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RESEARCH UPON CREATING A SYSTEM FOR CONVERSION THE WATER KINETIC ENERGY OF HILL AND MOUNTAIN RIVERS IN GREEN ENERGY, USING RECYCLING MATERIALS

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Abstract:

In the present paper is presented a system for generation of green energy which uses the power of streams water flow and is situated in mountain and hill areas. The hydro electric system consist of: a turbine which is in fact a wheel with wooden cups, a spindle to transmit the rotation motion, wheels for transmission of rotation, accessories, subsystem to transform the mechanical energy in electrical energy, unit for electricity storage, subsystem for collecting and transport of energy.

Recycling materials were used for electrical system: wood, steel, subassemblies resulted from agricultural machines or other installations out of order, or resulted from the Centre for Recycling Materials.

The whole system was designed to be rapidly and economically manufactured, with a minimum technical endowments.

An optimum management system is aimed to distribute the water flow rate from streams or derivates, from the main riverbed, so that the biodiversity and specificity of the local area will be not affected.

Key words: *wooden installation; hydro energy; green energy; Romanian traditions.*

INTRODUCTION

The present paper is a part of an extensive study entitled “Research for the settlement of new technical solutions of electrical power supply for Romanian traditional constructions from the Fagaras Mountains area, in the context of promotion of sustainable development programs".

The system presented in this paper promotes some solutions to regularly produce the electricity by means that can be easily found in the adjacent farms, small production units, holiday houses. As well, it could be an alternative for energy production in the case of calamities, when the energy from standard sources will be not available (Grecu 2015).

The last but not the least, the promotion for non-invasive utilisation of mountain stream courses, to protect the environment, taking over the stream flow by derivation for short distances of maximum 500m and return to the stream, was considered. This fact will contribute to maintaining the biodiversity of waters throughout the year, without the risk of dry out when the rainfall is reduced or absent. (Grecu 2015)

OBJECTIVES

Four objectives to carry out this research were proposed:

1. To identify Fagaras County as location of the system, the place where Romanian traditional water-mill machines worked in the past ;
2. Designing a new system for generation of green energy using the hydro power of hill and mountain streams;
3. Elaboration of an optimal management system for distribution of water flow rate to not disturb the biodiversity and the local communities;
4. The execution of the energetic system using recycling materials from the industrial and agrarian constructions, or from the Centre for Recycling Materials.

MATERIALS, METHOD, EQUIPMENTS

Preponderantly **recycled materials** were used for the proposed energetic system which is, in fact, a mini hydroelectric plant for conversion of water kinetic energy into electrical energy.

The barrage (Fig. 1) was performed from spruce logs processed on two surfaces. They derived from trees with knots and other defects, rejected from industrial processing. The diameter of the trees was approximately of 250mm and the length 2300mm.The logs were horizontally super positioned and finally embedded at the ends in concrete structure (4). As seen in (Fig. 1) and (Fig. 2) the structure of the barrage had a squared shape to give strength and protection for electrical and mechanical equipments. A squared structure ensures the resistance and secure of the turbine spindle.

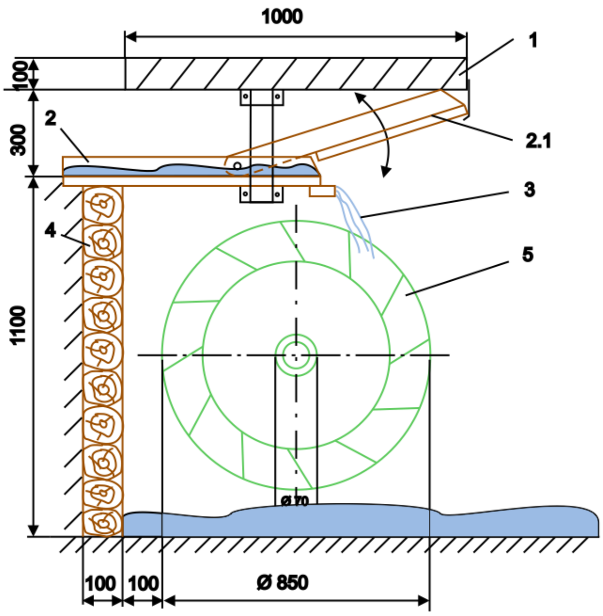

Fig. 1.
Cross section through the barrage, turbine, wooden spouts and bridge sustaining the mobile spout- Principial scheme
1 – bridge sustaining the mobile spout; 2 – fast spout; 2.1 –mobile spout 3- water flow rate; 4 – logs barrage; 5 – turbine.

