COMPLETELY STABILIZED OPERATING MODES OF THE CAR PROPULSION SYSTEMS

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Abstract: *By customizing a mathematical model, previously developed by the authors, has done a simulation to define a completely stabilized operating modes of propulsion systems and their dynamic, economic and pollution parameters. This provides, even the design phase, definition of additional constructive and functional criteria against the current, to ensure stable and economic operation, in an area as extensive.*
Key words: *automotive powertrain, stable and economic operation.*

1. PRELIMINARY CONSIDERATIONS

By customizing a mathematical model, previously developed by the authors, has done a complex simulation of the propulsion system behavior in various constructive-functional situations, called *MATCEL-PROP*.

The basic parameters required for simulation was determined for a typical car; significant values are highlighted in Fig. 1.

Fig. 1 - Basic parameters related coefficients picture

Fig. 2 highlights *characteristic* of the propulsion system model; it is the actual power and timing variations in the unmodified engine propulsion system obtained by simulation, in the form of an executable.

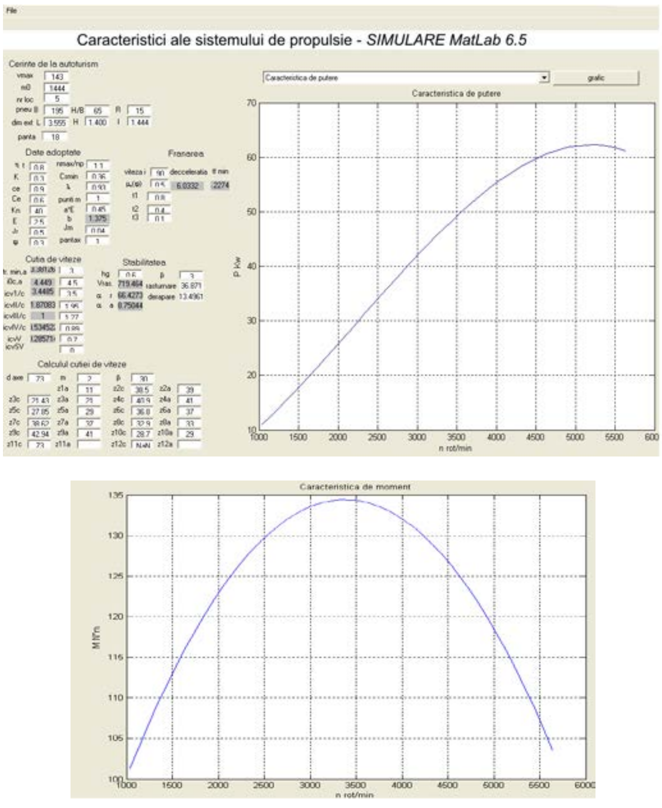

Fig. 2 - Characteristic of the propulsion system

2. CONCEPT DEVELOPMENT AND SIMULATION

From these raw elements, further presented the most significant results of simulation *MATCEL-PROP*, looks especially the problem of propulsion system stability. Were considered, in particular, common situation of equipment for the real propulsion system model of car chosen, designed to lead to some conclusions with applicative features, useful in terms of its mechanical and functional optimization [1]. Results are summarized using the variation diagrams of engine torque, M_m, resistant torque reduced to motor shaft, M_{rr} and specific fuel consumption, c_e, depending on the angular velocity ω of motor shaft, presented in figures below [2]. For each case, algorithm simulation allows determining the position of the system operating point corresponding to maximum speed of the car. On the other hand, in order to emphasize the stability of propulsion, these diagrams contain the tangent lines to variation curves of torques in the operating point, *Fct.tan.*M_m, respectively, *Fct.tan.*M_{rr}.

In this respect, a *first case* simulated and analyzed (*ES1*) with *MATCEL-PROP* considers basic equipment of the propulsion system, which includes an engine having the effective power value 64[kW], assimilated in the model with an engine power (P_e=P_m), and a 15" wheel diameter. By assigning the value 4 for main gear ratio, i_0, variations in Fig. 3 shows a *stable operating point* at maximum speed of 149[km/h], and further characterized by an acceptable specific effective fuel consumption, respectively 173[g/kWh].

