

## ENVIRONMENTAL IMPACT OF THE AUTOMOBILES

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### **Abstract**

*In the article one possible active way of reducing negative impact on gaseous emissions on the environment is analyzed. The core issue is not only fear that sources of energy can be exhausted but really topical and urgent is the question of environmental pollution. The impact on the environment caused by operation of automobiles is obvious. Although production of emissions in steady-state operations is more or less successfully solved, unsteady operational modes result in a substantially greater impact on the environment. They are, in particular, an engine start and an automobile start up. The article deals with an analysis of an automobile start up and offers some ways of reducing the impact on the environment during the start up. The articles also concerns on: impact of traffic on air pollution. relative comparison of influence of emissions of different types of transport, development of fuel consumption for road European spark ignition engines (ECE), development of limit values of solid particles for passenger and goods vehicles with diesel engines, possibilities of reducing negative impact on the environment caused by automobile operation, simulation of start up of the vehicle with a combustion engine, development of specific fuel consumption for different combustions engines.*

**Keywords:** *transport, road transport, simulation, combustion engines, air pollution, environmental protection*

### **1. Introduction**

The environment can be characterized as material world surrounding living organisms including human beings. It includes the basic natural components and sources – land, air, water, organisms, their communities, ecosystems and countryside including those parts which are influenced by human beings. The environment thus presents a complex of ecologic systems in which life is developed and realized. Transportation, in fact, influences the environment in two ways:

⇒ *In a positive way* – thanks to its purposeful displacement of people, raw materials and goods it realizes needs of society and some services and considerably contributes to the growth of tourism,

⇒ *In a negative way* – due to its existence, i.e. by means of its operation and equipment it damages and deteriorates the environment.

The burden laid on the environment by human activity – the traffic – is the result of bringing chemical, physical and biological components into the environment. It is important not to exceed the rate of sustainability of a territory and not damage it. The traffic has had a bad impact on the environment already when new roads are constructed and exploited, mostly due to noise and emission. Nowadays, technological methods and technical equipment have been developed that can ensure that the specified hygienic limits will not be exceeded. The

problem of air pollution caused by traffic cannot be solved by increasing the volumes of air polluting substances release as it is solved in industrial sectors, where permitted emission limits are secured by specifying the minimum chimney height. To reduce the impact of automobile traffic on pollution of the ground layer of the atmosphere, it means to reduce the emission of pollutants coming from vehicles by means of technical enhancement of the combustion process, by means of interception or transformation of the polluting substances with catalysts. Another solution can be to deflect or redirect traffic from the areas with the most polluted air.

Present negative impacts of transportation on majority of population are mostly emissions and noise. Biological impact of emissions can be approached from the following points of view:

- ⇒ Toxicity, when produced emissions result in poisons,
- ⇒ Genetics, when attention is paid to substances featuring carcinogen and mutagen effects,
- ⇒ Ecology, focusing on biotic and abiotic factors. From this point of view great potential danger is represented by unburned or evaporated carbon dioxides and nitrogen oxides.

In order to reduce risks of biological impact of exhaust emissions there are more strict limits on allowable production of emission imposed on both manufacturers and users. Diesel engines emissions are referred to as substances probably carcinogen for people and spark ignition engines emissions maybe carcinogen.

## 2. Impact of Traffic on Air Pollution

Traffic and traffic industry in Europe consumes up 20 % of the overall energy, and 83 % out of this amount is consumed by road traffic, which also produces 81 % of CO and 51 % of NO<sub>x</sub>. In Slovakia, the share of traffic in air pollution is about 23 %, while the main polluter, power engineering has a 42 % share in air pollution.

Referring Table 1 we can see that road – automobile transport has the greatest negative impact on the environment. The share of railway and air transport is relatively similar but considerably lower than the share of automobile transport. The share of water transport is negligible. Though, the comparison of individual branches of types of transport is problematic and depends on the choice of criteria.

Air pollution in the vicinity of roads is the result of pollutants coming from vehicle exhaust gases and the increased amount of dust caused by whirling of sedimentary particles on the surface of pavements and around the pavements.

Amount of emitted pollutants in emissions of combustion engines also depends on amount of consumed fuel. With a decreasing total amount of fuel – Fig. 1 – there is also a decrease in production of harmful emissions.

