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USE OF THE VEHICLE MOVEMENT MODEL TO DETERMINE ECONOMIC AND ENVIRONMENTAL IMPACT CAUSED BY SEPARATE VEHICLES

WYKORZYSTANIE MODELU RUCHU POJAZDU DO WYZNACZANIA WPŁYWU POSZCZEGÓLNYCH POJAZDÓW NA GOSPODARKĘ I ŚRODOWISKO

Głównym tematem pracy jest wykorzystanie modelu ruchu pojazdu do obiektywnego wyznaczania oddziaływania poszczególnych pojazdów na gospodarkę i środowisko. Pomiar rzeczywistej emisji substancji szkodliwych i zużycia paliwa dla pojedynczego pojazdu może wiązać się ze zbyt dużymi kosztami. Ceny analizatorów emisji spalin kształtują się na poziomie około 150 000 EU. Istnieje jednak możliwość pośredniego wyznaczenia rzeczywistej emisji substancji szkodliwych i zużycia paliwa. Omawiana metoda opiera się na wyznaczaniu przebiegu zmienności stopnia obciążenia silnika, jaką można przypisać danym wartościom emisji substancji szkodliwych i zużycia paliwa. Charakterystyki emisji silnika i zużycia paliwa muszą być wstępnie znane. Model ruchu pojazdu wykorzystuje się do wyznaczania przebiegu zmienności stopnia obciążenia silnika.

Słowa kluczowe: *prędkość pojazdu, opór nawierzchni, prędkość silnika, moment obrotowy silnika*

The main topic of the paper is usage of vehicle movement model for objective determination of economic and environmental impacts caused by separate vehicles. Measurement of the real production of harmful emissions and fuel consumption on a vehicle might be too expensive. The price of car emission analyzers are app. around 150 000 EU. But it is possible to determine the real production of harmful emissions and the fuel consumption indirectly. A principle of the method is based on determination of engine load course that is possible to be assigned to the production of harmful emission and the fuel consumption. Characteristics of the engine's emissions and the fuel consumption must be known preliminary. The model of the vehicle movement is used to determine the engine load course.

Keywords*: vehicle speed, road resistance, engine speed, engine torque*

1. Introduction

The model of the vehicle movement is applied on a cargo truck Avia D70. Urban Dynamometer Driving Schedule is used as a directive of the vehicle speed. It is possible to determine the engine speed from the vehicle speed and the transmission ratio. It is possible to determine the engine torque from the road resistance and the transmission ratio. The production of harmful emissions and the fuel consumption is assigned to the engine speed and the engine torque.

2. Methods

The whole model of the vehicle movement is created in the mathematical programme Mathcad. The road resistance is determined for the course of the vehicle speed (see fig. 1). The vehicle speed and the road resistance are subsequently recalculated for the engine speed and torque. The course of the instant and accumulated production of individual emissions and the fuel consumption are assigned to the engine speed and torque from emissions characteristics.

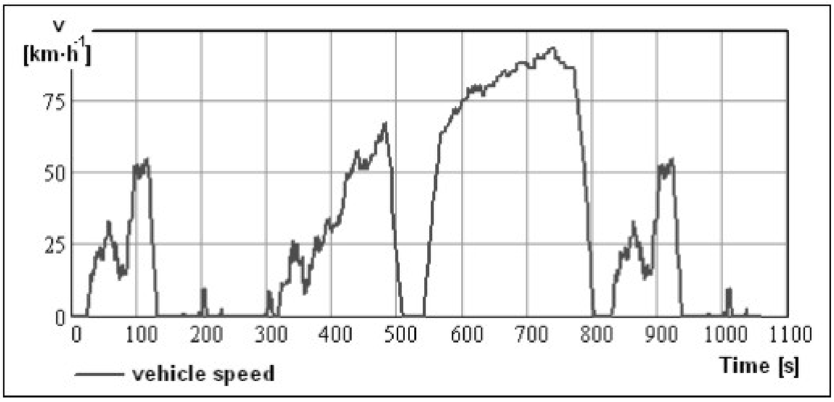

Fig. 1 The course of the vehicle speed

2.1. Road resistance

The total road resistance consists of the rolling resistance, the aerodynamic drag and the acceleration resistance. The gradient resistance is not included into model's plan; it is assumed a zero gradient. It was necessary to create the model of individual gear shifting and to reduce the inertia moment of rotator parties to sliding weight (see fig. 2) for determination of the acceleration resistance.