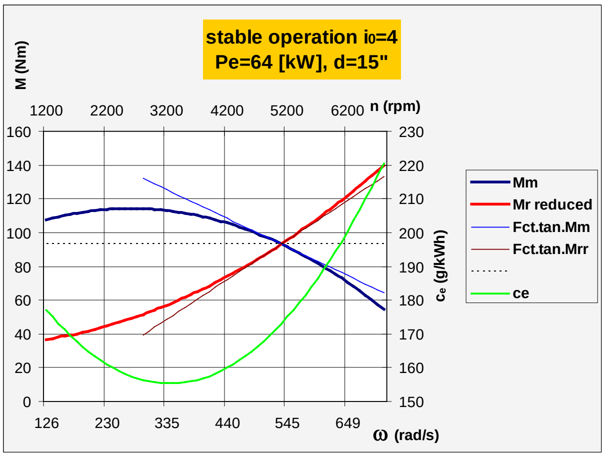

Fig. 3 - Conditions for stable operation of the propulsion system - highlighted by the simulation phase ES1

Still increasing main gear ratio by only *0.5*, thus leading to the value i_0*=4.5,* the propulsion system behavior becomes *unstable,* speed decreases slightly the value of 148[km/h], there the premises so that it can not be kept constant, while the value of specific effective fuel consumption rises to 173[g/kWh] to 186.4[g/kWh], situation highlighted by the diagrams in Fig. 4.

On the other hand, from baseline, summarized in Fig. 3, reducing by 0.5 the ratio main gear i_0, it reaches i_0*=3.5,* achieve a *very stable* operating point, leading to maximum speed 146.9[km/h], very stable value, made with a specific effective fuel consumption of 162[g/ kWh], which confirms the downward trend of this important parameter, with increasing stability of the system drive. This condition simulated propulsion system is presented through results obtained in Fig. 5.

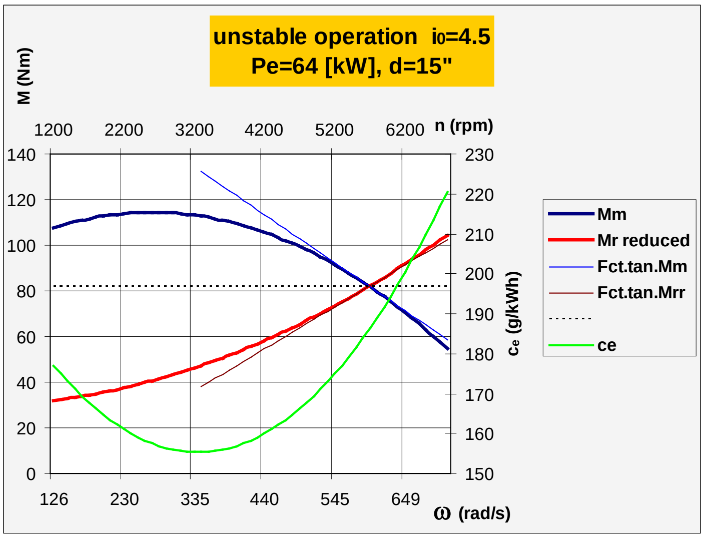

Fig. 4 - Conditions for unstable operation of the propulsion system - highlighted by the simulation phase ES1

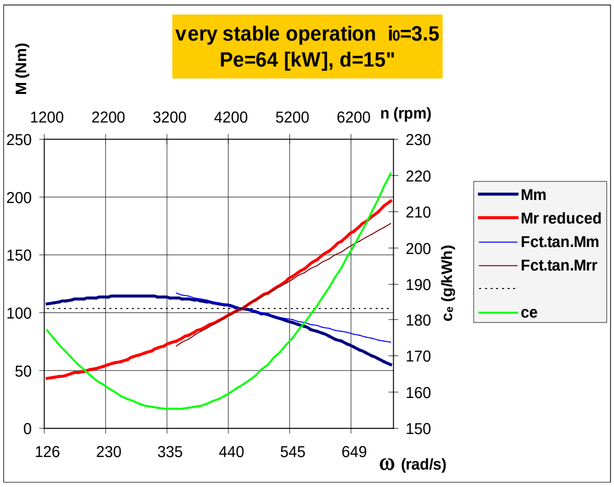

Fig. 5 Conditions for very stable operation of the propulsion system - highlighted by the simulation phase ES1

