Chapter 6

Conclusions and Scope for Future Work

6.1 Conclusions

Overall, it can be concluded that PTC technology is an advanced technology. It is capable of replacing conventional energy resources to a great extent. Given the scope of the use of concentrating solar power (CSP) technologies, parabolic trough solar collectors are an alternative technology to produce heat and electricity from solar energy. In this dissertation, a comprehensive design of line concentrating helical coil solar cavity has been introduced to model a parabolic trough solar collector (PTC).

Novelty of the present research research work is the design and development of double glazing helical coil solar cavity receiver with vacuum at the outer annulus for parabolic trough concentrator to reduce losses and enhance convective heat transfer coefficient so that maximum portion of sun energy can be converted to thermal energy. A helical coil (copper tube) surrounded by two concentric borosilicate glass cover keeping vacuum at annular space has been designed and fabricated. It was put at the focal line of a parabolic trough concentrator to absorb solar radiation reflected from the aperture of PTC. Heat transfer fluid is flowing through the helical coil receiver to receieve energy from sun and get heated. The thermal oil heat transfer process of the solar parabolic trough concentrator from input solar radiation to heated oil output is analysed. The process is sorted into the three following separate sections: glass covers heat transfer with solar radiation, absorber heat transfer with solar radiation, and absorber heat transfer with thermal oil. A dynamic model has been developed and validated by real operating data in typical spring and summer days.

A number of experiments has been performed on horizontal tube and helical coil receivers and it was found that the considerable change in the value of maximum conversion efficiency when the horizontal tube receiver has been replaced by helical coil receiver with vacuum tube outer cell. This is due to the reasons: first, the horizontal empty tube is converted into helical coil tube which is accountable for the enhancement of the convective heat transfer coefficient owing to the secondary flow and second, the double glazing evacuated tube over helical coil responsible for the reduction of heat losses due to conduction and convection. Heat loss from helical coil solar cavity receiver has also been investigated by varying vacuum pressure at annulus.

The effect of back pressure on the quality of vacuum has also been mentioned in this thesis. Back pressure increases as the glass cover temperature increases. The pressure at the annulus affects the temperature of receiver. Lower pressure at the annulus adds more temperature to the receiver. It was found experimentally that 4.35% increase in temperature of receiver with the decrease in annulus pressure of 46.15% under the same environmental conditions. Maximum conversion efficiency that has been achieved for helical coil solar cavity receiver is 21% more than that would achieve using the model of Milton Matos Rolim et al. (2009) for horizontal tube receiver.

The present thesis consists of six chapters and all reflects the major point relevant to our research work. In the first chapter of the thesis a brief description of solar concentrating solar technology with a special emphasis on parabolic trough solar collectors is performed. The state-of-the-art in modeling PTC is presented and main objectives in optical, thermal and aerodynamic modelling of the PTC are depicted. Chapter 1 comprises of the introduction & background of the problem, motivation, objectives, and novelty of the research work. This chapter also includes the conceptual definitions, framework and significant outcomes of the research. The scholarly, practical and personal significance of the thesis has been included in this chapter. Chapter 2 contains the literature review. It includes the previous literature which is needed to establish scholarly the significance of research problem in the relevant area. It also provides the conceptual framework or the perspective of the thesis. Awareness of the related area with the understanding of the research gap has been mentioned at the end of this chapter. Chapter 3 represents the description of experimental setup and their equipment used to measure input and output parameters under study. It also includes the design and manufacturing of the experimental setup under the Varanasi climatic zone. Chapter 4 includes the numerical modeling of parabolic trough concentrator. Optical, thermal and energetic modeling of the present experimental setup has been mentioned in this chapter. Performance model developed in this chapter is validated with the experimental results which confirm the validity and reliability of the data under Varanasi climatic zone. Chapter 5 comprises of the results and discussion. It includes the key finding of the research work and their comparison with the previous literature. This chapter presents the creative way to show the data using plots and explain the implications of our findings. Chapter 6 includes the conclusion, recommendation, acknowledgment, references, and appendices. This chapter also includes the list of publications.

Followings are the main outcomes of the present thesis work that have been pointed out:

- The optimum value of concentration ratio for parabolic trough concentrator is 81.69 and the ratio of height to the focal length is 1.7.

- Maximum conversion efficiency for empty tube receiver and evacuated helical coil receiver are 31% and 85% respectively for a given oil flow rate of 5.88 L/minute.

- It was observed that if the vacuum pressure at annulus increases from 20 torr to 30 torr, the losses from the receiver increases from 15J to 19J i.e. 26.67% loss occur if vacuum pressure increases by15% in the vacuum chamber. Hence, creating vacuum at annulus is one of the best way to minimize losses from the solar receiver.

- Enhancement in the convective heat transfer coefficient of 87.96 if horizontal tube receiver is replaced by double glazing helical coil solar cavity receiver with vacuum at outer annulus.

- Average thermal efficiency for the present experimental setup is 9.317% more than that of the thermal efficiency that was obtained by SNL test (1994).

- Maximum receiver temperature achieved for the present experimental setup is 565 K.

6.2 Scope for Future Work

There are a lot of future scope to the present work which are as follows:

- To design a cost effective trough made up of composite materials, to make the present setup lighter and durable.
- Parallel to the experimental and numerical work, simulation can be done to compare the simulated results with experimental and numerical investigation to optimize the collector design.
- The present experimental setup can be analyzed with several types of HTFs other than Mythol Therm 500 oil to compare the actual heat gains.
- Losses can be minimized by keeping the focal length less than the depth of PTC. Losses can also be investigated considering the combined effect of parameters:wind speed, wind direction, dust/dirt, building and trees around the PTC system.