Numerical Simulation of Heat Transfer and Flow Over A Roughened Surface Absorbing Solar Energy

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Abstract - Solar energy is being used in various applications of domestic and industrial purpose. Solar energy in the form of heat is abundantly available on the earth and is free for use. In present age of energy, this free form of energy can be used in the form of heat. Heat energy is used in heating of air and water in domestic use apart from other usages. Heat energy obtained from sun can also be used fro industrial purposes of dying of goods and many chemical and process industries, hotels, dairies , textiles, breweries & distilleries, chemical /bulk drugs units, electroplating/galvanizing units , pulp and paper industries etc.. This heat is also being used in generation of electricity. One of the applications of this heat in heating air is being done in solar air heater. Solar air heaters absorb the heat from the solar radiation falling over its absorber plate. Amount of absorption of this heat and further transfer of absorbed heat depends upon the surface properties of the absorber plate. The paper presents the simulated results of heat transfer and flow of air over the absorber plate when the surface of the absorber plate is roughened with the triangular shapes of different dimensions placed at a fixed interval. The results are obtained from the CFD simulation in the form of contours and plots. Numerical values of parameters of heat transfer are also presented. The results show the improved heat transfer as compared to flow over a smooth surface.

Keywords - Surface Roughness, CFD, Solar air heater, Heat Transfer.

I. INTRODUCTION

Energy is used to do work. It lights cities, powers vehicles, trains, planes and rockets. Energy warms the houses, used in cooking food, playing music and many other applications at home. There are many sources of energy. A few are Geothermal Energy, Solar Energy, Wind Energy, Nuclear Energy, Hydro Energy and Biomass Energy.

Demand for energy has been rising with the development of society and nation through increase in population, transportation and industrialization. Continuous use of fossil fuels is leading to energy starvation and serious problem of environment degradation.

II. SOURCES OF ENERGY

The sources of energy can be classified as conventional or non renewable and non conventional or renewable energy sources.

Non-conventional or renewable energy sources also called non-conventional energy sources. They are the sources that are continuously replenished by natural processes. Solar energy, wind energy, bio-energy hydropower etc., are the examples of some of the renewable energy sources.

Conventional or Nonrenewable energy sources include the fossil fuels such as oil, natural gas, and coal. The fossil fuels are formed over millions and millions of years by the action of heat from the Earth's core and pressure from rock and soil on the remains of dead plants and animals.

Solar Energy

Solar energy is the most readily available source of energy. It is freely available since prehistoric times. Solar energy is equivalent to over 15,000 times the world's annual commercial energy consumption reaches the earth every year.

As per the available data, India receives solar energy in the range of 5 to 7 kWh/m2 for about 300 days in a year. This energy is sufficient to produce 20 MW of solar power from solar plant from land area of per square kilometer.

III. NUMERICAL SIMULATION

Numerical simulation uses numerical approximation for the solution of problems of physics and engineering. Numerical simulation is being used since olden days to compute the numerical results of physical problems. Numerical analysis continues this long tradition of practical mathematical calculations. Modern numerical analysis does not seek exact answers, because exact answers are often impossible to obtain in practice. Instead,

much of numerical analysis is concerned with obtaining approximate solutions while maintaining reasonable bounds on errors.

This paper presents the numerical analysis of flow and heat transfer from a surface which has been roughened through the triangular elements of two different shape. These elements are alternatively arranged. The analysis is done with the help of Computational Fluid Dynamics, CFD method using ANSYS FLUENT Software. For the development of geometrical model and meshing GAMBIT software has been used. The problem consists of air flowing though a solar air heater and absorbing heat from the absorber plate. The results are obtained of temperature and flow contours for the three different air inlet velocities. The geometrical model is shown in figure 1.