We obtain the total road resistance influencing the vehicle during its drive by the sum of the individual road resistances in fig. 3.

2.2. Torque and power on vehicle wheels

We can determine the torque and the power acting on vehicle wheels (see fig. 4) from the total road resistance, dynamic radius of the wheel and the vehicle speed.

2.3. Determination of the course of engine speed and torque

It's possible to determine engine speed from the vehicle speed, the slip of driving wheels and the gear ratios. It's possible to determine the engine torque from road resistances, gear ratios and gearing effectiveness. Fig. 5 represents the course of

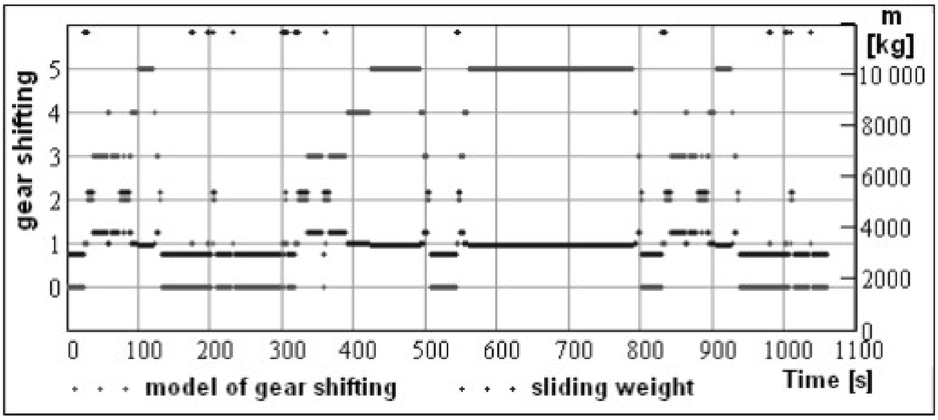

Fig. 2. Model of the gear shifting and sliding weight

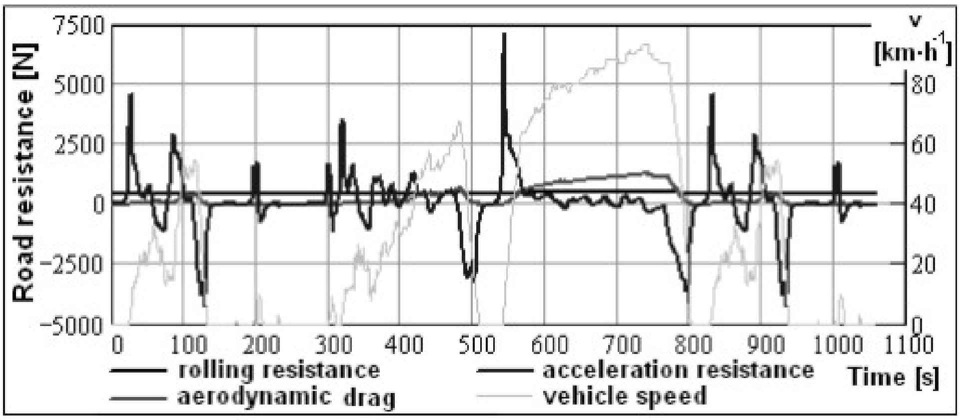

Fig. 3. The course of the road resistance

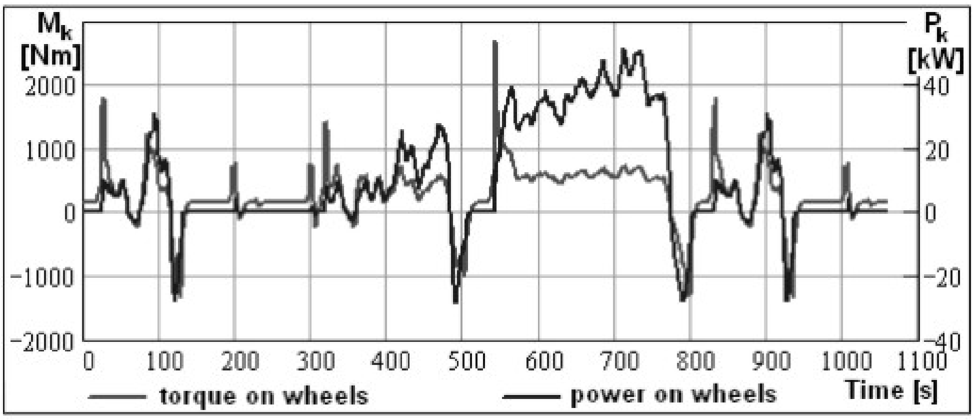

Fig. 4. The course of the torque on wheels and power on wheels

the engine speed and torque in the time of a drive. Fig. 6 represents the same values in the engine characteristic.

It's obvious from the fig. 6 that the condition characterizing idle speed of the engine was appropriately included in the conversion of the vehicle speed to engine speed. The conversion of the moment from wheels to the engine was appropriately restricted by the engine loss torque.

3. Result

We can determine the course of the instant and accumulate fuel consumption and emissions production for the course of the engine load if we know the necessary engine characteristic. Fig. 7 represents the characteristic of the hourly fuel consumption. Fig. 8 represents the course of the instant and accumulates fuel consumption. The instant and accumulate production of individual emissions components are determined by similar way.

