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Impact of parasite resistance on operation of ignition system in motor vehicle

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Summary. The paper presents the impact of parasite resistance occurring as the result of ageing of elements, humidification of the vehicle electric system or physical damage on the correct functioning of ignition systems in motor vehicles. The methods have been presented for detecting this type of failures and for analyzing the obtained results. The tests have been performed by means of typical diagnostic instruments available in every motor vehicle diagnostic *station. The mechanical and electronic* ignition systems have been used for testing. Furthermore, the paper presents the system proposed in order to automatically detect small changes in the resistance significantly affecting the functioning of the whole ignition system.

Key words: resistance, ignition system, ignition coil, ignition advance angle, oscillogram.

INTRODUCTION

The automotive electric and electronic technologies were developed parallel to combustion engines over the last century. This process encompassed the following basic phases: the development of electrical ignition systems and electric energy sources, the application of electrical lighting and starting methods. In spite of such dynamic progress, an average car today resembles its design from those years in one respect: most troubles are associated with still unreliable mixture ignition. However as a result of the introduction of electric and electronic solutions it was possible to resolve many problems associated with the construction of ignition systems.

The conditions of work as well as more and more stringent legal regulations in the scope of the equipment and requirements in the scope of safety and reliability of motor vehicles constitute big challenge to their designers and manufacturers. The electrical installation of a motor vehicle shall meet the conditions described in relevant standards [18, 19, 20]. Their scope encompasses the following features [4, 5, 6, 9]: operational and fire protection safety, durability, reliability, simplicity, resistance to vibration, humidity, shocks as well as to extremely high and low temperatures. Simultaneously these devices shall be characterized by low manufacturing costs, parts interchangeability as well as small sizes and weight. Incorrect functioning may result in vehicle immobilization or, in certain cases, even in hazard to persons travelling in the car and to other road users. Therefore the capability to get a correct diagnosis and to repair an element in accordance with proper procedure is extremely important in case of a failure. In order to achieve this goal, it is necessary to combine relevant diagnostic parameters with the vehicle element under testing [12, 13].

Owing to difficult working conditions in vehicle electrical installation, its failures are possible as a result of an additional resistance called parasite resistance occurring in these systems. The parasite resistance is generated under the influence of ageing electrical elements of vehicles, high air humidity or physical damages. These damages frequently result in the inefficiency of the whole circuit. In case of the ignition system, this inefficiency may lead to the engine immobilization. The value of resistance causing such inefficiencies may be equal to only a few ohms.

THE CHARACTERISTICS OF IGNITION SYSTEMS UNDER TESTING

The ignition of fuel and air mixture is the basic condition required for engine operation. Furthermore this ignition shall take place at proper time. The achievement of rated operating conditions of the motor vehicle i.e. proper engine power, durability, emission characteristics and fuel consumption [13, 16] is warranted in case of correct operation of this system. Therefore the symptoms of this system failure can be observed already in course of the operation. It must be remembered that the reasons and symptoms of specified inefficiency depend mainly on the ignition system design applied in this vehicle. The application of electronic control in the ignition systems [1, 2, 16], new designing and simulation techniques [10, 11, 15], new design solutions as well as the creation of diagnostic procedures using the hardware operating in OBD standard [7, 8] made it possible to significantly increase the reliability of these circuits. However it was impossible to completely eliminate the problems in course of their diagnosing.

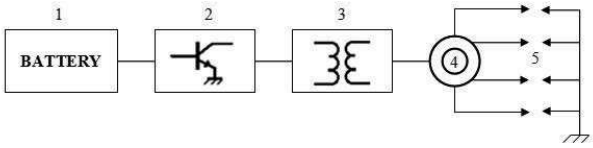


Fig. 1. Mechanical ignition system with an electronic interrupter: 1 – battery, 2 – ignition module, 3 – ignition coil, 4 – high tension distributor, 5 – spark plugs

Two popular ignition systems applied in passenger cars have been used in the tests i.e. (i) mechanical ignition system with high tension distributor and with an electronic interrupter (Fig. 1) and (ii) electronic ignition system without distributor and with individual ignition coils for each cylinder (Fig. 2).

