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Importance of Distance Ring in Panel Radiators

Důležitost distančního kroužku u deskových otopných těles

The paper deals with the summary and comparison of surface temperature results from mathematical simulations for different turning and geometry of distance rings based on numerical values of the temperature field on the panel radiator front plate. The changes in flow through individual channels are also compared with respect to the distance rings and the influence of velocity field on temperature field is commented. The results of the temperature and velocity fields for the two-way connection of the radiator for the given cases are given below.
Keywords: *CFD; heating radiator; distance ring*

Příspěvek se zabývá shrnutím a porovnáním výsledků povrchových teplot z matematických simulací pro různá natočení a změnu geometrie distančních kroužků na základě numerických hodnot teplotního pole na přední desce otopného tělesa. Jsou také porovnány změny v proudění jednotlivými kanálky s ohledem na změnu distančních kroužků a je komentován vliv rychlostního pole na pole teplotní. Dále jsou uvedeny výsledky teplotního a rychlostního pole pro oboustranné napojení otopného tělesa pro uvedené případy.
Klíčová slova: *CFD; otopné těleso; distanční kroužek*

INTRODUCTION

The panel radiators are produced by pressure welding of two steel plates. In the corners, a distance ring is inserted between the plates into the distribution chambers to maintain the required distance between the plates. Steel plates are pressed using press heads that are unified for the entire production line of the manufacturer. Thus, only the dimensions of the radiator plate change, but the shape of the channels and distribution chambers remains the same [1]. It is not appropriate to change the shape of the upper distribution chamber e.g. by constant static pressure because the customer requires aesthetically panel radiator parallel to the parapet. It would also have to be a different press head for each length of the radiator, which is not cost-effective.

The objective of this research is the uniformity of the temperature field on the front panel of the radiator. This equalization of the length of the radiator has an effect on heat transfer to the space, in particular to compensate for cold convective flow which arise in the windows below which the radiator primary placement. Another aspect is psychological, where it is better perceived when the radiator is warm to the touch along its entire length. The approach to the solution of temperature uniformity is not through the change of the geometry of the distribution chambers or whole radiator, but through the distance ring, which is a required part of the radiators from the technological and construction point of view.

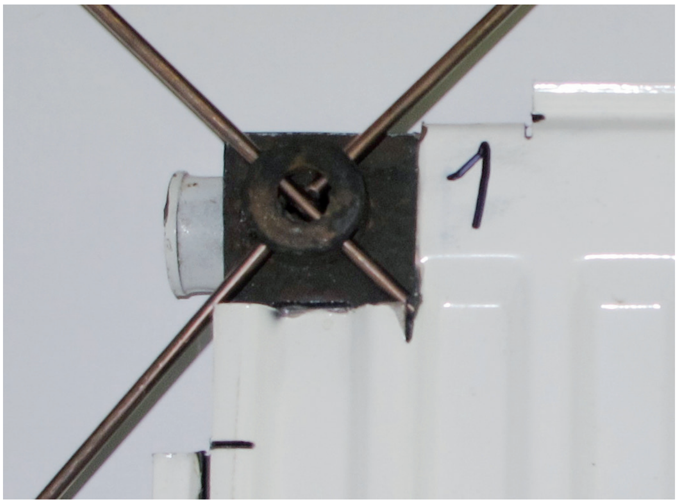


Fig. 1 Old type of distance ring with multiple holes and random turning

Previously, distance rings were made with multiple holes and their turning in the upper distribution chamber was completely random and therefore had different leaks into each radiator. It can be seen in Figure 1 Today produces distance rings with one hole directed in the axis of the upper distribution chamber. The distance ring by its change of turning around its axis and hole geometry affects the flow in the entire radiator.

MATHEMATICAL SIMULATION

Distance ring geometry and first results from mathematical simulation were presented in paper [2]. The temperature field was compared with the experiment and there was a visible similarity within the distribution of the temperature field captured by the thermal imaging camera. Thermal IR imaging has proved to be a powerful technique for studying the thermal behaviour of panel radiators [5]. Description of the velocity field near the inlet of the distance ring showing the bifurcation of the primary flow to the upper and lower edges of the distribution chamber, which mainly affect the flow in the second channel. It was therefore appropriate to focus on the modification of the simulation model, in particular the more detailed meshing of the boundary layer within the radiator and the selection of another turbulence model.

