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THE INFLUENCE OF CABLEWAY PARAMETERS ON THE ENERGY EFFICIENCY TRANSPORTATION PROCESS

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Abstract. The high importance of the development of alternative modes of transport, such as the cableways, leads the need to compare the various parameters and modes of this transport. It is rational to compare similar transportation systems in terms of energy efficiency parameters of the same type, such as drive type, capacity, travel speed, length, gradient angle, energy resources, ease of maintenance and upkeep. Electricity is currently the cleanest source of energy based on statistics. The drive has many parameters that affect its energy efficiency. A general method for calculating the energy efficiency of an electric motor for a cableway is presented. In order to ensure maximum energy efficiency in the process of transporting passengers by cableway, it is important when designing to correctly calculate the required maximum power.

Keywords: energy efficiency, resource saving, cableway, individual drive, alternative transport, transportation.

Introduction. Human activity is highly dependent on many factors. Some of them are electricity and transport. The problems of modern energy processes and transportation include a number of complex non-linear processes, within which many factors are hidden. One of them is the issue of energy efficiency.

Energy supply is one of the key vital services of our time [1]. Today, there are several major problems that globally affect the activities of urban dwellers around the world.

Passenger transportation problems include tasks to reduce energy consumption, harmful emissions, noise levels, as well as to increase capacity, travel speed, comfort level, and safety. One of the important vectors for the progress of modern transportation is the development of alternative types of transport. The issue of energy efficiency is not new and is related to a number of approaches that allow for maximum conservation of natural resources [2].

Basic material. Cableways, also known as aerial tramways or cable cars, are the alternative type of a transportation system that uses motors, cables, pulleys, cabins and support structures to transport passengers and goods. To evaluate the energy efficiency of a cableway system, several criteria can be considered.

The influence of some parameters was considered earlier e.g., for type of drive and drive efficiency [1, 3]. The general cableway parameters that affect energy efficiency are shown in fig. 1.

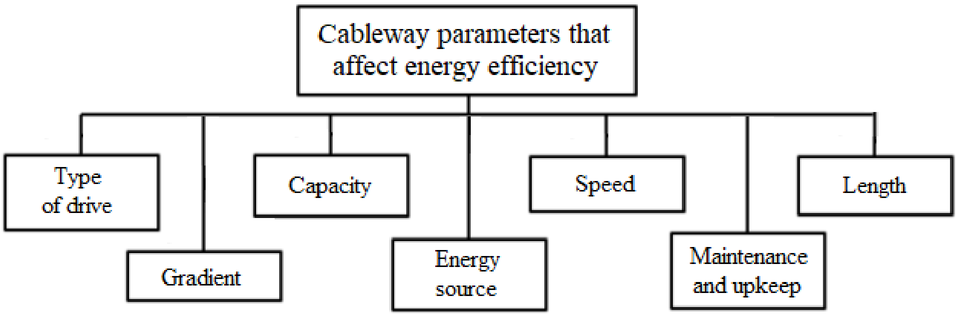

Figure 1 - Factors that affect the efficiency of cableway transport

The type of drive plays a significant role, since power depends on the tasks [3]. Conditionally, we will divide it into cableways with a central drive and an individual drive. The design of the cableway system, including the size and weight of the gondolas or cabins, the length and incline of the cable, and the type of motor used to power the system, can all impact its energy efficiency. Therefore, cableways that use more efficient drive systems, such as electric drives, tend to be more energy efficient than those that use old mechanical drives.

The capacity of a cableway system is the maximum number of passengers and goods that it can transport in each period. A system that can transport more passengers and goods per unit of energy is considered more energy efficient.

The speed at which a cableway system operates is another factor that influences its energy efficiency. A faster system may use more energy, but it can also transport more passengers or goods in a shorter period, which may result in overall energy savings. The speed of a cableway system is determined by a variety of factors, including safety, efficiency, and environmental factors, and is carefully designed and regulated to ensure the system operates effectively and safely. Frequency (interval) of departure of cabins also can impact its energy efficiency. Less frequent trips may use less energy than more frequent trips.

The length of a cableway system affects its energy efficiency. Longer systems require more energy to operate, but they may also transport more passengers or goods, which can result in overall energy savings.

The gradient, or slope, of a cableway system is another factor that influences its energy efficiency. Steeper gradients may require more energy to operate, but they may also result in faster transportation and, therefore, overall energy savings.

The source of energy used to power a cableway system can also impact its energy efficiency. Systems that use renewable energy sources, such as solar or wind power, are considered more energy-efficient than those that rely on non-renewable sources, such as fossil fuels. Measures to improve energy efficiency and GHG-emissions in motorized vehicles are given in table 1 [4]. Therefore, the use of electricity from renewable sources is a priority in design of alternative transport.

Table 1

Measures to improve energy efficiency and GHG-emissions in motorized vehicles

Reduction of fuel consumption:	Mixture of low carbon fuels:	Alternative fuel vehicles (AFVs):
Electrification of power	Ethanol (E5/E10)	Natural gas or biomethane
Light weight construction	Biodiesel (B7)	Ethanol (E85 to E100)
Optimization of auxiliaries	Hydrated vegetable oils (HVOs)	Liquefied petroleum gas
Aerodynamics	Biomass-to-liquid (BTL)	Electricity and hydrogen from low-carbon sources
Result: Climate and energy efficient vehicles		

The maintenance and upkeep of a cableway system can also impact its energy efficiency. Regular maintenance and upgrades can help to ensure that the system operates at peak efficiency, reducing energy waste and improving overall performance. This includes keeping the system clean and lubricated, replacing worn or damaged parts, and optimizing the system for maximum performance. Overall, an energy-efficient cableway system is one that can transport many passengers or goods quickly and efficiently, while minimizing energy consumption and waste.

General energy efficiency of the cableway system directly depends on the efficiency of the components that make up the system. One of the important components of the drive is the motor. To calculate the efficiency of a motor cableway, we can use the well-known formula (1) [5]:

$$\eta = \left(P_{out} / P_{in}\right) \cdot 100\%, \tag{1}$$

where: η – efficiency;

P_{out} – output power (mechanical power) of the cableway;

P_{in} – input power (electrical power) of the cableway.

The output power of the drive for cableway with self-propelled cars, can be calculated using the following formula (2):

$$P_{out} = F \cdot v \cdot \mu \cdot \varphi, \tag{2}$$

where: F – force exerted by the cableway or is used to move the wagon;

v – velocity of the cableway;

μ – constant of friction; φ – load factor.

The input power of electrical motor can be calculated by the formula (3):

$$P_{in} = U \cdot I, \tag{3}$$

where: I – current flowing through electrical motor of the cableway;
U – electric voltage.

For the drives of cableway with self-propelled cars, substitute the formulas (2) and (3) into (1), and we get (4):

$$\eta = \left(\frac{F \cdot v \cdot \mu \cdot \varphi}{U \cdot I} \right) \cdot 100\%. \tag{4}$$

In these formulas (2) and (4), the friction coefficient and load factor are considered for a more accurate calculation of the mechanical efficiency. For the entire system, such types of resistance as wind force and angle of inclination will also be considered.

Conclusions. The energy efficiency of the cableway transporting process plays a key role in the design of a particular mode of transport. When operating a cableway, in order to ensure the greatest energy efficiency, it is important to consider many parameters such as the type of drive, capacity, speed and frequency (interval), length, gradient (slope), energy source and ease of maintenance and upkeep. A formula is presented for calculating the energy efficiency for the cableway with self-propelled cars drives, taking into account friction forces and load factor.

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