A XVIII-a Conferință internațională – multidisciplinară
„Profesorul Dorin Pavel – fondatorul hidroenergeticii românești”
CLUJ NAPOCA, 2018

CONTRIBUȚII LA STUDIUL ECONOMIEI DE COMBUSTIBIL ȘI A AMPRENTEI DE CARBON ÎN CONDIȚII VARIATE DE FUNCȚIONARE PENTRU UN AUTOVEHICUL URBAN COMPACT LA UNIVERSITATEA TEHNICĂ DIN CLUJ-NAPOCA

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CONTRIBUTIONS TO FUEL ECONOMY AND CARBON FOOT PRINT STUDY IN VARIOUS OPERATION CONDITIONS FOR A CITY COMPACT SIZE CAR WITH AT TECHNICAL UNIVERSITY FROM CLUJ-NAPOCA

Carbon footprint and automotive pollution are some important concerns in transportation field. Main objective of the present work is to propose, develop and implement the new complex method of computer aided measurement concerning carbon footprint in urban driving condition of a city car with instruments and equipment available at Technical University from Cluj-Napoca. Specific objectives consist in experimental research of fuel consumption and economy, determination of pollutant emissions from the motor vehicle and pointing out the method’s fundamentals at Technical University of Cluj-Napoca. A new method of advanced technological research was developed during this study. The junction of computer aided processing and fuel/chemical efficiency evaluation is pointed out during the paper development. There were also highlighted the economy and carbon footprint trend lines in each particular context.

Keywords: carbon foot print, hydrocarbons, validation by experimental work

Cuvinte cheie: amprentă de carbon, hidrocarburi, validare prin parte experimentală

1. Introduction

Pollution and automobiles emissions are few of the most significant aspects in road traffic health and safety. The most important aim of the present paper is to state, develop and apply an innovative complex method of computer aided measurement concerning carbon footprint (CFP) in various driving conditions of a city car with high-tech instruments and equipment available at Automotive and Transportation department in Technical University from Cluj-Napoca. Particular targets consist in practical measurements of fuel specific consumption and economy, determination of pollutant emissions from the engine exhaust system and pointing out the method's fundamentals at Technical University of Cluj-Napoca.

By using the alternative fuels with bio-components the carbon footprint may be controlled and positively manipulated in order to diminish pollution level [1].

As greenhouse gas emissions that contribute to global warming increase, it is becoming more important to consider the "carbon footprints" of engineering projects [2].

Quality and main properties of fuels and lubricants in the case of using them with internal combustion engines are most important factors in determining the exhaust emissions and pollution level, as well as engine's reliability and working capacity, which is also the reason behind the scientific and engineering imperative for advanced research of those aspects in relation with fuel economy and carbon foot print in operating conditions of real engines on vehicles [3][4][5].

2. Materials and method

The adequated data in research are achieved when applying scientific method and by using proper devices as it is mentioned in the next chapters.

Methodology was sketched at Automotive and Transportation department in Technical University from Cluj-Napoca. Equipment was available in the Automobile Laboratory from Automotive and Transportations Department.

By implementing computer aided technologies, measuring the consumption level, considering the emissions and analyzing carbon footprint researchers can evaluate the importance and opportunity of using some vehicles for transport or other purposes in urban area. The present paper implements an advanced engineering method based on

computer aided measurements concerning operational parameters related to fuel economy and subsequent carbon footprint and pollution of a city car. The studied city car is a fully working model, which was used and monitored studied in relation with carbon dioxide emissions and fuel efficiency levels. A new method of advanced technological research was developed during this study. The junction of computer aided processing and fuel/chemical efficiency evaluation is pointed out during the paper development (figure 1).

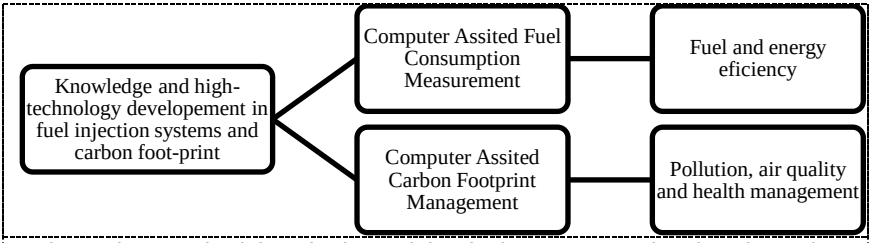


Fig. 1 Short methodology in determining fuel economy and carbon foot print

The injection system on the tested engine is shown in figure 2 **Eroare! Fără sursă de referință.**.

