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## **Safety of Pedestrian Crossings and Additional Lighting Using Green Energy**

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### **Abstract**

Additional safety and lighting of pedestrian crossings using green energy can be reached by using specially designed device for forced reduction of vehicle speed. Device performs two functions: during the movement of the vehicle above the device, it generates electrical energy, as well as works like a normal speed limiter (a thick plate that is attached to the road surface to slow down the velocity of vehicles). This paper takes a new look at the term of „sleeping policeman" - an element forcibly reducing the speed of vehicles, one of the measures to calm the traffic, in our case before the pedestrian crossing. "Sleeping policeman" offered in the frame of current research offers possibility also to generate green energy for additional lightening of pedestrian crossings. Both functions together, will bring pedestrian crossing to the new level of safety.

**KEY WORDS:** *transport infrastructure, sustainable transport system, green energy, lighting, pedestrian crossing, energy conversion, safety*

### **1. Introduction**

The principal characteristic of safety pedestrian crossings is minimal number of accidents with pedestrian involved. Unfortunately, statistics shows, that number of accidents on the pedestrian crossings are still high. The main goal of current article is to offer solution for making pedestrian crossing safer. In ideal case, pedestrian crossings are responsible for pedestrians' safety, but in many cases drivers did not drop velocity of the vehicle good enough, crossing the area of pedestrian crossing.

Traditionally, the focus has always been on road marking and special signs to underline the location of pedestrian crossing. Sometimes it is enough, but sometimes it is needed to use additional equipment. Few researchers have addressed the problem of insufficient lighting of pedestrian crossings, but this problem is still actual, especially in darkest time or when weather is rainy, or in other weather condition, when pedestrian crossings are not seen well enough. Despite this interest, no one to the best of our knowledge, did not offer adequate, simple enough solution for problem solving.

The present paper aims to offer the solution, which can help make pedestrian crossings safer and in same time will produce "green" electricity.

This paper takes a new look at the term of „sleeping policeman" - an element forcibly reducing the speed of vehicles, one of the measures to calm the traffic, in our case before the pedestrian crossing. "Sleeping policeman" offered in the frame of current research offers possibility also to generate green energy for additional lightening of pedestrian crossings. Both functions together, will bring pedestrian crossing to the new level of safety.

### **2. The Problem of Unlighted Pedestrian Crossings**

As it was mentioned above - the principal characteristic of safety pedestrian crossings is minimal number of accidents with pedestrian involved. Unfortunately, statistics shows, that number of accidents on the pedestrian crossings are still high.

The safety of all traffic participants depends not only on drivers and pedestrians, but also on the conditions of traffic, transport infrastructure, weather conditions, etc. More than 30% of traffic accidents to some extent concern pedestrians. The pedestrian can be the reason of road accident or/and a victim.

Unfortunately, pedestrian crossings cannot guarantee safety. The main causes of accidents at pedestrian crossings are poor lighting or its complete absence, long pedestrian crossings, high speed of moving vehicles through pedestrian crossings (i.e., the absence of speed limits) [1].

Of course, one cannot fail to mention the importance of a culture of driving and mutual respect for drivers and pedestrians as participants in road traffic. The society and the state must work together on this problem. In countries where this is given more attention, the number of accidents is much less than in countries with a more loyal attitude to violators of traffic rules.

In many countries, a lot of researches of the causes and factors that affect accidents are being done [2-7]. To conduct research, various technical devices are used to collect statistical data.

For example, in Israel, it was studied how the removal of marking pedestrian crossings could affect the safety of pedestrians [2]. The study confirmed that road marking is one of the factors of increasing safety, and its removal increases the risk for pedestrians.

Swedish scientists studied the factors that affect the speed of the car, the relationship between speed and traffic safety, as well as the way to influence the driver to change the speed [3]. They proposed a system that limits the maximum speed of the vehicle to improve the safety of all traffic participants.

In Belgium, they have made a study of the reasons for the violation of the rules for crossing the road by pedestrians [5]. It is determined that both traffic conditions and technical characteristics of pedestrian crossings have a significant effect on the frequency of violations. Because pedestrian crossings are part of the transport infrastructure, the most important task is to improve them.

