THE EXERGY - ONE WAY TO USE PROPERLY THE NON-CONVENTIONAL ENERGIES

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Abstract: The news energetic politics are very drastically with the pollution emissions. It is necessarily that the actual coil power plants are changing the management of the energy production; like solution for small entities is the use of the non-pollution energies: the potential energy of the geothermal wells, and the kinetic energy due to the power of winds.

Key words: available work, potential energy, kinetic energy, exergy

1. INTRODUCTION

The limited resources of the world's energy have caused many countries to reexamine their energy policies and take drastic measures in eliminating waste. Now, the interest in the scientific community is to develop new techniques to better utilize the existing limited resources. The first law of thermodynamics deals with the quantity of energy and asserts that energy can not be created or destroyed. This low serves as a bookkeeping of energy during a process and didn't offer challenges to the engineer. The second low deals with the quality of energy. More specifically, it is concerned with the degradation of energy during a process, the entropy generation, and the lost opportunities to do work.

The second low of thermodynamics has proved to be a very powerful tool in the optimization of complex thermodynamics systems. The exergy is the maximum useful work that could be obtained from the system at a given state in a specified environment

2. THE EXERGY -THE WORK POTENTIAL OF THE ENERGY

When a new energy source, like geothermal well, is discovered, the first thing that the explorers are doing is to estimate the amount of energy contained in the source. To build a power plant is necessary to know the work potential of the source, which is the amount of energy that can be extracting as useful work. The rest of energy is eventually discarded as waste energy and is not useful. It would be very desirable to have a property to enable the determination of the useful work potential of a given amount of energy at some specified state. This property is called *exergy,* wich is also called *avaible energy.*
The work potential of the energy contained in a system as a specific state is simply the maximum useful work that can be obtained from the system. This work during a process depends on the initial state, the process path and the final state.

$$\text{Work} = f(\text{initial state, process path, final state}) \quad (1)$$

In an exergetic analysis, the initial state is specified and it is not a variable. The output work is maximized when the process between two specific states is executed in a reversible way. Therefore, all the irreversibilities are neglected in determining the work potential. Finally, the system must be in the dead state at the end of the process to maximize the output work. A system must go to the dead state at the end of the process to maximize the output work because:

- if the system temperature at the final state is greater or less than the temperature of the environment it is possible to produce additional work by running a heat engine between these two temperatures levels. If the final pressure is greater or less than the pressure of the environment it is possible to obtain work by letting the system expand to the pressure of the environment;
- if the final velocity of the system is not zero, it is possible to catch extra kinetic energy by a turbine and to convert it to rotating work. There is no work that can be produced from a system that is initially at the dead state. The atmosphere that surrounds us is in the dead state, and the contained energy has no potential work.

It is very important to allow that the exergy of a system at a specified state depends on the conditions of the environment as well as the properties of the system; the exergy is a property of the system-environment combination and not at the system alone.

Like application it's possible to do the exergetic analysis of a Geothermal Plant, as fallow: In a village it has discovered an underground geothermal well containing water at 90°C, 100m below the surface. It must to evaluate the option using the water from this well to provide power to the village and to determine the maximum available work [kJ/kg] that could be obtained from a power plant that will pump water from the well, extract energy from the water and discharge the water to a lake at the surrounding temperature T_0= 20°C; the water temperature can be reduced to 30°C at the outlet of the power plant.

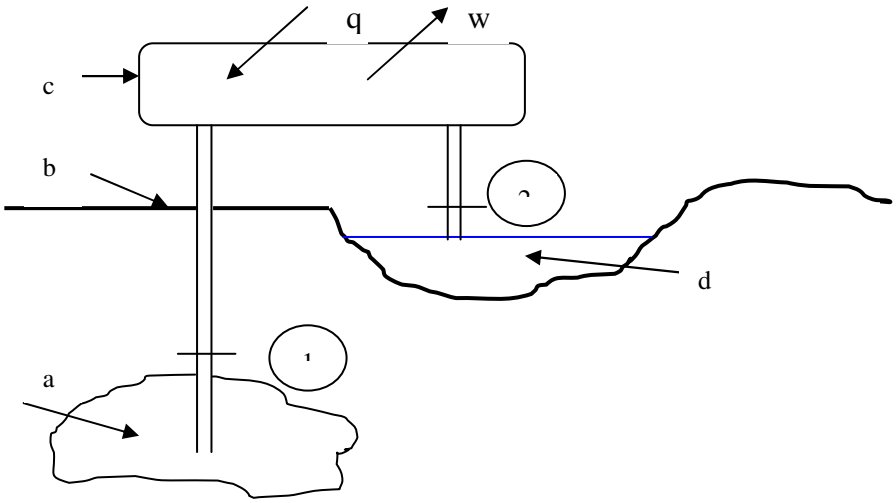

Fig.1. The geothermal power plant

a- geothermal well; b- soil; c-proposed power plant; d-lake or water basin; 1,2 -states

