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Smart speed bump for mechanical energy harvesting from roads

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ABSTRACT

A great deal of research has in recent years been carried out on harvesting energy using smart systems. Harvesting energy from the ambient environment has become an emerging technology for many applications, ranging from portable electric devices to renewable energy. This article constitutes a synthesis of work carried out within the framework of a study on systems for energy harvesting. The objective of the project was to design an intelligent retarder system. The advantage of the energy recovery system is that it transforms the kinetic energy produced by the passage of vehicles on the retarder to electric energy using a mechanism. The powers involved in this context can go up to 46 kW/h.

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1. INTRODUCTION

Generally, the production of electrical energy is done from fossil fuels (coal, oil, natural gas), and if these energies are clean and non-polluting, their production causes adverse effects on the environment, as well as these sources of energy are not renewable because they take millions of years to build up and because they are used much faster than the time needed to recreate reserves. In this context, several studies have been carried out to be able to recover electrical energy independently of these fossil fuels.

In 2008, the innowattech company tested a new technology called INNOWATTECH PIEZO ELECTRIC GENERATOR [1], is based on the principle of piezoelectricity [2-3]. The idea is to integrate piezoelectric single crystals in the road in order to recover and convert the mechanical energy produced by the passage of vehicles to electrical energy. One kilometer of this road allows innowatech to produce 400 kW per day and inject it into the public network. In 2009, the company sainsburg installed plates in their parking lot [4] in order to recover the kinetic energy by the passage of vehicles, but this time by a mechanism installed under the retarder. The objective of this installation is to supply the company's machines to reduce the loads due to energy, the power of which is generated by the retarder is 30 kW per hour. In the same year, inventor Peter Hughes proposed a new approach to kinetic energy harvesting [5], but this time with a new form of retarders. This invention is capable of supplying the surroundings with cylindrical breaks. Then, in 2011, the company New Energy Technology tested a retarder called MOTION POWER EXPRESS [6] composed of a mechanical-electrical conversion mechanism intended to supply a 150-foot screen during the day. Finally, in 2013, an Italian company asked the energy recovery market a speed bump [7] able to produce 6 GW per year with the passage of 400 vehicles per day, the throttle is equivalent to a high-power wind from 3MW.

Inspired by all these projects, this work is the update of speed bumps with a fairly simple and less expensive application, placed on motion transmission tools.

2. SYSTEM DESCRIPTION

The description relates to an energy harvesting retarder system. The interest of the system is to transform the kinetic energy produced by the passage of the vehicles on the retarder to an electric energy which can be used to supply the surroundings of the retarder by the mechanism able of producing a significant power of electricity, which the main use is public lighting to make sensors independent from the energy side.

Figure 1. Descriptive diagram of the intelligent retarder

3. FUNCTIONAL ANALYSIS OF THE SYSTEM

To define the expected functions of the model, we used the functional analysis. During this analysis, the product does not yet exist, a fortiori no solution is considered.

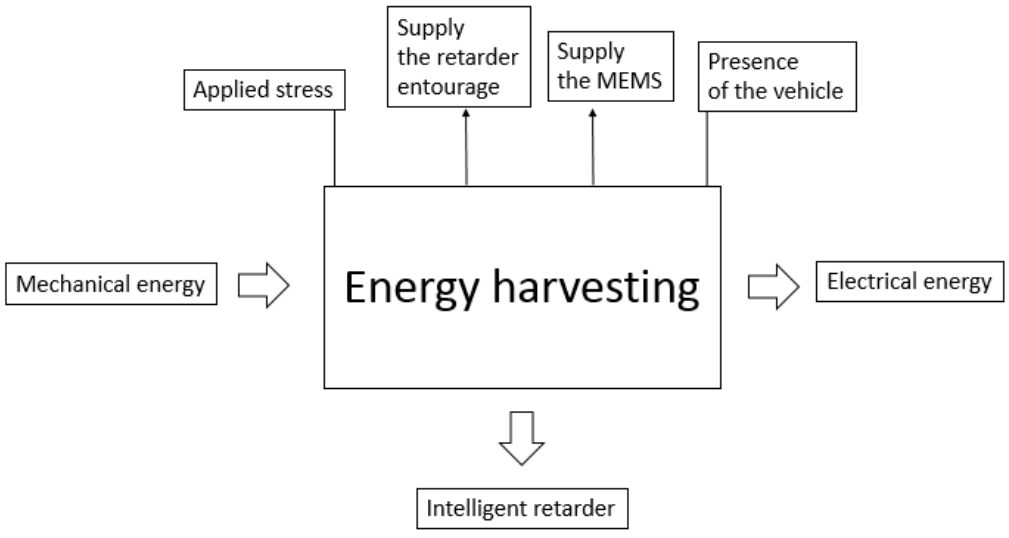

Figure 2. SADT diagram of the system

After having framed the context of the model, the SADT tool comes to allow us to define the various factors which will lead us to reach our goal which is to energy harvested by the use of a mechanical system. The energy recovered in this case is the mechanical energy produced by the passage of vehicles above the entrance to the overall system, but the technical functions and the associated solutions must be

more detailed, and to do this we have recourse to the diagram of FAST To detail the functions and the technological solutions of the system, we have broken down the diagram FAST corresponds to the global system (figure 3).