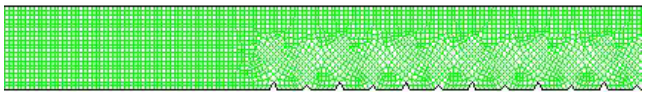


Figure 1: Geometrical Model with mesh

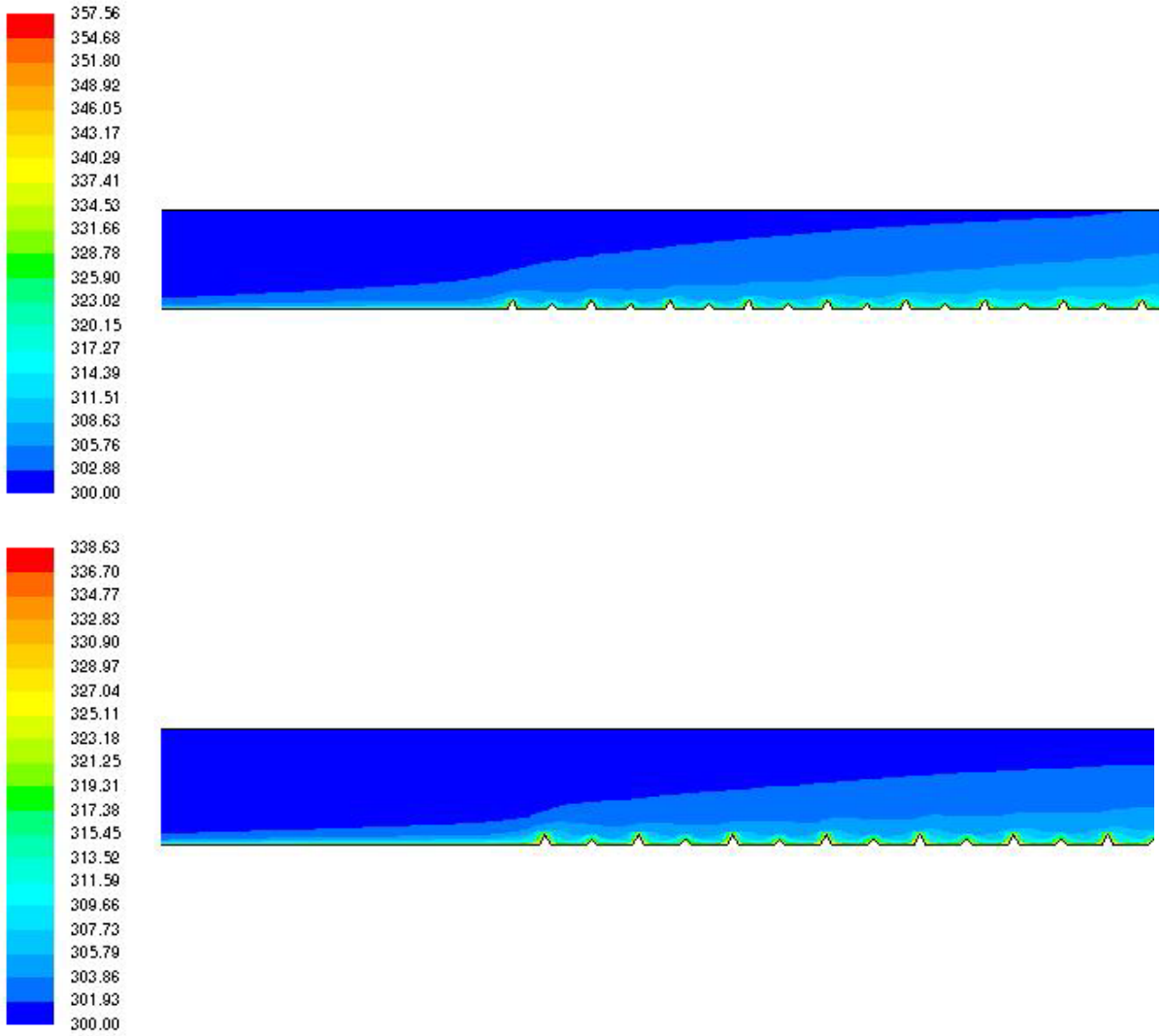
The configuration of the flow channel and ribs are shown in table 1.

Table 1

Length at inlet section	140 mm
Length of section at exit	140 mm
Length of Test section	500 mm
Height of test section	20 mm
Height of Ribs	2 mm and 1 mm
Pitch of rib	8mm

IV. TEMPERATURE CONTOURS

Temperature contours are obtained for three air velocities of 1.6m/s, 3.2m/s and 4.8m/s. The temperature contours are shown in figure 2.



