CONSIDERATIONS ON THE USE OF A PHOTOVOLTAIC PANEL FOR INCREASING THE AUTONOMY OF AN ELECTRIC BICYCLE

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ABSTRACT: The paper presents studies for increasing the autonomy of an electric bicycle by using a flexible / semi-flexible photovoltaic panel for charging the electric bicycle battery while it is stationary.

KEY WORDS: E-bike, photovoltaic panel, autonomy.

1. INTRODUCTION

Nowadays, there is an increasing interest in the use of alternative, non-polluting means of transport, especially for shorter trips and in urban areas. One of the variants is an electric bicycle, which is increasingly used for trips up to 20-30 km and with maximum speeds around 25 km / h.

In essence, an electric bicycle [1], [2] is a development of the classic bicycle, in the sense that the classic bicycle is attached to it by an electric motor, DC or AC, mounted on the frame or hub on the front or rear wheel. [2] [3] and powered by a system for its operation and control, implemented with a controller [4], [5]. The electric motor transmits the mechanical power of the wheel / wheels, being powered by a battery disposed on the bicycle. It is important for the battery to be light and reasonably priced, which is why the capacity of the batteries placed on the bicycle is relatively low, which limits the autonomy of the bicycles to a few tens of kilometers, even when the electric traction is well supplemented by the human traction.

An overview of the specific blocks of an electric bicycle and their interconnection is shown in figure 1.

A solution for increasing the autonomy of an electric bicycle is the use of a photovoltaic panel to charge the electric bicycle battery.

The paper summarizes the main types of electric bicycles and a study regarding the use of a semiflexible photovoltaic panel for charging the electric bicycle battery in order to increase its autonomy.

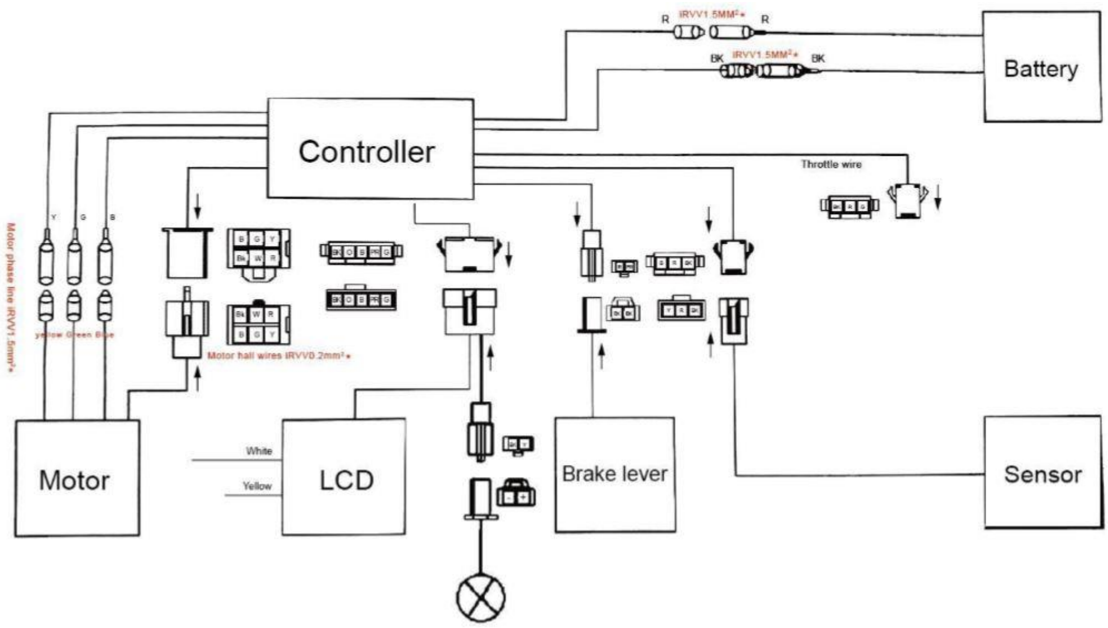

Figure 1. General summary scheme with the specific blocks of an electric bicycle

2. TECHNICAL REQUIREMENTS

2.1. Types of electric bicycles

Currently, there are three major types of electric bicycles [2]:
- Pedelec
- S-Pedelec
- Twist-N-Go

2.1.1. Pedelec type

The bike (figure 2) has pedaling assistance. According to the EU standard, engines with such electric bikes help to spin the pedal arms but only until they reach a speed of about 25 km / h, as they say, "stay on your own".

