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for heating process industries"

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АННОТАЦИЯ

Иброхимов Жасурбек “Саноат корхоналарининг технологик жараёнларни иссиқлик билан таъминловчи комбинациялашган қуёш энергетик қурилмасини яратиш ва тадқиқ қилиш” ФарПИ, 2014 йил, 92 бет, 33 иллюстрация. Энергетика факультети, “Электроника ва асбобсозлик” кафедраси, 5310202 “Энергиятежамкорлик” мутахассислиги бўйича магистрлик диссертацияси.

Диссертация ишда саноат корхоналарини технологик жараёнлари иссиқлик энергияси билан таъминлашда комбинациялашган ясси ва параболоцилиндрик концентраторлар коллекторлардан ташкил топган қуёш энергетик қурилмасини яратиш ва тадқиқ қилиш кўриб чиқилган. Иқтисодиётнинг турли тармоқларига, айниқса саноат корхоналари, коммунал хўжаликлар ва фермер хўжаликларининг кичик корхоналарига ушбу комбинациялашган қуёш энергетик қурилмасини тадбиқ этиш 30% дан 50% гача энергетик манбаларини тежаш имкониятини беради.

АННОТАЦИЯ

Иброхимов Жасурбек “Разработка и исследования комбинированной солнечной энергетической установки для теплоснабжения технологических процессов промышленных предприятий” ФерПИ, 2014 год, 92 стр., 33 ил. Факультет Энергетики, кафедра “Электроника и Приборостроение”, по специальности 5310202 “Энергоресурсосбережение” магистерская диссертация.

В диссертационном работе рассмотрено разработка и исследование комбинированных солнечных энергетических установок состоящих из плоских и параболоцилиндрических коллекторах. Применение комбинированных установки для теплоснабжения промышленных предприятий, коммунальных хозяйства, а также малых предприятий фермерских хозяйств обеспечить экономию от 30 % до 50 % энергетических ресурсов.

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Introduction

March 1, 2013 President of Uzbekistan Islam Karimov signed a decree "On measures for further development of alternative energy sources. "The decree states that Uzbekistan has significant experience conducting scientific and experimental research in the use of alternative energy sources, especially solar energy, which held development for decades. Decree approved the proposal of the Ministry of Economy, Ministry of Finance, the Academy of Sciences "Uzbekenergo" to establish the International Institute for Solar Energy Tashkent with the Asian Development Bank. The Decree also approved the proposal of the Ministry of Economy, Finance and "Uzbekenergo" implementation of the project construction of solar photovoltaic power plant of 100 MW in the Samarkand region.

Use of solar energy at the present stage of development of the field of scientific research and experimental development steadily moves to the practical application, and solar energy, as well as other forms of renewable energy, it is quite competitive, one of the purest forms, methods and ways of obtaining energy. [1]

President Islam Karimov spoke at the sixth meeting of the Asia Solar Energy Forum November 22, 2013 year.

Suffice it to note that, despite the negative impact of the global financial and economic crisis, the gross domestic product of Uzbekistan for the past six years, growing at an annual rate of more than 8 percent.

Over the years 2000-2013 it increased by 3,8 times, and the gross domestic product per capita - 3.2 times.

According to international financial institutions, such as high rates of economic growth in Uzbekistan continue in the short term.

The calculations show that given the high rate of development of leading industrial industry the country's electricity in 2030 will rise against the current year is about 2 times and amount to more than 105 billion kWh.

Speaking about the potential and prospects of the development of solar energy in Uzbekistan, I would like to emphasize the following.

In the first place, by geographical and climatic conditions of Uzbekistan has for this exceptionally favorable opportunities.

Number of sunny days per year, which is more than 320 days, our country is superior to many regions of the world.

According to estimates of the World Bank and the Asian, the gross potential for solar energy in Uzbekistan exceeds 51 billion tons of oil equivalent.

These resources, according to the calculations of experts, can produce electricity 40 times the volume of annual electricity consumption in our country this year. [2]

In recent years, many countries of the world expands the scope of the use of solar energy in industry, waste and agriculture. Solar energy cannot fully meet the energy needs of an industrial, municipal and agricultural object, but you can save a significant part of traditional energy resources. Therefore, solar energy is considered as an additional source of energy.

Small use amount of the solar power plants these industries are currently due to the fact that sufficient amounts are more expensive and more convenient sources of energy.

Relevance of the thesis. Use of solar energy in industrial a general industry and research work takes place in the solar energy industry, research and development of solar systems for the needs of the combined heat industrial process plant. Development of combined solar power plants in the economy within industries, especially needs for thermal processes in industrial plants to conserve natural resources

The goal and objective of the thesis. Aim of the thesis is the development and study of the combined solar power plant for process heating industry.

In accordance with the intended purpose in the following tasks:

- Analysis of modern combined solar energy systems for heating of industrial enterprises;
- Classification and comparative evaluation of flat and parabolic cylindrical diversion systems and design features of the basic units;
- Analysis of the energy balance of solar combined systems consisting of flat fields and reservoirs parabolic cylindrical industrial, municipal and agricultural use;
- Selection of concepts and flat parabolic cylindrical installations industrial, municipal, agricultural lands;
- Development and experimental study of the combined power plant, and to make recommendations for their use in real-world energy system.

Object and subject of study. As an object of study and discusses solar thermal power plants. The choice of this research subject is due to the efficiency of solar installations simple construction, dismantle and thermal mathematical model of combined action schemes, is solar power plants consisting of flat and parabolic cylindrical collector.

Analysis of the structure of energy consumption in the CIS showed that most - 54% - is consumed by industry, 20.4% - public utilities, 6.5% - in agriculture, etc. More than 60% of the energy consumed in the medium-and low-temperature processes, about 20% at high temperature and 20% - on power processes. It should be noted that most of the energy consumed is provided warmth. For example, for the U.S. industry is characterized by the following form of energy: thermal - 68.4; electromechanical - 19.2, electric - 2.8%, etc. [3].

Supply of thermal energy can be performed using a heat transfer medium (40.6%), and direct heating (67.8%). In practice, the thermal energy is usually transmitted to consumers with hot water, steam and heated air.

Studies total heat demand for U.S. industries like. function of the temperature at which energy is used (including high-temperature processes), showed that almost 28% of the heat is consumed at a temperature up to

415°C. This temperature level will be reached in the case of using solar energy installations with parabolic cylindrical concentrators. [3]

Scientific novelty of the thesis. Include the following:

- A combined solar power plant consisting of flat and cylindrical parabolic collector. Produced scheme to introduce the practice;
- Selected concept and the technical parameters of the combined systems;
- Analyzing the energy balance of the combined systems;
- Developed mathematical models combined thermal systems;
- Developed a software package for the calculation of the energy parameters of the combined systems;
- Investigated the operating modes of the combined systems.

The problem of increasing the efficiency of solar energy requires highly detailed study of heat transfer processes and the development of different variants of combined high-efficiency solar power systems practical purpose, as well as introducing them to various facilities.

Most efficient use of solar energy for industry, utilities and agriculture in the form of hot water, steam and heated air at low and medium temperatures (40-450 ° C), this temperature level can be effectively achieved by using a combination of solar power plant consisting of flat fields and parabolic cylindrical collectors. They belong to the low temperature and medium temperature settings with a range of work $40 \div 450^{\circ} \text{C}$. The greatest success in providing a warm industrial, municipal and agricultural objects attained by the combination of solar installations in the U.S., France, Germany, Austria, Italy and Japan. In several other countries, including the CIS, these works begin to develop. Demonstration plants are created, conducted their trial tests, and the results of tests to develop new projects practically applicable settings. Currently, these countries systematically research continues to improve the efficiency of the combined systems.

In this regard, posed in this paper the problem of development and research of the combined solar energy systems for heating industrial processes is relevant and is of great scientific and practical interest.

CHAPTER I. ANALYSIS OF THE CURRENT STATE OF RESEARCH ON THE DEVELOPMENT OF A COMBINED SYSTEM, CONSISTING OF THE FIELD FLAT AND PARABOLIC CYLINDRICAL COLLECTORS AND COMPARISON OF ENERGY PARAMETERS

1.1. Analysis of the current state of research on the development of combined systems.

In recent years all over the world, especially in Western Europe and Asia, has increased interest in renewable energy. Due to rising energy prices solution to this issue important for Uzbekistan.

However, in these regions, that is, in Europe, Asia, Australia and parts of South and North America - solar energy is mainly used either for home heating or to produce electricity. At the same time, almost always meant one of two things: either a small flat solar collectors installed, usually on rooftops and employees for heating and domestic hot water, solar power plants or large industrial-type on the basis of so-called parabolic cylindrical hubs designed to energize entire regions.

A golden mean - is the development of a medium-sized solar power systems to provide heat to individual industries. And there are many industries that need heat in that temperature range - roughly 150 to 400 degrees. That and the food industry and the chemical and textile, pharmaceutical, - the list is endless. They will be the main customers in the coming years.

The most advanced work to provide heat industrial facilities using solar flat and parabolic cylindrical collectors in the U.S. and developed European countries, such as France, Italy, Spain, Germany, etc.

Table. 1 shows the combined system, their location and some of the characteristics defined by the Ministry of Energy of the USA [2,3].

Now discuss in greater detail on the design features and operating characteristics of the plants listed in Table. 1.1.

In Sacramento (Calif.) at the "Campbell Soup" firms 'Aerotherm' "Akyureks" experienced solar installation, consisting of plane and parabolic cylindrical collectors [3]. The unit provides 54,0×10² liters of water per day at a temperature of 88-90° C for washing line canning industry. Water is heated in the flat collectors to a temperature of 60° C and then supplied to the company parabolic cylindrical concentrators "Akyureks". In these reservoirs the water is heated to 60° C in summer. Concentrating collectors of water flows into the storage tank capacity of 90,000 liters. Tank provides the water supply for night shifts, as well as hot water collects at the weekend. It has been established that the optimal field including 60% and 40% of flat concentrating collectors, delivers maximum performance with its minimum area 704 m². If all collectors were only flat or concentrating, then the performance of the field would have been less. Work energy system is automatically adjusted.

Location and some characteristics of plane and parabolic cylindrical solar installations, industrial plants operated USA [2-10]

Table 1.1.

Location	Process	Reservoir type	Company name
Hot water 60 – 100 °C			
Sacramento pcs. California	Wash jars	Flat and parabolic cylindrical	Campbell So up
of Harrisburg pcs. Pennsylvan ia	Heat treatment of concrete blocks	Approximate Facetparabolotsilindry	NY billing Products
Vario-100 – 176 °C			
of Fairfax pcs. Alabama	Drying the fabric	Parabolotsilindry	Westpoint Q uail

of Sherman pcs. Texas	Bleaching gauze	Parabolotsilindry	Johnson & Johnson
Pasadena pcs. California	Laundry	Parabolotsilindry	Home Clean ing End Laudri
Pairs average temperature 176 – 288 °C			
Dalton pcs. Joji	Production of latex	Approximate facettedparabolotsilindr	Dow Chemi cal
of Hobbs pcs. NM	Oil Refining	Parabolotsilindry	Saverne. Uni on Bldg.
Ontario pcs. Oregon	Potato Processing	Parabolotsilindry	About - Ida Company
in Mobile pcs. California	Heating oil	Parabolotsilindry	Ergon, Inc..
Using solar energy for industrial heating, financed by private organizations			
Youngstown pcs. Ohio	Anodizing aluminum	Multiple parabolic cylindrical Hub	General Extr usion.Inc..
of Mesa pcs. Arizona	Washing machines	Parabolotsilindry	Endiz Solar Truck & Car Wash.

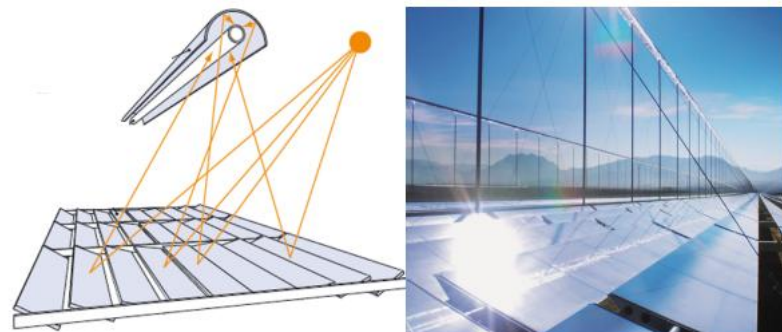


Fig. 1.1.1. Solar plant used in the concrete plant in Harrisburg (Pa.. USA)

[4]

On a concrete plant in Harrisburg (Pelsinvaniya) uses solar installation consisting of 70 collector modules (Fig. 1.1.1). [6]. Each module size of 5,2×2,75 m contains slightly curved mirror strips width 0,305m, forming eventually parabolic cylindrical form. The receiver is configured as a tube with a selective coating of black chrome. At the receiver, the water is heated to 93 °C and the heat exchanger maintains the temperature of water in underground concrete tank. Capacity of the storage tank 208 m is estimated that to maintain concrete blocks annually spent 206.7 million liters of fuel oil. For two years operation of the facility at the plant provides 35% of the hot water demand for the concrete curing process.

Other parabolic cylindrical installation company "Akyureks" built at the plant Johnson & Johnson in Sherman (TX), with a total area of 1070 m produces process steam at a temperature of 64°C [4]. Application installation saves 61,4×10³ liters of oil annually.

In the city of Mobile (, Alabama) to build a solar plant for the production of low and intermediate vapor pressures in the range 150-290 °C [7]. The unit is designed for heating the liquid fuel stored in large tanks. The system uses parabolic cylindrical collectors company "Akyureks" model 3001. Total area - 1874 m². Working synthetic body oil terminology 55. In the period of maximum solar radiation capacity of the unit is 0,8×10⁶ kcal / h, and the annual useful thermal energy -0,642×10⁶ kcal, which is equivalent to burning 134,7×10³ liters of fossil fuels.

In France, for example, firms Bertin & Gie Yointlly and RIC (ris.1.1.2.) Parabolic cylindrical installation designed to produce heat with operating temperatures up to 200 °C in order to ensure the technological needs of the plant [7]. The main part of the reservoir - parabolic cylindrical hub, it is made of high-gloss aluminum ($R_3=0,8H-0,9$) size 1×5,0 m focal length of 0.25 mm. Top hub closed transparent flat glass to reduce heat loss from the surface of the receiver. Geometric concentration reflector 23 is selected so that the unit was a

low-inertia, and for 5 min. provided the operating temperature rise of the temperature to 200 °C. Automatic tracking system provides rotation collectors with a total area of 100 sq. Optical losses installation is 35%. Heat losses from the surface of the selective receiver reach 120 W / m². Plant efficiency ranges from 40 to 50% yield at a temperature of 200 ° C. Estimated cost collector in mass production is 1000 francs / m².

In the Swiss city of Basel complex of 19 greenhouses equipped with combined heating and cooling system. [8] The system includes solar flat plate collectors on parabolic cylindrical Hub with a total area of 500 m², the battery heat, heat pump, double, working in a traditional heat source. Parabolic cylindrical collectors are located under a glass roof greenhouses. Automatic adjustment of the control circuits 38 includes heating and cooling for all 19 greenhouses and 6 circuits - for three transitional cameras. Due to optimization of the use of units scheduled to save 81 tons of oil per year, ie about 65% of total cost.

Company Tosiba (Japan) has developed a pilot plant for the combined generation of heat and electrical energy. [9] Installing low-temperature circuit has hot water in it to 105 ° C, accumulation and use it for heat and hot water, and high temperature hot water loop heat exchanger and produce steam at 165 and 200 ° C. Steam at a temperature of 200 °C is designed to leave the industrial consumer, and at a temperature of 165 °C is supplied to the steam turbine 5 kW. Exhaust steam from the steam turbine with hot water is used for evaporation of Freon-11, coming in freon 110 kW turbine. In the primary circuit is a synthetic heat transfer fluid. In the low-temperature circuit applied flat, stationary suntrap. In the high-loop tracking parabolic cylindrical collectors located orientation east-west and north-south. The total area of the solar collector - 603 m². Receiver parabolic cylindrical collector made of stainless steel pipe Ø50 mm with a selective coating of zirconium carbide.

Romanian IKSITIEEMR firm has developed and implemented a number of combined solar systems for technological needs of industry. [8]

For example, near Bucharest enterprise sausage works installation designed to provide hot water needed for hygienic operations and heating batteries climatic units adjacent to heating cameras.

For drying technology boards, near Bucharest were installed two solar air heating. The first unit consists of the surface of 352 m² formed from the collectors for heating water, sequentially arranged at an angle of 45⁰ to the horizontal. Collecting surface is located on the terrace of the dryer. Installation operates in forced circulation and reserve capacity of 20 m³. The unit is designed to operate year-round and frost protection is provided by automatic drain installation. Installing solar heated water passes through the heat tracing battery drying air. The second unit, built on the existing structure to the collector surface of 148 m², located on the south wall and roof of the drying volume, wall and roof inclined at 17⁰ and 75⁰, respectively.

Solar thermal system for heating the process water required in the textile industry. Receiving surface 200 m², formed of two rows of 50 solar collectors CH-2VL, at 45⁰ to the horizontal. Installation operates in forced circulation and reserve of 10 m³. The unit is designed to operate year-round and frost protection is provided by automatic drain installation.

Domestic solar technology also developed and tested a number of experienced parabolic cylindrical installations for use in state and collective farms, in food processing and light industries that require hot water, steam and electricity small capacity. Their design and specifications are given in [3]

1.2. Types of combined systems, the advantages of their application

Combined installation for photoelectrons thermal conversion solar energy [9]. Until recently, devices for solar energy has been traditionally divided into two large fundamentally different physics of solar energy conversion class - thermal collectors and photovoltaic modules. It is now possible to talk about a new direction - the photoelectric thermal conversion. In

this solar installation operates as a generator and electrical energy and as a heat absorber that produces both electricity and heat. Flat solar collectors have low energy performance, but they are reliable, easy to implement and operate and can be used all year round.

Solar combined photoelectrons thermal installation, in contrast, not only from traditional power plants and boilers, but also on the settings, convert renewable energy sources (wind power, geothermal, tidal, hydro), which can be installed in close proximity to the consumer. They can be installed directly in the heart of densely populated cities on the roofs of buildings to provide electricity to the utility sector and industry.

Application of solar installations for individual and industrial consumers with hot water and electricity to reduce the use of natural gas and other fossil fuels required for the production of heat and electricity, and can significantly reduce harmful emissions resulting from the combustion of different fuels at thermal power plants. Use in place of fossil fuels in industry and public utilities solar installations will significantly reduce the consumption of natural gas to reduce greenhouse gases and global warming on the planet.

