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NEW WAYS OF RENEWABLE SOURCES UTILIZATION FOR ELECTRICITY PRODUCTION

Abstract

Nowadays, different solutions for increasing energy production are investigated in the world. One of the ways is utilization of renewable energy sources in cogeneration devices – combined production of electricity and heat in one device, with a high overall efficiency. The article deals with principle of hot-air engine, its basic division and use in combined production of heat and electricity from biomass. The basic principle of engine is conversion of heat into mechanical energy, which is subsequently used for production of electricity. In the contribution is presented Stirling engine, which is driven by thermal energy from a concentrating solar collector and from biomass boiler.

Keywords: Stirling engine, internal combustion engine, biomass, boiler, concentrating solar collector

1. Introduction

Nowadays, the word energy is still quite frequent and inflected. The constant growth of prices of primary raw materials such as oil, natural gas and coal forces us to think about consumption and efficiency. Is the consumption of primary sources with respect to work performed proportional? Is the Energy used efficiently? Electricity, universal form of energy has become irreplaceable in our daily lives. In contrast, the thermal energy will be an important until the cold winter. Electricity and heat is influenced not only by thermal efficiency, but with a number of other factors, from which is the total efficiency directly related. One of the ways, how to produce heat and electricity, is the using of non-conventional devices with the application of renewable energy sources.

Using of renewable energy is supported worldwide and it also deals with environmental aspects of energetics. The main effort is to research the conditions of optimal performance and production technology for applications in renewable energy, to ensure the transfer of acquired knowledge into practice and thereby contribute to increase of region economic growth as well as all Slovakia.

Research of the new thermal cycles is oriented on optimizing of energy facilities generally, particularly with focusing on renewable energy sources (RES). The current types of thermal cycles for medium and low temperature gradients are technically and economically disadvantageous. Research priority is more efficient transformation of primary energy from renewable energy sources into electrical energy.

What is the reason of this work is low utilization of renewable energy sources and the absence of effective ways of transforming heat into electricity, thus efficient heat cycles in general. Currently there is no cost-effective energy system for converting heat of medium or low potential.

At this time we have an RES (not just for RES) good hardware, ie energy harvesting device, but is lacking good software, ie. good thermal cycle (= thermal transformation process) that converts the input energy on other form of energy without large and unnecessary losses. In the heat engine is for example the sequence of transformations following: thermal energy (explosion) → pressure energy → mechanical energy (rotational movement). In this work is hardware the prototype

power equipment and software will be new types of regenerative thermal cycles.

Quality thermal cycle significantly affects the final energy conversion efficiency, it is currently at ORC (Organic Rankin Cycle) for example. about 17%, which is about 35% compared to the efficiency in the conventional Rankine cycle and a 44% efficiency in a supercritical cycles on a large energy. It is too little.

The aim of the solution is the invention of thermal cycle with heat recovery particularly suitable for renewable energy sources (sun and biomass, ie medium and low temperature gradients), with a sufficiently high efficiency and with an eligible economy in several variants.

Increasing of present power installations efficiency for the production of electric energy is going towards enhancing the heat resistance of materials, that are in direct contact with the primary heat (flue gas) and resist of the high pressure of the supercritical steam (720°C and over 22 MPa).

People recently used primary sources apart from the efficiency of their use, however, technical progress and the depletion of resources forced people finding alternative and efficient options for their use. One such option is currently co-generation – the combined production of electricity and heat in one device, with a high overall efficiency [3].

2. Micro-cogeneration units with conventional motors

One option for the efficient use of primary energy sources can be micro-generation – the combined production of electric power and heat (CHP) with output up to 50 kWe. For householders is interesting power to 2 kWe.

As the main source of micro-cogeneration units are currently used in most internal combustion engines for natural gas, on which is explained the principle of the device. To the engine is delivered fuel, where during combustion we obtain mechanical work on the output shaft and thermal energy is removed through a cooling system consisting of a heat exchanger. These heat exchangers are connected to the serial circuit in which is working medium (most often water) heated in several stages. Multiphase heat recovery increases the overall efficiency of the cogeneration units and reduces the total cost of the required on fuel.

Possible alternatives to internal combustion engines are unconventional engines. They work on the principle of external combustion, so fuel combustion does not take place in the working cylinder. This allows, in contrast to conventional internal combustion engines,

control the course of the combustion process, the related quality, which is reflected in the composition of pollutants released into the atmosphere. Among the most famous hot air engine belongs Stirling engine and Ericsson engine. Ericsson engine is also the engine with external combustion, but the Stirling engine may have two possible options – open and closed [1].

