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Electric means of urban transport in practice

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Abstract – Currently, great attention is paid to environmental protection issues in the context of the impact of transport on the environment. Most research and analyzes on electromobility indicate that vehicles using electricity produce less pollution than vehicles powered by an internal combustion engine. Another problem is the number of vehicles on the road, causing traffic jams. A diminutive form of personal transport around the city can be proposed to reduce the number of motor vehicles on the streets. The proposed urban electric vehicle is a four-wheeled vehicle powered by a charging station based on renewable energy sources. It is intended mainly for transporting people with specific disabilities. It is intended mainly for transporting older people and people with specific disabilities. For health reasons, these people cannot use publicly available means of personal transport such as an electric scooter or an electric bicycle. The vehicle can handle bicycle paths, parks, and short distances. The use of the GPS and Line Follower systems based on the adaptation of the infrastructure to this vehicle will ensure its full autonomy. This article presents simulation tests of air resistance while driving using SOLIDWORKS Flow Simulation, then examines the technical parameters of the vehicle in real conditions, i.e., city driving. The research results turn out to be promising because the use of such a vehicle seems to be practical.

Key words – means of transport, electric vehicle, renewable energy sources, urban agglomeration

JEL Classification – R41

Introduction

Road transport is undoubtedly considered one of the more convenient and readily accessible means of transportation. It is ideal for covering distances between cities or municipalities. However, a problem arises when there is a need to travel from one point to another within the same city. Highly populated areas, especially during peak hours, are impassable for private cars without getting stuck in traffic jams. This problem is addressed by utilizing bicycle paths, sidewalks along main roads, and even those that shorten the distance with a route inaccessible to motor vehicles. In such cities, owning a bicycle is not necessary due to the easily accessible bike rental stations located in every neighborhood. Electric scooters or even Segways can also be used. Unfortunately, even these solutions are not suitable alternatives for everyone, especially for older or sick individuals. Therefore, we present an electric four-wheeled vehicle that enables smooth and individual mobility for people facing difficulties.

1. Means of Personal Transport

In today's rapidly developing world, mobility is essential to our everyday lives. With the progress of technology, means of personal transport are changing dynamically, striving for sustainable, efficient and modern mobility. Among the innovative solutions on the market, Personal Transport Means, widely known as UTO (Urban Transportation Options), stand out.

Alternative means of transport such as bicycles, electric scooters, public transport or walking allow you to avoid traffic jams. Unlike cars, which often get stuck in traffic jams, these means of transport provide greater flexibility and efficiency in getting around the city.

Personal transportation is environmentally friendly because cars cause greenhouse gas emissions and air pollution. Alternative means of transport, such as bicycles or electric scooters, are usually powered by electricity and do not emit exhaust gases. Due to the lower weight of such a vehicle and short distances, it is possible to use smaller batteries, thanks to which the charging time will be shorter and the amount of energy consumed will be lower. By choosing these means of transport, the negative impact on the environment is significantly reduced and the air quality in the city improves [1-2].

The parking problem will also be eliminated. Limited parking spaces are a common problem in many cities. You don't have to worry about finding a parking space when you choose alternative means of transport. You can reach your destination conveniently, avoiding the frustration of searching for available parking spaces.

Health benefits can be gained by using alternative modes of transport such as walking, cycling, or electric scooters and our electric vehicles. Regular physical activity on the way to work improves physical fitness, heart health, and overall quality of life [3-4].

2. Development of electromobility

The need to reduce greenhouse gases has forced new legal regulations that will reduce emissions from transport. The regulation assumes a decrease in CO_2 emissions into the atmosphere by 37.5% in 2030 for passenger cars compared to 2021. The changes are scheduled to start in 2021, and CO_2 emissions are limited to 95 gr/km this year. In 2025, the permissible CO_2 emission should be 80.75 gr/km, while in 2030 only 59.37 gr/km. Given current capabilities and technologies, a vehicle powered solely by hydrocarbon fuel cannot meet these standards. It is, therefore, necessary to use alternative drives. One of the directions of changes in the automotive industry is electromobility [5-6].

