MODEL TESTING OF THE DIAGNOSTIC PROCESS

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INTRODUCTION

Technical diagnostics deals with the problem of testing the state of the vehicle and its elements.Technical objects diagnostics is a field of science about operation, including problems of recognizing object technical state, without its disassembly or with partial disassembly which does not disturb basic functioning of element joints.

There are two main branches in the field of technical diagnostics:

- Testing particular technical objects,
- Testing models of diagnostic objects.

The process of technical state assessment consists of three basic tasks:

- Measuring diagnostic parameter value and comparing it with nominal value.
- Analysis of deviation character and causes.
- Stating probable value of vehicle efficient running measure.

There is one more important diagnosis element consisting in gathering, analysing and statistical handling of information about the characteristic inefficiencies, on the basis of which recommendations determining modernization and improvement directions can be stated.

MODELS OF TECHNICAL DIAGNOSTICS OBJECTS

The main point of technical diagnostics lies in making use of two characteristic features of technical devices. The first one is connected with the determined structure of each device dependent upon its usage properties. The structure is a group of this device constructional elements ordered in a fixed way to perform some functions. The second feature of technical devices is the fact that during their functioning various physical and chemical processes, called initial processes, are realized.

Assessment of a vehicle's technical state is dependent upon structure parameters values and their determination is crucial for explaining the essence of diagnostics.

However, it is not sufficient in practice because generally it is impossible to measure object structure parameters without its disassembly. It must be added that output parameters course is dependent upon a vehicle's technical state. Thus, output parameters values change together with the change of this state. If a vehicle's technical state depends on structure parameters values and their changes cause changes of output parameters values, it can be stated that output parameters reflect the character of vehicle elements mating and a vehicle's technical state.

The mutual relation between vehicle structure parameters and output parameters makes it possible to treat output parameters as parameters of a vehicle's technical state measured without its disassembly because physical-chemical processes and quantities describing them can be generally observed and measured from the outside [2, 5].

An initial parameter can be recognized as a diagnostic parameter of an object's technical state if it satisfies the following conditions:

– uniqueness (each structure parameter value corresponds to only one determined output parameter value),

– satisfactory width of the field of changes (possibly big relative change of output parameter value for a preset change of structure parameter value),

– availability (it is easy to measure the parameter).

The optimum results of complex objects' technical diagnostics can be obtained only as an effect of an analysis of many states of those objects in the course of their operation. The analysis can be carried out theoretically when a new object is worked out or experimentally during its operation. However, in many cases it is difficult or even impossible to perform such an experiment. That is why, there is a need for special methods based on studying analytical descriptions or graphoanalytical presentations of the basic properties of objects which serve as diagnostic models.

Analytical models, in which differential equations are used for describing the courses of processes in objects, are the most convenient ones. However, those models are often complicated for complex objects and are of no practical use.

That is why simpler models: functional and structural ones are used in technical diagnostics. The functional models of a diagnostic object is a graphical presentation of a device as a set of functional blocks (functional elements), each of which has a certain number of inputs and outputs marked with lines with arrows, where output functions of one block can be input functions of another. A functional model should explicitly determine verification which should be done in order to find all the inefficient elements.

A structural model of a diagnostic object is a graphical presentation of a device as a set of functional blocks [2, 8].

ML4.1 INJECTION SYSTEM AS DIAGNOSTIC MODEL

Motronic ML4.1 system, presented in [1, 6, 7], was used in the years 1987-1989, mainly in Opel-Vauxall engines, and was designed for 20NE and C20NE 2-litre units. In the ML4.1 system, engine temperature has the greatest correcting impact on injection duration and ignition advance angle. Signals from air temperature sensor, throttling value position sensor and also battery voltage value have smaller impact, though the signal coming from lambda probe is an important piece of information influencing injection duration. The characteristic feature of all systems controlling engine running – Motronic is the fact that the same microcomputer controls both the fuel injection and ignition. The microcomputer has two basic three-dimensional characteristics (maps).

In its memory:

– of fuel injection time,

– of ignition advance angle.

And additionally it stores separate characteristics of the fuel injection time for idle running. Those maps are presented as the function of engine load and speed.

Besides, they are corrected by some coefficients whose values depend on engine running conditions.

Recognizing engine running state and controlling engine running is possible due to adequate sensors and executory elements. The kind and number of sensors and executory elements to be used depends on the model of injection – ignition system Motronic. In spite of the important role of sensors, even a serious damage of one or more of them does not mean that the engine stops running. Motronic can run in emergency mode. Then steady, previously stated values are used by the microcomputer to control engine running. Structural function scheme of the system is presented in Fig. 1.

THE PERFORMANCE OF SIMULATION TESTS

The aim of the tests was to register signals from particular sensors for chosen states of system inefficiency and injection duration, ignition advance angle dependent upon rotational speed, load and engine temperature values.

