GENERATING MANAGEMENT PROGRAM OF THE TEST BENCH SKAD-1 FOR COMPUTER CONTROL OF AUTOMOTIVE GASOLINE INJECTION ENGINE

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Abstract: *The new requirements of modern automotives become more stringent corresponding to power, torque, fuel economy and ecology legislations [2]. The main factor in this area is the automotive engine fuel system, which is controlled by the electronic control unit (ECU). The electronic control of the Spark Ignition Engines (SI engines), as well as the Direct Ignition Engines (DI engines) is based on the certain sensors signals, program maps and management algorithms. The advanced automotive scientific research centres and automotive manufacturers design and develop a specialized laboratory, stationary and movable test benches and train complex for researching and testing of automotive sensors and actuators, automotive prototypes and series, and automotive units. The test benches for internal combustion engine (ICE) management are the equipment, which are used for ICE development, specification and testing. These test benches allow the engine to work at different work modes and states and ensured measurement of the engine physical work parameters. The design of the engine management test benches enable easy access to the ICE certain systems, units and details. This paper includes results of the generating a control program using the Flowcode 7.0 software of test bench SKAD-1 for computer management of automotive gasoline injection engine, with ability to programming input parameters and measuring the output results.*

Keywords: TEST BENCH, MANAGEMENT, GASOLINE INJECTION

1. Introduction

The automotive industry is one of the important sectors of the economy also undergo unceasing updating, in looking for competitive advantages even in small things, and more so using breakthrough technology [4]. Electronics, computers and sensors have become an integral part of any modern car.

In this connection, it is extremely important to study, design and develop management programs of automotive components and processes.

The structure of a test bench SKAD-1for computer control of automotive ICE with petrol injection is presented in Fig.1

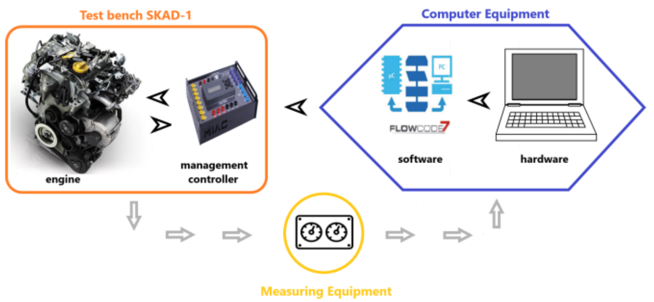

Fig.1. *Schematic diagram of a test bench SKAD-1 for computer management of automotive ICE with petrol injection [5, 6, 8]*

As a base of the test bench SKAD-1 is chosen automotive gasoline injected ICE brand Renault, Kangoo (98-09), engine capacity 1149 cm3, power 44kW (60 hp) / 5250 min-1, torque 105 Nm / 3500 rpm, cylinder diameter 69 mm, piston stroke 76.8 mm, compression ratio 9.6. The engine of the test bench SKAD-1 is equipped with its own electronic control unit brand name "Marelli".

The management controller of the engine ECU is Matrix MI0245, developed by Matrix Technology Solutions Limited, England [8]. With the MI0245 controller, the SKAD-1 engine is started and stopped, and in the future it is possible to design and reproduce individual engine operating points as part of the engine output characteristics.

Computer control of the test bench engine is carried out with computer equipment using the program product Flowcode7 [7], which is used to program and set up the management controller, which may be according to the purpose of the respective task or study.

The results of the programming, tuning and control of the test bench SKAD-1 are reported using the measuring equipment. For this purpose, a control panel is built on the test bench, which gives access to all signals of the sensors and actuators. An oscilloscope holder for measuring and recording real-time signals is provided. A gas analyzer can be connected to the test bench to measure the amount of exhaust emissions.

Measurement results serve as a benchmark and prerequisites for making adjustments to the management program and the operation of the test bench.

The test bench layout is designed with the perspective of being able to connect in the future to a dynamometer equipment to capture the full set of ICE characteristics of the test bench and to fully evaluate the management programming and setup parameters. The common view of the test bench SKAD-1 is represented in Fig.2.

