Consideration on the Implications of the WLTC - (Worldwide Harmonized Light-Duty Test Cycle) for a Middle Class Car

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Abstract. Legislation on emissions, reducing CO2 emissions and fuel consumption, as well as customer requests will result in the production of engines and propulsion systems from increasingly complex. In addition, producers should launch on the market several models and different versions to keep customer preferences. The legislation was based until now on testing procedures well known, includes standards for data actually achieved by using test cycles random and / or testing under real displacement, environmental and road conditions. Because the new test cycle WLTC involves more severe transient, at least as a percentage, it requires a more rigorous approach to engine calibration methods in parallel with a new development strategy powerplants. The paper analyzes the implications through computerized simulation test cycle WLTC future compared to the present NEDC for a middle class car. The results provide important insights about fuel consumption, CO2 that will respond favorably to the new development strategy powerplants.

Keywords: European regulations, fuel consumptions, atmospheric pollutants, NEDC, WLTC.

1 Introduction

According to ICCT (The International Council on Clean Transportation), in the past decade could be observed a trend that becomes dangerous: the gap between consumption and pollution in real life and those reported by manufacturers. It is estimated that, if in 2001 the difference between the theoretical and the real consumptions was 7-8%, 10 years after these difference are 3-4 times higher. For example, in 2013 was found a difference of 31% for private cars and 45% for company cars, which means an average increase of 38% of CO2 emanations in comparison with the real ones (Figure 1). Therefore, to eliminate these discrepancies, in 2017 the European Union intends to adopt a new cycle and a new test procedure called WLTP (Worldwide Harmonized Light Vehicles Test Procedures).

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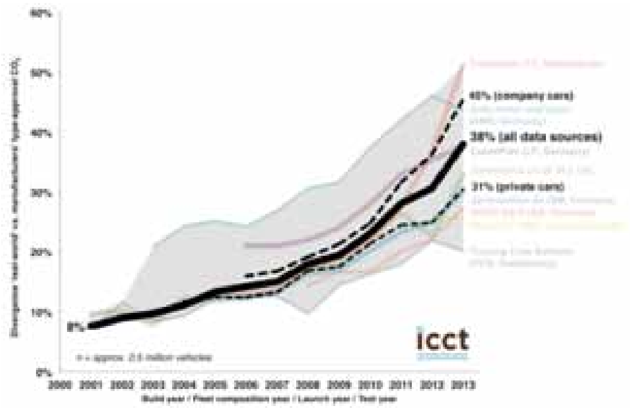

Fig. 1. Discrepancy between the real CO2 emissions and those reported by the car manufacturers. (Source: ICCT_LaboratoryToRoad 2014).

2 Comparative analysis of the NEDC driving cycle and WLTC and process simulation using AVL Cruise

2.1 The parameters of the NEDC driving cycle and WLTC

Table 1. Descriptive parameters of the driving cycles NEDC and WLTC (Source: ICCT_LaboratoryToRoad 2014).

	Units	NEDC	WLTC
Start condition		cold	cold
Duration	s	1180	1800
Distance	km	11.03	23.27
Mean velocity	km/h	33.6	46.5
Max. velocity	km/h	120.0	131.3
Stop phases		14	9
Durations:			
• Stop	s	280	226
• Constant driving	s	475	66
• Acceleration	s	247	789
• Deceleration	s	178	719
Shares:			
• Stop		23.7%	12.6%
• Constant driving		40.3%	3.7%
• Acceleration		20.9%	43.8%
• Deceleration		15.1%	39.9%
Mean positive acceleration	m/s^2	0.59	0.41
Max. positive acceleration	m/s^2	1.04	1.67
Mean positive 'vel * acc' (acceleration phases)	m^2/s^3	4.97	4.54
Mean positive 'vel * acc' (whole cycle)	m^2/s^3	1.04	1.99
Max. positive 'vel * acc'	m^2/s^3	9.22	21.01
Mean deceleration	m/s^2	-0.82	-0.45
Min. deceleration	m/s^2	-1.39	-1.50

Comparing the NEDC and the WLTC, the following observations can be made:

Cold start: The WLTC (1800 seconds and 23 km) is longer than the NEDC (1180 seconds and 11 km). Driving a vehicle with a cold engine increases CO2 due to higher mechanical friction and higher fluid viscosities

Vehicle load: The WLTC reaches higher speeds (131.3 km/h instead of 120 km/h) and has stronger acceleration forces (combined with higher vehicle inertia) and thereby, on average, higher vehicle loads than the NEDC.

