Results of the Computer Simulation of the Fuel Consumption of Automobiles in Acceleration Process

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Abstract: *Numerical investigation of the fuel consumption in acceleration process at uniform motion is made by using elaborated specified theoretical models and a program for computer simulation of the automobile, its aggregates and running processes. The results of the computer simulation are compared with experimental data of the fuel consumption in the same working conditions. The experiments are implemented at two regimes with different intensity of acceleration. The analysis of the obtained results shows that theoretical and experimental data have comparatively good coincidence. That is a reason to accept, that the model and algorithm of the program may be used for investigation of the economy indicators of mobile machines with a benzine engine. It is established theoretically and experimentally that for accelerating regimes with normal intensity, the fuel consumption increases by 1.5 to 2 times compared with those at uniform motion.*

Key words: *fuel consumption, computer simulation, acceleration, automobiles*

INTRODUCTION

During the last several years the production of computer components such as single-chip microprocessors and microcontrollers, interface adapters, timers, converters and other LSI integrated circuits in Bulgaria has ceased for various reasons. But the perspective of restoring some of the high-tech parks as well as the development of the labour market requires that the engineers in Computer Systems and Technology, trained at the Technical Universities, be familiarized in detail with the construction and functioning of the different parts of a computer.

During the design and theoretical assessment of the exploitation properties of mobile machines and its aggregates it is necessary to implement computer simulation of their work and running processes in the investigation. This makes the implementation of the investigation much easier and faster and improves the comprehension of the obtained results. In this scientific area there are considerable developments, which give a reason to accept that positive results were achieved [2, 4, 5, 6, 7, 8, 9, 10, 11, 12, 14]. Despite the achieved positive results, it can be accepted, that considerable problems in the theoretical assessment of the fuel economy of the automobile with benzine internal combustion engines exist [4, 9, 11,14]. The process of the driving and accelerating of machines in urban areas is quite complicated. It is a considerable part of total time and fuel consumption is considerably greater compared to those at uniform motion [7, 13].

LAYOUT

Object of the research

The objective of this work is to give an estimation of the possibility of using the specified models and the suggested algorithm for computer simulation using comparative analysis of the computer simulation results and experimental research of the fuel consumption of the automobile in a process of starting and acceleration.

Nature of the research

The developed model for computer simulation of the fuel consumption of mobile machines with benzine engine is used for theoretical research [9]. A simulation at uniform motion of speeds of movement, which varied for each gear in the boundaries, realized in time of the experiments when accelerating, is made using this model. After that a discrete simulation of the alteration of the fuel consumption in acceleration process for the same conditions and speeds of movement is made.

For reading the influence of the inertia forces for each experiment and for each gear the mean acceleration a_i is determined and implemented in the model.

$$a_i = \frac{(V_{i2} - V_{i1})}{(T_{i2} - T_{i1})}, \text{ m/s}^2 \quad (1)$$

where *i* is the gear number, for which the acceleration is calculated;

V_{i1} и and V_{i2} - values of the speed of movement for i-th gear in acceleration process at the beginning and the end of the interval for each acceleration is calculated;

T_{i1} and T_{i2} - values of the time of movement for the i-th gear in accelerating process at the beginning and the end of the interval;

For reading the influence of the rotation masses of the different gears the coefficient δ_{ai} is used [14]. It is determined by the relation

$$\delta_{ai} = 1 + \left(\delta_{1a} . i_{ki}^2 + \delta_{2a}\right) . \left(\frac{G}{G_i}\right) \quad (2)$$

where i_{ki} is the transmission ratio of the gear box of the i-th gear, which accomplishes acceleration;

G_1 and G_2 - the weight of the automobile at the nominal load and at acceleration of i-th gear respectively;

δ_{1a} and δ_{2a} - coefficients in the empiric relation: $\delta_{1a} = 0.04 \div 0.06$ and $\delta_{2a} = 0.03 \div 0.05$.

