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Direct Absorption Process in an Annular Space for Innovative Solar Collector

AMAR HASAN HAMEED

KTO Karatay University

MOHAMMED NAWAF

University Of Turkish Aeronautical Association

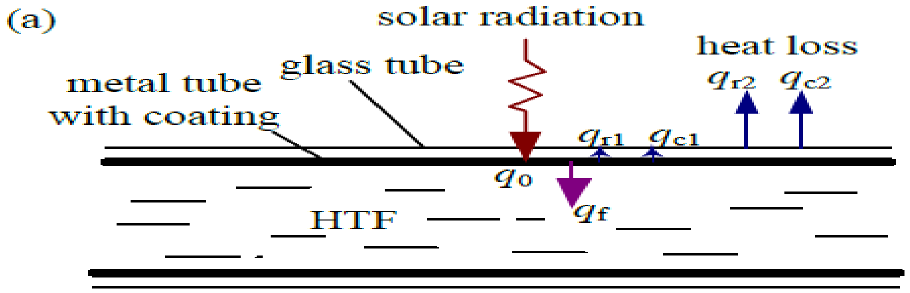
KTO KARATAY
ÜNİVERSİTESİ

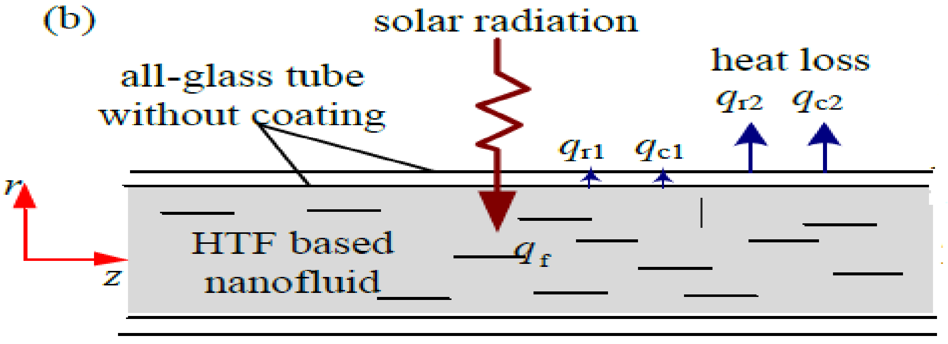
Introduction

➢ **Types of absorption solar radiation:-**

a- (IASC) **Heat transfer depend on conduction through the metal tube that is coated with spectral selective coating. This type has problem of the degradation of the coating with high temperature (addition cost).**

b- (DASC) **Heat transfer depend on direct absorption of solar energy through the glass tube by the nanofluid instead of spectral selective coating. And this type of solar collector is shown to be more efficient compared with first type.**





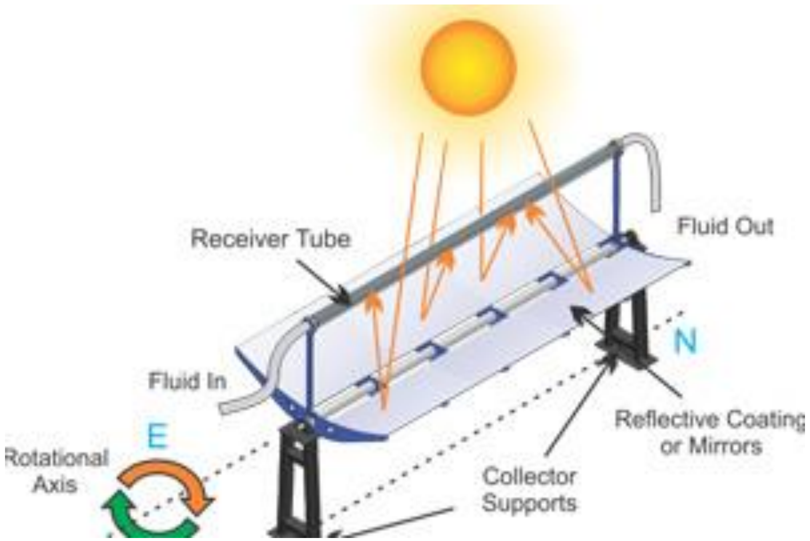
Introduction

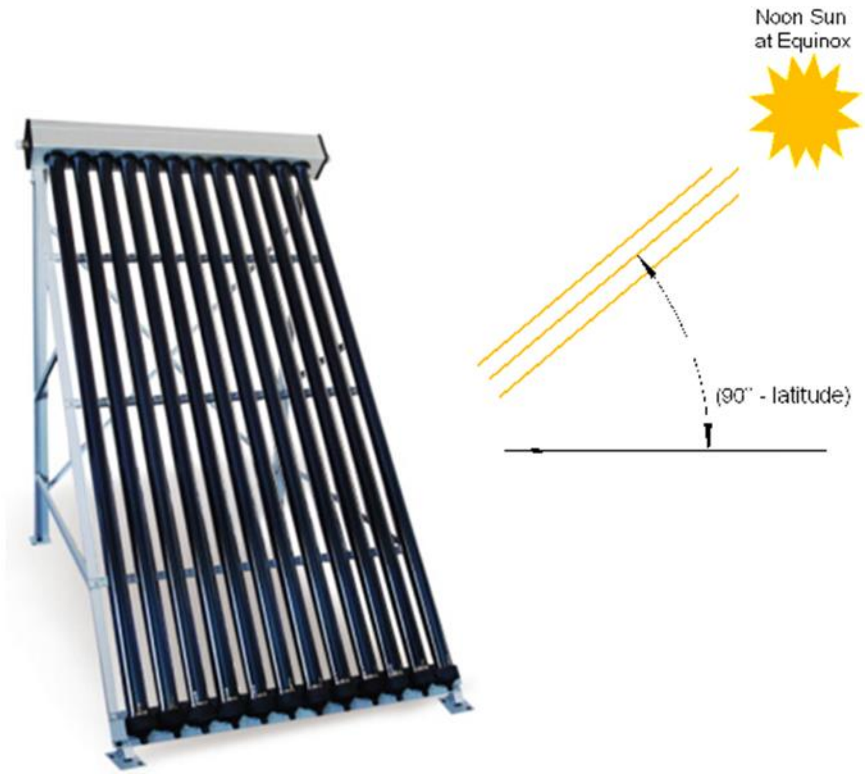
Types of direct absorption solar collector

There are two main different types of solar collector.

