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Experimental Study of the Car Acceleration, Equipped with On-Board Computer

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I. Introduction

Acceleration is one form of determining a vehicle's performances. Theoretical study of the acceleration process is aiming to determine the calculus methodology for time and covered space by the vehicle until reaching the speed of 100 km/h; with these parameters, acceleration performances of various similar cars may be compared. [1; 3] Experimental study of acceleration allows the setting of performances in certain movement and driving conditions; thus the dynamic performances and real efficiency performances may be set. [2]

In the paper herein a comparative study of acceleration is performed. The tests were carried out with a Logan Laureate vehicle that is equipped with an on-board computer. To this purpose 50 acceleration tests were selected and an additional 50 normal tests which are further on called non-acceleration tests. These later test describe a normal regular vehicle movement; speed variation character for the two cases is seen in figure 1, where also the maximum values overhaul are being presented.

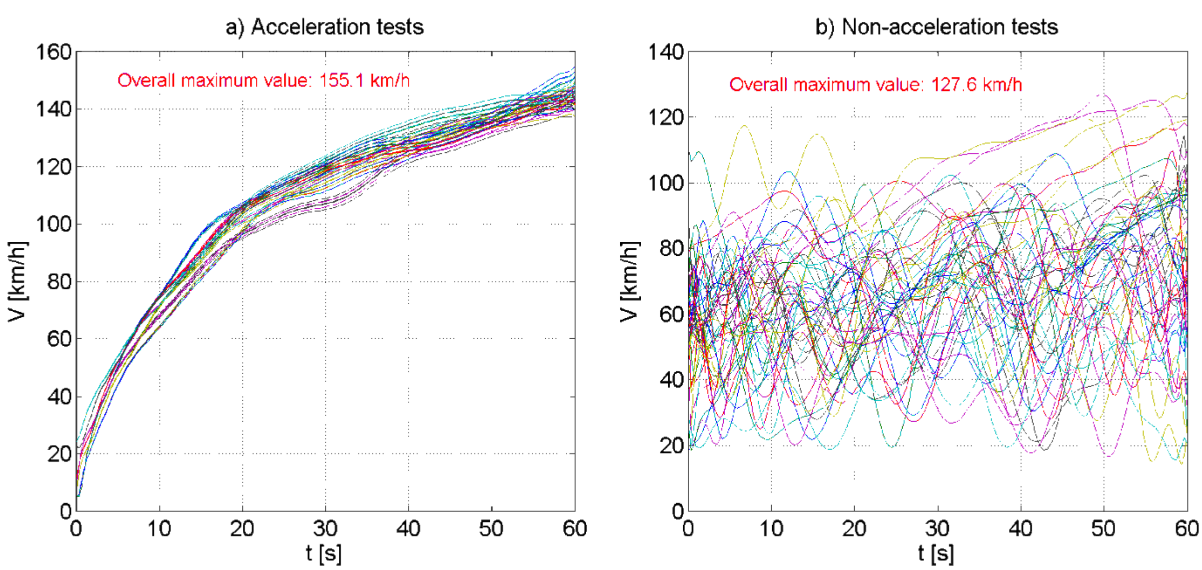

Figure 1 : Vehicle speed

We have to underline that in classical, theoretical study, the vehicle's acceleration is being studied having the engine performing on its exterior characteristic, in full throttle in order to estimate maximum performances [1; 3]. In practical situations, the engine operates in partial loads [2]. Indeed, as we can see from figure 2a, the engine operates in 44% of situations at level or high loads and within 50–95% (different from full loads) approximately equal as the non-acceleration tests from figure 2b. As we can see from figure 2, engine load is appreciated by the throttle's angular position ξ, as a percentage compared to its maximum opening position. In the literature engine load is also appreciated through the intake air pressure p_a.