The air is compressed in the compressor, it passes through the heat exchanger under constant pressure and take heat. Then the air expands adiabatically in the cylinder and makes a work. Some of this work is used to drive the compressor and the other part is converted to mechanical work with the help of the generator into electrical energy. On generating of heat energy may be used a wide range of fuel, because this is the external combustion engine. The fuel is combusted in a separate combustion chamber, optionally by a special device, and thermal energy is transformed with the aid of the heat exchanger to the working fluid. Working medium in an open cycle, usually dry air, at the end of the cycle is vented to the atmosphere. In closed system, the working medium after each cycle are cooled in the heat exchanger where the supplied heat energy is removed back into the cycle [2]. With using of the closed system is possible improve the efficiency of heating equipment. In Figure 1 we can see a diagram of unconventional micro-cogeneration units on base Ericsson-Brayton hot-air engine.

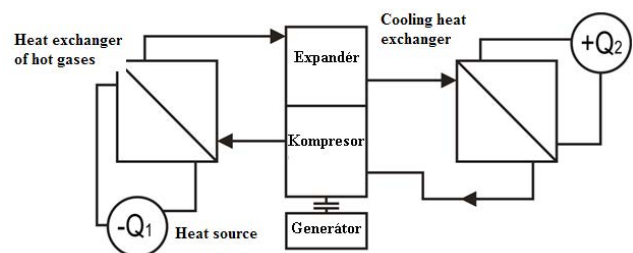


Fig. 1. Unconventional micro-cogeneration units on base Ericsson-Brayton engine

The proposed micro-cogeneration unit consists of two heat exchangers, one serves as a condenser and the other as the heater. Both of them have different requirements for operation. One of such requirements is to ensure optimum heat transfer from the working medium. The heat transfer is characterized by a coefficient of heat transfer and it subsequently characterizes the disposition of heat exchanger. The coefficient depends on the medium, on the heat capacity, from the structural arrangement and in some cases is significantly affected by used material of exchanger.

Additional requirements for the heat exchanger are the size, pressure loss and maintenance possibilities.

The next representative of the hot-air engine is a Stirling engine that converts heat into mechanical work. Mechanical energy can be used to drive a power generator. The engine, as well as Ericsson engine obtains the energy from an external source, the work cylinder is not burning any fuel. This allows using of any fuel and controlling of the combustion process, or it is also possible to use another source of heat, such as waste heat, solar energy and others. It can also be marked as combustion piston engine with external combustion. Heat is supplied from an external source instead of fuel combustion inside the cylinder, it

causes reduction of emissions compared with the emissions produced, for example in the internal combustion engine and there is no explosion. Stirling engine works on the principle of gas expansion. When the gas is heated, it expands, when cools, its volume decreases and it is giving the pistons in motion.

From the design point of view can be divided any structure Stirling engine into one of three modifications of α , β , γ (Fig. 2). They differ in design heater, cooler, regenerator and placing the pistons in the cylinders.

A special alternative is a Stirling engine with a free piston which operates without crank mechanism. Operation of the system may be described in the scheme in Figure 3. Micro-cogeneration unit uses

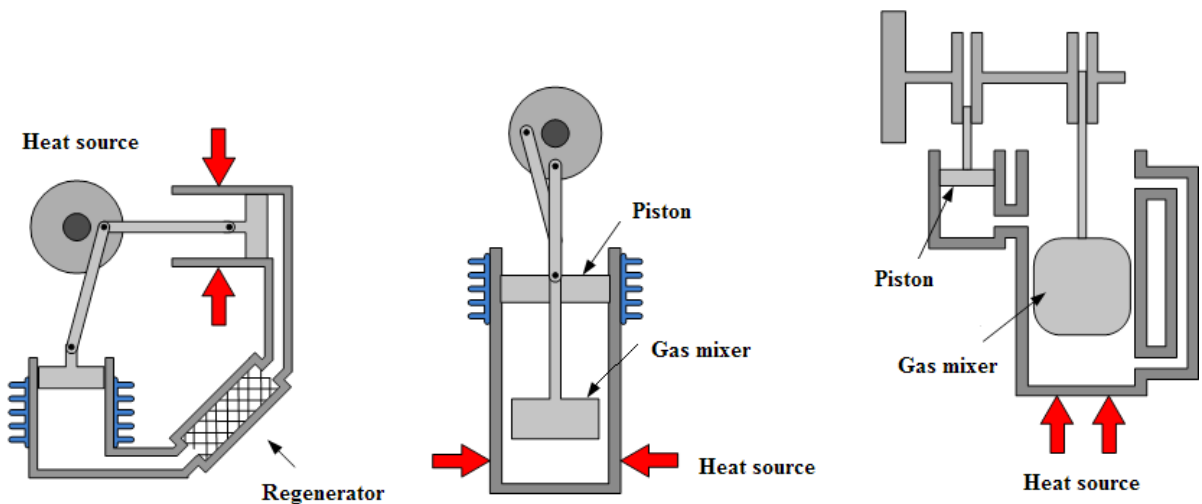


Fig. 2. Types of α , β , γ Stirling engine [4]

