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Low-Temperature Combined Floor/Radiator Heating Systems

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1. INTRODUCTION

Thermal performance of building envelopes has noticeably improved during last decades and therefore the heating load has fallen distinctly. That enables reduction of heat transfer areas or alternatively a decrease in the temperature of the heating medium. The latter option is especially interesting from the point of view of sustainability, as it makes feasible to apply alternative heat sources such as heat pumps, solar collectors or waste heat from industrial processes. These systems have higher efficiency if they deliver heat at lower temperature level.

2. DESCRIPTION OF A SYSTEM

2.1 Floor heating

One of the systems suitable for low-temperature heating is floor heating. But the temperature of the floor surface is limited due to thermal comfort reasons. Therefore, the heat transfer area must be much larger then in case of traditional convection radiators. Consequently, it may happen that the whole floor area that is available for heating is not enough to supply required heat stream. In that situation, combined floor/radiator heating systems can prove to be a valuable solution.

2.2 Combined floor/radiator heating systems

In these systems the heat is supplied to the room by a traditional radiator and the warm floor surface. This systems may include specially laid underfloor coil pipes. Such coil pipe may be connected in parallel (Fig. 1a) or in series (Fig. 1b) with a radiator. But when the simple pipes laid underfloor are designed only to supply water to a radiator, they usually provide large amount of heat to the room anyway. This paper deals with such case.

The pipe installed under the floor may be also put in a protective goffered pipe or an insulation pipe. Such methods limit the heat losses in some degree, but still large amount of heat may be supplied to the dwelling through the floor surface. This is a good tendency if the system is designed properly, as it uses some advantages of floor heating.

The dangerous phenomena which can arise are:

1. exceeding of permissible floor surface temperature (29–33°C),
2. lower temperature of the supply water coming to the radiator than assumed in design,
3. heat losses/gains to the adjacent dwellings,
4. "short circuit" between the supplying and return pipe with omission of the heated room.

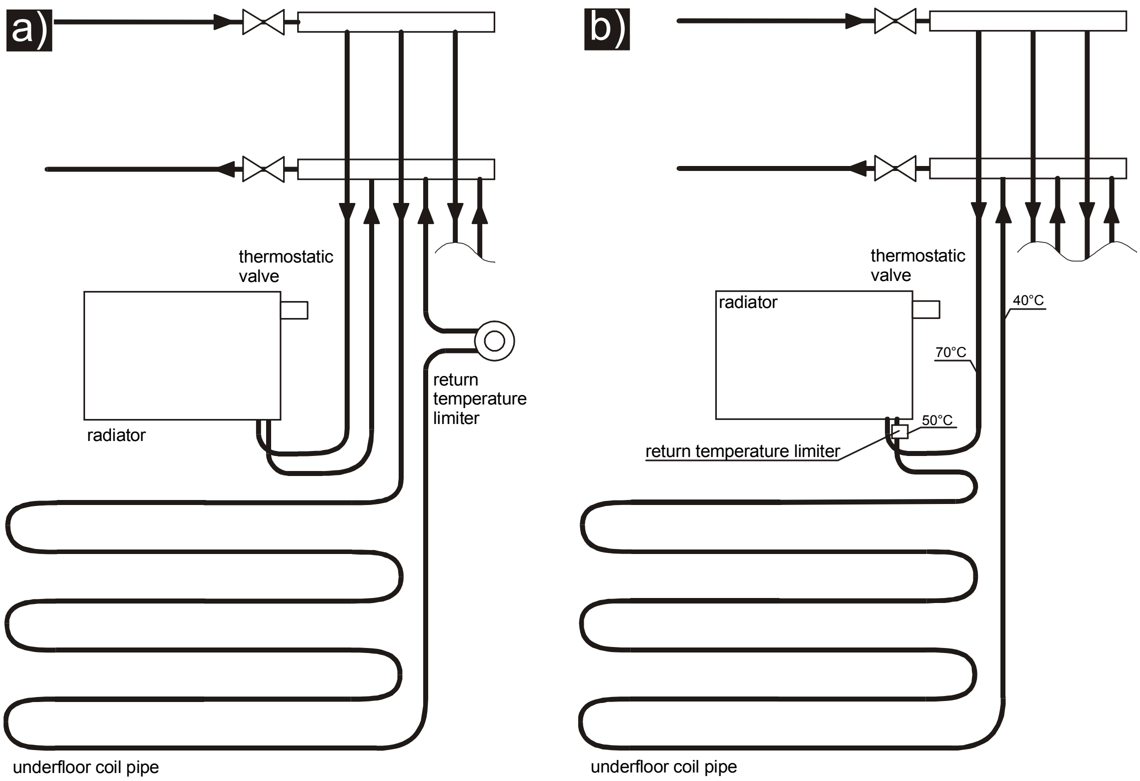

Figure 1 Underfloor coil pipes and radiator:
a) parallel connection; b) connection in series.