Figure 2. Pedelec electric bicycle

2.1.2. S-Pedelec type

S-Pedelec (figure 3) is the improved version of the Pedelec, characterized essentially by the fact that it does not have a speed limit, restricted above when pedaling and the cyclist, so the cyclist can significantly exceed the speed at which it is assisted, by about 25 km / h, the engine of this type generating power even above this speed.

Bicycles of this type allow to reach high speeds, without the need for the cyclist to make an effort comparable to that of a standard, classic bicycle. They are recommended for longer routes, especially when running on paved roads.

Figure 3. S-Pedelec electric bicycle

2.1.3. Twist-N-Go type

The bike (figure 4) has an acceleration button. The operation is similar to the types presented above, but with the major benefit that the rider can sit quietly in the saddle and start the engine, which will operate the pedaling system without the rider making any effort. In most cases, the engines can also provide pedaling assistance if the rider wishes, but there is also the option for the rider to let the engine produce all the power it needs.

Figure 4. Twist-N-Go electric bike

Depending on the use of electric bicycles [2] they can be:
1. Electric mountain bikes
2. Electric bicycles with thick wheels
3. Road electric bicycles
4. Electric hybrid bicycles
5. City electric bicycles
6. Foldable electric bicycles

Among the most important uses we mention:
- *The shuttle* - by which the people who use the e-bike have as main objective that to travel to and from the work place, the distance being reasonable, in the area of autonomy of the bicycle.
- *Recreational cycling* - through which interested persons make small trips, recreation, enjoying the natural environment and also making movement without overloading them, physically first and foremost.
- *Fitness* - is a newer use, but accepted by some people interested in the activity of maintaining a physical and mental tone.
- *Neo-motor rehabilitation* - through which the person carries out rehabilitation and recovery activity following accidents or diseases, especially of the locomotor system:

2.2. Case study

A study [6] regarding the possibility of using a SZ-100-33MF monocrystalline photovoltaic panel [7] has been carried out in order to increase the autonomy of an electric bicycle. The bicycle used is Sachs Alu Electra, equipped with a 20A NiCd / NiMh battery. The technical characteristics of a recent variant of the bicycle used are indicated in [8].

The evolution of the current through the motor induced takes into different operating regimes: acceleration, deceleration, constant speed (figure 5), in each case measuring the engine speed n.