In the concrete structure were included sand and rocks extracted from the streambed (Fig. 2).

Turbine was manufactured using a spindle from an agricultural machine, with a diameter of 70mm and a length of 2300mm. Two steel covers from a barrel were fixed on it at a distance of 800mm. 12 wooden cups between covers were fixed with screws. The wooden elements of cups originated from reused concrete formworks (Fig. 2).

The fast and mobile spouts were manufactured from the same wooden material.

The equipments consisting in belt wheels, intermediary spindle, were reused from agricultural equipments out of order, from a local farmer.

The alternator used for variant 1 for electricity generation and accumulator for energy storage originated from Dacia automobile.

The barrage was built on the previous emplacement of the old barrage that supplied with water the mill machine, using logs and soil as waterproofing materials. The energo-intenssive (cement) materials have been strictly limited to the protection and safety area of the construction.

Designing of the barrage, construction reinforcement and function of the turbine and equipments envisaged the topography of the land and the management of the water flow.

Thus, the barrage was elevated to distribute a quantity of water on an adjacent canal towards the old barrage, to ensure an independent “staircase” course for maintaining the aquatic biodiversity and migration of the fish fauna.

Before construction of gutters and canal for bringing the water into the pool, a mapping of the water stream was done. The main purpose of it was to irrigate the agricultural lands.

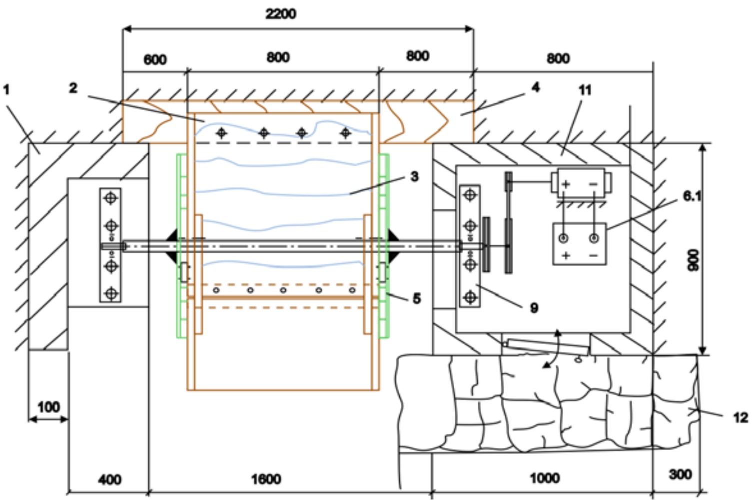

Fig. 2.
Longitudinal section through the concrete structure, turbine and wooden spouts – Principial scheme - Variant 2 including a generator unit
1 – edged concrete structure; 2 – fast/ immobile wooden spout 3 – water flow rate; 4 – log barrage; 5 – mobile spout; 6 – generator unit ; 6.1 – consumer; 9 - bearings; 11 – concrete structure.

RESULTS AND DISSCUSION

First objective of identifying the location for hydroelectric system was reached. It was Fagaras Mountain area, specific for development of handicraft techniques from ancient times. The land of emplacement was chosen on a stream derived from the main river, that have almost a constant water flow in time and that cross an agricultural land.

Designing the small hydroelectric station started with location and then the execution of subsystems and electric components.

The main components are presented in (Fig. 1), (Fig. 2) and (Fig. 3). The system is considering two variants: the first variant V1 proposed that electricity is generated by an alternator and for the second variant V2- the electricity is generated by an electric three-phase generator.

