ENGINE TORQUE DOSAGE IN PASSENGER CAR

Jerzy Jantos
Technical University of Opole, Poland
Mikołajczyka 5, 45-271 Opole
tel. ++48 77 4556041, fax. ++48 77 4581382

Abstract. Acceleration pedal scaling and its interpretation exerts significant influence on cooperation between the driver and automatic control systems of engine and vehicle. In this elaboration a supervisory controller is presented. It permits on programmed dosage of the engine torque. So it is possible to exert an advisable influence on the temporary processes, stepping out during car acceleration. For dependences identification, simulations investigations of the vehicle acceleration were done. These simulations were done with use of the Road Load Simulator. Thus the influence of transient process on engine work was taken into account. The investigations results for three different power units are enclosed. From the analysis it results, that visible advantages can be reached for every solution. However, the most important is the engine torque dosage in the drive automates.

1. Introduction

The idea of the intelligent acceleration pedal, examined in this elaboration, does not mean the use of simple electronic throttle control system. This idea means variable relationship between acceleration pedal position and engine torque. Introduction of such variable assigning should improve the cooperation among basic elements of power train in passenger car [6,8,9]. The task is very difficult, since in the examined system the driver cooperates with machine and with automatic control systems [7]. In modern solutions not only the driver decides about driving power value. On its value exerts the influence a lot of automatic auxiliary systems [5]. However these systems exclusively correct the driver activity in special road situations. Permanent influence on the control system with a man is advisable. This can be partly reached through selection of adjustable elements characteristics. In the power train, the acceleration pedal is the basic adjustable element. Relationship between its position and engine torque was called here Acceleration Pedal Characteristic – APC. Investigations of relationships between APC and engine work parameters during acceleration in passenger car are the subject of this paper.

2. Supervisory controller

Supervisory controller in the powertrain steering system permits, among others, for the interpretation of acceleration pedal inclination in the various ways. For example, it can be treated as engine torque demand, longitudinal acceleration or driving force demand. However not only diverse interpretation of accelerator position is possible. Also scaling, meaning calculation method of controlled value, is realized on the software way. So it can be adapted
to temporary movement conditions. The main elements of considered system (Fig.1) are:

- electronic acceleration pedal, electronic throttle unit, programmable micro controller, drive speed sensor, engine speed sensor and longitudinal acceleration sensor.

The realized tasks are the following:

- measurement of basic state coordinates (drive speed, engine speed, longitudinal acceleration, accelerator inclination) of regulation object,
- estimation of traffic conditions, state of regulation object and driver preferences (type),
- calculation of controlled variable value,
- calculation of steering variable value (throttle inclination in SI engine, fuel dose in CI engine)
- adjust of executive unit.

Coefficient of driver preferences (0-100 value) is fixed on the basis of accelerator speed value. Differentiation of accelerator sensitivity is reached through the function X introduction. It is a function of two arguments. Its value depends on accelerator inclination and driver's preferences coefficient. The temporary function X value is counted from matrix characteristic (Fig.2). When the coefficient of driver preferences is equal zero, the function X value is directly equal to relative value of accelerator inclination. With higher coefficient of driver preferences value, the value of function X grows more quickly than accelerator inclination. In detail the way of function X matrix qualification was introduced in [6]. Function X value can be treated as demand of:

- throttle inclination (I control variant),
- engine torque (II control variant),
- longitudinal car acceleration (III control variant)
- driving force (IV control variant – exclusively in CVT power train).
If the function X is interpreted as the required throttle inclination it is directly the input variable of throttle regulator! The second control variant demands counts of function X on engine torque value. To determine the copying function the engine characteristic was used (Fig.3).

As reference value the speed of the maximum engine torque was assumed. Fig.4 shows the graph of obtained function. The torque counted from this function is the input variable of dosage block of engine torque.

In the third control variant the required value of engine torque is enlarged with value of equivalent road load torque reduced on the crankshaft. Programmed dosage of engine torque is possible with use of existing executive arrangements. In chance of SI engine, it means necessity to suitable throttle inclination.

Required (theoretical) throttle inclination is counted from the „reverse quasi-stationary engine model“. This model is written in the matrix form in the controller memory (fig.5).

The independent variables of the examined function are: theoretical engine torque and temporary engine speed. Theoretical throttle inclination, counted with use of interpolations methods, is the input variable of the of throttle position regulator.