The reason for this approach to determination of the acceleration for each gear is the analysis of the graphs of the accelerations of some experiments [11, 13] and analysis of the graphs of the alteration of the rotation speed and of the speed of movement from present research. It is seen, that the graphs of the velocity are straight lines in whole scope of the velocity alteration. With some approximation an exception is only the process of acceleration at first and second transmission. Such an averaging is not a problem as our objective is to clarity if the model can be used for investigation of the acceleration process and not to register the transient processes at the beginning and end of acceleration. In addition the use of the averaged data for acceleration for each transmission gives a possibility to accelerate and lighten the research with satisfactory accuracy of the obtained results. These differences will lead to some differences between the theoretical and experimental data, but this will help us verity the fundamental initial preconditions for the improved models, the selected algorithm for connection and description of the process as a whole.

The literature review [2, 4, 5, 14] shows that one of the fundamental problems in theoretical assessment of the fuel economy is the accuracy of determination of the specific fuel consumption. Fig.1 shows the flowchart of the algorithm for determination of the specific fuel consumption with the model described in [9]. The proposed algorithm is interesting for the fact that the specific fuel consumption is calculated by the empiric relation is compared with the experimental data. Universal economy characteristics, load characteristics and experimental economy characteristics of automobiles with similar characteristics can be used as experimental data. This algorithm is also interesting with the fact that, it requires full "transparency" of the intermediate results so accuracy analysis of the determined specific consumption can be accomplished. This determines the type of the program, which is to be used for computer investigation.

A Reno-Clio 1.4i car was used for experimental investigation of determination of the fuel consumption in acceleration process. The investigation system includes a sensor for fuel consumption and the fuel feed system "GEPAR" [3], which is installed on the automobile. To decrease the influence of the inertia forces on the character of the process leading to consumption alteration at unestablished fuel movement and dephasing the characteristics a small inertia turbine sensor is used. The length of the pipelines between the sensor and the engine should be as small as possible. In addition experiments in small range of alteration of the intensity of acceleration, which encompasses the real working regimes, were made.