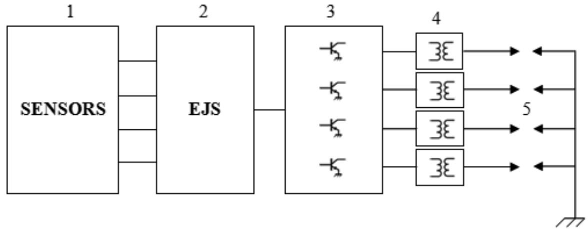
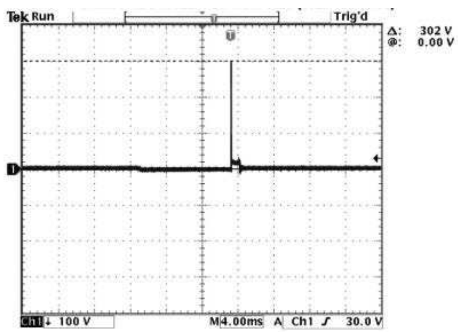
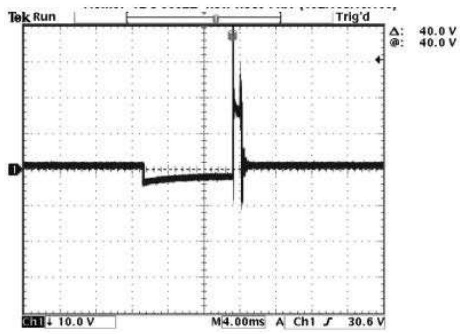
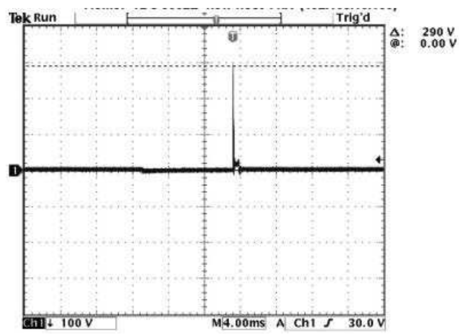
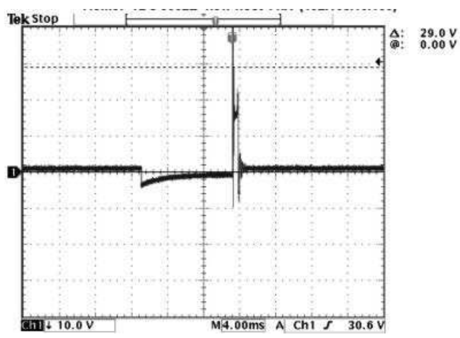
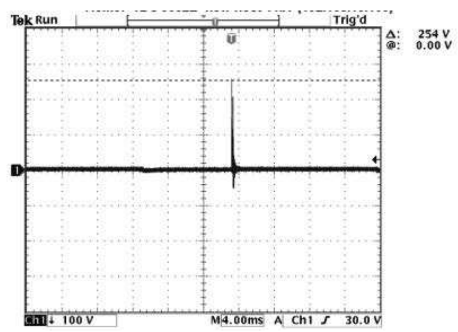
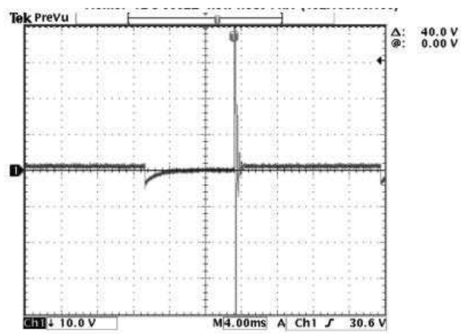
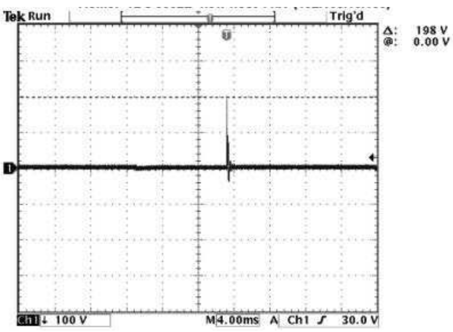
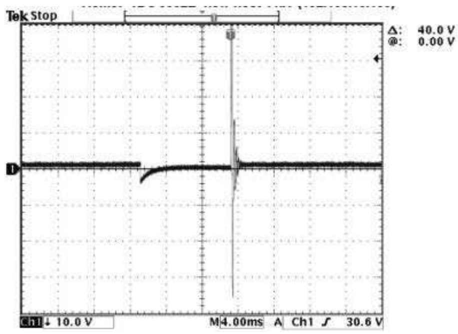


Fig. 2. Electronic ignition system with individual ignition coils for each cylinder: 1 – sensors, 2 – engine controller, 3 – ignition module, 4 – ignition coils, 5 – spark plugs

The parasite resistance was simulated in the both systems by means of a slide resistor connected between the ignition module and ignition coil (on low voltage side).

