The Analysis of Selected Factors Influence on the Fuel Consumption

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ABSTRACT— ***It is undisputed that people are largely responsible for the increasing value of emissions in the atmosphere. Mass use of motor vehicles, which are concentrated near the residences of the population is a reason for develop more pressure to reduce emissions just for this group of vehicles. In spite of ongoing efforts to reduce emissions from road transport, the results are not satisfactory because the transportation needs of society are still increasing. Produced emissions from road transport have a negative impact on the deepening problem of the greenhouse effect. The greenhouse effect is responsible for average value of atmospheric temperature which is constantly increasing. The increase in temperature causes the melting of glaciers and so connected increase in world sea levels, which can lead to disastrous changes of climate and weather on the planet. The article is focused on the analyses of the fuel consumption in the context of its environmental aspects according to factors like engine temperature, air temperature and type of tires because it is necessary to decrease vehicle consumption for slowing down of environmental warming.***

Keywords— human factors, the change of Earth´s climate, the industry, traffic, vehicle, fuel consumption, greenhouse gasses

1. INTRODUCTION

Most of the observed warming since the mid-20th century has been due to human-caused greenhouse gas emissions. Earth's temperature must be stable. This stability depends on the energy balance. If incoming energy from the sun is bigger the energy released back into space, Earth starts to be warmer. Figure 1 shows the change of the observed temperature in 20th century, black line.

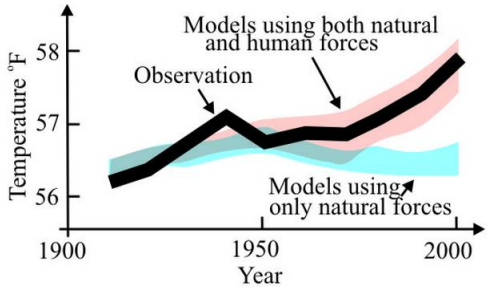

Figure 1: Comparation of the temperature development in 20th century [1]

Effects of natural processes are marked by the blue line. It seems no large changes are present during the past century. Models using influences of the natural and human activities are marked by the pink line and their characteristic is similar to the meteorological observations. It is clear, human activities have influence on climate system and especially greenhouse gases (GHG). The most important GHG are water vapor (H_2O), carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and several others. [1] The graph in Fig. 2 shows the increasing greenhouse gas concentrations in the atmosphere during last 2000 years.

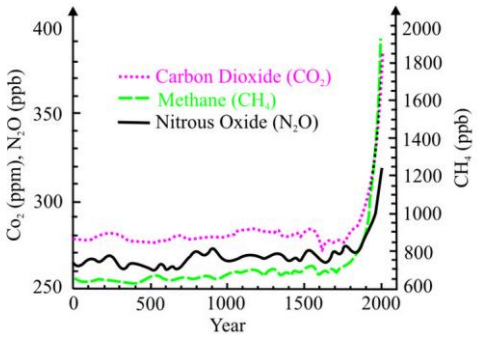

Figure 2: Development of GHG concentration between years 0-2000 [2]

Concentration GHG and temperature are increasing. Higher temperature often means strong storms, melting ice on the North Pole and the South Pole, higher sea level, etc. Who is responsible for GHG production? It is industry and transport mainly. Dependence between GHG production and vehicle fuel consumption is evident. The easiest way for decreasing of GHG production in area of transport is lower consumption of vehicles. What is the way for achieving this aim?

2. SOLUTION

Vehicle engine must produce as much energy as it is necessary for covering of the driving resistances and mechanical losses. With higher resistances and loses must vehicle engine must produce more energy. More energy means higher fuel consumption.

