Chapter 7

Conclusion

Analysis of heat transfer in various types of furnaces used in jaggery manufacturing plants are carried out in this thesis. On the basis of outcome of this analysis, the efficient furnace to improve the productivity and the thermal efficiency of single pan jaggery plant is developed. The research was carried out in three phases. In first phase, the study of available literature regarding performance evaluation of various types of jaggery plants was completed. In this study, it was observed that the use of multiple number of pans for jaggery production does not give appreciable increase in thermal efficiency of jaggery furnace. Hence the focus was made on experimental and CFD analysis of single pan jaggery making furnace. The experiments were performed on three single pan jaggery making furnaces with various pan modifications. The experimental results indicated that with conventional single pan jaggery making furnace, the thermal efficiency varies from 25-30% which is very less compared to ideal thermal efficiency value of 72%. In second phase, CFD analysis of existing single pan jaggery making furnace was carried out to validate the use of CFD as a tool for predicting performance of jaggery furnace by comparing with experimental data acquired. In third phase, typical standard size furnace was designed on the basis of data obtained from field visits and earlier research findings. For this standard size furnace the material for construction of furnace selected was fire bricks instead of masonry bricks. Using this standard size furnace and three different designs of pans, the CFD analysis for three jaggery furnaces was carried out using ANSYS-FLUENT software.

7.1 Conclusions:

Following conclusions are drawn from this study:

1. The jaggery furnace efficiency depends on number of parameters such as furnace diameter and depth, pan design, chimney top and bottom diameters, chimney height, number of air supply holes and their diameter. There is no standardisation available for above parameters as jaggery plants are developed mainly through experience gained over the years. This fact created a foundation for design of thermal efficient furnace by deciding standard values for above mentioned parameters.
2. In India, both single pan and multi pan furnaces are used in various parts of the country. However from this study it can be concluded that use of multiple number of pans does not contribute much in efficient utilization of heat for jaggery production. The typical multipan furnaces efficiencies obtained by various researchers are in the range of 30% - 40%. The main reason for lower efficiency of multipan furnaces can be explained as follows. In the multipan furnaces only the first pan placed over the combustion chamber receives heat by convection and radiation. The heat transfer to the next pans is mainly due to convection as they are far away from the flame. The next pans used are placed along the length of flue gas duct for which radiation view factor is much less.

3. The use of fins at the bottom of pan in case of single pan jaggery furnace is not desirable. According to results of this study, fins obstruct flow of flue gases, reduce the turbulence and hence heat transfer from flue gases to pan is affected. As per the findings of the study, with the use of finned bottom pan, jaggery furnace efficiency was reduced by 15.24% compared to flat base pan.

4. The use of spiral coil heat exchanger pan in single pan jaggery furnace is found most satisfactory. The thermal efficiency of jaggery furnace with spiral coil heat exchanger obtained is 52.76%. This value is much higher than traditional single pan jaggery making furnace efficiency which vary between 20-40%. Further use of spiral coil heat exchanger pan in jaggery furnace resulted in 9% gain in thermal efficiency compared to jaggery furnace with flat base pan. This increase in efficiency is due to turbulence induced in flue gases which is observed from streamline diagrams for flow of flue gases.

5. The use of spiral coil heat exchanger in single pan jaggery furnace also gives additional advantages such as it is compact in size, thus no need to increase size of pan. Due to induced turbulence in flue gases tendency for fouling is reduced.

6. Use of jaggery furnace with spiral coil heat exchanger requires less time for jaggery production. It is observed that time required per batch of jaggery production is 14.30% less compared to jaggery furnace with flat base pan. This helps to improve productivity of jaggery production. For five batches of jaggery production per day, 80 minutes time can be saved.
7.2 Scope for future work

In this study thermal analysis of single pan jaggery furnace is carried out with the use of ANSYS-FLUENT software. This research gives instincts for further work listed below.

1. The exhaustive experimentation can be carried out using spiral coil heat exchanger pan for evaluation of thermal efficiency of single pan jaggery furnace.

2. Experimental investigation on use of parallel fins on the bottom of pan can be done to check the effect of fins on heat transfer.

3. Combustion analysis for jaggery plant furnace can be done with bagasse as fuel.