The authors [6] analyzed data from the USA and Germany with the aim of studying the change in the number of pedestrians and cyclists per capita lost. The results showed that there are large differences in age groups in the lethality and serious injuries. Elderly people have the highest rates.

Ukraine also has serious problems with the safety of pedestrians who are road users. This is their fault, and the fault of the drivers. For clarity on fig.1, the causes of accidents are ranked by the number of victims in Ukraine in 2017 [8].

As can be seen from fig.1, one of the main causes of road accidents is speeding. But it is important to note that absolutely all the indicated reasons can lead to the tragedy of any of the road users, including pedestrians. In addition, in Ukraine a large number of pedestrian crossings have neither traffic lights nor normal marking. And some of them have very little coverage in the dark or are not illuminated at all.

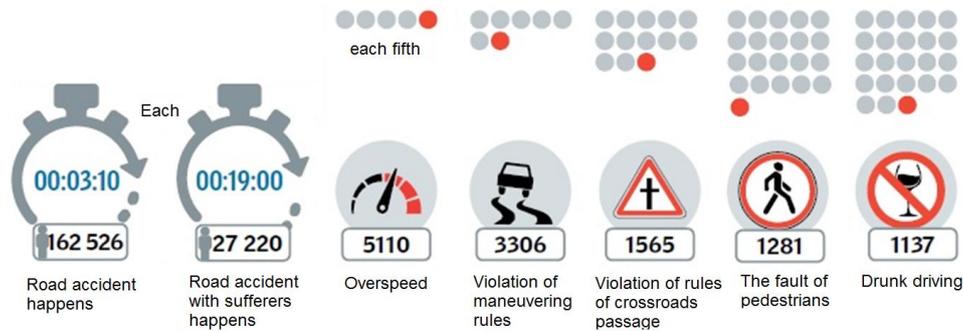


Fig. 1 Main causes of road traffic accidents with victims in Ukraine (Year 2017) [8]

Therefore, improving the safety of pedestrians can be divided into two components: reducing the speed of vehicles in front of pedestrian crossings and equipping pedestrian crossings themselves with additional technical means that promote observance of traffic rules by both pedestrians and drivers.

The question is – how to make pedestrian crossings safer? One of the possible solutions, offered by authors is described below.

### 3. Safety and Lighting of Pedestrian Crossings Using Green Energy

Additional safety and lighting of pedestrian crossings using green energy can be reached by using specially designed device for forced reduction of vehicle speed. Device performs two functions: during the movement of the vehicle above the device, it generates electrical energy, as well as works like a normal speed limiter (a thick plate that is attached to the road surface to slow down the velocity of vehicles).

At the same time, the process of conversion of kinetic energy into electrical energy will be more effective than in the above-mentioned devices due to the use of a cylindrical multiplier and a larger path of the drive strip of an electric generator. The essence of the proposed utility model is explained by schematic drawings - (Figs. 2-6) shows the construction and operation of the device for generating electric power and forced speed reduction with a multiplier.

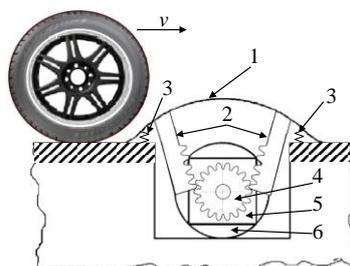


Fig. 2 Construction of the device for forced reduction of vehicle speed and generation of green energy.

The proposed device for generating electric power and forced speed reduction with a multiplier has the following structural elements (see Figs. 2, 3, 5): -a thick plate 1; -the rails of the electric generator drive 2; -springs 3; -drive gear of electric generator 4; -multiplier 5; -electric machine (electric generator) 6.

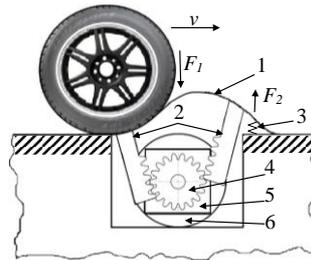


Fig. 3 Operation of the device for forced reduction of vehicle speed and generation of green energy. Step 1.  $F_1$  - force of pressing;  $F_2$  - force of action of a spring;  $v$  - vehicle speed.