As it is shown in Figure 2, large part of heat losses may be transferred to other rooms than that where the radiator, supplied by the these pipes, is installed. If this fact is not taken into account in the design process, it can lead to overheating of some rooms (especially the rooms with large number of pipes, like corridors and staircases) and not proper heating of other rooms.

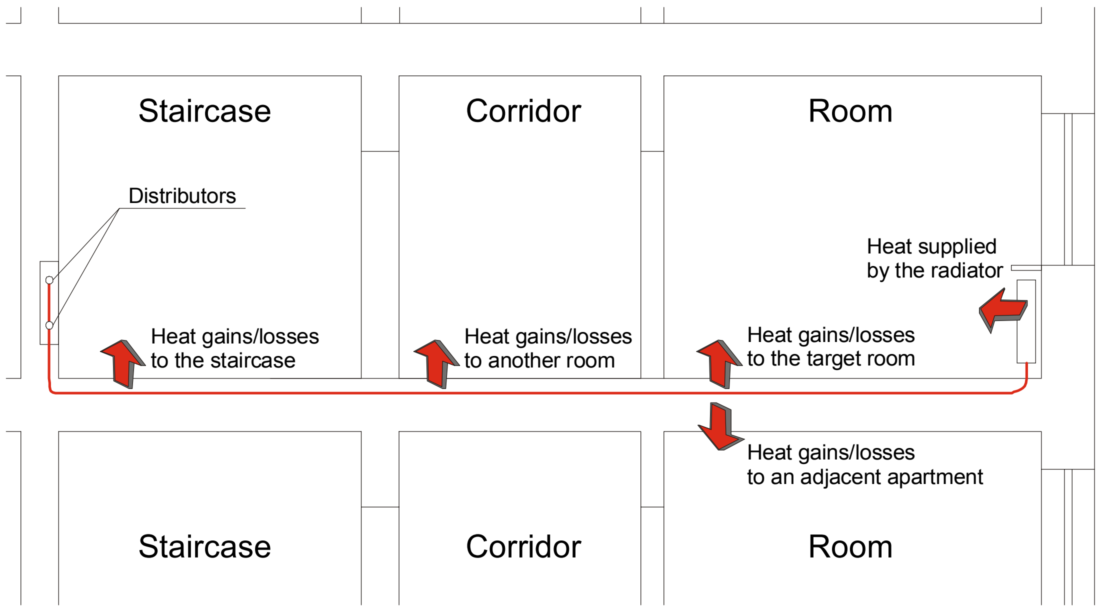

Figure 2 Heat gains/losses in case of water pipes laid underfloor.

The block diagram of such system is shown in Figure 3.