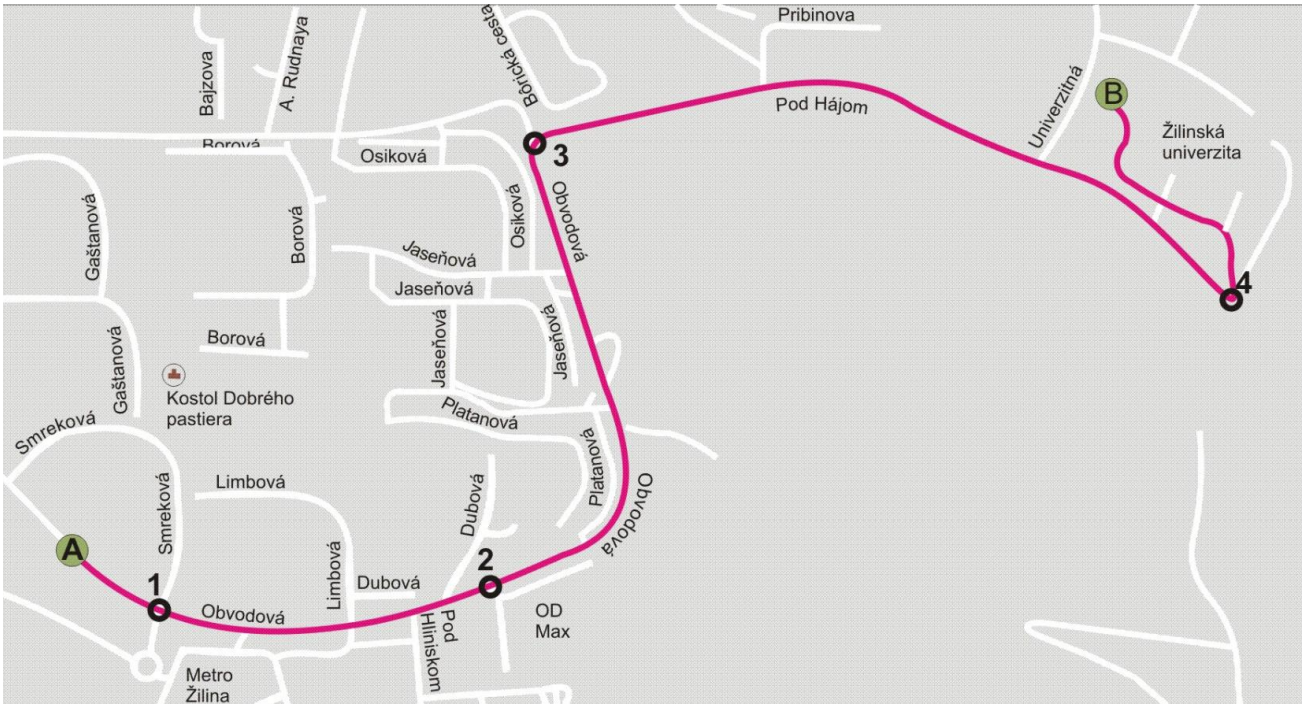

Figure 3: Measurement path [3]

Loses of moment transferred from engine to the wheel can be decreased by using transmission with lower number of toothed wheels and by using gear with higher efficiency. [4] Within vehicle driving resistances it is possible to calculate wind resistance, rolling resistance, slope resistance and inertia resistance. Their value is possible to minimalize by using of correct driving technique and by using of path without slope, intersections and sweeps. Vehicle's fuel consumption depends on working conditions, too.

2.1. Cold and warmed up engine

Result of experiment was to find out how much vehicle's fuel consumption will be changed in dependence if for driving is used vehicle with warmed up engine or it is cold. For comparation we used vehicle with engine warmed up by driving 5 kilometers in town traffic and vehicle that starts to drive after long time of parking.

It is important to achieve the same driving resistances for comparison. Comparison must be made on the same path for fulfill these conditions, it must be used the same vehicle and driver, too. Path marked in Fig. 3 was used for this purpose. Test was made from place A to place B. The numbers mark points where driver read information about vehicle fuel consumption. Results of measurements are summarised in Tables 1-5.

Table 1: Fuel consumption from position A to position 1

Distance from position A to position 1 [km]	0,13
Altitude difference from position A to position1 [m]	0
Average cold start consumption [liters/100km]	29,9
Average consumption engine warmed up [liters/100km]	18,7
Difference of consumption [liters/100km]	11,2

Table 2: Fuel consumption from position A to position 2

Distance from position A to position 2 [km]	0,55
Altitude difference from position A to position 2 [m]	0
Average cold start consumption [liters/100km]	12,5
Average consumption engine warmed up [liters/100km]	7,5
Difference of consumption [liters/100km]	5

