Chapter 5

Summary Of Results, Conclusions And Future Prospects

In this chapter we discuss the important conclusions and the nodal points emerging from our present study as well as the future prospects and other ideas for exploring the present work further.

5.1 Summary Of Results And Conclusions

We began in chapter 1 by introducing the elementary aspects of solar energy, the relevant technologies, the solar insolation and its measurements, and the Physics and technology of solar thermal conversions. We have also discussed about the types of solar cooker. The testing of solar cooker is also discussed elaborately and the standard equations are given to evaluate the two figures of merit of the cooker as given by Garg and Prakash [7].

We know that a table experiment is always helpful before going to a laboratory. In our case, a useful tool in this direction is provided by modelling and simulation using theoretical and computational ideas. Therefore in chapter 2, the following nodal points are discussed.
(a) The seven coupled differential equations of the cooker elements are solved under appropriate condition to obtain the temperature profiles of the solar cooker elements.

(b) The above theoretical cum computational analysis is carried out for ABSC and PBSC types of solar cookers.

(c) A theoretical analysis is also done for the maximum plate temperature with respect to variation in the available aperture area considering an appropriate scale factor.

(d) A theoretical analysis of the five elements and also for the seven elements of both the cookers are done, in chapter 2. We have adopted the finite difference method as the numerical approximation for solving the seven coupled differential equations. Our calculations were repeated by solving these equations by using the standard fourth order Runge-Kutta method. The results of both the methods are quite comparable as shown in figures 2.7 and 2.8.

(e) The computational simulation (chapter 2) was also used to ascertain the sensitivity of the performance of the cooker with respect to the values of the various heat transfer coefficients.

The main emphasis in this thesis has been on experimental results, which are presented and discussed in chapters 3 and 4. Chapter 3 deals with our solar cooker investigations. Thus we conclude as follows:

(a) The figures of merit of the two cooker systems (ABSC and PBSC) are experimentally obtained. The two figures of merit are mutually in agreement and are
also close to the value as reported by previous workers.

(b) The plate temperature profile is experimentally observed and is compared with our theoretically simulated plate temperature profile (Chapter 2). We have noticed that the agreement between theory and experiment is fairly well during rising temperature up to the stagnation value, but in the region of falling temperature an increasing discrepancy is noticed.

(c) The theoretical values of temperatures are falling faster than the observed data in our experiments. This is because of the fact that, in our numerical method the higher order corrections are neglected.

(d) Moreover the physical approximations adopted here in our differential equations (chapter 2) do not account for thermal inertia and temperature dependence of heat transfer coefficients. We believe that, the difference between the observed and calculated temperatures as given in equation 3.5.1 is an indication of the underlying approximations.

(e) Therefore, we have given the corrected (tuned) form of the plate temperature profile in the falling temperature region by considering the equation 3.5.1.

(f) We also studied an experiment by considering a copper plate as an absorber plate and it was found that the plate temperature of the cooker having copper plate as an absorber plate is higher, in fact it leads by 6 to 7 °C. So we suggest that if we consider copper as the absorber plate the efficiency of the cooker can be increased.
(g) We studied the characteristics of all the seven elements of the cooker experimentally, but detailed comparisons have not been made element-wise with our theoretical simulations. However, comparing the two types of data we find that amongst the seven elements, the cooking pot attains the highest maximum temperature (see figure 3.12), and this is also reflected in our theoretical analysis.

(h) The performance characteristics of the solar box cooker, i.e. the graph of sensible heating time $T_{bol} \rightarrow \frac{98-T_a}{T_a}$ figure 3.13 is studied. We find that the characteristic is comparable to that given by Garg and Kandpal [5].

(i) The thermal conduction bondage between the pot and the plate through the black paint of the cooker is tested with electrical backup (EBSC). It is found that the presence of the paint in between the bottom of the cooking pot and the plate, does not significantly affect the efficiency as per the data given in table 3.11, however, it is still hoped that the efficiency can be improved by improving the thermal conduction bondage between the pot and the plate.

(j) We also studied the effect of thermal bondage of the cooking pot with the plate of the solar cooker under insolation. We find that during early hours of rising sun, the energy gained by the pot (in contact) per second is all the time higher than that for the lifted one. And during later hours of declining sun, the energy lost by the pot (in contact) per second is also all the time higher. Thus the solar cooker will be a bit more efficient if it has a provision of lifting the pots in the later hours of a day.
Our chapter 4 describes the solar drying process and its relevant physical principles. The significance of this work is the introduction of a two in one solar thermal device. We have discussed in chapter 4 how a household solar cooker can be extended into a cooker cum dryer. Let us summarize the results and conclusions of that chapter.

