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CFD MODELING AND SIMULATION OF A TINY HOUSE IN EXTREME WEATHER CONDITIONS

Florin-Bogdan MARIN, Mihaela MARIN
"Dunarea de Jos" University of Galati, Romania
e-mail: flmarin@ugal.ro, mihaela.marin@ugal.ro

ABSTRACT

The subject of this research is the use of CFD techniques to identify the impact of using shutters in case of tiny house. Low temperatures and the aim to use as less energy amount as possible need solution. The composites shells allow designing efficient shutters that is isolating in an important manner windows. The CFD software allows to identify the air currents and the areas where heat is lost due to the extreme weather conditions.

KEYWORDS: CFD, modeling, simulation, house

1. Introduction

Nowadays energy crisis is concerning not only about the price of energy but also about its availability. It is publicly available information that different countries announced the possibility of blackout scenario. A lot of total energy consumption is concerning the heating of residential buildings. House design was previously taken into account relative low price of energy available on the market. However, nowadays reality show that this calculus should be updated [1-4].

The windows are causing a high amount of heat losses for most houses due to their relatively large area and thin dimension. These elements are thereby an important factor in insulation for tiny houses, for their specific characteristics such as the fact a small volume in a single room building [5-6]. All the walls are exposed to the elements. Their direct contact with the outdoor conditions makes one of the most important parts of the house, as the source of heat loss.

While the comfort means a wider surface of window to allow the owner a great view to nature, the thermal restrictions indicate to minimize the windows surface. Also, the natural light need translates to a wider surface condition to design.

Computational fluid dynamics (CFD) deals with the mechanics of fluids by using numerical models that is simulating the real case scenarios to estimate fluid flow and thermal transfer [7-9].

The principle of finite element simulation is that a structure, both fluid and part, is divided in multiple sub-parts called "finite element" and the model allows studying the interaction between these elements. The operation of separating or partitioning the part or the fluid domain is called "discretization" and is an important phase of simulation as the complicated parts, such in case of complex surface objects often cannot be completed by automated algorithm but manual operation should act [10-12].

When a building is heated, and this can be seen in case of extreme weather condition, the heat can be stored in its thermal mass, which is advantageous for buildings made of bricks or other materials that store heat. However, in case of tiny house made of composite panel is not an advantage over the classical buildings.

The best way to optimize window surface is to use store in order to be used during night, when the low temperature occurs or in case of low temperature during the entire day. This improves heat transfer between space outside taking into account glass thickened and thermal characteristics. In addition, insulation could be applied to the outer surface of the wall to keep the heat stored in the building.

2. Experimental procedure

In this research we aim to show the importance of the outer window shutters. The simulation of a tiny house heating is performed to calculate the thermal efficiency in extreme winter scenario to establish if shutters are efficient. The parameters are average mesh size 100 mm for fluid and 10 mm for parts. We considered the real dimensions of a tiny house 2000 x 10000 mm. The tiny houses are made of SIP sandwich composite made of 50 mm. We considered

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heating system and outside temperature of 20 Celsius degrees.

3. Results and discussions

Following the numerical experiments performed, the trajectories of the air currents are that described in Fig.1 We observed that there is a movement of the air currents from the heat source to the ceiling, where the air mass is colder. There is also a disordered and non-optimized motion in 3D space. Fig. 2 shows that there is a fairly good movement of the air mass in the vertical section in the sense that there is an upward rotational movement between the connecting sources.

The simulation was performed transiently and the situation represented in Figures 1, 2 and 3 is 20 minutes after the heating system has been switched on. We can note there are an important amount of thermal energy that is lost in the window area and also this is affecting the current in the tiny house in the sense that the currents are transferring the heat to the window. We also compared with the case of using shutters composed of 130 mm of 20 cm wood 80 foam and 20 cm wood the effect of insulation means 30% less heat loss. We considered that the shutters are in contact with the wall and is perfect contact allowing 50 mm of air insulation.

