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Low-emissivity transpired solar collectors

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Abstract

Transpired Solar Collectors (TSCs) are used around the world for pre-heating of ventilation air in buildings and agricultural drying. The current generation of TSCs tend to use pre-finished steel for the perforated absorber and coatings which were not principally designed for solar thermal applications. This means that while they have a relatively high absorptivity, they also have a high-emissivity, which results in high radiative losses when operating at low flow rates. A number of studies have shown that development of a low-emissivity coating for TSCs could lead to increased energy savings for the current range of applications and enable their use in solar cooling. This paper reports on the development of a new long-life (design life of over 50 years) low-emissivity (less than 0.30) coating for TSCs that will enable them to achieve a higher air temperature rise when operating at a low flow rate. In addition, the architecturally attractive appearance of the new low-emissivity coating may increase the appeal of TSCs to architects, thereby broadening the range of buildings with which they may be incorporated.

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Keywords: Ventilation; Solar Air Heating; Solar Thermal Collectors, Transpired Solar Collectors; Coatings; Building Integration; Architecture

1. Introduction

Transpired Solar Collectors (TSCs) are a type of once-through solar air heater and are used around the world for pre-heating of ventilation air in buildings and agricultural drying [1,2]. They increase the temperature of air by passing the air through a solar heated perforated metal sheet (as the outside air passes across the surface of the sheet and through the perforations, which are distributed evenly throughout the sheet, heat is transferred by convection from the metal sheet to the air). Figure 1 shows a simplified schematic of TSC. The potential air temperature rise, defined as the difference between the outside air temperature and the temperature of the air exiting the perforated sheet, is dependent upon the environmental conditions (air temperature and solar radiation), perforation design, coating characteristics, flow rate and the uniformity of the flow travelling through the perforated sheet area [3].

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The coatings used in the current generation of TSCs were not principally designed for solar thermal applications and thus, in comparison to other types of solar thermal collectors, their emissivity is relatively high. This means that operating TSCs at low suction velocities and at times of high solar radiation will result in relatively high radiation heat losses. Lowering the emissivity of a TSC absorber coating would minimise these radiation heat losses and enable TSCs to efficiently deliver higher air temperature rises. This was an area of future research identified by the National Renewable Energy Laboratory (NREL) in their original work on TSCs where they stated that the development of "selective surface absorbers would be useful in achieving higher collector temperature rise" [p.188] [4].

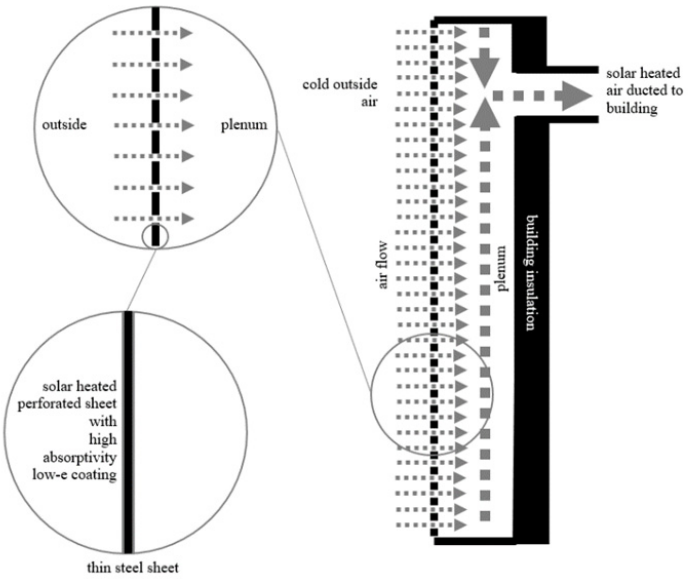

Fig. 1. Simple schematic showing a transpired solar collector with low-e coating on the perforated sheet

This paper reviews the current coatings used for TSCs, provides a summary of the previous research into Low-Emissivity TSCs (Low-E TSCs) and presents the characteristics of a low-emissivity coating currently being tested by Energy Transitions for high temperature and architectural TSC applications.

2. Current absorber coatings

Modern flat plate and evacuated tube solar thermal absorbers generally use low-emissivity, also known as spectrally selective, coatings or surface treatments to reduce radiative heat loss from the absorber to the relatively cold environment. There are a wide range of commercially available low-emissivity coatings and the selection of coating depends upon a wide range of factors such as cost, performance and stability. Commercially available low-emissivity coatings have solar absorption of around 0.95 and thermal emittance of around 0.05 [5,6].

Currently TSC absorbers are manufactured from either pre-finished aluminum or pre-finished steel sheets that are commonly used in the construction of industrial buildings. For example, Enerconcept Technologies use coatings such as KYNAR 500® PVDF [7,8], which is a polyvinylidene difluoride "resin used by licensed industrial paint manufacturers as the base resin in long-life coatings for aluminum, galvanized steel, and aluminized steel" [9] and which is commonly used for applications such as metal roofing and curtain walls. Most TSC manufacturers offer different color options, with the lighter colors having lower absorptivity and thus reduced performance. Choice of coating will be a balance between color and thermal performance.

The absorptivity of the highest performance of these coatings is around 0.94 and their emissivity is around 0.88 (see Table 1). Thus whilst the absorptivity of TSC absorber coatings almost match those used on flat plate and evacuated tube absorbers, their emissivity is far higher (0.88 compared with 0.05).