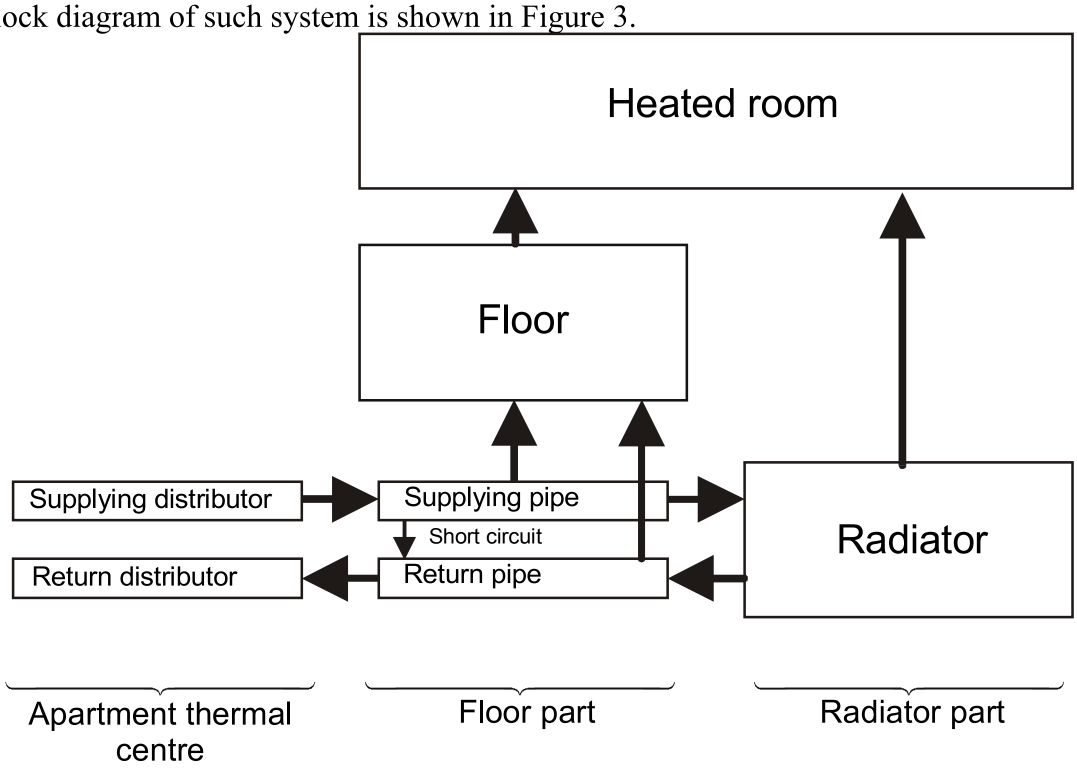

Figure 3 Block diagram of combined floor/radiator heating system in case of a radiator supplied by a pair of pipes laid under the floor. Heat streams are marked as arrows.

3. ANALYSIS OF HEAT EXCHANGE IN THE FLOOR

The presented study analyses the impact of the following factors on heat losses:

1. distance between the pipes,
2. the thickness of the concrete layer over the pipes,
3. insulation around the pipes.

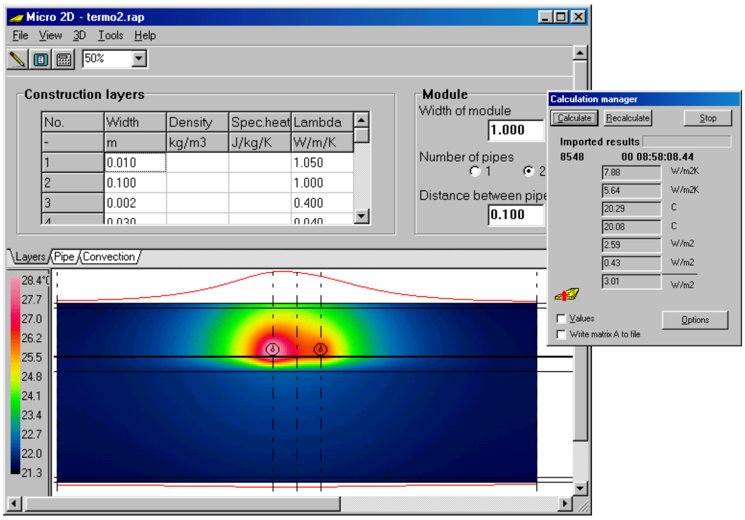

Figure 4 Program *Micro 2D 2.0*.

The study was carried out with use of the two dimensional mathematical model (computer program *Micro 2D*, developed in the Institute of Heating and Ventilation, Warsaw University of Technology).

The floor structure is shown in Figure 5 and Table 1. The pipes (12x1,8mm) are made of polyethylene and have conductivity of 0,46 W/(mK).

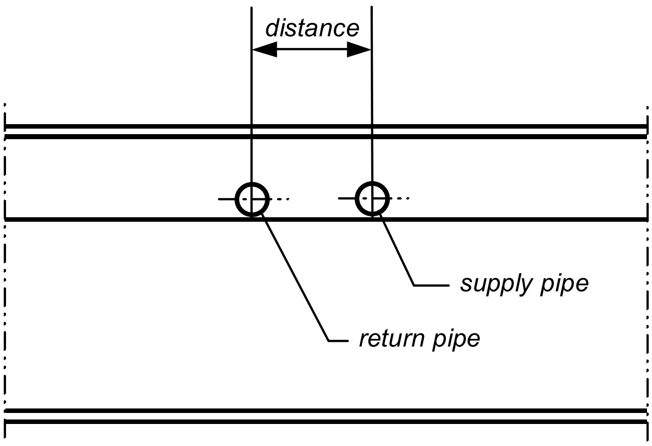

Figure 5 Basic scheme of floor assumed in the analysis.

Table 1 Floor structure.

