World Academy of Science, Engineering and Technology
International Journal of Energy and Power Engineering
Vol:11, No:06, 2017

# Modeling and Design of a Solar Thermal Open Volumetric Air Receiver

**Authors :** Piyush Sharma, Laltu Chandra, P. S. Ghoshdastidar, Rajiv Shekhar

**Abstract :** Metals processing operations such as melting and heat treatment of metals are energy-intensive, requiring temperatures greater than 500oC. The desired temperature in these industrial furnaces is attained by circulating electrically-heated air. In most of these furnaces, electricity produced from captive coal-based thermal power plants is used. Solar thermal energy could be a viable heat source in these furnaces. A retrofitted solar convective furnace (SCF) concept, which uses solar thermal generated hot air, has been proposed. Critical to the success of a SCF is the design of an open volumetric air receiver (OVAR), which can heat air in excess of 800oC. The OVAR is placed on top of a tower and receives concentrated solar radiation from a heliostat field. Absorbers, mixer assembly, and the return air flow chamber (RAFC) are the major components of an OVAR. The absorber is a porous structure that transfers heat from concentrated solar radiation to ambient air, referred to as primary air. The mixer ensures uniform air temperature at the receiver exit. Flow of the relatively cooler return air in the RAFC ensures that the absorbers do not fail by overheating. In an earlier publication, the detailed design basis, fabrication, and characterization of a 2 kWth open volumetric air receiver (OVAR) based laboratory solar air tower simulator was presented. Development of an experimentally-validated, CFD based mathematical model which can ultimately be used for the design and scale-up of an OVAR has been the major objective of this investigation. In contrast to the published literature, where flow and heat transfer have been modeled primarily in a single absorber module, the present study has modeled the entire receiver assembly, including the RAFC. Flow and heat transfer calculations have been carried out in ANSYS using the LTNE model. The complex return air flow pattern in the RAFC requires complicated meshes and is computational and time intensive. Hence a simple, realistic 1-D mathematical model, which circumvents the need for carrying out detailed flow and heat transfer calculations, has also been proposed. Several important results have emerged from this investigation. Circumferential electrical heating of absorbers can mimic frontal heating by concentrated solar radiation reasonably well in testing and characterizing the performance of an OVAR. Circumferential heating, therefore, obviates the need for expensive high solar concentration simulators. Predictions suggest that the ratio of power on aperture (POA) and mass flow rate of air (MFR) is a normalizing parameter for characterizing the thermal performance of an OVAR. Increasing POA/MFR increases the maximum temperature of air, but decreases the thermal efficiency of an OVAR. Predictions of the 1-D mathematical are within 5% of ANSYS predictions and computation time is reduced from ~ 5 hours to a few seconds.

**Keywords :** absorbers, mixer assembly, open volumetric air receiver, return air flow chamber, solar thermal energy
**Conference Title :** ICRSE 2017 : International Conference on Renewable and Sustainable Energy
**Conference Location :** San Francisco, United States
**Conference Dates :** June 06-07, 2018