Continuing the iteration of the *MATCEL-PROP*, the main gear ratio value $i_0=3$ is reached *extremely stable* operation of the propulsion system, characterized by a maximum speed value of 136.3 [km/h], in turn extremely constant value, in fact the smallest of speed values highlighted in this stage of the simulation and effective specific fuel consumption decreased to 155.6[g/kWh], situation presented in Fig. 6.

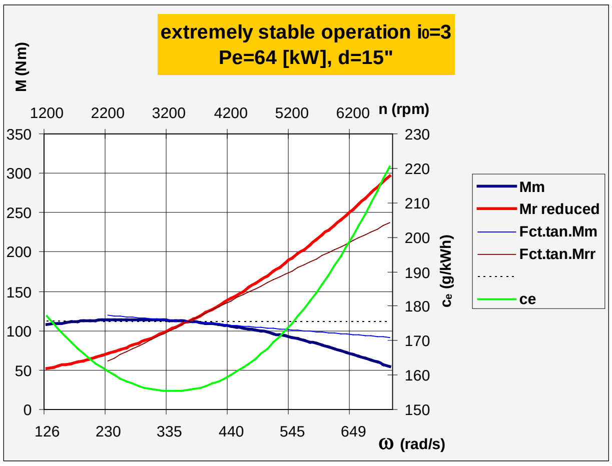

Fig. 6 - Conditions for extremely stable operation of the propulsion system - highlighted by the simulation phase ES1

Simulate a situation leading to opposite results as shown in Fig. 7, the $i_0=5$ value ratio of the main gear reach a *very unstable* operation, the operating point is characterized in this case by the speed increased to 144.9[km/h], but can not be maintained, obtained at engine speed of 6200[rpm] and effective specific fuel consumption increased to a value of 200.4[g/kWh].

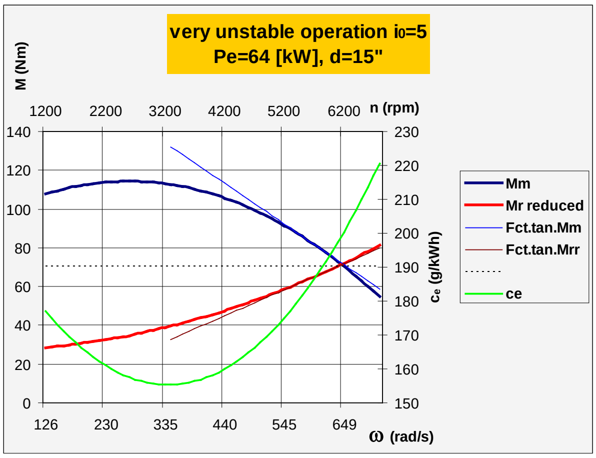

Fig. 7 - Conditions for very unstable operation of the propulsion system - highlighted by the simulation phase ES1

Simulation performed with *MATCEL-PROP* include a *second phase* of study (*ES2*), which takes into account the above stable conditions, characterized by the motorization of 64 [kW] and the main gear ratio value $i_0=4$, but with two-stage change diameter wheels. Thus, a diameter of 15"was increased to 16".

The *third phase* of study (*ES3*) addressed through simulation *MATCEL-PROP* envisages an engine characterized by increased power to 74 [kW], keeping the basic diameter of the wheel motors, thus is 15", but with the i_0 main gear ratio change, with steps of 0.5 in the range of normal values. *Stable* operation is achieved with the main gear ratio $i_0=3.7$.