Table 1. Relative comparison of influence of emissions of different types of transport

Transport	Emissions									Σ
	CO	CO <sub>2</sub>	HC	SO <sub>2</sub>	NO <sub>x</sub>	PM	Pb	Noise	Vibrations	
Road – passenger cars	3	1			3	1	2	1		13
Road – utility vehicles	1			1	3	3		3	3	14
Railway				1	1	1		2	1	6
Water				1	1	1				3
Air					1		1	3		6

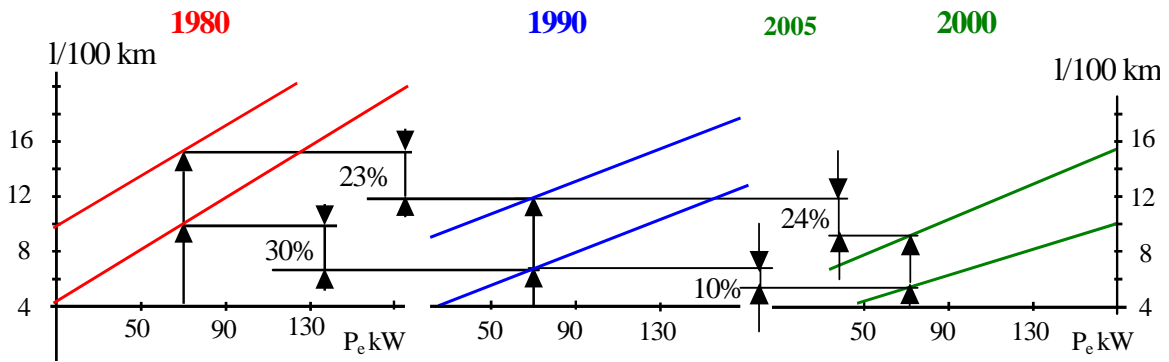


Fig. 1. Development of fuel consumption for road European spark ignition engines (ECE)

### 3. Possibilities of Reducing Negative Impact on The Environment Caused by Automobile Operation

Further traffic development is inseparably connected with the issue of life style values, living conditions and the level of economy. Such strategies that involve changes in traffic systems and some reduction of ineffective traffic seem to be perspective.

Main trends in reducing negative impact on the environment caused by automobile operation generally lie in:

- ⇒ Technical solutions in designing and operation,
- ⇒ Technological solutions in designing and operation,
- ⇒ System measures in organization and management of automobile operation,
- ⇒ Legislative, economic and cultural measures.

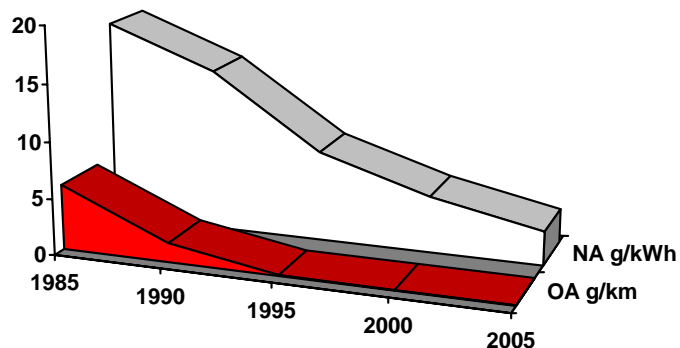


Fig. 2. Development of limit values of solid particles for passenger and goods vehicles with diesel engines

It is not only legislation – Figs. 2 and 3 – but also the relation to the environment that forces us to solve issues of automobile ecology and economy by means of technical and technological solutions. What has been achieved implementing some of the mentioned measures can be seen in Fig. 4.

### 4. Simulation of Start up of the Vehicle with a Combustion Engine

In this part we examine the influence of a torque curve shape in the speed engine characteristic on some vehicle properties during its start up. This shape change was achieved by an application of the valve gear with variable timing in the vehicle. The evaluation (of dynamic characteristics) is usually expressed in characteristics of the vehicle start up. The mentioned parameters consequently closely relate to economy and pollution of the environment due to operation of the vehicle. The unsteady operational mode of the engine during the vehicle start up is not defined only by increase in its speed and loading. From the

point of view of the pollution of the environment caused by exhaust emissions are highly important time intervals between the gear ratio changes. One criterion for the evaluation can be time needed for achieving the given speed of vehicle or time needed for covering the necessary distance.

