liquor obtained from dextrose production) are economically attractive. Ethyl alcohol obtained from molasses, agricultural wastes and other fermentable materials opens up a good scope for the production of a large number of synthetic organic chemicals presently being produced from scarce petroleum products. A distillery and a host of ethyl alcohol based synthetic organic chemicals may form a part of the down-stream units. Production of petrochemicals from ethanol is commercially viable (21). A captive power plant (cogeneration) will not only make the proposed complex independently in all respects, it will generate surplus power which may be supplied to the grid.

Resource Generation from Effluents :

Effluents from sugar, paper, and distillery units could be utilized for resource generation (16, 22).

They may be suitably treated to recover and recycle all valuable contaminants as well as treated water to the process. Biogas may be generated from distillery wastes and used for energy in boilers. The application of organic matter to soil is known to improve soil structure, its porosity and water holding capacity. The effluents from sugar and distillery units contain useful orgnic matter of plant and soil origin. They are rich in plant nutrients After suitable primary treatment effluents from those industries are ideally suited as *"liquid manner"* for irrigation (23). In view of this finding, it is feasible to conceive a complete cycle of regeneration of natural resources for sugar complexes. That is, the effluent streams after pretreatment are used as inputs for irrigation to produce sugarcane, corn and other biomass to be used as raw materials for these industries.

Techno-Economic Studies

The findings of techno-economic studies undertaken for the proposals of a combined sugar and paper mill and a sugar-cum-starch plant were highly encouraging (24, 25). The establishment of a sugar-alcohol-paper complex in Tamil Nadu shows a pioneering step in this direction (26). It is also heartening to note that one large paper mill in South India has set-up its own sugar mill with the primary aim of obtaining bagasse for paper production. That a few new sugar mills are planning to install co-generation facilities is also a welcome news.

Conclusions :

A changing scenario is on the horizon of Indian Paper and Sugar Industries. Co-generation and scope of parallel units have been recognised. A study of agro-based industries like paper and sugar units is particularly interesting. It emerges that the addition of a sugar mill and a distillery unit to a traditional paper mill would prove extremely advantageous. Substantial energy and cost savings with resultant lower costs of production of paper, sugar, alcohol and their derivatives may be realised. The findings of techno-economic studies for the proposals of a combined sugar paper mills and a sugar-cum-starch plant were highly encouraging. Hence, implementation of integrated agro-based complexes like paper-sugar and alcohol will prove very attractive. A concerted development effort (for new technology) in this direction will be in the larger national interests.

References :

1 Gehlawat, J.K., "Some thoughts on energy conservation in process industries", Chapter V-2, in book entitled Energy Conservation in Chemical and Applied Industries, Ed.S.K.Awasthi, South Asian Publishers, New Delhi, 1989.

2. Mahajani, V. V , "Planning and Design of Cogeneration in Chemical Plants", IE (I) Journal-CH, 71, 9, 1990.

3. Gehlawat. J.K., "Scope for Parallel Units in a Paper Complex for Energy Conservation", 1985 IPPTA Convention Proceedings.

4. Mangal Singh and Paul, B B , "Bagasse as Raw Material for Paper and Pulp" The Economic Times, Feb. 4, 1981.

5. Srinivasan, R "Stabilizing Sugar Production by Total Diversion of Bagasse for Paper Manufacture" National Seminar on Diversification in Sugar Industry held at Bangalore on 20.7. 1984.

6. Muralidharan, C.R., "Challenge of Organising Bagasse Based News Print-cum-Printing and Writing Paper Mill", National Seminar on Diversifications in Sugar Industry held at Bangalore on 20.7.1984.

7. Ramalinga Setty, T K., Subramanya, S.B. and Nagabhushan, S , "Bagasse based paper factory-an Indian Experience, National Seminar on Pulp and Paper Industry held at RRL Hyderabad on 25 3 1984.

8. Gehlawat, J.K., "Natural gas as fuel for sugar incustry", Proceedings of the conference on "Development of gas-based and petrochemicals industries in U.P.", UPSIDC, held at New Delhi, Feb. 17-18, 1989.

9. Gehlawat, J.K., "Natural gas as a Substitute Fuel for Bagasse", Proceedings of I.E. (I), CH Conference, Hyderabad, 8,9 Oct. 1992, p. 36.

10. Energy Committee in "Energy audit and conservation in Pulp and paper Industry", IPPTA Vol. 21, 1984.

11. Verma, A.K. and Khattar, H.K., "Economics of co-generation in Sugar Industry", Chapter 13 in "Modernisation of Indian Sugar Industry", Gehlawat, J.K. Ed., Arnold Publishers (India), New Delhi, 1990.

12. Rao,N.P., "By-products of Sugar-Paper Industry as Fuel/Power Sources, Proceedings of IE(I)-CH Conference, Hyderabad, 8,9 Oct. 1992. p. 54.

13. Gehlawat, J.K., Ed., "Modernisation of Indian Sugar Industries", Arnold Publishers (India) New Delhi, 1990.

14. Pathak, R.N., Rnikar, A.M., Bopardikar, S.V., Malshe, V.C. and Gehlawat, J.K., "Achieve High Recovery and steam Economy in Sugar Industry through Concentration of Secondary Juice by RO", Chem. Ind. News (in press).

15. Mishra, S.P , "Renewable energy resources and the place of sugar industries", News Letter, IE (I)-CH, 11,2,1982.

16. Gehlawat, J.K., "Wealth from Effluents of Agro-Industries", Proceedings of STAI Annual Convention held at Madras, Feb. 1990.

17. Singh, A., Das, K. and Sharma, D.K., "Integrated Process for Production of Xylose, Furfural and Glucose from Bagasse by Two-step Acid Hydrolysis", Ind. Engg.Chem. Proc. Res. Dev., 23, 257,1984.

18. Ghose, T. K., "Cellulose biosynthesis and hydrolysis of cellulosic substances', Adv. Biochem. Eng. 1977, 6, 39.

19. Ghose, T.K. and Ghosh, P., "Bioconversion of cellulosic substances, J. Appl. Chem. Biotechnol. 1978, 23, 309.

20. Ghose, T.K. and Ghosh, P., "Cellulose production and cellulose hydrolysis", Process Biochem. 1979, 14, 20.

21. Mashelkar, R.A., "Changing Scenario and Emerging Frontiers in R & D in Sugar By-products', Proceedings of STAI Seminar on Development of Sugar Complexes, Pune, 9th Sept. 91, p. 1.

22. Gehlawat, J.K , "Resource Regeneration from Industrial Effluents", Proceeding of HAZTECH International Conference on Pollution Prevention and Clean Technology, Pittsburg (USA), Oct. 2-4, 1990.

23. Tauro, P., "A Status Report on Distillery-Effluents", Haryana Agricultural University, Hisar (India). 1988.

24. Kelkar, R. K , "Studies in Techno-economic Feasibility of an Agro-base Cane-sugar-cum-Maize Starch Complex", M. Tech. Thesis, IIT Kanpur, 1979.

25. Niwas, S., "Techno Economics of a Proposed Sugar Mill Pulp Mill Complex", M. Tech. Thesis, IIT Kanpur, 1978.

26. Annon, "Ambitious Scheme to Create Sugar-alcohol-paper Complexes" The Economic Times, July 11, 1981. P. 4.