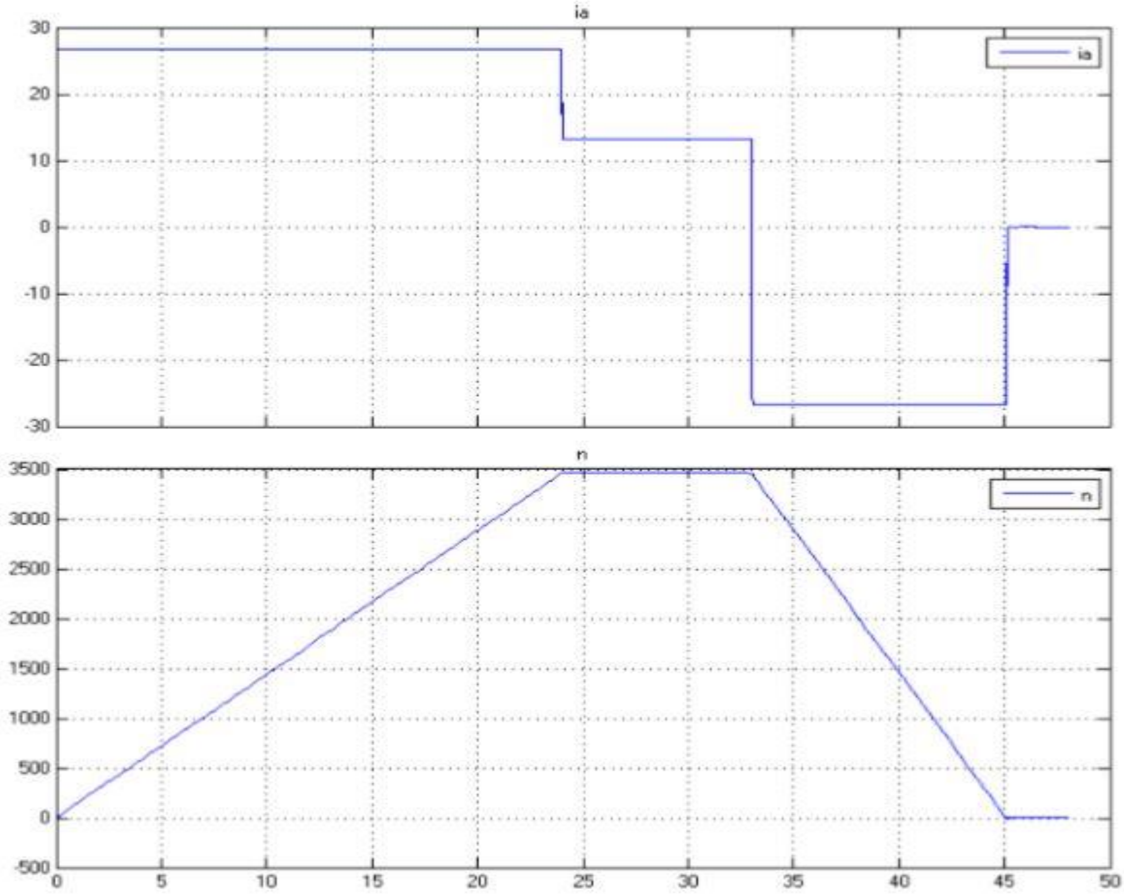

Figure 5. Evolution of induced current and speed

The evolution of the angular speed, the torque M and the power P developed by the electric motor were tracked (Figure 6), the equivalent power being determined, based on the relationship:

$$P_e = \sqrt{\frac{\sum_{i=1}^{4} P_i^2 t_i}{\sum_{i=1}^{4} t_i}} \quad \textbf{(1)}$$

$$P_e \approx 270\ \text{W} < 282\ \text{W} \quad \textbf{(2)}$$

where for the four consecutive times, based on figure 6 c, the values were considered:

t_1= 24 s **(3)**

t_2= 10 s **(4)**

t_3= 12 s **(5)**

t_4= 5 s **(6)**

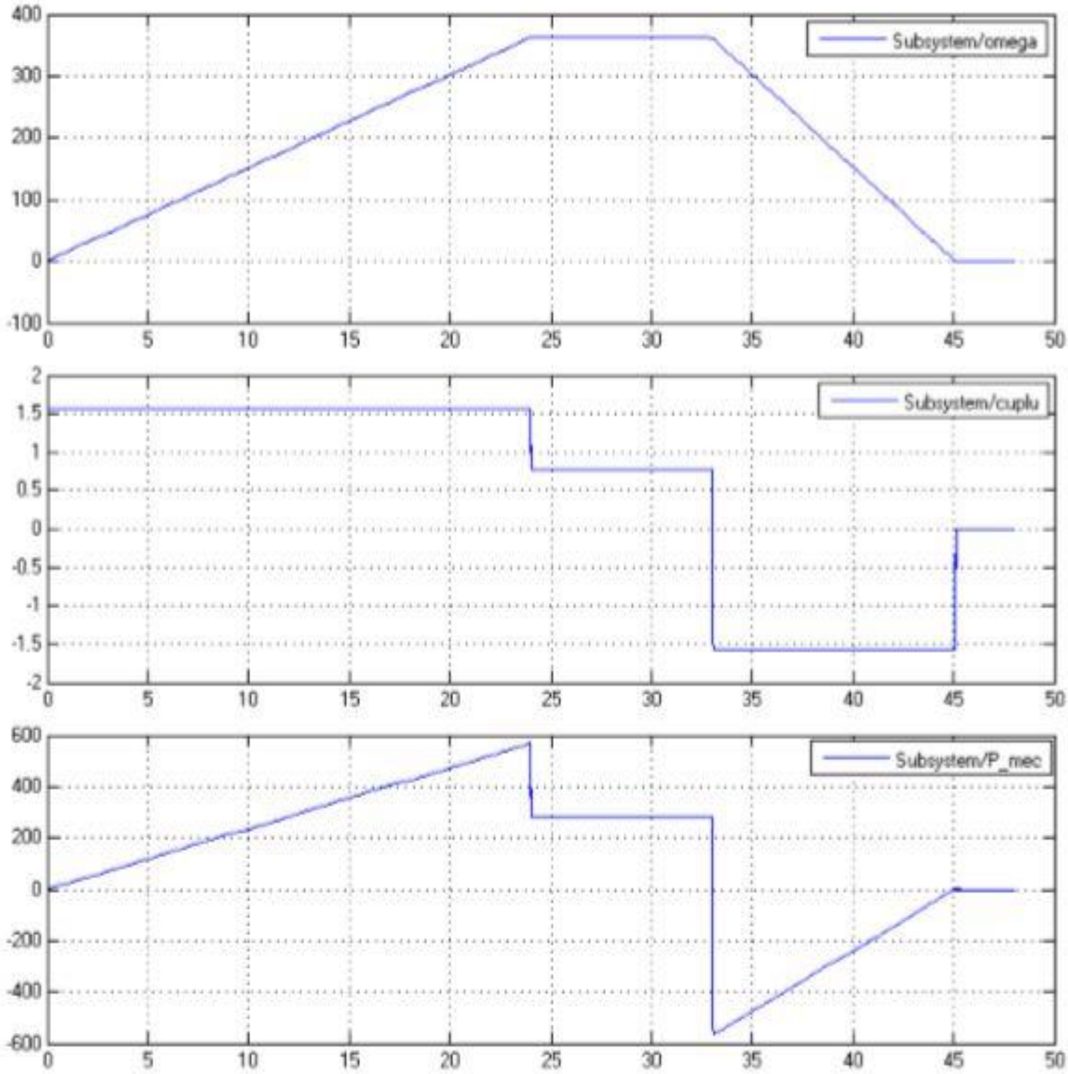

Figure 6. Evolution of torque and electric power developed by the electric motor

Based on the measurements in Table 1, the η_P efficiency of the photovoltaic panel was determined graphically.

The figure 7 present the efficiency η_P of the photovoltaic panel

Table 1 Measurements with the photovoltaic panel coupled

U_{IN} [V]	I_{IN} [A]	P_{IN} [W]	U_{OUT} [V]	I_{OUT} [A]	P_{OUT}t[W]	η_P [%]
17.00	0.60	10.20	30.00	0.30	9.00	88.24
17.00	2.70	45.90	27.00	1.15	31.05	67.65
17.00	6.00	102.00	26.00	2.20	57.20	56.08

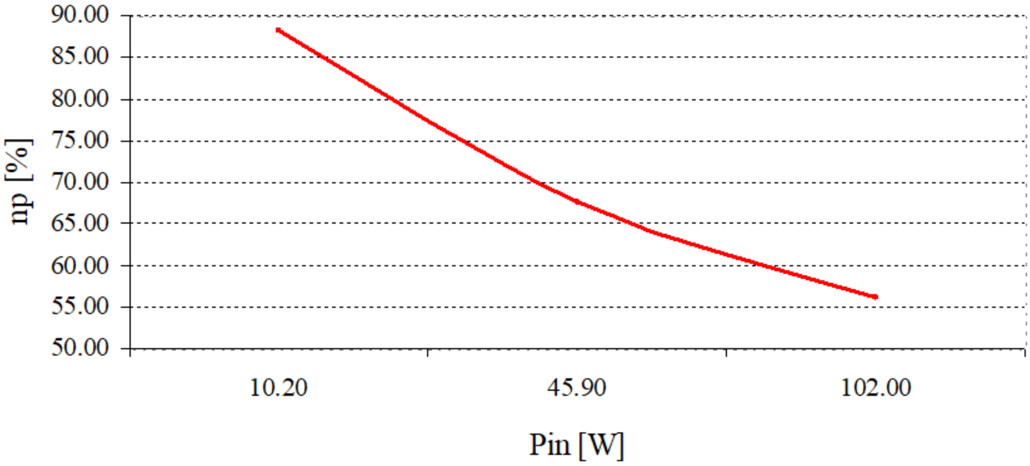

Figure 7. Photovoltaic panel efficiency

3. CONCLUSION

Following the study, the conclusions are:
1. The electric bicycle is a non-polluting means of travel and can be a useful and pleasant alternative for journeys up to about 30 km;
2. The electric bike is useful in maintaining the right tone and neuromotor recovery processes;
3. It is possible to use a photovoltaic panel to increase the autonomy of an electric bicycle by transferring the energy provided by it to the battery with which the electric bicycle is equipped;
4. The additional costs generated by the use of a photovoltaic panel are reduced;
5. The use of flexible / semi-flexible photovoltaic panels is recommended.

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