1- (None-concentrated) direct absorption solar collector

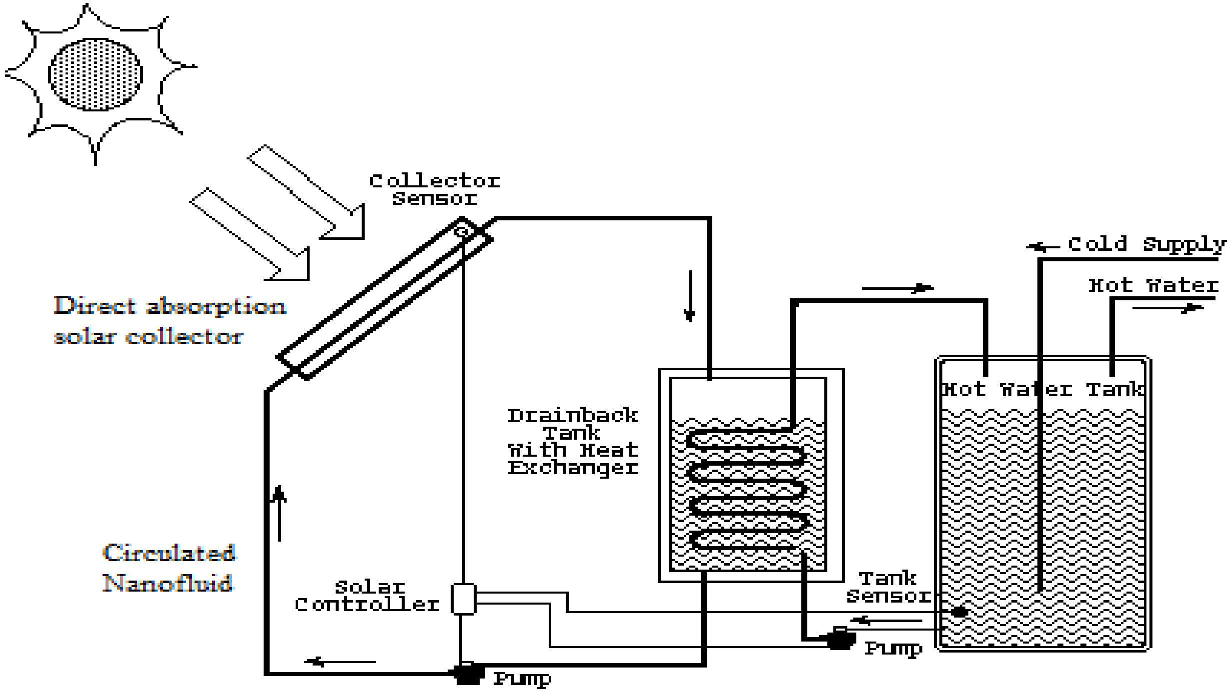
2- (Concentrated) direct absorption solar collector





Traditional type of DASC

- Nanofluid absorbs solar irradiation while flowing inside a long glass tubes.
- Nanofluid absorbs heat from irradiation, then it conveys the absorbed heat to a cold water through a heat exchanger .