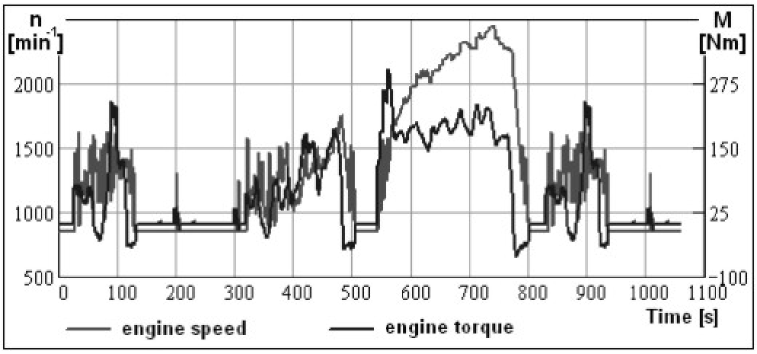

Fig. 5. The course of the engine speed and engine torque

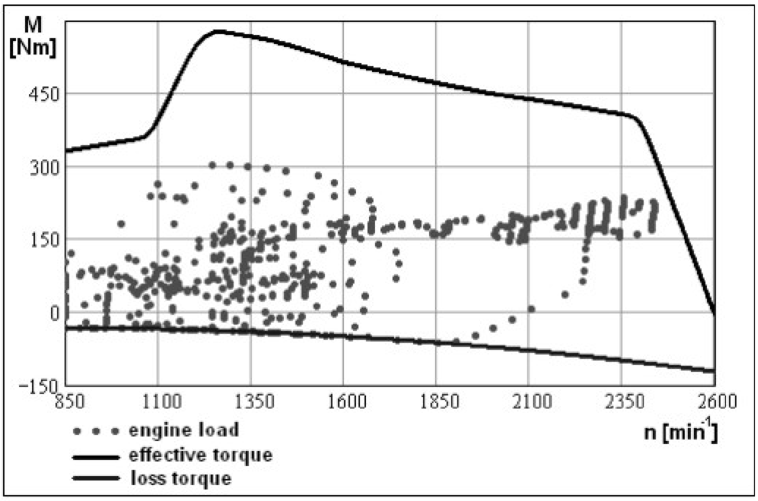

Fig. 6. Engine speed and engine torque in engine's characteristic

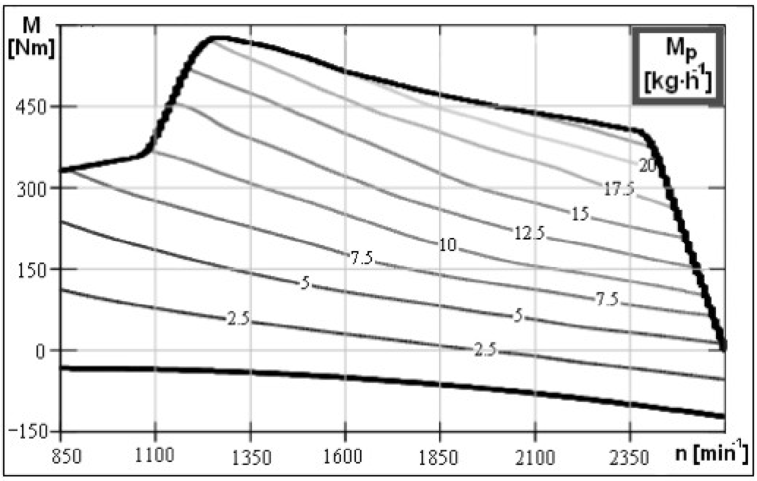

Fig. 7 Characteristic of the hourly fuel consumption

4. Discussion

It would be possible to supplement this computing model to calculate the resistance of gradient and replace the model of gear shifting by the real mode of gear shifting of the individual gear extents for practical application of the computing vehicle movement model's usage to determinate of economic and environmental impacts caused by separate vehicles. It would be necessary to equip the vehicle with a GPS receiver to determine the angle of gradient for determination of the gradient resistance. It's possible to determine the real course of shifting of gear ratio from the course of the vehicle speed and engine speed whose ratio is different for each gear ratio.

In the actual running the real fuel consumption and the production of emissions will be higher than the fuel consumption and the production of emissions determined from the computing model of the vehicle drive. It doesn't comprise the influence of the accrual of the fuel consumption and the production of emissions influenced by the engine acceleration. In case this model was used to pay for the emissions production, moderate benefit for a ratepayer is permissible.

5. Conclusion

By using the model of the vehicle movement it is possible to determine the fuel consumption and the production of harmful emissions. In this case the fuel consumption is 1,101 kg per 8,8 km, after recalculation it is 12,5 kg per 100 km. The production of emissions of CO_2 is 3,331 kg per 8,8 km, (37,501 kg per 100 km). The production of emissions of CO is 9,032 g per 8,8 km (101,709 g per 100 km). The production of emissions of HC is 0,309 g per 8,8 km (3,477 g per 100 km). Production of emissions of NO_X is 20,35 g per 8,8 km (229,164 g per 100 km). The production of PM is 0,516 g per 8,8 km (5,805 g per 100 km).

