The Indoor Climate Library and its Application to Heat and Moisture Transfer in a Vehicle Cabin

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This paper presents the newly developed Indoor Climate Library. The library facilitates simulation of the coupled heat and moisture transfer through envelopes and the interaction of envelopes with the interior air. The computation of coupled heat and moisture transfer becomes more and more important for the development of electric vehicles. Due to the lack of waste heat from the combustion engine the heating of a vehicle cabin during winter time becomes a challenge. One way to reduce heat losses through the envelope is to add insulation. However, insulation bears the risk of water accumulation and its performance usually decreases with increased water content. The Indoor Climate Library helps the user to detect such problems early in the product development process and to find remedies.

The user can build the whole model from predefined parameterized templates: Wall and window templates allow quick creation of models of different enclosures. The domain model contains the air in a room and is connected to the walls and windows. Outside surfaces are the interface between wall templates and the environment. The environment provides the boundary conditions of the simulation.

An insulated car cabin is considered as application example. Four passengers are supposed to travel one hour in the morning and one hour in the evening from Monday to Friday in winter conditions. During weekend the car is not used. Passengers emit heat and moisture according to sedentary work. Cabin enclosures are assumed to consist of three layers: 1 mm aluminium, 10 mm mineral wool and 1.2 mm cloth. Fenestration is assumed to be a one-pane window. Leakages are supposed to lead to one air change per hour (ACH) in the cabin. A ventilation system delivers 50 ACH during occupation of the vehicle. The supply temperature is controlled to result in a cabin air temperature of 22 °C.

With the Indoor Climate Library it could be shown that this wall design leads to considerable accumulation of water in the insulation. The model allows assessing remedies to this problem. In this example, the insulation thickness was increased. This results in considerably lower water accumulation which is beneficial for the performance of insulation and for the risk of mold growth.