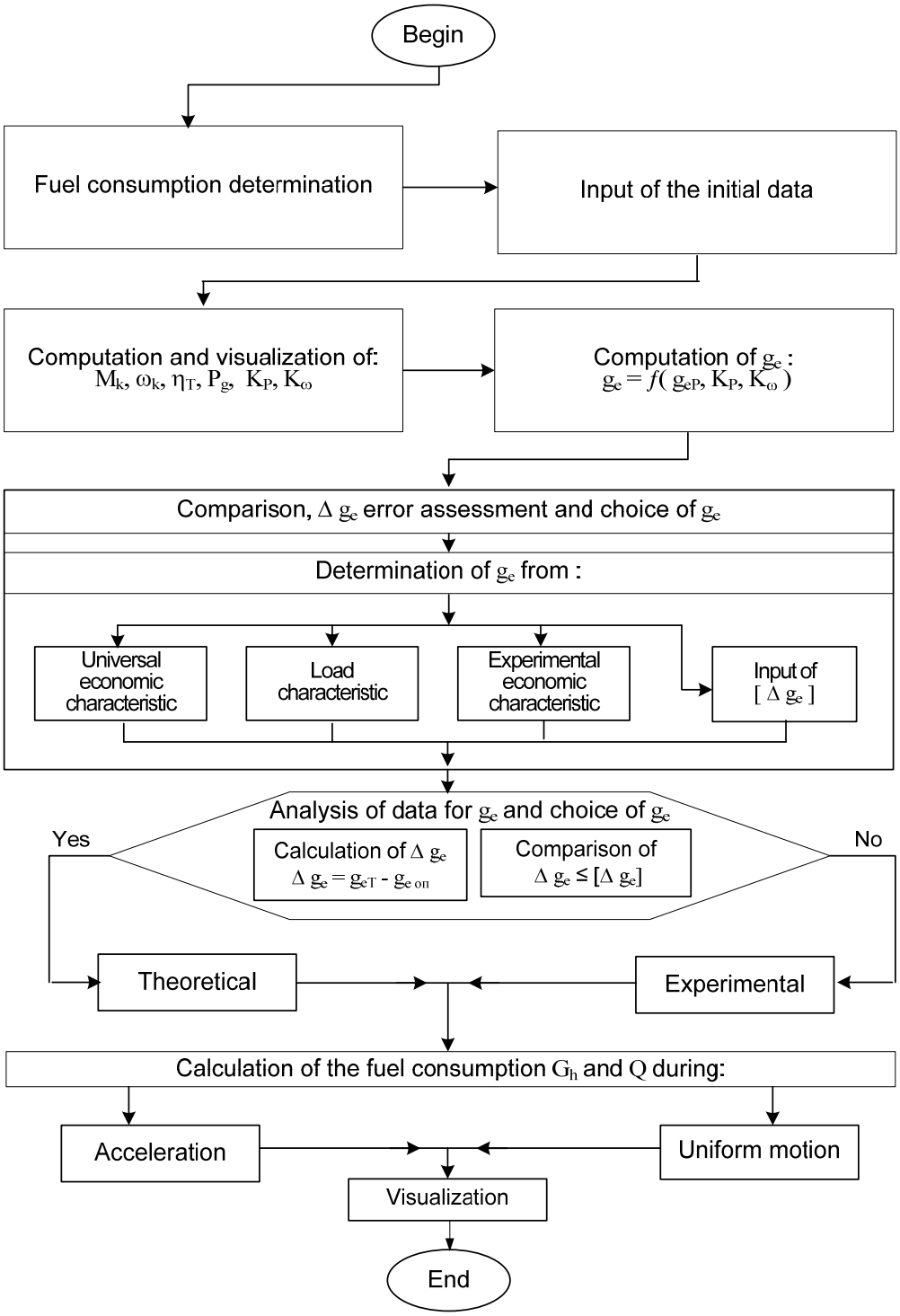

Fig.1. Flowchart of an algorithm for determination of the specific fuel consumption in a model for computer simulation of the fuel consumption of mobile machines with benzine engines

At the time of experiments the rotation speed of the engine, the velocity of the automobile and the engine fuel consumption are recorded. For recording of these indicators, a multiplex functional system NI USB-6008 [1] is used. Recordings of the indicators for two experiments, which were different by intensity of acceleration, are shown in fig.2 and fig.3. In first case (fig.2) the acceleration ranges from 1-st to 5-th gear from 0 to 1.2 m/s^2 for 55 seconds. In second case (fig.3) – the acceleration is for 90 seconds.

Characteristic regimes of the aggregates' work are shown clearly on the figures. The smoothness of the curves is achieved by using a creeping average method over a given number of the points (from 1 to 200).

Analysis of the obtained results

The comparison and analysis of the curves show that there is respectively exact correspondence of the moments of the gearshift and the alterations of the three curves - for rotation speed of the engine, velocity of the automobile and fuel consumption per hour.

The signals about the rotation speed and the velocity of the automobile are obtained by the standard sensors of automobile aggregates. In this way the experiments are simplified and accelerated. Such experiments with other automobiles were implemented for a relatively short time.

Theoretical investigations were implemented applying this scheme and the obtained results are shown in fig.4 and fig.5. The data for the fuel consumption is calculated for $dv/dt \neq 0$ (with solid lines) and for $dv/dt = 0$ (dashed lines). These data are mapped over the two recordings of the fuel consumption when accelerating - respectively with 55 seconds (fig.4) and 90 seconds (fig.5) of duration.