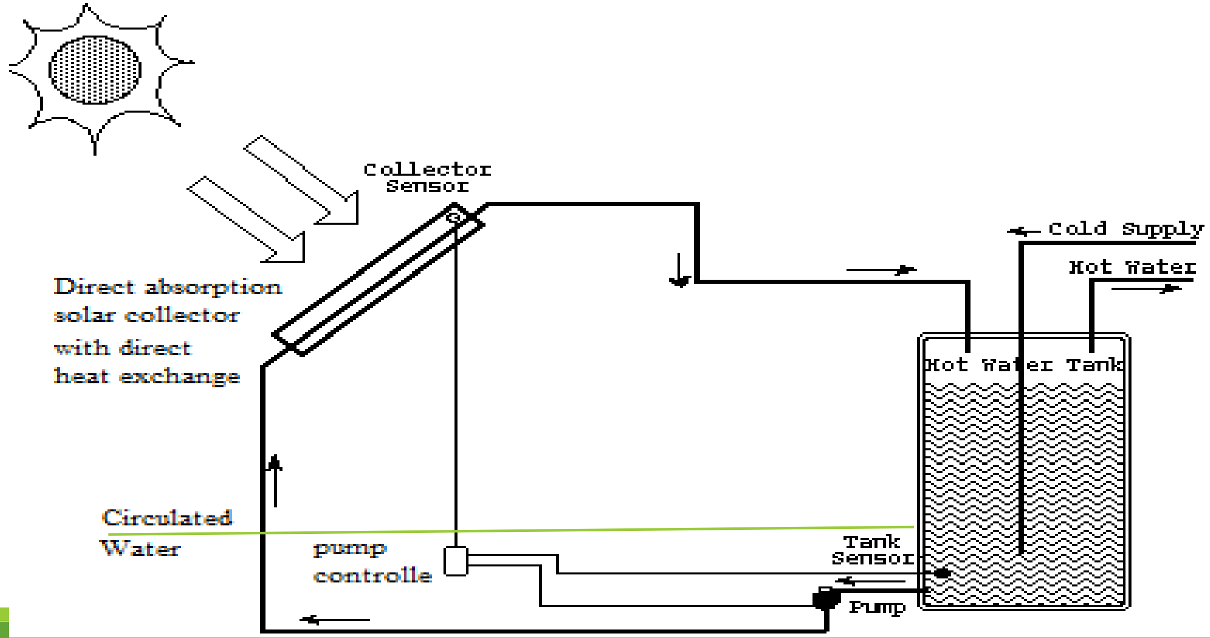


Traditional system of DASC with indirect heat exchange

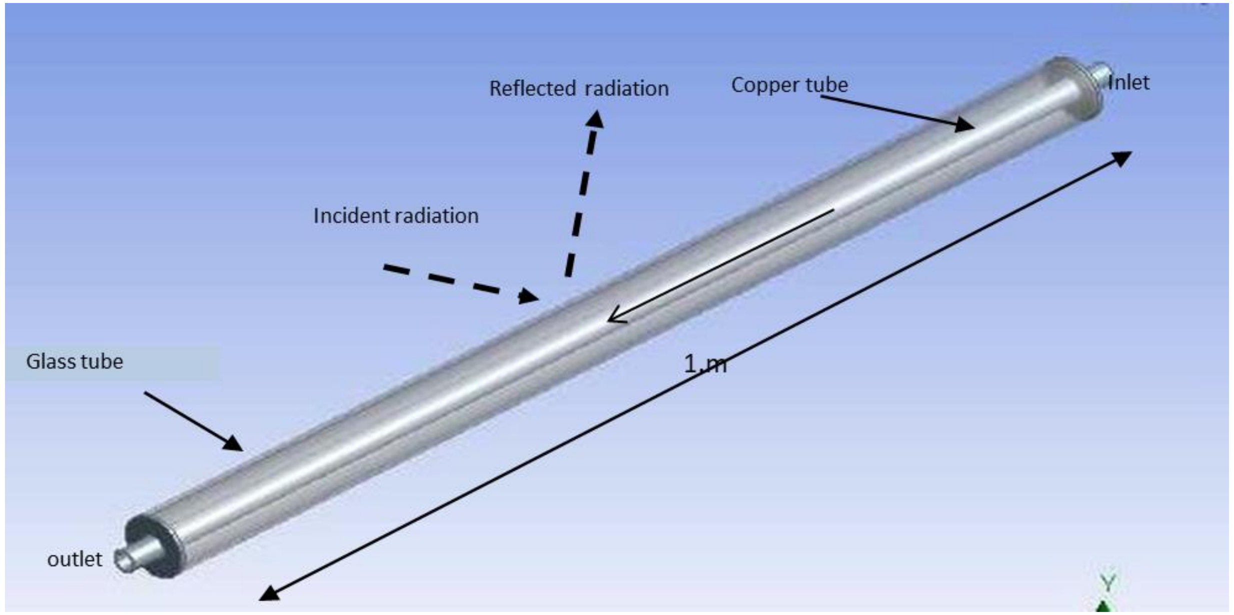
System of DASC with Direct Heat Exchange

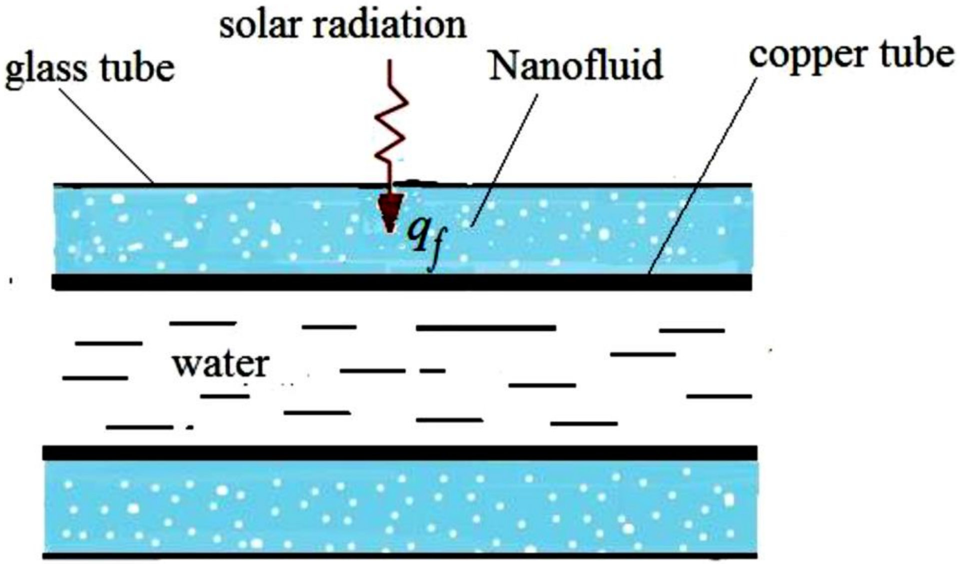
The new system will use the principle of direct heat exchange between the uncirculated nanofluid and circulating water inside the copper tube submerged in the nano-fluid inside glass tube.

New system of DASC with direct heat exchange



Technique of DASC New Design of NDASC





PURPOSE OF STUDY

1

- Increasing the thermal efficiency.