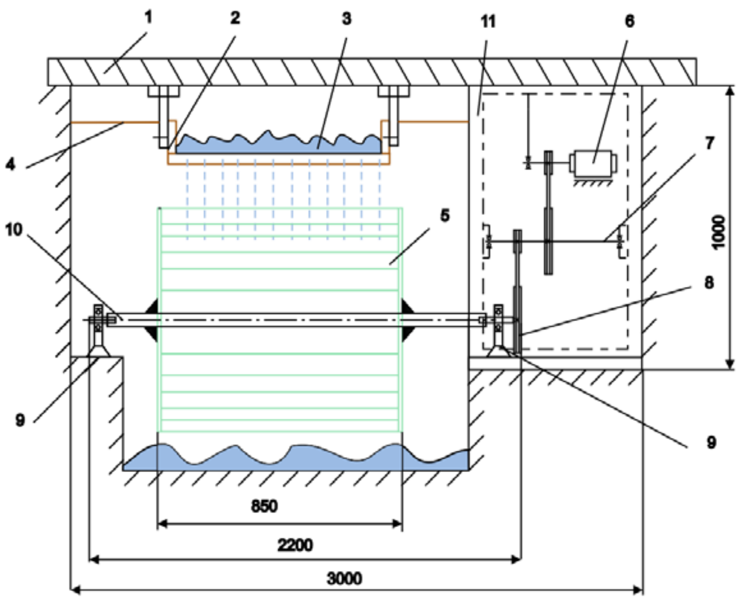

Fig. 3.
Longitudinal section through the bridge - Principial schema
Variant 1- with alternator
1 – overpass; 2 – fast spout; 3 – water flow rate; 4 – wooden barrage; 5 - turbine; 6 – alternator; 7 – trapezoidal transmission belts; 8 – pulley; 9 – spindle guide bearings; 10 – turbine spindle; 11 - concrete structure.

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A kinematic chain with intermediary spindle to transmit the rotating motion upwards of 1500rot/min was used for the **Variant 1.**

The transmission ratio is not constant; it depends of water flow rate and transmission loading based on slip coefficient.

The efficiency of belt transmission has a maximum value when the loading is optimum and consequently at an optimum slip coefficient.

The slip coefficient for trapezoidal transmission belts (k) is 0.02 (Manolescu 1998).

The calculation formula for the ratio of transmission motion (Radu 1997) according to the slip coefficient (k) is:

$$I = \frac{n_1}{n_2} = \frac{d_2}{d_1(1-k)} \quad (1)$$

where: I = transmission motion

n1 = rotation speed of the turbine spindle (rot/min)

n2 = rotation speed of the secondary spindle (rot/min)

d1 = diameter of the wheel on turbine spindle

d2 = diameter of the wheel on the intermediary spindle

k = coefficient of trapezoidal belt.

The main spindle (n1) generates 65-70 rot/min according to the variation of the water flow rate, approximately 30 l/s.

If the diameters d1 and d2 are known, n2 could be calculated using the formula (1) as:

$$n_2 = \frac{n_1 \cdot d_1 \cdot (1-k)}{d_2} = 343 \text{ rot/min} \quad (2)$$

where: n1 = 70rot/min

d1 = 400mm

d2 = 80mm

k = 0,02

The rotation speed of the alternator spindle (n3) was calculated with formula:

$$n_3 = \frac{n_2 \cdot d_3 \cdot (1-k)}{d_4} = 1680 \text{ rot/min} \quad (3)$$

where: n2 = 343rot/min

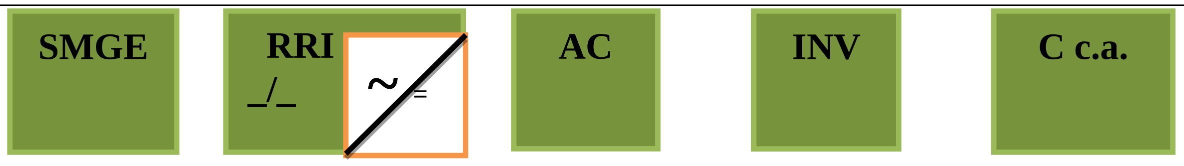
d3 = 400mm (diameter of the third wheel on the intermediary spindle))

d4 = 80mm (diameter of the wheel on the alternator spindle)

k = 0,02

After calculation, the rotation speed of the alternator spindle (n3) was 1680rot/min. It allows the whole system to function as an electric system with a battery of 12 volts similar with an automobile electric system.

The diagram for generation, conversion and utilisation of electric energy is presented in Fig. 4.



a	b	c	d	e

Fig. 4.
Block diagram of making a hydroelectric system of energy generation (Grecu 2015)
a - Mechanical generation system; b - rectifier and charging regulator; c - Battery; d - Inverter; e – Consumer.

Variant 2 aim to use a three-phase generator and manufacturing a short kinematic chain: wheel on the main axe of the turbine – transmission wheel on the generator axe.