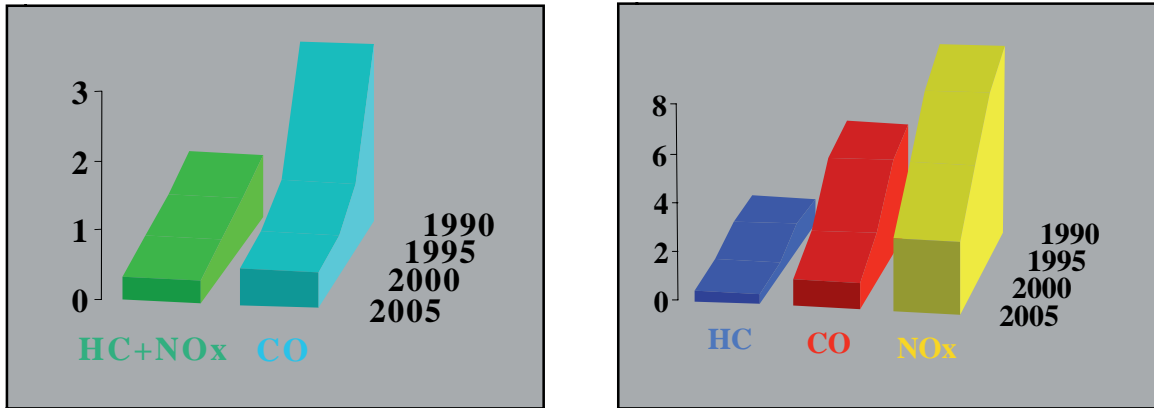


Fig. 3. Development of limit values of emissions in  $g.km^{-1}$  for light trucks with diesel engines (test ECE+EUDC) (left)  
Development of limit values of emissions in  $g.kW^{-1}h^{-1}$  for heavy duty trucks with diesel engines (test ECE R49) (right)

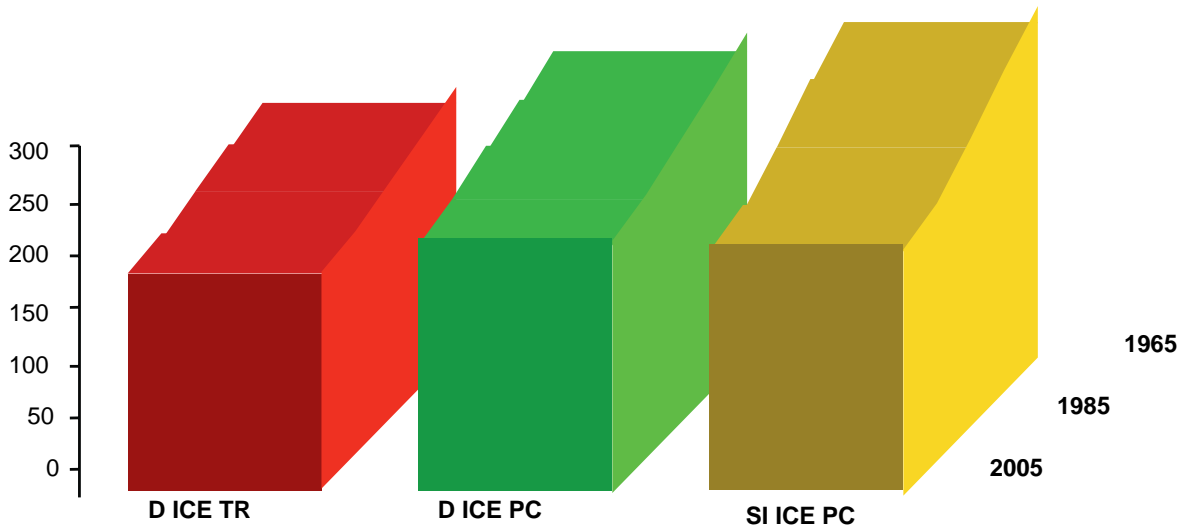


Fig. 4. Development of specific fuel consumption for different combustions engines in  $g.kW^{-1}h^{-1}$

The engine operation optimization in a wide range of rotational speed interval may be realized by application of the valve gear with a variable timing. This valve gear allows a direct affecting of the torque curve shape in the engine speed characteristic. A change of the torque curve shape as well as a change of absolute values of the achieved torque has influence on the vehicle driving properties. The present expansion of transportation induces, mostly in large towns, some problems resulting from inability to cope with situations on crowded roads and crossroads. There are more requirements put on a modern vehicle, namely to achieve high accelerations during start-ups at crossroads and, last but not least, during overtaking which is

closely related with safety of passengers. One objective is to evaluate – on the basis of a numeric simulation – influence of the torque curve shape change (achieved by means of variable timing of the valve gear) on some chosen parameters during the vehicle start-up. The standard input parameters are similar to those of the 1.3MPI vehicle. The computational model considers resistance of the wheel rolling on the roadway, air drag and elevation resistance. Shapes of the speed characteristic curves achieved by the valve gear variable timing (Fig. 5) were chosen as extreme cases so that the distinctions among individual cases would be clearly seen.