Fig.2. *Overview of the test bench SKAD-1: 1-test bench; 2- computer equipment; 3-measuring equipment*

To the technological possibilities of the test bench SKAD-1 can be noted:

1) Computer control via programmable controller MI0245;
2) Automatic control via the OEM electronic control unit Marelli;
3) Development of management programs with Flowcode7 software;

4) Oscilloscope measurement of input and output signals from sensors and actuators;

5) Exhaust emission measurement by exhaust gas analyzer;

6) Diagnostics via diagnostic interface;

7) 7) Ability to join to a dynamometer equipment.

The three-dimensional appearance of the developed test bench SKAD-1 is shown in Fig. 3.

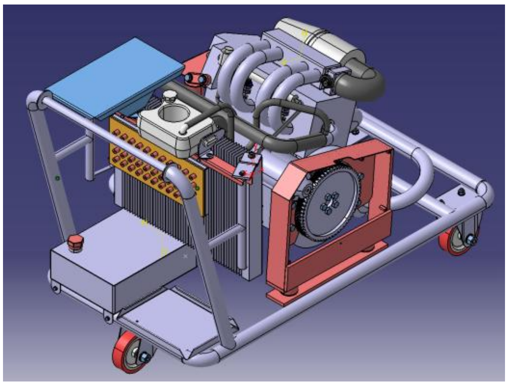

Fig. 3. *Three-dimensional model of the test bench SKAD-1*

2. Structure

The development of the management program of a SKAD-1 test bench for computer control of automotive ICE with gasoline injection was carried out with the software product Flowcode, a modern integrated development environment (IDE) for development of electronic and electromechanical systems [1, 3, 7]. The development of the SKAD-1 test bench management program consists of four stages.

The first stage of the analysis consists in choosing a corresponding process to be managed. By default, this is the process of starting, running, and stopping an ICE of the test bench. As a control system, a fuel injection system is selected as part of an ICE of the SKAD-1 test bench. In the analysis of the fuel ingection system the following components are specified as well as the respective connections between them:

1) Sensors – buttons for access, start, run and stop of SKAD-1 test bench;

2) Actuators – SKAD-1 engine main relay, a fuel pump relay, a starter relay, a fuel pump, fuel injectors;

3) Electronic control unit – controller MI0245 and SKAD-1 control board;

4) Sequence of work – access level 1, access level 2, ON, START, RUN, OFF;

5) ON / OFF conditions – switching ON the main relay in ON mode, switching ON the fuel pump and the starter in START mode, automatic shut-OFF of the starter after 1 s, normal operation in RUN mode, switching OFF the main relay and the fuel pump relay in OFF mode;

6) ON / OFF times – according to the control program, which may vary depending on the mode of operation;

7) ON / OFF state – depending on the position of the control buttons;

8) Forbidden operating modes – in OFF and FAILED modes;

9) Allowed modes of operation – in ON" and RUN modes.

The second stage (design stage) consists in generating the management program, which is related to the determination of macros for operating modes, parameters and function of the components and variables for the operating states.

The macros for operating modes are:

1) Master macro Main (main program);

2) GetCode access macro;

3) ON macro;

4) START macro.

3. Management Program

The algorithm of the SKAD-1 management program is shown in Fig. 4 to Fig. 9.

At the start (1) of the management program (fig.4), the MIAC controller screen is initialized (2) and the instruction label "Test bench SKAD1" (3) is made. Then follows positioning the cursor on the screen (4) and printing "ENTER CODE" (5). The value of the variable “ignition” (6) is initialized.