Recently, more and more studies are described different combination of solar collectors. We are currently conducting research on universal helioprofile combining water-air solar collectors for heating rooms and provide them with hot water, photovoltaic module to generate electricity.

The principle of operation of water-air solar collector based on radiant heating by solar radiation receiving element - helioprofile working surface, the bottom of which are solar cells, while heat is transferred from the receiver to the air and liquid coolants, are in special ducts inside helioprofile. To reduce heat loss to the environment receiving side profile has a protective glazing and the side and rear walls of the housing are thermal insulation. Profile is made of aluminum alloy and has a cylindrical cavity for flow of liquid or air coolant prismatic cavity for flow of coolant air or placing a heat accumulating material.

Combined Solar collector has a better efficiency, as well as cooling the solar cell increases its electrical efficiency. The use of flat reflective surfaces in the hub provides a noticeable improvement in the electrical characteristics of the output. The average power of each solar installation helioprofile flat concentrator reflective film increased from 18...19 to 27...28 watts. Use as hubs mirror reflective surface of cheap foil can significantly save costs for heat and electricity to a large extent, energy solar installation.

As of 2010 the most powerful solar thermal power plant (354 MW) was the Solar Energy Generating Systems, CA (USA) (Figure 1.2.1). [15]. The project, developed by Luz International, is a system of nine solar power plants located in the Mojave Desert in California. Five of them have a capacity of 30 MW each, two 80 MW and two 14 MW. When you create a power plant was used 936384 parabolic cylindrical hub, located on an area of 6.5 km^2 . In 2009, the capacity of the existing solar heating systems increased by 21%, reaching about 180 GW of thermal power. China has established 29 GW, or about 42 million m^2 . Most of the rest have to power mainly on the EU countries, where in 2009 it was found 2.9 GW (about 4,000,000 m^2). From the European Union the most progress reached Germany (1.1 GW tonnes, or 1.6 million m^2) [10].



Fig. 1.2.1. Thermal solar power Solar Energy Generating Systems, California, USA [15]

Solar power plants and combined fototermodynamical their estimated technical and economic characteristics [16].

On the basis of the developed mathematical model used to calculate the parameters of the combined fototermodynamical solar power, determine their effectiveness, the value of specific investment and power generation for several items on the territory of Russia. It is shown that all of these indicators are far superior installation combined photovoltaic and solar steam-turbine plant used separately.

In [12] formulated in ENIN nominated them. GM Krijjanovskogo concept of a combined fototermodynamical power plants, the efficiency of which is discussed in more detail [12]. Scheme combined solar power plants in line with its basic idea - combined in one unit and thermodynamic methods photoelectric energy conversion. This combination is based on the use of steam cycle for waste heat from the photovoltaic battery. The overall configuration of the proposed combined solar power (SSPS) is presented in (Fig.1.2.3.) At the station there is a field parabolic cylindrical mirror concentrators, which are located at the foci of linear receivers of solar radiation - photocells of one or more series of photovoltaic cells, waste heat from the steam turbine which is given to the power plant. Electricity from photobatteries through inverters enters the system of distribution of power, which is also supplied electricity from the generator steam turbine plant. Selecting this configuration justified successful experience of development and operation of solar power plants with thermodynamic parabolic cylindrical Hub firm Luz firm ORMAT power module and low-boiling working fluids.

Heat removal from photobatteries can be made by single-or two-loop. In the first case the heat is transferred directly from the photoelectric working fluid circulating in the loop steam turbine cycle. Dual-circuit includes a first circuit, filled with high-temperature coolant heat away from the photocells and transmits this heat exchanger, steam generator, the working body of the second circuit.

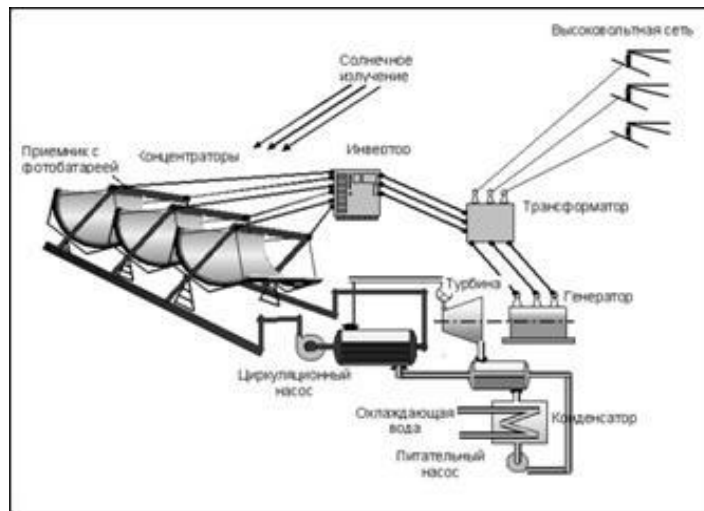


Fig.1.2.3. Overall configuration of the combined solar power

She and the other scheme has its advantages and disadvantages. Consider these schemes in more detail. Fig. 1.2.4 is a schematic flow diagram of a two combined solar power plant. The heat carrier heat transfer agent high temperature of photovoltaic is transferred to the steam generator working fluid. Intermediate coolant circulation pump ensures coolant. Dry saturated steam is the working fluid, formed in the steam fed to the turbine. Depending on the thermodynamic properties of the working fluid at the turbine outlet steam can be wet or superheated. In the first case, the steam enters a condenser in the second - in the heat exchanger, where the condensate preheating excessive heat depleted steam, cooled and then sent to the steam condenser. Condensate feed pump through the regenerator is supplied to the steam generator. Capacitor may, depending on local conditions to be water-cooled or air.

On fig.1.2.5.a schematic diagram of the single-combined solar power plant. Under this scheme, the heat from allotted photobatteries is transmitted directly to the working body. Each solar module is both at the same time the steam generator. Because you cannot avoid overheating of solar panels at a crisis point and the accompanying sharp deterioration in heat transfer, evaporation is carried to some marginal degree of dryness, when the channel walls retained liquid film.

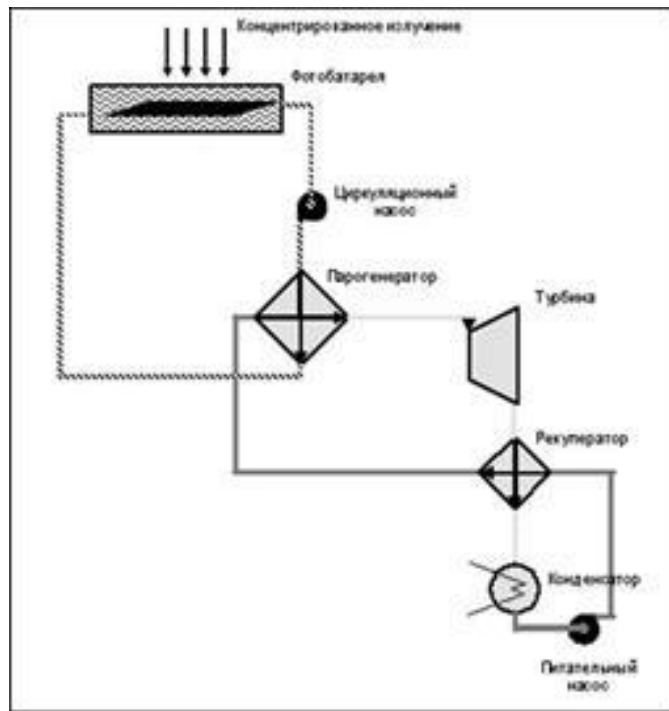


Fig.1.2.4. Schematic diagram of thermal double circuit combined solar power plant

After exiting the wet steam enters the channel in the separator, the separated steam is directed into the turbine, and the liquid on the circulation loop for mixing with the condensate, and to the input of the cooling channel. Assign all other elements of the unit is the same as in the two-loop.

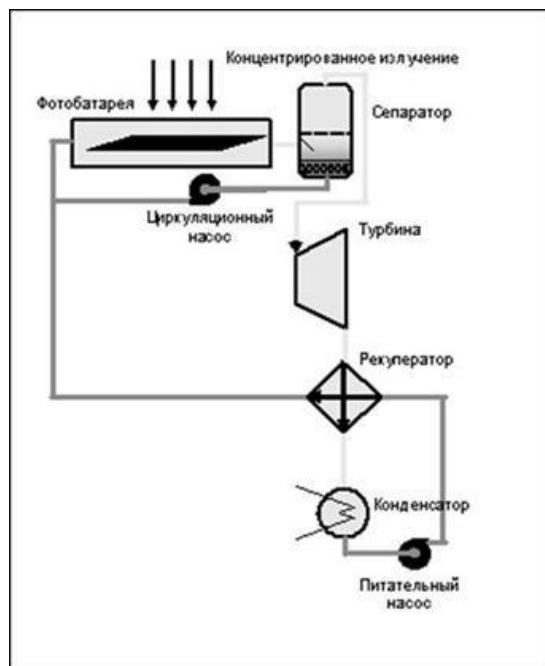


Fig.1.2.5. Schematic diagram of the single-circuit combined solar power plant

The advantage of two-loop circuit is the important fact that in the first circuit no overpressure. Concentrator solar radiation during the day revolve on slewing devices for orientation to the sun, which requires a mobile connections in the system to remove heat from photobatteries. Execution of such compounds in the absence of a significant excess pressure in the circuit is simpler than an overpressure. However, the disadvantage of a two-circuit is precisely the presence of the intermediate circuit, which has inevitable consequence energetic additional transmission loss of heat from the working fluid to the photocells. For single-circuit, on the contrary, the energy losses are minimal, but the removal of heat from the photocells is pressurized. Furthermore, since the photovoltaic modules are both steam-in cooling channels circulates photobatteries opaque vapor-liquid two-phase mixture, which excludes the use of more efficient cooling facial.

One of the key parameters of any of the power plant, including a combined consideration of solar power plants, it is output. If purely photovoltaic their effectiveness in the ideal case does not depend on the value of installed capacity, the steam-powered purely for (thermodynamic) solar power plants (as well as for traditional fuel) their efficiency and economic performance improved with increasing installed capacity. Since these combined cycle steam turbine installation uses her power should be sufficient to effectively use steam power equipment (primarily turbines). From our point of view the subject of the settlement analysis should be the combined solar power stations (stations) of two power levels, the first of which corresponds to the setting for independent power supply in remote areas without extensive network of power, and the second - a network installation. ie installation, integrated into the grid. The power level of the battery steam turbine combined plant should be at least 1 MW (minimum capacity of the existing turbines at low boiling working fluid). Since, as will be shown below, the power of the combined photovoltaic installation will be also about 1 MW, the total capacity will be about 2 MW. For network combined station minimum total capacity must be at least 10 MW, which is

determined by the minimum capacity of 5 MW turbines on existing moisture vapor steam.

In the world literature and practice of photovoltaic power is estimated so-called peak power, they may have at a flux density of incoming solar radiation to install $1.0 \text{ kW} / \text{m}^2$. Since the combined solar installation, at least half a photovoltaic, we will also be installed to measure its power peak values corresponding to said radiation flux density. Thus, the power level of said battery, and mains systems will be respectively 2 and 10 MW peak power.

In both cases, with the specified power level is best suited modular principle of the creation of photovoltaic power plants in which they are composed of a number of identical modules containing the hub of solar radiation, slewing and concentrated solar radiation receiver with photobatteries and its temperature control system.

One of the main parameters considered the combined solar energy Position is also the degree of concentration of solar radiation. As an initial value we choose geometric concentration $C = 100$. The consumption of solar cells per unit of power is reduced compared to a flat photobatteries was 100 times that favorably affects the technical and economic indicators of installation. Further, the concentration level is achievable using a relatively simple parabolic cylindrical concentrators. Optimal value C will be determined by the maximum efficiency of the combined plant and minimum investment.

The most important parameter affecting both the efficiency of solar cells, and the electrical efficiency of the thermodynamic power plant is operating temperature photovoltaic t_w . Its value will also be determined by calculation of physical and economic optimization.

Not less important than the choice of the type and range of the hub has its rotation scheme for the orientation to the sun. Strictly speaking, the concentrating system should be considered in the unity of its main parts, which is the hub itself and slewing bearings, orienting hub in the sun. The choice of a design scheme concentrating system causes a certain pattern of rotation. A

detailed analysis of the effectiveness of various design patterns in terms of the amount of incoming solar radiation is given in [3]. There it is shown that the choice of the constructive scheme also depends on the characteristics of "solar climate" in this or that point and on its latitude. Here we use the results of this analysis, we take as a starting condition that the combined solar power plant for autonomous application should use the rotation about two axes - vertical and horizontal. Thus, the combined solar power plant autonomous application will consist of identical modules containing parabolic cylindrical concentrator solar radiation, slewing bearings, providing a hub rotation about two axes, and the receiver of concentrated solar radiation and photo transformer system to remove heat from them.

For combined solar power plants, integrated into the grid, taking as a starting position, that she should have a uniaxial rotation system hub. The axis of rotation must be horizontal and oriented in north-south direction.

Thus, the network combined solar power plant (station) will consist of identical modules containing parabolic cylindrical concentrator solar radiation, slewing bearings, providing a hub rotation about a horizontal axis, oriented in north-south direction, and the receiver of concentrated solar radiation and system photo transformer removing heat from them.

For solar power plants with a combined single-circuit and thermal uniaxial orientation system most suitable working fluid is water, which provides the best performance of heat transfer in the cooling channel receiver at moderate temperatures (up to 15 bar) pressure. Under negative temperatures in the absence of solar radiation required drained into a storage tank heated.

For stand-alone station with dual-circuit thermal circuit suitable normal hexane, cyclopentane and methanol, as they have relatively high critical pressure and enable us to construct efficient low-power turbine. In our calculations, as the working fluid used n-hexane, thermodynamic and thermo physical properties are determined by the known method [4].

In order to optimize the parameters considered combined solar power developed a mathematical model that enables the variant and optimization calculations for different input source data.

The volume of articles allows only lead basic design formulas used:

Power flux of solar radiation reaching the station is

$$q_s = S \cdot F \quad (1.1) \text{ where}$$

S-flux density of direct solar radiation,

F-total aperture area parabolic cylindrical hubs.

Electric power photobatteries combined station N_1 is:

$$N_1 = q_s \cdot \eta_0 \cdot \varepsilon \cdot \eta_{PV} \quad (1.2)$$

η_0 - optical efficiency hub

η_{PV} - photobatteries efficiency taking into account the degree of concentration of the radiation and the operating temperature,

ε - the filling factor of the front surface of the radiation receiver photocells.

Electric power in the steam turbine of the station is:

$$q_T \eta_{TH} = q_s \eta_0 (\eta_{hl}^{rec} - \eta_{PV}) \eta_{TH} \quad (1.3)$$

η_{TH} - thermodynamic efficiency of conversion based on the performance of the turbine, generator, pumps and heat transfer losses.

Heat loss in the solar receiver consist of the actual radiation and convective heat loss to the atmosphere

$$q_{hl}^{rec} = F_{fs} [k\sigma T_{fs}^4 - k\sigma T_a^4 + \alpha_{conv}^a (T_{fs} - T_a)] \quad (1.4)$$

F_{FS} where - area of the free (non-insulated) surface of the receiver, T_{FS} - absolute temperature of the surface, T_A - air temperature, k-emissivity of the receiver, α_{conv}^a - the coefficient of convective heat transfer in the atmosphere.

Calculation of heat transfer in the cooling channel receiver of solar radiation, which is both a thermodynamic steam generator of the station, is determined by the heat balance equation:

$$q_T = G_{wfc} (h_{1c} - h_{2c}) \quad (1.5)$$

wherein G_{WFC} - the working fluid flow (or cooler in the special case of a two-circuit) in the cooling passage, H_{1C} H_{2C} - enthalpy of the working fluid at the inlet and the outlet channel as well as the equation of heat transfer from the working fluid to the photocells:

$$qT = \int_0^{fec} K_{ec} (t_c - t_{wf})df + \int_{fec}^{fch} K_{ev} (t_c - t_{wf})df \quad (1.6)$$

Here K_{ec} and K_{ev} - heat transfer coefficients on the economizer sections and the evaporating channels, t_c and t_{wf} - temperature of the working fluid and the photocells, F_{ec} and F_{CH} - surface area bathed by the economizer section and the channel in general.

In somewhat more detail the dependence of the photoelectric efficiency of solar concentration and temperature. It is known that the smallest decrease in efficiency with increasing temperature is characteristic of solar cells based on gallium arsenide. However, published data on their efficiency in the temperature range of 100-200⁰ C and a concentration of up to 100 are scarce and largely inconsistent.

In the Ioffe Institute. AF Ioffe RAS experimental studies of the effectiveness of single-crystal GaAs-elements in the specified range of temperature and concentration. These elements have been manufactured for use in concentrated solar flux. The experimental data are approximated by the equation expressing the dependence of the efficiency elements concentration and temperature to within $\pm 0,5$ absolute processes (Figure 1.2.6.). As seen from this figure, the efficiency of GaAs-elements in the temperature range of 150-200⁰ C is 19 - 17%.

Optimization calculations were carried out in the temperature range of the working fluid at the turbine inlet 150-200⁰ C and solar concentration 80-100. As the temperature increases the efficiency of photoelectric decreases and steam cycle, in contrast, increases natural to expect a certain optimum, providing maximum efficiency of the combined plant.

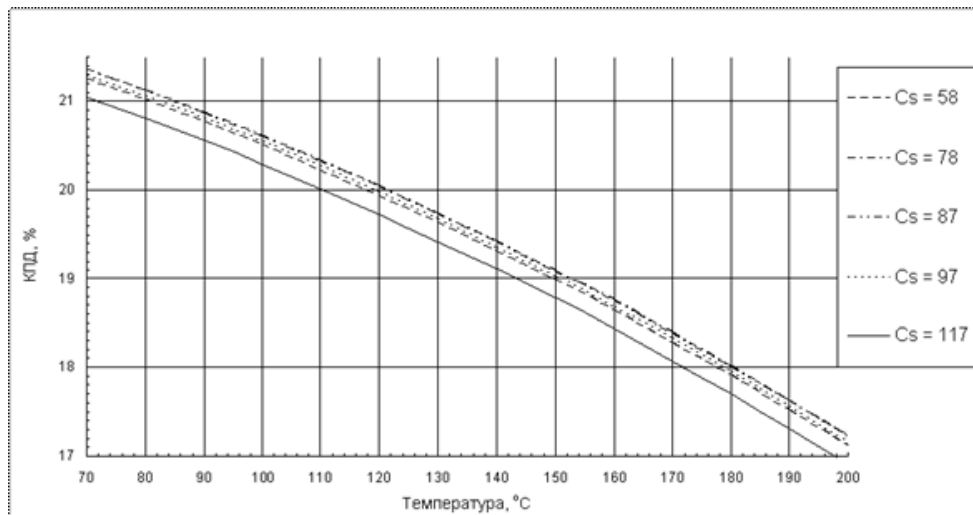


Fig1.2.6. Efficiency in relation to the elements of the concentration and temperature to within $\pm 0,5$ absolute processes [12]

However, the calculated results have shown that the selected range of temperature of its growth increases the overall plant efficiency, since the efficiency of steam cycle increases more intensively than reduced efficiency photocells. Consequently, the required optimum is at a temperature above 200°C , however, for this field are no experimental data on the effectiveness of GaAs-elements. Extrapolation of this region would be unreliable.