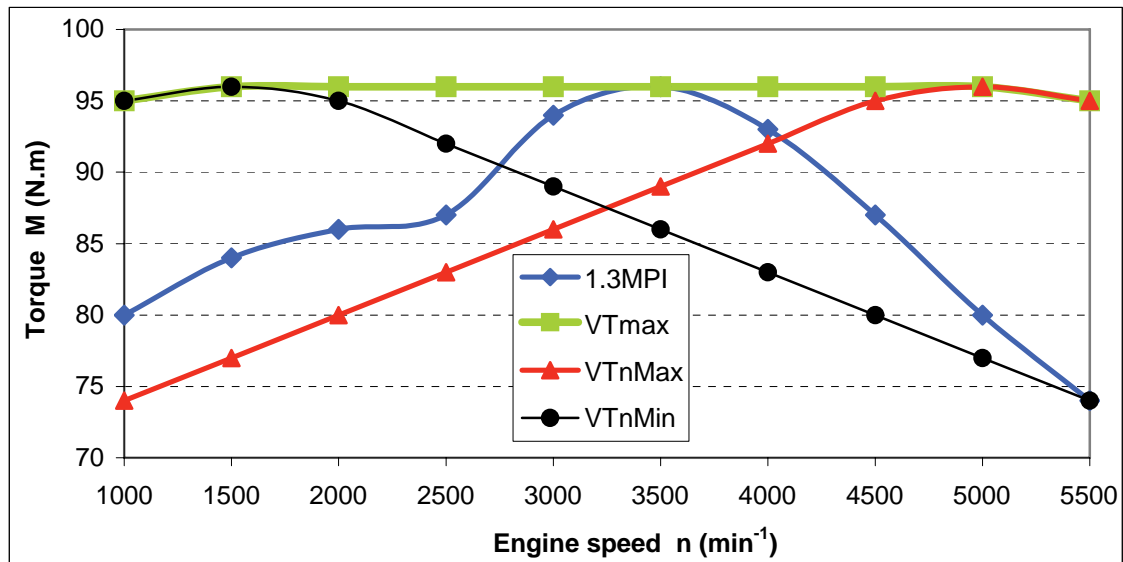


Fig. 5. Considered torque curves of outer engine speed characteristic for simulation

The case of the engine 1.3MPI corresponds to a real measured engine speed characteristic. The curve VTnMax holds for a case when the engine is tuned on the maximal rotational speed. The curve VTnMin holds for an engine which is tuned on the minimal rotational speed. The curve VTmax responds to an absolutely ideal case achieved by the valve gear variable timing for the considered combustion engine 1.3MPI. This ideal state may be achieved, for instance, by the variable timing system with a computer regulation. The computer determines parameters of regulation on the basis of a real engine state (rotational speed, load, temperatures...), for instance, in the area of low RPM the computer provides parameters responding to the curve VTnMin and, on the other hand, in the area of high RPM it provides parameters responding to the curve VTnMax. The result is the curve VTmax.

The model of a vehicle start up is to a certain extent simplified. On defining the roll resistance the uplift force resulting from air streaming along the vehicle is neglected. Another neglected thing is that the vector of the resultant force of air drag is not acting in the gravity center height, which may, in fact, induce a moment causing changes in values of compressive forces of individual wheels. The function of the clutch during the vehicle start up is specially modeled. In the computation the driver is considered to maintain the accelerator pedal in the maximal position, (i.e. the engine works on the outer speed characteristics) and to control the clutch so that the engine has a constant rotational speed of  $3500 \text{ min}^{-1}$  until the clutch joins the crankshaft with the gearbox shaft. Power losses in the clutch (due to different angle speeds of the crankshaft and input gearbox shaft) are transformed into heat and gradually decrease. They achieve the zero value at the moment when the clutch joins, which is when the vehicle achieves the velocity corresponding to the engine speed of  $3500 \text{ min}^{-1}$ .