(a) The performance characteristics of the empty mini solar dryer is studied. The peak dryer temperature was observed about 88 to 90 °C which is quite reasonable as suggested by Garg and Krishnan [35].

(b) The loaded dryer characteristics are also studied and the peak dryer cabinet temperature is observed to be about 60 to 66°Cs, which is an ideal range for drying.

(c) The items dried in the present dryer possess the quality comparable with the other dried products available commercially in the market.

(d) The present device is simple, portable, easy to operate for household purposes and the price is also quite reasonable for a common man. There is no operation cost, and the maintenance cost is also very reasonable.

Thus in this thesis, we have examined simple computational, theoretical and experimental ideas to investigate the solar cooker system and its modification as a cooker cum dryer. This is an applied research field and is closely related to the common man’s day to day need. Moreover solar energy will help to save the conventional energy sources. It is eco-friendly, so will help the environment. The solar cooker provides a good supplement to the present conventional cooking systems.
5.2 Future Prospects-Ideas For Further Exploration

(a) If the cooker is placed on a rotating platform, it can be tracked according to the position of the sun, for receiving maximum insolation all throughout the day (from sunrise to sunset). As the daily integrated insolation is increased many fold, more number of cookings per day is feasible. The tracking can be done manually or electronically by incorporating appropriate circuit and a servo motor.

(b) There is a scope for carrying out similar work as presented in this thesis, entirely for concentrated parabolic reflector solar cooker. The parabolic reflector helps in achieving higher peak temperatures, thereby reducing sensible heating time.

(c) In the present dryer the circulation of the vapour is by natural convection assisted by a chimney. There is no external control over the natural convection. The process of drying is critical of this vapour circulation (draft). A small solar photo voltaic panel capable of delivering electrical power of the order of 5-10 watts under normal solar insolation, can be used to drive a mini fan which can subsequently be employed to drive out the hot vapour from the dryer. The device still remains passive as no external electrical power is utilized. Also there is a natural advantage as the insolation increases, more vapour is generated, the fan move faster and vice versa.

(d) The efficiency of a solar dryer is directly related with its total capacity to catch the solar radiation during a day. This can be done by making a small modification in the present dryer. A blackened metallic plate/blackened many folded
metallic net can be placed just below the glass cover. This modification will reduce the sensible heating time, as the absorption of solar radiation is more than the previous one. There is also an additional advantage that the item under drying will be not exposed directly to the solar radiation, as a result the radiation bleaching will be completely avoided.

(e) There is always an optimum humidity and temperature for an item being dried. The control over these two parameters can be achieved by incorporating the temperature and humidity sensors in the drying chamber along with peripheral circuitry of actuators.

(f) The present portable dryer can be made still lighter by making the dryer attachment of lighter transparent materials like acrylic, plastic etc. This variation will make the operation more comfortable.

(g) Arrangement for keeping multiple trays inside the dryer can be done. This will enhance the quantity of the item dried in a single run.

(h) Mathematical modelling of the present dryer can be done vis-à-vis the modelling of conventional dryer.

(i) Data logging system can be employed to record the variation of various physical parameters with respect to the time of an experimental run. This will help in gathering large number of data and the confidence in our conclusions.

Thus, we have come to an end of this thesis with the conclusion that solar cookers and solar dryers the two useful solar devices, do not require a very high technology but on the other hand can help in solving the energy crisis for future prospects to a
great extent especially tropical countries, like our India where the availability of solar energy is in abundance.

The question which remains with us is that why we are not making use of this incredible bonanza of solar energy? As Dr. Hermann Scheer, President of EUROSOLAR, and winner of the Alternative Nobel Prize in 1999 has said: "Solar energy is the energy of the people. To use this energy does not require big corporations. It requires billions of investments by billions of people. They have the opportunity to switch over from being a part of the problem to becoming a part of the global solution. That is the globalization by the people." Thanks to the energy crisis which has made solar cooker and solar dryer a reality. The challenge is to make use of solar energy directly and in non-polluting fashion.

The conventional energy sources are for few more decades but the solar energy is forever and freely available at the premises of the users. Let us prepare a goal for availing the renewable energy on a large scale and stop not till this goal is reached.

"Arise, Awake and Stop not Till The Goal is Reached"

Swami Vivekanand