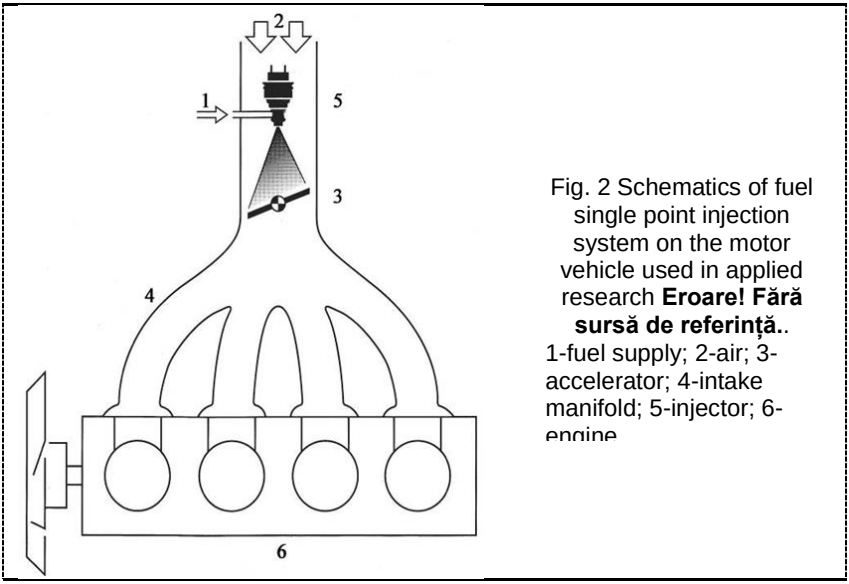
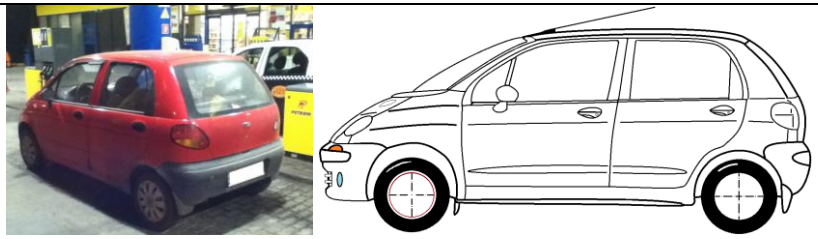


Fig. 2 Schematics of fuel single point injection system on the motor vehicle used in applied research **Eroare! Fără sursă de referință.**. 1-fuel supply; 2-air; 3-accelerator; 4-intake manifold; 5-injector; 6-engine

The EU6c Emission Regulation determined major modifications and additional systems and type approval tests in the 2017-2020

timeframe, including [7]: ● replacement of the NEDC by the WLTP for the determination of criteria emissions; ● additional cold start test for Diesel vehicles including NOx; ● introduction of the new Real Driving Emission test in order to control the criteria emissions under all realistic driving conditions; ● then our staff developed an advanced method for evaluating fuel economy and carbon foot print in the case of an existing and available city car. Used materials consist in one full operational city car (Figure 3) Daewoo Matiz model year 2005 and the specialized equipment necessary for applied research.

The testing equipment used in real conditions for developing the research paper there were mobile devices for fuel consumption determination and data recording. Also there was a test track for real driving advanced measuring as well as digital post-processing units.



a. b.

Fig. 3 Image of the tested vehicle for fuel economy and carbon foot print
a-real image; b-schematics

Specific effective fuel consumption is a special category of index and it is defined as fraction from hourly consumption of engine effective power. The components which define the fuel economy study are a part of the effective parameters. The study of the relation between the consumption and distance is made in order to determine the mileage of the car. According to empirical correlation, for a unit of fuel supplied to the engine cylinders there is a correspondence in output power at crankshaft, as in the next model **Eroare! Fără sursă de referință.**:

$$c_e = \frac{C_h}{P_e} = \frac{C_h}{\eta_m P_i} = \frac{c_i}{\eta_m} = \frac{860}{\eta_e Q_i} = \frac{3600}{\eta_e Q_i} \quad \left[\frac{kg}{kWh}\right], \tag{1}$$

where: C_h is hourly consumption, in kg; P_e – effective power output, in kW; η_m – mechanical eficiency; η_e – engine effective eficiency; P_i – indicated power output, in kW; c_i – specific indicated consumption, in kW; Q_i – calorific inferior power of fuel, in kcal/kg or in kJ/kg.

Taking into consideration the physical relation between indicated efficiency and calorific inferior power of fuel there may be determined

the level of specific indicated consumption, as mathematical model **Eroare! Fără sursă de referință.**:

$$c_i = \frac{3600}{\eta_i \cdot Q_i} \quad \left[\frac{kg}{kWh}\right], \tag{2}$$

where: η_i – engine indicated eficiency, which has the value of 0.25÷0.45 for internal combustion engines.

