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Influence of Cruise Control Use on Vehicle´s Consumption

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Abstract: Most vehicles used in road transport are powered by internal combustion engines. Depending on the nature of their operation, each vehicle releases a certain amount of emissions into the air. Among other things, emissions include carbon dioxide, which significantly contributes to the greenhouse effect. The quantity of CO2 produced is closely related to fuel consumption. The article presents the results of test drives which were performed on a passenger car meeting emission standard Euro 4. The aim of the study was to verify the impact of the use of cruise control on fuel consumption of the vehicle. The measurement was performed on the basis of test drives carried out on a highway section. The consumption was determined based on the data obtained from a diagnostic device, which was connected to the vehicle via OBD. The test drives were repeated several times in order to get as close as possible to the actual operation of the vehicle.

Keywords: Cruise control, fuel consumption, vehicle speed

1. Introduction

Road transport is one of the most widely used ways of moving people and goods. It significantly affects the quality of life of the population as well as the economic growth of most countries. The mobility of the population, as well as the transport of goods itself, has an impact on the environment. [1] Most vehicles are powered by internal combustion engines, which emit harmful substances into the air during their operation. This includes, in particular, the production of carbon monoxide (CO), nitrogen oxides (NOx), PM particles, and hydrocarbons (HC). The combustion process also produces carbon dioxide (CO_2), which contributes largely to global warming. [2,3]

The transport sector emissions account for almost 30% of all carbon dioxide emissions in the EU, with road transport emissions accounting for 72%. The European Union aims to reduce transport emissions by 60 % compared to 1990. [4] This plan is set for 2050. The largest producers

of CO_2 and greenhouse gases include passenger cars, which emit 60.7% of total transport emissions from transport, with freight transport emissions accounting for 26.2%. [5,6]

There is currently a lot of pressure on vehicle manufacturers to ensure that new vehicles meet strict emission standards. There have been many articles dealing with the research and searching for new ways to reduce emissions. [7-9] Vehicle´s consumption is also associated with emissions production. As for the issue of reducing fuel consumption, there are fuel-efficient driving techniques that may lower a vehicle´s fuel consumption. [10] Lowered fuel consumption may reduce the volume of emissions produced. . For these reasons, eco-driving training is offered, which is mainly focused on reducing vehicle´s consumption and also contributes to the efficiency of driving. [11-14]

2. System Characteristics and Performance of Driving Tests

Cruise control is a device that automatically maintains a constant vehicle speed when activated. This system is activated by a lever under the steering wheel or buttons placed directly on the steering wheel within reach of the driver. Once activated, the car maintains a constant speed and the driver does not have to keep the foot on the accelerator pedal. If the driver starts to act on the brake pedal, cruise control is automatically switched off to prevent the vehicle from braking while the engine is running. By using cruise control, the driver can increase but also decrease the speed of the vehicle. Some vehicles also deactivate the cruise control when the clutch pedal is depressed. Cruise control, therefore, provides the driver with the maximum comfort on highways or long sections. There are several types of cruise control. [15]

2.1 Adaptive Cruise Control ACC

This type of cruise control basically works like a classic one, which maintains a constant speed by controlling the throttle (transmission if it is automatic). If a vehicle with activated adaptive cruise control approaches a slower vehicle in front of it, it automatically brakes and maintains a constant safe following distance. When the first vehicle changes direction, the adaptive cruise control automatically increases the speed and continues at the set speed. [16]

Vehicles equipped with ACC work on the principle of microwave or laser radar, based on which the system can detect and warn the driver about approaching obstacles (slower-moving vehicles). The ACC system evaluates approaching obstacles and reduces the speed without any driver´s intervention necessary. The driver can choose from four programs that increase the smoothness of driving in tailback. If ACC determines that the vehicle is approaching an obstacle too quickly, the system alerts the driver and prepares the brake system for heavy braking (see Fig. 1). In such situations it also automatically and continuously reduces the speed of the vehicle. [17,18]