Table 1. Oscillograms on the low voltage side of mechanical ignition system

Value of parasite resistance	Voltage oscillogram on primary side of ignitron coil	Voltage oscillations oscillogram in course of spark discharge
0 Ω		
0,7 Ω		
2,2 Ω		

4,0 Ω (no spark discharge)		

Such location of parasite resistance has been applied in order to determine the impact of an additional resistance occurring in the conductors, on the contacts or ignition coil on the functioning of the whole circuit.

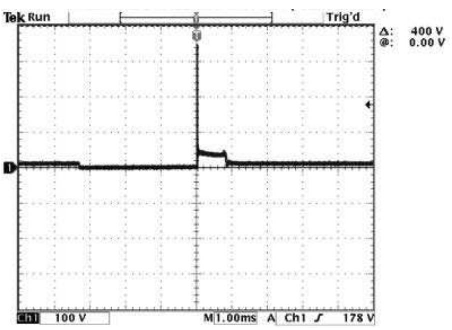
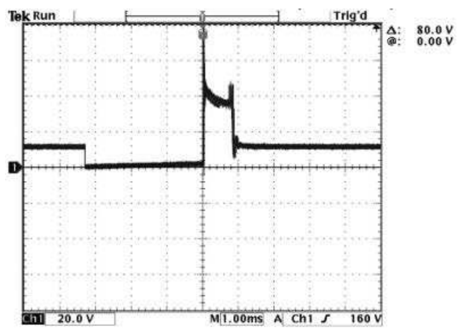
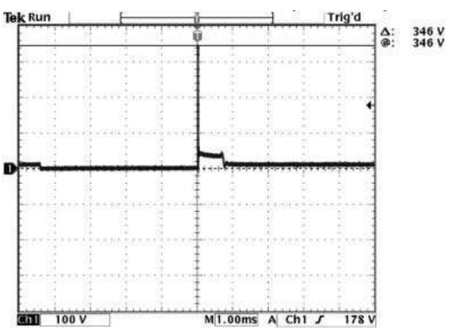
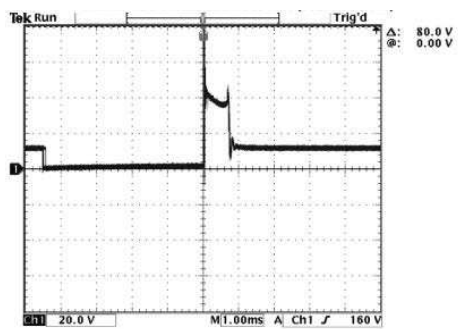
The preliminary tests revealed that there was no significant impact of the resistance change on high voltage side on the correct operation of the ignition system. Furthermore no symptoms indicating to this type of failure have been recorded in the installations equipped with OBD airborne diagnostic system.