3. Simulation investigations

Supervisory controller makes it possible to exert the influence on coordinates of temporary engine work point. However, it is possible during car acceleration only. When the vehicle speed is constant, the coordinates of engine work point result directly from condition of torque equilibrium (engine torque and road load torque). However, analysis of registered speed profiles shows on significant acceleration time participation in the general drive time. Simulation investigations of car acceleration process were done for the accelerator jump. Also initial (50 km/h) and final speed of drive (120 km/h) as well as acceleration time (about 50s) were assumed. Simulations were done with use of Road Load Simulator – RLS [3,5], for mentioned above control variants and three different power train units. The power train with:

- manual controlled transmission,
automated mechanical transmission,
continuously variable transmission was considered.
Results of investigations are presented below in separate points for each analysed powertrain solution.

3.1 Manual controlled transmission

In the traditional powertrain with manual controlled Mechanical Transmission - MT, selection of operation parameters (engine speed and engine torque) remains in driver management.

Engine speed is kinematics rigidly related with drive speed. Without driver participation, the change of transmission ratio is not possible. The supervisory controller can exert influence exclusively on the engine torque.

Temporary engine torque course registered during simulation of car acceleration is shown Fig.6a. Diverse dosage of engine torque exerts influence on obtained drive speed profile (Fig.6b). It also influences the fuel consumption (Fig.6c) and pollutant emission (Fig.7). It is visible, that from regard on most of criterions, the proposed ways of engine torque dosage are more profitable than the traditional solution.
3.2 Automatic Mechanical Transmission

Manual steering of engine speed is significant restrictive factor of control optimization of the power train. Transmission automatization objectives engine speed control. Therefore the problem of cooperation between driver, engine and transmission is especially important here [1]. In case of Automated Mechanical Transmission – AMT the key problem is to obtain good drivability and small fuel consumption at limited number of switches [2]. This problem demands solution in the control algorithm.

Throttle inclination increase connected with drive speed increase for constant accelerator position, characteristic for dosages of engine torque or longitudinal accelerations is profitable. Throttle line slope near to switching line course prevents their crossing. So change of the gear does not follow. However, direct throttle control lead to unprofitable, frequent gear changes. Simulation results in arrangement similar to previous are presented below.

In this chance, differences between examined control variants are more significant. Apart from lower fuel consumption (Fig.8b) and pollutant emission (Fig.9) significant improvement of drive comfort is visible (Figs.8a, 8b).

3.3 Continuously Variable Transmission

Continuously Variable Transmission - CVT gives greatest possibilities for cooperation between the engine and drive train [4,10,11]. However, its application does not lead to solving
all the problems. It is always difficult to obtain low fuel consumption and good drivability at the same time.

![Graph](image)

*Fig. 10. Transient process in the vehicle with CVT –I control variant*

The main input variable for CVT ratio control algorithm is the throttle inclination. Throttle inclination independent from accelerator position makes possible exerting an advisable influence on transmission ratio control algorithm.

![Graph](image)

*Fig. 11. Transient process in the vehicle with CVT –IV control variant*

For power train with CVT the control of driving force was proposed (IV control variant). Simulation investigations of car acceleration were made for previously took guidelines. The results are presented below. Significant changes in engine speed can be seen. For traditional control method (Fig. 10), engine speed suddenly grows up after accelerator jump.
In case of driving force control (Fig.11) initially jump of engine is not large. Then, with drive speed increase also engine speed grows up in proportion to drive speed. Such a course engine speed, as above marked, result from transmission ratio changes.

So significant differences in engine torque (fig 12a) and engine speed course (Fig 12b) exert expressive influence on parameters characterizing engine work and car movement. Driving force control decrease fuel consumption (Fig.12c) and pollutant emission too (Fig.13).

4. Conclusions

Programming dosages of engine torque in passenger car is profitable. Supervisory controller can improve traction properties and limit fuel consumption and pollutant emission. Best results are obtained for power train with CVT. However, even for the most simple solution with, manual controlled transmission improvement of work parameters in transient state is possible.

Acknowledgments

The Polish State Committee for Scientific Research supported this work in frame of Research Project No 9T12D00916 in years 1999-2001.
Dozowanie momentu obrotowego silnika w samochodzie osobowym

Streszczenie


References