1. INTRODUCTION

The sugar industry is one of the largest sectors of the Indian economy and India is now among the largest producers and consumers of sugar in the world. After Brazil, India is world’s second largest sugar producer. The maps shown in Figure 1 and Figure 2 indicate the geographical distribution of the sugar plants and other co-generation units working in conjunction with them.

Environmental protection requirements and keen competition force sugar industries to reduce energy consumption, recycle materials and energy and optimize continuously the operation of sugar process. Up to date, considerable improvements in sugar processing have been achieved. In the present context where the prices of sugar cane, sugar produced and molasses are fixed by the government authorities, the only methods for generating profits for sugar mills are by way of reducing manufacturing costs where steam and fuel economy plays a vital role. Plant automation packages are available nowadays which provide savings in bagasse or steam or electricity and also improve the sugar quality. Examples of such packages are Juice flow stabilization system, Lime sulphitation pH control system, Steam flow stabilization system, Pan automation package, Inhibition water control system etc.

Juice flow stabilization system is necessary due to the fluctuations of juice intakes and the volumes handled by raw juice tanks. The system eliminates the fluctuations in juice flow to the juice heaters in spite of crushing load fluctuations and hence ensures steady state equilibrium in boiling house and also prevents the pump from dry running. It is possible to evaluate the quantity of lime to be added for the sulphitation depending on the crushing rate. The lime sulphitation pH control system provides very effective clarification for the liquid phase reaction and thus improves the quality of sugar produced. Specialized systems have been designed for automation of both batch and continuous pans. The benefit of this system includes consistency in pan boiling and improvement in sugar grain formation. The inhibition water control system is aimed at optimizing TCD, brix and also cutting down on downstream steam consumption. The system provides substantial savings on overall steam consumption.
The economy of sugar manufacturing depends strongly on the Multiple-Effect Evaporator (MEE) because of the huge amount of thermal energy (steam) required during the process. The batch nature of the vacuum pan operation means that the demand of steam from the MEE station is intermittent, thus disturbing strongly the MEE. The resulting fluctuations in the brix of the syrup in turn causes the vacuum pans to have variable boiling times and steam consumption, which further disturb the MEE. Thus there is a kind of vicious interaction between the vacuum pans and the MEE. This fluctuation in the brix of the syrup is detrimental to energy economy. Vapour stabilization system is meant for automatic control and maintaining rate of vapour to the pan section, irrespective of the fluctuations in evaporation rates.

Figure 1. Sugar map of India
Considering the system complexities and non-linear nature of the systems discussed above, soft computing tools like Fuzzy logic find wide application in modeling and control of various sugar processes. Fuzzy logic system may be able to map the physical non-linear relation of input/output model without a precise mathematical formula.
Fuzzy logic can be successfully applied to carry out modeling and control of various parameter stabilization systems described above considering their non-linear nature. Fuzzy controllers may perform better than conventional model based controllers especially when applied to such non-linear processes which are difficult to model, and where there is a significant heuristic knowledge from the human operator. Steam & fuel economy and quality of sugar are the major two aspects to be considered while deciding the control strategies. There is highly flexible demand for steam when other co-generation units are functioning in conjunction with the sugar plant. Such uncertainties have to be considered while developing the Fuzzy model and deciding the control strategies. A probabilistic Fuzzy logic approach can take care of such uncertainties. Simulation of such systems can be done very effectively in MATLAB environment using Simulink, Fuzzy Logic Tool box etc.

Figure 2. Sugar map of Maharashtra