PAPER • OPEN ACCESS

Faults technology of Lada Kalina cars by means of defined complex of diagnostic parameters

View the article online for updates and enhancements.

IOP ebooks™

Bringing you innovative digital publishing with leading voices to create your essential collection of books in STEM research.

Start exploring the collection - download the first chapter of every title for free.

Faults technology of Lada Kalina cars by means of defined complex of diagnostic parameters

S V Bulatov

Orenburg State University, 13, Victory Ave., Orenburg, 460048, Russia

E-mail: bul.sergey2015@yandex.ru

Abstract. The technology of observing the big group of cars allows us to establish how often we meet the diagnoses that we are interested in and what the odds of these diagnoses are according to diagnostic parameters for the developed system. On the basis of the calculations according to the data of the experimental researches we can say that for the car with the set of signs, corresponding to the set complex of diagnostic parameters, the most probable diagnosis is the first one: fault of electrical equipment elements. The obvious condition of the diagnostics efficiency is the significant decline of the failure probability of nodes, units and vehicles in general and also the exception of incorrect scheduled maintenance that is reached under the qualitatively perfected system of diagnosing.

1. Introduction

Malfunction diagnosing of nodes, units and vehicles in general is detected in most cases according to several signs, and the analysis of these signs allows one "to establish" the most probable diagnosis [1–4]. If the repairmen's qualification is high and the used equipment, by means of which faults are detected, is more effective, the received result will be more reliable.

Sometimes various faults are partially followed by the identical diagnostic parameters when changing the technical condition of the vehicle. For example, the fault of the electrical equipment elements (D_1) is followed by uneven operation of the engine $- y_1$, the incomplete fuel combustion $- y_2$, the increased fuel consumption $- y_3$, obstructed or impossible engine starting $- y_4$. The incorrect valves adjustment (D_2) is followed by uneven operation of the engine $- y_1$, the incomplete fuel combustion $- y_2$, the increased fuel consumption $- y_3$.

The coking of piston rings (D_3) is followed by the signs mentioned earlier $y_1, ..., y_3$ and the presence of engine oil in the combustion chamber $- y_5$.

We will consolidate the description of the above-stated diagnoses in a matrix, designating the existence of the sign as '1', and the lack of the sign as 'O' (table 1).

Table 1. Diagnosis matrix

Diagn oses	Diagnostic parameters				
	y_1	y_2	y_3	y_4	y_5
D_1	1	1	1	1	0
D_2	1	1	1	0	0
D_3	1	1	1	0	1

The controlled diagnostic parameters have accidental dispersion because of measurement errors, the accidental combination of operation modes of different elements of the vehicle, etc. Therefore, the existence or the absence of the diagnostic sign according to certain diagnosis D_i is not a reliable event ('1' or 'O'), and is observed with some conditional probability $P_{Di}(y_j)$.

2. Method of forecasting

We will make the calculation of the most probable diagnosis according to Bayes's formula [5–8] that is applied to diagnostics:

$$P_{yj}(D_i) = \frac{P(D_i)P_{D_i}(y_j)}{P(y_j)} \tag{1}$$

where $P_{yj}(D_i)$ – probability of D_i diagnosis while observing y_j parameter; $P(D_i)$ – probability of D_i diagnosis; $P_{Di}(y_j)$ – probability of y_j parameter observation under the D_i diagnosis; $P(y_j)$ – probability of y_j parameter observation according to all diagnoses.

During diagnosis, according to a complex of signs, the formula will be written in the same way, but instead of the single y_j parameter, the complex of y^* parameters will be considered.

The probability of the joint observation of the independent signs, which make up the analyzed complex of diagnostic parameters, can be expressed by the multiplication of the observation probabilities of each parameter under the considered diagnosis:

$$P_{D_i}\left(y_j^*\right) = P_{D_i}(y_1)P_{D_i}(y_2)P_{D_i}(y_3)...P_{D_i}(y_n) . \tag{2}$$

If there are no some signs in the complex, the multiplication has the absence probability of the diagnostic parameter $P_{D_i}\left(\tilde{y}_j\right) = 1 - P_{D_i}(\tilde{y}_j)$.