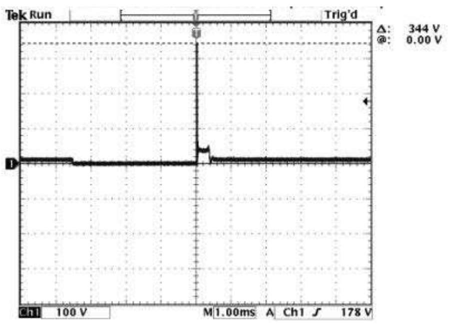
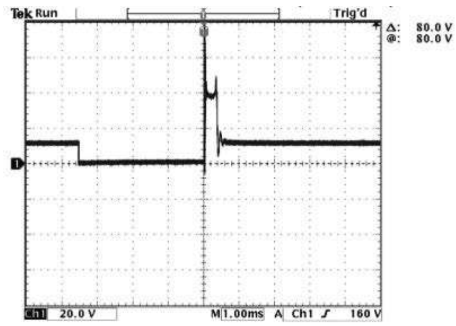
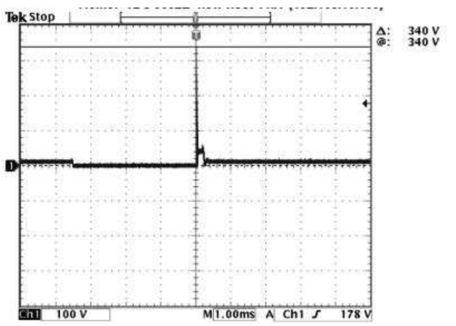
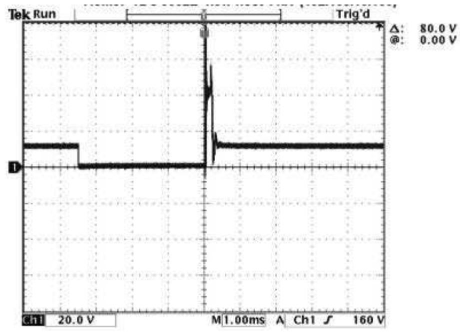
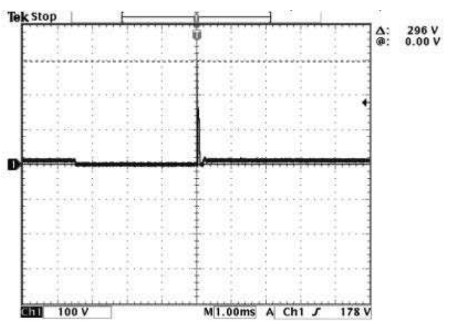
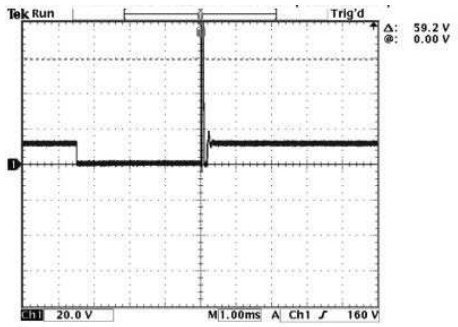
LABORATORY TESTS

The occurrence of parasite resistance in the low voltage circuit of the ignition system may contribute to unstable engine operation or even to the lack of fuel and air mixture in case of high values of parasite resistance. On the basis of the shapes of oscillograms obtained on the low voltage side of the ignition system, it is possible to determine the accurate value of parasite resistance as well as its limit value as the determinant to qualify if the system is efficient or not. The examples of curves for mechanical and electronic ignition system are illustrated in Tables No 1 and 2. The determination of corresponding parameter and its combination with the type of failure makes it possible to create a diagnostic monitor which will be used for automatic detection of the value of parasite resistance its impact, using OBD airborne diagnostic standard.

Analyzing the obtained results, we can see certain repeatability of measurements regardless of the con-

Table. 2. Oscillograms on the low voltage side of electronic ignition system without distributor

Value of parasite resistance	Voltage oscillogram on primary side of ignitron coil	Voltage oscillations oscillogram in course of spark discharge
0 Ω		
0,9 Ω		

2,7 Ω		
3,9 Ω		
6,6 Ω (no spark discharge)		

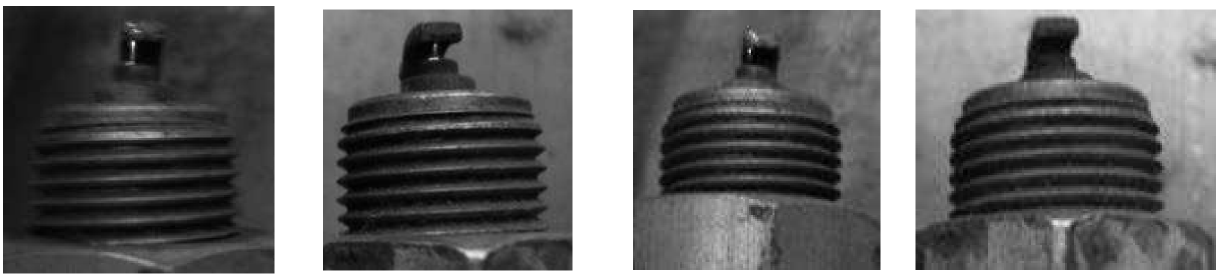
struction and generation of applied ignition system. Two parameters can be used in order to determine the of parasite resistance and to qualify the system as inefficient, i.e. (i) voltage "peak value" in course of discharge as the parameter significantly reducing its value if an additional resistance occurs (ii) another method consists in the analysis of the shape of oscillations occurring after electric discharge on spark plug.