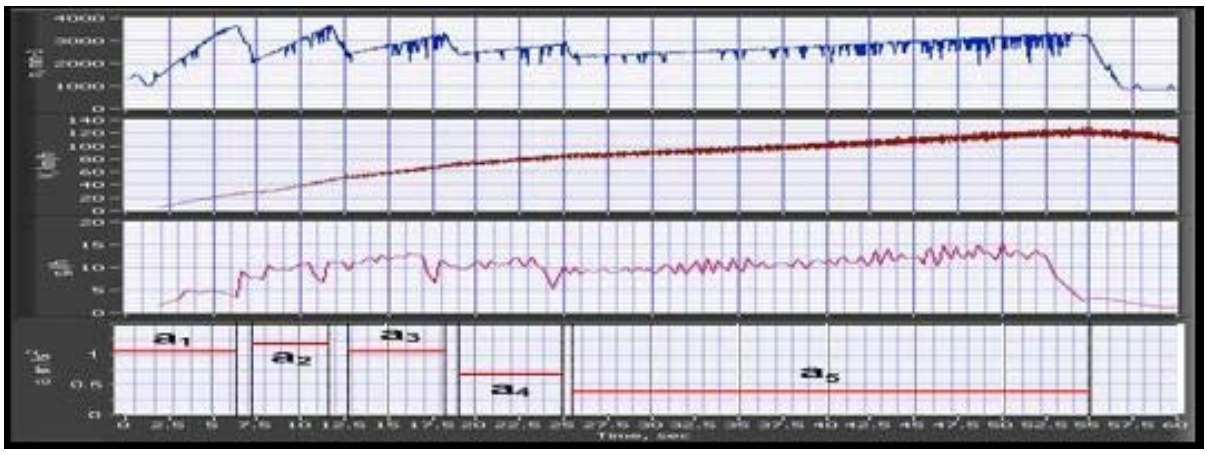

Fig.2. Recording of the acceleration process with 55 seconds duration

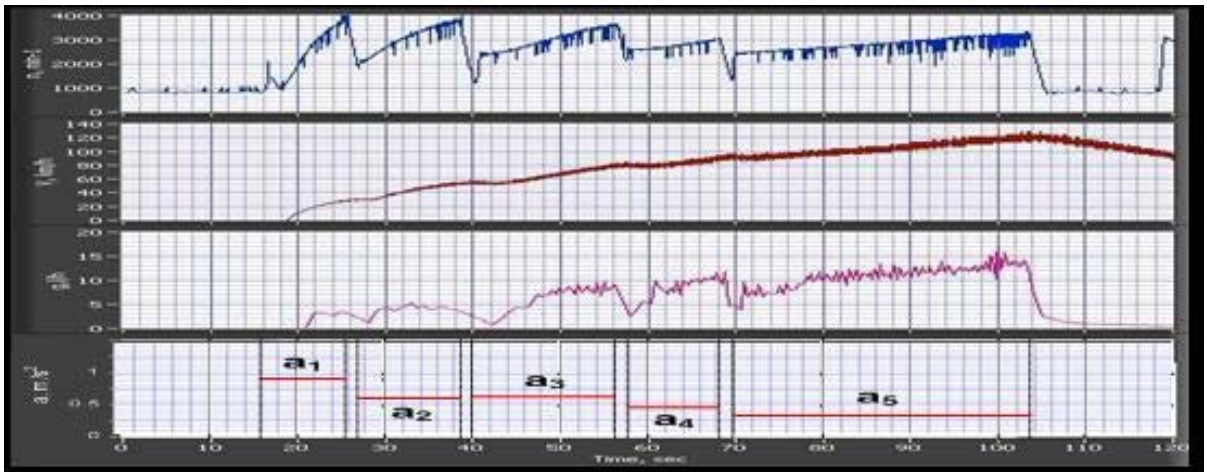

Fig.3. Recording of the acceleration process with 90 seconds duration

The figures show that the experiment in fig.4 is implemented with bigger intensity especially for the 2-nd, 3-th and 4-th gear, where the mean fuel consumption is almost two times greater than those in fig.5 for the same gears.