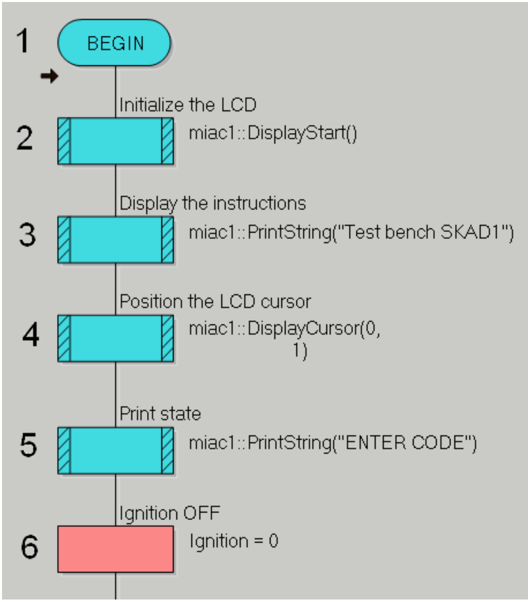

Fig. 4. *Initialization*

Since it is necessary to periodically repeat the following instructions (fig.5), the loop function (7) is used. In the cycle, the access codes for accessing the first level are checked in the macro GetCode (8), where the variable “Passcode1” is checking [9]. The checking proceeds after the setting a combination for the first code.

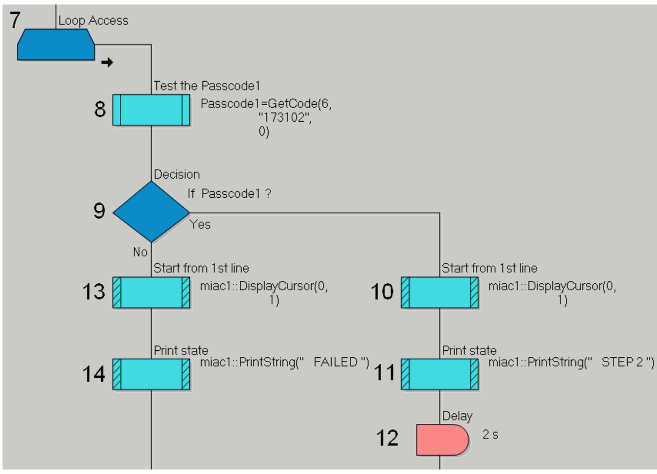

Fig. 5. *Accessing the first level*

The decision function (Decision) (8) - fig. 5 is used after the introduction of the first code for verification of its correctness. If the entered combination is wrong, the screen cursor (13) activates and "FAILED" message (14) is printed, the cycle ends and the program returns to begin 1 (fig.4). When the entered combination is correct, the cursor (10) activates and the message "STEP 2" (11) is printed on the controller display. The Delay function (12) increases the time interval from the message inscription until it is hidden.

Then the access codes for accessing the second level (fig.6) are checked in the same macro GetCode (15), where the variable “Passcode2” is checking.

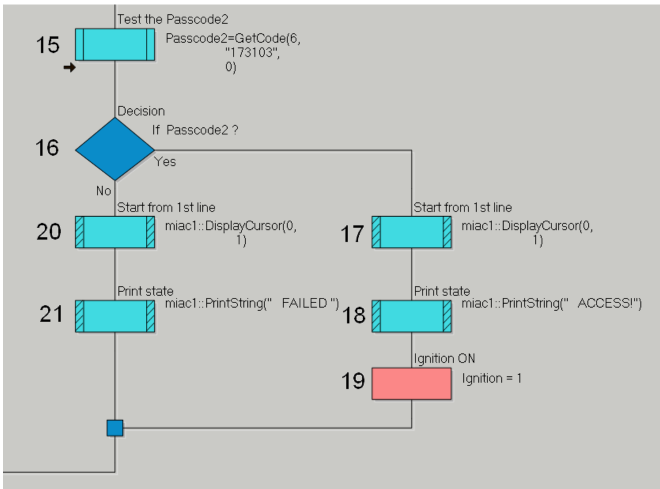

Fig. 6. Accessing the second level

The checking proceed after the set a combination for the second code. The decision (16) is used ageain after the introduction of the second code for verification of its correctness. If the entered combination is wrong, the screen cursor (20) activates and "FAILED" message (21) is printed, the cycle ends and the program returns to begin 1 (fig.4). When the entered combination is correct, the cursor (17) activates and the message "ACCESS!" (18) is printed on the controller display. The value of the variable “ignition” (19) is changed, allowing access to the "ON" and "START" macros - fig.7.

