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Electrical Generator's Manufacturing through Recycled Materials for Self-consumption

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Abstract: The reduction of the useful life of some technologies for various reasons currently generates a large amount of electronic waste whose main destination is landfills located in underdeveloped countries. On the other hand, the lack of availability of electrical energy can encourage the use of other less efficient means of generation with a greater environmental impact. To overcome these problems, it is proposed to recover certain wastes in the manufacture of small wind turbines for use in the construction of these countries. This article provides a practical example of the design of the electric machine and its performance in building with the positive social, economic and environmental impact of the regions involved.

Key words: Landfills, self-consumption, wind turbine, magnets, synchronous generator.

1. Introduction

For several years now, certain economically disadvantaged regions of the world have been afflicted by the synergies of certain events with serious consequences. One of these events is the emergence of extensive waste disposal sites for electrical and electronic devices; another is the unavailability of thermal and electrical energy in homes.

The relentless growth of demand in the market for the performance of electrical and electronic products and the reduction in the purchase price experienced in recent years [1, 2] have enabled the option to purchase and replace equipment in the face of possible repairs, thus reducing its useful life and consequently increasing the amount of waste generated [3].

Although initially the 1992 Basel Convention [4] agreed that signatory countries should treat electronic waste within their borders and at the same time the 1991 Bamako Convention [5] prohibited the import of hazardous waste, one of the destinations for waste generated globally, mainly in developed non-signatory countries, is in model regions in sub-Saharan Africa [3, 6, 7, 8]. In most cases, waste-importing countries accept e-waste through legal loopholes or tricks [2, 5, [9] because they allow some metals to be obtained in comparison with the corresponding minerals extracted from the mine [10, 11] and, in addition, the lack of environmental control and regulation for the e-waste recycling industry allows the neediest populations to find an economic opportunity [8, 11].

Faced with this problem, reuse in the dumps themselves is one of the main solutions [2, 12], but the type of manufacturing of electrical and electronic waste and the lack of resources and preparation of the population [2] mean that the collection of certain materials for their subsequent sale is carried out through uncontrolled recycling in unsafe and unhealthy conditions [1, 6, 11], which in turn generates certain proven and quantified environmental impacts: high levels of heavy metals, chemicals such as the phthalates DEHP and DBP (which interfere with reproduction) or chlorinated dioxins which are linked

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to cancer [1-3, 6, 10, 11].

From origin countries, research on future eco-designs minimizing the use of toxic compounds and metals [11] and establishing an adequate lifetime [3] is considered, but in addition, legislation establishes the responsibility of producers for the subsequent management of waste by encouraging the reuse and recycling of waste at the end of its life [13] also, on restrictions on the use of certain substances [14], issues that would favour the task of treatment and reuse.

On the other hand, developing countries often have inefficient energy generating and transporting systems, which made difficult his technical and economic access for the populations, forced to use natural resources such as wood [15]. Around 2.4 billion people depend on wood for cooking or heating, as an example, in Africa, forest-based energy is one of the top sources of energy for the 60% of households [16], where this raw material represents the only source of affordable and available energy.

The firewood and charcoal production is often, in developing countries and economies in transition the main use of woody biomass, for example, in Togo, the per capita firewood and coal consumption is estimated at 347 and 75 kg respectively [17] but the existing deforestation caused by indiscriminate logging and the use of wood as fuel is directly related to the contamination of river and air water (Fig. 1), hindering the progress of certain activities such as fishing industry.

This is accompanied by significant population growth [7] and high per capita energy consumption to meet minimum housing needs due to the lack of efficiency in energy generation, transportation and consumption [18]. In Togo, the population has increased by 30% in the last 10 years, and losses in electrical transportation have been estimated at 26.2%. In addition, the lack of efficiency in buildings and appliances reduces thermal performance values to below 10%, which implies an increase in the amount of material used to obtain the same amount of energy.

Against this background, and in addition with the measures offered internationally, do not completely solve the problems presented, it is necessary to manage the waste by applying a correct reuse and find an energy alternative that allows the residential supply of the population, reducing as far as possible the indiscriminate use of the wood and added impacts.

2. Case Study and Goals to Be Developed

The study proposed will describe a practical case of manufacturing small wind turbines for self-consumption in buildings from recycled materials that can easily be found in electrical and electronic landfills, and its contribution to the problems described above. The workshop schools where the practice will take place are places where students develop practical work that empowers them for their working life, sometimes linked to the marketing of manufactured products.

