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A comparative evaluation of floor heating systems performance

O evaluare comparativă a performanței sistemelor de încălzire prin pardoseală

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Abstract. *Underfloor heating systems ensure maximum comfort through optimal vertical temperature distribution, and the possibility of exact control and programming of the indoor climate. Used as a total heating source, the underfloor heating system will provide all the heat requirements of the space to be heated, provided that the external walls are properly insulated. In the study, two underfloor heating systems were analyzed using the dynamic simulation feature of the HTflux software. Following these simulations, temperature differences will be observed in front of the floor finish depending on the type of system used. The wet screed system heats up significantly faster and reaches a higher temperature by approximately 4.5% compared to the dry screed system.*

Key words: heating floor, wet and dry system, thermal inertia, temperature distribution

1. Introduction

Underfloor heating is a modern option for ensuring thermal comfort in homes, but also in other spaces, such as offices or various buildings. Even if the alternative is modern, thanks to existing new technologies, the underfloor heating procedure has been used since the time of the Romans. Briefly, rooms with tiled or mosaic floors were heated by a fire that was built in a space below. This system in ancient Rome was called hypocaust (Fig. 1), which was based on floor heating and worked by circulating hot air under a double floor and through double walls [1]. The gases were thus directed through channels in several rooms. The hypocaust was one of the first central heating systems on the floor.

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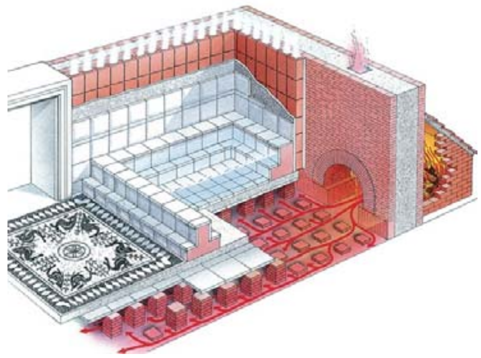

Fig. 1. Warm air circulation using the hypocaust floor heating system [1]

With the reconstruction of Europe that took place after the Second World War, there was an effective development of underfloor heating systems, using a technique of embedding ½" steel pipes without layers of thermal insulation under them. This is how underfloor heating systems were developed, and this led both to the discovery of the advantages of these types of heating systems, as well as to the discovery of the disadvantages caused by the lack of advanced research into the effects of the incorrect use of these heating systems on humans.

Compared to the heating system with radiators mounted on the walls, the floor heating system with hot water is more advantageous. When using an underfloor heating system, the heat is released evenly at the ground level and thus ensures an increase in thermal comfort.

From a practical point of view, the intermittent operation of underfloor heating systems is challenging due to the heating times resulting from the heat capacity of the floor. Therefore, two underfloor heating systems were analyzed in a comparative simulation study.

2. Description of underfloor heating systems

Underfloor heating systems are a prerequisite for the comfort of your own home for a pleasant and enjoyable life. In recent years, underfloor heating systems have started to be used on a large scale in Romania as well.

Studying the underfloor heating system, we will come across 2 variants of it, namely: the wet system and the dry stem, analyzing which is the most efficient.

2.1. Underfloor heating using the wet system

2.1.1. Castellated panel

A castellated panel is formed in the lower part of expanded polystyrene and in the upper part of thermoformed covering film, in which pipe fixing knots are incorporated (Fig.2). The insulation is made of sintered polystyrene, molded to a high density, and then hot-jointed with the help of a special rigid polystyrene film.[2] This process gives the panel greater mechanical resistance and creates a vapor barrier on the surface.

The perimeter strip is placed around the area to be heated, providing a barrier against perimeter heat loss and for screed expansion.

The panels are placed over the concrete slab and interlock to form a continuous layer. Tiles are especially useful where there is a limitation of floor height.[3] The PE-Xa pipe will be clamped between nuts, which fix it and hold it in place, at a suitable mounting step.