Engine speed: Besides the load of the engine, engine speed has a direct impact on CO2 emissions. Generally, higher engine speeds cause higher friction and pumping losses and worsen the CO2 performance. Therefore, gear shift strategies for automatic transmissions are designed to achieve lower engine speeds by shifting more rapidly into lower numeric gear ratios. In the NEDC, vehicles with manual transmissions have to follow strict specifications that determine at which point in time a certain gear position has to be selected This regime will change in the WLTP where the gear shift points will be adapted to the individual characteristics of the vehicle.

As the WLTP shifting points are clearly at lower engine speeds compared to the NEDC, this new method will reduce engine speeds for manual transmission vehicles and will result in proportionally lower CO2 emissions for these vehicles in the WLTC.

Stop share: In the WLTC (12.6% stop share) there are less stop phases than in the NEDC (23.7% stop share). Stop-start systems shut down the engine during vehicle stop phases and—in an ideal case—reduce idle emissions to zero. In WLTP, this technology will result in lower CO2 savings than is currently the case in NEDC.

Starting with 2020, all new vehicles will be tested only with WLTP and the CO2 emission targets should met by this procedure. It is necessary to translate the NEDC cycle target of 95 g CO2/km in an equivalent objective based on WLTP (Figure 2).

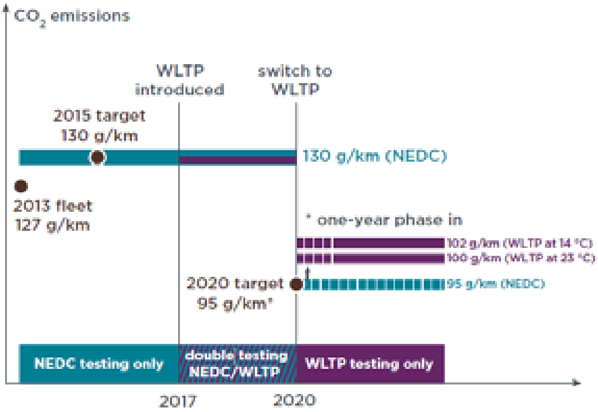

Fig. 2. The deadlines for implementation of WLTP in EU (Source: ICCT_LaboratoryToRoad 2014).

2.2 The algorithm simulation process using the application AVL Cruise

AVL Cruise application is a suite of software tools for the simulation of a wide variety of car models, which can generate, develop and study the various categories of vehicle construction with various propulsive systems solutions (thermal, electric or hybrid). The steps in the process of computer simulation (Figure 3) are as follows:

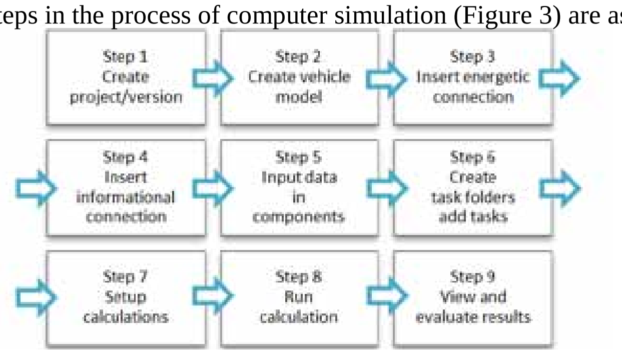

Fig. 3. Process simulation algorithm

3 Modeling of a middle-class car fitted with SI engine using AVL Cruise

According to statistics, official data show that the national car park in Romania count at the end of 2015, about 6.6 million units, up 5.27 % from the same period last year, when count 6.27 million of copies. Used preferred brand in Romania continued to be Volkswagen (18.311 units, + 15.48 % relative T1 of 2015), followed by Opel (10 662 units, +15.50 %) and Audi (4,962 units, +35.24%).