2

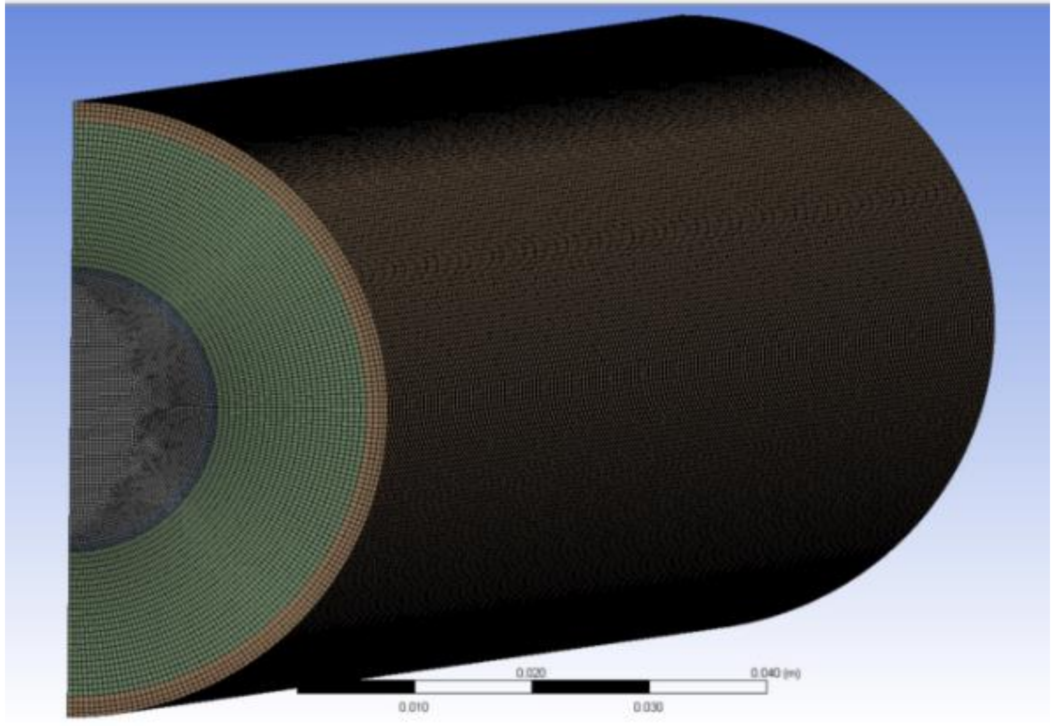
- Develop new configuration for direct absorption solar radiation.

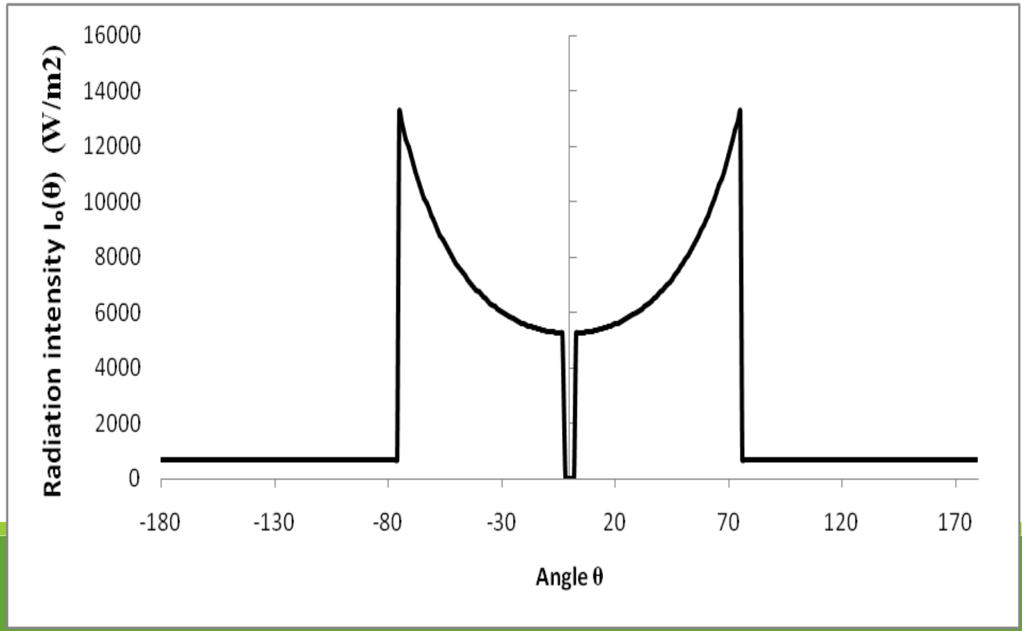
3

- Decrease the coast of Solar Collector.

Simulation

- ANSYS FLUENT simulator is used to perform numerical simulation of receiver unit for solar collector tube subjected to concentrated solar radiation.
- Mesh is generated in 3-dimensional model using mesh manager in ANSYS FLUENT (multi zone type is used) , both B.C and flow was assumed symmetry, because of the solar radiation incident angle on the receiver tube is assumed constant.



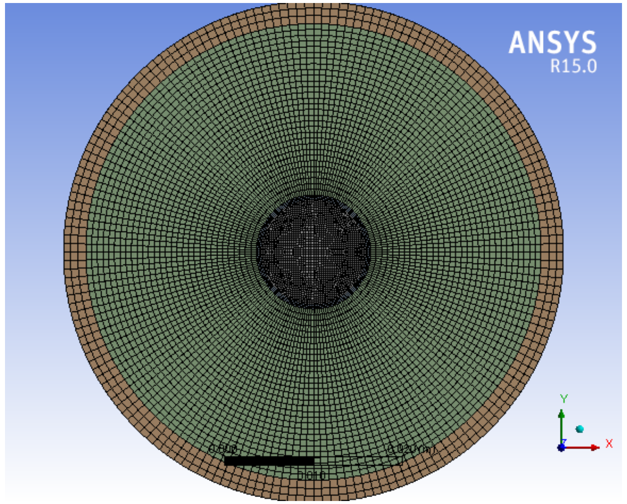


Simulation

- The mathematical form of energy equation including source term can express heat transfer in nano-fluid region. The steady state form of energy equation which has been solved in nano-fluid region is stated below;
- $\frac{\partial(\rho u_x T_f)}{\partial x} + \frac{\partial(\rho u_y T_f)}{\partial y} + \frac{\partial(\rho u_z T_f)}{\partial z} = \frac{\partial}{\partial x}\left[\frac{k}{C}\frac{\partial T_f}{\partial x}\right] + \frac{\partial}{\partial y}\left[\frac{k}{C}\frac{\partial T_f}{\partial y}\right] + \frac{\partial}{\partial z}\left[\frac{k}{C}\frac{\partial T_f}{\partial z}\right] + \Phi$
- The source term is defined by using User Defined Function (UDF) which is compiled with ANSYS FLUENT.
- Boundary conditions and properties of all zones is defined to the model in accordance with the physical model.