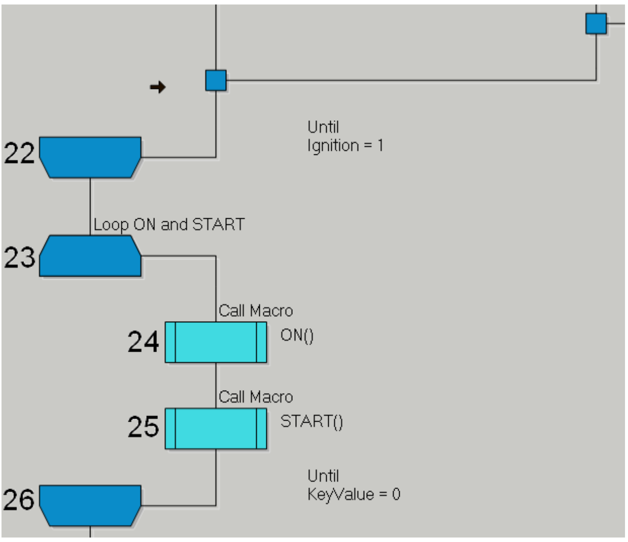

Fig. 7. Implementing the loop for ON and START macro

The program exits from the code verification loop (22) and introduces a new cycle entry (23) command. It runs the macro "ON" (24) and the macro "START" (25). If the variable “keyvalue”, which is set by the controller keypad is equal to zero the cycle (26) ends (fig.8).

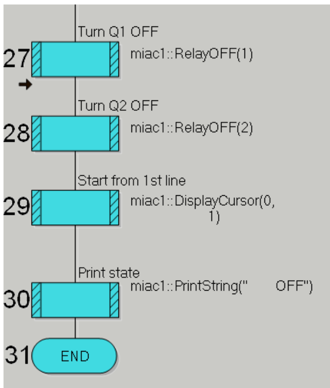

Fig. 8. End of management program

Then the output "Q1" of the controller, which is used to control the main relay, is switched OFF (27) and the main relay is turned OFF. Switching OFF the output "Q2" (28) via which the fuel pump relay is supplied leads to turn the fuel pump OFF. The cursor (29) activates and the controller display shows "OFF" (30). The program goes in end (31). Program goes to begin by the controller reset.

4. Management program macros

The management program macros are an ON macro to turn ON the SKAD-1 main engine relay and a START macro to start the SKAD-1 engine.

ON macro algorithm for switching ON the SKAD-1 main engine relay is shown in fig. 9.

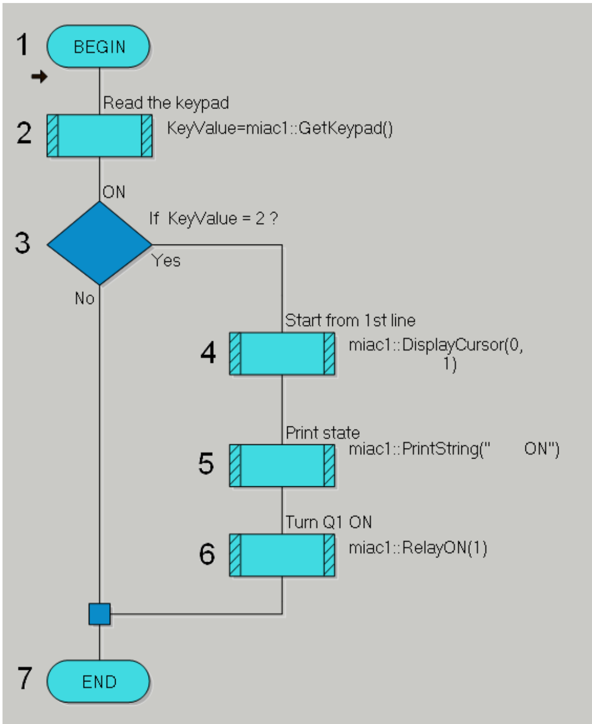

Fig. 9. ON macro

After the begin (1) the controller keypad (2) is read. The decision (3) compares the different keypad values. If the set value of the “keyvalue” variable is equal to two then the cursor (4) activates, and "ON" is printed on the display (5). The output "Q1" (6) is switched ON which turns the SKAD-1 main engine relay ON. With different set value or unpressed button, the macro goes to end (7) and because of the loop (fig.7) goes again to begin (1).