Measurements were carried out for:

– a wide range of temperatures (the system enables temperature control from,

– 12 to 81°C), the potentiometer on the main board, Fig. 2, acts as temperature sensor,

– various rotational speeds in the range form 800 to 3000 rpm (the system enables rotational speed control from 100 to 5000 rpm by means of the autotransformer),

– various load values for different position of flowmeter flap.

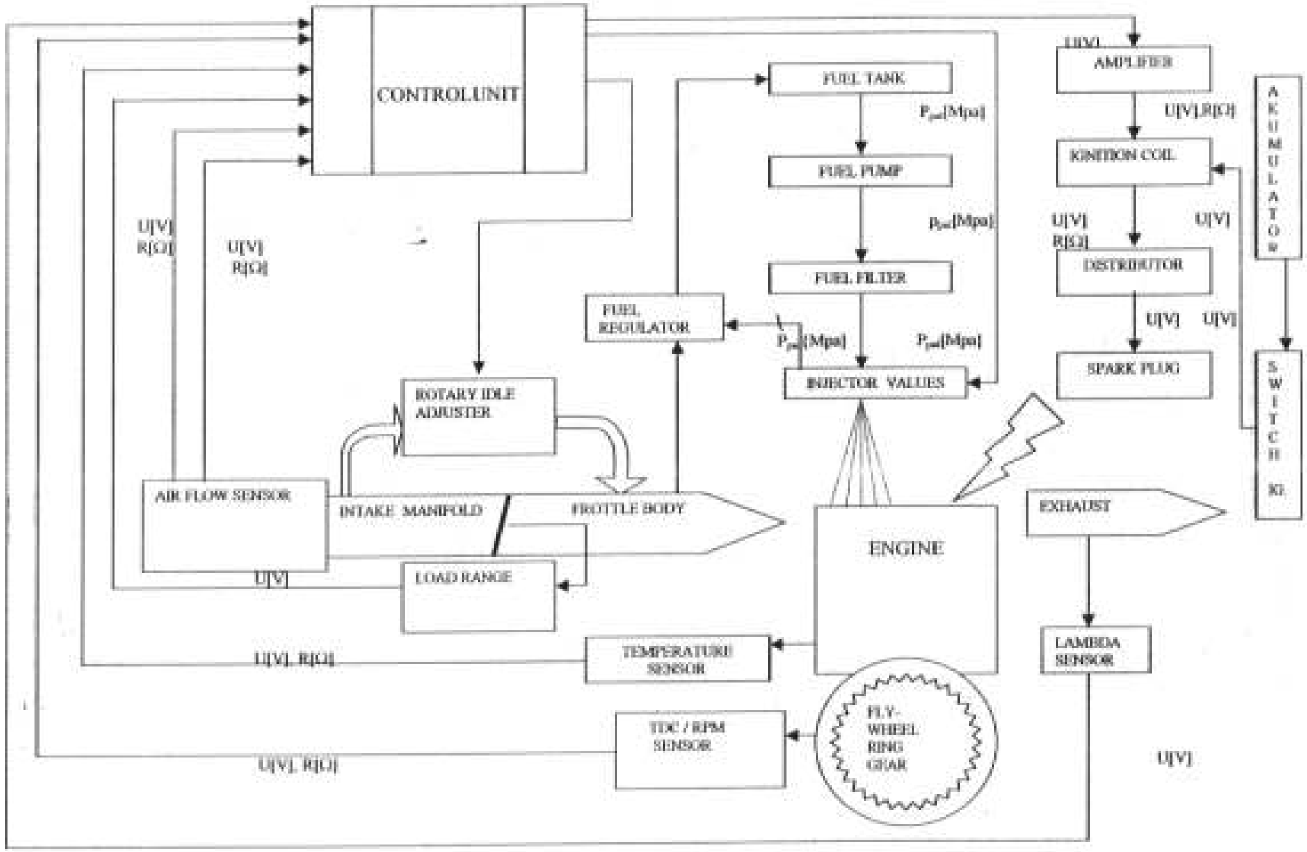

Fig. 1. Structural-function diagnostic scheme of Motronic ML4.1 system

Additionally, for the speed 800 rpm throttling value position sensor contact should be made and for higher rotational speeds both idle running rotational speed contact and maximum load contact should be open. For maximum rotational speed (5000 rpm) maximum load contact should be made.

Signals sent from sensors to the controller and signals sent from the controller to executory elements were registered by means of KTS500 diagnostic device.

Due to that device, five of the following values could be observed simultanously: rotational speed [rpm], load value [V] (flowmeter voltage), engine temperature [°C], sucked air temperature [°C], injection advance angle, signal from throttling value position sensor, signal from lambda probe.