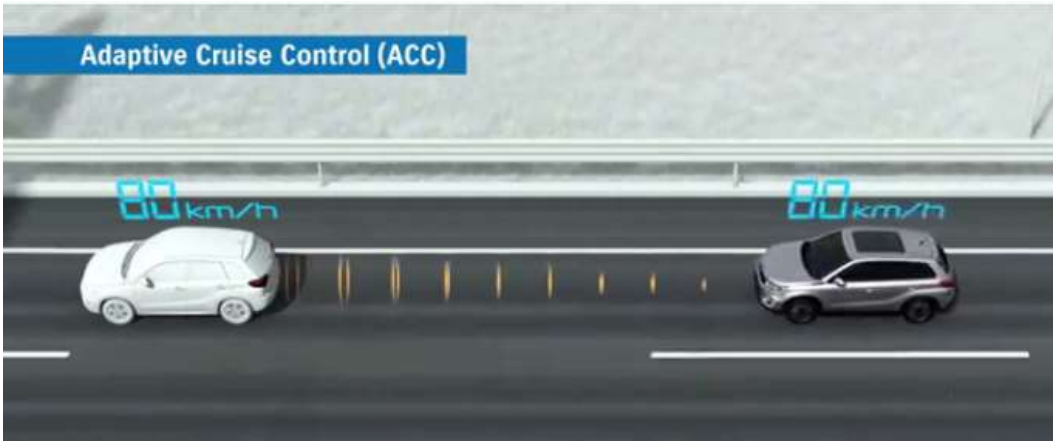


Fig. 1 ACC after activation. Source: authors (Internet)

2.2 Predictive Cruise Control, (Cruise Control Based on Topography)

Predictive cruise control, cruise control based on topography is a type of cruise control which uses GPS technology to determine the position of the vehicle and predict the topography of the road in front of the vehicle. At present, this system has full coverage for Western and Central Europe.

Cruise control based on topography seeks to eliminate the disadvantages of a common cruise control using topographic data from road maps. This information is combined with GPS data to determine the position of the vehicle, based on which the most economical current vehicle speed is calculated. [19]

Scania has developed the Active Prediction system, which helps drivers save fuel and reduce their impact on the environment. It is a system that adapts to driving technique thanks to the topography.

In normal operation, the cruise control based on topography reads the data on roads up to 3 km in front of the vehicle, with the focus on the identification of:

- approaching climb - when and how much the speed needs to be increased for the vehicle to start climbing with the maximum engine torque,
- impending descent - when and how much the speed should be reduced.

The system is activated when the cruising speed set is higher than 60 $km.h^{-1}$; at lower speeds, the usual cruise control function is used. When the cruise control system is active, it can change the vehicle speed in the range of + 4% to - 8% compared to the cruise speed set by the driver. The driver cannot change this range, as it is set by the system. The system can regulate cruise control based on a continuous evaluation of several factors related to the vehicle and topography. Cruise control based on topography is also connected with adaptive cruise control, which means that the vehicle maintains a safe following distance from the vehicle in front of it.

2.3 Performing Measurements – Methodology

The vehicle´s consumption was determined on the basis of driving tests performed on a selected section of a road using various driving techniques. Such tests have the most accurate explanatory value because it is a ride in real conditions and the measurements provide data on actual consumption.

The vehicle was inspected before the actual measurements were taken. In particular, the tire pressure was checked and we also made sure that the vehicle was in good technical condition. Each driving technique was measured on the same section of the road under the same ambient conditions. This enabled the quantification of the data obtained, as well as their mutual comparison. The measurements were repeated 3 times for each driving technique so that the measured data were as accurate as possible and corresponded to the actual driving of the vehicle. A diagnostic device was connected to the car throughout the measurement via OBD, which read the required data from the engine control unit.