In this way, different possibilities are offered, among which are: the reuse of waste without aggressive methodologies for health and the environment, technical training in the assembly and operation of wind turbines, the creation of new economic and collaborative lines and the workers mobility between regions and electrical self-generation in buildings with the consequent reduction of forest biomass burning and its corresponding environmental impact (Fig. 2).

Following the proposed tasks, a controlled recycling can be obtained as it has happened in other regions [2] but it is also carried through the native population out,

Fig. 1 Togo river's pollution.

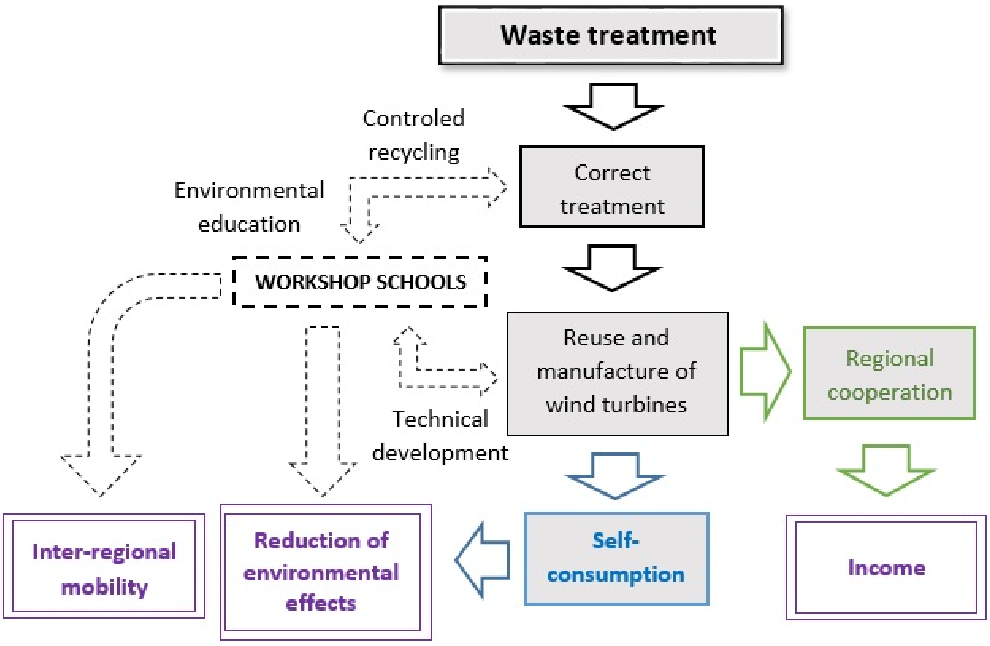

Fig. 2 Diagram and possibilities.

accelerating the formation and adoption of the renewable technologies presented [15]. The case study can be focused on the Accra region, in Sub-Saharan Africa, where one of the largest electronic dumps in the world is located [6] and close to countries such as Togo, Benin, etc., with the aspects presented above and considered in "electric poverty" by the International Energy Agency [15].

In this article a practical example is described, where the obtaining of the electric machine of a wind turbine is presented, showing the possibilities using the motors and magnets obtained through controlled extraction and treatment of frequent residues in the existing landfills [2].

3. Practical Methodology

The wind turbine will be configured as a synchronous generator with permanent magnets, which will need a winding stator and a rotor permanent magnet based. For this purpose, firstly a selection of the appropriate devices and their location is carried out and then treated to finish with the corresponding performance analysis.

3.1 Choose and Material Location

The stator and the rotor are obtained by different means; all controlled requiring in the worst case a small mechanical adjustment. Initially, considering the single-phase machines, the stator can be obtained from the following motors.

- Squirrel cage motors with capacitor and universal motors, both formed by a stator designed by stacked plates in a symmetrical set of protruding poles, easy to identify, where the coils that will generate the induction on the rotor are housed. This kind of motors allows the use of the stator without complicated adaptations needed and it can be easily found. They are the most common motor in appliances that need a lot of torque for their operation, such as washing machines, dryers, etc.
- Permanent magnet motor with the rotor made up of permanent magnets as main aspect. This is very interesting for the present work, because no modification is required to work as generator. This kind of motor, usually common, is designed for low power projects, around 30 W and they can be located in car alternators, small appliances, water pumps and

Fig. 3 Hard disks.

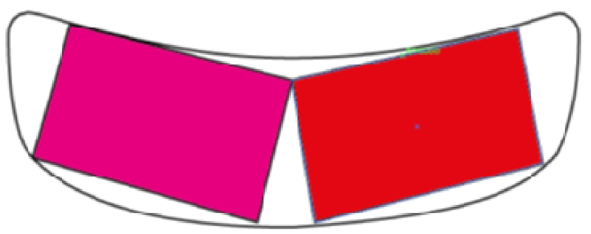

Fig. 4 Cutting neodymium magnets.

power tools such as drills.