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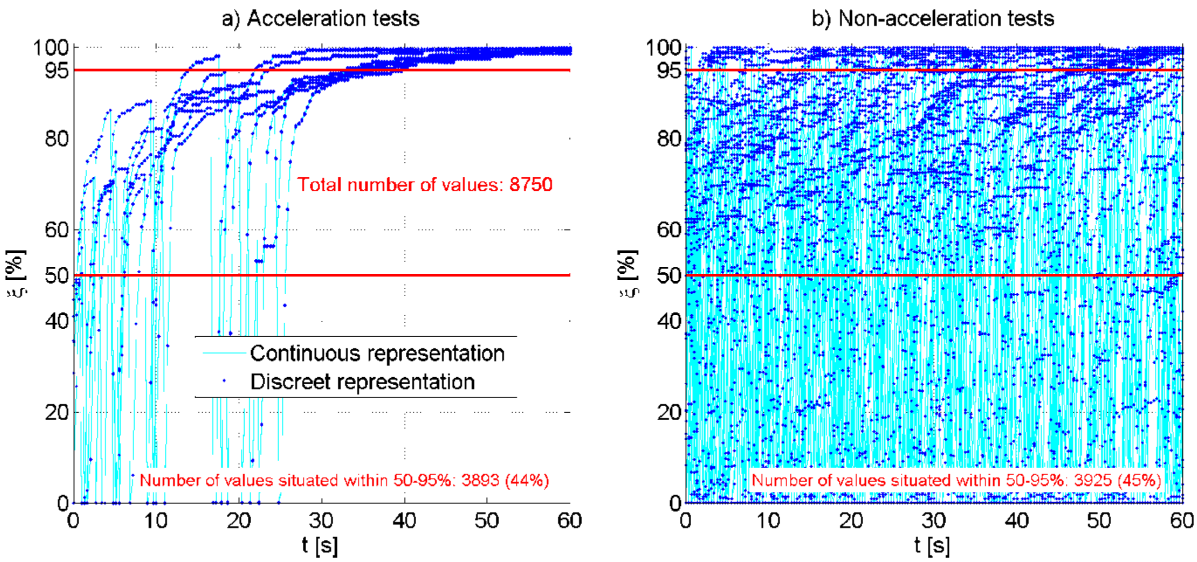

Figure 2 : Throttle's position (engine load)

Discrete representation of data allow for data set prominence where most are concentrated as we can see from figure 3 for engine speed *n*. As we can see form figure 3a, in the case of acceleration 90% of the values are situated within 3000-4800 rev/min; similarly from figure 3b we can see that the non-acceleration tests 67% of the values are within 2000–3000 range, meaning below the value range as the case of acceleration tests.