For the measurements and tests, an M1 Ford Focus II facelift passenger car was selected (see Fig. 2). When choosing a vehicle, it was considered the need for the results to be usable and provide useful information to a wider range of readers (drivers, motor vehicle operators, etc.). The selected type of vehicle is commonly available and often encountered on the road. Driving characteristics (see Table 1) and motorization are comparable to other vehicles used in road traffic.



Fig. 2 Vehicle used for measurement. Source: authors

Table 1 Technical parameters of the measured vehicle. Source: authors

Technical parameters of the measured vehicle	
Brand	Ford
Trade name	Focus
Engine code	G8DB
Number of cylinders	4
Cylinder displacement	1 560 cm^3
Highest engine power	80.00 kW
Speed at max. moment	4 000 min^{-1}
Highest design speed	188 $km.h^{-1}$
Fuel type	diesel
Length	4 468 mm
Width	1 839 mm
Height	1 537 mm
Operating weight	1 391 kg
Maximum permissible total weight	1 885 kg
Size and type of tires	205/55 R16 91H

The measurements were performed on 16 October 2019 in the evening, as at that time the minimum intensity of vehicles on the selected road was assumed. This way the authors tried to eliminate unwanted interventions in the measurement and to maintain road safety.

2.4 Description of Testing Route

The effects of cruise control on vehicle´s consumption were measured on the D1 highway section between Bytča and Žilina. Cruise control, as well as OBD diagnostics, were activated when the test vehicle was on the highway, which enabled the minimal distortion of the measured data. The measurements were ended at a highway exit (exit 8, in the direction of Žilina - West) – see Fig. 3 and 4. The measured data were saved after disconnecting the OBD diagnostics.



Fig. 3 Route for performed measurement. Source: authors (by Google Earth)

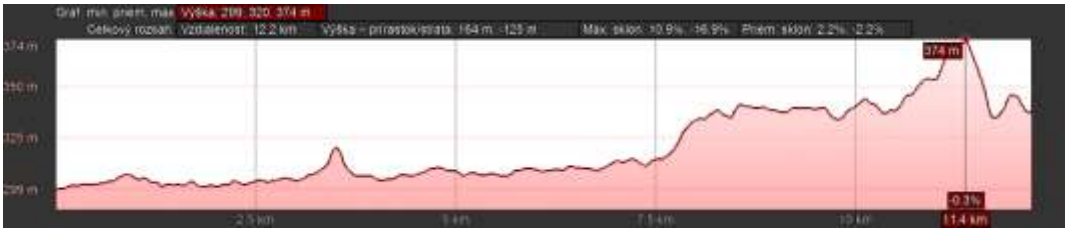


Fig. 4 Height guidance of testing route Source: authors (by Google Earth)

The impact of cruise control on vehicle´s consumption was determined on a 12.2 km long route. Drivers usually activate cruise control on highways. For this reason, the measurements were also performed on a highway. We tried to simulate the most typical ride, during which the cruise control was activated. The vehicle moved along the route without significant ascents, descents, but from the 7th kilometer, the vehicle began to overcome the ascent, which represents 63 altitude meters on a 4-km section.

3. Evaluation of Driving Tests

The driving tests enabled to determine the effect of cruise control on the vehicle fuel consumption as well as on the engine load. The test began with the vehicle riding on a selected highway section and the subsequent activation of cruise control. The driver achieved the set speed and only then activated cruise control. The speed at which cruise control was activated was set at 120 km.h^{-1} with respect to the current conditions (fog). The entire section of the measuring route was driven 3 times with activated cruise control and 3 times when the accelerator pedal was controlled by the driver's foot (i. e. without cruise control). This comparison provided the vehicle operator with the information on the extent to which cruise control is used effectively and how it affects the monitored data.