The algorithm of the START macro to start the SKAD-1 engine is shown in fig. 10.

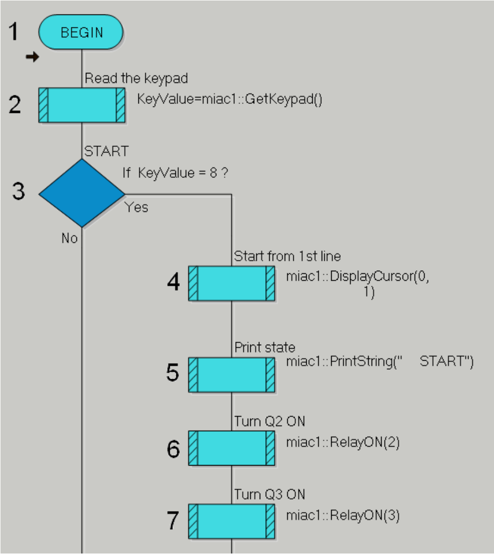

Fig. 10. *START macro-first part*

After the begin (1) the controller keypad (2) is read. The decision (3) compares the different keypad values. If the set value of the “keyvalue” variable is equal to eight then the cursor (4) activates, and "START" is printed on the display (5). The output "Q2" (6) is switched ON, which turns the fuel pump relay ON. The output "Q3" (7) is also switched ON, which turns the starter relay ON.

A delay of one second (8) is set (fig.11) during which the SKAD-1 engine is starting. After 1 s the output "Q3" (9) is turned OFF. The cursor (10) activates and the display (11) of the controller prints "RUN". The controller keypad (12) continues to be read.

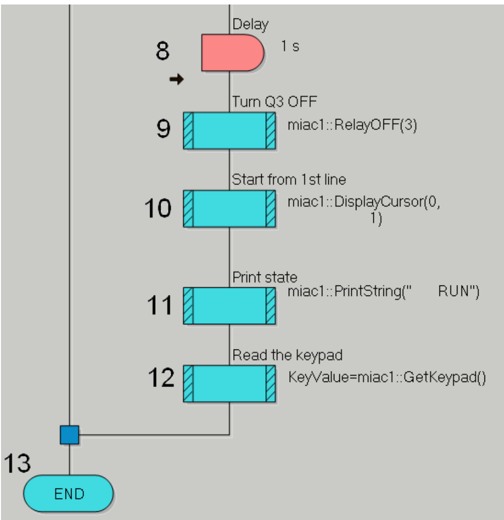

Fig. 11. *START macro-second part*

With different set value or unpressed button, the macro goes to end (13) and because of the loop (fig.7) goes again to begin (1).

During the RUN mode the SKAD-1 engine is running and sensors and actuators signals can be measured, such as the intake air temperature sensor, the manifold air pressure sensor, the throttle position sensor, the knock sensor, the engine coolant temperature sensor, the oxygen sensor (lambda-probe), the ignition coil, the electromagnetic injectors, auxiliary air device (idling), etc.

The third stage of program implementation consists in transferring the generated management program (hex file) and its execution using the MI245 controller and the SKAD-1 control panel.

The fourth stage of program development continues with adjustments and changes of the parameters in the management program, reproduction of the program and analysis of the results obtained.

5. Conclusion

The developed management program covers the process of switching ON, starting and switching OFF the SKAD-1 test bench. This can be used as the basis for future development of management programs to design work points from the ICE operating regime and its self-management via the controller MI0245.

The management program can be used as a successful basis for further programming of the test bench, according to the interests and creativity of students and researchers in the researching of the processes in automotive technique.

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