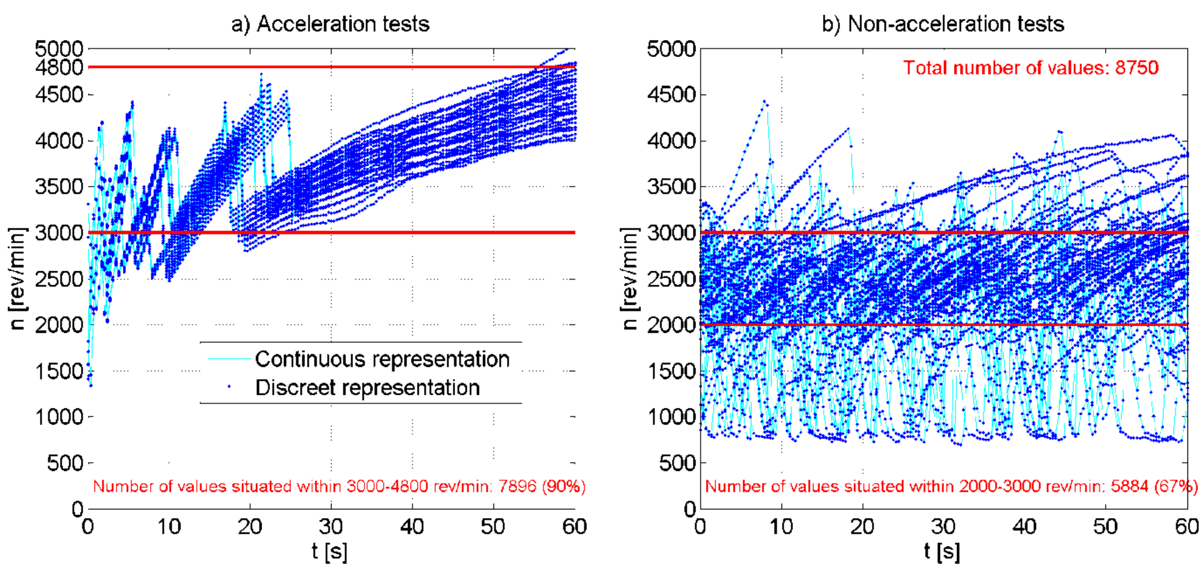

Figure 3 : Engine speed

Highlighting ranges where most experimental data are concentrated may also be observed in the parameters' bivariable dependence graph. To this purpose an example is being presented in figure 4, where the dependence from the engine speed and its torque is presented; the graphs also gives the external characteristic of the engine (B representing maximum torque) with its power P_e and torque M_e. As we can see from figure 4a, a great majority of torque values in the case of acceleration are found in the right side of maximum torque (in the area of high power output, area A). In exchange in the case of non-acceleration (regular movement), most values for the engine torque are in the left side of maximum torque (at lower power outputs).

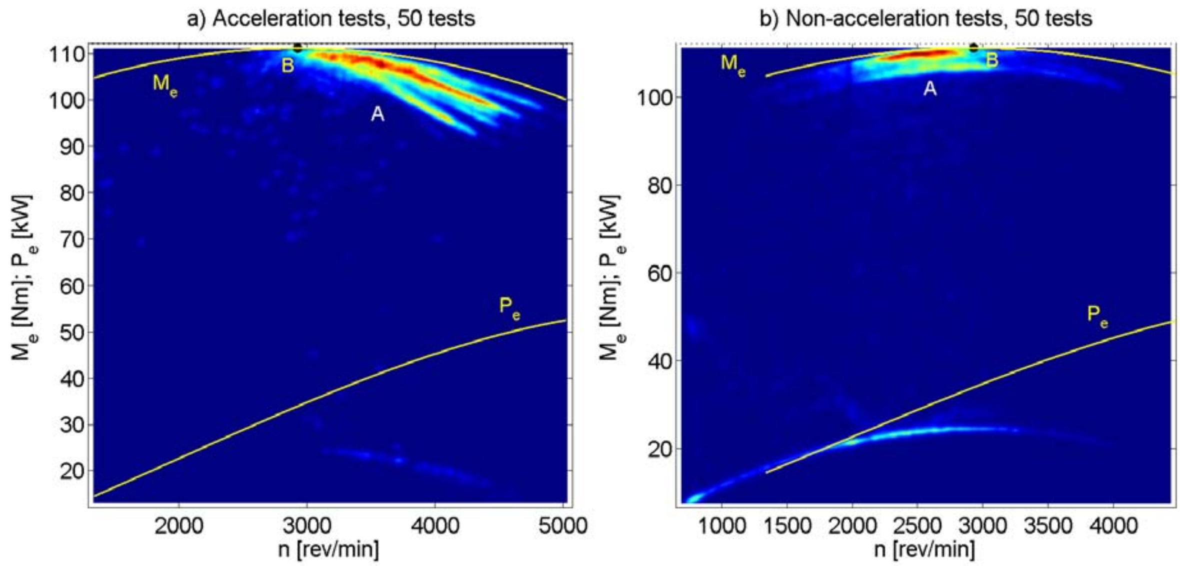

Figure 4 : Engine speed and torque dependence

The graphs from figure 1a and 3a also highlight the fact that in the case of an electronically controlled vehicle it is difficult to notice the moments of time where gears are shifted if the vehicle's speed is targeted (figure 1a), but we need to analyze the engine's speed (figure 3a) The main cause is of course the rapidity with which the gears are shifted, without double clutching, with almost instantaneous shifting from one speed to another; the mentioned aspect is also revealed in figure 5 where the shifting duration are shown for one acceleration test. The graph from figure 5 highlights the moments of time needed for gear shifting, marked on the graph I–V, as well as the acceleration time t_d=36,7 s on which a speed of 120 km/h (point P) is reached.