The total efficiency Gross combined single-installation in the considered range of temperature and concentration ranges from 0.276 to 0.295, and efficiency taking into account the net energy consumption for own needs, including the conversion of DC to AC, from 0.256 to 0.277. For installation of a two-efficiency Gross is from 0.256 to 0.274, and efficiency net from 0,230 to 0,245. According to these data, the effectiveness of combination solar power plant fototermodynamic 1.5-2 times higher than the efficiency of photovoltaic solar plants and steam power applied separately.

The calculation results also show that for single-setting temperature before the turbine $150, 175$ and 200°C the proportion of the steam turbine installation in its total capacity is 0.45, respectively; 0.49 and 0.53, and 0.42 for dual-circuit; 0.47 and 0.51.

Higher efficiency of the combined solar power plants cannot itself unambiguously state its benefits without the technical and economic evaluation. The assessment of capital costs showed that they make up for the single-unit from 1700 to 1850 dollars/kW, and for the installation of a two-from 2050 to \$ 2,200 / kW in the considered range of temperature and concentration.

Since many types of equipment needed for the creation of the combined solar installations, the industry is not made, the assessment of capital costs, of course, linked to a number of assumptions. For example, we assumed that the cost per unit area of GaAs-photocells 10 times higher than the cost per unit area of silicon photobatteries, the price is known. The cost of the concentrating system is the cost of mirrors, slewing device on which are mounted mirrors, electric and automatic control systems. Cost polished glass mirrors according to the Institute of Technical Glass when ordering at least 5 thousand m² is \$ 100 per 1 m². Cost of positioner (GTC) is estimated based on preliminary design module parabolic cylindrical Hub commissioned by one of ENIN design institutes in the early nineties. When specific metal GTC 43.4 kg per 1 m² aperture area module its unit cost in the current prices is 86.8 dollars/m². Similar assumptions made by the management system of rotation module system for converting direct current into alternating etc.

Thermodynamic conversion system composition equipment parameters and the working medium power level is acting analogues in geothermal energy.

Single circuit similar energy installations steam geothermal power plants in the fields (basic equipment - separators, wet steam turbine outlet steam temperature of 150-200 MW capacity 5-30). The total capacity of geothermal power plants of this type is about 2 MW. In the world of established prices such power equipment 500-700 dollars/kW depending on the power and steam parameters. Given the absence of a combined solar power expensive system to prevent corrosion and scaling when exposed mineralized geothermal water that is needed for geothermal power plants, take specific capital investment in equipment bottoming cycle equal to 500 dollars/kW.

Two pipe system is also similar to dual-circuit geothermal power plants, geothermal brines using heat with temperatures 120-2000 C (basic equipment - steam generators, heat exchangers, air condensers, turbines, low-boiling working fluids capacity of 0.5-3 MW). The total capacity of geothermal power plants, and disposition of waste heat of about 400 MW. The main manufacturer of the equipment - an Israeli company ORMAT - set equipment prices 700-1000 dollars/kW depending on the temperature of heating water and power plant capacity. For the same reasons as for the single-circuit system take specific capital investment in equipment bottoming cycle equal to 700 dollars/kW.

Of course, the above data on specific capital investments are approximate. Their real value can only be determined by the design-budget documentation when working design. However, we can assume that our assessment of specific of capital has an error of $\pm 20\%$. We believe that the average unit capital costs combined solar power plant \$ 2,000/kW. This is 4-5 times lower than, for example, for photovoltaic installation on the basis of flat photovoltaic modules with Si-elements and 2.25 less than for steam-turbine solar power company Luz, built in the USA. Thus, a significant increase in the efficiency of solar power combined fototermodynamical results in a significant improvement in their technical and economic characteristics.

Using the method described in [3] calculated the power generation single-network combined solar power plant of 10 MW nominal and nominal battery combined unit capacity of 2 MW for the southern Transbaikalia (Climate Data Weather Mangut) and Astrakhan. However, we can compare more indicative value of the specific power generation per 1m² aperture area concentrating system. This value for the climatic condition Mangutov and Astrakhan in the network is combined unit 380 and 314 kWh/m², and for stand-alone installation of 390 and 322 kWh/m² respectively.

Research Institute of semiconductor devices ("NCEP") together with the administration and the Tomsk Oblast Tomsk Polytechnic University (TPU)

plan by September 2012 to equip one of the remote villages of the wind and solar power for 7 million rubles.



Fig.1.2.7. Wind and solar power

For the pilot project was selected village Alataevo Parabelsky district. It was originally planned that the specialists in the summer 2012 there will install solar panels for street lighting.

In a single site will be located two to 19 kilowatts of wind turbines and solar power for seven kilowatts. This is enough to provide electricity to the village. [15]

Company "ROTEK" (part of the group "Renova"), with the support of scientists from the Physico-Technical Institute. AF Joffe intends to introduce in Russia combined diesel-solar power plants. Of course, the above data on specific capital investments are approximate. Their real value can only be determined by the design-budget documentation when working design. However, we can assume that our assessment of specific of capital has an error of $\pm 20\%$.



Fig.1.2.8. Combined diesel-solar power plant

The structure of this complex will include about 500 thin-film solar cell modules from "Hevel" (SP "Renova" and "RUSNANO") with a total peak power of 60 kW and two Italian Pramac diesel generators with a rated capacity of 43 kW each (briefly it may rise up to 50 kW).

Unite the efforts of all of these sources will inverter modules, transformers, fuses and controls, as well as the buffer battery (70 Ah, 240).

Total capacity of the combined plant exceed 100 kW. The share of the solar panels should account for more than 70% of electricity generation.

The total cost of the equipment of one such system is estimated at about 10 million rubles. Given the price of diesel fuel, as well as its introduction into remote areas hybrid installation should pay for itself in 2-3 years.

According to the company "ROTEK", the first instance of domestic diesel-solar power plant should start operating this year. Place of residence is not already selected, but considered the Altai Republic and Yakutia. [16]

Advantages of using combined power:

- Save money on power plant maintenance
- Fuel Economy
- Low emission of harmful substances into the environment
- Low noise power plants



Fig.1.2.9. Application of combined power

Company "PSM" ("industrial machine") is in talks on cooperation with the Russian Corporation of Nanotechnologies - JSC "RUSNANO". During negotiations bude discussed the development and introduction of combined energy sources, combining alternative and traditional small-scale energy. [17]

Types of combined systems.



Fig.1.2.10. Wind turbine generating set + DGS+ inverter + control system



Fig.1.2.11. Solar battery + inverter + DGS+ management system

Within the framework of the Federal Target Program "Research and development on priority directions of scientific-technological complex of Russia in 2007 - 2013 years" FTI. AF Joffe together with "ROTEK" (included in the "Renova") and with the involvement of OOO "STC thin-film technologies in power at the Ioffe Institute. AF Ioffe "(subsidiary company" Hevel "- SP" Renova "and" RUSNANO ") will develop and implement the first in Russia autonomous diesel-solar power.

Installed capacity of the experimental hybrid power plant, in which the share of solar power more than 70 percent to reach more than 100 kW. In the manufacture of power plant will be used photovoltaic modules based on advanced thin film technology. Work to improve their performance will be the Scientific and Technical Center of thin-film technologies based on FTI. A.F.Ioffe.

Upon completion of testing and commissioning of diesel solar power plant is scheduled to develop a standard solution for the introduction of independent power supply in areas with high levels of diesel generation.

According to the General Director of the Scientific and Technical Center of thin-film technologies in power at the A.F.Ioffe Institute. AF Vladimir A.Ioffe Korabel'nikova, "combining photovoltaic systems with diesel generation at times reducing the operating costs of the consumer by reducing the amount of fossil fuels."

As the General Director of JSC "ROTEK" Mikhail Lifshits, "autonomous hybrid power plant using solar generation are technically efficient and cost-effective solution for the Russian regions with high solar radiation, for example, Southern Russia, South-Eastern Siberia, Yakutia, Transbaikalia and the Far East, where the cost of diesel generation is 30-40 rubles kW/h. " [18]

Combined power plant where, along with renewable energy sources used fuel cells and batteries. [18] One of the trends in recent years is the steady growth of the energy produced from renewable sources based on solar, wind and other settings. This along with the obvious advantages and has a fundamental disadvantage associated with the variability of electricity generated (dark, no wind or too much wind, etc.). This drawback can be successfully compensated by creating combined power plants, where, along with renewable energy sources used fuel cells and batteries. Wherein hydrogen for the fuel cell can be obtained in an electrolytic cell during the most efficient operation of the RES, may be stored in special containers, and if necessary, be used to generate electricity.



Fig.1.2.12. Combined power plants with renewable energy sources [18].

The establishment of such combined power from renewable energy sources is certainly true for our country.

According to the Chairman of the Scientific Council of RAS (Russia) on alternative renewable energy Oleg Popel, 2/3 of the country are out of district energy networks. In these areas, home to about 20 million people, and the electricity tariffs of up to 25 rubles/KWh. Most regions of the country is energy - the fuel in them are imported from outside, which raises the question of regional energy security. In addition, only half of the gasified urban areas and less than 35% of villages. All these arguments can justify the need to develop a small power distribution based on alternative energy sources and new energy efficient technologies.

In addition to providing energy to consumers caught "overboard" centralized networks, low energy distribution (MRE) and the need, for example, to provide an emergency reserve for energy sensitive and strategically important objects: standby power system for the CBR, for telecommunication nodes (Rostelecom and etc.), to cover peak loads on the individual grid substations Russia. Need MRE and during the implementation of investment projects when you need to "power up" the industrial and logistics facilities, the president said the NGO "National Association of small power" Vladimir Sumenkov.

Leaders to launch new facilities are MRE Khanty-Mansiysk (about 1000 MW), Moscow (350 MW), Yamal-Nenets Autonomous District (195 MW), Moscow region (100 MW) and Bashkortostan (65 MW).

Most of the objects are still working on natural gas. However, more talk and hear predictions about the use of energy in a small distribution of renewable energy sources (RES).

The volume of global investment in renewable energy increased by 32% in 2010 - to a record 211 billion (compared with \$ 150 billion in 2009 and \$ 30 billion in 2004). In particular, the significant investments made in the sector of wind energy in China and small-sized solar installations in Europe. In addition, according to International Finance corporation, investment in new generating

capacity from renewable energy sources in recent years more than 50% of total global investment in new generation capacity.

In Uzbekistan, although understand the value of the accelerated introduction of renewable energy, but there are opponents that focus more on the continued use of hydrocarbons.

The main argument of opponents of the accelerated introduction of renewable energy sources are the high capital cost of the energy projects of this type. However, these costs are actually decreasing every year - for example, solar panels are already below 1500 dollars/KW.

RES good by the fact that their facilities are completely absent marginal costs for electricity generation, as well as the cost of volatility risk. And that is important - RES give clean, safe energy, which reduces greenhouse gas emissions.

Every year on the solar energy is increasingly referred to as the real source of energy worldwide. According to the company, "Hevel-Solar", the amount of solar energy reaching the Earth exceeds the energy of all the world's oil, gas, coal and other energy resources, including renewable energy. And the use of only 0.0125% of solar energy can provide all the needs of today's global energy 0.5% - fully cover the needs in the future.

Many European countries were in favor of solar energy development seriously. In particular, the German experience shows that in the period from 2000 to 2007, the multiplier effect of solar energy to the economy amounted to 5.4 euros at a cost of less than 1.5 euros per month per household.

World "sunshine" industry for 25 years of development has also achieved good results - the price of PV installations fell 20 times. In addition, it was possible to make the transition from NEC to mass production, production from piece to large industries with a unit capacity of more than 1 GW/year and from a niche market for enthusiasts to the global market volume of 40 billion euros, highlighted in "Hevel-Solar."

Projected European Photovoltaic Association (EPIA), by 2030 solar power plants around the world will produce 200-400 GW, which will meet the electricity needs of 14% of the population.

In Uzbekistan, there is a huge background of solar energy development. These include a significant scientific and technological potential of Uzbekistan, a high level of solar radiation (insolation) in most parts of the territory of Uzbekistan. In addition, solar generation will be involved in the replacement of outdated power capacity during the upcoming modernization of fixed assets of domestic electricity. Very high potential for significant multiplier effect in the economy through the development of related high-tech, innovative industries: microelectronics, semiconductors, production of energy storage and intelligent networks.

It is important to encourage the development of solar energy in Uzbekistan now because it will enable the use of the most advanced technology at this stage of their rapid development, where technology transfer is still possible. After achieving competitiveness of solar power generation with traditional development of national capacity in this area would be extremely difficult.

1.3. The main findings and conclusions of recommendation based on the analysis of research and development of modern combined systems for domestic hot water needs of industry technology

Based on the analysis of research and development of modern combined systems for domestic hot water needs of industry technology made the following major findings:

1. Comparison of the effectiveness and parabolic cylindrical flat collector is shown in Figure 1.3.1. Refill system with hubs in the existing hot water system of technological facilities aimed at reducing the consumption of fossil fuels and the workload of the conventional boiler for sunny days. Required high "return" the temperature in the conventional system design eliminates the use of

flat-plate collectors. This is the first evidence of the effectiveness of the use of solar systems with concentrators.

Another significant advantage of solar installations proof hubs connected with the work of heating and hot water in winter. Solar installation, thanks to its focus and concentrating solar power, can be designed to work in winter with temperature coolant above 100 °C.

Improve the efficiency of flat-plate collectors can be achieved through the application of their design elements concentrating optimal form.

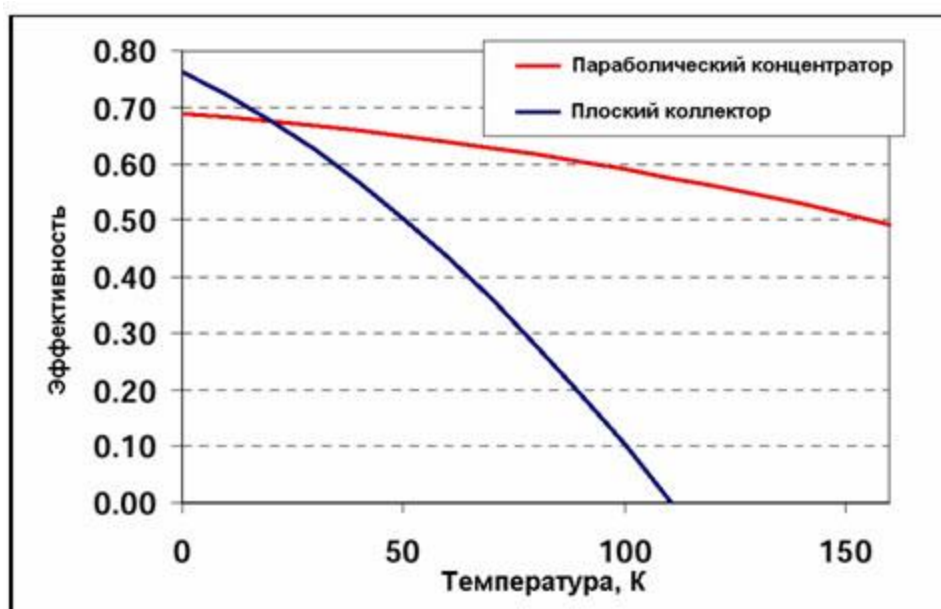


Fig. 1.3.1. Parabolic cylindrical efficiency curves and flat collectors [9]

2. Solar installations for process heat from renewable energy sources is a priority, as they are:

- Fill the needed niche industrial heat with temperature 80 - 200 ° C;
- Can work in conjunction with other sources of heat and do not require special communications.

3. Solar collectors are used for heating of industrial and residential premises for domestic hot water production processes and domestic needs. The greatest number of industrial processes that use heat and hot water (30-90 ° C),

are in the food and textile industries, which thus have the highest potential for use of solar collectors.

4. Increased operating temperatures up to 120-250 °C is possible by the introduction of solar collectors using hubs parabolic cylindrical reflectors. For higher operating temperatures are required for sun tracking device.

5. Given the growing demand for process heat and to increase the efficiency of solar installations in the world searching for new schemes of solar installations based on the reflection properties of surfaces hubs. To create such facilities need not apply hubs with a high degree of concentration, requiring high precision manufacturing and expensive system of tracking the Sun. For example, the basic cost (75% of total cost) solar station tower falls on a field of heliostats. Heating the coolant to a temperature of 80 - 200 °C in a solar installation can be achieved through the use of a stationary concentrator.

6. Needs analysis process heat in the production of building materials and household needs and the results of this analysis and the results of theoretical studies of the reflected solar radiation flux is designed, manufactured and tested a prototype of a solar installation with a fixed hub with temperature coolant above 100 °C. Tests have shown the following:

- Considering that the sun tracking systems increase the cost of installing solar battery, it is appropriate to apply the solar concentrator units with fixed temperature for 80 - 150 °C and a concentration degree of 10 to 50.

- Collectors of solar energy concentrators have the solar collector heat loss through the glazing is less than the flat CSE by reducing the glazing area is proportional to the degree of concentration of the collector.

7. Representatives of low-temperature solar systems are flat plate collectors, medium temperature - flat plate collectors with concentrating elements and high - concentrating systems. Efficiency of the main types of concentrating collectors with existing elements can be represented as a graph (Figure 1.3.2.) Where the geometric mean concentration factor K is expressed through the dependence on the angle of the rays $\cos \alpha$.

The geometric mean concentration ratio is determined from the ratio of $K = D / d$,
 where D -width of the inlet;
 d - the width of the outlet (the receiving plate).