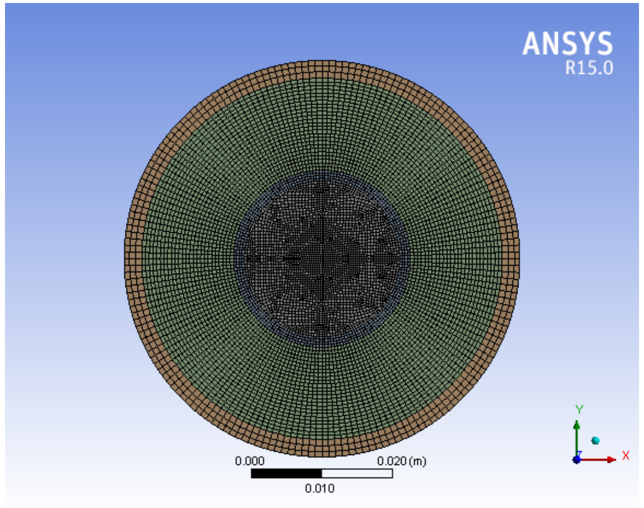
Simulation

- To obtain high efficiency of the new type of SC, we selected three models of collectors with size ratio of glass to copper tube (1/4, 1/2, 3/4).
- Glass tube diameter is constant (51mm) and standard copper tubes are used at ratios ¼, ½ , ¾ .



