Chapter-5

COMPARISON OF FLOOR HEATING AND RADIATOR SYSTEMS IN TERMS OF ENERGY EFFICIENCY IN BUILDING HEATING SYSTEMS

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1. Introduction

The energy need in our world increases by about 4-5% every year. In parallel with this increase in demand, energy costs are also increasing, and users are charged a heavy bill every month. Therefore, consumers resort to new ways to reduce energy costs at a manageable level. Keeping the maintenance / repair cost of the system low together with an optimum scale heating / cooling system equipment, an efficient use of energy in the equipment and the selection of a suitable equipment / fuel system is an important engineering approach in this respect. Current climatic conditions are the biggest factor in determining the heating / cooling requirement of a unit. The climatic conditions and fuel configuration of a location are often beyond the discretion of the users. For this reason, it is the most practical solution to make a design that will provide the minimum cost conditions and maximum system life of the system to be operated within the framework of these two basic factors. Energy costs can generally differ from region to region. The first factor for the user in resource selection should be environment and cost. The most important issue that the user will pay attention to from now on is to choose a new and highly efficient system, thus minimizing monthly energy costs.

Although very high prices are paid for the energy consumed in the operation of the heater, cooler and lighting systems and devices we use in our houses, we cannot see the benefit we expect. There are three main reasons for this. The first reason is that energy prices, especially electricity and natural gas, are very high in our country. The second reason is that the heaters, coolers, lighting systems and devices we use in our houses are unconsciously operated and used in a way that causes low efficiency and low efficiency. The third reason is that our houses are not well insulated with their architectural design to protect them against cold and heat and to provide lighting.

Heating systems, in general, are systems that provide thermal comfort in spaces by compensating the heat losses between the indoor and outdoor environments. These systems have an important place in people's lives in terms of comfort. The design of the systems is important for people to benefit from these systems under comfortable and economic conditions.

In the selection of a heating system, advantages and disadvantages should be evaluated and the most suitable system solution should be found in terms of thermal comfort.[1] In this context, heating systems can be examined under two main headings:

- Central heating systems
- District heating systems

In central heating systems, a central heater (such as a boiler) for heating the fluid (water, air or steam) to be used, a piping that will distribute the heated fluid and a final conductor that will transmit the heat to the environment by convection is required. In central heating systems, the entire system has a pump that circulates the heating water. Hot water is usually used to feed another heat exchanger to provide domestic hot water stored in a water tank. In heating systems where air is used, air is circulated through duct systems.[2]

District heating systems are basically similar to central heating systems. However, in these systems, users do not like the spaces through a common central system of the building, but individually. The system that feeds the heater that will transmit the heat to the environment becomes a smaller capacity device such as a combi boiler. In these systems, circulation pumps are usually on the device. Furthermore, individual heating appliances such as air conditioning (hot air convection), stoves (solid fuel, electric or liquid fuel such as kerosene) and fireplaces are also widely used today.[3]

When space-heating systems are examined, it is seen that hot water heating systems are the most preferred systems in terms of comfort. In hot water heating systems, energy is obtained by burning gas, liquid or solid fuels in the boiler and this energy is used for heating the water. The heated water is transmitted to the space through various heat emitters such as radiators, fan-coils, air appliances, floor-heating pipes with the help of a pump. Thus, the temperature of the space is increased by the heat transfer that occurs between these devices and the space.[4]

In this study, within the scope of district heating systems, the uses of the systems that provide the final heat transfer with hot water, underfloor heating and radiator elements and their comparisons on thermal comfort will be discussed. In this study, the cost of energy used in various buildings, the advantages of high-efficiency new modern systems that will ensure efficient use of energy, the application of energy management in buildings, financial comparison of systems according to different fuels are examined.

2. Floor Heating Systems

Operating the heating / cooling system of a building under optimum conditions in terms of energy efficiency is accepted as the most important approach in this context. The application of both the existing system in the building and new technologies, process and other equipment, operation and maintenance procedures and energy documentation methods to an existing facility requires many levels of training. Detailed training is needed, especially when large expenditures are made for new equipment with high-energy efficiency. Maximum efficiency and maximum savings from such systems can only be achieved with the correct operation of the system and a suitable maintenance / repair period.