Figure 4 shows the interactions between the main components and sequences of research and development activity staged up for the present paper.

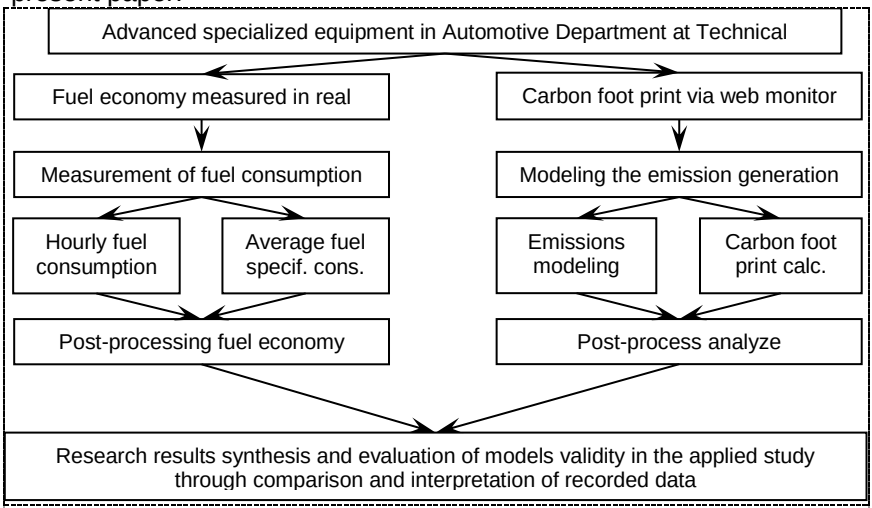


Fig. 4 Structure of research sequences following the methodological protocol

3. Experimental setups

The experimental car and measuring equipment were linked via testbed cables or mobile high-tech devices. The car was driven both on the road track and on the test bed in the Automobile laboratory from the Technical University were is a specialized roller-tester available in order to monitor the power-train behavior in some operating conditions.

In order to obtain accurate experimental results and to make some interesting observation in relation with the fuel consumption in the operational situation and on this basis to determine the carbon footprint there were installed specialized experimental apparatus. The power-train output and fuel economy are usually analyzed on specialized test beds available at high-tech automotive research laboratories as shown in figure 5 [9].

The present paper is limited to the sketching out and implementing of a new affordable engineering method in computer aided measuring and analyzing the consumption parameters and carbon foot print for city car usage, but it may be developed and implemented for other motor vehicles. The proposed personalized analyzing strategy applied adequately in the developed paper for tested city car, but needs to be reconsidered in order to extend it for various series of vehicles.

Fig. 5 Experimental test bed for on vehicle research concerning fuel economy, carbon footprint and power output [9]

Experimental testing data results

Table 1. City car technical date **Eroare! Fără sursă de referință.**.

Parameter	**Real Value**
Manufacturer	Daewoo
Model	Matiz
Engine displacement	796 cm^3
Fuel	gasoline
Fuel consumption standard	5.5 %
Engine power	50 HP (38 kW)
Engine torque	69 Nm
Carbon foot print for standard fuel consumption	0.01 metric tons: 100 km in a petrol vehicle doing 5.5 L/100 km

The authors are experienced in internal combustion engines and alternative energy sources for motor vehicles. The consideration of computer aided technologies aspects in a city car operating conditions represents an extension of research capabilities, technologies and work. There were also studied in the past work some particular measurements of fuel economy and emissions, but this paper is one of the main parts in a scientific project which analyses important aspects that define carbon footprint and consumption evaluating criteria by

using advanced engineering methods in relation with computer aided processing available in polytechnic approach.

4. Results and discussion

In table 2 are presented experimental testing data results concerning moment of entry, distance traveled, gasoline amount supplied to the fuel tank, fuel cost per liter, Fuel consumption, temperature, significant points in traveled area.

Experimental testing data results CO_2

Table 2

						Cons or
12.2016	21:50	51855.1	0	25.08	5.2	
01.2017	22:07	51909.2	54	4.26	4.79	7
01.2017	13:00	51956.2	101.1	2.70	5.56	5
02.2017	8:51	52456.6	601.5	30.71	4.82	6
02.2017	15:24	52652.8	196.2	10.27	4.82	5
03.2017	9:40	52770,7	117,4	9.25	4,63	7
17.03.19	18:56	52876.3	105.6	7.63	4.59	7
17.03.19	19:07	52879.3	108.6	9.13	4.59	8
17.03.26	22:15	53133	253.7	13.65	4.59	5
17.04.02	22:15	53227	93.9	6.46	4.65	6

After setting the equipment in order to acquire data from sensors and the engine, the operation was successfully put up and results started to record.

