CHAPTER 10
CONCLUSION

In this work three different cross section geometries of heat pipe and three profiles of absorber plates are investigated experimentally at indoor and outdoor conditions.

- The three profiles of heat pipes designed are of circular, elliptical, and semi-circular cross sections with the dimension as follows

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Circular</th>
<th>Elliptical</th>
<th>Semi-circular</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of heat pipe</td>
<td>900 mm</td>
<td>900 mm</td>
<td>900 mm</td>
</tr>
<tr>
<td>Evaporator length</td>
<td>630 mm</td>
<td>630 mm</td>
<td>630 mm</td>
</tr>
<tr>
<td>Adiabatic length</td>
<td>90 mm</td>
<td>90 mm</td>
<td>90 mm</td>
</tr>
<tr>
<td>Condenser length</td>
<td>180 mm</td>
<td>180 mm</td>
<td>180 mm</td>
</tr>
<tr>
<td>Outside diameter HP</td>
<td>19 mm</td>
<td>12 x 24 mm</td>
<td>24 mm</td>
</tr>
</tbody>
</table>

- The various limitations of heat pipe are: capillary limit of 9858.89 W, sonic limit of 1773.59 W, entrainment limit of 8177.12 W, and boiling limit of 6180.05 W. This is used for deciding the input parameter of maximum heat input to the evaporator section.

- A laboratory scale test setup is designed. To obtain steady state condition of heat pipe, constant heat input is given to the Solar Simulator/Collector using artificial lighting system. Solar simulator designed for a output of 1800 W, consists of 6 Halogen bulbs of 300 W each is used to produce heat/light source for the setup. The halogens bulbs are attached to anodised polished reflector which increase the radiation on collector surface. The heat pipe
integrated with various profiles of absorber plate is used in the solar simulator.

- The optimised values for the input parameters for CHP with various absorber plate profiles by the RSM using BBD design are
  
  - CHP-FAP: heat input of 1400W; Inclination angle of 50°; flow rate of 100ml/min.
  
  - CHP-VGAP: heat input of 1360W; Inclination angle of 60°; flow rate of 120ml/min.
  
  - CHP-VTAP: heat input of 1400W; Inclination angle of 47°; flow rate of 120ml/min.

- The best performing absorber plate profile for CHP is VTAP. The heat output obtained is 153.44W, thermal resistance 0.0174°C/W and a thermal efficiency of 37.93%. This is due to the circular cross section paves way for proper execution of vaporization and condensation cycle. The geometry aids the flow of condensate from the condenser section to evaporator section. Further the V-Trough geometry of the absorber plate enhances the incidence of solar radiance on to the heat pipe. This is because the angle of V-Trough makes sure that the solar radiance is uniform throughout the day on the surface of CHP which results in enhanced thermal performance in CHP-VTAP than other profiles.

- The optimised values for the input parameters for EHP with various absorber plate profiles by the RSM using BBD design are

  - EHP-FAP: heat input of 1399W; Inclination angle of 60°; flow rate of 120ml/min.
- EHP-VGAP: heat input of 1400 W; Inclination angle of 47°; flow rate of 100ml/min.
- EHP-VTAP: heat input of 1400W; Inclination angle of 40°; flow rate of 120ml/min.

- The best performing absorber plate profile for EHP is VTAP. The heat output obtained is 123.27W, thermal resistance 0.024°C/W and a thermal efficiency of 31.37 %. The flow of condensate from the condenser section to evaporator section is limited because of EHP. This is due to the fact the gravitational force has a significant effect on the flow of working fluid between the evaporator and condenser section along the capillary action of wick. Further the V-Trough geometry of the absorber plate enhances the incidence of solar radiance on to the heat pipe. This is because the angle of V-Trough makes sure that the solar radiance is uniform throughout the day on the surface of EHP. The Flat plate on other hand, due to its shape, is not capable of providing enough radiance on EHP. Though the radiance is maximum for the V-Groove at a particular orientation angle, the radiance is not uniformly transferred to EHP which results in a performance lower than that of the V-trough.

- The optimised values for the input parameters for SCHP with various absorber plate profiles by the RSM using BBD design are
  - SCHP-FAP: heat input of 1399 W; Inclination angle of 30°; flow rate of 115ml/min.
  - SCHP-VGAP: heat input of 1399 W; Inclination angle of 30°; flow rate of 120ml/min.
  - SCHP-VTAP: heat input of 1400W; Inclination angle of 49°; flow rate of 115ml/min.
The best performing absorber plate profile for SCHP is VGAP. The heat output obtained is 150.12W, thermal resistance 0.0294°C/W and a thermal efficiency of 37.95%. This is due to the semi-circular cross section paves way for proper execution of vaporization and condensation cycle. The geometry aids the flow of condensate from the condenser section to evaporator section. Further the V-Groove geometry of the absorber plate enhances the incidence of radiance on to the semi-circular heat pipe. This is because the angle of V-Groove makes sure that the radiance is uniform throughout on a semi-circular cross section because of the flat top surface and semi-circular bottom surface. The Flat plate on other hand, due to its shape, is not capable of providing enough radiance to SCHP. Though the radiance is maximum for the V-Trough at a particular orientation angle, the radiance is not uniformly transferred to the SCHP which results in a performance lower than that of the V-Groove profile.

The overall best performance is found in the case of circular cross section heat pipe integrated with V-Trough absorber profile. The system resulted in a maximum heat output of 155.44 Watts, a minimum thermal resistance of 0.0174°C/W and maximum thermal efficiency of 39.65% with the input parameters, heat input of 1400 W at an inclination angle of 47° and flow rate of 120 ml/min.

The performance of circular heat pipe integrated with V-Trough profile is closely followed by the semi-circular heat pipe integrated with V-Groove absorber profile. This system produced a maximum heat output of 150.12 W, a thermal resistance of 0.029°C/W and thermal efficiency of 37.95% with heat input of 1400 Watts, an inclination angle of 30° and a flow rate of 120 ml/min. This is
due to the geometry of heat pipe placed in absorber plate profile which ensures the proper heat transfer from absorber plate in case of circular and semi-circular heat pipe. Hence enhanced thermal performance is observed. Further the absorber profiles, V-Trough and V-Groove has increased concentration ratio of solar radiance twice that of flat profile.

- The best performing combination of the indoor setup is tested in outdoor condition. The outdoor results are compared with that of indoor. From the results, it is observed that there are deviations from that of indoor. This due to the fact that in the outdoor conditions the solar radiance is not uniform on the surface of heat pipe throughout the day.

### 10.1 FUTURE SCOPE

Following research work need to be carried out so that proposed ideas can be applied for enhancement of thermal performance on heat pipes.

1. The study and comparison of other cross section geometries like rectangular and square plate with the circular cross section heat pipe will be useful for benchmarking the system.

2. More experimental results are needed to confirm the flooding limit, dry out limit and entrainment limit in heat pipe.

3. The performance of other working fluids like nano fluid for semi-circular and elliptical section geometry heat pipe should be the subject of further studies.

4. The different cross section geometry of heat pipes is to be analysed on tracking type collectors for further studies.