Floor heating systems are a heating system that distributes the heat losses in the spaces by spreading the energy received from the heat source through the pipes in the floor concrete under the floor, and heats the floor and therefore the environment. The main principle of the system is to meet the amount of energy to meet the heat loss in a volume whose heat loss has been calculated by circulating hot water supplied from a central producer through special pipes under the flooring material. Warm water spreads over the entire floor area and provides a homogeneous heating.[5]

2.1 Working and Application Principles of Floor Heating Systems

In the application of floor heating systems, insulation material serving as heat and sound insulation and polypropylene foil are laid on the leveled reinforced concrete floor and wall edges. Then, fixing elements are used according to the chosen laying method and pipe distances (modulation).[3]

Since the lengths of the pipes to be applied to the ground will be limited to 80 - 120 m depending on whether or not there is a circulation pump in the collector, which will be mounted at the starting point and which functions as a water distribution and collection unit, the pipes are not applied to the floor in a single group. From the starting point until the appropriate meter is completed, the pipe is laid like a resistance and the starting point is returned, this round trip process is called a group (Figure 1).[3]

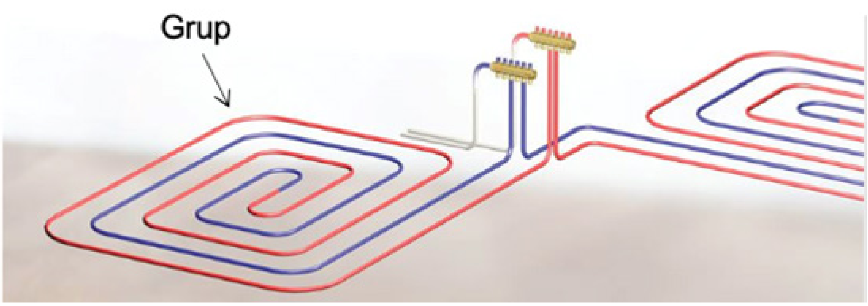

Figure 1. Group representation in floor heating system.[3]

After the pipes are laid according to the chosen laying style and pipe spacing, each mouth is connected to the collector. The location of the collector should be determined to be at a suitable distance to all places where underfloor heating pipe will be laid. Each group is controlled by a separate valve. A large room can be heated by more than one group (Figure 2).[3]

Figure 2. Different laying styles for groups.[3]

Pipe diameters and wall thicknesses used in underfloor heating systems are elements that affect performance. As the transported water, capacity will change depending on the pipe diameter, the thermal efficiency changes and similarly, the wall thicknesses are effective in the heat transfer coefficient of the pipes. For example, when a pipe with a diameter of 16 mm and a wall thickness of 2 mm is used in a floor heating system in an area of 1 m2, 0.113 liters of water is carried in 1 meter of the pipe and the system is fed with 45 degrees of water and placed in a 4 cm screed under ceramic at 10 cm intervals, 24 degrees in the room. It gives 152 W of heat per square meter. This value decreases by 32% in parquet, 25% in carpet and 50% in laminate. Generally, pipe-laying intervals in underfloor heating systems are applied as 10 cm. In areas with high heat loss such as windows, doors and balconies, this gap is applied as 5 cm. In this way, there is a 10 m pipe consumption in the middle of a 1 m2 area and 20 m pipe consumption in areas with high heat losses.[3]

2.2 Floor Heating Systems Features and Advantages

In recent years, in addition to their use in public spaces and spaces (such as mosques, baths, saunas, greenhouses, roads, etc.), their use in private spaces such as residences has increased, floor heating systems are systems designed to provide a more comfortable heat distribution with less energy.

The under-floor temperature of a healthy person is 25 ° C on average. For underfloor heating systems determined by international standards, the healthy floor temperature is maximum 29 ° C. These temperatures should not exceed 29 ° C in common areas, 33 ° C in the bathroom, and 35 ° C in the edge areas where heat loss is high.[6]

It is clear that there will be heat transfer between a person with a body temperature of 36.5 ° C and a room with a lower temperature. The heat lost by convection from the body due to excessive air movements, the heat lost by radiation due to the cold wall and ceiling surfaces, and the heat lost through the conduction from the foot surface that is in constant contact with the floor give a feeling of chill.[5]

A more homogeneous temperature distribution is provided both horizontally and vertically in a space heated by underfloor heating system. The air in the place heated by the underfloor heating system rises towards the upper parts of the space. As it rises, the air movements towards the upper parts of the space weaken and the air gets cooler. Thus, hot air accumulates in the living space, not on the upper part of the space. This uniform temperature distribution from floor to ceiling is the most suitable profile for the theoretically ideal heat dissipation profile.[5]

When evaluated in this context, the advantages of the floor heating system in terms of application, use and comfort can be summarized as follows:

- Since it is a screed application, it does not narrow the usage areas in the spaces.
- It is comfortable because it provides a homogeneous thermal distribution in spaces; the heat in the environment does not accumulate in the ceiling area and remains at human height.
- It provides high efficiency from heating devices such as combi boilers and boilers, as it operates at low heating return temperatures such as 30-40 degrees.
- In terms of application, laying and installation speed is high.
- For each room, the desired room temperature can be adjusted by throttling or closing the valve of the relevant group in the collector.
- The service life of the pipes varies according to the operating temperature and pressure, and it can be up to 50 years.[3]

3. Radiator Heating Systems

Various energy sources are used in the heating / cooling sector to meet the need for heating, cooling, steam, hot water or cooling. These fuels include domestic lignite and imported coal, natural gas, heavy fuel oil, light fuel oil (heating fuel), LPG, diesel and electricity. The energy saving potentials of energy sources and their economy accordingly depend on the unit price of the fuel, the calorific value of the fuel and the efficiency of the boiler and burner where the fuel is burned. Comparison of systems using different fuels should be repeated constantly, as fuel prices change constantly due to various reasons.