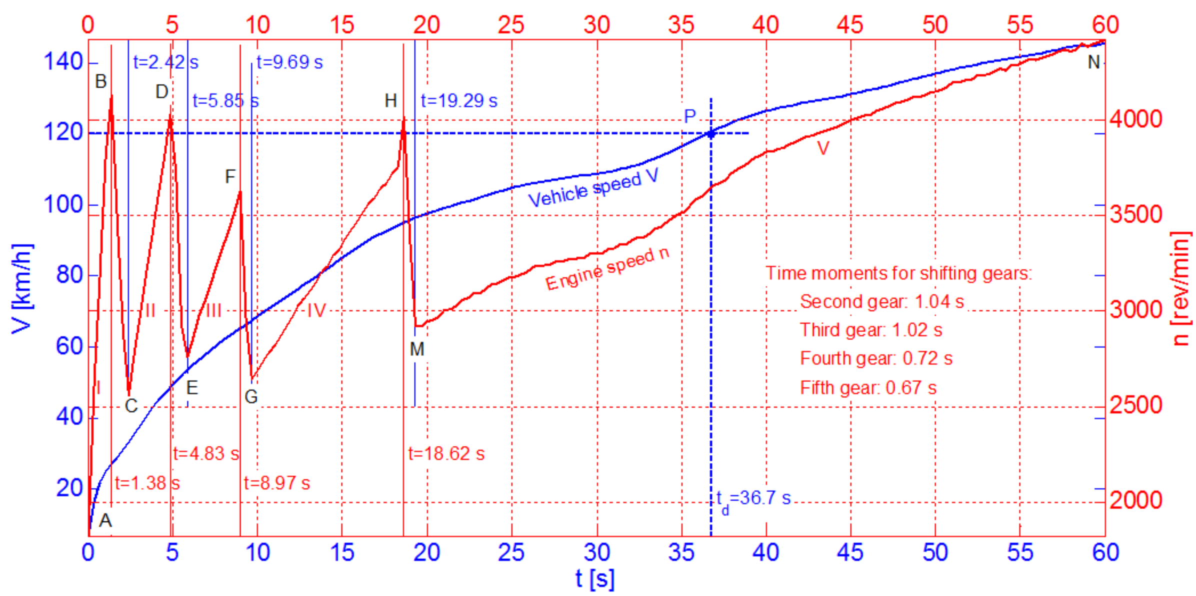

Figure 5 : Time moments needed for shifting gears in the case of acceleration test.

The two targeted forms of movement also have other particularities as we can see from figure 6 where engine hourly fuel consumption is presented C_h. As we can see from figure 6a, in the case of acceleration we clearly can distinguish fuel consumptions through gears I–V, which is not the case for non-acceleration tests (figure 6b). The graphs also highlight the fact that as the vehicle speed *V* increases so does the fuel consumption. In order to better accentuate the nature of the process and their evolution tendencies a discreet representation of data was used.