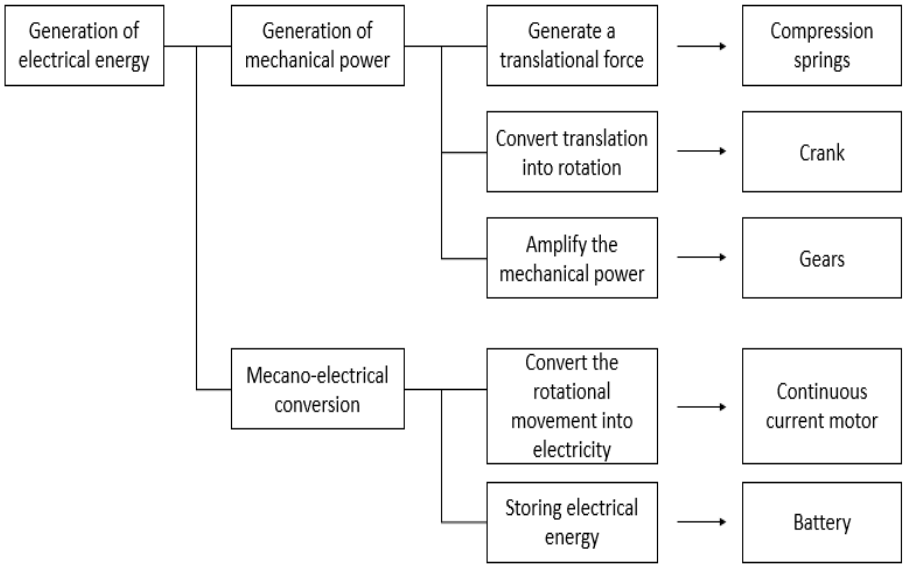

Figure 3. FAST diagram of the system

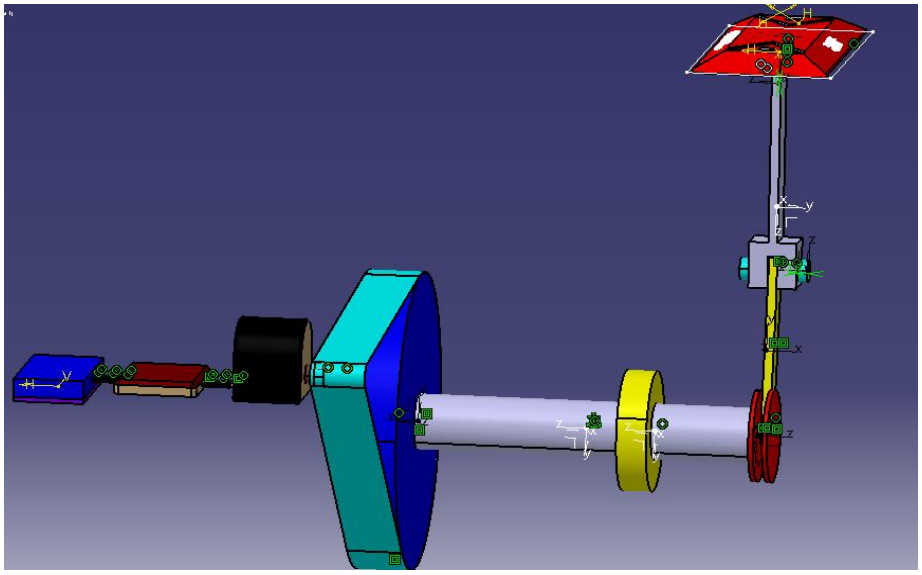

Figure 4. Global perspective of the system

4. SYSTEM COMPOSITIONS

4.1 The composition of the mechanical system:

The purpose of the mechanical composition of the mechanism is to generate a maximum of rotation for the supply of a direct current motor; and for proper operation, it has been proposed to use mechanical subsystems mentioned in figure 5.