Radiator systems are at the top of the systems used in the heating of spaces in buildings. In these applications, the thermal comfort of the space depends on parameters such as the location of the radiators in the space, the materials used on the heating surfaces, the heating surface areas, the operating temperature, and the obstacles located around the radiators in the space.

In today's world where the value of energy gradually increases and the desired comfort level increases, it is important for designers, practitioners and users to understand the effects of these parameters.[4]

3.1 Working and Application Principles of Radiator Heating Systems

In radiators, heat spreads to the environment in two ways: radiation (radiation) and convection. In 90/70 degree hot water heating plants, the average surface temperature is 80 degrees, and the amount of radiation at this low temperature is low. Generally, only 20-40% of the heat in radiators is emitted by radiation. The main part is spread by convection. The type of paint and the geometry of the radiator affect the heat transfer by radiation rather than the material of the radiator. Radiation is high in black and matte painted radiators. However, the color of the paint is not very effective. Radiation is significantly reduced in shiny metallic paints. Shiny metallic paints such as aluminum or bronze reduce the radiation to 50% and the total radiator heat power to 10%. The second factor is the radiator geometry. Radiators with a large external projection surface area also have a high rate of radiation. In this respect, the rate of radiation is high in thin cast radiators and panel radiators. Since finned surfaces are used in aluminum radiators, the outer surfaces do not come into direct contact with water and have a lower temperature. For this reason, radiation rates are also low. Surface smoothness also has an effect on radiation. Roughcast surfaces radiate slightly better than flat surfaces.[7]

Radiator placements recommended in terms of efficiency according to TS 2164/2 are included. According to these data, when the distance from the wall at the rear of the radiator to the wall is at least 40 mm and the distance from the bottom to the base is 100 mm, it was predicted that the efficiency would be 100% and the efficiency of other cases was determined by comparing it.[4]

The places where the most heat loss is experienced in buildings are glass and external walls. Double glazing applications will not be able to completely prevent heat loss, no matter how good the thermal insulation applications are. Therefore, the radiators should be designed primarily by being mounted under glass. However, if the radiator cannot be mounted under glass due to architectural requirements, it should be mounted not on the interior wall of the building, but on the outer wall of the building where heat loss is most experienced.[7]

When choosing the location of the radiator, care should be taken to ensure that it is cleaned to allow heat dissipation. The windows of heated volumes are the coldest places. For this reason, placing the radiators under the windows is preferred. In volumes with large heat loss and a large number of windows, placing a heater in front of each window would be appropriate to distribute the heat properly. If it becomes necessary to place the radiator on the inner wall surface, the majority of the outer surface areas of the radiator should be parallel to the outer wall faces. The effect of cold air intake from cold surfaces can be compensated. Heat transfer in radiators is mostly through heat conduction. Therefore, the radiators should be placed in the room in such a way that the ambient air can easily enter the lower part of the radiator, move along the radiator, and rise towards the upper part.[7]

3.2 Radiator Heating Systems Features and Advantages

Application in heating systems with radiators takes place with distribution over a pipe network. In this distribution, return pipes are laid from the collector boxes to each radiator through the screed. Heating pipes are passed through the larger diameter protective spiral casing pipes so that they do not damage the screed and the floor due to the expansion at high temperature (70 to 90 degrees) in operation, so that there is a free space for expansion between the protective spiral-casing pipe and the heating pipe. The air in this volume also provides heat insulation and prevents unnecessary heating and heat loss in the places where the pipes pass (Figure 3).[3]

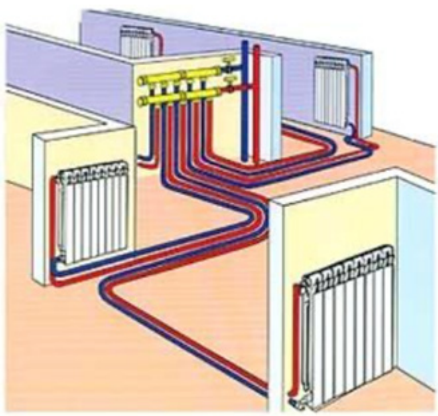

Figure 3. Piping and collector connection for radiators.[3]