The simulation is *MATCEL-PROP* addresses equally the *fourth stage* of the study (*ES4*), leaving, primarily from reduced engine power, thus is 54 [kW] and secondly, as described above, driving wheel diameter 15". Also, in this case is considered the i_0 main gear ratio change with steps of 0.5. Initializing the study from $i_0=4.2$ is reached to a *stable* operating state. The results obtained in the *four stages of the study* are summarized in Fig. 8, Fig. 9, Fig. 10 and Fig. 11, actually describing simulated behavior of the propulsion system, assessed by the stability parameter variation Δ.

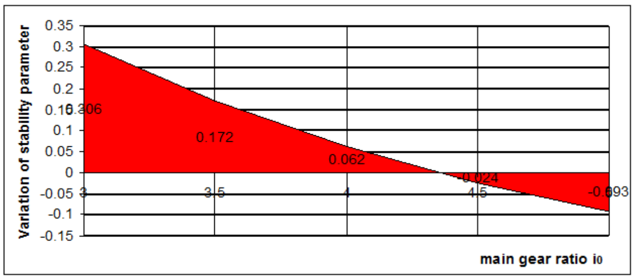

Fig. 8 - Variation of stability parameter with main gear ratio change obtained by simulating MATCEL-PROP for propulsion engine power of 64[kW]

Fig. 9 - Variation of stability parameter obtained by simulating MATCEL-PROP for changing wheel diameter

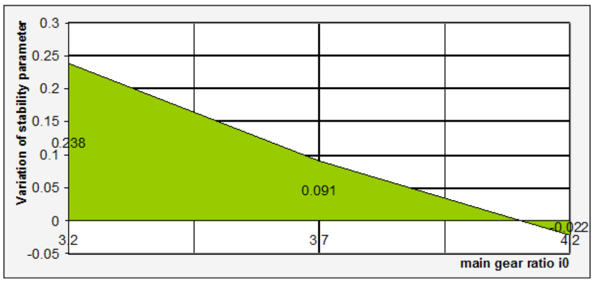

Fig. 10 - Variation of stability parameter with main gear ratio change obtained by simulating MATCEL-PROP for propulsion engine power of 74[kW]

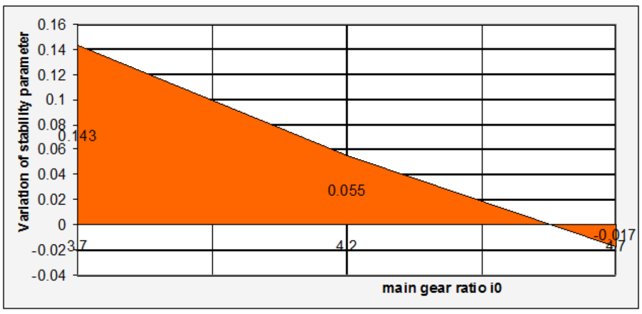

Fig. 11 - Variation of stability parameter with main gear ratio change obtained by simulating MATCEL-PROP for propulsion engine power of 54[kW]

On the other hand, the evolution of specific fuel consumption values for different states of the propulsion system is highlighted in Fig. 12. It can thus be noted that increased stability during operation of the propulsion system, values of these inputs are reduced, which is very advantageous.

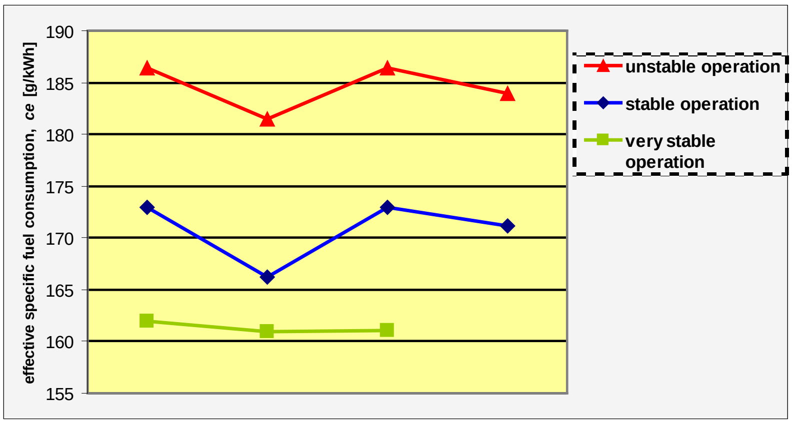

Fig. 12 - Evolution of effective specific fuel consumption values for different states of the propulsion system

Using the Fig. 13 a,b,c shown the variation of these inputs for the three states of the system, and that each state consumption values are very close together, being practically constant regardless of equipment and characteristics of propulsion system that obtains the condition of its.