Table 3: Fuel consumption from position A to position 3

Distance from position A to position 3 [km]	1,3
Altitude difference from position A to position 3 [m]	0
Average cold start consumption [liters/100km]	7,8
Average consumption engine warmed up [liters/100km]	5,2
Difference of consumption [liters/100km]	2,6

Table 4: Fuel consumption from position A to position 4

Distance from position A to position 4 [km]	2,1
Altitude difference from position A to position 4 [m]	30
Average cold start consumption [liters/100km]	9,3
Average consumption engine warmed up [liters/100km]	7,2
Difference of consumption [liters/100km]	2,1

Table 5: Fuel consumption from position A to position B

Distance from position A to position B [km]	2,6
Altitude difference from position A to position B [m]	20
Average cold start consumption [liters/100km]	8,7
Average consumption engine warmed up [liters/100km]	6,8
Difference of consumption [liters/100km]	1,9

Measurement was made when outside temperature was 8°C. Driver had to start engine, wait 15 seconds and then reverse back into the route with vehicle from parking place. Then he accelerated to the speed fifty kilometers per hour and used the fourth gear for driving. He changed to the third gear because of overcome slope in position 3. He changed to the second gear in position 4 and drive to the position B. It is possible to see that vehicle with warmed up engine achieve significant lower fuel consumption. Vehicle with cold engine needs approximately 300 meters of riding to the moment when lambda sonda starts to work. Engine control unit for this time manages the preparing of rich working mixture. It is possible to see in Tables 1-5. Average vehicle consumption was lowering till vehicle achieves position 3. Last row of Tables shows us how the difference of consumption decreases with overcome distance. We can say it is because of vehicle engine starts to be warmed.

2.2. Air temperature

Influence of air temperature on fuel consumption if the engine is cold is another angle of view. For this comparation the same path was used as in the previous case. For measurement vehicle Toyota Yaris was used. Driver had to wait 15

seconds after the start of engine. Then he flinched with the vehicle from parking place back into the route and accelerated to the speed fifty kilometers per hour. The fourth gear was used for riding. Driver had to change gear to the third one because of overcome slope at position 3. He changed to the second gear in position 4. The second gear was used till the position B. Measurement was suspended in the case of decreasing speed or waiting for leaving parking place in accordance to the traffic conditions. Different air temperature can affect rolling resistance because the walls of the tire are rigid. Low environment temperature causes lower gas pressure inside tire, too. It's reason why rolling resistance is higher. Air temperature can affect not only value of rolling resistance; it can affect air resistance, too. The air density is higher with lower temperature and air resistance is higher, too.

These two conditions cause change of driving resistance and for their overcoming vehicle engine ha to produce higher power. It causes higher fuel consumption. Figure 4 shows us the change of fuel consumption. It is possible to see permanent increasing of consumption together with air temperature decreasing.