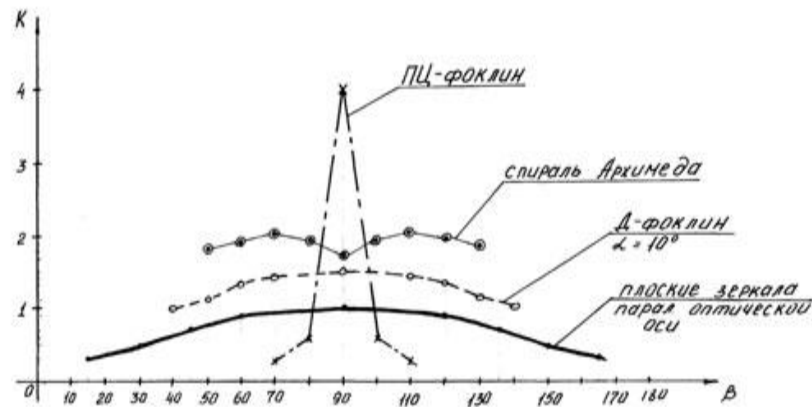


Fig. 1.3.2. Efficiency of the main types of concentrating collectors with existing elements

Study of mathematical and computer models show that giving the highest concentration of PC-focline can only be used as tracking. In the flat-plate collectors with concentrating the elements in which no tracking of the sun, the greatest concentration factor provided concentrating elements specified in the form of a spiral . Payback hub area of 1m^2 - 7 years, 10m^2 - 3 years.

During operation of solar concentrators in winter economically advantageous to use them with an area of fighting off surface 10 m and more.meters.

8. Developed entirely new system of automatic orientation hubs on the Sun.

The system works based on the use of the laws of celestial mechanics and high stability over the movement of the planets, including the Earth and the solar system. This allows for any geographically specific point of our planet very accurately calculate the trajectory of the sun and its position in the sky at a given

time, ie the Sun each year on the same day and time at a certain latitude has the same coordinates on the horizon .

So, knowing the geographical coordinates of the place where there should be a hub, you can always pinpoint the place the sun and orient the hub on the specified coordinates, regardless of the weather.

Management hub by using the developed computer applications.

Using the software, the hub will be first to the starting point, and then take the position that it should take in the date and time data. The program keeps track of time and with a certain periodicity generates control pulses to drive the horizontal and vertical control hub. After sunset (when the vertical component of the coordinates is zero), the program generates an impulse control when developing a hub which will return to the point of coming and will be at this point, until the time comes to sunrise the next day.

9. Active methods of solar energy, especially in systems with hubs allow for stable operation of the hot water systems of industrial facilities not only in summer but also in winter. Solar collectors allow for an industrial facility with hot water (80%) and heat (up to 50%) due to solar energy to provide hot water at 100% in the summer. These figures may vary, depending on the type of solar collector and storage. But in any case, solar collectors can significantly reduce the consumption of electricity and gas. Equipment for the combined production of heat (or cold) and electricity (which saves 40% energy compared to separate production).

10. Currently in Uzbekistan there are very few companies producing reservoirs suitable for reliable operation. Collectors of these firms do not have a selective coating, cheap and simple design, mainly oriented to the domestic market. Niche for the use of these reservoirs in Uzbekistan is big enough. The analysis of simulation results solar water installation with various collectors found that quite effective and less costly in Uzbekistan is to use a simple solar collector.

Effective use of solar water heaters in Uzbekistan is only possible during the period March-April and October. With an increase in the specific area of the number of days solar water heating temperature to an acceptable increases. Water temperature of at least 45 °C at 2-3 m² solar collector in the summer months is achieved in 22-27 cases. Analysis of simulation results shows that in the summer time the consumer will have enough water heated by the middle of the day (11-13 hours), and by the end of the day is likely to heat up the water in the tank to 55-60 °C.

11. Industrialized countries intensively developed commercial use of solar energy for heat supply of industrial facilities. Ultimately, up to ten percent of the total energy consumed in industrialized countries may be obtained by rational use of solar energy. Practical implementation of this approach will reduce energy consumption, reduce the consumption of fossil fuels and a positive impact on the environment, will significantly reduce the production of electricity by other means.

12. The hot water and heating - are the main problems faced by many businesses, farms and so on. Traditionally, the heating is carried out using the gas, solid and liquid fuels, electricity. But all these types of heating very costly, lead to the depletion of natural resources and the negative impact on the ecology

13. Using a combination of solar hot water and heating industry offers excellent economic incentives. High energy costs can be reduced by several times. Decrease in the proportion of energy in the production cost can significantly increase the competitiveness of the product.

In the CIS energy cost of the product varies from 10% to 70%, which is 5-10 times higher than the world level.

In the chemical industry production costs for energy accounts for about 70%.

In metallurgy - up to 27%.

The pace of growth of tariffs for energy exceeds the rate of growth of prices for products of most sectors of the economy. This was one of the major

reasons for the increasing share of energy costs in production costs. As the analysis of activity of a number of machine-building enterprises, the share of the cost of electricity and heat in the cost of production has increased from 1.2% in 1990 to 16-20% in 1999. A similar trend is observed in light industry, where the survey has allowed to establish the cost of increasing the share of electric and thermal energy production cost from 8-9% in 1995 to 17-19% in 1999. [19]

It should be emphasized that a decrease in industrial output 3-4 times the energy consumption enterprises reduced by just a factor of 1,5-2. Use in the production of obsolete equipment, due primarily, lack of major industrial enterprises of funds for its replacement or modernization leads to wastage of energy resources and only aggravates the situation.

Volatile economy demands more and more energy for work and development. With traditional energy supply raises a lot of organizational, financial and technical difficulties with the growth capacity of the enterprise, as often required the construction of new power lines, construction of new transformer substations, relining mains and etc.

CHAPTER II. ENERGY BALANCE AND HEAT MATHEMATICAL MODEL FOR CALCULATING A COMBINED SYSTEM CONSISTING OF THE FIELD FLAT AND PARABOLIC CYLINDRICAL COLLECTORS FOR HEATING PROCESS INDUSTRIAL ENTERPRISES

In industry and municipal services most widely adopted combined solar plants that produce hot water, steam and heated air for technological needs. In this regard, we consider the energy balance, heat and mathematical calculation model used most effectively combined systems consisting of a flat field and parabolic cylindrical collectors in industrial enterprises.

2.1. Design features and the geometrical, optical and energetic parameters of the combined systems, consisting of flat fields and parabolic cylindrical collectors.

The main characteristic features of solar heating systems for industrial processes are the following:

- large scatter of the installed generating capacity of the units from 0.5 kW to 1000 kW or more and therefore modularity structures of large systems of this type;

- wide operating temperature range: $60 \div 100$ ° C - for hot water, $100 \div 170$ ° C - for low-temperature steam and $170 \div 300$ ° C - for medium temperature vapor;

- use of high flat (evacuated) and parabolic cylindrical hubs medium accuracy, increasing the concentration of sunlight in $25 \div 50$ times;

- the use of selectively coated with a heat sink vacuum transparent thermal insulation for operating temperatures of $150 \div 300$ ° C and more simple, but quite effective heat sink designs for operating temperatures $60 \div 150$ ° C;

- application of automation systems for tracking and management hubs power plant as a whole;

- the use of additional energy equipment: steam generators, heat doubles, steam turbines or heat engines, photo-thermoelectric and more.

Initial data for the selection of geometric, optical and energy parameters, as well as structural materials for composite systems consisting of flat fields and parabolic cylindrical collectors are required generating capacity, operating temperature, terrain and climate data used additional energy efficiency equipment. This takes into account the relationship of these parameters, technical and technological characteristics of the manufacturer, as well as economic opportunities for the consumer.

In general, the geometrical, optical and energy parameters of the combined systems composed of flat field and parabolic cylindrical collector depends on numerous factors, which requires optimization calculations for each selected

parameter. Currently, the most characteristic of solar combined systems used for heating industrial processes are approximately the following parameters: area - $10 \div 100 \text{ m}^2$, the mirror-reflective materials with a reflection coefficient - $0,85 \div 0,9$, the degree of concentration - $25 \div 50$; evacuated or simple selective collector with an absorption coefficient - $0,9 \div 0,95$ and emissivity $0,1 \div 0,5$, thermal efficiency - $0,4 \div 0,70$.

2.2. Energy balance of solar combined systems consisting of flat fields and reservoirs parabolic cylindrical industrial, municipal and agricultural purposes

On Fig.2.2.1 schematically shows the main energy losses in relation to the incident energy, radiation for **solar** combined systems consisting of flat fields and reservoirs parabolic cylindrical industrial, municipal and agricultural purposes. Shown that the main energy loss associated with the work plane and parabolic cylindrical collector connecting heat transfer loop, heat storage, steam generator, a heat engine, water-lifting pump, etc. These schemes energy balance are common, and can be regarded as typical for a large number of solar systems combined consisting of a flat field and parabolic cylindrical collectors of this type.

In general, the heat balance equation combined solar systems consisting of a flat field and parabolic cylindrical collectors for process heat can be written as:

$$Q_{nod}^{n.k.} = Q_{onm}^{nk} + Q_{nol}^{mex} + \sum Q_{men.n}, \quad (2.1)$$

where: Q_{nod}^{nk} - The amount of solar energy incident on the surface of the collector array (flat and parabolic cylindrical collector);

Q_{onm}^{nk} - optical loss from the surface of the field collectors (flat and parabolic cylindrical collector);

Q_{nol}^{mex} - the amount of useful heat for technological needs in the form of hot water or steam;

$$\sum Q_{men.n} = Q_{men.n}^{n\kappa} + Q_{men.n}^{II.\Gamma} + Q_{men.n}^{TP} \quad (2.3)$$

where: $Q_{men.n}^{II.\Gamma}$ - Loss of heat from the surface of the steam generator;

$Q_{men.n}^{TP}$ - Losses on the hot sections of the pipeline connecting the flat and parabolic cylindrical collector with a steam generator and a steam generator with the consumer.

The general expression for the heat balance equation water-pump (Fig. 2.1) operating system on the thermodynamic energy conversion:

$$Q_{nad}^{n.\kappa} = Q_{onm.n}^{n.\kappa} + Q_{men.n}^{n-\kappa} + Q_{men.l}^{mp} + Q_{men}^{ox.g} + Q_{men.n}^{n.M} + N_{\Sigma}^{n.M} + N_{\Sigma}^H + N_{\epsilon}, \quad (2.4)$$

where: $Q_{men.n}^{n.M}$ - Heat losses in the steam engine;

$Q_{men}^{ox.g}$ - Heat given off in the cooling water;

$N_{\Sigma}^{n.M}$, N_{Σ}^H - The total power loss in the steam engine and the pump as a result of mechanical, hydraulic or other losses;

N_{ϵ} - The power imparted to the water..

Overall efficiency of solar energy conversion by the thermodynamic cycle is defined as follows:

$$\eta_{полн} = \eta_{n.\kappa} \cdot \eta_{n.z} \cdot \eta_{mp} \cdot \eta_{n.M} \cdot \eta_H, \quad (2.5)$$

where: $\eta_{n.\kappa}$ - The efficiency of field collectors (flat and parabolic cylindrical collector);

$\eta_{n.z}$ - the efficiency of the steam generator;

η_{mp} - the efficiency of the pipeline;

$\eta_{n.M}$ - the efficiency of the steam engine;

η_H - efficiency of the pump.

2.3. Mathematical model for calculating the combined solar systems consisting of a flat field and parabolic cylindrical collectors for hot water supply for industrial and municipal enterprises

Most solar hot water systems combined industrial and municipal work by the thermal model shown in Fig.2.3.1, and consist of the following components: flat and parabolic cylindrical collectors, accumulator tank, circulating pumps and backup hot water system is supplied with hot water at $60 \div 100 \text{ }^\circ \text{C}$.

The hot water system is based on single-scheme, ie heated water in the flat and parabolic cylindrical collectors enters the storage tank of hot water. The water from the central water supply network into the lower part of the accumulator tank, and hot water for the selection processes is carried out from the top of the tank. Frost protection system is draining the water from the reservoir.

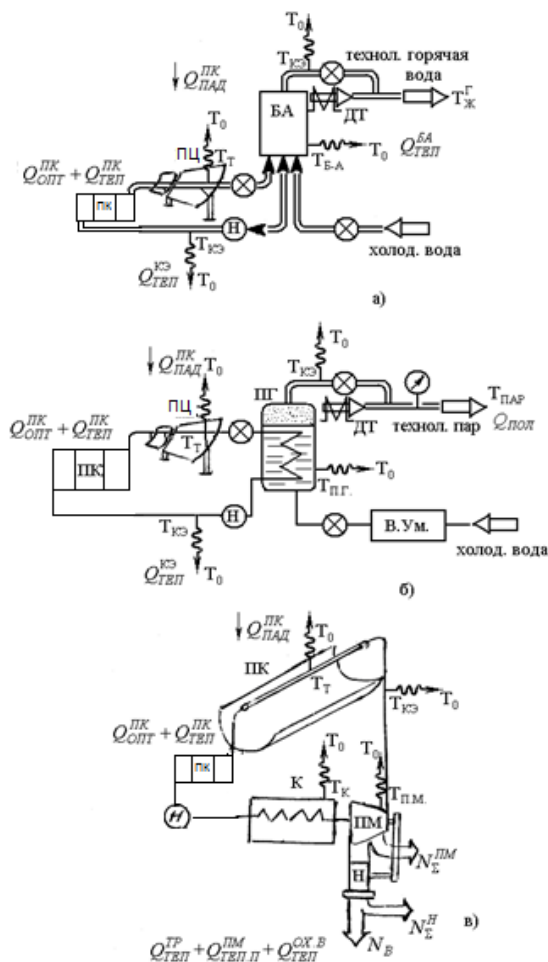


Fig.2.3.1. Combined solar hot water systems for industrial and municipal companies producing hot water (a), the pair (b), and water lift (in).

When the temperature drops below the desired operating water temperature for the process T_2^m included under study DT, which will heats up the water that flows from the storage tank.

After the system is as follows. The circulation of water through the collector box occurs if the equilibrium temperature absorbing surface temperature T_∞ of the heat more at the bottom of the accumulator tank by the amount Due to temperature T_B differences in the main pipelines of the loop ΔT ,

$$T_\infty \geq T_B + \Delta T \quad (2.6)$$

Selection of the hot water tank from the upper portion of the accumulator flow rate is carried out to places of demand. Of Fig.2.3.2 shows that consumption is defined as follows:

$$m_r = m_\Gamma^T \text{ при } T_B \leq T_\Gamma^T$$

at and the equality

$$m_r \cdot C_P \cdot T_B + (m_\Gamma^T - m_r) \cdot \zeta_P \cdot \tau_{x.б.} = m_\Gamma^T \cdot C_P \cdot T_\Gamma^T \quad (2.7)$$

define

$$m_r = m_\Gamma^T \frac{T_\Gamma^T - T_{x.б.}}{T_B - T_{x.б.}} \text{ при } T_B > T_\Gamma^T \quad (2.8)$$

where: T_Γ^T , m_Γ^T - Temperature and flow rate, defined schedule load process;

$T_{x.б.}$ - The temperature of the water recharge of the central water supply system.

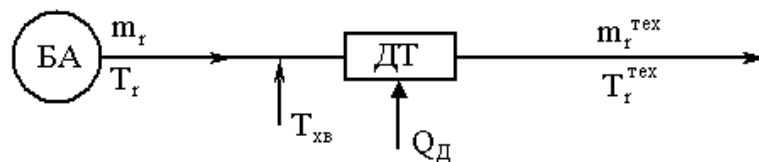


Fig.2.3.2 scheme for determining m_r

In describing the mathematical model of combined solar systems consisting of a flat field and parabolic cylindrical collector hot water following assumptions were made: neglect flow maldistribution between solar collectors; not taken into

account the loss of heat from the surface of the connecting lines; based on the results of preliminary calculations, neglect temperature gradient along the perimeter and heat loss by conduction to the heat sink supporting structural elements. These assumptions greatly simplify the mathematical model of the system, and consider the flat and parabolic cylindrical collectors as a single collector.

For its consideration of the energy balance in time, the estimated period of operation of the system is partitioned into N equal parts with step $\Delta\tau$, For each τ_i time points $(i=1,2,\dots,N)$ at the beginning of the step is considered a heat balance of each system element. However, the main dependence, used in the calculation of each component at time τ_i and the functional relationship between the elements listed below.

Block plane and parabolic cylindrical collectors. To determine the useful heat $Q_{\text{пол}}^{\text{нк}}$, Entering the tank battery from flat and parabolic cylindrical collectors, the equation of energy balance collector, expressed through the equilibrium temperature of the absorbing surface of collectors T_{∞} and temperature T_B at the bottom of tank

$$Q_{\text{пол}}^{\text{нк}} = F_3 \cdot F_R \cdot U_L \cdot C^{-1} (T_{\infty} - T_B) \quad (2.9)$$

The equilibrium temperature T_{∞} the absorbing surface of the collector is determined by formula (3)

$$T_{\infty} = T_O + \frac{E_O \cdot \eta_O \cdot K_{\text{зан}} \cdot C}{U_L}, \quad (2.10)$$

where: $K_{\text{зан}}$ - Coefficient reflecting the dusty surface of the field headers.

When calculating the flux density of direct solar radiation are used mainly modes of orientation flat and rotating around a horizontal axis North-South or East-West parabolic cylindrical collectors.

Heat loss associated with partial boiling and evaporation of water, determined by the formula:

$$Q_{\text{исп}}^{\text{ном.}} = Q_{\text{пол}}^{\text{нк}} - m_{\kappa} \cdot C_P (T_u - T_B) \quad (2.11)$$

where: T_u - Boiling point of water;

m_k - The water consumption in the circuit system.

Evaporated water flow is determined by the well-known formula:

$$m_u = Q_u / r. \quad (2.12)$$

In view of (2.2.5) water temperature at the outlet of the heat sink parabolic cylindrical collector is given by:

$$T_{\kappa}^{6blx} = T_B + \frac{Q_{nno} - Q_{ucn}^{nom}}{m_k C_P}. \quad (2.13)$$

In the final time τ_k the calculated use of the system are determined by the following quantities characterizing the energy balance in flat water heating collectors and parabolic cylindrical:

1. Summa incident (direct component) of solar radiation $Q_{nad} \sum$ perpendicular to the surface of the collector beams:

$$Q_{nad} \sum = \sum_{I=1}^N E_{oi} \cdot F_3 \cdot \Delta\tau \cdot 10^{-3}. \quad (2.14)$$

2. Summary solar energy $Q_{noz} \sum$, Absorbed in the field (heat sink) Collector:

$$Q_{noz} \sum = \sum_{I=1}^N E_{oi} \cdot F_3 \cdot \eta_o \cdot \Delta\tau \cdot 10^{-3}. \quad (2.15)$$

3. Summary optical losses in planar and parabolic cylindrical collectors

$$Q_{onm} \sum^{nom} = Q_{nad} \sum - Q_{noz} \sum. \quad (2.16)$$

4. Solar energy $Q_{noz} \sum_{\mu.H}$, Absorbed during operation of the circulation pump the water through the manifold. Value $Q_{noz} \sum_{\mu.H}$ determined using equation (2.2.8) when the condition $T_{\infty} \geq T_B + \Delta T$.