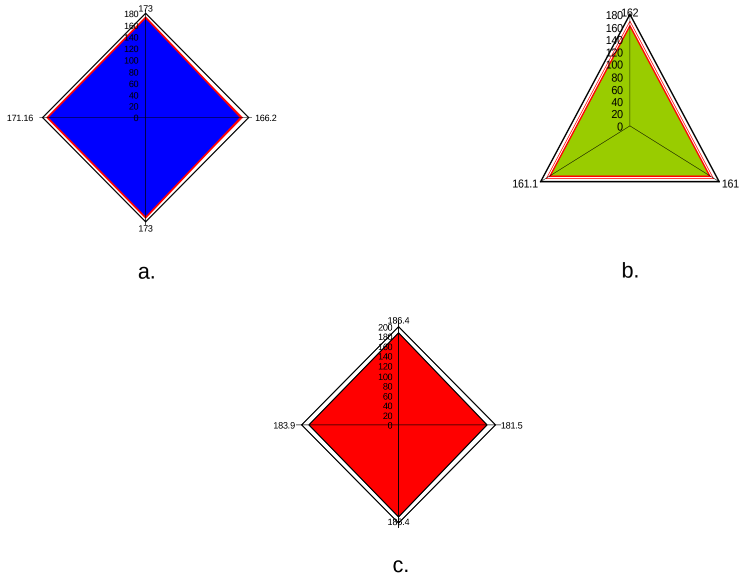

Fig. 13 - The range of values of effective specific fuel consumption corresponding of the three states of propulsion system

3. CONCLUSIONS

Based on *MATCEL-PROP* simulation, design using *CATIA V5R16* environment has created a *virtual model of transmission* [3], as a complex part of the propulsion system for the most stable operating situation highlighted. It was also considered the modelling of dynamic phenomena mainly in order to validate *the equivalent mechanical model of the propulsion system*.

Since the equivalent model substitute the presence of trees, gears and other rotating masses, specific to propulsion system, also was considered useful an evaluation of a discrete model of the propulsion system, encompassing such elements assimilated in mechanical model.

Thus, the Fig.14 is presented all the rotating masses of real gearbox model consisting of a mechanical gearbox with fixed axes, with 5-speed synchronized.

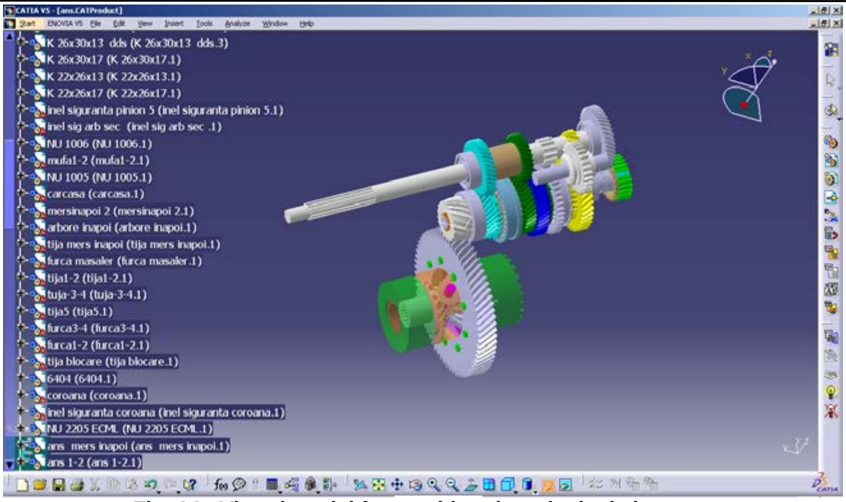

Fig. 14 - Virtual model for meshing the principal elements of propulsion system based on the simulation performed

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