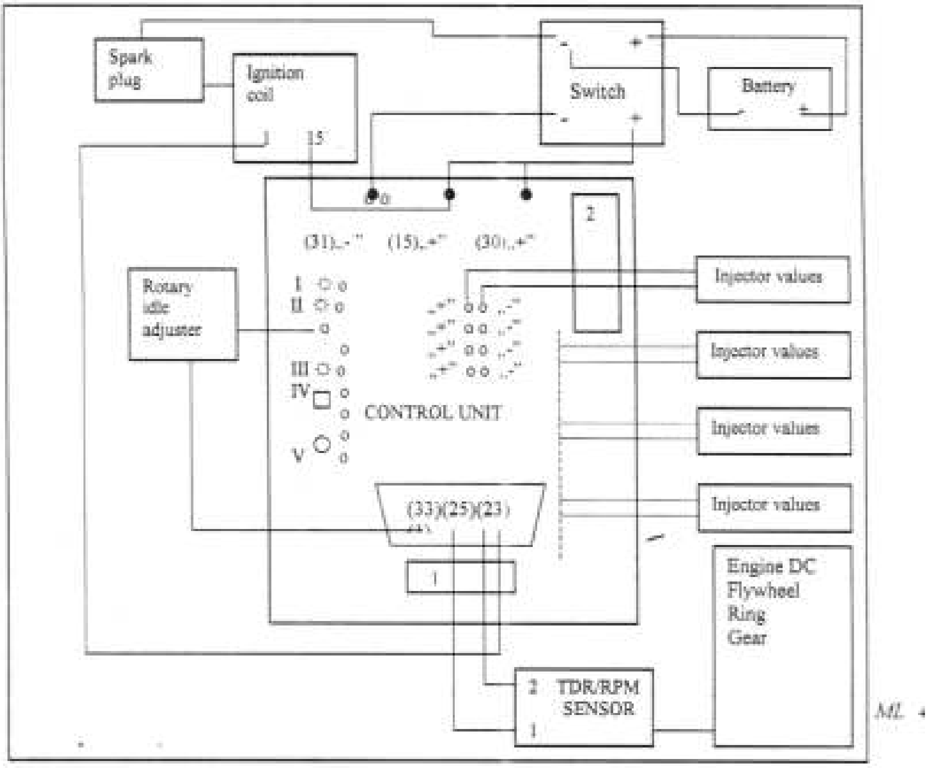

Fig. 2. Block scheme of Motronic ML4.1 system test stand

Additionally, the simulation of sensor and executory elements damage is possible on the test stand. Damage simulation was carried out by disconnecting a given element form the controller or by changing input parameter values.

System errors recognized by the controller have been shown in Table 1.

Table. 1. Fault diagnosis code

Fault Code	Information Sensor	Fault
12	Diagnosis initiation	
13	Oxygen sensor	No voltage change
14	Temperature sensor	Voltage too low
15	Temperature sensor	Voltage too high
35	Idle air control	Poor or no idle speed control
44	Lambda sensor	Air/fuel mixture too lean
45	Lambda sensor	Air/fuel mixture too rich
48	Supply voltage	Voltage too low
49	Supply voltage	Voltage too high
51	Programmable memory	Programme error (PROM)
65	Idle speed potentiometer	Voltage too low
66	Idle speed potentiometer	Voltage too high
67	Throttle valve switch	Idle speed switch not opening
69	Air temperature sensor	Voltage too low
71	Air temperature sensor	Voltage to high
72	Throttle valve switch	Full load switch not opening
73	Air flow sensor	Voltage too low
74	Air flow sensor	Voltage too high
75	Transmission switch	Voltage too low

Each code of Bosch Motronic ML4.1 system inefficiency is made up of two digits.

The characteristics of injection duration and ignition advance angle are presented in Fig. 3-6.

