UDC 621.311.243 https://doi.org/10.33619/2414-2948/91/47

10 T/D SOLAR HOT WATER PROJECT OF BUILDING

*©**Shu Yugang,** ORCID: 0000-0002-7317-1949, Jiangsu University of Science and Technology, Zhenjiang, China, 18251896606@163.com*

ПРОЕКТИРОВАНИЕ ЗДАНИЯ С СОЛНЕЧНЫМ ПОДОГРЕВОМ ГОРЯЧЕЙ ВОДЫ ОБЪЕМОМ 10 ТОНН В ДЕНЬ

*©**Шу Юйган,** ORCID: 0000-0002-7317-1949, Цзянсуский университет науки и технологии, г. Чжэньцзян, Китай, 18251896606@163.com*

Abstract. With the development and growth of renewable energy application technology, the technology of using solar energy to supply domestic hot water is becoming increasingly mature. Centralized solar hot water systems play an important role in alleviating energy problems, and scholars from all walks of life are studying how to design solar building hot water projects. The solar hot water system uses a solar collector to collect the heat of the sun, and the collected heat is transmitted to a water storage tank for insulation through a circulating water pump. It is matched with appropriate energy sources such as electricity, gas, and fuel to heat the water in the tank and become a relatively stable quantitative energy source. Compared to household independent systems, centralized solar hot water systems have gradually become the mainstream form of solar hot water systems due to their high degree of integration, good integration with buildings, easy operation and maintenance, mutual balance of water usage among users, and easy implementation of instant heating. This article designs a 10 t/d building solar hot water project.

Аннотация. Солнечные водонагревательные системы используют солнечные коллекторы для сбора солнечного тепла, которое передается через циркулирующий насос в резервуар для хранения тепла. Он соответствует соответствующим источникам энергии, таким как электричество, газ и топливо, нагревая воду в резервуарах для воды и становясь относительно стабильным количественным источником энергии. По сравнению с домашними автономными системами централизованные солнечные системы горячей воды постепенно становятся доминирующей формой солнечных систем горячей воды из-за их высокой интеграции, хорошей интеграции со зданием, простоты эксплуатации и обслуживания, баланса воды между пользователями и простоты достижения мгновенного отопления. Рассматриваются проект здания с солнечной горячей водой на 10 тонн в день.

Keywords: centralized solar hot water, solar water heaters, building design.

Ключевые слова: централизованная солнечная горячая вода, солнечные водонагреватели, проектирование зданий.

Introduction

The heating of traditional buildings mainly relies on conventional energy, which not only consumes a large amount of conventional energy but also brings enormous pressure to the natural environment. Nowadays, buildings are developing towards green buildings. This use of green and environmentally friendly materials can reduce costs and also meet the integration of architecture and the ecological environment [1]. Under the trend of advanced building development and energy-saving development, solar powered buildings will become increasingly common and bring greater convenience to people's living standards.

This article introduces how to design a solar hot water system and design a solar hot water project with a daily average of 10t/d for buildings through a case study. The design conditions are that the building is a hotel in Harbin, Heilongjiang Province, with a total of 70 rooms on the third floor. Solar collectors are used for solar energy collection, and solar hot water is mainly used for washing. Ensure that the minimum water temperature after design is 45°C. The hot water project needs to consider year-round operation.

Selection of collectors

For the local situation in Harbin, I choose a heat pipe vacuum tube collector, which can meet the local operating requirements. It has the following advantages:

(1) Frost resistant, there is no water inside the vacuum heat pipe, and the vacuum heat pipe adopts special anti freezing measures, thus having strong anti freezing ability, even at an ambient temperature of -40 °C, it will not freeze;

(2) Quick start, the liquid working fluid in the heat pipe has a very small mass and thermal capacity, so the start is fast and can output high energy under transient irradiation;

(3) Heat pipes with good insulation performance have unique "thermal diode characteristics", and heat can only be transferred from the lower part (evaporation section) to the upper part (condensation section), but not from the upper part (condensation section) to the lower part (evaporation section). Therefore, when the solar radiation is low, the heat transfer medium in the heat pipe and heat storage can be reduced to dissipate heat to the outside world;