The current stage of electromobility development in Poland can be described as initial. It is regulated by the Act on Electromobility and Alternative Fuels. An electromobility development plan was also created, adopting three stages. The first stage includes preparation for the development of electromobility and covers the years from 2016 to 2018. The second stage includes the construction of electric vehicle power infrastructure and incentives to purchase electric vehicles and covers the years from 2019 to 2020. The third stage leads to the perception of electromobility as a necessary direction for the development of modern transport. It assumes greater demand for electric cars and the gradual phase-out of combustion vehicles. This stage covers the years 2020 to 2025 [7-10].

The number of EVs and PHEVs is constantly growing. As of December 2019, there were 6,672 vehicles, of which 4,178 were EVs and 2,494 were PHEVs. The situation is similar with the number of charging stations, of which there were 888, of which 624 were AC charging stations and 264 were DC. As of September 2022, there were as many as 54,795 vehicles, including 27,595 PHEVs and 27,200 EVs. In the case of charging stations, their number more than doubled - to 2,460, including 1,759 AC stations and 701 DC stations [11-14].

3. Project of Electric Vehicle

The project's first stage was to prepare a virtual 3D vehicle model. Then, the actual design was made, which still requires many changes and improvements.

Fig. 1. Problems of modern means of transport [1]

Fig. 2. View of the 3D model of electric vehicle (own research)

Fig. 3. View of the concept of electric vehicle (own research)

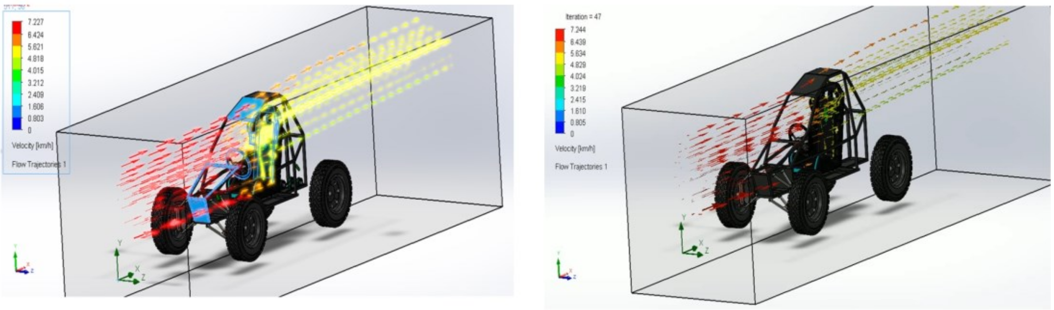

Fig. 4. Simulation of airflow in a 3D model: on left with vehicle body, on right without vehicle body

Fig. 5. Vehicle testing in urban conditions (own research)

The proposed means of personal transport is a four-wheeled vehicle. This vehicle is equipped with a 500 W electric motor. It is a brushless motor with a planetary gear. In the future, we intend to install a 36 V photovoltaic panel on the roof of our vehicle. However, the photos show the installed combustion engine, which was only used to test the braking system and suspension stiffness and observe the vehicle's behaviour while driving.

The main assumptions of the project are to ensure comfortable mobility for older people, as well as sick people with mild or moderate degrees of disability and mobility limitations. The vehicle is environmentally friendly. It will ultimately use dedicated charging stations powered by solar panels, because the energy needed to charge such a vehicle is lower than in the case of passenger cars. A line tracking system, GPS, and a camera will be installed in the vehicle shortly. This system will support vehicle operators by making them semi-autonomous.

4. Simulation Research

An analysis was performed in the SOLIDWORKS program to verify the resistance while the vehicle moved. A wind tunnel was used in the analysis. The vehicle was simulated moving at a speed of approximately 7 kph, and it was observed that the shape of the vehicle did not significantly affect it's performance.

Based on simulation tests conducted using the SOLIDWORKS Flow Simulation module, it was determined that using SOLIDWORKS engineering software allows for accurate design and simulation of vehicles. Conducting simulation studies in the real world (CFD - Computational Fluid Dynamics) would be difficult and expensive. The use of this vehicle in urban areas will improve traffic flow and reduce congestion, provided that the road infrastructure is properly designed. Additionally, it will facilitate mobility for elderly and disabled people who usually cannot use electric two-wheelers, such as scooters or bicycles.

