NOVATEUR PUBLICATIONS
JournalNX- A Multidisciplinary Peer Reviewed Journal
ISSN No: 2581 - 4230
VOLUME 7, ISSUE 3, Mar. -2021

EFFICIENCY OF SOLAR COLLECTORS AND WATER HEATING UNITS AND DEVELOPMENT OF METHODOLOGICAL BASIS OF THEIR THERMAL TESTS

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ABSTRACT:

This article presents technologies for effective heating of water by solar radiation for domestic purposes and market types of heaters are well developed and widely available. An overview of cost-effective areas of application of solar water heaters in the world is given. The unified methods of objective assessment of the thermal performance of solar collectors described.

Keywords: energy crisis, renewable energy sources, efficient heating, solar radiation, heaters, solar collector.

INTRODUCTION:

The energy crisis in the second half of the 70s was the impetus for a sharp increase in interest to renewable energy sources in many countries. Despite the subsequent significant drop in oil prices, work on the use of renewable energy sources continues to this day. Abroad, these works stimulated not so much by the limited reserves of cheap fossil fuels as by environmental problems arising from the use of traditional energy resources. In our conditions, to the environmental reasons for the current popularity of renewable energy sources, others added, primarily due to the tendency to decentralize energy supply and the desire of consumers, especially in areas remote from centralized energy supply systems, to improve the reliability of energy supply. An important factor is the continuous growth of tariffs for heat and electricity. The use of renewable energy sources, requiring significant initial costs, but not associated with significant operating costs, in this case becomes very promising.

At present, technologies for efficient heating by solar radiation of water for domestic purposes are quite well developed and are widely available on the market. The cost-effective applications of solar water heaters already been largely mastered. For example, in the United States, over 60% of swimming pools are solar-heated. More than 80% of homes in Israel, Cyprus and several other countries are mandatorily equipped with solar water heaters. There is an increased demand for solar water heating installations in Germany, Switzerland, Sweden, Canada and other relatively northern countries. By the end of 2000, 11.7 million m^2 of solar collectors installed in European countries [1], of which 62% are in Germany, Greece and Austria. The same countries characterized by the highest growth rates in the production of solar collectors - in 2000 per 1000 people population in Austria was set at 18.9 m^2, in Greece - 16.2 m^2, in Germany - 7.5 m^2. The European Commission has set a goal to increase the area of solar collectors installed in Europe to 100 million m^2 by 2010. Even more impressive figures for the production of solar collectors and solar heat supply units demonstrated by China [2]. Where in 2000 year 9 million m^2 produced, and 6 million m^2 of collectors installed. The production growth rate in 2000 was 41%. In total, by the end of 2000. China

had solar water heating installations with a total area of 26 million m^2. The total area of installed solar collectors in the world exceeds 60 million m^2, which is equivalent to replacing traditional energy sources in the amount of about 8-10 million tons of fuel equivalent per year.

Despite the artificially set low prices for traditional energy resources, the state also paid some attention to the development of solar technology. At the same time, these efforts were directed mainly to the southern republics (Turkmenistan, Uzbekistan, Georgia, Armenia, Ukraine, etc.), where climatic conditions are certainly more favorable for the use of solar energy than in Russia. As a result, the number of solar installations in operation today is very limited. Nevertheless, in recent years, about a dozen potential manufacturers of solar collectors and water heaters have appeared in the country with technologies for their serial production tested in the release of pilot and small batches.

The urgency of the problem. In recent years, due to the rapid rise in energy prices and the desire to improve the reliability of heat supply to consumers, there have been trends in the development of the domestic market for solar water heating installations (SVU) and solar heat supply systems, which for a long time lagged behind the markets of other countries. The increasingly widespread use of such installations poses the problem of evaluating the effectiveness of such systems, which can be solved by mathematical modeling of solar heat supply installations, which requires knowledge of the thermal parameters of solar collectors.

Currently, there are no unified methods for an objective assessment of the thermal performance of solar collectors and solar heat supply systems. As a result, the parameters of solar water heaters given by the manufacturers in the technical documentation are not sufficiently substantiated and are not suitable for comparing installations with each other. The emerging market for solar equipment requires certification and certification of solar collectors. The solution to this problem includes the development of a system of tests aimed at determining the thermal efficiency of collectors, their reliability, and quality control of manufacturing.

The development of engineering methods for calculating the efficiency of using solar installations in climatic conditions is also relevant, providing a visual presentation of the results that is acceptable both for equipment manufacturers and for its potential consumers.