The impact of parasite resistance discussed above on the shape and distribution of the spark between electrodes of the spark plug has been illustrated in Fig. 3. The impact of energy supplied to spark plugs is crucial for reliable ignition of fuel and air mixture. Its reduction directly contributes to unstable operation of the combustion engine as well as to increased levels of toxic compounds emitted by the vehicle into the ambient atmosphere.

CONCLUSIONS

The application of electronic control systems in engine operation contributed to the increase of reliability of the circuits responsible for the ignition of fuel and air mixture. However it was impossible to eliminate all

a) b) c) d)



e) f) g) h)

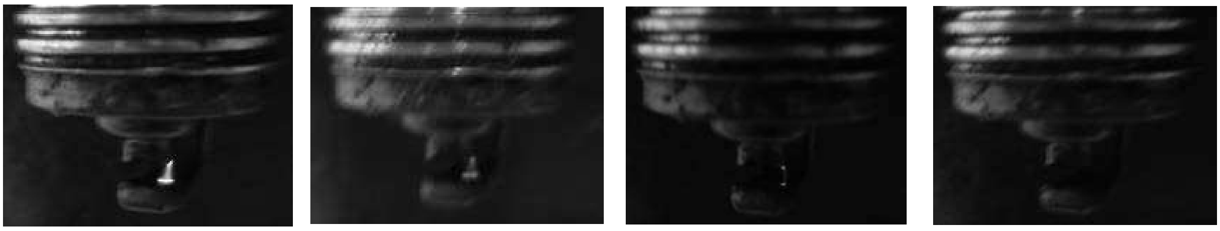


Fig. 3. Spark discharges on spark plugs for various values of parasite resistance: (mechanical system) - a) 0Ω; b) 0,7 Ω; c) 2,2 Ω; d) 4 Ω; (electronic system without distributor) - e) 0 Ω; f) 0,9 Ω; g) 3,9 Ω; h) 6,6 Ω

problems. From the tests presented in this study it appears that the ignition energy is significantly affected by an insignificant value of parasite resistance occurring in the low voltage circuit of ignition system. Such failures are possible as the result of ageing of elements, humidification of the installation or physical damages. The diagnostics of such failures and their localization is extremely difficult.

A possible solution consists in the combination of corresponding diagnostic parameter (in this case the value of ignition voltage on primary side of ignition coil) with the value of parasite resistance at which the ignition system ceases to operate correctly. Therefore it is possible to create a diagnostic monitor automatically detecting this type of failure and operating in OBD standard. Furthermore, the risk of vehicle immobilization caused by an incorrectly operating ignition system could be reduced in case of application of CAN or LIN communication bus [3, 17].

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WPŁYW REZYSTANCJI PASOŻYTNICZEJ NA DZIAŁANIE UKŁADU ZAPŁONOWEGO SAMOCHODU

S t r e s z c z e n i e . W artykule przedstawiono wpływ rezystancji pasożytniczej powstającej pod wpływem: starzenia się elementów, zawilgoceniem instalacji elektrycznej pojazdu lub uszkodzenia mechanicznego, na poprawną pracę układu zapłonowego pojazdów samochodowych. Przedstawiono sposoby wykrywania tego typu uszkodzeń oraz analizowania otrzymanych wyników. Badania przeprowadzono za pomocą typowych przyrządów diagnostycznych znajdujących się w każdej stacji kontroli pojazdów. Do badań wykorzystano mechaniczny i elektroniczny układ zapłonowy. W artykule podano ponadto propozycję układu automatycznie wykrywającego niewielkie zmiany recytacji, które znacząco wpływają na działanie całego układu zapłonowego.

S ł o w a k l u c z o w e : rezystancja, układ zapłonowy, cewka zapłonowa, kąt wyprzedzenia zapłonu, oscylogram.