When evaluating driving with the use of cruise control on the highway section, it is not very important to evaluate the vehicle speed or engine speed. These are essentially constant during the journey and their values do not change. However, certain engine power is required to maintain a constant speed (overcoming gradients) of the vehicle. The consumption of the vehicle is based on it.

The essence of these measurements on a highway section was to find out how cruise control affects the consumption of the vehicle and to what extent its activation represents an advantage or. disadvantages for the driver.

The vehicle consumption was determined based on the data provided by OBD diagnostics. The data on fuel flow was mainly monitored, based on which it was possible to calculate the absolute liters consumed for a specific measurement. The odometer allowed the accurate calculation of the vehicle fuel consumption in l/100 km.

As for the other monitored data, the following information was interesting for the purposes of this article (see Table 2):

- engine power,
- engine speed,
- vehicle speed.

Table 2 Comparison of vehicle´s consumption by cruise control use. Source: authors

Measurement number	Fuel consumption [l]	Distance traveled [km]	Vehicle´s consumption [l / 100 km]	Average
Fuel consumption with cruise control activated				
1	0.836	10.13	8.25	8.16
2	0.897	11.1	8.9	
3	0.899	11.4	8.14	
Fuel consumption when driving without cruise control				
1	0.811	10.85	8.11	8.10
2	0.851	10.42	8.12	
3	0.88	10.88	8.1	

Vehicle´s consumption was calculated for a specific section of the highway. From Table 2, it can be stated that the vehicle´s consumption was lower when the accelerator pedal was operated by the driver. This means that the vehicle consumes more fuel when cruise control is activated.

The influence of the vehicle speed on fuel vehicle´s consumption is presented in Fig. 5 below.

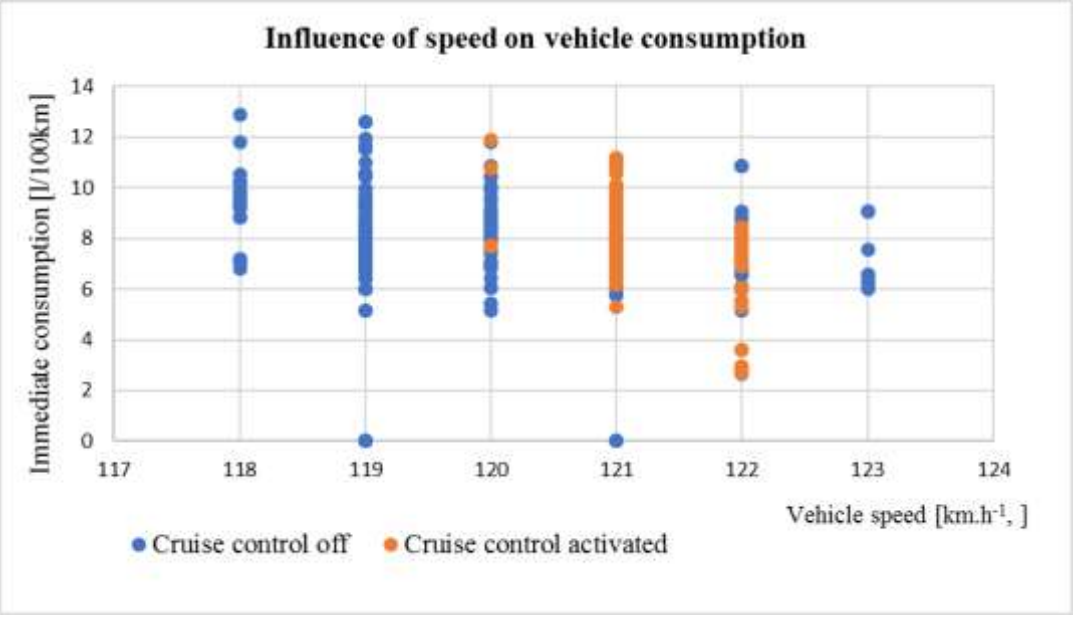


Fig. 5 Influence of speed on vehicle fuel consumption. Source: authors

Regarding the effect of speed on vehicle fuel consumption, Fig. 5 shows how the vehicle´s consumption changes depending on the speed. When cruise control is activated (orange), constant

speed is maintained the measurement period. With the cruise control deactivated (blue), the vehicle speed ranges from 118 to 120 km.h^{-1}. This is the result of an increase in consumption when activating cruise control.