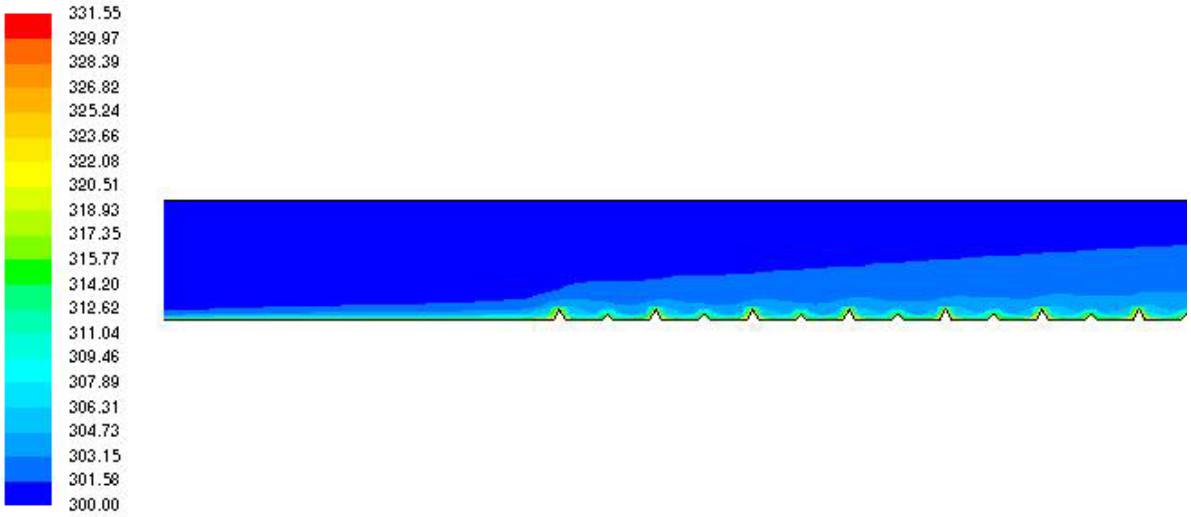
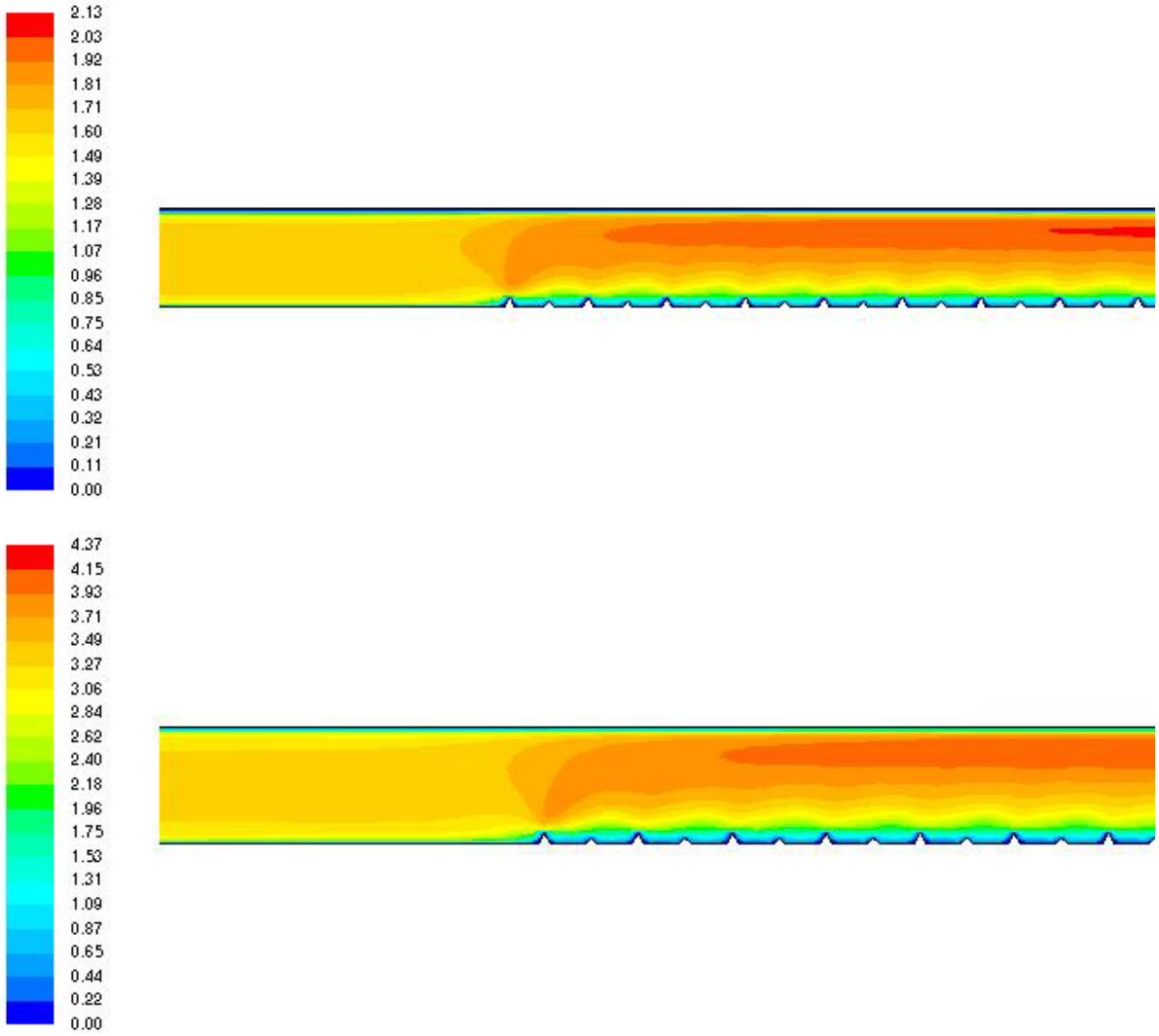