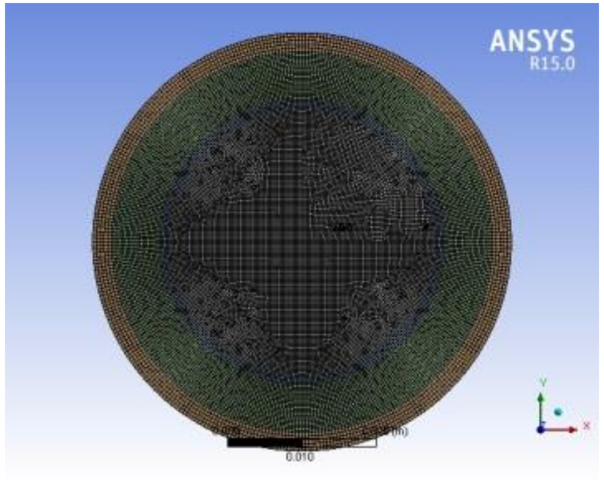
Dc = 12.75mm

¼ ratio



Dc = 25.5 mm

1/2 ratio

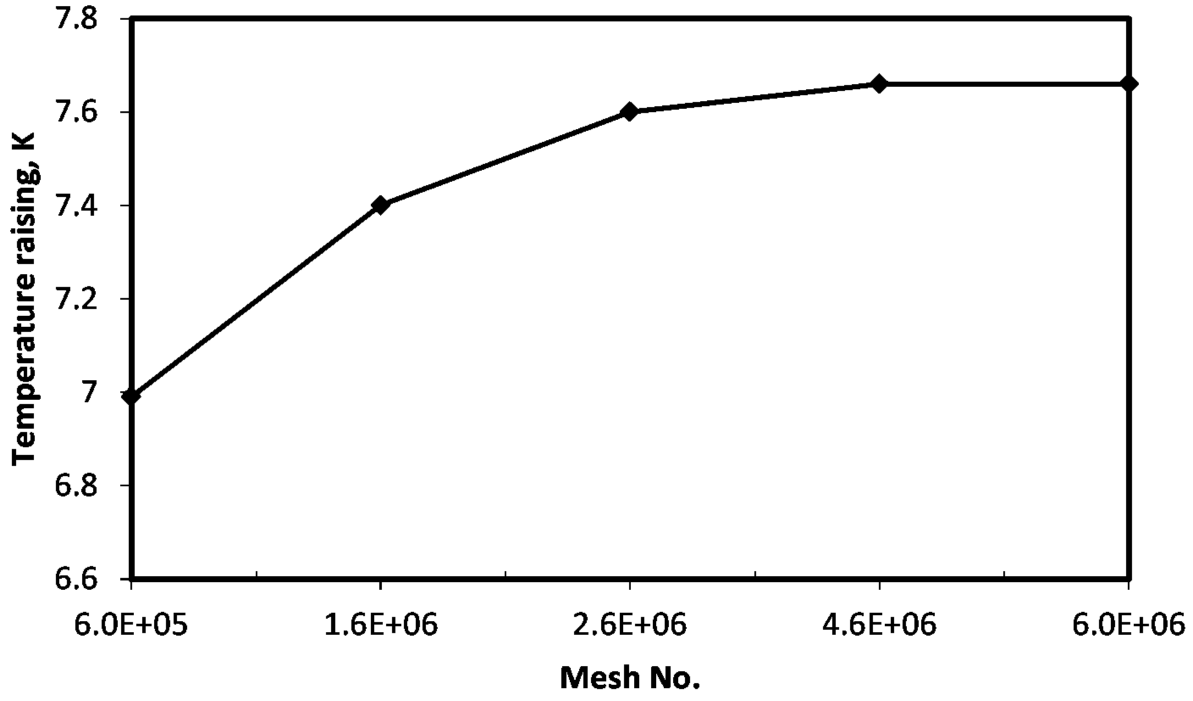


Dc = 38 mm

3/4 ratio

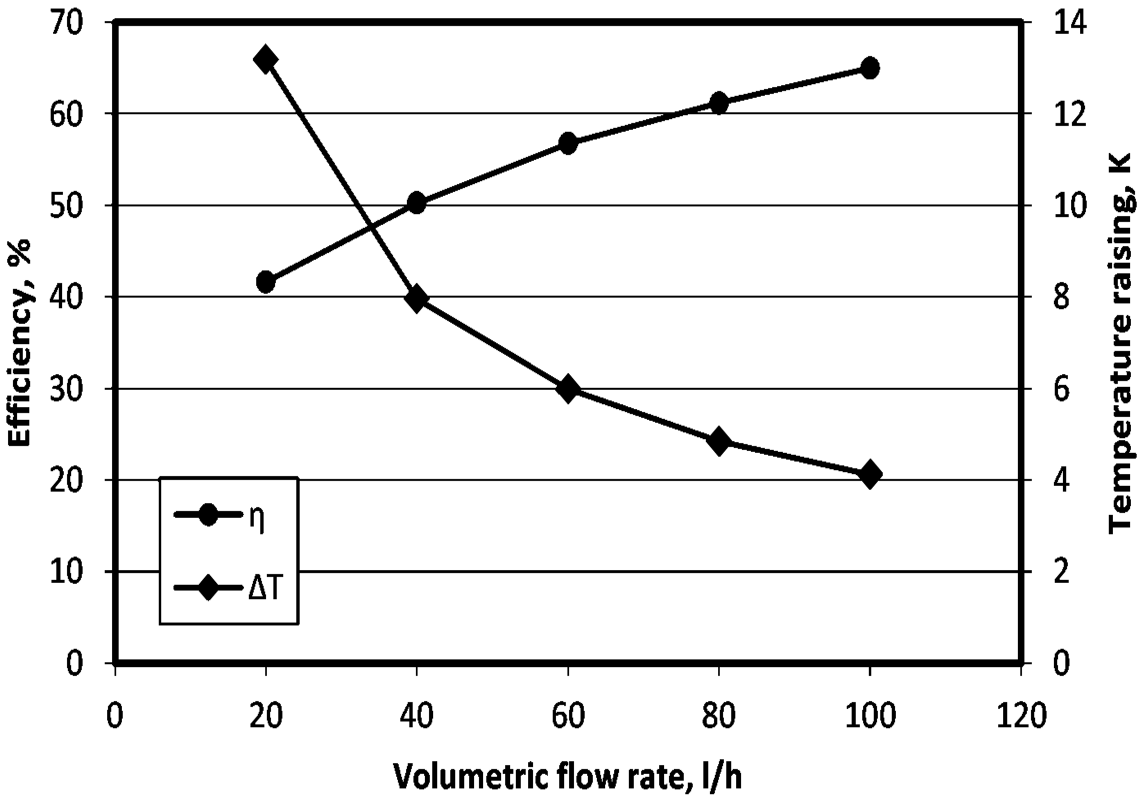
Results

- The number of cells of model has been increased (from 6,00,000 – 6,000,000 million cells in 5 attempts), until the results are stabilized. The computed efficiency of SC of one meter length is observed during mesh refinment.
- The mesh with 4.6 million cells is concluded to be fine enough in this study.



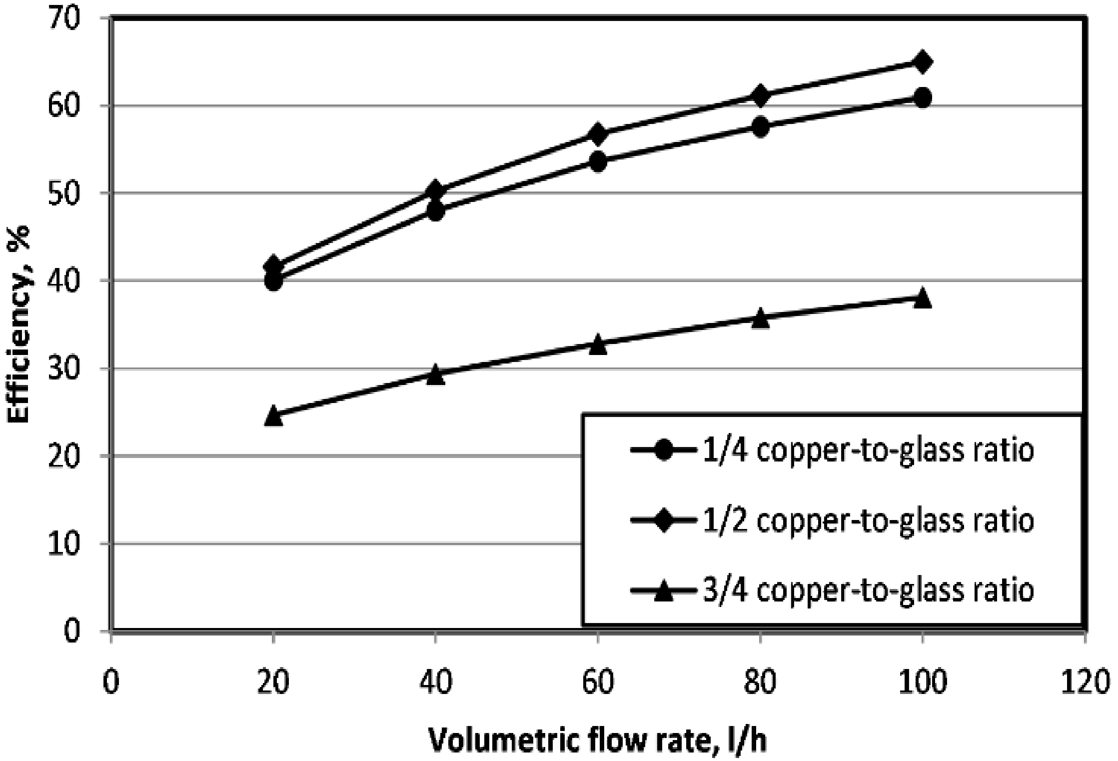
Results

Improving the efficiency by this substantial rate up to 65% refers to the role of thermal resistance between water and copper tube.