The rotation speed was calculated with formula (1) as:

$$n_2 = \frac{n_1 \cdot d_1 \cdot (1-k)}{d_2} = 343 \text{ rot/min} \quad (4)$$

where: n1 = 70rot/min (rotation speed of the turbine)

d1 = 400mm (diameter of the turbine spindle

d2 = 80mm (diameter of the hydro generator spindle)

k = 0,02

For a rotation speed 340rot/min, the generated electricity could be used for different activities (e.g. lighting).

For the present research a higher rotation speed was not tested. The mini hydroelectric dam station described above is presented in (Fig. 5).

a b

Fig. 5.
Mini hydroelectric dam station:
a – Front view – stream derivation; b – Right view – mini hydroelectric dam station.

In Fig.6 are presented in detail the main components of the hydroelectric station.

Fig. 6.
Mini hydroelectric dam station
Detail of component parts: wooden fast spout and mobile spout, turbine with wooden elements and spindle.

The third objective envisaged the optimal management system for distribution of water flow rate (Fig. 7). As a result of the optimum management of the water flow rate, electric power is produced and environment protection was achieved as main activities. An additional facility to irrigate the surrounding agricultural land when draught was obtained.

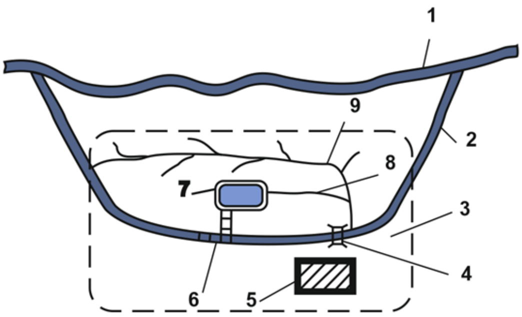


Fig. 7.
The management system for distribution of water flow rate
1 – main stream (streambed); 2 – derivation of the stream; 3 – agricultural land; 4 – mini hydroelectric station; 5 – mini construction; 6 – stairs for water flowing from pool; 7 – pool for aquatic fauna regeneration; 8 – penstock channel; 9 – irrigation canal.

The old pool for watermill machine and the penstock channel were rehabilitated by underpinning with river stones. As consequence, the biodiversity was maintained and improved. The water flows through a staircase wooden spouts. The proposed system allows to the free circulation of the aquatic fauna on the secondary course of the stream and the possibility of its regeneration into the pool (Fig. 8).

a **b**

Fig. 8.
Distribution of water flow rate
a – left view- deviation of the stream and water pool; b – right view – pool and mini hydroelectric station.

The execution of a traditional mini hydroelectric system using recycling materials available in agrarian households and additional new equipment, by allocation of low investments has a big potential, in the context of sustainable development.

In (Fig. 9) and (Fig. 10) is presented the hydropower system.

Fig. 9.
Detail for turbine and equipment Turbine ongoing – The mobile spout is up.

Fig. 10.
Detail for turbine and equipment- Front view- Turbine at rest.

CONCLUSIONS

The presented hydroelectric system based on ecological principles without a major intervention in natural environment and using traditional and recycling materials offers the following advantages:

- Reveals the Romanian traditions and rebuilds the specificity of the Fagaras County in terms of handicraft techniques.
- The system construction allows building adjacent constructions with a specific architecture and design such as "local fingerprint".
- The old irrigation channels for agricultural lands and orchards will be activated.
- The management of water flow rate will lead to optimal distribution of water quantity to produce electricity and to increase the agricultural production.
- A large amount of recycling material as subsystems could be used for a long period of time.
- As previously presented in similar studies (Grecu 2015) the mini hydropower dam station is an integrated system of electrical "green energy" production. The project includes additional two systems for generation of electricity by wind force and solar radiation. Thus, when one of the agents that generate energy is not available its functions can be fulfilled by the other one.
- The construction of the station described above on a short distance of 500m, is an alternative to the present proposed system of mini hydro power stations, more expensive and non-friendly with environment.
- The aim of this project to produce "green energy" was to use the local materials, on the existing streams or derivates, so that minimum electricity could be obtained even in times of stress, when life of people is in danger.
- The project is ongoing and will continue with designing of other new subsystems of electrical power generation by using the wind force and solar radiation, as well as a fourth system by using the geothermal energy.

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