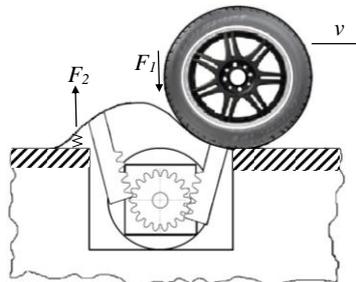


Fig. 4 Operation of the device for forced reduction of vehicle speed and generation of green energy. Step 2.

The device works as follows: when the vehicle wheel at a speed  $v$  hits the plate 1 which is attached to the road surface to slow down the passage of vehicles that is connected to the electric generator drive rails 2 and the springs 3, the thick plate 1 starts to move downward under the weight of the vehicle - under the action of pressing force  $F_1$  (Figs. 2-4), thereby moving one of the electric generator drive rails 2, which with its teeth is coupled to the drive gear of the generator 6. The power driver's drive rail 2 moves down to the full compression of the spring 3, and thereby rotates the drive gear of the electric generator 4, which is rigidly fixed to the shaft of the multiplier 5, which increases the rotational speed of the rotor of the electric machine (electric generator) 6.

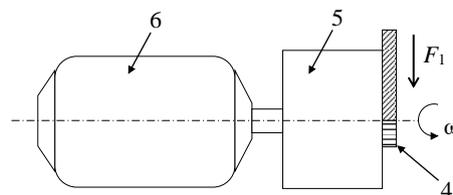


Fig. 5 The multiplier increases the rotational speed of the rotor of the electric generator

Where  $\omega$  - angular speed of rotation.

When the wheel moves to the second half of the thick plate 1, the process is repeated, but the second power strip of the electric generator 2 starts to work. At the same time, the spring 3, which was compressed by the wheel, is straightened by the force  $F_2$ , and the second spring, on the contrary, by the action of the force  $F_1$  and the rotor of the electric generator, under the action of the second power strip of the electric generator 2 through the drive gear of the electric generator 4, it starts to rotate in the opposite direction and leads the EMF in the stator windings with a negative value. The stator windings of the generator are connected to the electric rectifier 7 (Fig. 6).

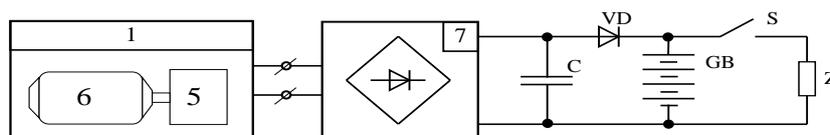


Fig. 6 The stator windings of the generator are connected to the electric rectifier

Where C - capacitive storage; VD - the diode; GB - rechargeable battery; S - switch; Z - the load.

When the EMF is guided along the windings, an alternating electric current begins to flow, and after it is rectified on the electric rectifier 7, it charges the capacitive storage C and through the diode VD - the battery GB. The

switch S turns on the power supply to the load Z.

Thus, the device for generating electric power and forced speed reduction with a multiplier makes it possible to increase the efficiency of energy conversion from pressing to electrical by using an electromechanical energy converter based on an electric machine, which is driven via a reducer, increase the speed of rotation-the multiplier, and also performs function of the speed limiter of vehicles.

The proposed electric power generation device can be used as a vehicle speed limiting device that simultaneously generates renewable electricity. Electricity produced by the device can be used for additional power supply to electricity consumers - households, schools, office buildings, shopping centers and the like.

The analysis of the causes of road accidents involving pedestrians (part 1) showed that the very first step in solving this problem is the development of devices that force both pedestrians and drivers to comply with the rules of the road. This can be achieved by applying non-standard ways of attracting the attention of all traffic participants to the signal of a traffic light at pedestrian crossings. The second part presents and describes in detail the operation of one of the possible devices, which not only reduces the speed of vehicles, but also allows the generation of some green energy. Based on the studies carried out and the developments presented, it is proposed to equip pedestrian crossings with the device described above, in conjunction with the signaling system described in [9, 10] (see Fig.7).