The purpose of this work is to develop and substantiate dynamic testing methods for solar collectors, create appropriate mathematical models, develop practical recommendations for testing industrially produced solar collectors and develop engineering methods for assessing the efficiency of solar water heating installations in various climatic conditions. In accordance with the target area of work, the objectives of the study are:

1. Analysis of the known mathematical models and test methods for solar collectors used abroad, from the point of view of the possibility and feasibility of their implementation.
2. Creation of a dynamic model of a flat solar collector that correctly describes the temperature field in it at a time-variable temperature of the coolant at the collector inlet. Obtaining regression equations, with the help of which, because of processing experimental data, it is possible to determine its main thermal characteristics when testing a solar collector.
3. Experimental testing of the developed technique. Field testing of several solar collector designs.

4. Investigation of the influence of the thermal characteristics of a solar collector on the efficiency of water heating installations. Creation of an engineering methodology for calculating the effectiveness of their use in various climatic conditions.

5. A three-element model of a flat solar collector has been developed, taking into account local heat transfer between the absorbing panel of the collector and the coolant, as well as radiation-convective heat transfer between the absorbing panel and the glazing considered as a lumped element. An analytical solution to the system of equations of the three-element model obtained.

6. Regression equations formulated for the method of dynamic testing of solar collectors at a variable inlet temperature of the coolant.

7. The developed test methodology tested by comparing the results of dynamic tests with the results of stationary ones.

8. A new approach to determining the performance of solar water heating installations is proposed, within which the efficiency of a water heating installation is estimated by the number of days per year (or during another calendar period) when the installation provides water heating to a temperature exceeding the control one. Mathematical modeling of water heating installations in climatic conditions carried out. An engineering technique for evaluating the efficiency of solar water heaters developed. The reliability of the research results ensured by a systematic assessment of the accuracy of the initial assumptions and hypotheses, the correct application of an adequate mathematical apparatus and confirmed by comparison in limiting and special cases with the known results, as well as a satisfactory agreement between the calculated data and experiment. The developed engineering methodology for calculating the efficiency of using the solar air installation is a useful and convenient tool for making practical decisions on the configuration of installations and their application in various climatic conditions for both developers and potential users of the solar air installation.

In recent years, there have been trends in the development of the domestic market for solar water heating installations and solar heating systems, which for a long time lagged behind the markets of other countries. Installations developed by Russian manufacturers, as a rule, meet modern requirements; however, their main thermal technical characteristics indicated in the technical documentation are not sufficiently substantiated and are not suitable for an objective comparison of installations with each other. One of the main reasons is the lack of coordinated unified methods and means of objective assessment of the technical characteristics of solar heat supply systems and their elements in the country. Test procedures for solar collectors are not fully developed and not standardized. Based on this, taking into account domestic and foreign experience, the thesis developed theoretical and methodological foundations for testing solar collectors, carried out a set of experimental studies aimed at creating a methodological and regulatory framework for the subsequent organization of certification tests of solar collectors.

A detailed analysis and comparison of known test methods for solar collectors used abroad carried out. It is shown that when organizing a test system under conditions, the optimal orientation is to conduct experiments not in laboratory (using simulators of solar radiation), but in natural conditions. This is associated with significant material costs for creating simulators of solar radiation. On the other hand, in climatic conditions, the

application of quasi-stationary full-scale test methods widespread in southern countries is difficult due to the small number of days with stable sunshine under a clear sky. Therefore, it is important to solve the problem of improving existing and creating new dynamic methods for testing solar collectors. For the first time, a three-element model of a flat solar collector has been developed, which takes into account local heat transfer between the absorbing plate of the collector and the coolant, as well as radiative-convective heat transfer between the absorbing plate and the glazing, considered as a lumped element. Based on the analytical solution of the equations of the three-element model, regression equations are obtained, with the help of which, as a result of processing the experimental data obtained during the tests of the solar collector, it is possible to determine its key thermal characteristics - optical efficiency and the heat loss factor. An important feature of the proposed method is that the tests do not require either strict selection of clear days or thermo stating of the coolant at the collector inlet, which gives rise to testing under conditions close to the actual operating conditions of solar installations directly at the facilities. This greatly simplifies the process of possible periodic testing and monitoring of the thermal characteristics of solar collectors during the period of their operation.

Using the example of individual solar water heating installations, it is demonstrated how the thermal characteristics of a collector, determined as a result of its tests, can be used to predict the efficiency of such installations. The simulation results are summarized in the form of universal dependences of the number of days on which the water is heated no lower than to the control temperature values (37 °C, 45 °C and 55 °C) on the amount of solar radiation arriving at the earth's surface in different periods of the year. On the basis, of the obtained dependencies, an engineering method is proposed for calculating the efficiency of a solar water heating installation and a reasonable choice of the area of solar collectors with a known calculated daily water consumption. In contrast to the known approaches, the proposed engineering technique allows both the manufacturer of solar water heating installations and their potential consumer to quickly, simply and visually assess the possibility of using and select the most suitable configuration of the installation based on the conditions and climatic characteristics of the place of operation.

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