Assuming the vehicle user weighs 100 kilograms and estimates the vehicle's mass to be 100 kilograms, including groceries, to accelerate the vehicle to a speed of 7 km/h, we need to deliver a power of 200 Watts. Equipping the vehicle with two 12V, 45Ah gel batteries, traveling at a constant maximum speed of 7 km/h, will allow for a range of approximately 35 kilometres. The estimated driving time would be 5 hours.

5. Urban Research

The next stage of the research was the measurement of the vehicle's technical parameters in urban conditions. The device VBOX Motorsport was installed in the vehicle. Measurements of maximum speed, overload, and geographical coordinates were made.

Test drives were carried out in Katowice, on a cobblestone surface. The weather was rainless, but the surface was wet. There was quite a strong wind during the measurements. The temperature was around about 3 degrees. The conditions were challenging, but the vehicle coped without any problems. This proves the wide usability of this means of transport.

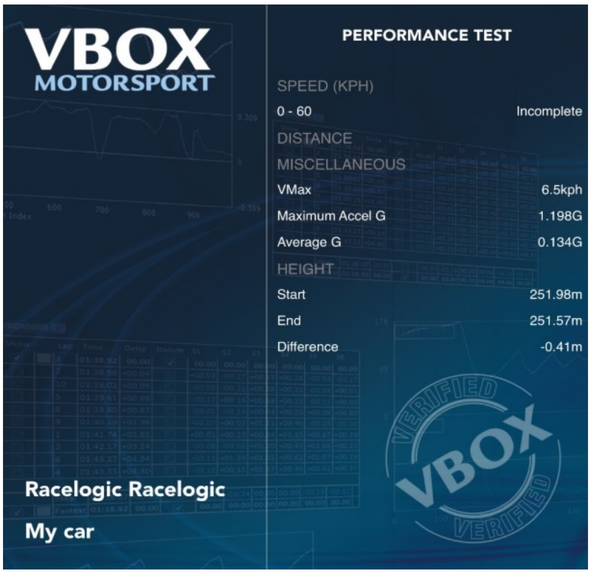

Fig. 6. Program screen view (own research)

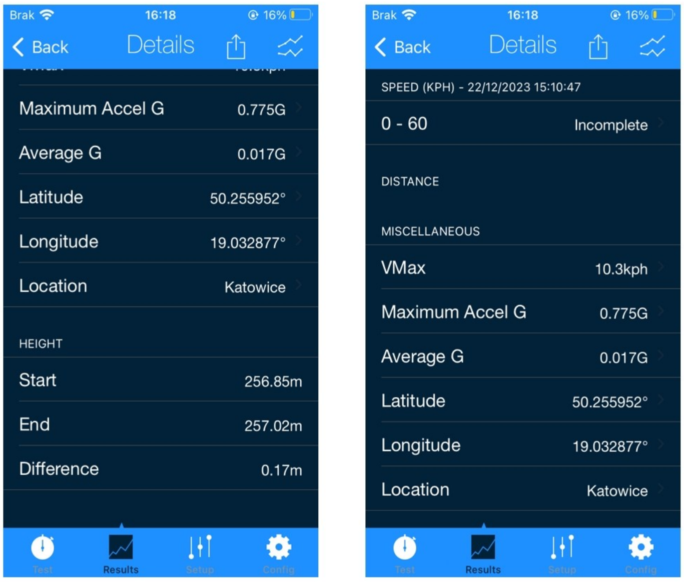

Fig. 7. View of measurement parameters (own research)