(4) Strong pressure bearing capacity, there is no water in the vacuum collector tube, and the collector tube and its system can withstand the pressure of water and the pressure of the circulating pump. The collector can also generate hot water with a pressure of 106Pa or above, and even high-pressure steam;

(5) Good heat shock resistance, no water is needed for the collector tube, and it will not be affected by rapid temperature changes;

(6) Safe and reliable operation, with "dry connection" adopted for the heat collection pipe, without water leakage problem;

(7) Easy to install and maintain, due to the use of "dry connection" for the collector tubes, this connection method not only facilitates installation, but also eliminates the need to stop the system operation when replacing the collector tubes:

$$Q_d = \frac{mq_r C(t_r - t_1)\rho_r}{86400} \quad (1)$$

Where, Q_d is Daily heat consumption，W: m is Hot water calculation unit number of people. Number of people or beds；q_r is Hot water consumption quota，$\frac{L}{Person\cdot d:}$: C is Specific heat capacity of water at constant pressure，choose 4.18 kJ/(kg·℃）；t_r is Temperature of hot water, ℃；t_1 is Temperature of cold water,℃；ρ_r is Hot water density，kg/L : It is found that the density of hot water at a temperature of 50℃ is 0.998 kg/L . The design requirements are 10t/d, then$q_{rd} = q_r m$ =10000 L : Design hot water temperature t_r = 50℃. According to the solar hot water system design manual obtained [2].

summer t_1 =20 °C; winter t_1 =10 °C summer: $Q_d = \frac{mq_rC(t_r-t_1)\rho_r}{86400} = \frac{10000\times4.18\times(50-20)\times0.998}{86400} = 14.48kW$

winter: $Q_d = \frac{mq_rC(t_r-t_1)\rho_r}{86400} = \frac{10000\times4.18\times(50-10)\times0.998}{86400} = 19.3kW$

Calculation of design hourly heat consumption and water consumption

select $K_h = 6.84$. Calculated from 1 summer $Q_d = \frac{mq_rC(t_r-t_1)\rho_r}{86400} = 14.48\ kW$: winter $Q_d = 19.3\ kW$.

$$\text{summer}: Q_h = K_h\frac{mq_rC(t_r-t_1)\rho_r}{86400} = 6.84\times14.48 = 99kW \quad (2)$$

$$\text{winter}: Q_h = K_h\frac{mq_rC(t_r-t_1)\rho_r}{86400} = 6.84\times19.3 = 132kW$$

Calculation of hot water quantity. The design hourly hot water volume can be calculated according to the following formula:

$$q_{rh} = \frac{Q_h}{1.163(t_r-t_1)\rho_r} \quad (3)$$

Where, q_{rh} is Design hourly hot water volume, L/h; Q_h is heat consumption, W.

Calculated from Equation 3.2 above: summer $Q_h = 99\ kW$; winter $Q_h = 132kW$

summer: $q_{rh} = \frac{Q_h}{1.163(t_r-t_1)\rho_r} = \frac{99}{1.163\times(50-20)} = 2840\ L/h$

winter: $q_{rh} = \frac{Q_h}{1.163(t_r-t_1)\rho_r} = \frac{132}{1.163\times(50-10)} = 2840\ L/h$

In solar hot water systems, the system flow rate is designed to be 60 L/min then, Full-time hot water supply system, water consumption calculation formula:

$$Q_h = K_h\frac{mq_r}{T} \quad (4)$$

In the formula, Q_h is Maximum hourly hot water consumption, $\frac{L}{h}$: T is Hot water supply time, h; K_h is Hourly variation coefficient for full-time hot water supply.

Due to 24-hour heating water, so $T = 24h$, From (1.1) $mq_r = 10000L$

$$Q_h = K_h\frac{mq_r}{T} = 6.84\times\frac{10000}{24} = 2850W$$

Calculation of thermal load of solar water heating system

$$Q = cM\Delta T \quad (5)$$

Where, Q is Thermal load of the system, MJ: c is Specific heat capacity of water, $4.18kJ/(kg \bullet K)$; M — is Capacity of the system, 10000 kg : ΔT — is The difference between the required water temperature of the system and the basic water temperature,°C. Designed to 50 °C.