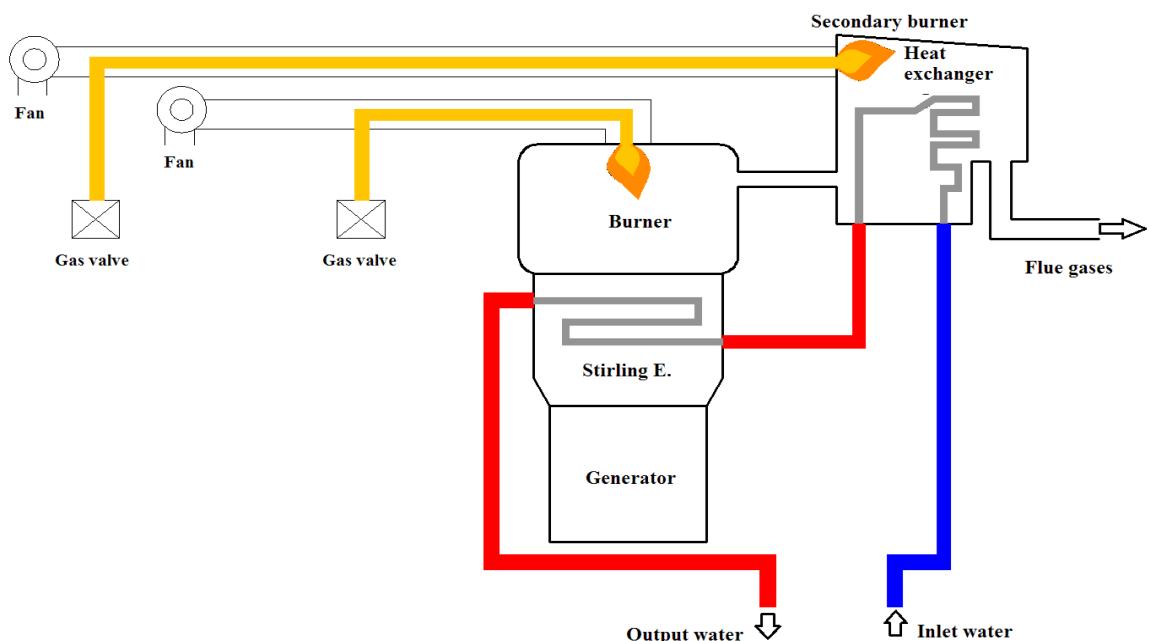


Fig. 3. Working principle Stirling engine

a four-cylinder double acting Stirling engine type γ , which runs on natural gas. The movement of the pistons is ensured by expansion and compression of the nitrogen (working gas), which is closed under pressure in cylinders. The working gas expands when heated fuel burnt in a combustion chamber located above the rolls. Compression occurs when cooled with the assistance of the inlet of the heating water that flows through the water jacket inside the base part of the engine. Moving the piston up and down mechanically converts the rotational movement, which is the single-phase four-pole generator, into electric energy 230 V and 50 Hz.

3. Experimental device

As mentioned above, for drive of the Stirling engine energy from the sun or from biomass can

be used, and in this project is engine driven just by these renewable energy sources. In terms of heat gains is possible to connect to the Stirling engine solar collector, the effectiveness of engine depends on the difference of working fluid temperature in the compression and expansion part. For biomass burning has been designed and constructed a furnace prototype that enables to burn pieces of wood or wood pellets. Concentric solar collector is also developed by researchers from the University of Žilina.

The compressor is connected into a closed circuit, what allows using of other working medium than dry air at higher pressure. The problem is the necessity to observe the temperature of the working fluid at the inlet to the compressor at a value prescribed by the manufacturer. Because of this, was to the system added a regenerator and a cooling exchanger.

