Таблица 2 / Table 2

Результаты обработки экспериментальных данных по низкотемпературному пуску при батарее, заряженной на 75%

The experimental data on low-temperature start with a 75% charged battery

Диапазон температур, ^{0}C Temperature range, ^{0}C	$-18...-19$		$-22...-24$		$-25...-26$		Всего / Total	
	$N_{поп}(N_{уд})$	u	$N_{поп}(N_{уд})$	u	$N_{поп}(N_{уд})$	u	$N_{уд}$	$N_{неуд}$
1	2	3	2	3	2	3	4	5
Серийная Standard	7 (3)	0,43	6 (1)	0,17	9 (1)	0,11	5	17
Экспериментальная Experimental	7 (4)	0,57	8 (3)	0,38	11 (4)	0,36	11	15

результаты пуска при использовании серийной и экспериментальной систем зажигания статистически не различимы (вероятности пуска ДВС одинаковы).

При использовании заряженных на 100% аккумуляторных батарей параметр T составил 0,147 (по данным четвертой и пятой колонок таблицы 1), а критический параметр $T_{кр}$, при котором еще не отвергается нулевая гипотеза (по данным [1] при доверительной вероятности 0,9), – 2,706. Следовательно, $T \langle T_{кр}$. Это означает, что в случае применения аккумуляторной батареи, заряженной на 100%, вероятности удачного пуска ДВС от серийной и экспериментальной систем зажигания статистически не различимы.

Для батарей, заряженных на 75%, ситуация иная (таблица 2). Параметр $T = 15{,}57$ и оказывается много больше, чем $T_{кр} = 2{,}706$. Из этого можно сделать вывод, что нулевая гипотеза отвергается, то есть вероятность пуска при использовании экспериментальной системы зажигания выше, чем при использовании серийной.

ВЫВОДЫ

Применение системы зажигания с адаптируемыми преобразователями параметров электрической энергии позволяет улучшить пусковые характеристики бензинового двигателя при частично разряженной аккумуляторной батарее и отрицательных температурах окружающей среды. Для полностью заряженной аккумуляторной батареи использование экспериментальной системы зажигания обладает тем преимуществом, что исключает избыточные перегрузки элементов системы [2].

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IGNITION SYSTEM WITH ADAPTABLE CONVERTER

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ABSTRACT

Starting of cold car internal combustion engine often becomes a problem. To ensure a consistent spark formation, certain conditions and efforts are required, including the choice of optimal operation of accumulator batteries, voltage indicators. This article provides general approaches to solving related tasks and evaluates the results of experimental studies of the ignition system when it is powered by an adaptive converter of electric energy pulse parameters at low temperatures.

ENGLISH SUMMARY

Background. *At low temperatures, start of cold internal combustion engine is often difficult. At start a marked decrease in board voltage occurs that may cause faulty operation of ignition system, and in the absence of uninterrupted spark formation start of the engine is not possible.*

It is possible to provide continuous spark formation, if the voltage to the ignition system is increased to a level close to the nominal. When selecting the voltage it should be taken into account that at the time of starting the ballasting resistor is removed from the circuit of the ignition coil. For this reason, it is better to limit the voltage at 10 V.

Step-up converter of voltage helps to solve the designated problem.

Objective. *The objective of the authors is to investigate different aspects of application of pulse converters of electrical energy parameters.*

Methods. *The authors conducted field research, used descriptive method, analysis and mathematical calculations.*

Results. *If the voltage level at the output of the scheme is below 5.5 V, the pulse generator, assembled on an electronic chip, does not work due to low voltage of this electronic chip.*

If the input voltage exceeds the above mentioned level threshold, the generator runs at a frequency of about 5 kHz and a pulse voltage from its output periodically is commuted by high-current transistor. During conductivity state of the transistor inductance coil is charged by current, and when closing the transistor stored energy in the inductor through the opened diode charges the storage capacitor. The process then repeats, and the capacitor's voltage increases.

Storage capacitor discharge occurs through the ignition system (the primary circuit of the ignition coil and the output pip of a switching unit). Through the application of an up-converter, system is powered by increased voltage as compared with the level of on-board network voltage. If the output voltage exceeds the level of about 10 V (12 V for onboard network) converter turns off, which is provided by Zener diode, after the breakdown of which generator will stop generating the pulse voltage and the ignition system is powered directly from in vehicle network through the inductor and the diode, thus not only increases reliability of the ignition system, but also saves accumulator battery life.

In order to evaluate the effectiveness of the ignition system with voltage converter experimental studies were conducted. In this performance of the system was estimated under the most difficult starting conditions – without preheating. Start of the engine was carried out using standard batteries (6ST-90 EMC). Variants of batteries' condition: cold – 100% state of charge; cold – 75% state of charge.

Tests consisted of comparison of cold starts of the engine by means of experimental and standard ignition systems at the same air temperature. The main evaluation parameter was the number of start's trials. Duration of each trial was up to 10 sec with an interval of 1 min. To avoid failures in the next start due to spattering of spark plugs, the engine warm-up was performed after each start when rotational frequency of a crankshaft was 1500–2000 min^{-1}. With the same purpose after each unsuccessful start spark plugs were checked and cleaned. In addition, this operation was carried out regularly after every three starts.

During tests 35 starts of the engine were conducted at different temperatures below zero temperature (for 100% state of charge see Table 1, and for 75% state of charge – Table 2). Only by three attempts start of the engine had not been committed because of poor carburetion and intense spattering of spark plugs.

For each temperature range in the second column of tables 1 and 2 there are indications of the number of trials of engine starts ($N_{пон}$), in brackets – the number of successful trials ($N_{уд}$). The third column gives the coefficient of **u**, *equal to the ratio of successful starts of internal combustion engine to the number of trials. The closer to unity is the ratio, the better are the starting properties of the engine.*

The fourth and fifth columns of Tables 1 and 2 show the total number of successful and unsuccessful trials of start. Due to the relatively small amount of experimental data, statistical processing of results is held for the entire temperature range.

In processing the experimental data criterion 2 (chi-square) was used. [1] Under the null hypothesis it was understood that the results of start using standard and experimental ignition systems are not statistically distinguishable (probability of start of the internal combustion engine is the same).

When using 100% charged batteries parameter T was 0,147 (according to the fourth and fifth columns of Table 1), and the critical parameter $T_{кр}$ was – 2,706, when the null hypothesis has not yet been rejected (according to [1] at a confidence level of 0.9) – 2,706. Consequently, $T \langle T_{кр}$. It means that when 100% charged battery is used, probability of a successful start of the internal combustion engine from the standard and experimental ignition systems is statistically indistinguishable.

For 75% charged batteries the situation is different (Table 2). The parameter $T = 15{,}57$ is much greater than $T_{кр} = 2{,}706$. Thus, it is possible to conclude that the null hypothesis is rejected, i. e. the probability of start using experimental ignition system is higher than when using the standard one.

Conclusion. *Application of the ignition system with adaptable converters of electrical energy parameters can improve the starting properties of a gasoline engine with a partially charged battery and negative ambient temperatures. For a fully charged battery the use of experimental ignition system has the advantage of eliminating redundant overloads of system elements [2].*

Keywords: *internal combustion engine, car, ignition system, low temperatures, accumulator batteries, field research, pulse adaptive converter of electric energy parameters.*

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