The comparison of the theoretical and experimental data of the fuel consumption for $dv/dt \neq 0$ shows, that their numerical values have a comparatively good coincidence. Increasing character of the alteration of the fuel consumption with increase of the speed of movement is confirmed. The theoretical data are obtained for mean values of the acceleration for each transmission. The influence of the unestablished working regimes of the engine on its characteristics is not taken into account in the theoretical data. This can lead to some differences. In this case the corrections for specific fuel consumption, calculating by classic empiric relation, is not implemented either. This influence is essential at very little loads. When accelerating the inertia forces are commensurable with other resistance forces and the load becomes significantly greater. Using tabular data for the torque and the power of the engine it was noticed that for the examined cases of accelerating there is no need of correction of the specific fuel consumption. The obtained results are satisfactory and one can accept that these results reflect sufficiently correctly the experimental data both in magnitude and character of alteration.

In the same figures the theoretical data of the fuel consumption, calculated for $dv/dt = 0$, are shown with dashed lines. The influence of the acceleration of the automobile on the fuel consumption is considerable.

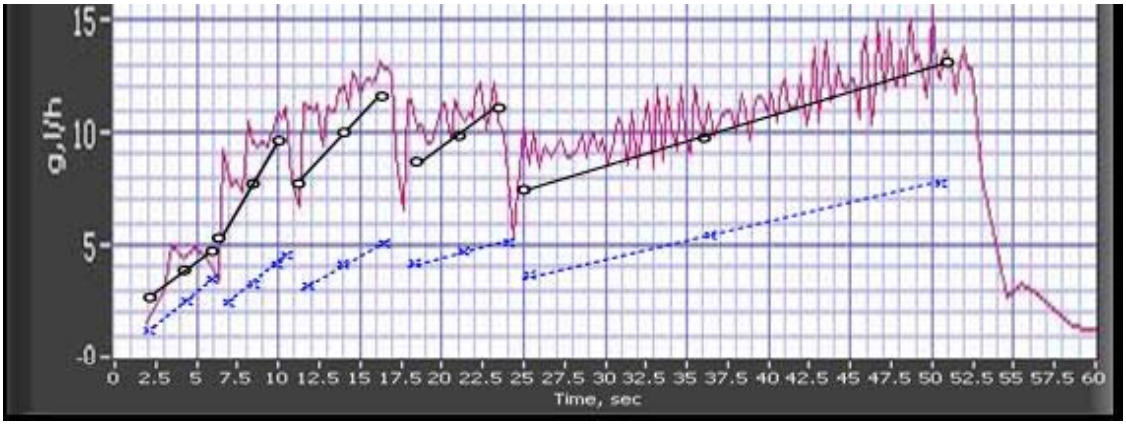

Fig.4. Experimental and theoretical data for the fuel consumption of the automobile Reno Clio 1.4i in acceleration regime with 55 seconds of duration: ~~~ experimental, o—o—o theoretical for $dv/dt \neq 0$, ·-·-· theoretical for $dv/dt = 0$