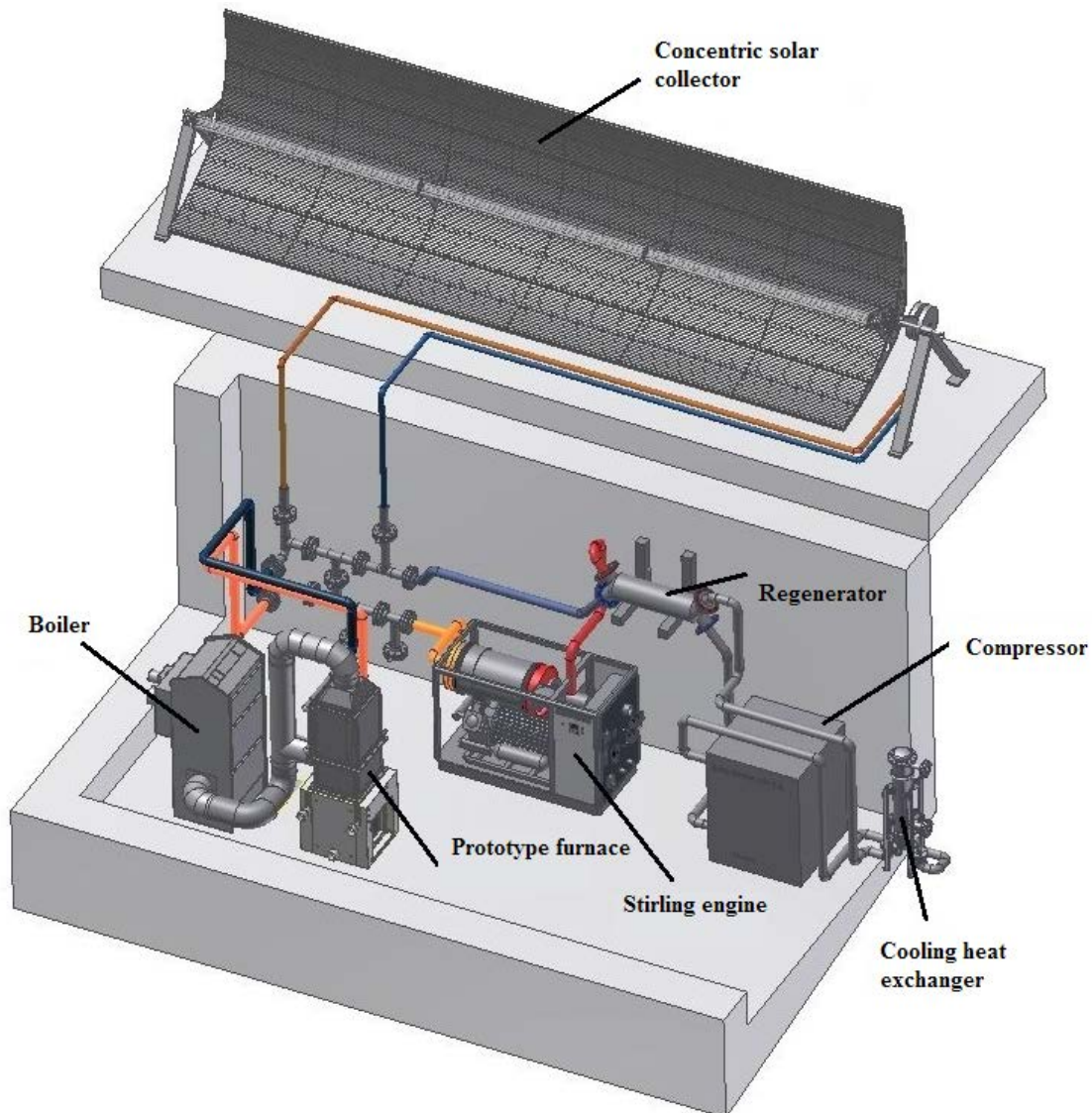


Fig. 4. Scheme of experimental device

Regenerator for hot-air engine is used for the recovery of thermal energy from the medium behind the engine to the medium, which flows out of the compressor. The cooling heat exchanger, serves for cooling of the operating medium before entering to the compressor on required temperature. The source of heat is concentric solar collector and prototype furnaces for biomass burning. Transport of energy from the combustion of biomass in to the working medium of the engine provides a hot-air heat exchanger which is part of the furnace. This device is connected to the boiler, which uses the residual heat from the flue gas.

The project output will be a set of knowledge about the optimal function of new advanced thermal cycles in the prototype power equipment. From the research issues will be proposed technical solutions, which will be used mainly at renewable energy sources, for increasing the efficiency of the conversion of heat into electricity, shortening the payback period and improve their functions. Starting of all device is expected in the coming months.

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4. Conclusions

The issue of this project is consistent with the long-term aim of the Slovak Republic in the field of science and research of energetics. The necessity of development and optimization of advanced thermal cycles, particularly suitable for medium and low temperature used in renewable energy sources is very topical. Research in this area has to resolve the questions, how to decrease import of primary fuels (oil, gas) and with what equipment to produce electrical energy by using of RES. The strategic aim is by realization of the project is through transferring of the latest results to the practice from new ways of transformation of thermal energy into other forms of energy, particularly electricity and new technologies of production, respectively practical design solutions for applications of alternative energy sources.

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