5. Total amount of heat $Q_{nol} \sum^{\mathcal{B}}$, Entering the storage tank of the flat collectors parabolic cylindrical

$$Q_{nol} \sum^{\mathcal{B}} = \sum_{i=1}^N Q_{noli}^{nk} \Delta\tau \cdot 10^{-3} = \sum_{i=1}^N [m_k - m_u] C_P [T_{\kappa}^{6blx} - T_B] \Delta\tau \cdot 10^{-3}. \quad (2.17)$$

6. Heat loss collectors $Q_{men}^{nom} \overline{m.c}$, Due to the inability of heat removal coolant absorbed solar radiation provided .

$$T_{\infty} < T_B + \Delta T .$$

$$Q_{men}^{nom} \overline{m.c} = Q_{noz} \overline{\Sigma} - Q_{noz} \overline{\Sigma} - Q_{noz} \overline{m.H} . \quad (2.18)$$

7. Total heat loss $Q_{men}^{nom} \overline{\Sigma}$ taking into account heat $Q_{men}^{nom} \overline{m}$ losses partially vaporized water at a rate of m_u

$$Q_{men}^{nom} \overline{\Sigma} = \sum_{i=1}^N \left[m_{ui} \cdot C_P \overline{\Sigma} (T_u - T_B) \right] + Q_{men}^{nom} \overline{m.c} \overline{\Delta\tau} \cdot 10^{-3} . \quad (2.19)$$

8. Heat loss in the reservoir when the pump:

$$Q_{men}^{nom} \overline{m.H} = Q_{noz} \overline{m.H} - Q_{noz} \overline{\Sigma} - Q_{men}^{nom} \overline{\Sigma} . \quad (2.20)$$

Heat storage tank . To simplify the mathematical model of an accumulator tank heat balance equation can be written without heat stratification and heat loss from the surface of the tank:

$$M_B \cdot F_3 \cdot C_P \frac{dT_B}{d\tau} = \left[m_k - m_u \right] \overline{\Sigma} \left[\overline{m.k} - T_B \right] + \left[m_r + m_u \right] \overline{\Sigma} \left[T_{x.6} - T_B \right] . \quad (2.21)$$

where: M_B - The weight of water in the storage tank 1 m² of collector area, kg/m².

Integrating (2.21) in the Eulerian model, we determine the T_{Bi+1} temperature water at the time of step:

$$T_{Bi+1} = T_{Bi} + \frac{\Delta\tau}{M_B \cdot F_3} \left[\left[m_k - m_u \right] \overline{\Sigma} \left[\overline{m.k} - T_{Bi} \right] + \left[m_r + m_u \right] \overline{\Sigma} \left[T_{x.6} - T_{Bi} \right] \right] . \quad (2.22)$$

Stand-in hot water . Total amount of energy $Q_{II} \overline{\Sigma}$, Expended to reheat water backup circuit load to a temperature T_{II}^T over the estimated period of operation of the system is determined by the formula:

$$Q_{II} \overline{\Sigma} = \sum_{i=1}^N \left[m_{II}^T \cdot C_P \left[T_{II}^T - T_{Bi} \right] \overline{\Sigma} \Delta\tau \cdot 10^{-3} \right] . \quad (2.23)$$

Circuit load hot water. total amount of energy $Q_{h \Sigma}$, To be allowed to the consumer with m_{Γ}^T , flow load Determined by the following equation:

$$Q_{h \Sigma} = \sum_{i=1}^N \left[m_{\Gamma}^T \cdot C_P \cdot \Delta \tau (T_{\Gamma}^T - T_{x.6}) \right] \cdot 10^{-3} = Q_{h \text{sym}} \cdot N_{\vartheta} \quad (2.24)$$

where: $Q_{h \text{sym}}$ - Daily heat load hot water, kWh / day;

N_{ϑ} - The number of days during the period of system operation, day / year.

In addition, a finite time τ_k , Determined by the total amount of solar heat input to the load of the system and provides for the use of solar energy.

$$Q_c \Sigma = \sum_{i=1}^N \left[q_r \cdot C_P (T_B - T_{x.6}) \Delta \tau \cdot 10^{-3} \right] \quad (2.25)$$

According to the above heat developed here and mathematical models are a software package for the calculation and optimization modes combined systems based on experimental and calculated parameters determination parabolic cylindrical flat and collectors in a wide range of operating conditions

CHAPTER III. DEVELOPMENT OF AN EXPERIMENTAL COMBINED SOLAR INSTALLATION CONSISTING OF FLAT FIELD AND HEAT FOR COLLECTORS PARABOLIC CYLINDRICAL PROCESS INDUSTRIAL ENTERPRISES

3.1. Purpose and brief technical description of the combined systems, consisting of a flat field and parabolic cylindrical collectors

The efficiency of solar systems can be improved by combining, i.e. focusing and using flat collectors together. In this regard, the objective of the project is to develop and study the combined solar power plant, consisting of flat and parabolic cylindrical collectors for heating process industries.

On Fig.3.1.1. shows a schematic diagram of the proposed combined solar power plant, consisting of flat and parabolic cylindrical collectors.

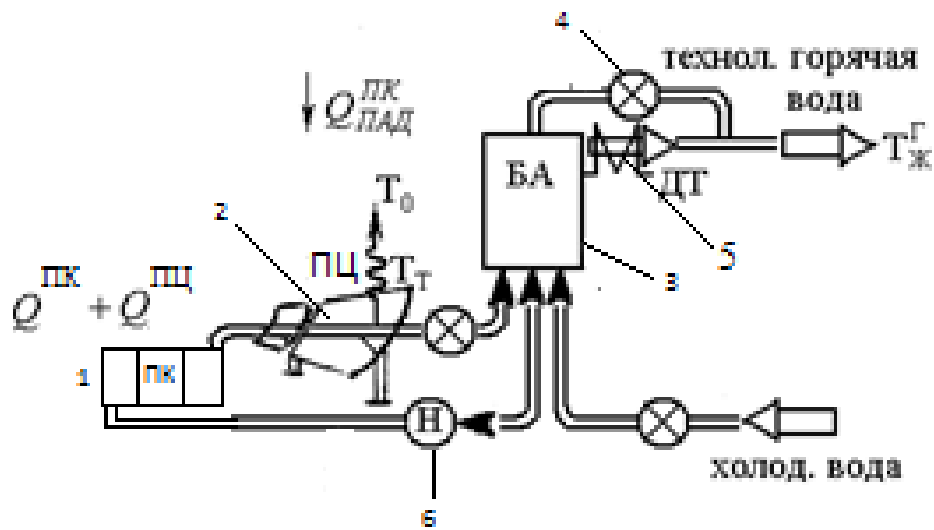


Fig. 3.1.1. Scheme combined solar power plant, consisting of flat and parabolic cylindrical collectors: 1 - flat plate collectors; 2 - parabolic cylindrical collector; 3 - storage tank; 4 - valve; 5 - understudy temperature; 6 - The water pump

The principle of the combined solar installation is as follows: Water is heated to a temperature of flat collectors 40-60 ° C, then fed to parabolic cylindrical concentrators, where the operating temperature may reach 150-300 ° C. It is necessary to set the optimum field (comprising approximately 60% and 40% of flat focusing).

Combined systems consist of solar collectors - parabolic cylindrical, vacuum or flat plate collectors, battery-tank thermal understudy to raise the temperature of the water pump for circulating fluid.

1. Flat-plate collectors. They consist of an absorbent element, a thermally insulating layer and a transparent (glass) coatings. These collectors can heat water to a temperature of 200 degrees (stagnation of the system). However, the operating temperature of flat collectors from 40-60 ° C.

2. Vacuum collectors. Consists of heat pipes, which in structure resemble a thermos, but with clear outer part of the tube. The inside of the tube is coated with a special substance that absorbs sunlight. Also, the tube can act as a heat conductor. Such tubes in the lower portion contains water, which is heated and converted into steam. Vacuum collectors can heat water up to 250-300 degrees (with a limited selection of heat), and to the boiling point at negative ambient temperature, the operating temperature of 60-80 ° C.

3. Parabolic cylindrical collector. Parabolic cylindrical parabolic cylindrical collector consists of a hub of the heat flow type and automatic tracking of the sun. The concentrator increases the efficiency of the collector is several times.

Principle of operation of the solar collector. Solar collectors absorb solar radiation and convert it into heat. Heat is transferred into the tube of collectors, in which water circulates. Water is gradually heated during the day, until it reaches the desired temperature, providing heat and hot water facility.

Heating system and hot water through the solar collector consists of the following elements:

1. Collector
2. Sunny Drive
3. Management station controller or pump unit
4. Expansion tank
5. Coolant (water or antifreeze)
6. Plumbing and heating systems.

Solar collectors to allow for hot water (up to 80%) and heat (up to 50%) due to solar energy to provide hot water to 100% in the summer. These figures may vary, depending on the type of solar collector and storage. But in any case, solar collectors can significantly reduce the consumption of electricity and gas.

Providing facility heating and hot water using solar collectors consists of the following stages:

1. Study object, determination of the needs of the object in the hot water and heating systems, in determining the need for additional measures - insulation object pipeline replacement and heating system, and so on;
2. Selection reservoir and other system components;
3. Drafting and other technical documentation;
4. Acquisition of equipment;
5. Mounting system;
6. Commissioning, commissioning of the object;
7. Guarantee service.

In solar water heating systems use special coolants. The basic requirements for such coolants: freezeproof to $-30\text{ }^{\circ}\text{C}$ and heat resistance up to $+200\text{ }^{\circ}\text{C}$. The most commonly used heat transfer fluids based on propylene glycol. This is due to non-toxicity of propylene glycol (a food additive E1520) and meet all the stated requirements. For high heliosystem (above $300\text{ }^{\circ}\text{C}$) are special types of coolants based salt solutions, silicone oil or coolants. If it is water, its temperature can reach 200 degrees - that is enough for the process, consuming about a third of all the heat consumed in the industry. If used as a heating medium oil, the operating temperature of the output hub can be increased to 400 degrees.

High-oil thermal oil, workable in the range $280\text{-}320\text{ }^{\circ}\text{C}$, are the products of deep processing of oil, which is achieved due to the technological processes of high aromatic content. Therefore, these oils often abbreviated as AMT (flavored thermal oil), and then the next number indicates the approximate maximum permissible temperature of prolonged use. Are organic heat carrier oils : mineral and synthetic, for use in closed (vacuum) and Deck (bath, double boiler) loop. Temperature range in which various coolants varies from $-115\text{ }^{\circ}\text{C}$ to about $410\text{ }^{\circ}\text{C}$. When choosing an oil-coolant must focus on the recommended temperature range of use, that best illustrates the technological processes of production. Coolants are long term, if they operate under normal conditions and temperatures no higher than

recommended. However, in practice, the shelf life of the liquid depends on many factors: the presence or absence of temperature gradients in the system, the uniformity of heating of various parts of the system, the absence of contact with air in the expansion chamber. In a properly designed and functioning coolant system is a few years. Heat transfer fluids may be used in both liquid and vapor phase.

When transferring heat via organic coolants are used mineral and synthetic oils. Maximum temperature reached during the application of synthetic oils is about 410 ° C. Equipment such coolants is an ideal basis for the use of heat in various industrial processes.

3.2. Development of combined solar experimental setup consisting of a flat field and parabolic cylindrical collectors for heating process industries.

In Fergana Polytechnic Institute on schedule project developed an experimental model of combined solar heating systems for industrial processes.

On helio range Institute is in experimental operation parabolic cylindrical power module installation and flat plate collectors designed (Figure 3.1.1). On installation explores opportunities to work together and parabolic cylindrical flat collectors.

Solar energy module installation parabolic cylindrical main structural component of the energy module is parabolic cylindrical hub. The frame hub (Fig.3.2.1.) Is a bearing frame V-shaped cross section, which are units for exhibitions and lodgments fastening and fixing the reflecting coating. Parabolic cylindrical hub shell formed elastically curved cradles made of stainless steel sheet 2 mm thick. Lodgments over stacked and secured by special side clamps gloss aluminum sheets. Dimensions aperture mirror 1,7×5 m, focal length 650mm, aperture angle - 120 °C. Hub with heat receiving suspended on

two welded farms to ensure its installation at a predetermined angle to the horizon. Weight power module - 257 kg



Fig. 3.2.1. Frame parabolic cylindrical Hub

In the focal plane of the hub with three adjustable racks installed solar receiver flow type. Given the fact that this unit is designed for low operating temperatures (110-130 °C), using simple and tech design of the heat. The receiver is a steel pipe with an outer diameter of 42 mm, covered with heat-resistant black paint KO 819 with an absorption coefficient of solar radiation $A_s = 0.91$.



Fig.3.2.2. A heat energy module installation parabolic cylindrical

For a heat insulation placed in a tube of a glass with molybdenum $d_H=70$ mm, a wall thickness $\delta=1\div 1,5$ mm. In the non-irradiated sector gap between the heat receiving and glass tubes filled with insulating material - asbestos; outside the glass tube is coated with polyurethane foam. Power module is equipped with

an automatic solar tracking. Test results module showed that the average energy density of sunlight reflector $K_{CP} = 24$ and an average thermal efficiency module $\eta_T=40\%$ at an operating temperature up to $T = 200^\circ \text{C}$ (Fig.3.2.3).



Fig. 3.2.3. Parabolic cylindrical energy module installation.

Installation is very simple circuit (Fig. 3.2.3.). She single-circuit, with one coolant. Power module is placed horizontally and is oriented east-west direction. Scheme installation horizontal optical axis has significant advantages, particularly simplified construction and supports components of the apparatus for tracking the sun.

Fig. 3.2.4. shows typical curves of the distribution of the radiant flux reflected by three mirrors measured микро фото датчик. It can be seen that the maximum density of the radiant flux E_{max} in the center of the focal image at

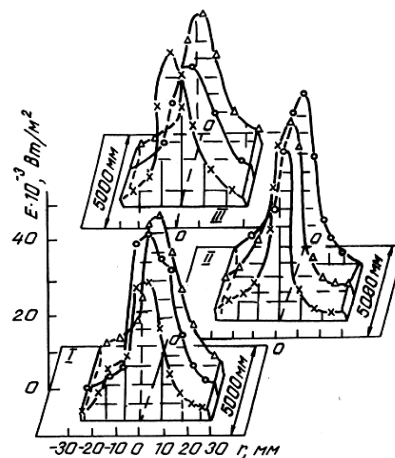


Fig. 3.2.4. Typical curves of the distribution of the radiant flux reflected from the three mirrors

$E_{\max} E_0 = 690 \div 730 \text{ W / m}^2$ is $50 \cdot 10^3 \div 54 \cdot 10^3 \text{ W / m}^2$. Capture coefficient of radiant flux is also quite high - $0,92 \div 0,96$, which confirms the choice of the diameter of the receiver. The average degree of power concentration of $K_3 = 34$. Results calorimetric position forced flow of water through the receiver at a constant rate allowed us to determine the thermal efficiency in different modes depending on the amount of direct solar radiation and other environmental parameters. From Fig. 3.2.5. shows that the thermal efficiency of the plant in operating conditions - $42 \div 43\%$, can thus be obtained to 3 kW of heat.

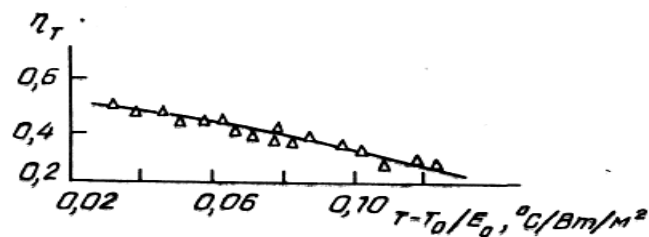


Fig. 3.2.5. The thermal efficiency of the solar energy module parabolotsilindricheskoy устанoвки

Power module installation parabolic cylindrical also tested in conjunction with a cheap and simple conical heater, providing an initial heating water to a temperature of $40\text{-}50^\circ\text{C}$ with capacity of 500 liters per day. Teamwork combined system is shown in Fig. 3.2.6.