The influence of engine speed on vehicle fuel consumption is presented in Fig. 6.

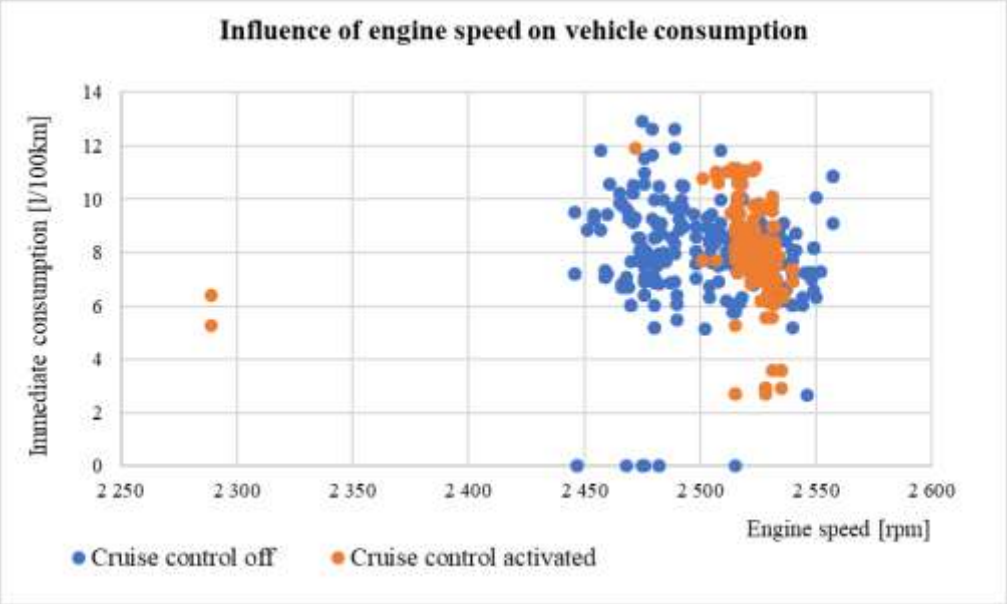


Fig. 6 Influence of engine speed on vehicle fuel consumption. Source: authors

Engine speed is directly dependent on the vehicle speed and the gear engaged. With the cruise control deactivated, it is possible to monitor the variance of the detected values in the graph, as in the case of the vehicle speed.

The course of the monitored influence of the engine power on vehicle fuel consumption is shown in Fig. 7.