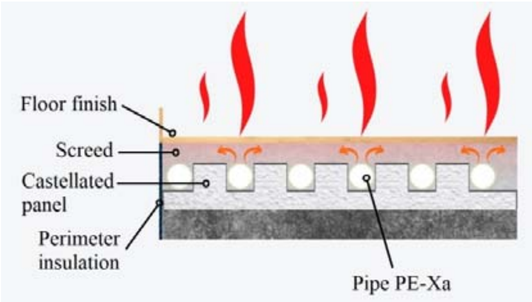

Fig. 2. Floor heating system with castellated panel [2]

2.1.2. Tacker plate

The tacker system shown in Fig. 3 is widely used due to the versatility of installation. Insulation panels are generally supplied from EPS expanded polystyrene, providing additional strength. The panels have a heat-shrinkable foil of high productivity and resistance with excellent tolerance to varied operating conditions.[3] The foil provides a grid reference for proper pipe spacing and fixing and is also waterproof.

The perimeter strip is placed around the area to be heated, providing a barrier against perimeter heat loss and for screed expansion.

Insulating Tacker boards are placed over the entire surface of the floor. The PE-Xa pipes are then laid in the circuits and secured with specially designed Tacker pins, installed with a special gun. These pins are completely fixed in the insulating material, thus preventing the pipe from lifting during the pouring of the screed.

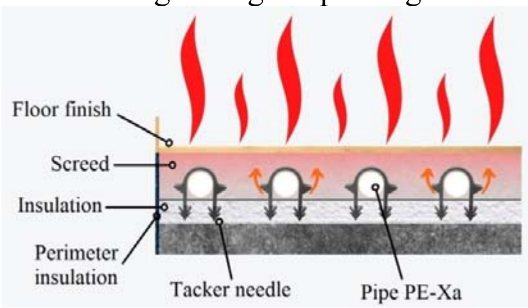

Fig. 3. Underfloor heating system with Tacker plate [3]

2.2. Underfloor heating using the dry system

The dry underfloor heating system is a flexible solution characterized by low construction height and low weight. The system is suitable both for new construction and for the modernization of old buildings. It is quick and easy to assemble and can be started immediately after assembly.

Figure 4 shows the four component elements of the system: polystyrene mounting plate, heat diffusion plates, pipe, and polyethylene film. 12.5 mm fiber-reinforced gypsum boards must be placed over the system. [4] They can be mounted individually or overlapped in two layers. The heat diffusion plate is easy to cut and has preformed channels in which the aluminum heat diffusion plates are placed, and then the pipe is placed.

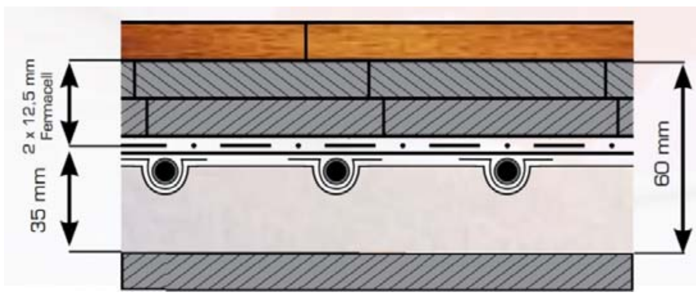

Fig. 4. Dry floor heating system [4]

3. Comparison of underfloor heating systems

In the study presented below, two underfloor heating systems are simulated using the dynamic simulation feature of HTflux.[5] Based on these transient simulations we will observe the temperature differences in front of the floor finish. This temperature distribution always depends on the entire configuration of the heating system, the construction of the floor, and the ambient conditions.

The first configuration represented in Fig. 5 a) is a dry floor heating system, consisting of heat-insulating boards inside which the PE-Xa 16x2 mm heating pipes are placed, and a 25 mm thick dry screed will be poured over them.

The second configuration represented in Fig. 5 b) is a common detail, used for wet systems, where PE-Xa 16x2 mm pipes are directly integrated into a 50 mm thick wet screed. The pipes will be placed on a 30 mm thick EPS insulation board.

Both constructions have a parquet layer on top of 3 mm.

The behavior of a heating system depends not only on the construction of the underfloor heating, but also on the heating device, the length of the pipes, but also on many other factors.[6] In this study, we assumed a constant room temperature of 22ºC and a heating agent temperature on a tour of 40ºC. It was assumed that the heating system was off, which means that the water temperature inside the pipes was close to the indoor temperature. From this initial state, we will start the heating with the socalled step function, suddenly setting the temperature of the heating medium to a level of 40 °C at a certain time.