Summer: $\Delta T = t_r - t_1 = 50 - 20 = 30°C$

Spring and autumn: $\Delta T = t_r - t_1 = 50 - 15 = 35°C$

Winter: $\Delta T = t_r - t_1 = 50 - 10 = 40°C$

Summer: $Q = cM\Delta T = 4.18\times30\times10000 = 1254MJ$

Spring and autumn: $Q = cM\Delta T = 4.18\times35\times10000 = 1463MJ$

Winter: $Q = cM\Delta T = 4.18\times40\times10000 = 1672MJ$

The calculation results are summarized in the table below:

Ccording to the solar energy design manual, the total annual radiation amount in Harbin is

4942.51 MJ/m^2[3].

Table 1

TABLE OF REQUIRED HEAT LOAD PER TON OF HOT WATER

Season	*Required water temperature ^0C*	*Basic water temperature ^0C*	*Temperature rise ^0C*	*Required thermal load*
Summer	50	20	30	1254 MJ
Spring and autumn	50	15	35	1463 MJ
Winter	50	10	40	1672 MJ

Calculation of daylighting area of heat collector:

$$A = \frac{Qf}{J_t \eta_s (1 - \eta_L)} \tag{6}$$

Where, A is Solar hot water system heat collection area,m^2； Q is Thermal load of solar hot water system, MJ； f is Solar guarantee rate, with a national standard value range of 0.3～0.8，According to Harbin area:f =45%. Refer to Appendix 2: J_t is Average daily solar irradiance, MJ; η_s is Average collector efficiency, %:Based on experience, the value should be 0.3～0.5；take η_s=0.4/; η_L— is Heat loss rate of water tank and pipeline, %:Based on experience, the value should be 0.20～0.30: take η_L=0.28.

According to local actual conditions, the average daily solar radiation amount in Harbin in three quarters $J_t$can be taken as 23 MJ/m^2, 20 MJ/m^2, 17 MJ/m^2. According to the calculation results in 3.5:

$$\text{Summer: } A = \frac{Qf}{J_t \eta_s (1-\eta_L)} = \frac{1254 \times 0.45}{23 \times 0.4 \times (1-0.28)} = 85.2 m^2$$

$$\text{Spring and Autumn: } A = \frac{Qf}{J_t \eta_s (1-\eta_L)} = \frac{1463 \times 0.45}{20 \times 0.4 \times (1-0.28)} = 114.3 m^2$$

$$\text{Winter: } A = \frac{Qf}{J_t \eta_s (1-\eta_L)} = \frac{1672 \times 0.45}{17 \times 0.4 \times (1-0.28)} = 153.68 m^2$$

Collate the appeal calculation results into the following Table 2.

Table 2

SUMMARY OF CALCULATION RESULTS

Season	*Required water temperature,℃*	*Basic water temperature,℃*	*temperature rise,℃*	*Required thermal load*, MJ	*Heat collection area*, m^2	*Solar assurance rate, %*
Summer	50	20	30	1254	85.2	45
Spring and Autumn	50	15	35	1463	114.3	45
Winter	50	10	40	1672	153.68	45

In order to operate the solar hot water project throughout the year, the area of the solar collector is taken as 153.6 m^2.

Select SEIDO 1-16 heat pipe vacuum tube heat collector. Vacuum tube specification：$\phi 100 \times 2m$ Number of vacuum tubes 16. Requires 48 sets of SEIDO 1-16 heat pipe vacuum tube heat collectors (768 heat pipe vacuum heat collectors in total)

The heat collector adopts series and parallel connection. Each row on the left adopts series connection, with 8 pieces in each row. The three rows are connected in parallel. The modules composed of the three rows on the left are the same as those on the right, and the modules with 8 pieces in each row are connected in series. Schematic diagram of specific collector layout, as follows (Figure 1).

Operation mode of solar hot water system. According to the solar water heater selection table in Appendix 3, the active circulation system can be selected for the solar water heater system used in hotels. A circulating water pump is installed on the pipeline between the heat collector and the water storage tank and serves as the power for circulating water in the system. The system has a control device that controls the water pump based on the temperature difference between the collector outlet and the water storage tank. Install a check valve at the inlet of the water pump to prevent heat loss from the system due to water backflow at night. The following is a system diagram (Figure 2).

