CHAPTER V

CONCLUSION AND RECOMMENDATION

Conclusion

1. From the preliminary study, the equilibrium moisture content (EMC) of chillies at 32.2°C, 48.9°C and 68.3°C with relative humidity between 11.1% - 96.5% were determined and used to estimate the parameters in the expressions of the moisture desorption isotherm models by using the non-linear regression. The results indicated that the Modified Halsey Model was appropriate to describe EMC of chillies as the following equation.

$$M = \left[\frac{-\exp(4.153975 - 0.005358T)}{\ln(RH)} \right]^{1/1.61421}$$

It was used to predicted the desorption isotherm of chillies for drying temperature of 50, 60 and 70 °C. It showed that at constant ERH, the EMC decreased with increasing surrounding air temperature. These isotherms will be useful to the prediction and control for chillies drying process.

From the study of the application of dryer system by using biomass and solar energy, the system comprised solar dryer system with solar collector area of 1.9 m^2 in corrugated absorber plate type, and downdraft gasifier system which used corn cob as fuels. It could be summarized as follows:

2. The specific heat of chilies increased linearly when the moisture content increased. It can be expressed as:

$$c_p = 0.3536 + 0.0009\ MC$$

3. From the results, to generate the producer gas from the downdraft reactor of 0.374 m^3 can produce 39.25 MJ/hr from 60 kg of corn cob for 8 hours of working time. It was found that the flow rate of inlet air effected to the gas productions from the biomass reactor. In addition, the appropriate flow rate of air inlet to the reactor was 5.44 x 10^{-3} kg/s. The average main compositions of producer gas are 19% of CO, 18.5% of CO_2, and 7.4% of H_2 while the average temperature in the combustion zone was 680 ^{o}C. This shows that the insulation of reactor needs to be improved. At air flow rate of 5.44 x 10^{-3} kg/s, corn cob feed rate of 7.5 kg/h, and corn cob moisture content of 12.1 %, the equilibrium model shows that almost components are in good agreement with experimental data except hydrogen which is more than the experimental data. The results showed that the average thermal efficiency of biomass reactor was 34.7 %

4. The results indicated that the outlet air temperature from the solar collector could be predicted from global solar radiation (especially in high range of radiation) and inlet air temperature as the following.

$$T_{f,o} = 0.03983 G_T + T_{f,i}$$

The results showed that the outlet air temperature from the solar collector by mathematical model closed to the results from the experiments for high range of global solar radiation and the average outlet air temperature from the solar collector was 61.7 ^{o}C.

5. Chillies of 19.2 kg in average were dried by a dryer using only solar energy in each batch. The experimental resulted that the average drying rate was 2.8 kg water evaporated/day or 0.7 kg water evaporated/h. The solar dryer can reduce the average moisture content of chillies from 312.3 %db to 8.0 %db within 25 hours of drying time and 54.7 ^{o}C of average temperature of drying air. It indicated that the average first law efficiency of the drying system was 32.5 % by using only solar energy.

6. By using both solar and biomass energy to dry approximately 20 kg of chillies for each batch, the experimental resulted that the average drying rate was 3.42 kg water evaporated/day or 0.76 kg water evaporated/h. The dryer which use both solar

and biomass energy could reduce the average moisture content of chillies from 300.0 %db to 8.0 %db with 18 hours at the average temperature of drying air of 60.0 ^{o}C. And it was found that the average first law efficiency of the drying system was 19.9 % by using both solar and biomass energy. The efficiency from hybrid system was lower than using only solar energy because the flow rate of the producer gas could not be controlled properly and the movement of the upper part of the gas tank could not move well. They need to be developed in the further study.

7. The color of fresh and open sun dried chillies from the local market which obtained color value in CIE Lab, L*a* b* of 26.62, 41.36, 20.15 and 25.41, 8.41,13.75 respectively. The color of chillies from the solar dryer is lighter. In addition, the color of dried chillies which were blanched and dried in biomass/solar dryer was lightest in red with CIE Lab, 26.61, 41.36 and 20.15. It was closed to the required color in chillies market.

8. The experimental results showed that the average total energy consumption for drying chillies 19.2 kg was 12.78 MJ/kg-water evaporated, of which 12.4 MJ/kg-water evaporated from solar energy and 0.38 MJ/kg-water evaporated from electricity whereas the average total energy consumption for drying 20 kg of chillies was 12.60 MJ/kg-water evaporated, of which 5.04 MJ/kg-water evaporated from solar energy, 7.32 MJ/kg-water evaporated from producer gas and 0.14 MJ/kg-water evaporated from electricity.

9. The empirical drying model which is useful for drying rate and drying time prediction, was determined to be suitable model for chillies drying based on Page Drying Model which R^2 of 0.99. The model shows as the following:

$$MR = \exp(-xt^{y})$$

Whereas

x = 0.387075

y = -0.655268 + 0.038546 T - 0.399721 M_{in}

The study indicated that the dryer system using biomass and solar energy can be use efficiently to dry chillies in order to get the required moisture content and color. This dryer system is useful in term of using agricultural wastes as the supplementary heat source whereas the solar energy is the main energy source. It is environmental friendly application. It can make the product which will be value added. And also, it has possibility to be applied to use in industrial scale in area that has high potential of biomass.

Recommendation

1. The biomass gasifier system should be improved to rise up the temperature inside the reactor such as insulation and fuel feed system. Various biomasses should be investigated with this system.
2. The storage thank should be improved for the well movement of the upper tank to move properly when the produce gas pressures it.
3. The control set should be able to properly control the flow rate of the gas which flows to the combustion chamber in order to obtain the optimum heating rate to the drying system.