CHAPTER – V

SUMMARY AND CONCLUSIONS

This study includes development of prototype of functionally successful solar tunnel dryer for two different industrial applications. The design of forced convection type solar tunnel dryer differs, based on the products to be dried. Attempts have been made to design forced convection type solar tunnel dryer for drying of different products on large scale. The solar tunnel dryer suitable for drying industrial products such as processed tobacco and Di-basic Calcium Phosphate on large scale were developed. In this context, different units based on concept of solar tunnel drying systems were designed and installed at M/s Miraj Pvt. Ltd., Nathdawara, and M/s Phosphate India Pvt. Ltd, Udaipur for drying 0.5 ton Processed Tobacco and 1 ton Di-basic Calcium Phosphate, respectively. The system have been designed based on nature of material to be dry, its initial and final moisture content and quantity etc..

The performance of solar tunnel dryer for drying processed tobacco was studied at no load in natural convection mode, no load in forced convection mode and full load conditions. The air temperature was measured at different locations of the solar tunnel dryer viz. at bottom tray, at mid tray, at upper tray, at north wall and south side from mid tray, respectively. The performance of system was evaluated for drying processed tobacco during the months of December and April. The maximum average air temperature attained was 47, 52, and 44.2 °C inside the dryer at no load without solar collectors, no load with solar collectors and for full load conditions, respectively during the month of December. The maximum ambient temperature attended during this month was 26.8, 26.3 and 27 °C at no load without using solar collectors, no load using solar collectors and full load conditions, respectively. The maximum average air temperature was attended as 60, 75.29, and 72.1 °C inside the dryer at no load without using solar collectors, no load using solar collectors and full load conditions, respectively, during the month of April. The maximum ambient temperature attended during this month was 40, 41.9 and 40.1 °C at no load without using solar collectors, no load using solar collectors and full load conditions, respectively.

The relative humidity inside the solar tunnel dryer varied from 35 to 78 per cent and from 30 to 69 per cent at full load conditions in the months of December and April, respectively. The collector efficiency ranged from 28.56 to 67.85 per cent and from 32.58 to 63.25 per cent at no load conditions in the months of December and April, respectively. The system drying efficiency ranged from 6.96 to 47.25 per cent and from 7.28 to 53.26 per cent at full load conditions in the months of December and April, respectively. The pick-up
efficiency ranged from 6.32 to 26.26 per cent and from 7.53 to 27.8 per cent at full load conditions in the months of December and April, respectively.

The performance of solar tunnel dryer for drying Di-basic Calcium Phosphate was evaluated through no load and full load conditions tests in the months of December and April. The maximum average air temperature observed was 44.5, 49.8, and 45.2 °C inside the dryer at no load without using solar collectors, no load using solar collectors and full load conditions, respectively during the month of December. The maximum ambient temperature observed during this month was 27.1, 26.9 and 27.2 °C at no load without using solar collectors, no load using solar collectors and full load conditions, respectively. The maximum average air temperature was attained as 59.81, 66.8, and 64.1 °C inside the dryer at no load without using solar collectors, no load using solar collectors and full load conditions, respectively, during the month of April. The maximum ambient temperature attained during this month was 44, 41.9 and 41.3 °C at no load without using solar collectors, no load using solar collectors and full load conditions, respectively.

The relative humidity inside the solar tunnel dryer varied from 38 to 85 per cent and from 36 to 74 per cent at full load conditions in the months of December and April, respectively. The collector efficiency ranged from 30.25 to 66.29 per cent and from 31.25 to 68.29 per cent at no load conditions in the months of December and April, respectively. The system drying efficiency ranged from 6.96 to 45.26 per cent and from 7.28 to 51.25 per cent at full load conditions in the months of December and April, respectively. The pick-up efficiency ranged from 5.11 to 25.01 per cent and from 6.54 to 28.56 per cent at full load conditions in the months of December and April, respectively.

Techno-economic analysis of solar tunnel dryer for drying processed tobacco and Di-basic Calcium Phosphate were carried out using three different economic indicators namely net present worth (NPW), benefit cost ratio (B/C ratio) and pay back period.

Following conclusions were drawn:

1. For drying half ton processed tobacco an forced convection type solar tunnel dryer, floor area of 60 m² was designed and commissioned at M/s Miraj Pvt. Ltd., Nathdawara.

2. Another solar tunnel dryer was designed and commissioned at M/s Phosphate India Pvt. Ltd, Udaipur with a floor area of 78.75 m² for drying a batch of 1 ton Di-basic Calcium Phosphate.
3. Average air temperature observed in the solar tunnel dryer was about 20-23 °C higher than the ambient temperature which led to considerable reduction in drying time in comparison to that of conventional sun drying for drying of Processed Tobacco.

4. It was also observed that the moisture content of processed tobacco under full load condition of the dryer reduced from 137.8 per cent (d.b.) initial value to a 10.08 per cent (d.b.) in 8 sunshine hours. The moisture content decreased with drying time, whereas drying rate followed the trend of solar insolation i.e. increasing up to 13 hours and then decreasing. processed tobacco dried completely in falling rate period zone only.

5. The air temperature inside the solar tunnel dryer was higher than outside by 19-23 °C and the moisture content of wet Di-basic Calcium Phosphate reduced from an initial value of 66.67 to 10.5 per cent (d.b.) in 10 hours for drying. No constant rate drying period was observed. The drying rate for wet Di-basic Calcium Phosphate varied similarly as solar insolation, whereas the moisture reduced continuously with cumulative drying hours.

6. The solar tunnel dryer is able to reduce the drying time and to increase the product quality in comparison to the sun drying.

7. The cost benefit ratio (B/C ratio) and pay back period of solar tunnel dryer for drying Processed Tobacco are 6.81 and 6 months, 8 days respectively.

8. The net present worth (NPW) of solar tunnel dryer for drying processed tobacco is Rs. 68,81,061.

9. The net present worth (NPW), benefit cost ratio (B/C ratio) and pay back period of solar tunnel dryer for drying Di-basic Calcium Phosphate are Rs. 28,23,511, 3.33 and 5 months respectively.

10. Economical indicators suggest that a solar tunnel dryer is a viable option for drying different agro-industrial and chemical products.