A description of the creation of a new mathematical model including the setting of a mathematical simulation and assessment of a suitable turbulence model is given in [3]. This mathematical model was much more accurate and with better modeling of the boundary flow layer at the walls. The results of the velocity field near the inlet of the distance ring confirmed the same character and the primary flow from the hole of the distance ring remain uniform as shown in Figure 2.

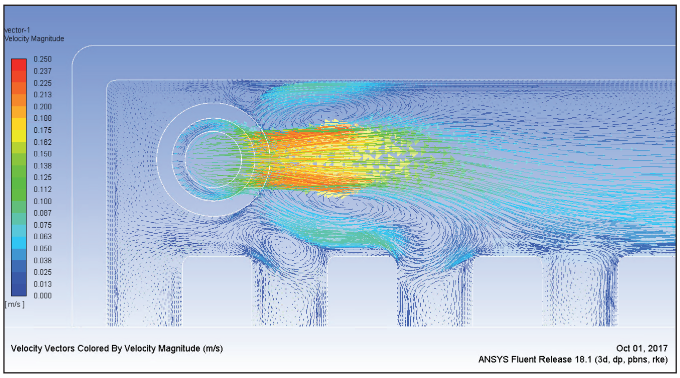


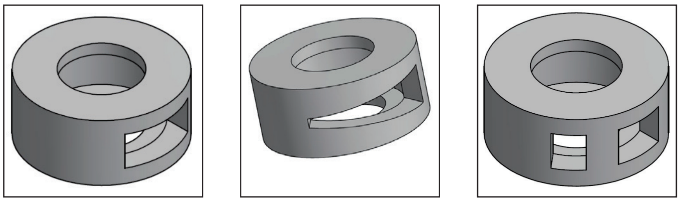
Fig. 2 Vector field of velocity profile in the area of the input distance ring [3]

The comparison of surface temperatures was evaluated based on the displayed temperature fields. This can, of course, be perceived subjectively, and so in this article a comparison of the surface temperature values on the area of the front plate divided by length or height into sections is given. The body was divided into ten sections by length and height, and the mean temperature was evaluated in each. The ideal situation would be equal to the average temperature of each section along the length of the radiator.

COMPARISON OF TEMPERATURE FIELDS

At first, the effect of the turning the distance ring was observed [3]. The assumption was that by turning the distance ring towards the upper distribution chamber, the flow to the right half of the radiator will increase and thus the mean temperature in this part will increase. The distance ring was turned by 10 ° and 20 ° from the axis of the upper distribution chamber towards its upper edge. The turning is seen in Figure 3. As a result of the turning, the flow rate in the second to fourth ducts was reduced and a cooler area was formed in the lower section. The flow to the right side of the body was also increased as expected, but there was no significant increase in mean surface temperature or uniformity along the body length. This is also evident in Figure 5 and Figure 6. The results for the turned distance rings show the lowest mean temperatures in the first section in which the first three channels are just included.

As the results of the mathematical simulation show, the turning of the distance ring towards the upper edge of the distribution chamber does not have a positive effect on the uniformity of the temperature field of the body. If the distance ring is turned clockwise through its hole, the flow in the first ducts will increase significantly. Thus, another direction of research has been given with a view to changing the geometry of the distance ring, ie mainly its holes.



a) b) c)

Fig. 4 From left – a) distance ring with one hole; b) wedge hole; c) two holes 10/3

Furthermore, a distance ring with a wedge-shaped hole was formed [4]. Its model is shown in the middle in Figure 4. The result is, according to Figure 5, that the temperature field in the first sections has a higher mean temperature, but which decreases along the length of the radiator. It would be preferable to influence the flow so that in the first four segments decreased mean temperature.