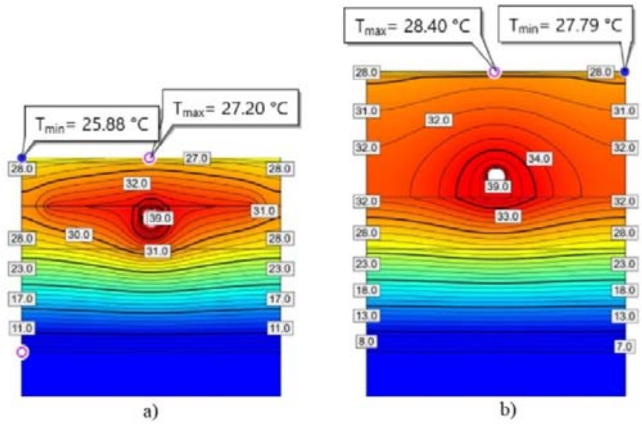

Fig. 5. Temperature distribution depending on the type of underfloor heating system
a) Dry system; b) Wet system

As can be seen, the wet screed construction heats up significantly faster and reaches a temperature in front of the floor finish of approximately 28.40 ºC, thus being 4.5% higher than the dry screed construction.

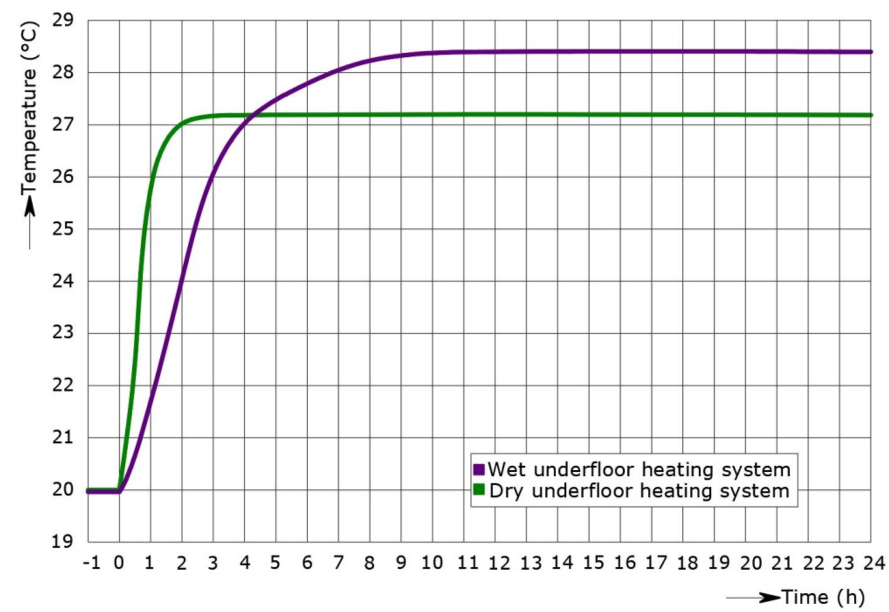

Fig. 6. The maximum temperature on the floor surface during the heating period

In Fig. 6 it can be seen that the dry screed system heats up significantly faster, needing 2 hours to stabilize the temperature, compared to the wet screed system which needs a longer time, of approximately 8 hours to stabilize. The heating times depend to a large extent on the installation heights and the structures of the underfloor heating systems.

It can be seen that the wet system becomes much more efficient over time due to the high temperature on the surface of the finished floor.

4. Conclusions

The dry underfloor heating system has a lower temperature compared to the finished floor, due to the fact that the pipe is integrated into the thermal insulation panels that do not allow the thermal load to be distributed over the entire circumference of the pipe.

The wet underfloor heating system with the Tacker plate becomes the most efficient, due to the greater contact surface between the screed and the pipe, respectively the heat transfer efficiency. In the system with the plate with nuts, the embedment of the pipe in the screed is weaker, due to the nuts that isolate part of the pipe.

Obviously, the dry system has little inertia and is suitable for buildings where people are passing by and spend little time. The wet one is slower, but it is preferable to use it anywhere with a known schedule: residential buildings, halls, schools, etc.

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