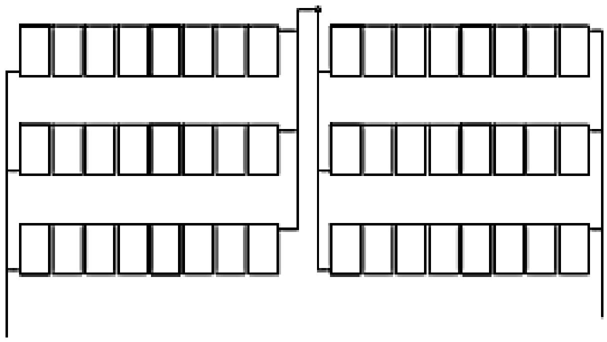

Figure 1. Layout of Heat Collector

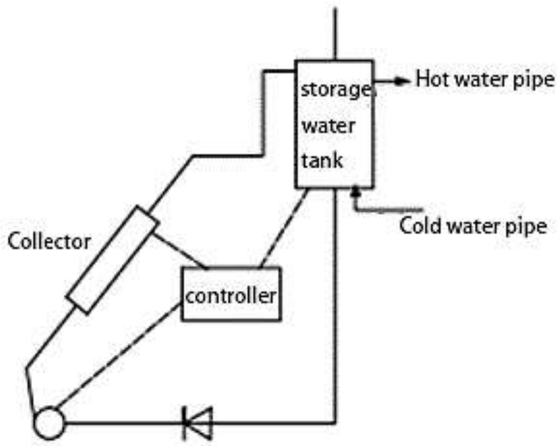

Figure 2. Figure name

Calculation of installation angle of solar collector. The optimal installation angle of a solar collector should be calculated based on the combination of the season in which the water heater is used and the local geographic latitude. Generally, the following formula can be used for calculation throughout the year:

$$\theta = \Phi \pm 10° \quad (7)$$

Where, θ is Installation angle of solar collector, (^{0}): Φ is Local geographical latitude, (^{0}). During winter use $\theta = \Phi + 10°$, During summer use $\theta = \Phi - 10°$. According to the solar hot water system and its design [42], It is found that the local latitude of Harbin is $45°45'$

Winter installation angle: $\theta = \Phi + 10°$ =45°+10°=55°

Summer installation angle: $\theta = \Phi - 10°$ =45°-10°=35°

Take the installation angle θ for winter use is 55°, for summer use，the θ is 35°. To ensure a fixed angle installation and avoid adjusting the angle in winter and summer, refer to the optimal inclination angle in Harbin based on the solar water heating system and its design:

$$\theta = \Phi + 3° = 48°$$

Calculation of the minimum distance between the solar collector and the shelter or between the front and rear rows of solar collectors without shading:

$$\sin\alpha = \sin\Phi \sin\sigma + \cos\Phi \cos\sigma \cos\omega \quad (8)$$

$$\sin\gamma = \frac{\cos\sigma \sin\omega}{\cos\alpha} \quad (9)$$

$$S = \frac{H\cos\gamma}{\tan\alpha} \quad (10)$$

Where, S is Minimum distance between the heat collector and the shade or between the front and rear rows of the heat collector，m； H is The vertical distance between the highest point of the sunshade and the lowest point of the heat collector (or the vertical distance between the highest point of the previous row and the lowest point of the subsequent row of heat collectors)，m； Φ is Check the solar water heating system design manual for local latitude [2], The local latitude of Harbin is $45°45'$ α is Solar altitude angle (90°< α <90°), (º)； γ is Solar azimuth, (º): ω isTime angle (calculated from noon, negative in the morning and positive in the afternoon, which is equal to the number of hours from noon multiplied by 15°C，(º): σ is Declination angle, (º).

According to the solar hot water system manual [41]. Find out the local latitude of Harbin $\Phi = 45°41'$. Red Tail Angle of the Sun: $\delta = 0.36 - 22.9\cos(0.9856n) - 0.37(2 \times 0.9856n) - 0.15\cos(3 \times 0.9856n) + 4\sin(0.9856n)$

Where n refers to the general day of the year on which the calculation date occurs.