The maximum available work of the extracted water can be calculated with the relation (2):

$$w_{rev} = (i_1 - i_2) + T_0 \cdot (s_2 - s_1) - g \cdot (h_2 - h_1) \left[\frac{kJ}{kg}\right] \quad (2)$$

i_1, i_2 –enthalpies [kJ/kg]; s_1, s_2 –entropies [kJ/kgK]; g- gravitational acceleration [m/s^2]; h_1, h_2-bench marks [m], T_0 –environmental temperature [K]

$$w_{rev} = 28{,}1 \left[\frac{kJ}{kg}\right]$$

3. THE EXERGY OF THE KINETIC ENERGY

Kinetic energy is a form of mechanical energy and it can be converted to work entirely. Therefore, the potential work (exergy) of the kinetic energy of a system is equal to the kinetic energy itself regardless of the temperature and the pressure of the environment. The expression (1) show the relation for the specific exergy of kinetic energy:

$$e_{ke} = \frac{v^2}{2} \left[\frac{J}{kg}\right] \tag{3}$$

v -the velocity of the system relative to the environment

Like application it's possible to calculate the maximum power generated by a wind turbine

Many regions from Romania are with heavy winds especially in the winter. Like solution to produce electrical power or to decrease the cost for electrical energy in this region it's possible to use wind turbines. In the future, the use of them will diminish the pollution generated by the classical power plants.
A wind turbine with a 12 m diameter of the rotor will be installed at a location where the wind has an average velocity of 10 m/s and the desirable thing is to determine the maximum power generated by the wind turbine.

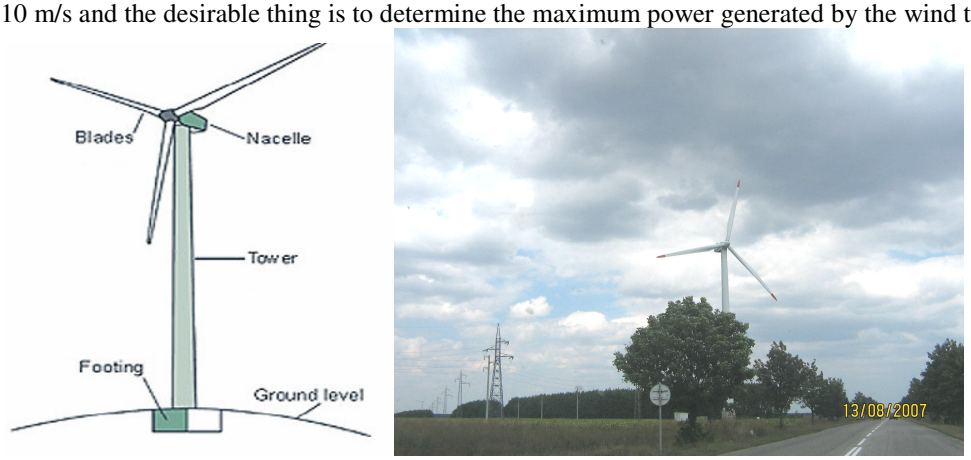

Fig.2. A simplified schema of a wind turbine

The air flowing with the wind has the same properties like the stagnant atmospheric air except that it possesses a velocity. This air will reach the dead state when it is brought to a complete stop. The specific exergy of the blowing air is simply the kinetic energy it possesses.

From the relation (3) the value of the specific exergy will be: $e_{ke} = 0{,}05\left[\frac{kJ}{kg}\right]$. This mean that every unit mass of air flowing with a velocity of 10 m/s has a work potential of 0,05 [kJ/kg].

The maximum power will be calculated by the relation (4):

$$E_t = \dot{m} \cdot e_{ke} \text{ [kW]} \tag{4}$$

The mass flow rate of the air passing through the rotor of the wind turbine is determined by the relation (5):

$$\dot{m} = \rho \cdot A \cdot v = \rho \cdot \frac{\pi \cdot D^2}{4} \cdot v \left[\frac{kg}{s} \right] \tag{5}$$

ρ is the density of the air at T_0

The value of the maximum power or the exergetic flow of the turbine will be:

$$E_t = 66{,}8 \text{ [kW]}.$$

Assuming a conversion efficiency of 30%, this wind turbine will convert 20 [kW] to electricity.

4. CONCLUSIONS

In this paper there are presented only two ways to produce non pollutant the energy. With an exergo-economical analysis the result will be that is cheaper to produce energy with low emissions for any kind of power plant.

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