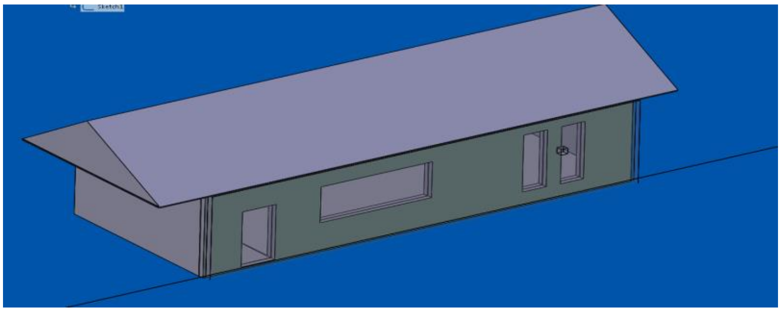

Fig. 1. *3D model of the tiny house design*

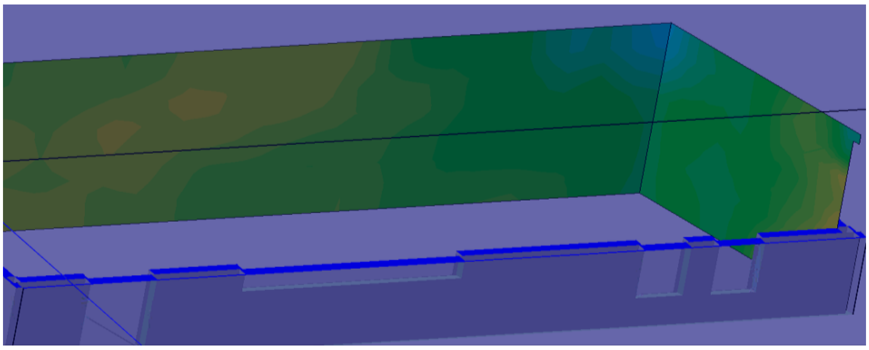

Fig. 2. *Wall temperature of the tiny house*

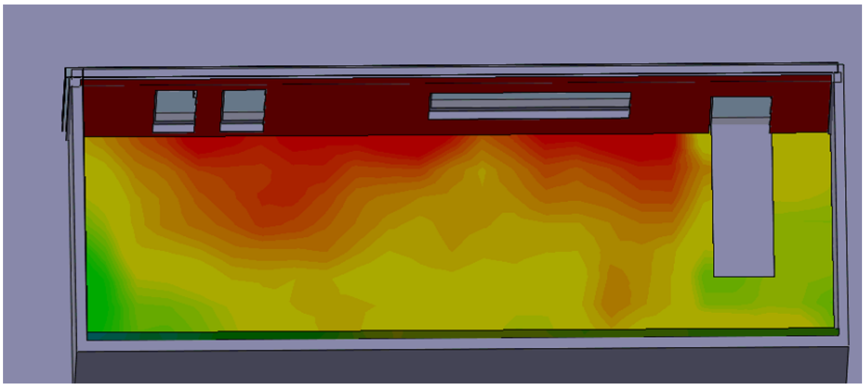

Fig. 3. *Air temperature variation at a height of 50 cm to the ground in the tiny house*

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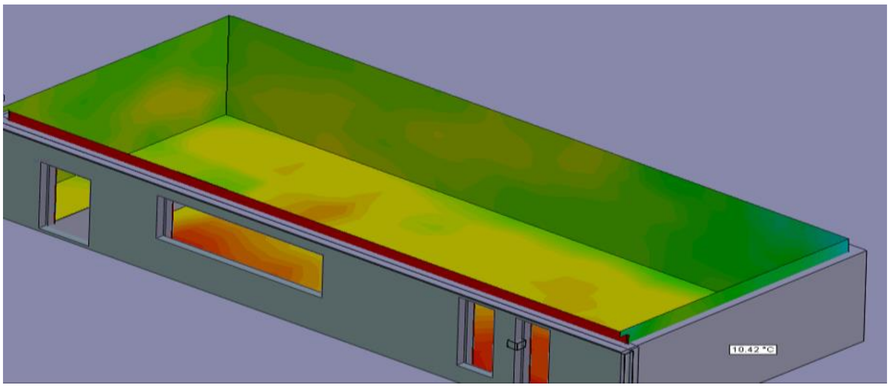

Fig. 4. *Air fluid temperature in a horizontal plane of the tiny house*

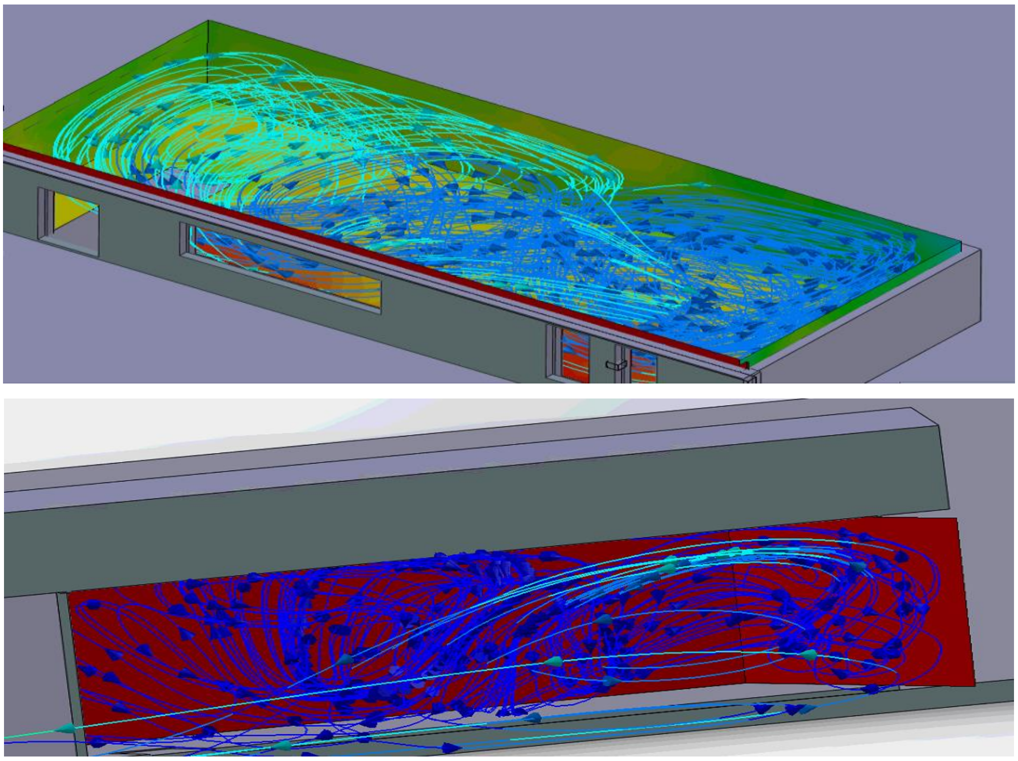

Fig. 5. *Fluid trajectories in the tiny house and the temperature associated with each trajectory line*

4. Conclusions

- CFD techniques allow the simulation of heating/cooling/ventilation of houses;
- The shutter allows improving 30% heating efficiency;
- The simulation for the solar input depending on the geographical positioning and the season should be further taken into account for the location of a tiny house;
- Tiny houses have some particularities that mean special restrictions in relation to their design.

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