The vehicle velocity value for the clutch join moment (during the vehicle start up):

$$v_{\min} = r_{\text{kolesa}} \cdot 2\pi \cdot \frac{n_{\min}}{i_{\text{stály}} \cdot i_1} \quad (1)$$

Equation of the vehicle motion:

$$(m_{\text{AUTA}} + m_{\text{ROTred}}) \cdot \frac{d^2 x(t)}{dt^2} = F_{\text{hmacia}}(t) - F_{\text{odporová}}(t) \quad (2)$$

The results are calculated for all four considered shapes of the outer speed characteristics torque curve (Fig. 5), given by parameters of variable timing. In Fig. 6 there are velocity behaviors covering time interval of 120 s after the vehicle start. Approximately after 90 s in all cases there is velocity conditioning and within 120 s the velocity values are nearly conditioned. Variable timing has an obvious influence on the maximal achieved velocity value of the vehicle. The vehicle covers more than 4 km until it achieves the maximum velocity. A change of velocity from 0 to 100 km.h<sup>-1</sup> (Fig. 7) is achieved – according to the calculations – in the case of VTmax in the quickest time interval of 14.3 s and in the case of VTnMin in the longest time interval of 17.3 s.

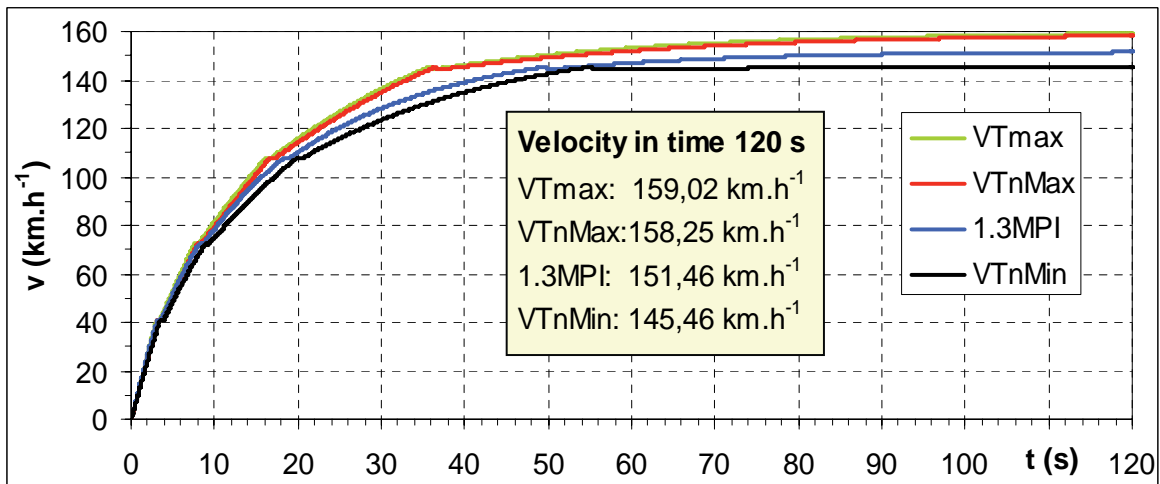


Fig. 6. Velocity behaviors until the conditioned state

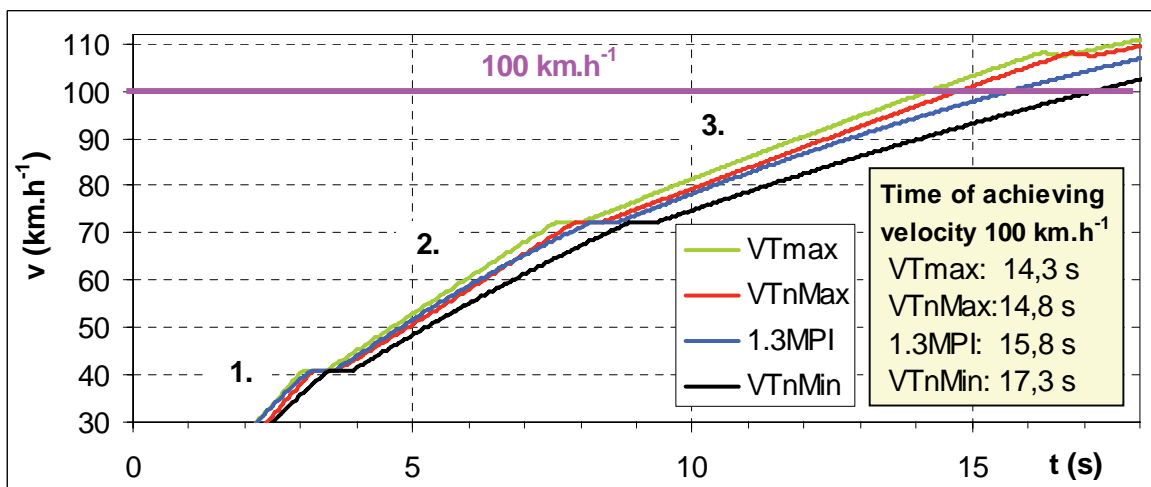


Fig. 7. Detail from the zone of achieving 100 km.h<sup>-1</sup> for various valve gear timing