Fig. 3.2.6. Combined system collaboration parabolic cylindrical manifold with conical cylinder

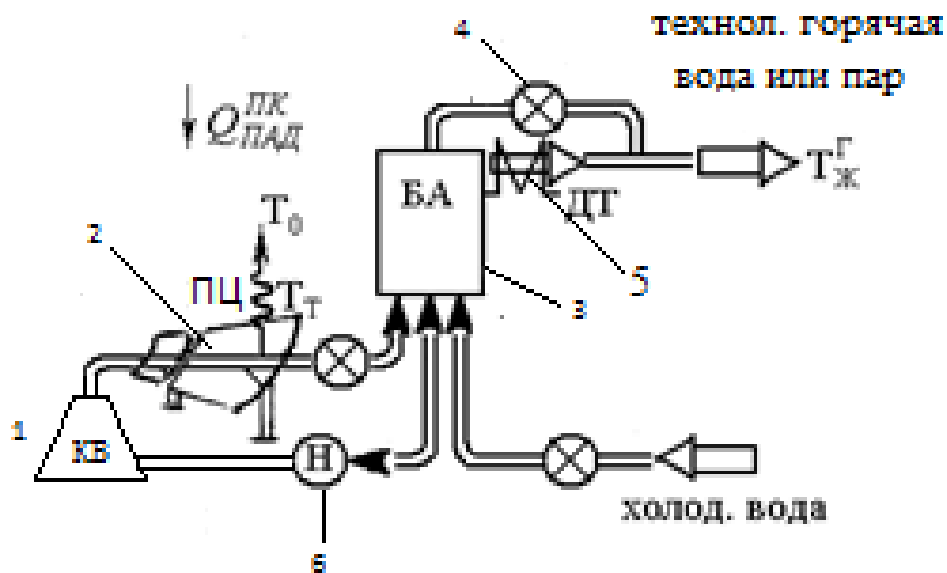


Fig. 3.2.7. Thermal circuit combined with a conical heater installation and parabolotsilindricheskim collector for hot water technology

In Fergana Polytechnic Institute under the State grant № 13-024 entitled "Research and creation of energy efficient solar water collectors" developed and investigated a simpler and cheaper design flat solar collector (Fig.3.2.8.). Joint test of this type of flat-plate collector with parabolic cylindrical collector. Wide operating temperature range: $60 \div 100^{\circ} \text{C}$ - hot water, $100 \div 170^{\circ} \text{C}$ - for low-temperature steam and $170 \div 300^{\circ} \text{C}$ - for a couple of average temperatures

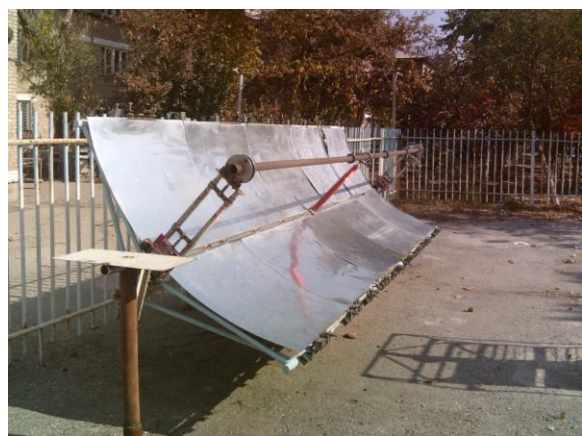


Fig. 3.2.8. General view of the flat solar collector

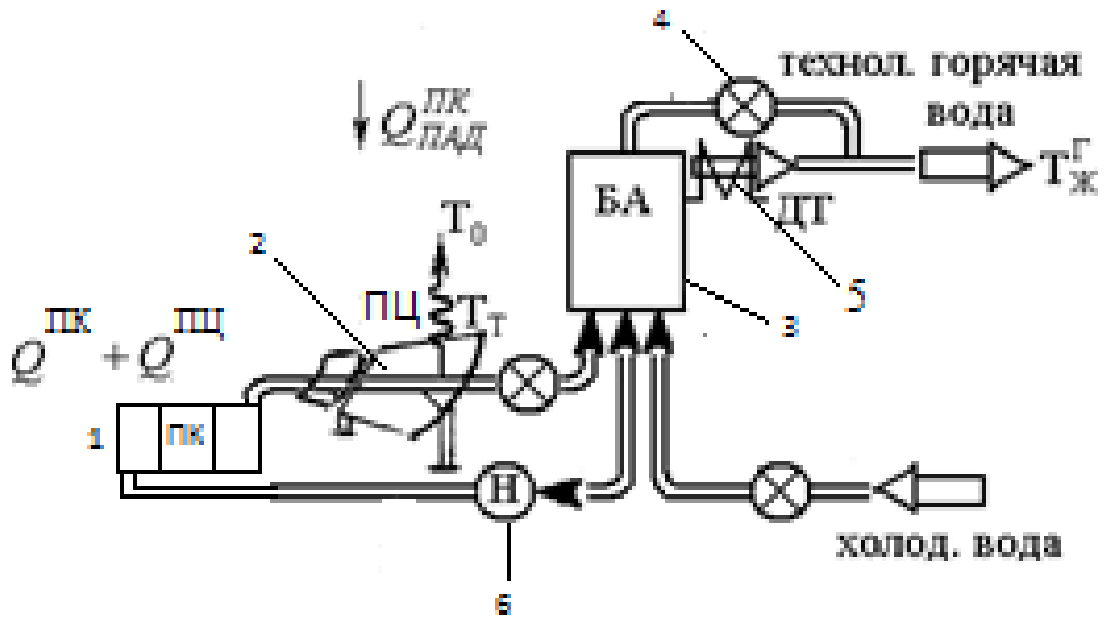


Fig.3.2.9. Thermal Design of the combined plant with flat and parabolic cylindrical collectors for hot water technology

3.3. Development of a software package for the calculation and optimization of combined systems

On the basis of analysis and systematization of the energy balance, creating heat and mathematical models combined solar energy system consisting of flat and parabolic cylindrical collectors developed a software package for the calculation and optimization modes combined systems based on experimental and calculated parameters determination of their constituent elements in the main a wide range of operating conditions; including geometric-optical, thermal parameters and the flat-plate collector parabolic cylindrical hub, as well as temperature control system as a whole. Annex 1-2 shows text and preliminary results of calculations of the individual elements of the combined system by a computer program developed in the language of MATLAB.

In industry and municipal services most widely adopted combined solar plants that produce hot water, steam and heated air for technological needs. In

this regard, are actual energy balance, heat and mathematical calculation model used most effectively combined systems consisting of a flat field and parabolic cylindrical collectors in industrial enterprises [3-6].

Analysis and systematization of energy balance, creating heat and mathematical models combined solar energy system consisting of flat and parabolic cylindrical collectors developed a software package for the calculation and optimization modes combined systems based on experimental and calculated parameters determination of their constituent basic elements in a wide range operating conditions; including geometric-optical, thermal parameters and the flat-plate collector parabolic cylindrical hub, as well as temperature control system as a whole.

The program displays data dependencies resulting from calculations with respect to certain input parameters. Four input parameters: solar radiation (in the program referred to as E_0), the area of the hub (denoted as S_p), the pipe temperature (denoted as t_t) and wind speed (denoted as v). Data obtained from calculations are useful heat (q_{pol}) and collector efficiency (k_{pd}).

Description of the structure of the program.

The program consists of four modules:

1. Main - main module in which laid down the principle of construction schedules
2. Data - module linking external database data ("Base.mdb") with the program.
3. Graf - designed for setting construction schedule.
4. Firmul-
designed for obtain text data, and also submitted Data in external database data.

The module firmul laid following formula for calculating the required data:

$$A = \frac{0.6 \cdot B_1 \cdot \left(\frac{d_C - d_T}{2} \right)^{0.75} T_T^{0.25}}{\ln \frac{d_C}{d_T} + 5.5 \cdot d_T \cdot \varepsilon_{T.C.} \cdot 10^{-8} \cdot T_T^3 + d_C \left[\alpha_{C.O} + 0.044 \varepsilon_{C.O} \cdot 10^{-8} (T_T + 4T_0)^3 \right]}$$

$$T_C = T_T - \frac{T_T - T_0}{1 + A}$$

$$\lambda_{\text{ЭKB}} = B_1 \cdot \left(\frac{d_C - d_T}{2} \right)^{0.75} \cdot (T_T - T_C)^{0.25}$$

$$\alpha_1 = \frac{2\lambda_{\text{ЭKB}}}{\ln \frac{d_C}{d_T}} + 4\varepsilon_{T.C.} \cdot \sigma \cdot d_T \left(\frac{T_T + T_C}{2} \right)^3$$

$$\alpha_2 = \alpha_{C.O} + 4\varepsilon_{C.O} \cdot \sigma \left(\frac{T_C + T_0}{2} \right)^3$$

$$\alpha_3 = \alpha_{H3.O} + 4\varepsilon_{H3.O} \cdot \sigma \left(\frac{T_{H3} + T_0}{2} \right)^3$$

$$\alpha'_{\text{ЭKB}} = \frac{\alpha_1 \cdot \alpha_2 \cdot d_C}{\alpha_1 + \alpha_2 \cdot d_C}$$

$$\alpha''_{\text{ЭKB}} = \frac{2 \cdot \lambda_{H3} \cdot \alpha_3 \cdot d_C}{2 \cdot \lambda_{H3} + \alpha_3 \cdot d_C \cdot \ln \frac{d_C}{d_T}}$$

$$\alpha_{\text{ЭKB}} = \alpha'_{\text{ЭKB}} + 2\alpha''_{\text{ЭKB}}$$

$$Q_{\text{ПОР}} = E_0 \cdot F_3 \cdot R_3 \cdot \eta_y \cdot \eta_{\text{ЗАТ}} \cdot \tau_{T.C.} \cdot A_S$$

$$Q_{\text{ПОЛ}} = Q_{\text{ПОР}} - \alpha_{\text{ЭKB}} \frac{\pi (T_T - T_0)^3}{3}$$

$$\eta_{\text{УСТ}} = \frac{Q_{\text{ПОЛ}}}{E_0 \cdot F_3}$$

Restrictions independent input parameters:

- For solar radiation - 600 - 1000 W / m² in increments of 100 W / m².
- For pipe temperature - 50 - 150 °C with step change of 50 °C
- Hub for the area - 10 - 50 m² with step change of 10 m².
- For wind speed - 1 - 5 m / s with a step change of 1 m / a

With all the possible initial data can be obtained 375 results of calculations of useful heat

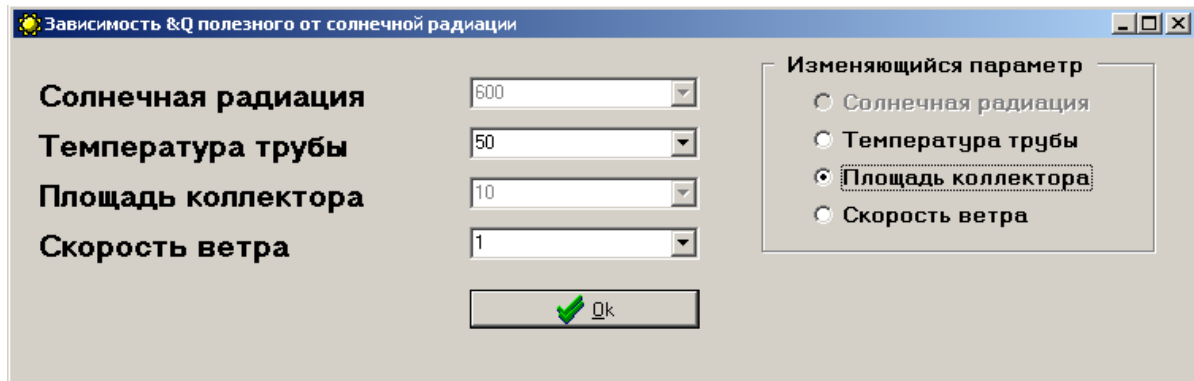


Fig. 3.3.1 Source data

On Fig.3.3.2. shows the results of calculation of the energy parameters parabolic cylindrical collector using a computer model developed

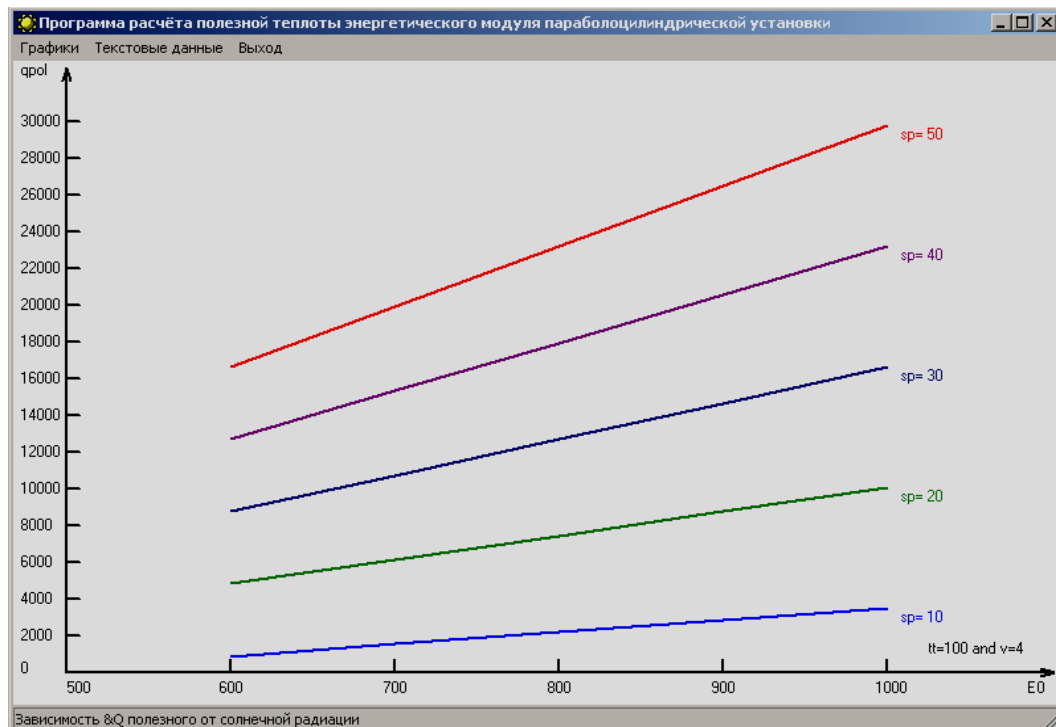


Fig. 3.3.2 The dependence of Q useful heat according to the incident solar radiation.

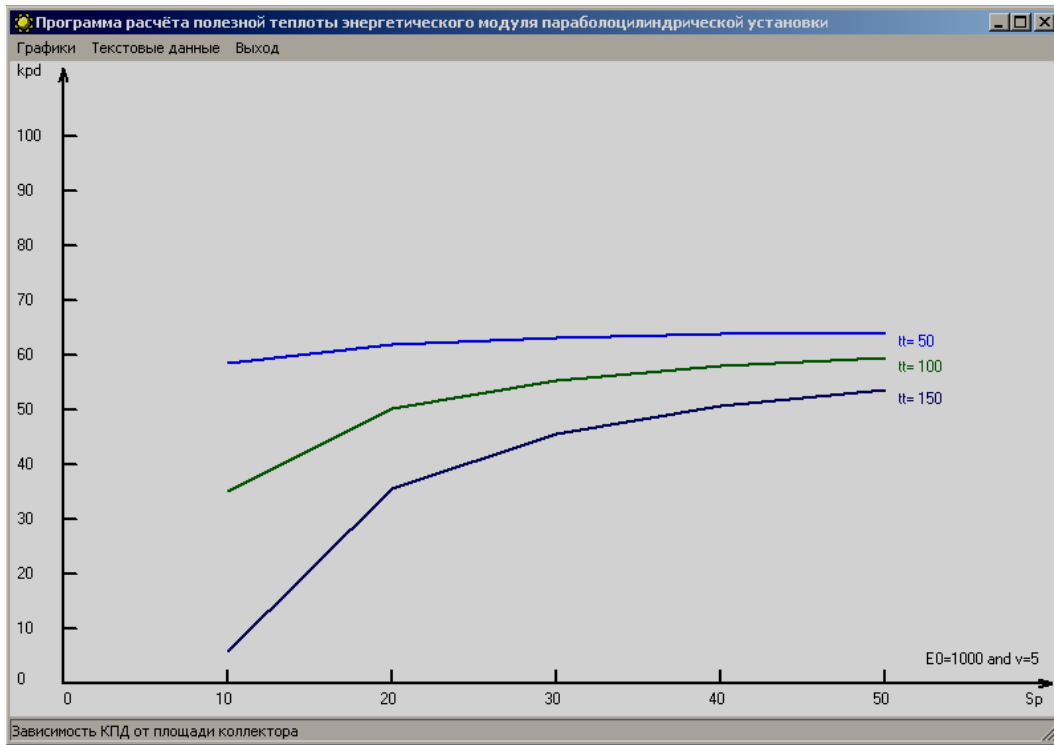


Fig. 3.3.3. Dependence of the efficiency of the collector area parabolic cylindrical

In general, based on the established computer model can be calculated and optimized modes combined systems based on experimental and calculated parameters determination parabolic cylindrical flat and collectors, as well as a wide range of operating conditions.

Conclusion

1. Currently, the most efficient use of solar energy for industry and public utilities in the form of hot water, steam and heated air at low and medium temperatures (40-400 ° C). This temperature level can be achieved by using a combined solar systems consisting of a flat field and parabolic cylindrical collectors.

2. Greatest success in providing a warm industrial objects attained by the combined solar systems consisting of a flat field and parabolic cylindrical collectors for hot water supply of industrial and utility companies in the United States. In several other countries, including the CIS, these works are just beginning to develop. Demonstration plants are created, conducted their trial tests, and the results of tests to develop new projects practically applicable settings.

3. Due to the simplicity of design and high efficiency solar combined systems consisting of flat fields and parabolic cylindrical collectors can become a universal tool for large-scale deployment of solar energy in industry, waste and agriculture.

4. Analysis of design features, geometrical, optical and energy parameters for solar heating process industries are the following:

a) a large scatter of the installed generating capacity of the units from 0.5 kW to 1000 kW or more;

b) a wide operating temperature range: 60 ÷ 100 ° C - hot water, 100 ÷ 170 ° C - for low-temperature steam and 170 ÷ 200 ° C - for medium temperature vapor;

c) the use of high efficiency flat-plate collectors and concentrators parabolic cylindrical medium accuracy, increasing the concentration of sunlight in 25 ÷ 50 times;

g) The application of selectively coated with a heat sink with a transparent vacuum thermal insulation for operating temperatures of 150 ÷ 300 ° C and a simple but quite effective heat sink designs for operating temperatures 60 ÷ 150 ° C;

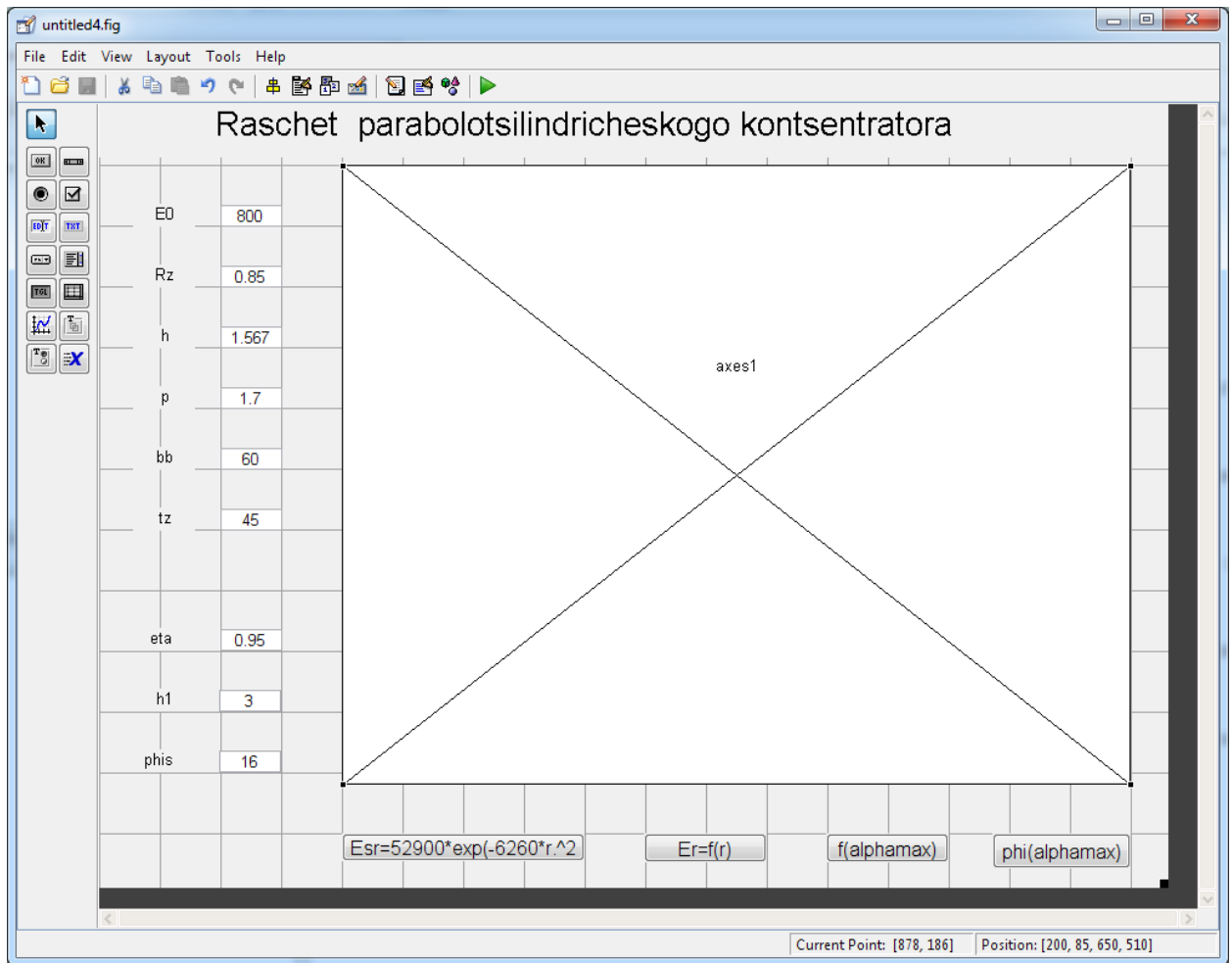
- d) the use of automation for tracking systems hubs and control of the power plant, as a whole;
- e) use of additional energy equipment: steam generators, heat doubles, steam turbines or heat engines, photo-thermal generators, etc.