The observation probability of signs' complex, according to all diagnoses, is determined by the formula of total probability:

$$P\left(y_j^{\wedge}\right) = \sum_{l}^{m} P(D_i)P_{D_i}(y_j) . \tag{3}$$

Then it is necessary to consider the condition of the effective application of the diagnostics in vehicles faults detection [9, 10]:

$$\frac{C_f^D Q}{\overline{x}_f^D} + \frac{C_m(1-Q)}{\overline{x}_m} + \frac{C_D}{x_D} < \frac{C_f}{\overline{x}_f} + \frac{C_{MS}}{x_{MS}} , \tag{4}$$

where C_f^D – the average cost of refusal when using the diagnostics, rub; Q – the probability of the vehicle elements failures during the diagnostics existence; $\overline{x}_f^D$ – the average operating time of the malfunction under the diagnostics existence, km; C_m – the average cost of the scheduled maintenance, rub; $\overline{x}_m$ – the average operating time of the scheduled maintenance, km; C_D – the diagnosing cost, rub; x_D – the diagnosing frequency, km; C_f – the average cost of malfunctions according to the planned system of the maintenance service (MS), rub; $\overline{x}_f$ – the average operating time of the malfunction according to the planned system of the MS, km; C_{MS} – the cost of the MS, rub; x_{MS} – frequency of the MS, km.

3. Experimental research

Observing the big group of the Lada Kalina cars, we have established how often we meet the diagnoses $P(D_i)$ that we are interested in and with what probability there are diagnostic parameters $P_{Di}(y_j)$ accepted for the developed system (figure 1).

Figure 1. Diagnosis of Lada Kalina.

During the experimental researches for the probabilities determination of various signs observation the diagnosing results of the faults in the Lada Kalina cars are presented in table 2.

Table 2. Results of experimental research

Diagnosis	Probabilities of diagnostic parameters					Probability of the diagnosis $P(D_i)$
	$P_{Di}(y_1)$	$P_{Di}(y_2)$	$P_{Di}(y_3)$	$P_{Di}(y_4)$	$P_{Di}(y_5)$	
D_1	1.0	0.8	0.9	1.0	0.2	0.05
D_2	0.9	0.7	0.9	0.0	0.2	0.10
D_3	0.6	0.1	0.9	0.1	0.9	0.30
D_4	0.1	0.1	0.0	0.1	0.0	0.55

As we use the probabilistic approach, one more diagnosis is added to three diagnoses mentioned above (table 2). This diagnosis forms the full group of events, the D_4 diagnosis means other possible malfunctions.

We made the diagnosis for the car with the complex of signs: uneven engine operation − y_1, the incomplete fuel combustion − y_2, obstructed or impossible engine starting − y_4, other diagnostic parameters are not observed (noted by the sign '~') i.e.:

$$y = \{y_1, y_2, \tilde{y}_3, \tilde{y}_4, \tilde{y}_5\}. \tag{5}$$

Using the data from table 2, we will calculate the diagnoses probabilities for the complex of the diagnostic parameters $y^* = \{y_1, y_2, y_3, y_4, \tilde{y}_5\}$.

As a result, we will receive $P_{y^*}(D_1) = 0.849$; $P_y(D_2) = 0$; $P_y(D_3) = 0.00477$; $P_y(D_4) = 0.146$.

On the basis of the calculations according to the data of the experimental researches we can say that for the car with the set of signs, corresponding to the set complex of diagnostic parameters, the most probable diagnosis is the first one: fault of electrical equipment elements (figure 2).
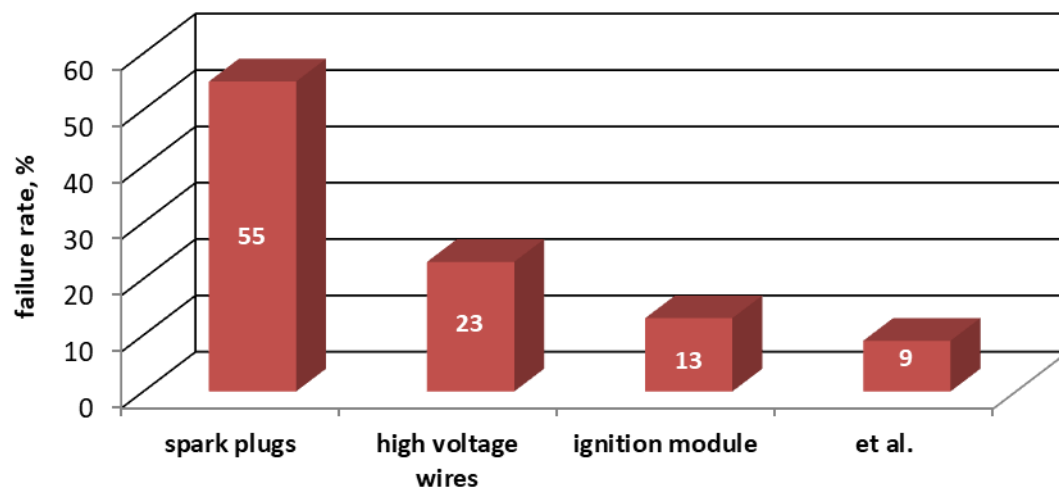
Figure 2. Fault of electrical equipment elements.

