Special aspects of the test of ATV equipped with the electronic engine management system Continental M3C on a dynamometer test bench

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Abstract. In this article the problems of taking characteristics of the power plant of BRP Can-Am Outlander max 570 at its loading on a dynamometer test bench DynaPack are considered. The possibilities of using input and output electrical signals of sensors and actuators of the electronic engine management system Continental M3C, including the use of third-party electronic engine management unit M74CAN cars VAZ. The schematic solutions for obtaining the value of the engine crankshaft speed of the ATV by the standard software of the DynaPack dynamometric stand are proposed. Based on the analysis of the developed circuit solutions, as well as the features of loading, power plant in general, and the engine in particular, on the dynamometer test bench DynaPack decided to use the fuel injector control signals to determine the speed of the crankshaft engine. To increase the stability of the results of the series of experiments, a method of monitoring the position of the engine throttle valve was proposed. In conclusion, the speed characteristics of the BRP Can-Am Outlander max 570 quad bike power plant at various levels of opening the throttle valve are shown.

Description of the test bench and the ATV

The dynamometer test bench Dynapack [1–13] was used (Figure 1) to estimate the power plant power parameters of the BRP Can-Am Outlander max 570 ATV in the whole operational range of engine crankshaft rotation frequency by means of obtaining its external and partial speed characteristics. In connection with the use of stepless transmission in the design of the ATV power plant at the stage of preparation of tests the problem of introduction of the value of the crankshaft rotation frequency of its engine into the software of the dynamometer test bench was solved.

The BRP Can-Am Outlander max 570 [5] ATV is equipped with a gasoline, V — shaped, two-cylinder engine with distributed fuel injection and electronic control. The engine/electronic control module (EECM) is based on an electronic control module (ECM) Continental M3C. This control unit processes the crankshaft position sensor (CSPS) signal, among other things, to determine both the crankshaft position and the speed of the crankshaft. The ECM also has a diagnostic line via the CAN bus and a closed proprietary diagnostic information transfer protocol [14–20], which includes, among other things, information on the current crankshaft speed of the engine. The direct connection of the ECM diagnostic line to the DynaPack dynamometer has not been successful. This version of the DynaPack dynamometer software does not support the operation of this diagnostic information transfer protocol.
Sensor equipment

The mechanism for determining the position of the engine crankshaft is shown in Figure 2 and consists of a reference disc — 1 with the number of teeth 36-2 and CSPS — 2.

Figure 1 shows the waveform of the CSPS signal. The shape of the CSPS signal is close to the sinusoidal one, with a surge of increased amplitude and period at the point of passage of two teeth. Signal frequency with CSPS at the given reference disk, without taking into account bursts, is in a range from 28 kHz to 220 kHz at speeds of rotation of a crankshaft from 800 to 6000 rpm accordingly. Possibility of signal supply with CSPS directly to the logic input of the DynaPack dynamometric stand speed control is limited by the negative component of the signal and the value of the signal amplitude, which reaches 50 V in some modes. In order to eliminate these drawbacks, the implemented scheme shown in Figure 3 was implemented.
Fig. 2. Mechanism for determining the position of the engine crankshaft.

Fig. 3. Connecting the CSPS to the RPM pickup input of the DynaPack dynamometer test bench.

In this scheme, the CSPS signal is rectified by a two-period rectifier VD1, and is fed to the voltage divider assembled on the resistors R1 and R2, which has a division coefficient of 4:1. A positive signal with a safe amplitude of no more than 12.5V is fed to the logical speed monitoring input of the DynaPack dynamometer test bench. Application of the above described scheme has not yielded satisfactory results. The speed control of the DynaPack dynamometer test bench did not function adequately and the low input resistance of the circuit negatively affected the quality of signal processing by the standard ECM, which was expressed in the difficult starting of the engine.

Fig. 4. Connection of CSPS to ECM M74CAN of VAZ vehicles to DynaPack dynamometer test bench by means of CAN bus.
The next way to receive the signal from CSPS was the use of an external ECM M74CAN car VAZ. In this scheme ECM M74CAN was connected to the CSPS (Figure 4) in parallel to the regular ECM as in the previous scheme, but the input resistance of the signal processing channel with CSPS ECM M74CAN has an order of magnitude greater resistance than the previous scheme, which minimizes the negative impact on the operation of the regular ECM. The ECM M74CAN processed the signal from the CSPS and transmitted the engine crankshaft speed to the DynaPack dynamometer using the CAN bus with a known diagnostic protocol.