Changing the size or shape of one hole in the distance ring does not uniformize the temperature field, because it is mainly about correctly adjusting the direction and speed of the flow from the distance ring. It is appropriate to maintain the portion of the flow in the direction of the upper distribution chamber and then point the second hole towards the channels that showed lower flow, and in its lower part was thus achieving lower surface temperature. The same assumption was made for the wedge hole, but by dividing it into two holes, the flow can be better directed.

We have therefore focused on a distance ring with two holes. The area of the two holes will be as large as the area of one hole. Split ratio 10/3 is selected, where the larger hole will aim at an angle of 20 ° to the upper edge of the distribution chamber, and a smaller hole will be directed between the second and the third channel at an angle of 30 °. According to the results of the mathematical simulation, the average temperature in the first sections decreased compared to the turned rings or the wedge hole. The temperature field shown in [3] shows the decrease of the cold part in the lower part of the second to the fourth channel. The assumption was therefore partially met.

However, there is no change in the temperature field in the second half. To achieve this change, it is necessary to increase the flow velocity in the

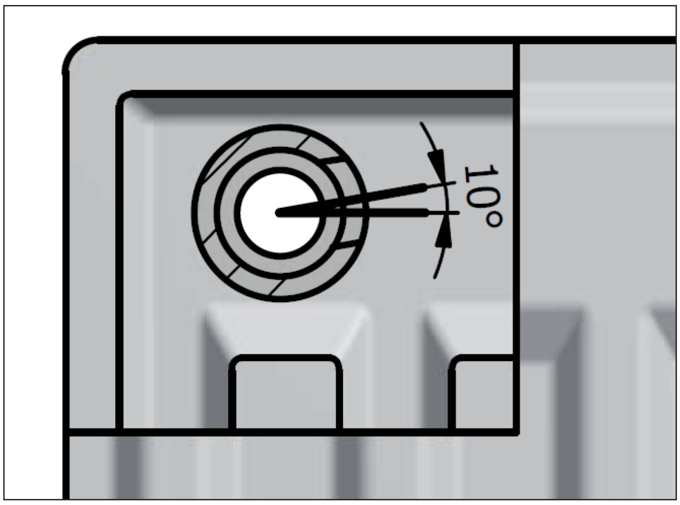


Fig. 3 Turning of distance ring from the axis of the upper distribution chamber towards its upper edge by 10°

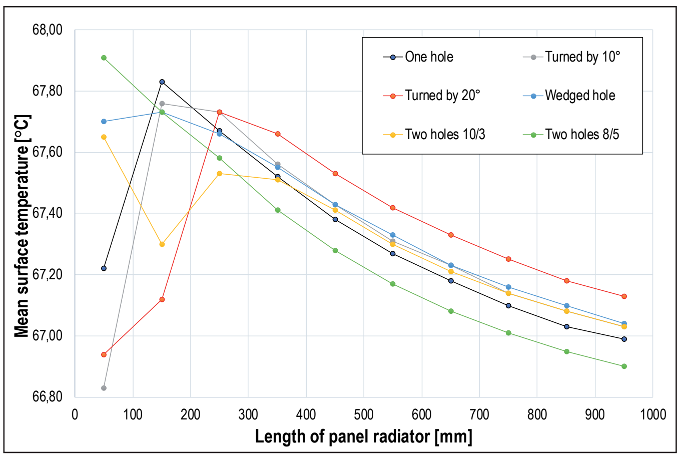


Fig. 5 Comparison of mean surface temperatures for individual sections along the radiator length

upper distribution chamber to cool the water less. In another mathematical simulation, the split ratio of both holes is changed from 10/3 to 8/5 with the assumption that the flow velocity in the upper hole is increased and thus the temperature field in the second half of the body is affected. However, the temperature and velocity fields did not evolve with respect to requirements. Visible change is again in the first half of the radiator, where there was an increase in flow rate in the upper part of the first channels, thus causing the channels to heat up more deeply and the temperature field appears more uneven than in the previous simulation.

It was a comparison of surface temperatures along the length of the radiator. It is also possible to compare the mean surface temperatures of the front plate divided by the height of the radiator. The results show that turning and changing the distance ring geometry does not affect the mean segment temperature over the height.