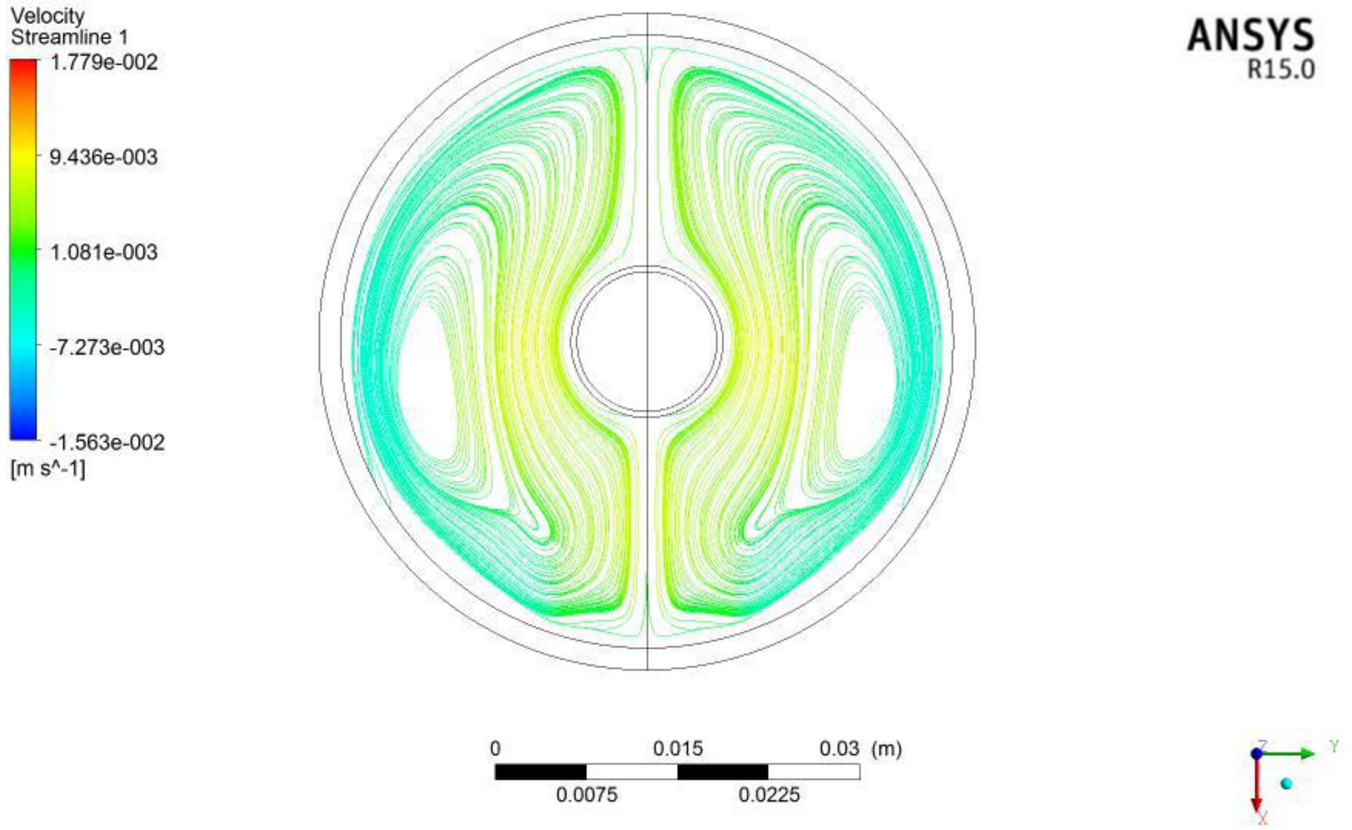


Results

The optimum copper-to-glass size ratio is (1/2) ratio because of enough absorption depth, moderate Reynolds number in water side, and enough space for free convection.