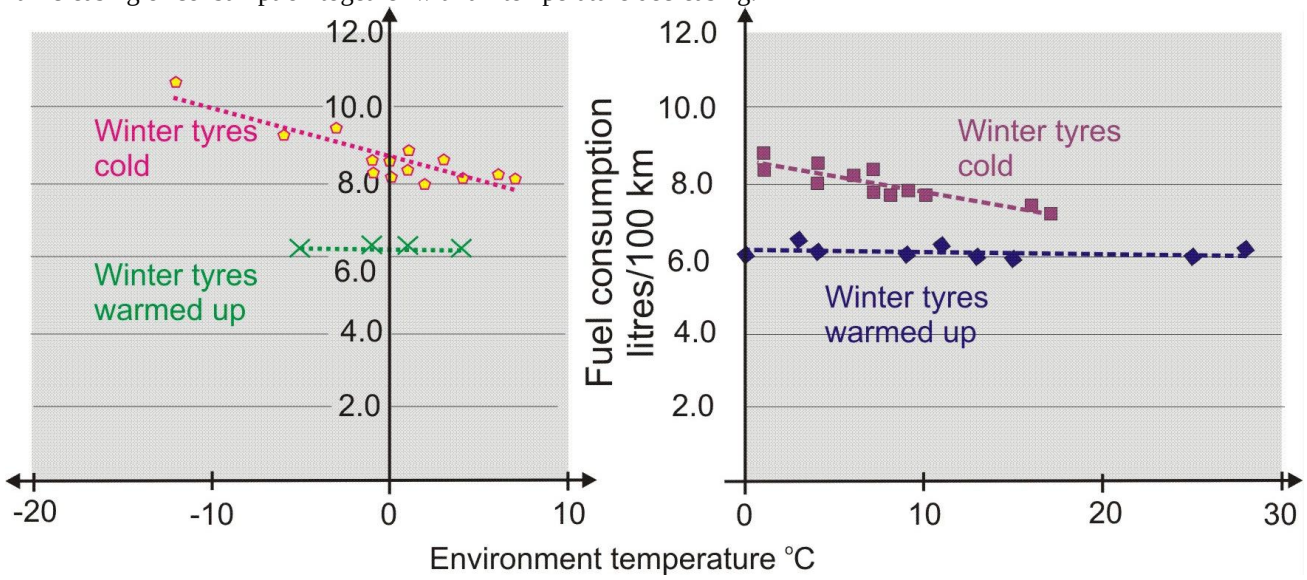

Figure 4: Change of fuel consumption of Toyota Yaris in dependence of air temperature [6]

2.3. Summer and winter tyres

We can often listen that the winter tyres have higher rolling resistance and it is reason for higher vehicle fuel consumption equipped with them.

Figure 4 shows us comparation of the personal vehicle Toyota Yaris consumption if are used the winter or the summer tyres. This figure offers us influence of the engine operating temperatures, too. Measurement in case of cold state was made so that the driver starts drive immediately after the engine was started up. The vehicle's engine and the tyres were warmed up by the driving vehicle on the long distance for warmed up measurement.

Figure 4 shows us that the slope of the curve for the fuel consumption is similar for the cold tyres. The winter tyres show a steep increase as summer tyres. As the air temperature is lower the consumption increasing. It is possible to see that the winter tyres achieve lower fuel consumption in the interval of the air temperature from 0 °C to 10 °C.

For warm up state of the tyres it is possible to see low influence of the air temperature on fuel consumption.

Because measurement was made on the same track the vehicle's consumption can affect only rolling resistance and air resistance How does vehicle consumption change in dependence on air temperature? Vehicle's engine and tyres were warmed up for this comparation because of excluding influence of air temperature to the rolling resistance and influence of engine cold start. There we can see that vehicle fuel consumption increases slowly, on Figure 4. It is result of change air resistance. We can calculate it by next formula:

$$A_R = \frac{1}{2}\rho v^2 c_x S$$

where:

AR is vehicle air resistance [N],
ρ is air density [kg/m^3],
cx is drag coefficient,
S is size of the vehicle frontal area [m^2],
v is vehicle speed [m/s].

Air density is 1.162 kg per m^3 at temperature 30 ºC. It achieves 1.365 kg per m^3 if temperature decreases to -15 ºC. The air resistance of the experimental vehicle increases from 141.2 N at 30 ºC to 165.9 N if air temperature is -15 ºC. The difference is 24.7 N. So we can suppose that rolling resistance of the tyres does not affect vehicle consumption in case of driving in the town. Tyre of Dunlop and Matador production were used for this comparation. For confirmation of these supposes we did the same experiment with vehicle Suzuki SX4 equipped by the tyres of Continental production. In this experiment we found that vehicle consumption was lower if winter tyres were used. Difference was 0.2 litres per hundred kilometres in case of engine warmed up.

On base of these results, it is possible to write, that for temperature under 10 ºC it is better use winter tyres. It offers us lower fuel consumption.

3. CONCLUSIONS

For slowing down of the environmental warming it is necessary to decrease the vehicle consumption. The vehicle consumption affects CO_2 production. 2.5 kg of CO_2 is produced if engine of vehicle burns one lifter of petrol. [7]

We show that the vehicle consumption rapidly decrease wit overcoming distance. The easier way for decreasing of CO_2 production is not using vehicle for short ride. Vehicle engine and its catalyst need some time form warming up. For vehicle warming up it is necessary to overcome about 3 km and catalyst warming takes about 20 seconds. Vehicle consumption is higher because of its warming up. It is necessary to do it. Emissions produced at the first 20 seconds are not reduced in the catalyst.

Using winter tyre for temperature under 10 °C can decrease the vehicle's fuel consumption. Important reason for using of them is safety of traffic, too.

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