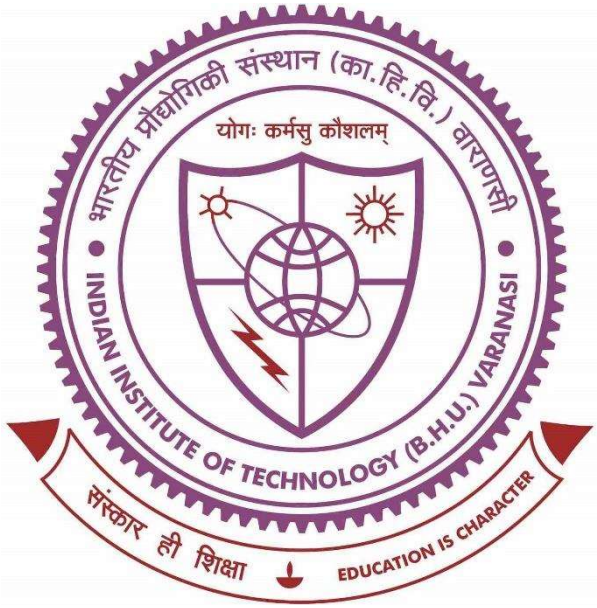
STUDIES ON MULTI-PURPOSE HEAT PUMP DRYER



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DOCTOR OF PHILOSOPHY

by

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CHAPTER 9

CONCLUDING REMARKS AND FUTURE SCOPE

9.1. Conclusions

Experimental as well as numerical studies on the multipurpose heat pump dryer are conducted for the simple heat pump dryer and the hybrid source heat pump dryer. Various low-GWP refrigerants are compared for the heat pump dryer. Experimental energy, exergy, and economic analysis are carried out for different hybrid heat pump dryers and also for the heat pump dryer integrated with air conditioning. Various performance parameters such as moisture extraction rate, specific moisture extraction rate, energy efficiency, drying efficiency, payback period, and exergoeconomic factor are considered.

From present investigations, the main inferences can be summarized as:

- Total energy consumption was lowest for the closed system heat pump drying of banana and potato chips. The total energy consumptions for banana chips in the open and closed system are 3.3, 2.41kWh and for potato chips are 3.564, and 3.51kWh, respectively.
- Based on the performance parameters such as MER, SMER, and drying efficiency, the closed system drying is better than the open system drying with simple HPD in the given humid and hot atmosphere for the fruits and the vegetable drying.
- Within studied refrigerants, R152a and R32 yield better performance; however, R152a may be more favorable for HPD due to lower GWP.
- SAHPD system is better based on SMER, and SIAHPD is better than others based on MER in the given humid and hot atmosphere for drying banana chips.

- The drying cost of the material per kg and the total energy consumption to the system are minimum for the solar-assisted heat pump dryer and it is highest for the infrared-assisted heat pump dryer.
- The MER, SMER, and energy efficiency are much higher for waste heat recovery assisted HPD as compared to the simple-HPD in the closed-loop system drying.
- The payback period of using waste heat recovery assisted HPD over the simple-HPD in the closed-loop is found to the 33 months.
- The performance parameters such as MER, SMER, energy efficiency, energy consumption, and drying efficiency are better for the intermittent drying of food chips with solar-assisted HPD as compared to continuous drying.
- The per kg drying cost of the radish chips with SAHPD is lower for the intermittency ratio of 0.2 (higher off time) and higher for the continuous drying.
- The intermittent drying can be recommended as compared to continuous drying for the better quality of product at higher drying temperature with better performance and lower energy consumption.
- The overall system coefficient of performance (OSCOP) is found to be much higher than the COP of the single system (heat pump or air conditioner) with an average value of 7.456 in the input temperature range of 26-45°C because it gives the advantage of both systems with the single energy input source.
- The total annual profit gain by using the combined system (HP drying + air conditioning) instead of the separate systems of HP drying or air conditioning is $309, thus the energy savings can be achieved by using the combined heat pump dryer and air conditioning system instead of the individual system.

9.2. Future scope

- Development and experimental analysis of the solar-assisted heat pump dryer with air conditioning for hot and humid environments.
- Numerical and experimental analysis of the solar-assisted chemical heat pump dryer for food and vegetable drying.
- Numerical and experimental analysis of the solar-assisted radio-frequency heat pump dryer.
- Experimental analysis of intermittent drying of food and biomaterials with heat pump dryer assisted with waste heat recovery from thermal power plants.
- Experimental analysis of intermittent drying of food and biomaterials with ground source assisted heat pump dryer.