At the corresponding vernal equinox (or autumnal equinox), $\delta =$-58, the corresponding time angle of 9:00 (or 15:00) $\omega = 3 \times 15 = 45°$ count:

$$\sin\alpha = \sin\Phi\sin\sigma + \cos\Phi\cos\sigma\cos\omega = -0.335$$

$$\alpha = -19°$$

$$\sin\gamma = \frac{\cos\sigma\sin\omega}{\cos\alpha} = 0.396$$

$$S = \frac{H\cos\gamma}{\tan\alpha} = 2.7H$$

$$S = 2.7H = 2.7 \times 2\sin 4\,8° = 4 \text{ m}$$

Therefore, it is necessary to ensure that the distance between the front and rear rows of the heat collector is 2.7 times the height, i.e., the spacing is 4 m. The water storage tank is an important component of a solar water heater, mainly used for the storage of hot and cold water, with good thermal insulation capacity. The material selected for the water tank, the shape of the structure, and the insulation material will directly affect the performance and operating efficiency of the water heater.

Table 3

CLASSIFICATION OF WATER STORAGE TANKS

Classification basis	*Water tank type*
Appearance	Square water tank
	Cylindrical water tank
	Spherical water tank
Placement method	Vertical water tank
	Horizontal water tank
for thermal insulation	thermal insulation water tank
	Non insulated water tank
Water pressure status	Pressurized water tank
	Non pressurized water tank

According to Appendix 4, two 5000L cylindrical water tanks can be selected for vertical installation. Water tank parameters: $\phi 1700 \times 2200$; Two water tanks installed in series; The schematic diagram is shown in Figure 3.

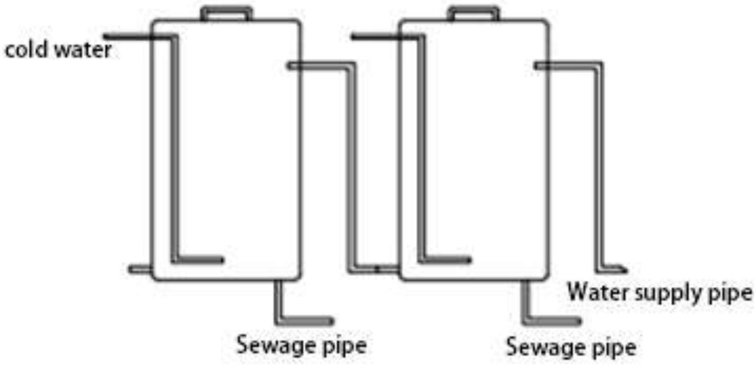

Figure 3. Schematic Diagram of Water Tank

Design of water tank bracket and reinforced base. According to Appendix 5, the bearing beam size selection is 550 × 350 T-beam. According to Appendix 6, the I-shaped steel for the water tank reinforcement base is selected as 10#. The arc base is designed with a radian of 100º and a width of 300 mm. The fixed iron plate is made of 12 mm thick Q235 steel plate, on which four fixing screw holes are drilled. There is no strict requirement for the height of the water tank bracket for solar forced circulation, which is generally 20 cm. It is sufficient to meet the requirements of the sewage connection of the water tank and prevent the water tank shell from being easily damaged, so the water tank height is set to 20 cm.

Calculation of thermal insulation thickness of pipes and water tanks in solar hot water systems. The purpose of using thermal insulation materials for solar water heating devices is to reduce the heat loss of the system. The connecting pipes between the heat collector and the heat collector, the connecting pipes between the front and rear rows of the heat collector, and the water delivery pipes between the heat collector arrangement and the water storage tank, as well as the water storage tank itself, are all energy consumption points, and the heat loss at these points is considerable. In order to reduce heat loss, it is necessary to insulate these points or surfaces.

$$\textit{Average wall temperature: } \delta = \lambda\left(\frac{T_1 - T_2}{q} - R_2\right) \quad (11)$$

$$\textit{Pipe insulation thickness: } In\left(\frac{D}{d}\right) = 2\pi\lambda\left(\frac{T_1 - T_2}{q} - R_1\right) \quad (12)$$

$$\delta = \frac{d}{2}\left(\frac{D}{d} - 1\right) \quad (13)$$

Where, q is Standard unit loss of bottle wall or pipe, $kcal/(m^2/h)$ or $kcal/(m/h)$, R_2, R_1 is Thermal resistance of heat dissipation from the insulation layer on the outer surface of a flat wall plate or pipe to the outside air $(m^2/h/k)$ or $(m/h/k)/kcal$: T_1 is The outer surface temperature of the pipe or equipment (i.e., the temperature on the inner surface side of the main insulation layer), ^{0}C, T_2 is Air temperature around the insulation structure, ^{0}C, λ is Thermal conductivity of thermal insulation materials, $kcal/(m/h/k)$: D is Diameter of main insulation layer, m: d is Pipe OD, m.