5. Based on the analysis and systematization of the energy balance, created heat and mathematical model for calculating the combined system consisting of flat fields and parabolic cylindrical collectors for heating industrial processes

6. Based on the developed mathematical models of heat and developed a software package for the calculation and optimization modes combined systems based on experimental and calculated parameters determination parabolic cylindrical flat and collectors, as well as a wide range of operating conditions.

7. Designed and constructed an experimental model of combined solar installation consisting of flat fields and parabolic cylindrical collectors for heating industrial processes, and made preliminary tests on helio range FerPI.

Application
 Application 1
Calculation parabolic cylindrical concentrator with use
Programs MATLAB



function varargout = untitled4(varargin)

% UNTITLED4 M-file for untitled4.fig

% UNTITLED4, by itself, creates a new UNTITLED4 or raises the existing
 % singleton*.

%

% H = UNTITLED4 returns the handle to a new UNTITLED4 or the handle
 to

% the existing singleton*.

```

%
% UNTITLED4('CALLBACK',hObject,eventData,handles,...) calls the local
% function named CALLBACK in UNTITLED4.M with the given input
arguments.
%
% UNTITLED4('Property','Value',...) creates a new UNTITLED4 or raises
the
% existing singleton*. Starting from the left, property value pairs are
% applied to the GUI before untitled4_OpeningFunction gets called. An
% unrecognized property name or invalid value makes property application
% stop. All inputs are passed to untitled4_OpeningFcn via varargin.
%
% *See GUI Options on GUIDE's Tools menu. Choose "GUI allows only
one
% instance to run (singleton)".
%
% See also: GUIDE, GUIDATA, GUIHANDLES

% Edit the above text to modify the response to help untitled4

% Last Modified by GUIDE v2.5 03-Nov-2012 14:02:47

% Begin initialization code - DO NOT EDIT
gui_Singleton = 1;
gui_State = struct('gui_Name',    mfilename, ...
    'gui_Singleton', gui_Singleton, ...
    'gui_OpeningFcn', @untitled4_OpeningFcn, ...
    'gui_OutputFcn', @untitled4_OutputFcn, ...
    'gui_LayoutFcn', [] , ...
    'gui_Callback', []);

```

```

if nargin & isstr(varargin{1})
    gui_State.gui_Callback = str2func(varargin{1});
end

if nargin
    [varargout{1:nargout}] = gui_mainfcn(gui_State, varargin{:});
else
    gui_mainfcn(gui_State, varargin{:});
end
% End initialization code - DO NOT EDIT

% --- Executes just before untitled4 is made visible.
function untitled4_OpeningFcn(hObject, eventdata, handles, varargin)
% This function has no output args, see OutputFcn.
% hObject    handle to figure
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
% varargin   command line arguments to untitled4 (see VARARGIN)

% Choose default command line output for untitled4
handles.output = hObject;

% Update handles structure
guidata(hObject, handles);

% UIWAIT makes untitled4 wait for user response (see UIRESUME)
% uiwait(handles.figure1);

% --- Outputs from this function are returned to the command line.
function varargout = untitled4_OutputFcn(hObject, eventdata, handles)

```

```

% varargout cell array for returning output args (see VARARGOUT);
% hObject handle to figure
% eventdata reserved - to be defined in a future version of MATLAB
% handles structure with handles and user data (see GUIDATA)

% Get default command line output from handles structure
varargout{1} = handles.output;

% --- Executes during object creation, after setting all properties.
function edit1_CreateFcn(hObject, eventdata, handles)
% hObject handle to edit1 (see GCBO)
% eventdata reserved - to be defined in a future version of MATLAB
% handles empty - handles not created until after all CreateFcns called

% Hint: edit controls usually have a white background on Windows.
% See ISPC and COMPUTER.
if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end

function edit1_Callback(hObject, eventdata, handles)
% hObject handle to edit1 (see GCBO)
% eventdata reserved - to be defined in a future version of MATLAB
% handles structure with handles and user data (see GUIDATA)
% Hints: get(hObject,'String') returns contents of edit1 as text
% str2double(get(hObject,'String')) returns contents of edit1 as a double

% --- Executes during object creation, after setting all properties.

```

```

function edit2_CreateFcn(hObject, eventdata, handles)
% hObject    handle to edit2 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    empty - handles not created until after all CreateFcns called
% Hint: edit controls usually have a white background on Windows.
%         See ISPC and COMPUTER.
if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end

```

```

function edit2_Callback(hObject, eventdata, handles)
% hObject    handle to edit2 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Hints: get(hObject,'String') returns contents of edit2 as text
%        str2double(get(hObject,'String')) returns contents of edit2 as a double

```

```

% --- Executes during object creation, after setting all properties.
function edit3_CreateFcn(hObject, eventdata, handles)
% hObject    handle to edit3 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    empty - handles not created until after all CreateFcns called

% Hint: edit controls usually have a white background on Windows.
%         See ISPC and COMPUTER.
if ispc
    set(hObject,'BackgroundColor','white');

```

```

else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end

```

```

function edit3_Callback(hObject, eventdata, handles)

```

```

% hObject handle to edit3 (see GCBO)

```

```

% eventdata reserved - to be defined in a future version of MATLAB

```

```

% handles structure with handles and user data (see GUIDATA)

```

```

% Hints: get(hObject,'String') returns contents of edit3 as text

```

```

% str2double(get(hObject,'String')) returns contents of edit3 as a double

```

```

% --- Executes on button press in pushbutton1.

```

```

function pushbutton1_Callback(hObject, eventdata, handles)

```

```

% hObject handle to pushbutton1 (see GCBO)

```

```

% eventdata reserved - to be defined in a future version of MATLAB

```

```

% handles structure with handles and user data (see GUIDATA)

```

```

h1=findobj(gcf,'tag','edit1'); E0=str2num(get(h1,'string')); % ВВОД ИСХОДНЫХ

```

```

h2=findobj(gcf,'tag','edit2'); Rz=str2num(get(h2,'string')); % ДАННЫХ

```

```

h3=findobj(gcf,'tag','edit3'); h=str2num(get(h3,'string'));

```

```

h4=findobj(gcf,'tag','edit4'); p=str2num(get(h1,'string')); % ВВОД ИСХОДНЫХ

```

```

h5=findobj(gcf,'tag','edit5'); bb=str2num(get(h2,'string')); % ДАННЫХ

```

```

h6=findobj(gcf,'tag','edit6'); tz=str2num(get(h3,'string'));

```

```

    b=p*tz/(1+cos(bb))

```

```

    r=-0.0883:0.001:0.0883;

```

```

    plot(r,52900*exp(-6260*r.^2)); grid on % построение графика

```

```

% --- Executes during object creation, after setting all properties.

```

```

function edit4_CreateFcn(hObject, eventdata, handles)
% hObject    handle to edit4 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    empty - handles not created until after all CreateFcns called

% Hint: edit controls usually have a white background on Windows.
%       See ISPC and COMPUTER.
if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end

```

```

function edit4_Callback(hObject, eventdata, handles)
% hObject    handle to edit4 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Hints: get(hObject,'String') returns contents of edit4 as text
%       str2double(get(hObject,'String')) returns contents of edit4 as a double

```

```

% --- Executes during object creation, after setting all properties.
function edit5_CreateFcn(hObject, eventdata, handles)
% hObject    handle to edit5 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    empty - handles not created until after all CreateFcns called

% Hint: edit controls usually have a white background on Windows.
%       See ISPC and COMPUTER.

```

```

if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end

```

```

function edit5_Callback(hObject, eventdata, handles)
% hObject    handle to edit5 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Hints: get(hObject,'String') returns contents of edit5 as text
%        str2double(get(hObject,'String')) returns contents of edit5 as a double

```

```

% --- Executes during object creation, after setting all properties.
function edit6_CreateFcn(hObject, eventdata, handles)
% hObject    handle to edit6 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    empty - handles not created until after all CreateFcns called

```

```

% Hint: edit controls usually have a white background on Windows.
%       See ISPC and COMPUTER.

```

```

if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end

```

```

function edit6_Callback(hObject, eventdata, handles)

```

```

% hObject handle to edit6 (see GCBO)
% eventdata reserved - to be defined in a future version of MATLAB
% handles structure with handles and user data (see GUIDATA)

% Hints: get(hObject,'String') returns contents of edit6 as text
% str2double(get(hObject,'String')) returns contents of edit6 as a double

% --- Executes on button press in pushbutton2.
function pushbutton2_Callback(hObject, eventdata, handles)
% hObject handle to pushbutton2 (see GCBO)
% eventdata reserved - to be defined in a future version of MATLAB
% handles structure with handles and user data (see GUIDATA)
h1=findobj(gcf,'tag','edit1'); E0=str2num(get(h1,'string'));
h2=findobj(gcf,'tag','edit2'); Rz=str2num(get(h2,'string'));
h3=findobj(gcf,'tag','edit3'); h=str2num(get(h3,'string'));
h4=findobj(gcf,'tag','edit4'); p=str2num(get(h1,'string'));
h5=findobj(gcf,'tag','edit5'); bb=str2num(get(h2,'string'));
h6=findobj(gcf,'tag','edit6'); tz=str2num(get(h3,'string'));
    b=p*tz/(1+cos(bb))
C2=(180*h*(1+cos(b))/(3.14*p))^2
Emax=50000
C2=6286.002199
r=-0.03:0.001:0.03
Esr=Emax*(1-exp(-C2*r.^2))/2./r./sqrt(C2)

plot(r,Esr)
axis([-0.03 0.03 -16000 16000])
Ksr=Esr/E0

% --- Executes on button press in pushbutton3.

```

```

function pushbutton3_Callback(hObject, eventdata, handles)
% hObject    handle to pushbutton3 (see GCBO)
% eventdata reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
h7=findobj(gcf,'tag','edit7'); eta=str2num(get(h7,'string')); % ВВОД ИСХОДНЫХ
h8=findobj(gcf,'tag','edit8'); h=str2num(get(h8,'string')); % ДАННЫХ
h9=findobj(gcf,'tag','edit9'); phis=str2num(get(h9,'string'));

alphamax=0:90
falphamax=(1./tan(alphamax./2.*pi/180)).*(alphamax.*pi/180+tan(alphamax./2.
*pi/180))
plot(alphamax,falphamax)

% --- Executes on button press in pushbutton4.
function pushbutton4_Callback(hObject, eventdata, handles)
% hObject    handle to pushbutton4 (see GCBO)
% eventdata reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
h7=findobj(gcf,'tag','edit7'); eta=str2num(get(h7,'string')); % ВВОД ИСХОДНЫХ
h8=findobj(gcf,'tag','edit8'); h=str2num(get(h8,'string')); % ДАННЫХ
h9=findobj(gcf,'tag','edit9'); phis=str2num(get(h9,'string'));
alphamax=0:90
falphamax=(1./tan(alphamax./2.*pi/180)).*(alphamax.*pi/180+tan(alphamax./2.
*pi/180))
phi=sqrt(log(1/(1-eta)))*(1/h).*falphamax
plot(alphamax,phi)
Digits=4
Deltaphil=0.5*(1.06*pi/180-0.00465)
Deltaphil*180/pi

```

```

function edit7_Callback(hObject, eventdata, handles)
% hObject    handle to edit7 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Hints: get(hObject,'String') returns contents of edit7 as text
%        str2double(get(hObject,'String')) returns contents of edit7 as a double

% --- Executes during object creation, after setting all properties.
function edit7_CreateFcn(hObject, eventdata, handles)
% hObject    handle to edit7 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    empty - handles not created until after all CreateFcns called

% Hint: edit controls usually have a white background on Windows.
%       See ISPC and COMPUTER.
if ispc && isequal(get(hObject,'BackgroundColor'),
get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end

```

```

function edit8_Callback(hObject, eventdata, handles)
% hObject    handle to edit8 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Hints: get(hObject,'String') returns contents of edit8 as text

```

```

%      str2double(get(hObject,'String')) returns contents of edit8 as a double

% --- Executes during object creation, after setting all properties.
function edit8_CreateFcn(hObject, eventdata, handles)
% hObject    handle to edit8 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    empty - handles not created until after all CreateFcns called

% Hint: edit controls usually have a white background on Windows.
%      See ISPC and COMPUTER.
if ispc && isequal(get(hObject,'BackgroundColor'),
get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end

function edit9_Callback(hObject, eventdata, handles)
% hObject    handle to edit9 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Hints: get(hObject,'String') returns contents of edit9 as text
%      str2double(get(hObject,'String')) returns contents of edit9 as a double

% --- Executes during object creation, after setting all properties.
function edit9_CreateFcn(hObject, eventdata, handles)
% hObject    handle to edit9 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    empty - handles not created until after all CreateFcns called

```

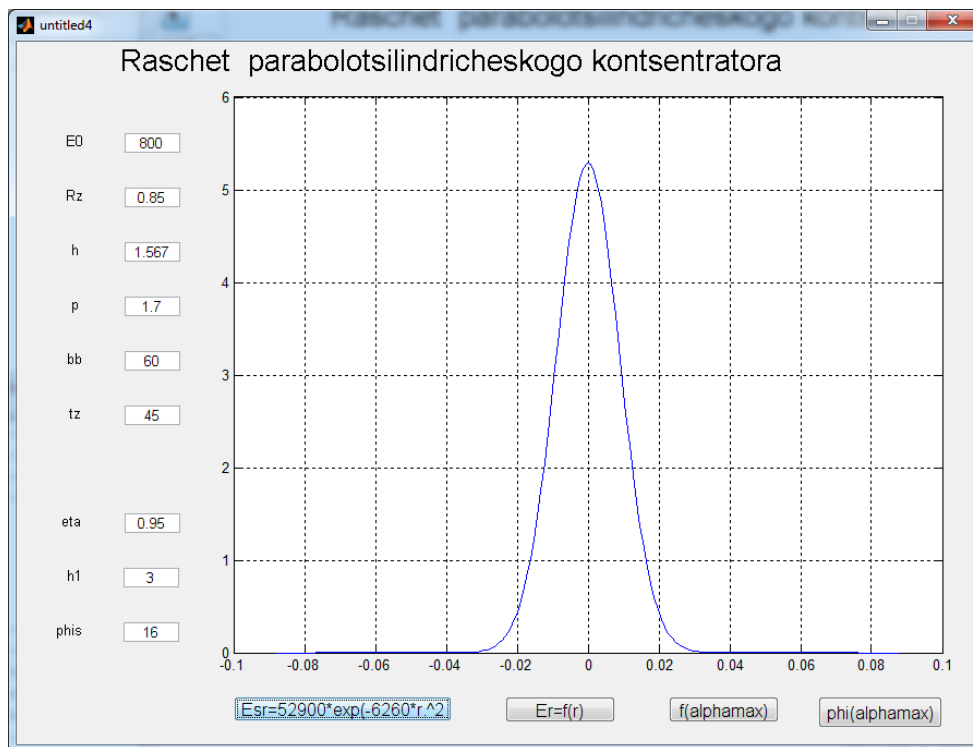
% Hint: edit controls usually have a white background on Windows.

% See ISPC and COMPUTER.