Some of the application advantages of the radiator systems can be listed as installation speed, reduction of pressure losses due to the routing of the pipes, low local flow losses, ease of modification when necessary due to the system operating in a protective casing.[3]

4. Results and Discussion

In order for the heating / cooling systems to be operated under optimum conditions in terms of energy efficiency, buildings must have a building energy management and energy accounting periodically updated and supervised by experts. In order to minimize the heating / cooling costs; The places that cause air leaks, heating losses, cooling gains in the building components must be repaired and their sealing must be ensured in a perfect way with suitable gasket / wick elements. The user should choose the most appropriate fuel and system according to the region and replace the existing low-efficiency classic units with new high-efficiency models. In these modifications, the initial investment cost, operating cost, payback period and environmental criteria should be taken into consideration, and new high efficiency models should be preferred instead of uneconomic modifications.

While designing the energy efficiency of the heating / cooling system with a new building, the concepts of climate, maximum benefit from daylight and clean environment should be considered as basic criteria of the design. The combination of architectural and engineering disciplines in the early design process constitutes an important step in achieving a sustainable energy saving goal. The precautions to be taken during the early design process minimize the subsequent modifications in the heating / cooling systems and ensure that the costs are reflected to the user at a minimum level.

While the operating temperature of the water is 90-70 degrees in radiator heating systems, the inlet temperature is 50-60 degrees in a single pipe system in floor heating. Thus, by allowing the system heating fluid temperature to be selected at a lower temperature, it both reduces operating costs and saves energy.[5] In addition, the small difference between the heating water and room temperature in the floor heating system is a factor that prevents the formation of excessive airflow.

In radiator heating systems, the heated air moves towards the ceiling area, stays there, and starts to cool. The cooled air then moves towards the floor surface and causes a cooler and not very comfortable environment in the main position of the living area (Figure 4).

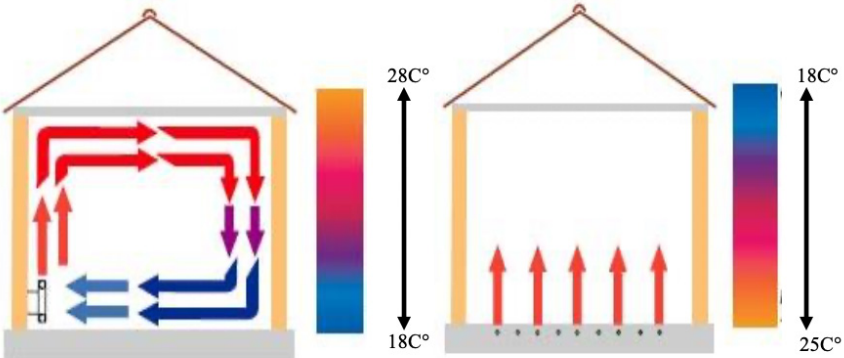

Figure 4. Comparison of hot air movement in radiator and floor heating systems.[1]

In floor heating systems, on the other hand, the system that is placed inside the floor provides the heating of the entire floor and with this, the movement of hot air from the entire floor surface occur upwards. It provides a warm and more comfortable environment in the main living area as the hot air starts to cool as it approaches the ceiling surface. In Figure 8, the mentioned hot air movement belonging to the two systems can be seen comparatively.

One of the important differences between the two systems is that, in the system with radiators, hot air is distributed locally within the space, whereas in the floor heating system, the hot air is distributed homogeneously.[1]

Another difference between the two systems is the dust flight caused by the airflow caused by the displacement of the hot and cold air in the environment. These dust particles, which are formed due to particles burning at high temperatures, are mostly seen in this system due to the operating temperature above 50 degrees of the radiator system. In addition, continuous hot and cold air displacement (non-homogeneous hot air movement) causes dust transport. On the other hand, since the floor heating systems have an operating temperature of 45-50 degrees, they both prevent dust formation largely and reduce the airflow movement due to the homogeneous hot air movement, thus preventing dust transport.[1]

5. Conclusion

Energy saving is doing the same job using less energy. Energy saving does not only mean less use of energy. Energy saving means using energy more efficiently by improving traditional methods and using new technologies. The cheapest energy is the energy saved.

While heating from the radiator does not provide a homogeneous thermal comfort for the environment, the floor heating system, where the floor serves as a complete heating element, provides a more homogeneous thermal comfort at different points of the environment. It is possible to conclude that floor-heating systems create a more homogeneous thermal comfort environment compared to radiator heating systems.[8]

The difference between the operating temperatures of the systems (90-70 degrees in a radiator system, 50-60 degrees in floor heating) creates a serious difference in terms of energy consumption and sustainability of the systems. In this context, it can be concluded that underfloor heating is more economical and suitable for long-term use in terms of performance.

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