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TUBE FIN HEAT EXCHANGER SET UP

LEMFELD František, FRAŇA Karel

This article deals with numerical simulation of the floor heating convector fins in 3D. Numerical simulation is focused on cooling mode of the floor heating convector. Geometrical model represents section of the heat exchanger – two fins with the gap between, pipes are not involved. Two types of fin are examined – sinusoidal and angular shape with different fin spacing. For the numerical simulation was used commercial software Ansys Fluent.

Key words: numerical simulation, heat exchanger

1. Introduction

Heat convector systems have many construction variations [1]. One of them is installation of the convector to the floor. This is the type of examined convector.

Heating convector consists of the outer container, which is the shell placed to the floor. Inside the container is the water-air exchanger with axial radiator fan. The exchanger has system of pipes equipped with the lamellae. The pipes are separated to two independent sets, one for the cooling and the other for the heating mode. Above the heat exchanger is covering aluminium grid. The example of floor heating convector is on fig. 1.

Fig. 1 – example of the floor heating convector

The temperature difference of the outer air and heating water in the heating mode is considerably higher, then the temperature difference in the cooling mode (surrounding air to coolant). That is why the set of the pipes for the cooling has more pipes then the set of the pipes for heating (fig. 2).

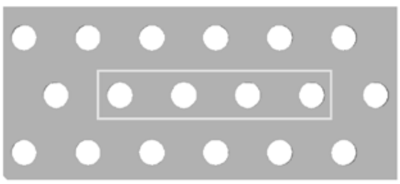


Fig. 2 – lamella of the heat exchanger with marked pipes designated for heating

The cooperating company, which produces convectors of various types, had insufficient information about processes inside the convectors. That is why the numerical simulation is used to show the effects inside the convector. The objective of the work is to find possibility of optimization for the floor heating and cooling convectors.

One of the parameters which affect cooling output of the heat exchanger is fin spacing. Create the heat exchanger with modified fin spacing is possible, so this parameter was examined in a range from 2 mm to 4 mm.

Simulations were made for sinusoidal and angular shape of the fin. Results are presented with constant inlet velocity.

Because major part of the cooling output is carried by the fins [1], for comparison of the spacing effect were created models without pipes.

2. Geometry and computational grid

Model of the angular fin is shown on the fig. 3. On the left side we can see the straight entering area with length of 50 mm, then starts the fin with length corresponding to the convectors heat exchanger. Models were created with different spacing for both sinusoidal and angular fin for 2; 2,5; 3; 3,5 and 4 mm.

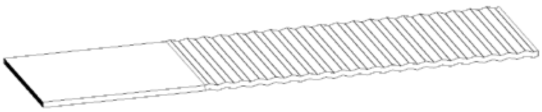


Fig. 3 – model of the sinusoidal fin

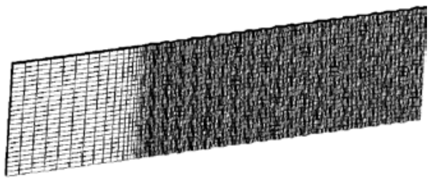


Fig. 4 – computational grid

The computational grids were created in the Ansys Design Modeller and have from 70 000 to 90 000 hexahedral cells. On the fig. 4 is presented the computational grid for sinusoidal fin with 2,5 mm spacing. Volume between fins has higher sizing factor then the straight entering area on the left side of model.

3. Numerical simulation

For the numerical simulation was used commercial software Ansys Fluent. The flow is solved as an unsteady by the LES model. All simulations were made in cooling mode.

Because the pipes for cooling in a real heat-exchanger covers almost whole area of the fin (see fig. 2), temperature of the fins was set to 9 °C as a constant value. Room temperature of ingoing air is 22 °C. Inlet velocity is 4 m/s in case of Re = 500 with initial fin spacing h = 2 mm. The calculations were made to the time of 1 second, and then continued for 0,6 second for time average values, all with the time step 0,001 second.

The configuration of boundary conditions is on fig. 5. Straight entering area has heat flux = 0 and has no effect to the temperature of ingoing air.

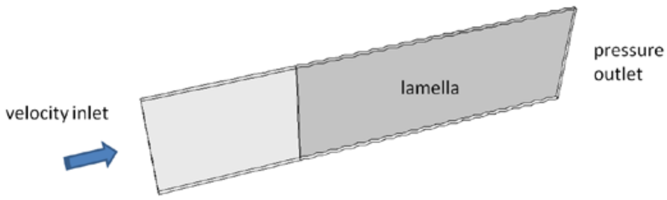


Fig. 5 – configuration of boundary conditions

The velocity and temperature field is compared on the plane placed simultaneously to the direction of the flow in the centre of the model.

4. Results

First part of results presents velocity field in case of sinusoidal lamellas. On figures 6 and 7 we can observe contours of velocity for lamella's distance from 2 up to 4 mm. In case of smaller gap shape is shape of the main flow affected by the shape of the fins. This effect lowers at higher gaps.