The machine's rotor will be made by arranging the magnets obtained from different sources. As an example, there are permanent magnets suitable for making a constant magnetic field in the hard disks of computers and in microwaves. Neodymium permanent magnets obtained from 3.5" HDD type hard disks (Fig. 3) are very common in these dumps. A neodymium magnet is a rare earth type, it is a permanent magnet made from an alloy of iron, boron and neodymium being a high field strength magnet. It is also possible to find two magnets inside microwaves, in this case made of ferrite, usually with a cylindrical shape of about 58 mm in external diameter and 13 mm in depth.

3.2 Desing and Assasembly

Obtaining the stator windings and removing the magnets from both the hard disks and the microwaves are based on a simple dismantling of the corresponding waste.

The subsequent task will be to obtain and analyse the stator, obtaining its dimensional, structural (experimental case, stator with axial winding) and electrical data from the nameplate as a motor (e.g. universal motor obtained from a washing machine).

By identifying the number of stator poles (i.e. two poles), the corresponding rotor is designed, which can be approached from two situations. If you already have an even number of magnets that fit easily on the rotor surface, you can calculate the power that the motor could give in its operation as a generator with the new magnet rotor. On the other hand, if a certain power is desired, the value of the field to be generated and consequently the dimension of the magnets to provide this field can be obtained, taking into account the possible dimensions of the rotor.

Neodymium magnets are similar to ceramics, so it is not difficult to carve them to obtain a certain shape. Given the original U-shape found in Fig. 3, the best way to obtain it, wasting the minimum material, is as shown in Fig. 4. The magnets obtained would have approximate dimensions of 20 × 10 × 5 mm (Fig. 4).

In the case of neodymium magnets, depending on the type of generator, different magnet arrangements are possible, either in an axial arrangement (Fig. 5) where the axis of rotation is parallel to the magnetic field of the magnets and the stator grooves in a radial manner, or in a radial arrangement (Fig. 6) where the axis of rotation is perpendicular to the magnetic field of the magnets and the stator grooves in an axial manner.

An asset of the radial arrangement of the magnets is that the required field value can be established by simply stacking the magnets symmetrically as required. With regard to the axial arrangement, a 3D printer is used to design the body and the necessary magnet slots, such as the rotor in Fig. 7.

In the next case of study, from which the electrical operating measurements will be taken later, given the dimensions of the stator, it is preferable to use the microwave magnets in the arrangement shown in Fig. 8, using a 12 mm square section steel bar to create a magnetic path and join the two poles.

3.3 Research Trials

It must be borne in mind that the maximum power that can be achieved, as a generator, will be very

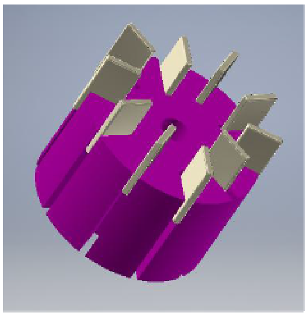

Fig. 5 Neodymium magnets with axial rotor arrangements.

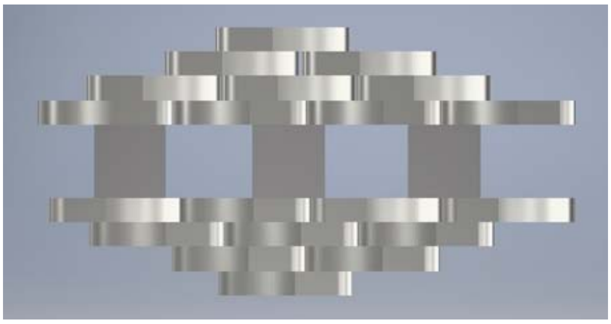

Fig. 6 Neodymium magnets with radial rotor arrangements.

Fig. 7 Rotor with hard disk magnets.

Fig. 8 Rotor with microwave magnets.

difficult to exceed half the value as a motor.

In the lab, use a compound motor to spin the generator to be tested and a tachometer to determine the rotation speed of the motor shaft (Fig. 9).

In the first part of the test, with the multi-meter continuity function, the ohms between the different

Fig. 9 Test and measurement laboratory.