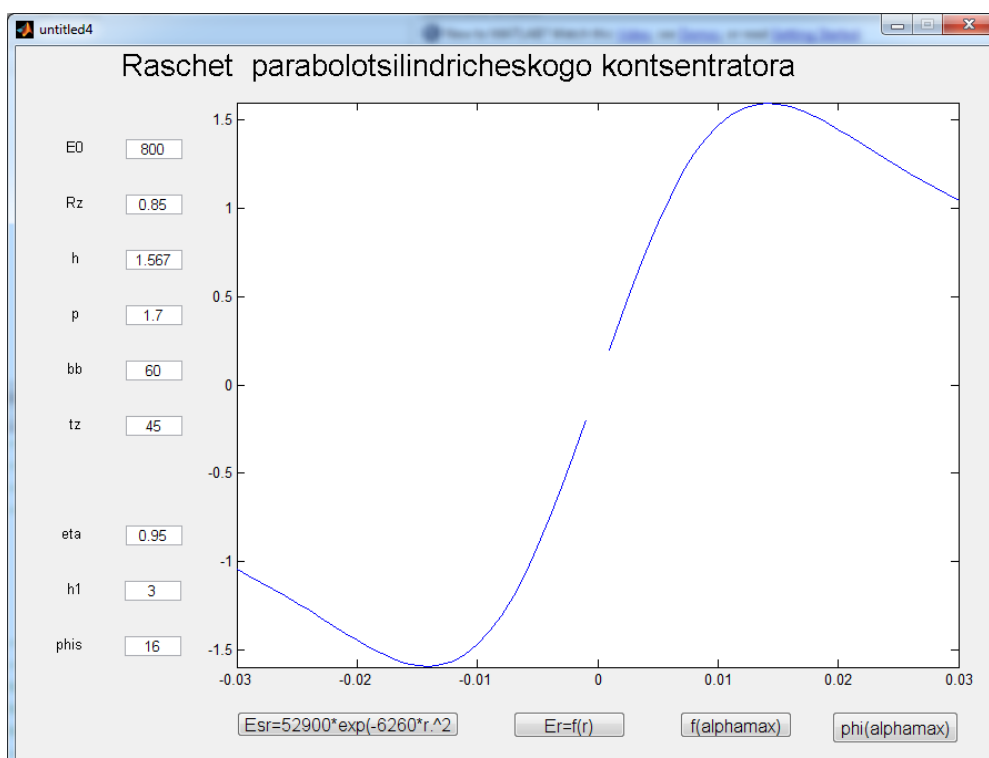
if ispc && isequal(get(hObject,'BackgroundColor'),

get(0,'defaultUicontrolBackgroundColor'))

set(hObject,'BackgroundColor','white');



end



The program of calculation of selection of hot water from the top part of the accumulator for needs of technological processes

```
function varargout = mrGraf3(varargin)
arguments.
gui_Singleton = 1;
gui_State = struct('gui_Name',    mfilename, ...
                  'gui_Singleton', gui_Singleton, ...
                  'gui_OpeningFcn', @mrGraf3_OpeningFcn, ...
                  'gui_OutputFcn', @mrGraf3_OutputFcn, ...
                  'gui_LayoutFcn', [] , ...
                  'gui_Callback', []);
if nargin & isstr(varargin{1})
    gui_State.gui_Callback = str2func(varargin{1});
end

if nargout
    [varargout{1:nargout}] = gui_mainfcn(gui_State, varargin{:});
else
    gui_mainfcn(gui_State, varargin{:});
end

function mrGraf3_OpeningFcn(hObject, eventdata, handles, varargin)
handles.output = hObject;

guidata(hObject, handles);
function varargout = mrGraf3_OutputFcn(hObject, eventdata, handles)
varargout{1} = handles.output;

function edit1_CreateFcn(hObject, eventdata, handles)
if ispc
```

```

    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end

```

```

function edit1_Callback(hObject, eventdata, handles)
function pushbutton1_Callback(hObject, eventdata, handles)
mrT= str2double(get(handles.edit1, 'String'));
TB= str2double(get(handles.edit2, 'String'));
TGT= str2double(get(handles.edit3, 'String'));
TXB= str2double(get(handles.edit4, 'String'));

```

```

subplot(2,2,1)
for TB=60:0.1:90
if TB>TGT
    mrGrafik=mrT*(TGT-TXB)/(TB-TXB)
else
    mrGrafik=mrT
end
    plot(TB,mrGrafik,'>b');
hold on
end
    xlabel('TB','FontSize',16)
    ylabel('mr','FontSize',16)

```

```

set(handles.edit5, 'String',mrGrafik)

```

```

mrT= str2double(get(handles.edit1, 'String'));
TB= str2double(get(handles.edit2, 'String'));
TGT= str2double(get(handles.edit3, 'String'));

```

```

TXB= str2double(get(handles.edit4, 'String'));
subplot(2,2,2)
for TGT=60:0.1:300
if TB>TGT
    mrGrafik=mrT*(TGT-TXB)/(TB-TXB)
else
    mrGrafik=mrT
end
    plot(TGT,mrGrafik,'or');
hold on
end
    xlabel('TGT','FontSize',16)
ylabel('mr','FontSize',16)

set(handles.edit5, 'String',mrGrafik)

```

```

mrT= str2double(get(handles.edit1, 'String'));
TB= str2double(get(handles.edit2, 'String'));
TGT= str2double(get(handles.edit3, 'String'));
TXB= str2double(get(handles.edit4, 'String'));
subplot(2,2,3)
for TXB=10:0.1:25
if TB>TGT
    mrGrafik=mrT*(TGT-TXB)/(TB-TXB)
else
    mrGrafik=mrT
end
    plot(TXB,mrGrafik,'dg');
hold on

```

```

end
    xlabel('TXB','FontSize',16)
ylabel('mr','FontSize',16)

set(handles.edit5, 'String',mrGrafik)

function edit2_CreateFcn(hObject, eventdata, handles)
if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end

function edit2_Callback(hObject, eventdata, handles)
function edit3_CreateFcn(hObject, eventdata, handles)
if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end

function edit3_Callback(hObject, eventdata, handles)
function edit4_CreateFcn(hObject, eventdata, handles)
if ispc
    set(hObject,'BackgroundColor','white');

```

```
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end
```

```
function edit4_Callback(hObject, eventdata, handles)
```

```
function edit5_CreateFcn(hObject, eventdata, handles)
```

```
if ispc
```

```
    set(hObject,'BackgroundColor','white');
```

```
else
```

```
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end
```

```
function edit5_Callback(hObject, eventdata, handles)
```

```
function pushbutton3_Callback(hObject, eventdata, handles)
```

```
subplot(2,2,1)
```

```
cla
```

```
function pushbutton4_Callback(hObject, eventdata, handles)
```

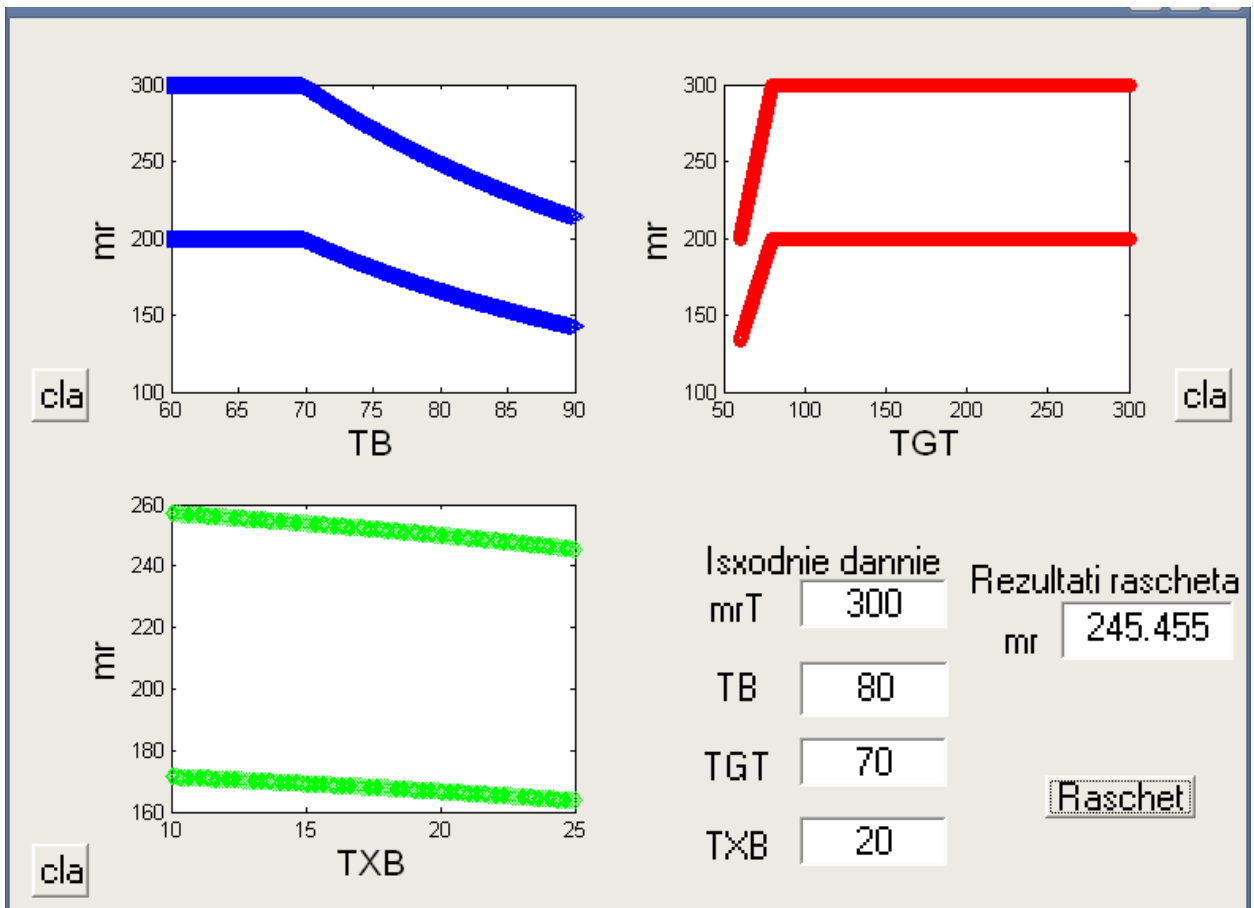
```
subplot(2,2,2)
```

```
cla
```

```
function pushbutton5_Callback(hObject, eventdata, handles)
```

```
subplot(2,2,3)
```

```
cla
```



The program of calculation of thermal productivity of the block parabolic cylindrical collectors

```
function varargout = Qpolpk3(varargin)
```

```
arguments.
```

```
gui_Singleton = 1;
```

```
gui_State = struct('gui_Name',    mfilename, ...
```

```
    'gui_Singleton',  gui_Singleton, ...
```

```
    'gui_OpeningFcn', @Qpolpk3_OpeningFcn, ...
```

```
    'gui_OutputFcn',  @Qpolpk3_OutputFcn, ...
```

```
    'gui_LayoutFcn', [] , ...
```

```
    'gui_Callback',  []);
```

```
if nargin & isstr(varargin{1})
```

```
    gui_State.gui_Callback = str2func(varargin{1});
```

```
end
```

```

if nargout
    [varargout{1:nargout}] = gui_mainfcn(gui_State, varargin{:});
else
    gui_mainfcn(gui_State, varargin{:});
end
function Qpolpk3_OpeningFcn(hObject, eventdata, handles, varargin)
handles.output = hObject;

guidata(hObject, handles);
function varargout = Qpolpk3_OutputFcn(hObject, eventdata, handles)
varargout{1} = handles.output;
function edit1_CreateFcn(hObject, eventdata, handles)
if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end

function edit1_Callback(hObject, eventdata, handles)
function pushbutton1_Callback(hObject, eventdata, handles)
To= str2double(get(handles.edit1, 'String'));
Eo= str2double(get(handles.edit2, 'String'));
nyuo= str2double(get(handles.edit3, 'String'));
Kzap= str2double(get(handles.edit4, 'String'));

C= str2double(get(handles.edit5, 'String'));
UL= str2double(get(handles.edit6, 'String'));
TB= str2double(get(handles.edit7, 'String'));
FR= str2double(get(handles.edit8, 'String'));

```

```
F3= str2double(get(handles.edit9, 'String'));
```

```
T8=To+Eo*nyuo*Kzap*C/UL;
```

```
Qpolpk3=F3*FR*UL*(T8-TB)/C;
```

```
set(handles.edit11, 'String',T8);
```

```
set(handles.edit12, 'String',Qpolpk3);
```

```
TB= str2double(get(handles.edit7, 'String'));
```

```
subplot(2,2,1)
```

```
for TB=60:0.1:150
```

```
    T8=To+Eo*nyuo*Kzap*C/UL;
```

```
    Qpolpk3=F3*FR*UL*(T8-TB)/C;
```

```
    plot(TB,Qpolpk3,'or');
```

```
    hold on
```

```
end
```

```
    xlabel('TB','FontSize',16)
```

```
    ylabel('Qpolpk','FontSize',16)
```

```
subplot(2,2,2)
```

```
for Eo=300:0.1:1000
```

```
    T8=To+Eo*nyuo*Kzap*C/UL;
```

```
    Qpolpk3=F3*FR*UL*(T8-TB)/C;
```

```
    plot(Eo,Qpolpk3,'ok');
```

```
    hold on
```

```
end
```

```
    xlabel('Eo','FontSize',16)
```

```
    ylabel('Qpolpk','FontSize',16)
```

```

Eo= str2double(get(handles.edit2, 'String'));
subplot(2,2,3)
F3=300:0.1:1000
    T8=To+Eo*nyuo*Kzap*C/UL;
Qpolpk3=F3*FR*UL*(T8-TB)/C;
    plot(F3,Qpolpk3,'om');

    xlabel('F3','FontSize',16)
ylabel('Qpolpk','FontSize',16)
hold on
function edit2_CreateFcn(hObject, eventdata, handles)
if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end

function edit2_Callback(hObject, eventdata, handles)
function edit3_CreateFcn(hObject, eventdata, handles)
if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end

function edit3_Callback(hObject, eventdata, handles)

```

```

function edit4_CreateFcn(hObject, eventdata, handles)
if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end
function edit4_Callback(hObject, eventdata, handles)
function edit5_CreateFcn(hObject, eventdata, handles)
if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end
function edit5_Callback(hObject, eventdata, handles)
function edit6_CreateFcn(hObject, eventdata, handles)
if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end
function edit6_Callback(hObject, eventdata, handles)
function edit7_CreateFcn(hObject, eventdata, handles)
if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end
function edit7_Callback(hObject, eventdata, handles)
function edit8_CreateFcn(hObject, eventdata, handles)
if ispc

```

```

    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end
function edit8_Callback(hObject, eventdata, handles)
function edit9_CreateFcn(hObject, eventdata, handles)
if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end
function edit9_Callback(hObject, eventdata, handles)
function edit10_CreateFcn(hObject, eventdata, handles)
if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end
function edit10_Callback(hObject, eventdata, handles)
function edit11_CreateFcn(hObject, eventdata, handles)
if ispc
    set(hObject,'BackgroundColor','white');
else
    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end
function edit11_Callback(hObject, eventdata, handles)
function edit12_CreateFcn(hObject, eventdata, handles)
if ispc
    set(hObject,'BackgroundColor','white');
else

```

```

    set(hObject,'BackgroundColor',get(0,'defaultUicontrolBackgroundColor'));
end
function edit12_Callback(hObject, eventdata, handles)
function pushbutton4_Callback(hObject, eventdata, handles)
subplot(2,2,1)
cla

function pushbutton5_Callback(hObject, eventdata, handles)
subplot(2,2,2)
cla

function pushbutton6_Callback(hObject, eventdata, handles)
subplot(2,2,3)
cla

function pushbutton7_Callback(hObject, eventdata, handles)
To= str2double(get(handles.edit1, 'String'));
Eo= str2double(get(handles.edit2, 'String'));
nyuo= str2double(get(handles.edit3, 'String'));
Kzap= str2double(get(handles.edit4, 'String'));
C= str2double(get(handles.edit5, 'String'));
UL= str2double(get(handles.edit6, 'String'));
TB= str2double(get(handles.edit7, 'String'));
FR= str2double(get(handles.edit8, 'String'));
F3= str2double(get(handles.edit9, 'String'));
T8=To+Eo*nyuo*Kzap*C/UL;
Qpolpk3=F3*FR*UL*(T8-TB)/C;

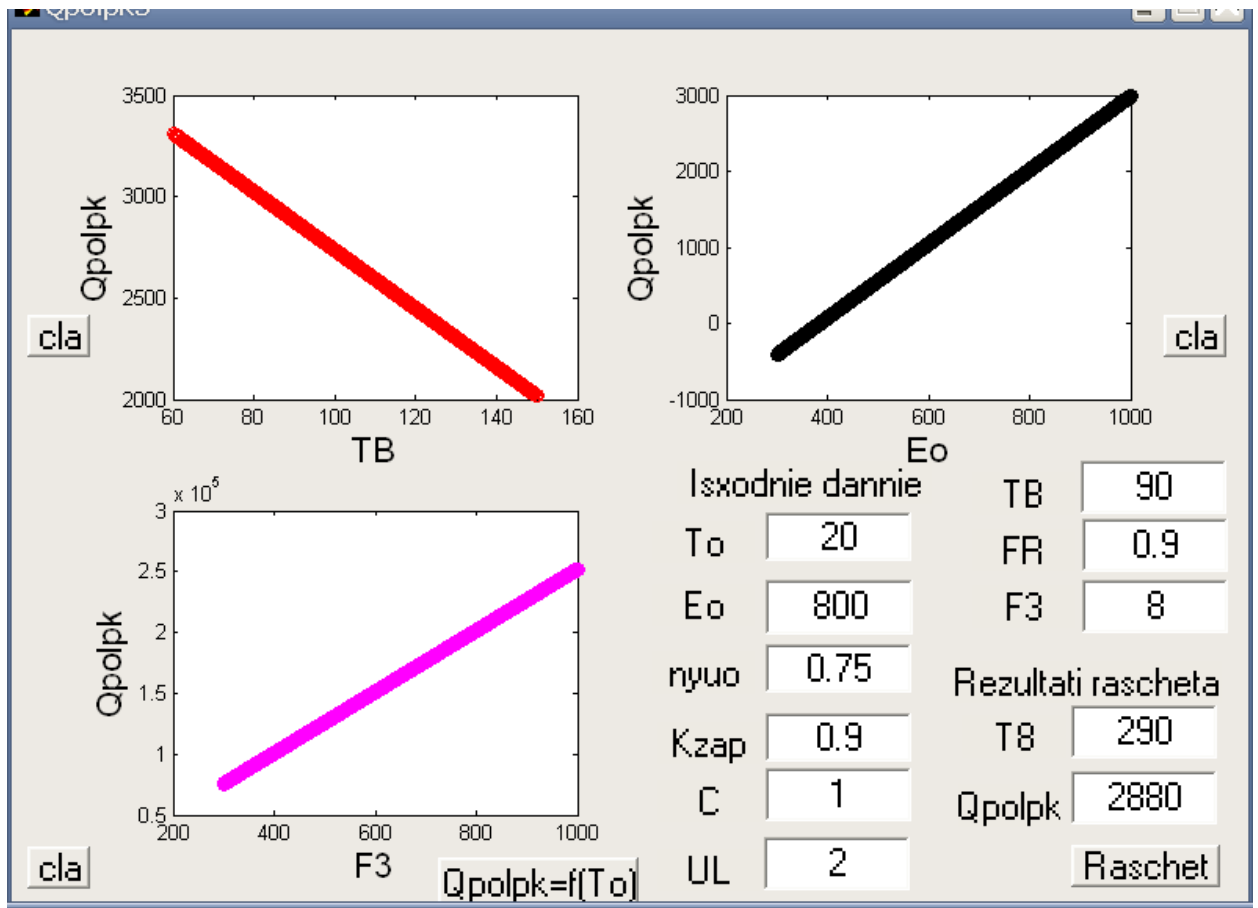
set(handles.edit11, 'String',T8);
set(handles.edit12, 'String',Qpolpk3);
subplot(2,2,3)
To=300:0.1:1000

```

```

T8=To+Eo*nyuo*Kzap*C/UL;
Qpolpk3=F3*FR*UL*(T8-TB)/C;
plot(To,Qpolpk3,'ob');
xlabel('To','FontSize',16)
ylabel('Qpolpk','FontSize',16)
hold on

```



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