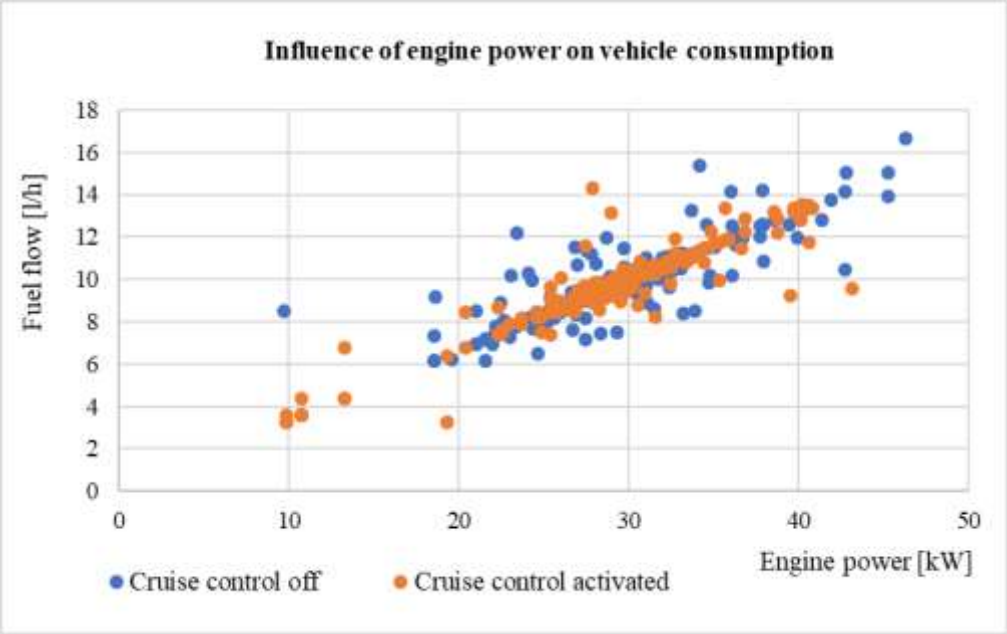


Fig. 7 Influence of engine power on vehicle fuel consumption. Source: authors

The fuel flow and the vehicle fuel consumption increases with growing. The graph in Fig. 7 indicates that the increasing consumption of the vehicle is directly proportional to the increasing engine power.

In the Fig. 8 below, the performance of the vehicle while driving is described.