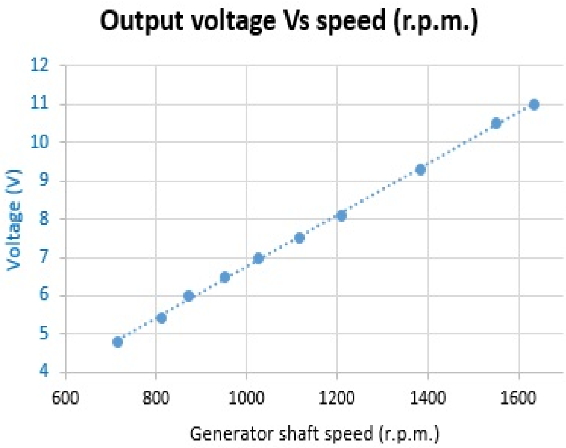

Fig. 10 Vacuum generator output voltage according to revolutions (r.p.m.).

motor outputs have been measured. So, the internal construction of a two-phase motor with two poles in the stator is confirmed.

Then, the voltage and intensity offered by the generator designed at a certain speed (r.p.m) are measured. Initially, these are measured in vacuum (Fig. 10) and subsequently under load with two output resistors of 10 and 58 ohms (Figs. 11 and 12), respectively.

Based on the graph could obtain the following information:

- The linear character in vacuum and load of the generator operation given the proportionality of the flow with the intensity.
- The possible impact of the converter resistance to the output of the generating machine.
- Despite an amorphous design of the rotor with a non-homogeneous air gap, acceptable output characteristics are achieved.

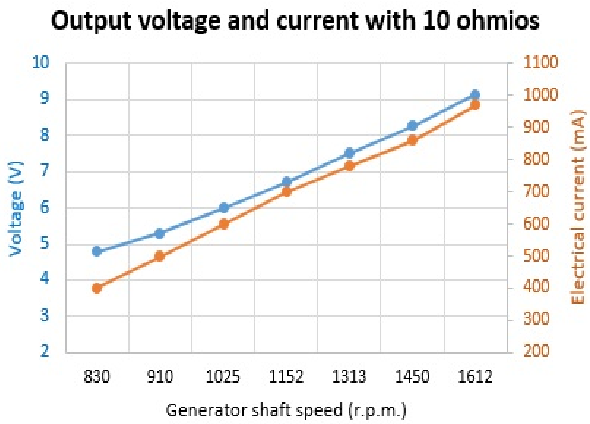

Fig. 11 Output voltage and current according to generator revolutions (r.p.m.) with an electrical load of 10 ohmios.

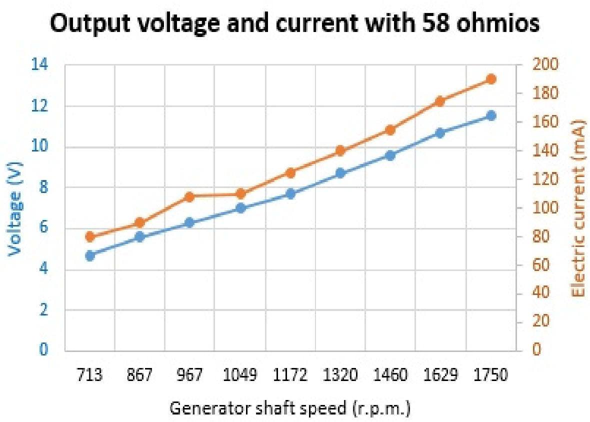

Fig. 12 Output voltage and current according to generator revolutions (r.p.m.) with an electrical load of 58 ohmios.

Sufficient electrical values can be obtained by suitable signal processing for use in battery charging or direct DC supply to the installation of the corresponding building, as there is the possibility of making a DC installation to reduce the costs of the inverter [18].

From this point you can obtain the power curve of the machine trying to improve the parameters of the machine obtained.

4. Conclusions

The short practical example given above shows the possibility of controlled recycling of materials suitable for the manufacture of the electrical machine of the wind turbine. Different possibilities of location, treatment and disposition of elements found in landfills are presented, demonstrating their possibilities as generating machines. In addition, at the same time, the students are trained to deal with possible variations and characteristics of the material used, issues that enable the social, economic and environmental possibilities shown in Fig. 2:

- The generators made allow their use in the self-consumption of the remote houses in the treated regions.
- If the region where the workshop schools are located does not have a wind with these characteristics, there is the possibility of marketing the manufactured equipment and establishing cooperation between regions according to the characteristic resources [15].
- On the other hand, training the population in the intrinsic design of manufactured machines also favors the mobility of individuals between regions, given that in recent years renewable energies have found greater possibilities in emerging countries than in developed ones [15].

In addition, health and hygiene in the treatment of waste and the possible reduction of the forest mass used as an energy source reduce the impact on the population.

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