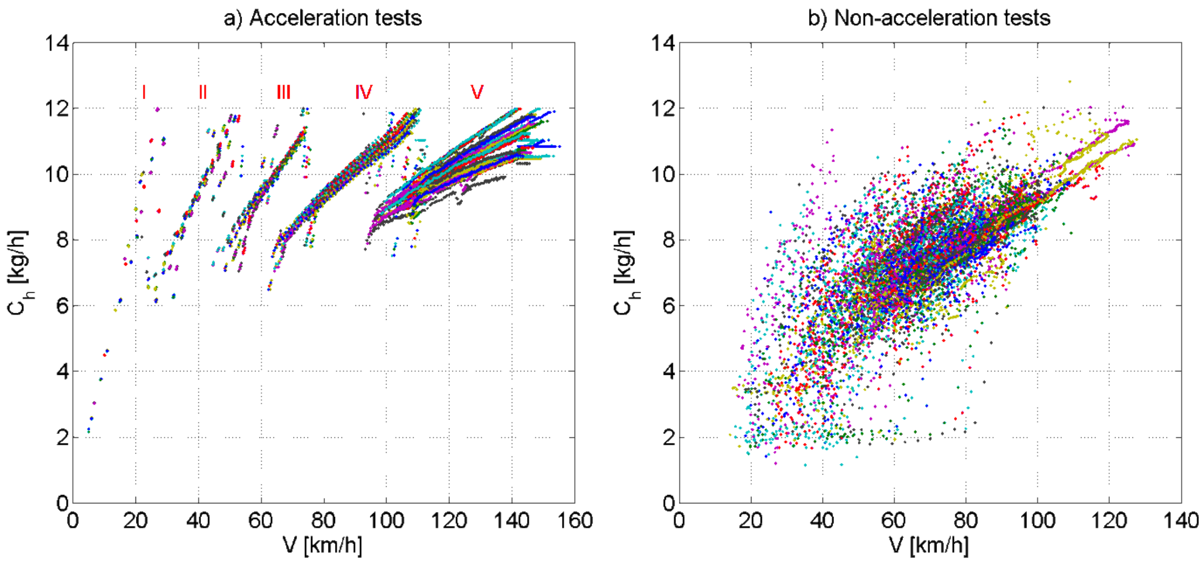

Figure 6 : Hourly fuel consumption and vehicle speed dependence

From figure 7 we can deduct a functional dependence between the acceleration pedal position *p* and engine speed *n*; area A from the graph allows for setting the delay between the moment the acceleration pedal is engaged and the moment the engine speed starts to vary. Besides, this graph allows for setting of times on which the driver acted upon the acceleration pedal in order to change gears.