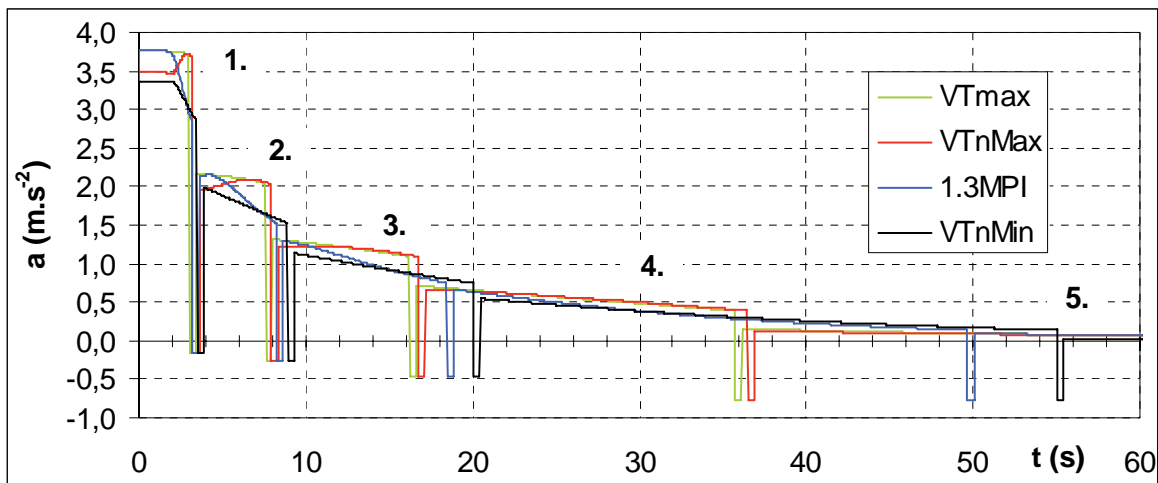


Fig. 8. Acceleration behaviors for various valve gear timing

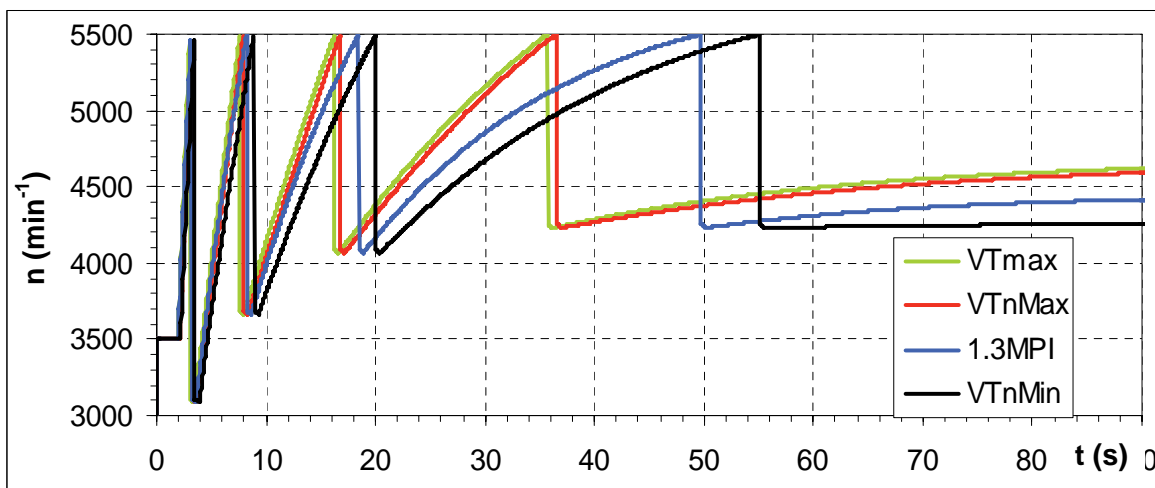


Fig. 9. Engine rotational speed time behaviors for various valve gear timing

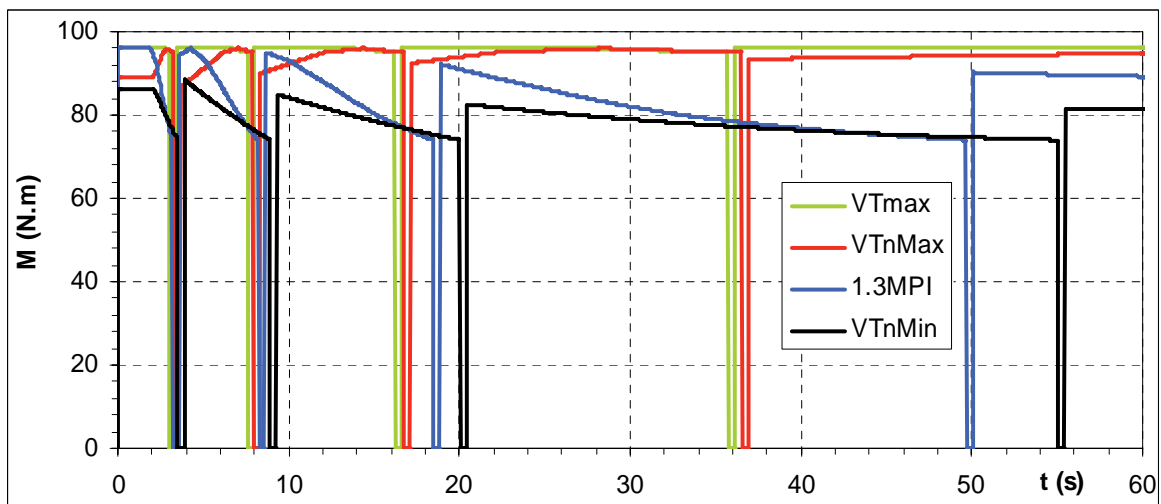