No.	Layer	Thickness, m	Heat conductivity, W/(mK)	Heat resistance, m^2K/W
1	Tiles	0,010	1,05	0,010
2	Concrete	0,057	1,00	0,057
3	Beam-and-slab floor	0,220	–	0,180
4	Plaster work	0,010	0,820	0,012

Figure 6 shows the influence of the distance between the pipes on heat exchange. The symbols have the following meanings:

q.up. – density of the heat stream to the room over the floor,
q.down. – density of the heat stream to the room under the floor,
q.sum. – total density of the heat stream to the rooms over and under the floor,
q.r.p. – density of the heat stream from return pipe,
q.s.p. – density of the heat stream from supply pipe,
q.s.c. – density of the "short circuit" heat stream.

Higher distance between the pipes means higher heat stream to the rooms over and under the floor, as a wider stripe of the floor works as the floor heater.

The "short circuit" heat stream increases when the distance gets smaller. When the distance between the pipes' axes is 5 cm or higher, there is no "short circuit" heat stream at all.

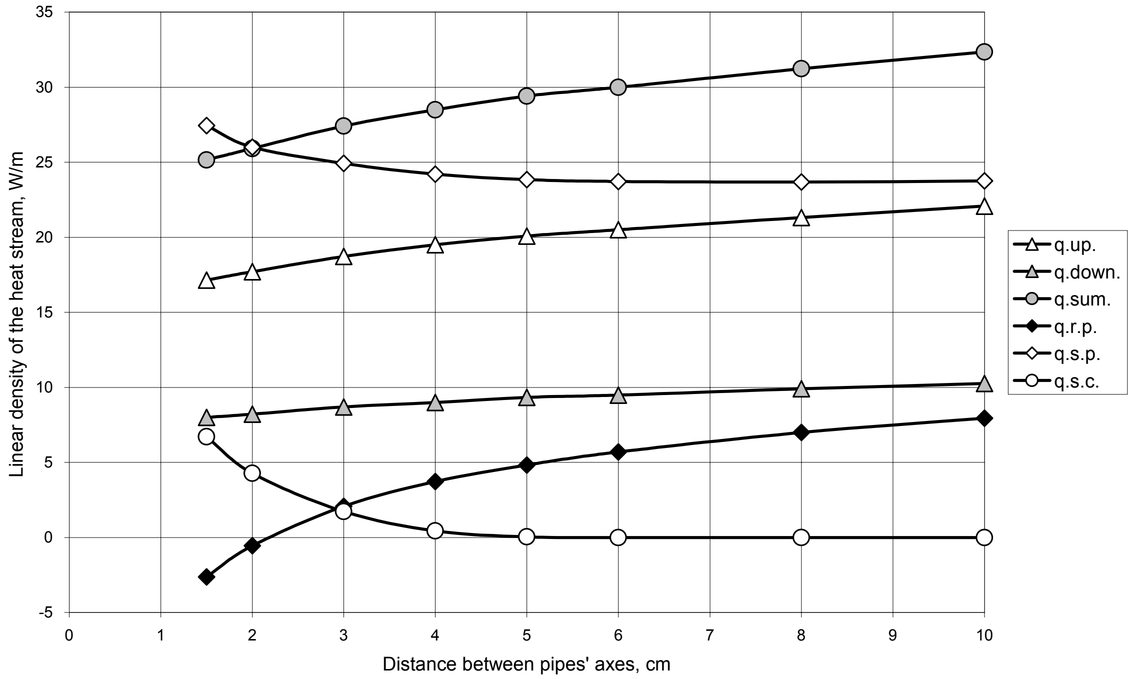

Figure 6 Heat exchange analysis in dependence of the distance between the pipes. Water parameters 40/30°C.

Figure 7 illustrates the influence of the thickness of the concrete layer over the pipes on the heat streams. When the layer over the pipes gets thicker, less heat is transferred to the room over the floor and more – to the room underneath. In the presented case there is no "short circuit" heat stream, because of the distance between the pipes.