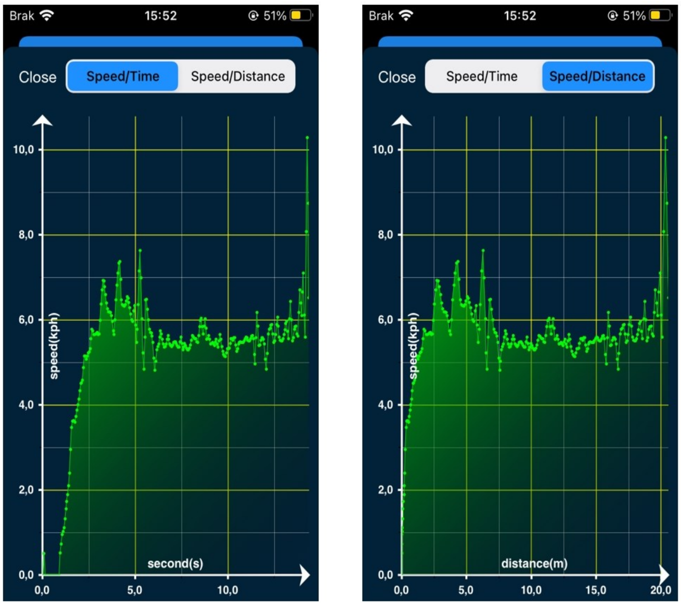

Fig. 8. View of measurement parameters - time and distance (own research)

Measurements were made at a distance of 20 meters. The measurement time was 15 seconds. The maximum speed was 10.3 kph, while the average speed ranged from 5 to 7 kph. The maximum acceleration was 0.775 G, and the overload was 0.017 G. The vehicle accelerates to 7 kph in 3 seconds Research shows that accelerating a vehicle does not cause sudden overloads, so it is safe for the elderly and sick.

Tests in urban areas show that the vehicle can move on various surfaces using large wheels. The vehicle is stable, quiet, and easy to use. It could perfectly serve as a public means of transport for people with mobility problems who cannot use other available means of UTO transport.

CONCLUSIONS

Based on this research, utilizing the proposed vehicle in urban areas will enhance the mobility of elderly and disabled individuals who cannot use electric two-wheelers such as scooters or bicycles. This will reduce traffic congestion as the number of car trips transporting those individuals will decrease. Equipping the vehicle with an electric drive and adapting the charging station to use renewable energy sources will enable relatively ecological and economical operation. Due to the drive used, the vehicle will be quiet, and due to its low weight, it will not consume as much energy as a passenger car.

In the subsequent phases of the project, the implementation of sensors and systems is planned. Such solutions will be a significant step towards constructing a user-friendly and operationally autonomous vehicle.

In summary, alternative modes of transportation are superior to automobiles in their ability to avoid traffic congestion, reduce pollution, eliminate parking problems, and provide health benefits. By choosing these modes of transport, we are choosing a more sustainable and environmentally friendly way of traveling in urban areas.

ELEKTRYCZNY ŚRODEK TRANSPORTU MIEJSKIEGO W PRAKTYCE

Obecnie bardzo dużą wagę przykłada się do zagadnień ochrony środowiska naturalnego w kontekście wpływu transportu na środowisko. Większość badań i analiz dotyczących elektromobilności wskazuje, że pojazdy wykorzystujące energię elektryczną produkują mniej zanieczyszczeń niż pojazdy napędzane silnikiem spalinowym. Dąży się do ograniczenia emisji zanieczyszczeń. Kolejnym problemem jest duża ilość pojazdów poruszających się po drogach, powodujące korki drogowe. W celu zmniejszenia liczby pojazdów samochodowych na ulicach można zaproponować niewielki środek transportu osobistego poruszający się po mieście. Zaproponowany przez nas miejski pojazd elektryczny to pojazd czterokołowy zasilany stacją ładującą opartą na odnawialnych źródłach energii. Przeznaczony jest głównie do transportu osób z pewnymi dysfunkcjami oraz osób starszych. Osoby te nie mogą korzystać z przyczyn zdrowotnych z ogólnodostępnych środków transportu osobistego jak: hulajnoga elektryczna lub rower elektryczny . Pojazd poradzi sobie na ścieżkach rowerowych, w parkach oraz na krótkich dystansach w mieście. Wykorzystanie systemu GPS oraz systemu Line Follower w oparciu o dostosowanie infrastruktury do owego pojazdu zapewni mu pełną autonomiczność. W niniejszym artykule przedstawiono badania symulacyjne oporu powietrza podczas jazdy za pomocą SOLIDWORKS Flow Simulation, następnie przedstawiono badania parametrów technicznych pojazdu w warunkach rzeczywistych, czyli jazdy po mieście. Wyniki badań okazują się być obiecujące, ponieważ zastosowanie takiego pojazdu wydaje się być praktyczne.

Słowa kluczowe: środki transportu, pojazd elektryczny, odnawialne źródła energii, aglomeracja miejska.

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