The most common problem is the failure of spark plugs (figure 3).

Figure 3. Faulty spark plugs.

4. Conclusion

The coking of piston rings is almost improbable, it is a little probable if the engine valves are not adjusted. If the first diagnosis is not confirmed while checking the engine, then the fourth diagnosis will be the second in order of importance: the fault cause of the engine of the Lada Kalina car is in something else.

The obvious condition of the diagnostics efficiency is the significant decline of the failures' probability of nodes, units and vehicles in general and also the exception of incorrect scheduled maintenance that is reached under the qualitatively perfected system of diagnosing. Aiming diagnostics when controlling the most important nodes, units and systems of the vehicle it is possible to reduce the cost of failures.

The diagnostics efficiency depends largely on the variation coefficient of operating time to the limit condition of the vehicle elements. At rather stable values of this operating time it is possible to predict reliably the moment of failure and in due time to carry out the maintenance service (MS) and also to plan in advance the costs of buying necessary repair parts [9–18].

References
[1]   Kuznetsov E S 2004 *Technical Operation of Cars* (Moscow: Transport)
[2]   Fastovtsev G V 1989 *The Organization of Maintenance and Repair of Cars* (Moscow: Transport)
[3]   Kubarev A I 1989 *Reliability in Mechanical Engineering* (Moscow: Izd-vo standards)
[4]   Karagodin V I and Mitrokhin N N 2001 *Repair of Motor Vehicles and Engines* (Moscow: Skill. ouch. school)
[5]   Fomina E V, Kozhukhova N I, Sverguzova S V and Fomin A E 2018 Application of mathematical model methods for optimization tasks in construction materials technology *J. of Physics: Conf. Series (Electronic Materials vol 1015)* ed E Schöll (UK: Institute of Physics and IOP Publishing Limited) 052015
[6]   Glushchenko V V 2018 Modeling methods of technical services for transport operation *J. of Physics: Conf. Series (Electronic Materials vol 1118)* ed E Schöll (UK: Institute of Physics and IOP Publishing Limited) 012016
[7]   Gnedenko B V, Belyaev Yu K and Soloviev A D 1965 *Mathematical Methods in Reliability Theory* (Moscow: Nauka)
[8]   Wentzel E S 2001 *Probability Theory* (Moscow: Vysshaya Shkola)
[9]   Bulatov S V 2018 Expense management of transmission spare parts taking into account their quality for rolling stock *Journal of Physics: Conference Series (Electronic Materials vol 1118)* ed E Schöll (UK: Institute of Physics and IOP Publishing Limited) 012011
[10]   Goryaeva I A and Goryaeva E N 2012 Dependence of costs on spare parts on the age of the rolling stock of motor vehicles *Herald of SUSU* [in Russian – Vestnik Yuzhno-Uralskogo gosudarstvennogo universiteta] **44(24)** 185–186
[11]   Gise R 1991 Modern concept of complex management of circulating material resources *Motor Transport Enterprise* **3** 105-107
[12]   Gordon M 1994 *Logistics* (Moscow: Transport)
[13]   Boutellier R 2006 *Strategy and Organization of Supply* (Moscow: KIA center)
[14]   Lukinsky V S, Berezhnoy V I and Berezhnaya E V 2004 *Logistics of Road Transport* (Moscow: Finance and statistics)
[15]   Berezhnaya E V 1994 *Forecasting on the Basis of Time Series* (Stavropol: SGTU)
[16]   Schonberger R 1988 *Japanese Methods of Management of Production* (Moscow: Economics)
[17]   Bulatov S V 2018 Requirement definition of passenger motor transport enterprises for spare parts by method of short-term combined forecasting *Journal of Physics: Conference Series (Electronic Materials vol 1015)* ed E Schöll (UK: Institute of Physics and IOP Publishing Limited) 052004
[18]   Kruglov M G, Sergeev S K and Taktashov V A 1997 *Management of Quality Systems* (Moscow: IPK Publishing house of standards)