HYDRAULIC CONNECTION OF RADIATOR

All previous mathematical simulations were created for a radiator model, which has one side connected to the top down, as was the case with the experiment. However, radiators are often connected to the heating system on both sides. Therefore, a mathematical simulation and comparison of the temperature and velocity fields for a distance ring with one hole (common) directed to the axis of the upper distribution chamber and the distance ring with the two holes in the ratio 03/10.

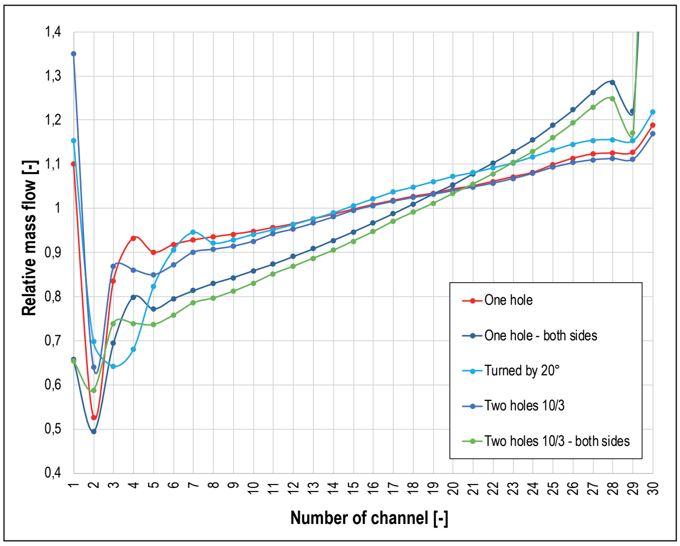


Fig. 6 Comparison of flow rates of individual radiator channels

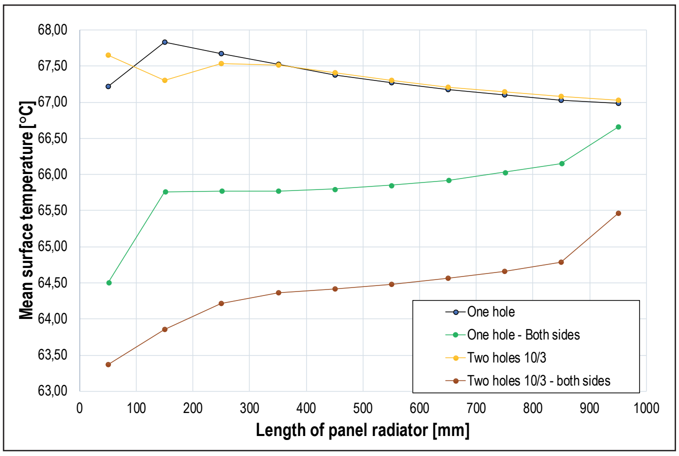


Fig. 7 Comparison of mean surface temperatures for individual sections along the radiator length

Figure 7 shows a comparison for the mentioned cases in one-sided and two-sided connection. With the same boundary conditions, mass flow rate and inlet temperature, the opposite direction of the mean surface temperature drop can be seen. Overall, these mean temperatures are lower and more in the left side of the radiator. This is due to the reduced flow rates of the channels in this section, as seen in Figure 6, where the flow rates are shown by individual channels for all the cases mentioned. Conversely, in the right part of the radiator, flow rates are higher, and even at the last channel being proportional to three times the flow rate (for clarity not shown in the graph).

CONCLUSION

In the overall comparison of Figure 5 shows that the most uniform temperature field along the length of the body is in the radiator with a distance ring with two holes. From the results of the velocity field in Figure 6, a higher flow rate in the second channel is seen compared to the ordinary distance ring model, which increased the surface temperature in this section. However, the flow rate is significantly increased through the first passage, which should be further reduced by adjusting the size or geometry of both holes. In the right part of the body, this flow without significant changes compared to the distance ring with one hole.

Two-sided connection leads to an overall change of flow inside the body. The flow rate in the left side of the body is significantly reduced and increased in the right side. The largest flow occurs in the last channel, which leads to the drain distance ring. This change in flow has a great effect on the temperature field. There is an overall decrease in mean surface temperatures in the compared sections along the length of the radiator.

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