As such, computerized simulation using AVL Cruise I chose as the most widely used standard car in Romania, Volkswagen brand with spark-ignition engine and a cylinder capacity of 1.4 l. This car belongs to the category of light vehicles whose group powerplant will be equipped for the purpose of the simulation with a manual transmission and an automatic gearbox for the NEDC test cycle and WLTC.

To simulate the operation of the car chosen by middle class with the internal combustion engine was created and developed the model for computer simulation in AVL Cruise application version 2014.

3.1 Comparative interpretation of the results obtained

General data of car:

Model	Volkswagen Golf 5
Engine type	1.4 i 16V (75 Hp)
Power	75 CP /5000 rot/min
Capacity	1390 cm3
Engine torque	126 Nm /3800 rot/min

Fuel type	Gasoline
Traction	Front-wheel drive
Unladen mass	1189 kg
Maximum authorised mass	1780 kg

It can be seen that NEDC have stabilized speed zones with slow acceleration while in the WLTC they are more aggressive due to the operation in the transitional phases.

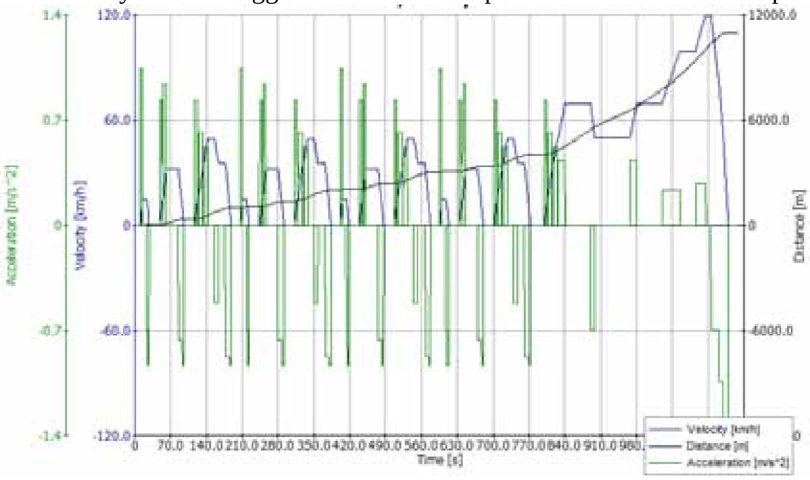

Fig. 4. NEDC test cycle profile

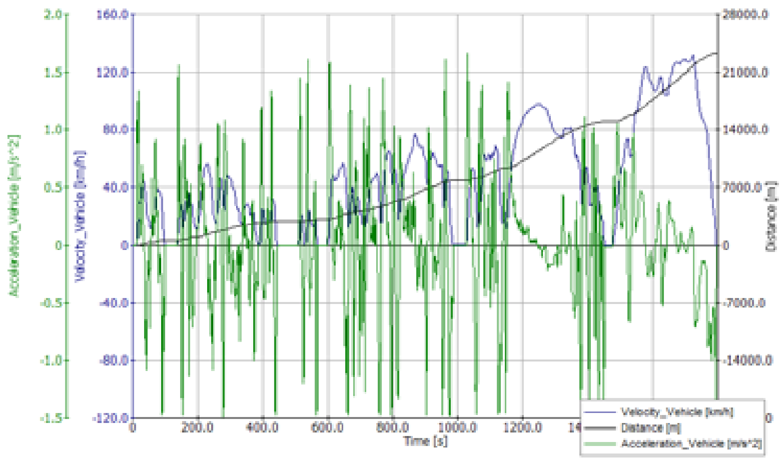

Fig. 5. WLTC test cycle profile

In cartogram consumption by NEDC test cycle it could be seen that the operation points are restrained and are concentrating in the first part of cartogram.

