Thermal Performance Analysis of Silicon Carbide Ceramic Foam Used for Solar Air Receiver

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Abstract

Using air as heat transfer fluid for electricity generation offers some significant advantages for the development of Concentrated Solar Power (CSP): high conversion efficiency, low environmental impact and being used in deserts or other areas scarce of water resources. Silicon carbide ceramic foams have the characteristics of light weight, high strength, large specific surface areas, high porosity, excellent thermal shock resistance performance which make them particularly fit for absorber material in CSP. In this paper, thermal performance of silicon carbide ceramic foam as solar air receiver is investigated experimentally and analytically. By testing and one dimensional model calculation, silicon carbide ceramic foam is validated the very good material to be used as absorber under highly concentrated solar flux. The presented work is the first step of developing 1MWth solar air receiver project.

1. INTRODUCTION

Solar tower is a promising upcoming technology which has been paid more attention in recent years by many countries such as USA, Israel, Spain, Italy, France, Germany, Australia, Korean and China. A central receiver is stationed on the top of a tower at the focus of an array of heliostats, which reflect concentrated radiation into it. The main difference between solar thermal electricity and fossil fuel power plant is the receiver of solar tower power plant. The boilers used in most fossil fuel power plants have developed for more one hundred years. The heat loads on boilers are controllable because of the controllable fuel input. But for receivers used in solar thermal power it is difficult to distribute the heat flux focused by hundreds of heliostats for the Sun movements and complicated circumstances. So receiver is one of the key equipments in whole solar tower power plant and has attracted many researchers engaged in. In past four decades, water/steam, molten salt, liquid metal and air have been used as heat transfer fluid in solar receivers (Manuel,2002). There is evident difference for air compared to other three materials. For water/steam, molten salt or liquid metal get heat inside absorber tubes in two dimensions, and the heat transfer process between absorber and air takes place in whole volume. Metal wire/mesh (Meinecke,1991), porous ceramic (James,1991) and porcupine ceramic tube (Karni,1998) have been tested. Until now, the maximum outlet air temperature is 1700°C (Karni,1998). Solar tower is a promising upcoming technology which has been paid more attention in recent years by many countries such as USA, Israel, Spain, Italy, France and China. A central receiver is stationed on the top of a tower at the focus of an array of heliostats, which reflect concentrated radiation into it. The main difference between solar thermal power and fossil fuel power plant is the receiver of solar tower power plant. The boilers used in most fossil fuel power plants have developed for more one hundred years. The heat loads on boilers are controllable because of the controllable fuel input. But for receivers used in solar thermal power it is difficult to distribute the heat flux focused by hundreds of heliostats for the Sun movements and complicated circumstances. So receiver is one of the key equipments in whole solar tower power plant and has attracted many researchers engaged in. In past four decades, water/steam, molten salt, liquid metal and air have been used as heat transfer fluid in solar receivers (Manuel,2002). There is evident difference for air compared to other three materials. For water/steam, molten salt or liquid metal get heat inside absorber tubes in two dimensions, and the heat transfer process between absorber and air takes place in whole volume. Metal wire/mesh (Meinecke,1991), porous ceramic (James,1991) and porcupine ceramic tube (Karni,1998) have been tested. Until now, the