The use of ECM M74CAN allowed the DynaPack dynamometer to obtain the value of the engine crankshaft speed that does not correspond to the actual speed, but is proportional to the actual speed with unsystematic and unpredictable obviously erroneous values. The discrepancy between the obtained and the actual speed is explained by the difference between the reference disks used to work with ECM M74CAN and M3C is expressed in a conversion factor of 1.67. In the first case the reference disc has 60-2 teeth, and in the second case it has 36-2 teeth. The discrepancy between the obtained and the real engine speed and the presence of irregular and clearly erroneous values complicated the processing of experimental data. This fact pointed to the need to apply another solution. Later it was decided not to use the signal with CSPS, due to its relatively complicated processing, and the use of the fuel injector control signal. In this control system fuel injection is a priority in the phased mode. That is, each nozzle, without taking into account transients, receives a control pulse once in two turns of the crankshaft. During transients, such as sudden acceleration or engine deceleration, it is possible to switch to asynchronous injection and completely switch off the fuel supply, which will bring significant errors in the value of the engine crankshaft speed obtained from these signals. On the dynamometer test bench DynaPack in particular, and taking into account the peculiarities of loading of the power plant in general, and the engine in particular, expressed in the absence of sharp acceleration and deceleration, and, accordingly, errors caused by these transients, it was decided to use the fuel injector control signals to determine the speed of the engine crankshaft. Figure 5 shows the scheme of the fuel injector control signal converter into the signals received by the input RPM pickup of the DynaPack dynamometer test bench with high input resistance to minimize changes in the dynamic parameters of the fuel injector and, consequently, the working process and engine parameters in particular and the power plant in general.

![Diagram](image_url)

**Fig. 5.** Fuel Injector Signal Converter Diagram to the signals received by the RPM pickup input of the DynaPack dynamometer.
The circuit is based on a comparator made on an operating amplifier (OA) LM358. When the VT1 nozzle control transistor L1 is opened, the potential of the OA DA1 inverter input becomes less than the potential at the non-inverter input (half the supply voltage) and is close to the mass potential, resulting in switching the output to a logical unit. When the VT1 transistor is closed, the potential of the OA DA1 inverter input will be greater than the potential of the non-inverting input and the output will switch to logic zero. The VD1 diode is required to protect the OA DA1 inverter input from dangerous voltage surges when the VT1 transistor is closed. The large input impedance of the OA LM358 ensures minimal impact on the fuel injector dynamics. The operation of this circuit has been stable and found to be satisfactory.

In order to ensure the stability of the results of the series of experiments, it is advisable to control the position of the throttle valve. The standard EECM is equipped with a throttle position sensor (TPS), which is a potentiometer. The removal of the signal from the standard TPS is easy and does not require any signal level converters. Figure 6 shows the connection diagram of the adapter to remove the signal from the TPS. The adapter is designed to prevent damage to the wiring harness of the TPS to ECM connection of the EECM standard.

![Fig. 6. The schematic diagram of the adapter to remove the signal from the TPS.](image)

The signal of this sensor changes within the limits suitable for the stand (0-5V, taking into account the sensitivity zones). Then the signal was calibrated to display as 0-100% of the throttle opening.

**Experiment results**

The measures have allowed to provide stable reception by the software of dynamometric stand DynaPack of authentic value of speed of a crankshaft of the engine and an angle of opening of a throttle valve during carrying out of tests.

The result of the tests was a series of partial throttle angle increments of 10% and the external speed characteristics (Figure 7) of the power plant of the BRP Can-Am Outlander max 570 in the entire operational range of engine speeds.
Conclusion

As a result of the experiments, stable reception of the signal by the DynaPack dynamometer bench software was provided and reliable values of the engine crankshaft speed and the throttle opening angle were obtained during the tests.

As a result of the tests, a series of partial and external high-speed characteristics of the BRP Can-Am Outlander max 570 power plant was obtained in the entire operating range of engine speeds.

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