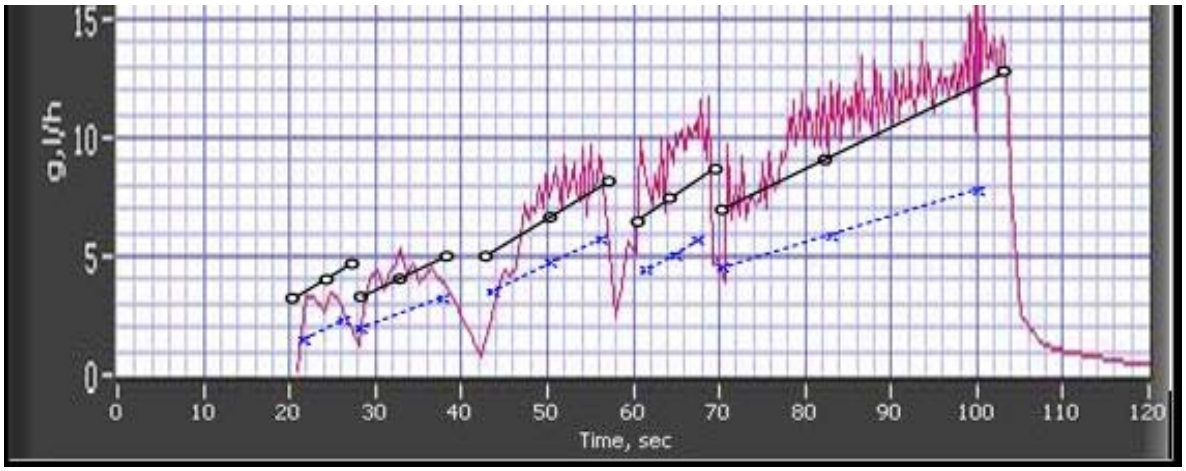

Fig.5. Experimental and theoretical data for the fuel consumption of the automobile Reno Clio 1.4i on acceleration regime with 90 seconds of duration: ~~~ experimental, o—o—o theoretical for $dv/dt \neq 0$, ·-·-· theoretical for $dv/dt = 0$

Depending on the magnitude of the acceleration and number of the switched gear, the fuel consumption at $dv/dt \neq 0$ is on average about two times greater than those at $dv/dt = 0,$ for acceleration with duration of 55 seconds. For the acceleration with duration of 90 seconds this difference is about 1.5 times. The increase of the average fuel consumption during the motion of the same automobile in urban areas compared with those at uniform motion is in the interval 1.5÷1.6 times [13].

The obtained results show that the suggested model for computer simulation of the fuel consumption of the automobile with benzine engine gives comparatively good results for assessment of its economy properties in acceleration process. This gives a reason to accept, that the theoretical models and the algorithm of the calculating approach can be used for theoretical assessment of the economy properties of the automobiles with benzine engines.

At this stage the used improved models and accepted form of computer simulation are maximally "transparent" for all steps of the different stages of the fuel consumption calculating process. This "transparency" of the intermediate results gives a possibility to assess and analyse the alteration of all the indicators of the machine and its aggregates and if it is necessary to assess the stage of influence of these indicators.

These results depend on experience and skill of the person, doing this investigation. Nevertheless, confirmation results of the fuel consumption at unestablished working regimes were obtained, which is a reason to accept that a satisfactory accuracy in the theoretical assessment of fuel economy of the automobile with benzine engines is achieved.

This first research and its results confirm that acceptable for the practice instruments for theoretical assessment of the fuel economy in acceleration process of the automobile with benzine engine have been developed. These results give a reason to recommend that the work for computer simulation must continue in order improve this part of the model, which will help to decrease the influence of the subject factor and to accelerate and lighten the investigation.

CONCLUSIONS

The following conclusions can be drawn:

1. Using the improved model for computer simulation of the work of the automobile with benzine engine and its aggregates, an investigation of the fuel consumption when accelerating is made. Confirmation original results were achieved, giving a reason to accept that the model for computer simulation can be used for assessment of the economy properties of mobile machines.

2. The developed investigation system "GEPAR" and the used turbine sensor for fuel consumption can be recommended for assessment of the fuel economy in acceleration process of mobile machines with internal combustion engines.

3. The theoretically received numerical values of the fuel consumption in acceleration process and the character of its alteration depending on the velocity for each gear are confirmed experimentally.

4. The fuel consumption on the 1-st gear is very small compared with those on the other gears. This consumption doesn't exercise essential influence on fuel economy of the investigated machine.

5. It is proved theoretically and experimentally that the fuel consumption in acceleration regimes with real (normal) intensity, increase from 1.5 to 2 times compared with those at uniform motion.

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