Fig. 10. Torque of engine time behavior for various valve gear timing

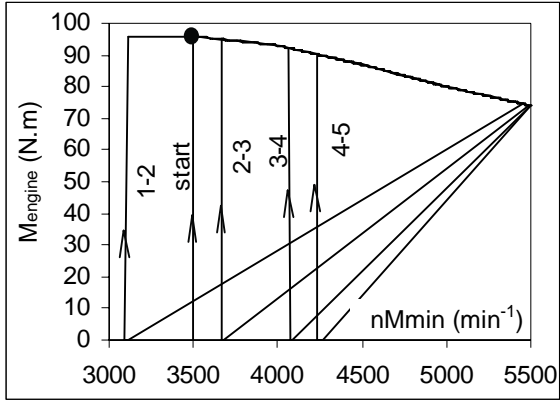


Fig. 11. Gear ratio changes (1.3MPI)

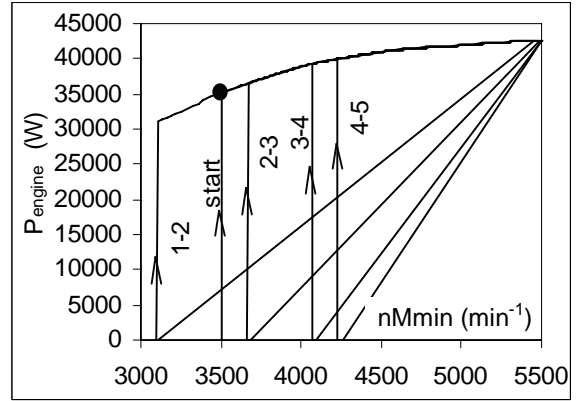


Fig. 12. Gear ratio changes (1.3MPI)

