Energy consumption analysis of motor vehicles

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Abstract **The work presents the problem of energy consumption of motor vehicles. It discusses issues connected with the problem of the consumption of fuel resources in the European Union. It presents the methods of determining the energy needed for the vehicle to move and the results of energy consumption analysis of a sample internal combustion car and an analysis of the energy recovery possibilities.**

Keywords **fuel resources, car energy, energy storage devices**

I. Introduction

People's growing mobility in recent years contributes to a considerable increase of the number of cars. The total number of cars in the European Union is close to 300 million [1,3]. Despite significant reduction of average fuel consumption by motor vehicles (5.8 l/100 km on average in the EU-27 countries – the lowest in Portugal 5.1 l/100 km, and the highest in Sweden 6.3 l/100 km), road vehicles in the European Union consume over 260 megatons of oil equivalents a year [3].

Some of the drivers try to look for savings by choosing smaller cars. Another popular solution that provides savings is buying a car that is adjusted to burn LPG – in 2010 the rate of newly registered cars with the LPG system in the EU-27 countries was 3.4%, and it was only 0.1% in the UE-12 countries [3].

A fashionable but not yet popular solution is enhancing the vehicle with a different motor type or replacing the combustion engine with an electric engine. In 2010, the number of cars with hybrid engines in the UE-27 countries was 0,6%, and the number of cars with an electric engine was 0,01% [1]. Although the number increases very rapidly, it indicates that the drivers still consider such solutions as not very economical.

That is why the work presents an analysis of the energy consumption of passenger cars, focusing on the energy that can be recovered. Preliminary experimental research involving a comparison of the energy consumption level in a car without an energy recovery system and a car with an energy recovery system was conducted.

II. The forces operating on a motor vehicle

The forces operating on a motor vehicle depend on many factors, the most important of which include the driving force (F_R), the rolling resistance (F_R) and the aerodynamic resistance (F_A).

The simplified formula used to determine the rolling resistance looks as follows [2]:

$$F_R = mgf_{t0}(1 + Kv^2) \qquad (1)$$

where: m – vehicle mass, g – gravitational acceleration, v – vehicle speed, K – additional rolling resistance co-efficient, f_{t0} – rolling resistance coefficient at low speeds.

Another important force acting opposite to the direction of the moving car is the aerodynamic force resulting from the longitudinal air resistance (F_A) [2]:

$$F_A = \frac{1}{2}\rho c_x A {v_w}^2 \qquad (2)$$

where ρ – air density, c_x – longitudinal air resistance coefficient, A – vehicle frontal area, v_w – vehicle speed in relation to the air.

On the basis of the determined air resistance values and for the given value of the momentary speed v of the vehicle and assuming a given level of the drive unit efficiency, it is possible to estimate the driving force and the energy necessary to cover the set moving distance.

III. Research, test analyses and conclusions

In order to estimate the energy savings that can be obtained during the drive, an analysis of the energy consumption during the drive in an Opel Vectra car with the total mass of 1700 kg was performed on a few roads with different characteristics. On the basis of the dependencies presented, the forces operating on the vehicle and the energy needed for acceleration as well as the energy that can be recovered during braking and that should be stored in the batteries and ultracapacitors were determined. Sample results are presented on Fig. 1. It requires, however, the selection of the appropriate parameters of the electric energy containers.

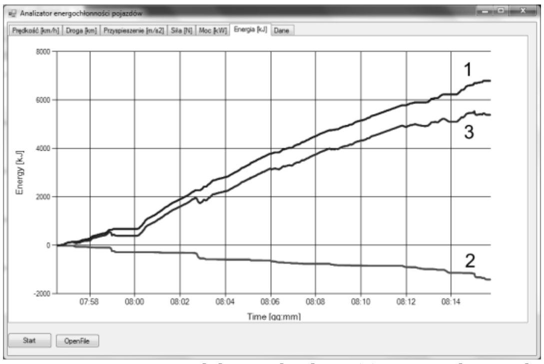

Fig. 1. Energy consumed during the drive (1), energy that can be recovered during speed loss (2) and their sum (3) as a function of time

In this way it was proven that it is possible to obtain energy savings at the rate of several tens of percent – over 20% in the presented case of a drive in an unbuilt area. However, attention must be paid to the selection of the appropriate energy containers.

IV. References

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