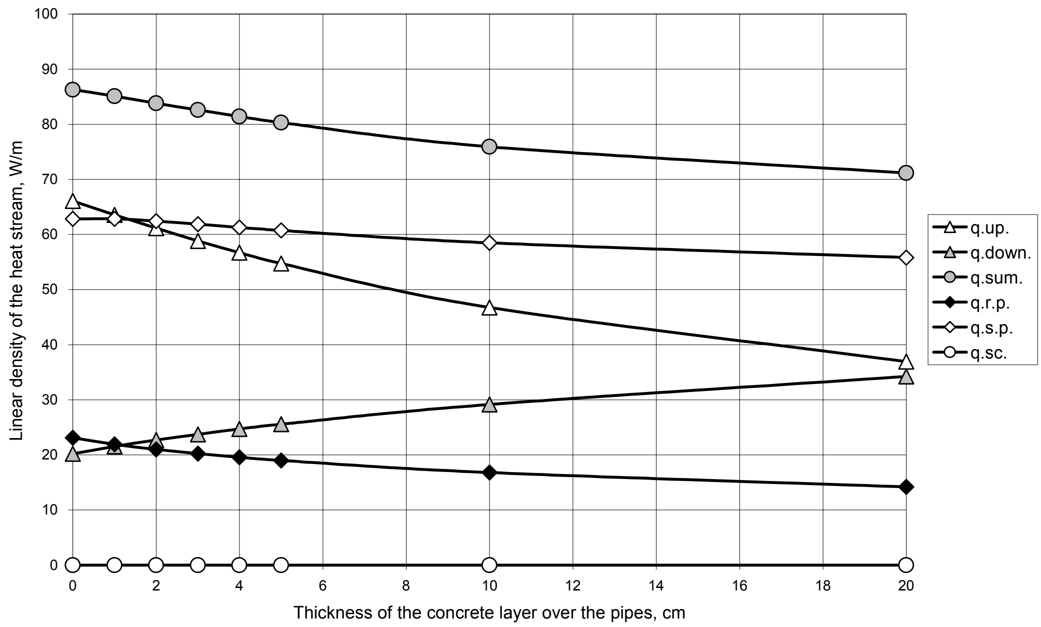

Figure 7 Heat exchange analysis in dependence of the thickness of the concrete layer over the pipes. Distance between pipes' axes equals 5 cm. Water parameters 70/50°C.

Figure 8 demonstrates the influence of the insulation on the heat exchange in the floor. Use of the 9 mm insulation (external diameter equals 30 mm) reduces considerably (by 78%) heat losses from the pipes. The insulation of 13 mm gives 14% more reduction in comparison to 9 mm. With higher insulation thickness a very small "short circuit" is observed. This is due to the fact that on the external surfaces of the insulation pipes the temperature is in that case comparable to the air temperature in the rooms.

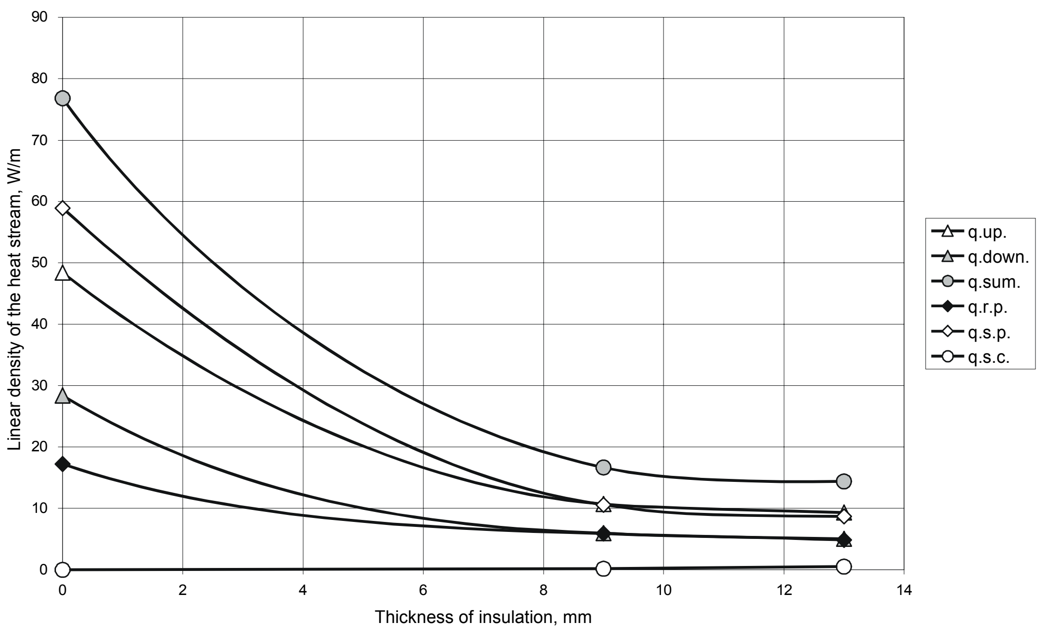

Figure 8 Heat exchange analysis in dependence of the thickness of the insulation pipes. Distance between pipes' axes equals 5 cm. Water parameters 70/50°C.

4. CONCLUSIONS

It was shown that water pipes laid underfloor supply considerable amount of heat to the dwellings. Even when the pipes are insulated, some heat is transferred to the rooms. Therefore that heat exchange should be taken into account in the heat balances of the appropriate rooms during the design process.

5. REFERENCES

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