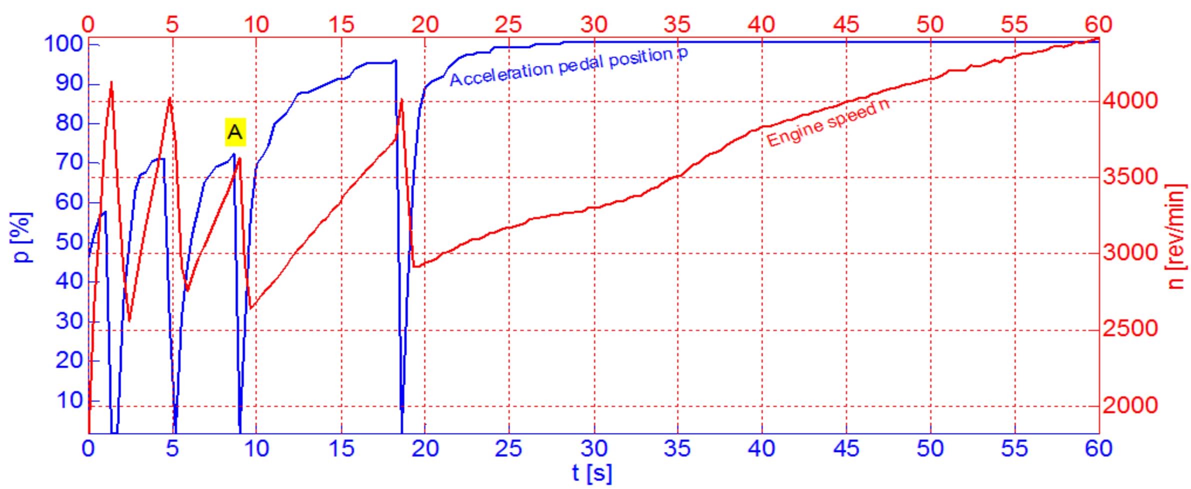

Figure 7 : Acceleration pedal position and engine speed, an acceleration test

In order to analyze the energetic efficiency of the acceleration, figure 8 presents engine torque M_e depending on its speed *n* for various values of actual specific fuel consumption c_e. In fact this represents the well known spatial static characteristic of engine c_e=f(n, M_e), but transposed in 2D having izo-consumption curves where c_e=const. (a so called complex characteristic). Based on this characteristic we get the classical economic pole, A dot on the graphic where c_e=240,5 g/(kWh). Likewise, the graph also presents another spatial static engine characteristic that of η_e=f(n, M_e), also transposed into 2D having curves of constant engine efficiency η_e=const.; based on this the well known energetic pole is achieved, dot C where η_e=30.23%. The graph also presents the engine's external characteristic M_e=f(n), on full load (for ξ=100%), dot B being specific for maximum engine torque; we can see the energetic pole C is situated on the external characteristic. As we can see from figure 8, the experimental values specific for acceleration are closer to the economic pole A and to the energetic pole C than the case of the non-acceleration tests data; therefore, the engine is more efficient in case of acceleration.

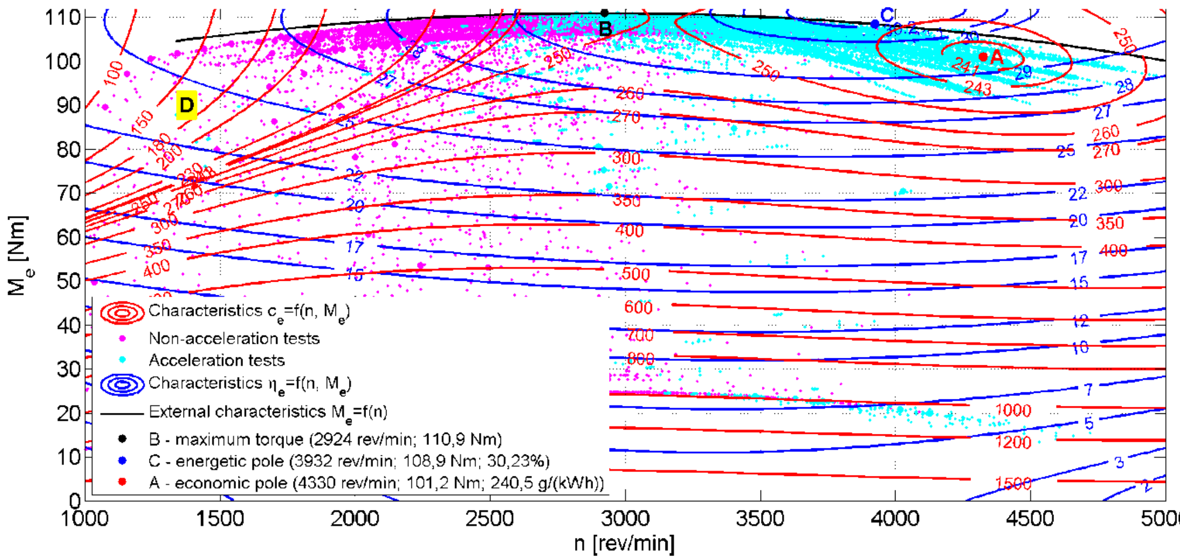

Figure 8 : Engine complex static characteristics

We also need to mention that the experimental values specific for acceleration are situated closer to the economical pole A, fuel consumptions being greater than those recorded in the case of non-acceleration tests, as we can see in figure 9 where the average values of hourly fuel consumption C_h and the fuel consumption registered for 100 covered kilometers are presented C_{100}. This has two causes: first of all in the case of acceleration tests, the recorded engine power is higher (see fig.4); secondly from figure 8 we can see that the experimental data specific for non-acceleration tests are closer to D area, where specific consumptions are lower even than the classical A economical pole. In other words, in this second case the consumption values are shrunk without having another economical pole (a minimum value) other that A dot.