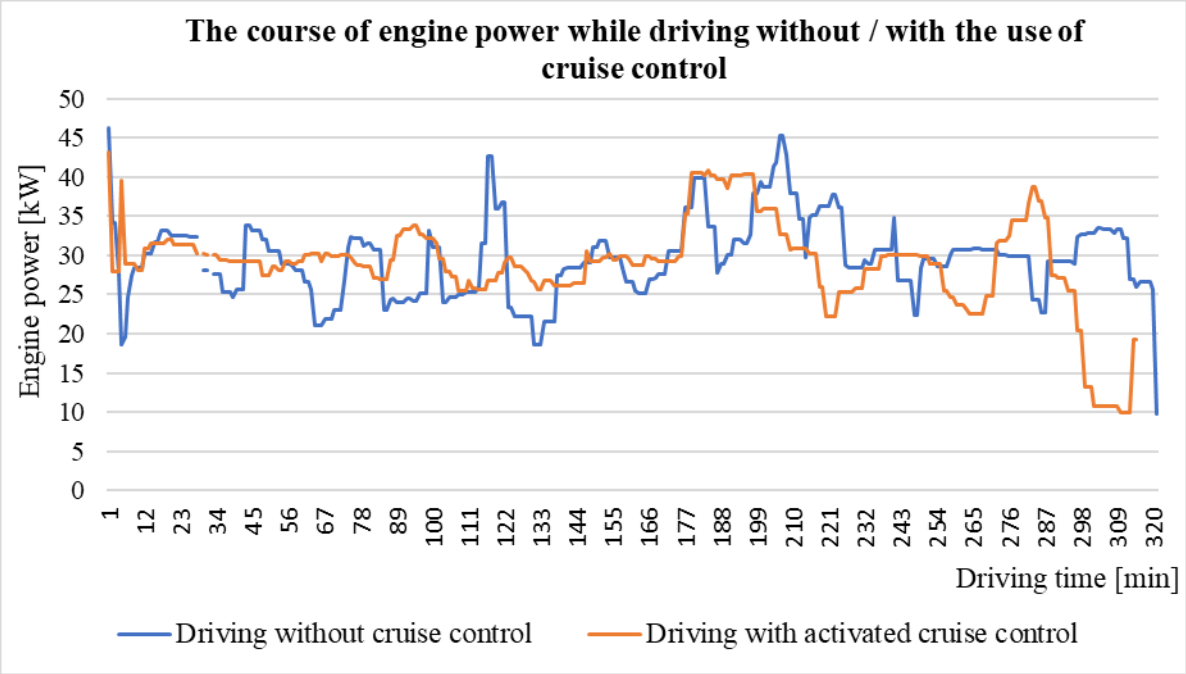


Fig. 8 Vehicle performance while driving. Source: authors

From the graphs showing a comparison of the immediate fuel consumption while driving and the monitored parameters (vehicle speed, engine speed), it can be stated that the resulting consumption actually corresponds to their increase or decrease. This is best seen in the graphs of engine power and fuel flow. The fuel flow increases with the engine power, which means that the higher the engine power, the higher the fuel consumption is. However, this may not be the rule for engine speed and vehicle speed. If the terrain over which the vehicle is moving is slightly downhill or flat, the actual fuel flow is lower at constant RPM´s and speed than when the vehicle overcomes a climb.

When creating a graph of the course of engine power depending on the driving time, a fluctuating course of power can be noticed. When driving with activated cruise control, the vehicle maintains a constant engine power without any significant deviations; on the contrary, when driving with the accelerator pedal controlled by the driver, this course is fluctuating and uneven. This is due to the fact that the driver does not keep the accelerator pedal equally depressed during the entire driving time, stepping on it more when driving uphill, less when descending.

By monitoring the individual courses, it can be stated that the vehicle shows higher consumption values when the cruise control is activated than when driving without it. This is evidenced by the variances of the values within the individual graphs. When cruise control is

activated, the points (engine speed - instantaneous consumption, vehicle speed - instantaneous consumption, fuel flow - engine power) are concentrated in one place, or along the curve at engine power, so when the cruise control is off, there can be seen some variances of the monitored values. This fact is the reason of the higher consumption when the cruise control is activated.

These are undoubtedly the benefits of using cruise control. With the cruise control activated, the driver does not have to keep the foot on the accelerator pedal, the vehicle maintains a constant speed, and also the engine power is even. Of course, overcoming inclines will increase engine power and RPM´s even when cruise control is activated.

4. Discussion and Conclusion

From the performed measurements and individual calculations, it is possible to process a conclusion in the form of recommendations, which will be addressed directly to the vehicles as well as to the driver himself. The results are directly applicable in practice when driving and maintaining the vehicle. The partial results of the measurements point to the fact that drivers can influence the consumption of the vehicle and thus the production of emissions. The aim was to point out the specifics of the evaluated driving techniques and their impact on fuel consumption. The driving tests performed actually confirmed the initial assumption and enabled the quantification of the individual impacts of driving techniques on fuel consumption and thus on emissions production [20]. The data and results obtained can be fully applied to all vehicles running on the principle of internal combustion engines. [21]

Many drivers want to make traveling as easy as possible, or make it easier. One of the ways to achieve this is to activate cruise control on straight sections of roads, where it is supposed that the driver does not change the vehicle speed or gear for a long time. That is why the cruise control effect on vehicle´s consumption were examined.

By driving on the specified highway section, it was possible to calculate the fuel consumption depending on the activation of the cruise control. Subsequently, this speed was compared with the consumption of a vehicle moving in the same section, but without activated cruise control. The comparison showed a difference in consumption of 0.06 l/100 km, which indicates that the vehicle consumed more fuel while driving with the cruise control activated. As the measuring route was relatively short, it can be assumed that the difference can be even higher. The comparison of the other monitored data showed that cruise control maintains stable engine power, and thus prevents sudden fluctuations in power or fuel consumption. In terms of comfort, the driver can take the foot off the accelerator pedal and fully concentrate on driving when the cruise control is activated. When driving on long distances, driving without cruise control could be uncomfortable and exhausting if the driver's shoes are not suitable.

One of the conclusions and recommendations formulated is definitely the recommended use of cruise control where r appropriate. Despite increasing the fuel consumption in comparison with driving without ACC activated, the advantages are indisputable for long distance driving.

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