6. References

[1] Hromádko J., Hromádko J.: *Problems of Power Parameter Measurement of Constant-Speed Engines with Small Cylinder Volume by Acceleration Method.* IX Ogolnopolska Konferencia Naukova, Poznaň, 2006. ISBN 83-7160-418-1.

[2] Hromádko J., Hromádko J.: *The alternative determination of specific fuel consumption.* XXXVII. Mezinárodní konference kateder a pracovišť spalovacích motorů českých a slovenských vysokých škol, Praha, 2006. ISBN 80-213-1510-5.

[3] Hromádko J., Hromádko J.: *Problems of fuel consamption measurement.* XXXVII. Mezinárodní konference kateder a pracovišť spalovacích motorů českých a slovenských vysokých škol, Praha, 2006. ISBN 80-213-1510-5.

[4] Kadleček B.: *Dynamické testování výkonových parametrů spalovacích motorů*. In: NDT Bulletin č. 2/2001 (časopis ČNDT Česká společnost pro nedestruktivní testování ročník 11 č. 2) s. 109-110, ISSN 1213-3825.

[5] Kadleček B., Pejša L., Růžička M.: *The Comparison of Power, Economy and Ecological Parameters of Spark-ignition Engine of Lawn Mowers*, Eksploatacja i Niezawodność - Maintenance And Reliability, nr /2005, Warsaw, ISSN 1507-2711.

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Ministry of Transport Czech Republic (project No. CG912-058-520) „Methodology of quantification and assessment of transport's environmental and safety impacts".

Ministry of Education, Youth and Sports Czech Republic, action EU COST 356 „Towards the definition of a measurable environmentally sustainable transport" integrated project COST 356, No. OC 193). "The assessment methods and multidisciplinary evaluation of transport impacts on the sustainable environment".

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