Polystyrene foam board is selected as the external thermal insulation layer of the water storage tank, and the thermal conductivity of polystyrene foam board $\lambda = 0.05$ $kcal/(m/h/k)$. According to the solar hot water system manual, the annual average outdoor temperature in Harbin is: The local annual average outdoor temperature in Harbin is T_a = 4.2^{0}C, q = 50 $kcal/(m/h)$, R_2 = 0.1 $kcal/(m/h/k)$. Calculated:

$$\delta = \lambda\left(\frac{T_1 - T_2}{q} - R_2\right) = 0.05 \times (\frac{50 - 4.2}{50} - 0.1) = 0.0408(m)$$

Therefore, the insulation thickness of the water storage tank is 40.8mm. Polystyrene foam board 40.8 mm is selected as the thermal insulation layer of water tank. The water storage tank shall be designed with the following pipe joints: upper circulation pipe orifice, lower circulation pipe orifice, heat supply water inlet, and sewage pipe orifice. Design requirements:

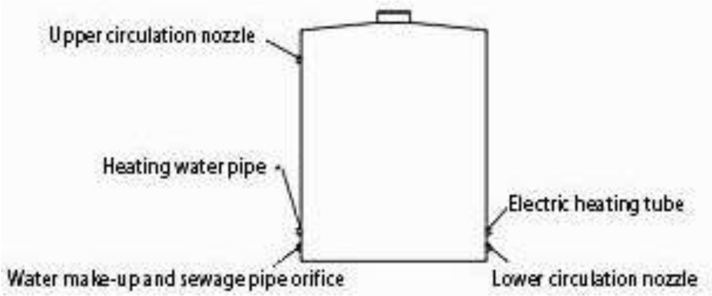

Figure 4. Location of Water Storage Tank Orifice

Table 4

Nozzle Name	*Technical requirement*
Upper circulation port	Flush with the outlet water and cannot be lower than 2/3 of the height of the water tank
Lower circulation port	50mm from the bottom of the water tank
Heating water pipe outlet	200mm from the bottom of the water tank
Makeup water pipe orifice	30mm above the bottom, equipped with a hat type water shield at the cold water inlet of the water tank
Blowdown pipe orifice	At the lowest part of the bottom or side of the water tank

Calculation of the effective volume, circulating flow rate, and electric heater power of the heat storage tank in a solar hot water system. Effective volume of heat storage tank:

$$V = (50 \sim 100)\, A_s \tag{14}$$

Where, V is Effective volume of heat storage tank, L; A_s is Heat collection area of the system, m^2. According to the local solar radiation amount and water temperature requirements, 70 is comprehensively selected in combination with the solar energy design manual, and the calculation results are based on 3.6, $A_2 = 153.6$ m^2:

$$V = 70 \times 153.6 = 10752\ L$$

The circulating flow rate is:

$$Q_y = (0.01 - 0.02) A_s \tag{15}$$

Where, Q_y is Circulating flow rate of the system. L/s: A_2 is Heat collection area of the system, m^2.

$$Q_y = 0.01 A_s = 0.01 \times 153.6 = 1.536\ L/s$$

Determination of the pipe diameter of the main pipe of the heat collection cycle:

$$d_j = \sqrt{4q/\pi\,\upsilon} \tag{16}$$

Where, q is Design flow, Generally taken as 0.01～0.02 $L/(s/m^2)$, then 0.6～1.2 $L/(min/m^2)$, According to the solar hot water system manual take 0.01 $L/(s/m^2)$; d_j is Calculated inner diameter of pipeline, m: υ is velocity of flow, *m/s*, usually its range is 0.8~2.0 *m/s* the $v = 1$ *m/s*.

$$d_j = \sqrt{4q/\pi v} = \sqrt{4 \times 0.01/\pi \times 1} = 0.0356m$$

According to the flow rate of the heat collection system, it can be selected and calculated according to Appendix 7, and DN40 pipes can be selected.