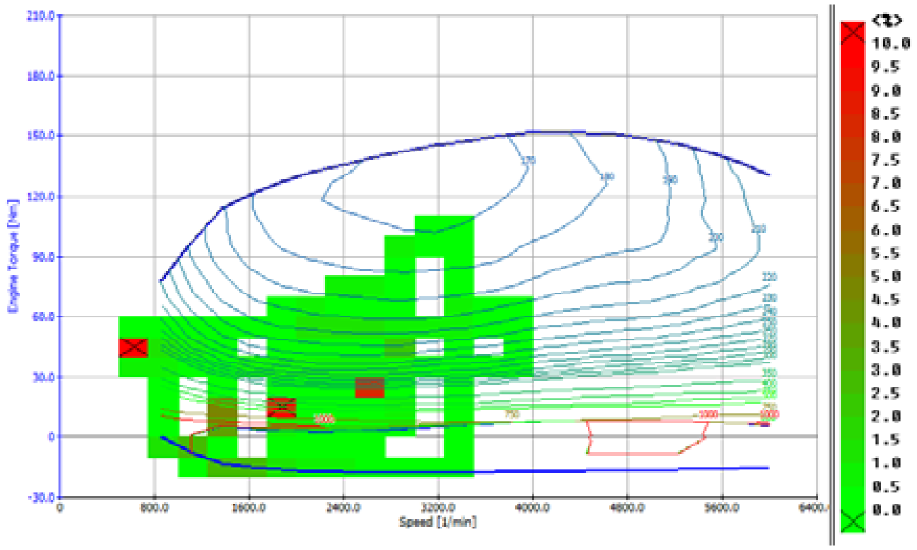

Fig. 6. Map of consumption by NEDC test cycle (Source: AVL Cruise 2014)

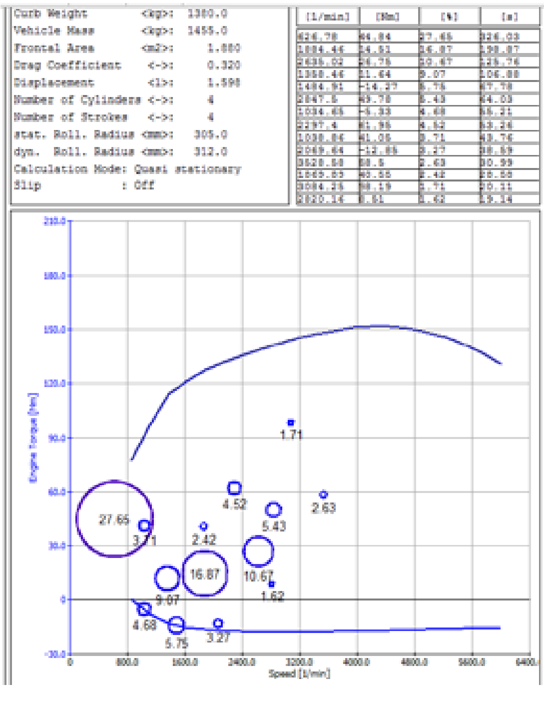

Fig. 7. Map of consumption by NEDC test cycle (Source: AVL Cruise 2014)

In the cartogram of WLTC consumption test cycle it could be seen that almost all of the operating points are used.