In figure 6 is shown the graphic presentation of the mileage values recorded in each case of measurement. It can be said that the highest values recorded in mileage evaluation are outlined either in the city area travels or at low temperatures. Determination in 09.01.2017 was put up after almost a month spent in city driving so the fuel average consumption had increased a little bit more than usual.

In the figure 7 there are experimental results shown in graphic related to carbon footprint generated by each travel in particular expressed in metric tons.

5. Conclusions

Rewriting the standards in fuel economy and lower carbon foot print is close related to the engine pollution research and management. Consumption parameters are not working as sole aspects in some

closed environment. They should be analyzed in correlation with the whole assembly which is the operating power-train in the real working context. The fuel supply and economy aspects, as well as the carbon foot print, have a significant influence in automotive operation and exploitation division. More or less they also have a determining financial influence when reliability, service and maintenance of the car are considered.

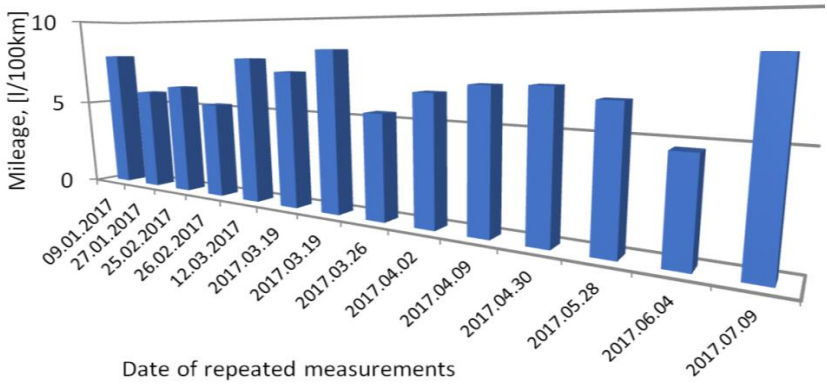


Fig. 6 Experimental test results concerning mileage or specific fuel consumption

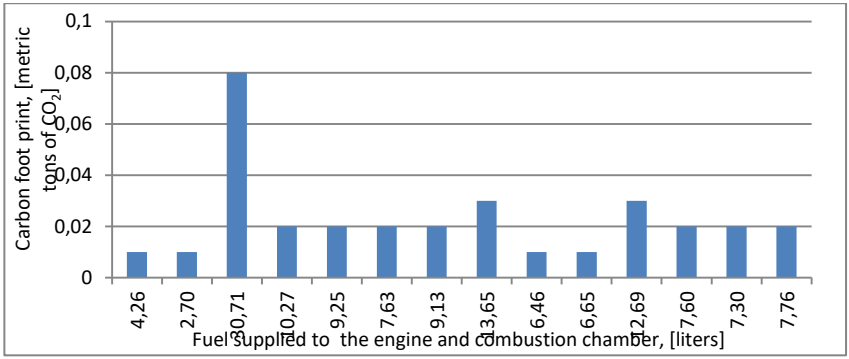


Fig. 7 Experimental test results concerning carbon foot print in metric tons of

Carbon foot print is directly related to fuel consumption in that manner which quantifies the mass supplied from tank to the engine. Thus the fuel takes place in the conversion process from liquid chemical component through thermal energy and finally in mechanical work and carbon waste products and residues.

The three measurements from mars with higher values of mileage recorded were also in the city area predominant travels.

Defining the set of expectations in fuel economy and carbon footprint is tight related to the consumption evaluation and research. Engine operating parameters and exhaust gases are not manifesting in isolation of the whole surrounding environment. The engine, the operating processes and the fuel efficiency should be studied in connection with the complex structure and multitude of influences which happens to be the entire motor vehicle moving on the city roads and impacting the surrounding ambient. The fuel efficiency and carbon footprint aspects have great influence on the vehicle's use and destination, but also they have a health and economic impact when it comes to mankind. Further research perspectives are consisting in developing auxiliary systems in order to ease up the consumption measurement on board and in any condition of road traffic for CFP definition. In the following studies there will be more data analyzed and a complex interpretation will be facilitated. Some new apparatus and data acquisition technics are preprogramed to be implemented in measurement applied chain.

Acknowledgement

The research has been financed by the program PNCDI III, with the project type "Transfer de cunoaştere la agentul economic «Bridge Grant»", project code PN-III-P2-2.1-BG-2016-0305, the contract number 78BG / 2016, and title: "CREŞTEREA COMPETITIVITĂŢII SC ARTECOM SRL PRIN OPTIMIZAREA UNUI ECHIPAMENT DE PRELUCRAT SOLUL ÎN ADÂNCIME".

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