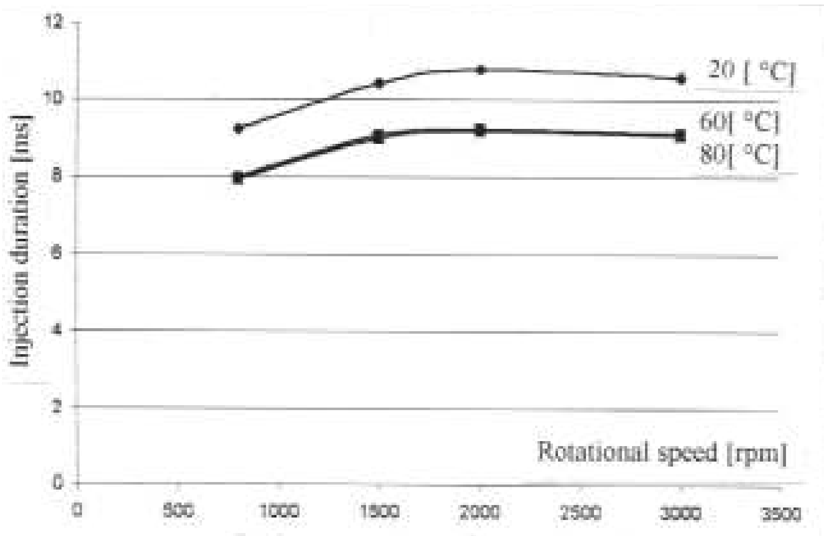

Fig. 3. Characteristic of injection duration as function of engine speed

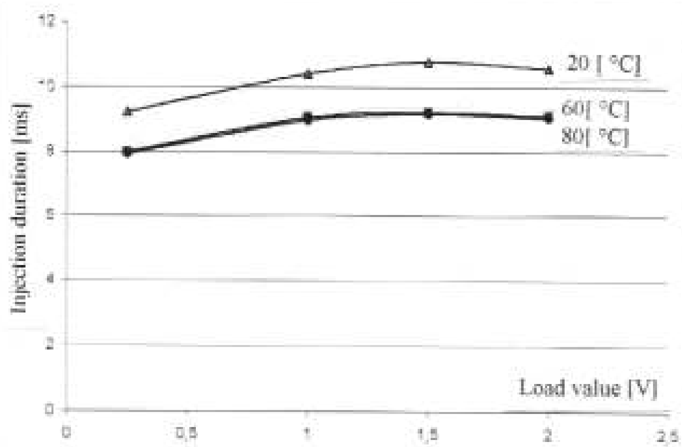

Fig. 4. Characteristic of injection duration as function of load

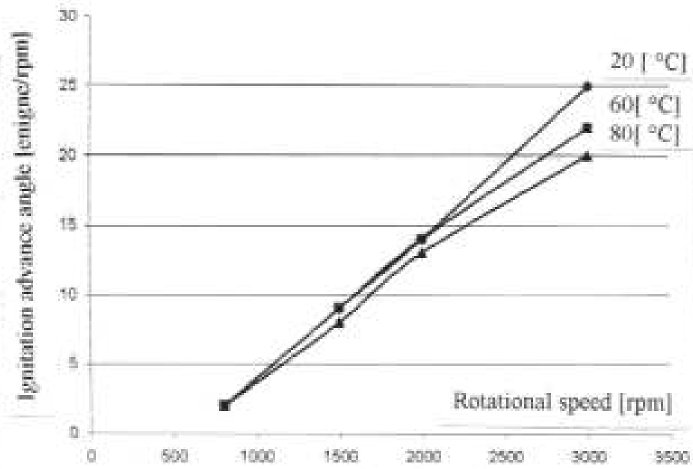

Fig. 5. Characteristic of ignition advance angle as function of engine speed

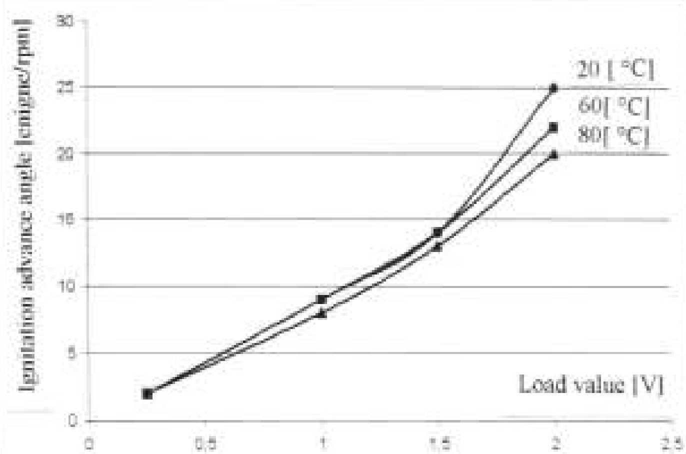

Fig. 6. Characteristic of ignition advance angle as function of engine load

CONCLUSIONS

It can be stated on the basis of the obtained characteristics that for the rotational speed in the range from 800 to 3000 rpm, with preset load and for various temperatures, injection time changes in the range from about 8 ms to about 10 ms. However, in the field from idle running rotational speed to 2000 rpm, injection time increase and above that speed begins to decrease slightly, which is connected with system correction. A considerable influence of engine low temperature on injection time can also be observed. The difference in the injection time for a cold and a hot engine is more than 1 ms. However, when an engine is not fully heated up, its injection time only slightly differs from a hot engine's injection time. On the basis of the carried out damage simulation it can be stated that not all codes prove inefficiency state, which can be explained by the lack of combustion process.

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SUMMARY

The diagnostic model of fuel injection system ML4.1 made by Bosch and results of the active experiment carried out for such a system on a specially designed test stand have been presented in the paper. KTS 500 diagnostic device was used for measurement results verification.