Selection of Pump for Solar Instant Heat Circulation System

1. Frictional head loss of pipe network:

$$\sum h_f = i_1 l_1 + i_2 l_2 + i_3 l_3 + \ldots + i_n l_n \tag{17}$$

Where: $\sum h_f$ is Total system loss along the way, kP_a: l_1, l_2 ... l_n is Pipe length of each calculated pipe section: m: i_1, i_2 ... i_n is Head loss per unit length of each calculated pipe section, kP_a/m.

1). Head loss per unit length:

$$i = 105C^{-1.85} d_j^{-4.87} q_g^{1.85} \tag{18}$$

Where, i is Resistance per unit length of each calculated pipe section, kP_a/m: C is Hayden William coefficient, various plastic pipes, lined (coated) pipes C = 140, Copper pipe, stainless steel pipe C = 130, Cast iron pipe lined with cement and resin C = 130, Ordinary steel pipe and cast iron pipe C = 100: Select stainless steel pipe, so C =130; q_g is Design second flow rate, m^3/s, dj is Calculated inner diameter of pipeline, m According to the table d_j= 38.5 mm.

Calculated based on appeal 3.15: $q_g = 1.5\,L/s$ so that; $q_g = 1.5 \times 10^{-3}\, m^3/s$;

$$i = 105C^{-1.85} d_j^{-4.87} q_g^{1.85} = 105 \times 130^{-1.85} \times 0.0385^{-4.87} \times 0.0015^{1.85} = 596kPa/m$$

2) Local head loss

$$H_m = \frac{\xi v^2}{2g} \tag{19}$$

In the formula, H_m is Local head loss, m: ξ is Local resistance coefficient: v is Velocity in pipe, m/s: g is Gravitational acceleration, m/s^2.

Due to the particularly large number of fittings such as elbows, tees, and ball valves in solar hot water systems, the local head loss is not calculated one by one, but is approximately calculated as 30% of the total loss along the path.

2. Lift of forced circulation pump

1) Hydraulic calculation of the most unfavorable point of the system:

$$H \geq \Delta H - 1.3 \sum h_f \tag{20}$$

Where, H is Water head requirements at the most unfavorable point, m:

ΔH is Height difference between the lowest water level and the most unfavorable point of the water tank, m; $1.3\sum h_f$ is Total head loss at the most unfavorable point of the water tank, m. The system diagram of the solar hot water system is as follows (Figure 5).

The amount of coal saved per year by solar water heating systems is:

$$G = \frac{AQ}{Q_H^P \eta_1} = \frac{A\beta E\eta_S}{Q_H^P \eta_1} \tag{21}$$

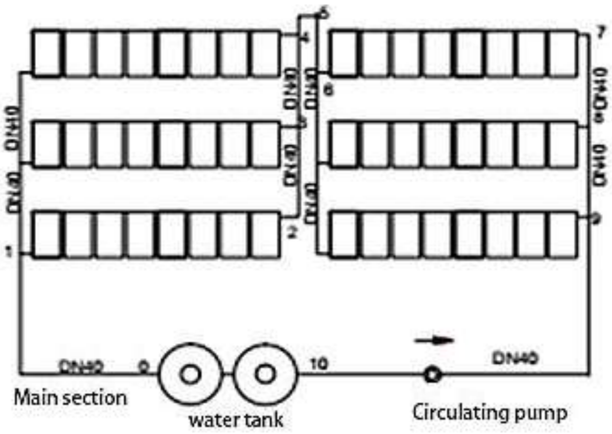

Figure 5. Schematic diagram of solar energy system

Analysis of energy consumption of solar hot water systems. Where, A is Daylighting area of solar water heaters, m^2: β is Annual availability of solar radiation energy, %: E is Solar radiation amount, $kj/(m^2/a)$: η_S is Thermal efficiency of solar water heaters, % Q_H^P is Calorific value of coal, kj/kg: η_1 is Thermal efficiency of coal-fired boilers, %. Ordinary commercial coal $Q_H^P = 16748$ *kj/kg*. The thermal efficiency of coal-fired boilers is average $\eta_1 = 0.4$:

$$G = \frac{A\beta E\eta_S}{Q_H^P\eta_1} = \frac{153.6\times0.45\times4941510\times0.4}{16748\times0.4} = 20394kg$$