Figure 2: Temperature contours for three flow velocities

V. VELOCITY CONTOURS

Velocity contours for the flow with the three values of the velocities are also obtained. These velocity contours are shown in figure 3.



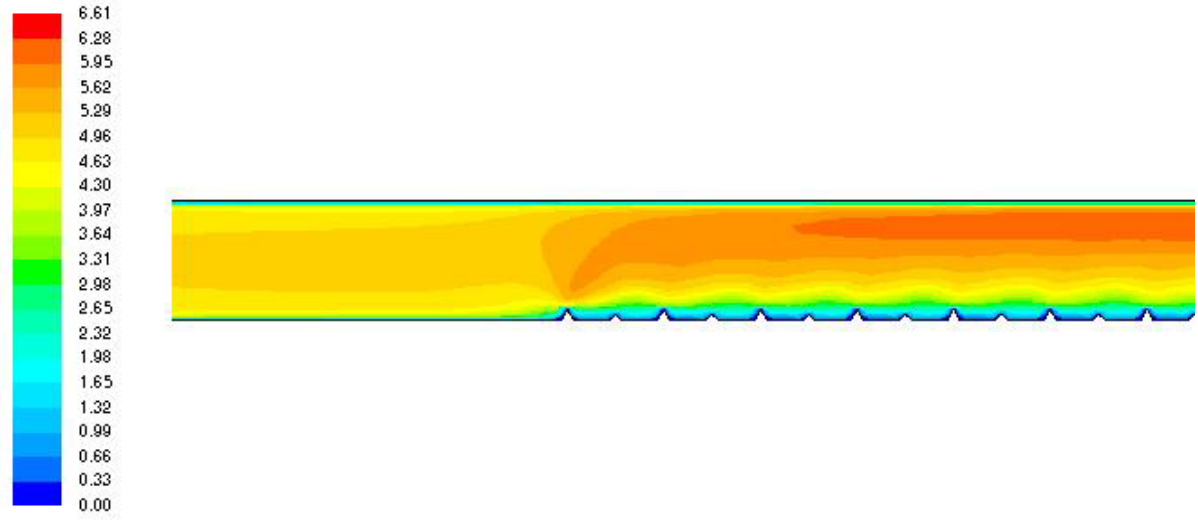


Figure 3: Velocity contours for three flow velocities

VI. CONCLUSION AND DISCUSSION

The results are obtained in the form of simulation of temperature and velocity contours for the flow channel of solar air heater with roughened surface. Three values of velocity of flowing air over the surface of the absorber plate have been used as an input. The CFD results in the form of temperature contours are showing that flow over the roughened surface is more turbulent as compared to the inlet and exit section and heat transfer is decreasing with the increase in the velocity of air flow. The heat transfer over the smooth section is not showing appreciable increase in het transfer but over the roughened surface the heat transfer is more. The values of velocity of the flow in velocity contours show that the small variation of velocity in the flow region is occurring. This means due the roughness provided over the test section, the heat transfer is improving and velocity distribution is also changing with small values. These contours also show that the increase in velocity is improving heat flow.

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