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Rational scheme of staged heat-pump heating system

The concept to apply heat pumps (HPs) in the field of heating and cooling depends on the one hand upon the need to burn fossil fuels at modern combined heat and power (CHP) and in boilers as world reserves of the organic fuel is constantly shrinking. On the other hand, fuel combustion accompanied by significant air emissions of such harmful gases as nitrogen oxides, carbon dioxide, carbon monoxide, sulfur oxides, and many others exerts a detrimental effect on the environment, living organisms, climate and atmosphere. Heat-pump heating systems represent one of the most effective alternative means of solving the problem. In the majority of cases heating systems based on heat pumps, are even more effective than those by individual power plants and boilers. Heat pumps are widely used for heating of residential and office buildings in Sweden, Germany, the United States and other countries with climatic conditions similar to Ukrainian ones.

Methods of analysis and numerical simulation implemented in Mathcad Professional package applications were applied.

Every heat-pump heating system has its own limit of the coolant temperature heating at which the system consumes the same amount of energy (in terms of conventional fuel) to compare with the boiler unit; the subsequent increase in load heat pump is more energy-intensive than that of boiler’s. As a result, bivalent heating systems are used. They are a combination of heat pump and boiler to be connected at the moments of peak loads. However, application of dual-mode heating circuit involves expensive boilers which capacity is not less than 60 % of the total load. The feature makes their use economically disadvantageous. In addition, the price of gas has a strong tendency to continuous rise.

Thus, the technique to improve the efficiency of heat pump involving the increased number of heat pumps heating sequentially a coolant up to the desired temperature has been suggested and substantiated analytically.

Consequently, the developed automated methodology has helped analyze and determine that the most efficient intermediate heating temperature for a coolant is 40...45 °C in terms of two-stage heat pump heating systems. In this context conditional fuel saving is up to 12 % in comparison with a boiler or a single-stage HS for high- thermal load; moreover, that makes it senseless to use peaking gas boiler.

In addition, it has been determined that three-stage heat pumping unit where intermediate temperatures of a coolant are 30 °C to 60 °C is the most energy-efficient circuit as it provides the most uniform load distribution among compressors.