The graphs from figure 9, which indicates a higher fuel consumption in the case of the acceleration tests (the graphs from the left side), show an even more diverse fuel consumption for the non-acceleration tests (the graphs from the right side).

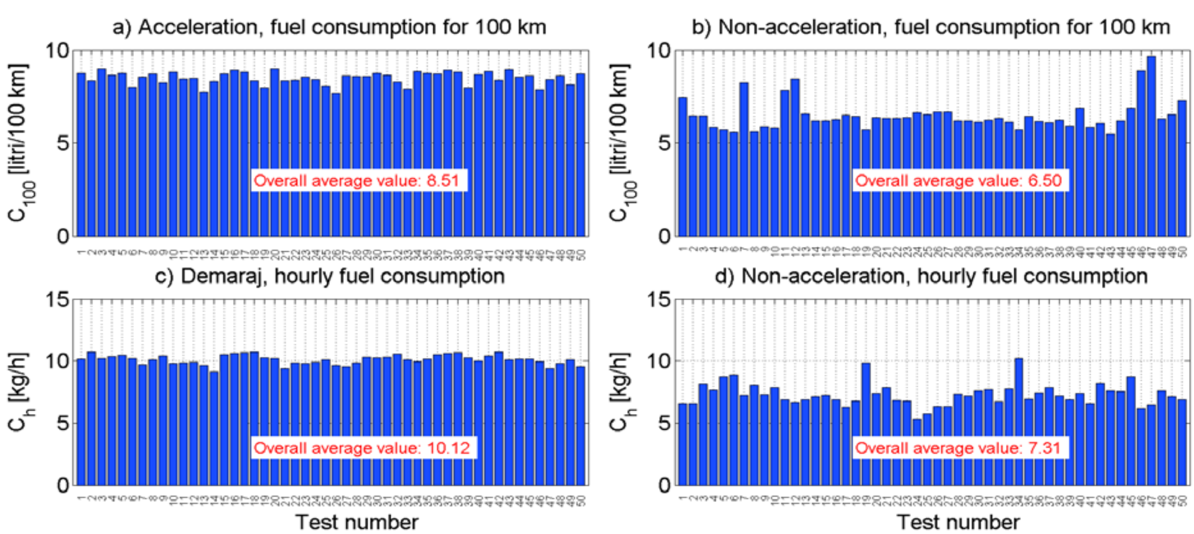

Figure 9 : Average values for fuel consumption registered during tests

Higher fuel consumption values in the case of acceleration tests ensures higher vehicle speeds as we can see from figure 10, where average values and maximum values are presented for each test and overall. Comparing the upper graphs with the lower graphs we can see that in the case of the acceleration tests we achieved an average value for the vehicle speed which is 51.1% higher than the case of the non-acceleration test-runs and a maximum value which is 21.6% higher.

