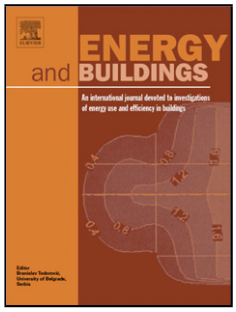

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Rigid Polyurethane Foams Incorporated with Phase Change Materials: A State-of-the-Art Review and Future Research Pathways

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Highlights

(1) Review of combination of thermal insulation and thermal energy storage.

(2) Compressive strength of PU-PCM foam decreases with respect to pure PU foam.

(3) Environmental friendly blowing agent based PU-PCM foam should be investigated.

(4) It is necessary to study thermal conductivity and thermal aging of PU-PCM foam.

(5) Effectiveness of PCM in the whole foam insulation layer is questionable.

Abstract: Taking the joint advantages of the thermal energy storage capacity of phase change materials (PCM) and the excellent thermal insulation performance of rigid polyurethane (PU) foams, much attention has been paid to an idea that incorporates PCM into PU foam to promote energy efficiency in buildings. In this paper, a comprehensive review of PU-PCM foams was conducted from the perspectives of synthesis methods, phase change characterization, mechanical strength, cell morphology, thermal performance et al. It is shown that thermal energy storage capacity in PU-PCM foam is enhanced significantly while mechanical strength is decreased with respect to pure PU foam. Thermal conductivity was only investigated by one group with a conclusion that it maintains nearly constant when having PCM content increased. The authors strongly suggest more research work on this topic. In order to modify this new thermal insulating material, some other future research opportunities, such as formulation recipe improvement, thermal insulation performance, thermal aging and general energy saving evaluations, are explored to improve this composite. A challenge is also raised related to the low active thermal capacity of the PCM with fixed phase change temperature within a temperature gradient in the PU layer with low thermal conductivity.

Key words: phase change materials; polyurethane foam; energy storage; thermal insulation; building envelope; Little effort has been spent on the question of the effect of the PCM on the thermal conductivity of the PU foam.

1 Introduction

Globally fossil fuels are dominating the world energy market and it is predicted that fossil fuels will continue to produce 75-80% of the world´s primary energy by 2030 [1]. Worldwide environmental concerns due to their usage, and finite reserves of these fuels have increased an intention to reduce their consumption in all economic sectors of the world. About 30-40% of the world's primary energy is consumed by the building sector, which is responsible for one-third of the globe's green house gas emissions [2]. Being an excellent thermal insulating material, rigid polyurethane foam (RPUF) has been widely used in the field of thermal insulation in building envelopes to save energy due to their