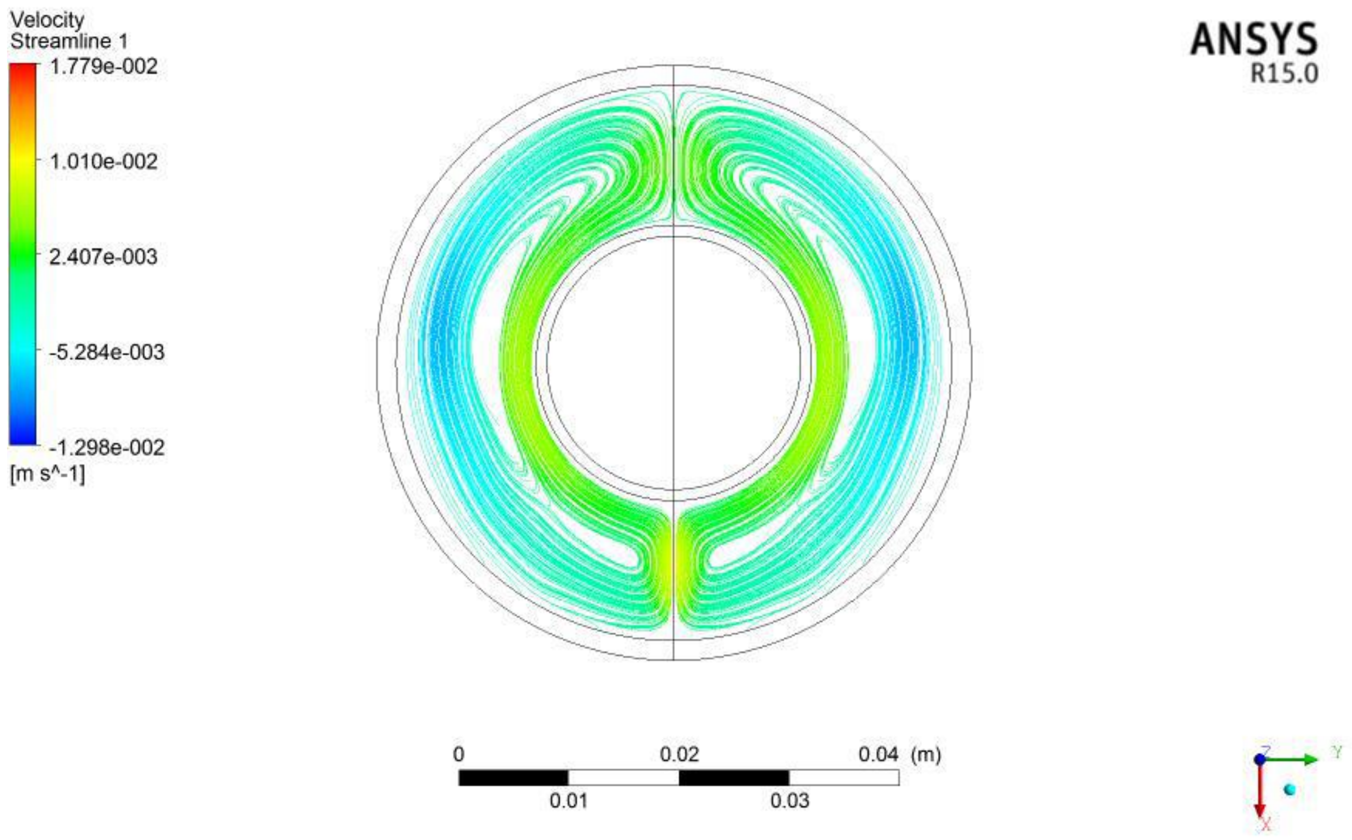


Streamlines in the cross-section at z = 0.95 m



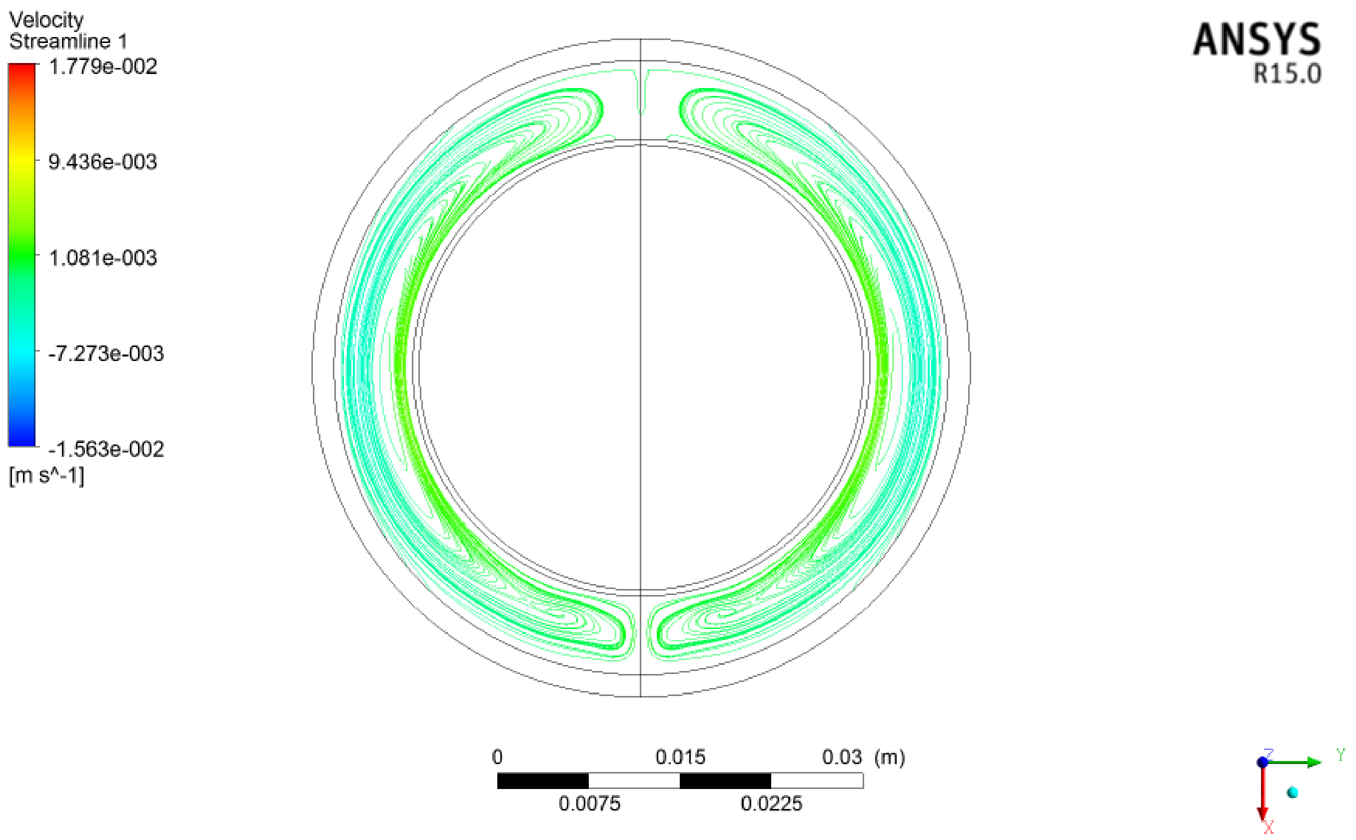
Model ¼

Streamlines in the cross-section at z = 0.95 m



Model 1/2

Streamlines in the cross-section at z = 0.95 m



Model 3/4

Conclusion

- Using nano-fluid in direct absorption system with direct heat exchange improves the performance of solar collector.
- The losses of exchanging heat in external separate heat exchanger will not be existent.
- Decrease the cost of manufacture and maintenance of solar collector due to simplified design.
- Numerical efficiency values up to 65% with increasing mass flow rate of water for one tube of SC.
- The optimum performance is obtained in (1/2) size ratio.

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