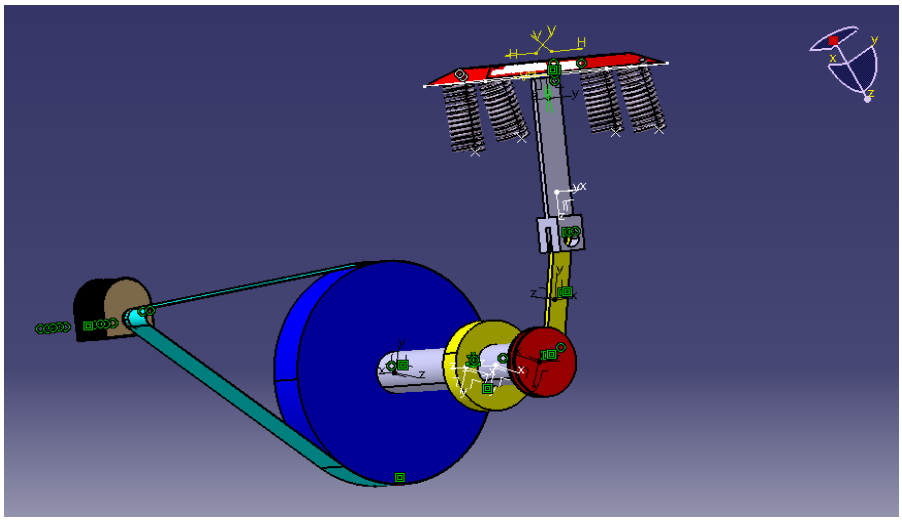

Figure 5. Mechanical part of the system

Compression springs: The mass of the vehicle running on the retarder must not exceed 50 Kg. The latter is supported by 5 springs which are distributed under the retarder, so each spring must withstand 1/5 of the overall force, m = 10 Kg.
Rod-crank: The connecting rod-crank system is a model of mechanism, which owes its name to the two parts that characterize it. It is, above all, a mechanical system for transforming movement.
Power multiplication system: After studying the power multiplication systems (pulley, belt, gear), we concluded that the gears will be more useful for our model, since they do not take up space compared to the belt pulley, on the other hand the latter will be very useful to us if we manage to carry out the project on a large scale given its output and its cost especially the synchronous belts. Less expensive, accessible, and above all, since they provide more advantages than disadvantages, parallel gears with helical teeth have a good multiplication system. Therefore, we only have sizing this system.

4.2 Electrical composition of the mechanism

The essential objective of the electrical composition of the mechanism is to convert mechanical energy into a form that is more usable, simple to store and which meets quality and safety standards. This electrical energy requires an installation made up of several well-chosen elements.
At the beginning, it is necessary to proceed by a general study of the whole system in order to choose and calculate the recovered power.

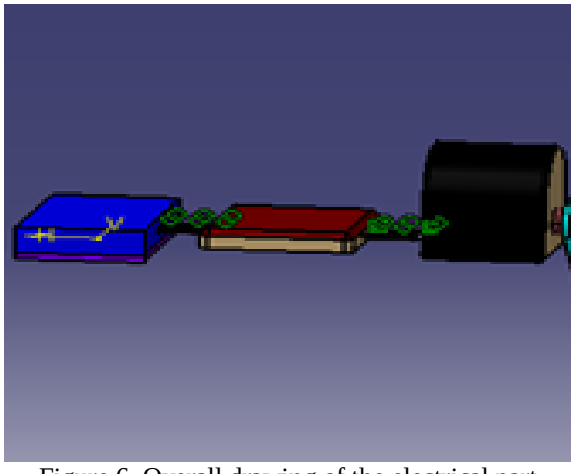

Figure 6. Overall drawing of the electrical part

The composition of the electrical part is summarized in the following elements:
A direct current machine is an electrical machine. It is an electromechanical converter allowing the bidirectional conversion of energy between an electrical installation carried by a direct current and a mechanical device. It is also called a dynamo.

The battery is used to supply the equipment which must remain energized (the surroundings of the retarder).

5. ENERGY BALANCE:

The number of teeth was chosen according to international standards and according to the type of gear used in the model.

Data: The force applied to the bearing surface F = 100N. The distance between the bearing surface and the center of the connecting rod is d = 20 cm

Calculation of the power generated by the system:

Ce = F*d

Ce = 20 N.m

Cs = n 2 .Ce (-1) (We / Ws)

Cs = 1.73 N.m

Pa = Cs.Ws

Pa = 36.2 W

Pu = n1.Pu

Pu = 28.9W

With Ce, Cs, n2 , m, We, Ws, Pa, Pu and n1 respectively the input torque of the gear train, output torque of the gear train, efficiency of the gear train, number of contacts between the pinions, input speed of the gear train, output speed of the gear train, mechanical power absorbed, useful power and efficiency of the direct current motor (we estimated the losses at 20%) [9-11].

The following table gives the values of the power per hour as a function of the flow of the cars passing over the retarder.

Number of cars per hour	Power in kW/h
100	5.8
200	11.6
400	23.2
800	46.4

Table 1. Energy balance for the real system

With an easily available energy source, “road” energy recovery [8] would constitute a new source of clean and renewable energy. This system does not require any human intervention except preventive maintenance or battery change.

Conclusion

The works presented in our article allow the concept ion of a new system for the recovery of kinetic energy. Following our study, we were able to observe thanks to the system design that it is possible to make the mechanical-electrical conversion of the energy generated by the passage of vehicles on the retarders.

We are therefore going to devote the next study to the production of the model, the marketing and the study and detailed analysis of the various organs of the system in order to be able to act directly and propose improvement actions.

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