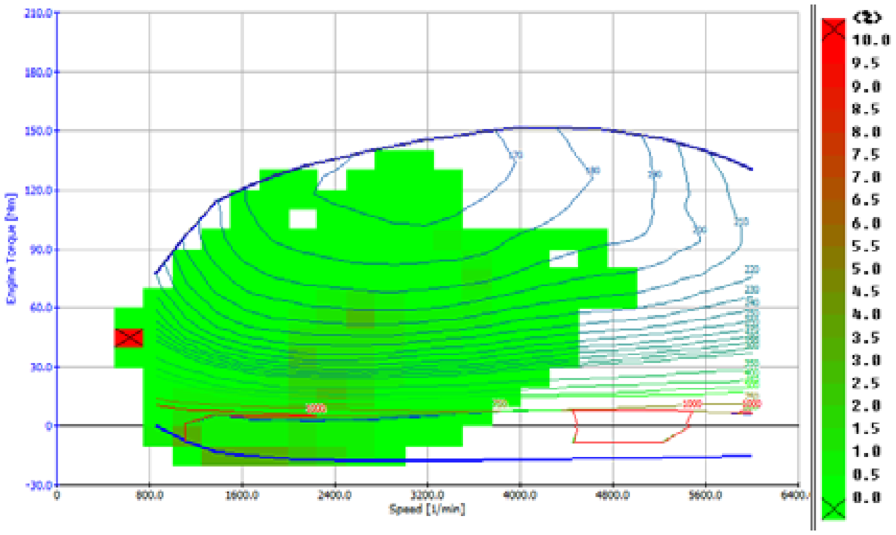

Fig. 8. Map of consumption by WLTC test cycle (Source: AVL Cruise 2014)

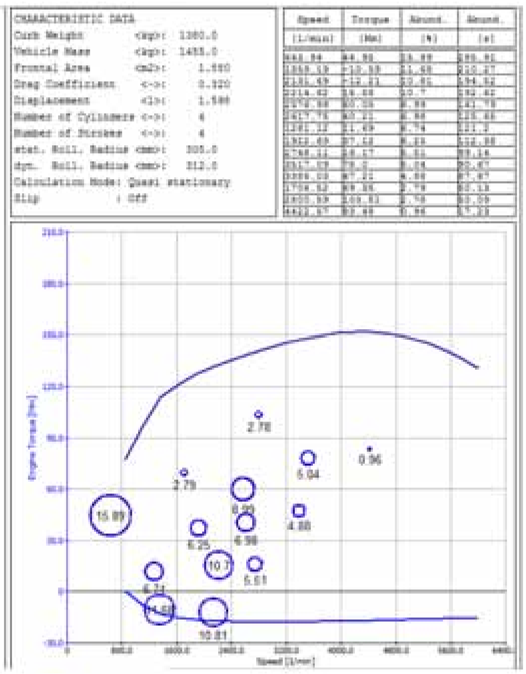

Fig. 9. Map of consumption by WLTC test cycle (Source: AVL Cruise 2014)

Below are the results obtained by computerized simulation using AVL Cruise for the middle-class car with SI engine, for the following proposed models:

- car with manual transmission for NEDC and WLTC test cycles
- car with automatic transmission for NEDC and WLTC test cycles.

Case 1: car with manual transmission (5-speed)

Table 2. Fuel consumption and CO2 emission for a car with a manual transmission, tested by NEDC and WLTC test cycles

	NEDC	WLTC
Fuel Consumption	5.4 [l/100km]	7.3 [l/100km]
CO2 emission	133 g CO2/km	183 g CO2/km
Comparison NEDC vs. WLTC [l/100km]	35.18 %	
Comparison NEDC vs. WLTC [g CO2/km]	37.59 %	

Case 2: car with automatic transmission (5-speed)

Table 3. Fuel consumption and CO2 for a car with a automatic transmission, tested by NEDC and WLTC test cycles

	NEDC	WLTC
Fuel Consumption	6.5 [l/100km]	7.7 [l/100km]
CO2 emission	136 g CO2/km	185 g CO2/km
Comparison NEDC vs. WLTC [l/100km]	18.46 %	
Comparison NEDC vs. WLTC [g CO2/km]	36.02 %	

4 Conclusions

Application of simulation processes using AVL Cruise offers a number of advantages such as reduced costs for the car manufacturers and the opportunity to revise the car structure at any stage of the process.

The data obtained as a result of computer simulation using AVL Cruise shows a noticeable increase of fuel consumption and CO2 emission in the transition loads for NEDC vs. WLTC in the case of the car with manual transmission: fuel consumption increases with 1.9 l /100 km (35.18%) and emission with 50 g CO2/km (37.59 %).

Instead, the car with automatic transmission has a more favorable situation for NEDC vs. WLTC: fuel consumption increases with 1.2 l/100 km (18.46 %) and emission increases with 49 g CO2/km (36.02 %).

In order to respond more favorably to the new WTLC test cycle, it is necessary to use the automatic transmission and a more rigorous approach to engine calibration methods, together with a new strategy of development of the engines, because the WLTC test cycle is much tougher and is characterized by transient running stages.

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