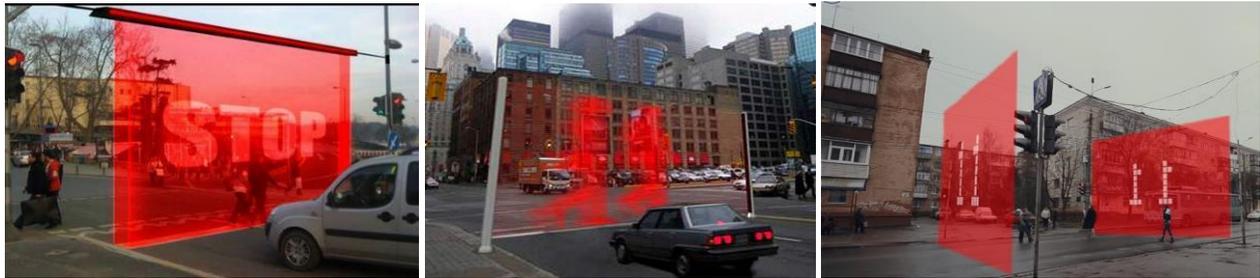


Fig. 7 Traffic light equipped with laser devices [9, 10]

These systems (see Fig. 7) need a constant power supply, and the proposed device (see Figs. 2-6) is able to generate the necessary amount of electricity for their operation. Such cooperation will, in the opinion of the authors, significantly reduce the accident rate on the road crossings and make them adjustable. At the same time, energy for traffic lights is generated by vehicles traveling along this section of the road. If the road section is sufficiently brisk, it is obvious that the generated green energy will be more than necessary for the functioning of this system. Consequently, surplus energy can be transferred to other (third-party) consumers. That is to say, this device (technical system) is an alternative and decentralized source of electricity. And here, in our opinion, we are already talking about energy-efficient and energy-saving technologies. And this topic is one of the most urgent in the modern world [11, 12].

After the offering current solution – the question will be – how to perform energy flow measurement? Introduction to that problem solving will be given in next section.

#### 4. Energy Flow Measurement

Current solution of "sleeping policeman", able to produce green electricity needs an adequate energy flow measurements. There are some researches below, which in good way describe the possibilities to perform this action in different ways.

Because some consumers of electric energy work on direct current, they in their composition have converters of alternating current to constant and vice versa. This allows them to work with AC sources.

Often, the energy produced cannot be consumed at once, and even the generation of energy can be unstable. Therefore, in order to conserve excess energy and then use it, various types of energy storage devices are used: batteries, super capacitors, fuel cells, superconducting inductive storage, etc.

Such devices are connected to the micro-networks of direct current through bi-directional converters AC-DC-AC. Monitoring of the energy flow near consumers / sources of the DC chip and AC network allows determining the efficiency of the system, as well as the vulnerability of the system in terms of energy flow. This makes it possible to make changes to the workflow of devices to improve efficiency [18].

If the consumer generates a non-sinusoidal current form, then the calculation of energy consumption is based on instantaneous power values. To calculate instantaneous power, average power or consumed energy, instantaneous values of current and voltage are read [8], [14].

There is another method in which the values of voltage and current are averaged over multi-order delta-sigma modulation and multiplied. But installing devices for measuring / monitoring electricity near each consumer or generator is very expensive [18]. The authors of [15], [16] proposed several methods to reduce these costs. The main drawback is the need to use a separate low power source to measure the power supply IC and, as a consequence, increase the own consumption of the measuring device. Measurements of the energy of alternating and direct current are the difference due to the difference in the environment of AC and DC, especially if a bi-directional energy flow occurs. To solve this problem, a method was proposed for measuring the energy consumption of a fuzzy sample [17].

## 5. Conclusions

There is presented the analysis of the main causes of road accidents with pedestrians involved. The analysis addresses the main causes of such accidents in different countries. Main methods for eliminating these causes are given, which should lead to reduce number of road accidents.

Presented studies are not exhaustive, but clearly formulate and describe one of the possible ways to improve safety at pedestrian crossings.

The technical solution of the device for compulsorily reducing the speed of vehicles before pedestrian crossings is given. This device can be considered as an alternative and decentralized source of green energy, which is able to provide electricity for own needs and transfer its surpluses to other consumers.

It is offered to combine into a single system both components - the device considered to reduce the speed of vehicles and traffic light equipped with laser. Such a system is sufficiently visible for all road users and is able to provide the required safety at pedestrian crossings, making them adjustable. Laser light illumination makes a pedestrian crossing noticeable at any time of the day and, in fact, under all weather conditions.

Issues of measuring and accounting of generated electricity by the proposed technical system are also considered.

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