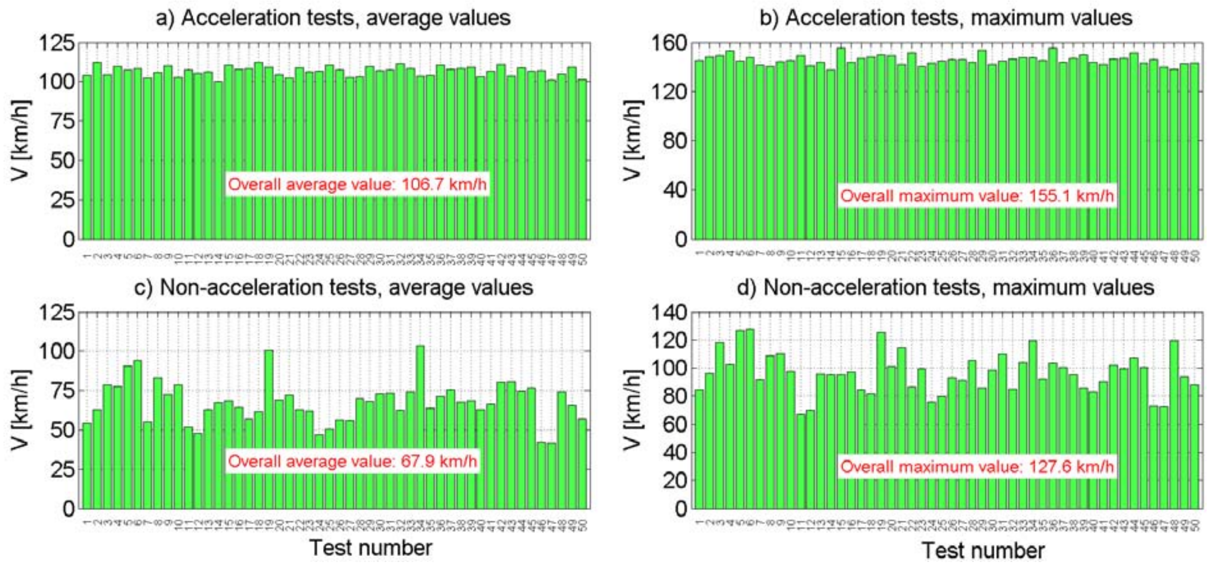

Figure 10 : Vehicle speed average and maximum values for each test

From figure 11a we can see that I the case of acceleration tests the aerodynamic resistances are most important (engulfing 51.75% of all resistance forces), and figure 11b shows that in the case of a normal vehicle movement (non-acceleration tests), the rolling resistances are most important (36.88% of the total), but not as accentuated, the three components being closer together in their importance (approximately 1 third each).

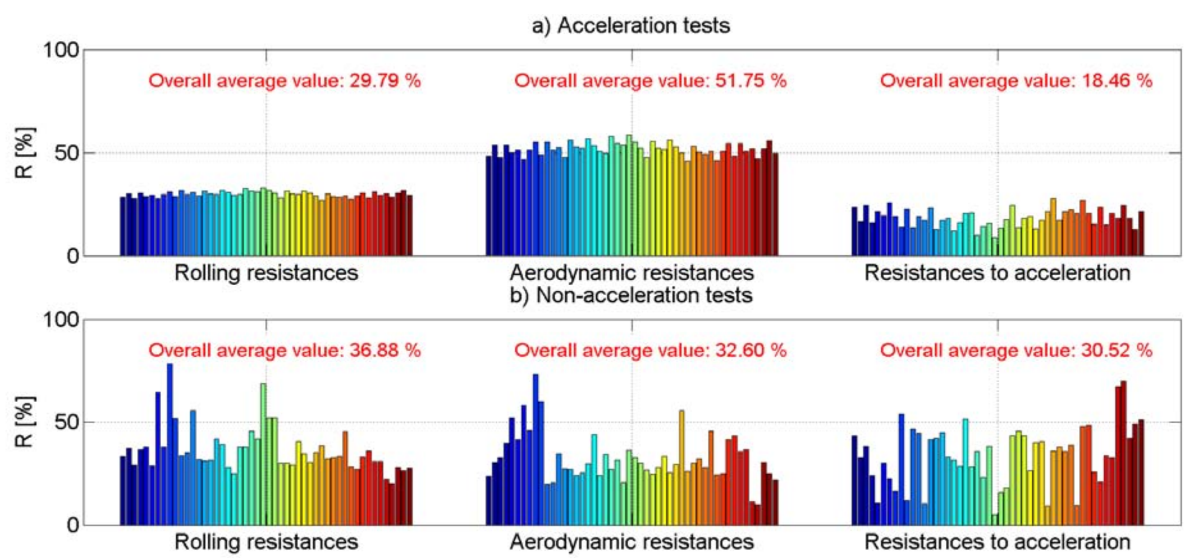

Figure 11 : Percentage average values for progression resistance in the case of each test

Similarly we can perform acceleration study following other issues like parameter functional dependence establishment or the influence of certain factors onto the acceleration it's self.

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