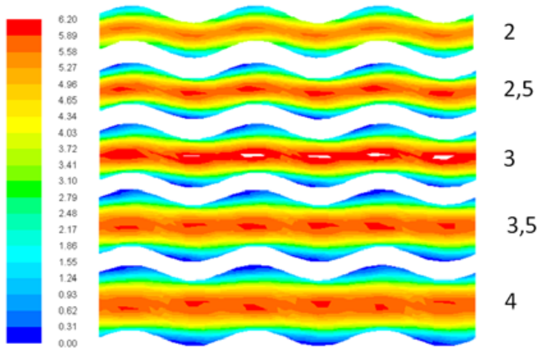


Fig. 6 – velocity for sinusoidal lamellas

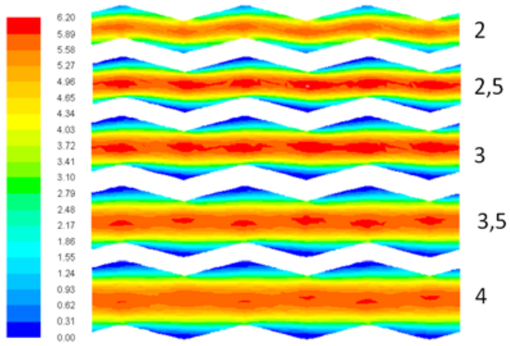


Fig. 7 – velocity for angular lamellas

On figure 8 and 9 we can observe contours of temperature for sinusoidal and angular set of fins. Observed area starts after 1st period of fins because at this part of fins we can see higher temperature differences. With higher distance between fins temperature rises as a consequence of decreased cooling ability. Maximal temperature is limited to 292 K. Temperature difference of 2 mm and 4 mm distance is about 5 °C.

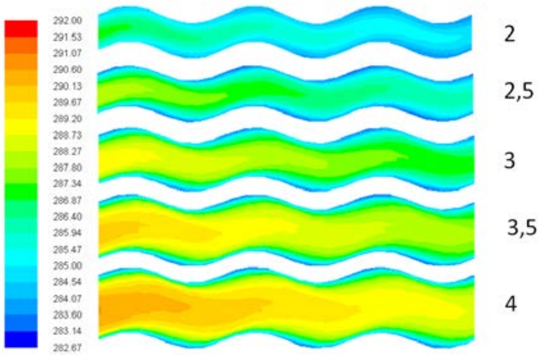


Fig. 8 – temperature for sinusoidal lamellas

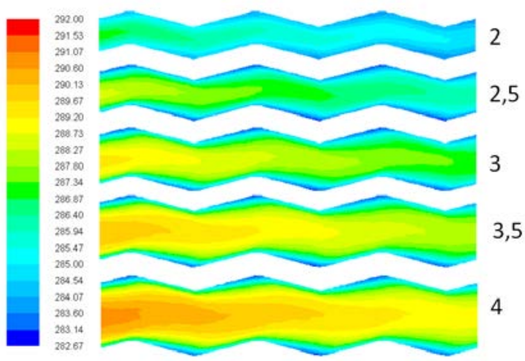
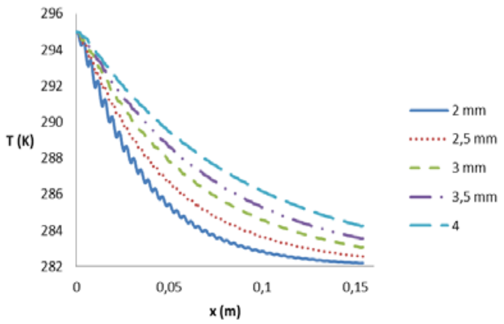


Fig. 9 – temperature for angular lamellas

From the comparison of sinusoidal and angular fin temperature fields we can observe slightly lower field at sinusoidal fin. This effect is mostly visible on 4 mm fin distance.



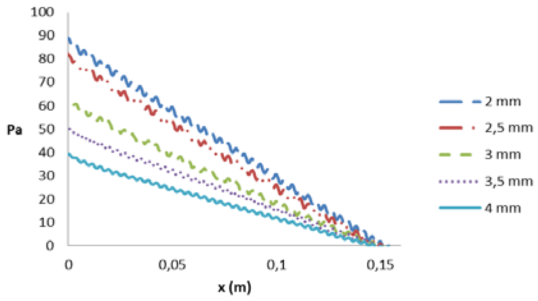


Fig. 10 – temperature along the fins

Fig. 11 – total pressure along the fins

On fig. 10 we can observe graph of temperature along the sinusoidal fins. Temperature is measured on the line in the middle of model (between fins), length of the fin is 154 mm (x direction). The oscillation at first third of lamella in case of smaller gaps is caused by the shape of the main flow. Inlet temperature is 295 K and in case of 2 mm fins decreases almost to 282 K. On fig. 11 we can see development of pressure along the fins. Pressure drops within increased gap between fins.

Conclusion

Distance between fins has significant influence to the temperature fields along the fins. With higher fin spacing temperature rises in case of both types of lamellas, but resistance in form of pressure is decreasing. Simulated mode with constant inlet velocity can help to choose optimal distance between fins for optimal service of floor heating convectors.

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Ing. LEMFELD František, Technical University of Liberec, Studentska 2, Liberec, frantisek.lemfeld@tul.cz

doc. Ing. FRAŇA Karel, Technical University of Liberec, Studentska 2, Liberec, karel.frana@tul.cz