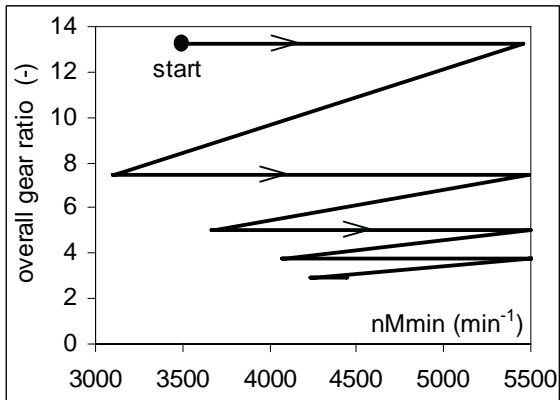


Fig. 13. Overall gear ratio on RPM

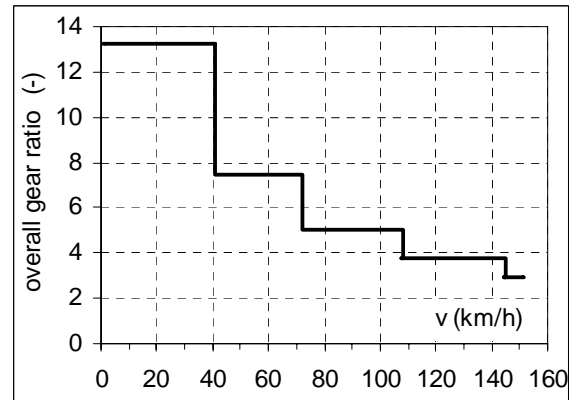


Fig. 14. Overall gear ratio on velocity

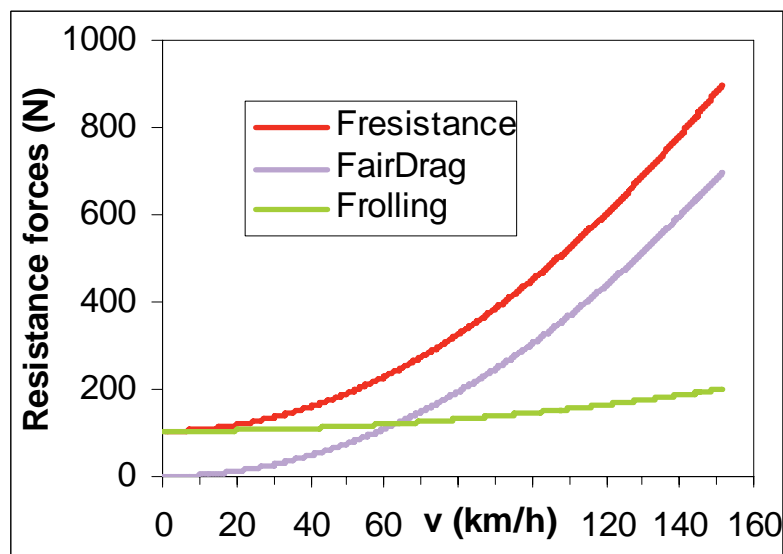


Fig. 15. Resistance forces behavior



The vehicle acceleration (Fig. 8) gradually decreases until it reaches the zero value at achieving the maximum velocity. The acceleration is negative during gear ratio changes as a result of deceleration, which is caused by resistance forces acting against the vehicle motion. The higher is the velocity the higher is the value of deceleration during gear ratio changes. This is given by the increasing dependence of resistance forces on the vehicle velocity, which is illustrated in Fig 9.

The engine parameter time dependencies, as rotational speed and torque, are shown in Figs. 9 and 10. The gear ratio changing in the case of the 1.3MPI engine is in Figs. 11 and 12. The value of the moving force at the maximum vehicle speed is equal to the value of resistance force. The total resistance force is, in this solved case, given by a sum of air drag force and roll resistance force (Fig. 15).

The used model enables to analyze influences of the engine valve gear variable timing and other interesting parameters. The numeric simulation has provided the expected result, which is the achievement of optimal parameters for valve gear variable timing for calculations related to  $VT_{max}$ . Time needed for achieving  $100 \text{ km}\cdot\text{h}^{-1}$  has been reduced by 1.5 s in the case of  $VT_{max}$  when compared with the standard timing of the 1.3MPI engine, which amounts to 9.49 per cent.

This result is very significant when we take into consideration that it has been achieved only due to a better regulation of the engine cylinders filling by means of a variable timed valve gear, without any change of the engine dimensions, compression ratio or maximum value of rotational speed.

## 5. Conclusions

Attention paid to the environment through legislative measures forces manufacturers of means of transport to reduce levels of gaseous and noise emissions. The reduction can be, in fact, approached in two ways:

- ⇒ Actively – reduction and elimination of emissions directly in the source,
- ⇒ Passively - additional reduction and elimination.

In the article one possible active way (use of variable timed valve gear) of reducing negative impact on gaseous emissions on the environment is analyzed. The core issue is not only fear that sources of energy can be exhausted but really topical and urgent is the question of environmental pollution. This has been caused by the fact that emissions produced by means of transport influence life on the Earth not only directly but also indirectly. It is proved that gases being harmless to people as carbon dioxide  $\text{CO}_2$ , methane  $\text{CH}_4$ , nitrogen oxide  $\text{N}_2\text{O}$  as well as halogen hydrocarbons influence the atmosphere. The solution of particular tasks thus concerns not only manufacturers of means of transport, constructions of transport routes but also operation. There are many means of transport on roads and highways. The source of energy, for most of them, is a combustion engine. The means of transport not only pollute the air, land and water, cause noise and vibrations and occupy land, produce other waste from their operation and also in their production but they also consume energies that cannot be recycled and sometimes produce harmful esthetic and psychological effects. On the other hand, it is necessary to underline the positive role of transport too. All the above facts emphasize the need to solve the issues of means of transport and the environmental protection with utmost seriousness and responsibility.

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