If standard coal is used for unified calculation, the amount of standard coal that can be saved by the solar hot water in one year is (standard coal $Q = 29308$ *kJ/kg*:

$$G' = 20394 \times \frac{16748}{29308} = 11654kg = 11.65t$$

Using heating equipment that burns natural gas. Calorific value of natural gas Q = 35000 *kJ/kg*. Thermal efficiency of heating equipment burning natural gas $\eta_1 = 0.7$ then，

$$G = \frac{A\beta E\eta_S}{Q_H^P\eta_1} = \frac{153.6\times0.45\times4941510\times0.4}{35000\times0.7} = 5576kg$$

Compared to equipment that burns natural gas, it can save 5.5 t of natural gas a year.

Use equipment that burns light diesel fuel. Calorific value of light diesel fuel Q = 42000 *kJ/kg*. The thermal efficiency of its heating equipment The thermal efficiency of its heating equipment $\eta_1 = 0.85$ count， $G = \frac{A\beta E\eta_S}{Q_H^P\eta_1} = \frac{153.6\times0.45\times4941510\times0.4}{42000\times0.85} = 3827kg$

Compared to equipment using light diesel fuel, it can save 3.8% of light diesel fuel a year.

Equipment using city gas. Calorific value of urban gas Q = 35000 *kJ/kg*. The thermal efficiency of its heating equipment $\eta_1 = 0.7$.

$$G = \frac{A\beta E\eta_S}{Q_H^P\eta_1} = \frac{153.6\times0.45\times4941510\times0.4}{35000\times0.7} = 5576\ kg$$

Compared to heating equipment using gas, it can save 5.5% of gas a year. It can be seen that solar water heating systems are quite energy-saving, and they can save a lot of ordinary energy every year. This solar water system can save 5.5 tons of natural gas, 5.5 tons of coal gas, 3.5 tons of light diesel oil, and 11.65 tons of standard coal within a year of use. This shows that the energy saving of using this solar water heating system to prepare hot water is very significant.

References:

1. Wang, Siguo (2014). Exploring Green Building Design in Public Building Design. *Engineering Technology,* (11), 32-36.

2. Yuan, Ying, & Wang, Ziwen (2005). The only way to integrate solar water heaters with architectural design. *Journal of Solar Energy,* (2), 44-48.

3. Yuan, Jiapu, Zhang, Guangshun, & Zhang, Jinfeng (2008). Design Manual for Solar Water Heating Systems. Beijing, Chemical Industry Press.

4. Yao, Junhong, Liu, Gongqing, & Wei, Jianghong (2013). Solar water heating system and its design. Tsinghua University Press, Beijing.

Список литературы:

1. Wang Siguo. Exploring Green Building Design in Public Building Design // Engineering Technology. 2014. №11. P. 32-36.

2. Yuan Ying, Wang Ziwen. The only way to integrate solar water heaters with architectural design // Journal of Solar Energy. 2005. №2. P. 44-48.

3. Yuan Jiapu, Zhang Guangshun, Zhang Jinfeng, Design Manual for Solar Water Heating Systems. Beijing. Chemical Industry Press, 2008.

4. Yao Junhong, Liu Gongqing, Wei Jianghong, Solar water heating system and its design. Tsinghua University Press, Beijing, 2013.

Работа поступила
в редакцию 11.05.2023 г.

Принята к публикации
18.05.2023 г.

Ссылка для цитирования:

Shu Yugang 10 t/d Solar Hot Water Project of Building // Бюллетень науки и практики. 2023. Т. 9. №6. С. 397-407. https://doi.org/10.33619/2414-2948/91/47

Cite as (APA):

Shu, Yugang (2023). 10 t/d Solar Hot Water Project of Building. *Bulletin of Science and Practice, 9*(6), 397-407. https://doi.org/10.33619/2414-2948/91/47