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RELIABILITY AS CAR PARTS` QUALITY MEASURE

Reliability of a car depends from of its systems, subsystems and parts' reliability which have direct and indirect impact on the final product's quality.

Reliability of a car depends on the reliability of its elements and these are linked together forming specific systems. So, impairment or malfunction of only one of these elements influences in a specific way some other elements, and the other way round which depends upon the system of arrangement (in series or in parallel).

NIEZAWODNOŚĆ JAKO MIARA JAKOŚCI ELEMENTÓW POJAZDÓW SAMOCHODOWYCH

W pracy powiązano trwałość i jakość eksploatacyjną pojazdu samochodowego, będącego zbiorem zespołów, układów i szeregu części, z niezawodnością.

Hierarchiczne uporządkowanie podziału strukturalnego elementów pojazdu, umożliwia przybliżenie złożonego problemu niezawodności i zrozumienie istotnych czynników wpływających na jego ocenę.

1. INTRODUCTION

A car, being a mechanical object, characterizes with certain durability and preparedness to exploitation. These qualities prove its reliability.
Mechanical objects can be divided into:

- objects without any standards of durability and reliability,
- objects characterized by high reliability and low durability (spacecraft, military vehicles),
- objects characterized by very long durability and indefinite reliability which can be repeatedly repaired (building machines),
- objects of both high reliability and long durability among which you can surely find a car.

Quality of a mechanical object is understood as a group of features and proprieties of a product or services deciding about the abilities of the product or service to fulfill some stated

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and expected needs. In case of general requirements (technical, economical, exploitative or market requirements) we can speak about total quality, though it is more common to talk about exploitative one, which is understood as level of consumers' requirements satisfaction.

The requirements are mainly connected with vehicle functioning, safety of exploitation, reliability, durability and its technical preparedness.

Reliability of a vehicle is mostly defined as probability that its durability T is longer than the time t given in technical description, R(T,t).[1] According to Polish Standards reliability is defined as a mechanical vehicle propriety characterizing its ability of exploitation and operation in certain defined conditions and a defined period of time.

2. EXPLOITATIVE QUALITY OF A CAR

Quality of a car is a function of quality of its production stages, which are: the conception, the project, the description of records, the materials, the production technology, the exploitation, the possibility to scrap and the utilization.

Costs have a lot to do with quality of a vehicle. We generally divide the costs into the costs of production K_1 and the costs of exploitation K_2 (Figure 1.)

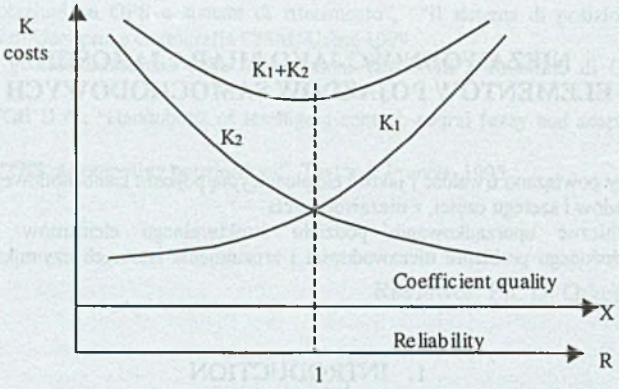

Fig.1. Dependence of costs production and exploitation object from his quality/ reliability, 1- optimum economically quality and reliablity object

A producer estimates a car's quality by the level of its structure adaptation to production. A user of a car, on the other hand, will consider good such a car that is able to satisfy their requirements of exploitation.

Total quality features of a car can be divided into two groups:

- The group of determined (permanent) features, whose parameters are not dependent upon time, the spectrum causing physical aging and exploitation conditions, eg shape and size of a car, a number of seats in a passenger car, load capacity in tones and the size of truck load platform.

- The group of scholastic features (chance dependent), whose parameters change, together with the spectrum of aging (the influence of exploitation conditions), in the wrong direction for exploitation quality (reliability, durability, repair susceptibility and other).

Exploitation quality can be symbolically presented:

$$J_E = \left(\frac{N}{N_w}; \frac{T}{T_w}; \frac{P_N}{P_{NW}}; \frac{H_T}{H_{TW}}; \frac{E}{E_w}; \frac{K}{K_w}; \frac{S}{S_w}; \frac{Z_{pT}}{Z_{pTW}}; \frac{G_j}{G_{jw}} \ldots \right) \quad (1)$$

where:

N -exploitation reliability of a car,
T -exploitation durability of a car,
P_N -service and repair susceptibility of a car,
H_T -transport efficiency of a car,
E -exploitation economy,
K -driving comfort,
S -exploitation effectiveness of a car (maximum speed, optimum driving speed, acceleration, load capacity, manageability, etc;),
Z_{pT}-coping with ground conditions,
G_j -weight of a car (t/HP). UNIT individual

Only some of the parameters are chosen to evaluate a car's exploitation quality.

Objective and explicit evaluation of a product is possible only with the use of special instruments allowing quantitative evaluation of quality. The work [2] suggests adaptation of a 10-class and 5-level scale of quality evaluation (Table 1).

Table 1

Quality evaluation scale

Object quality levels		Object quality class		State evaluation	Rate variation
Description	Number	Description	Number		
Excellent	1	Excellent	1,0	Very advantageous	max.
		Outstanding	0,9		
Normal	0,75	Advantegeous	0,8	Advantageous	
		Good	0,7		
Average	0,5	Mild	0,6	Neutral	optimal
		Neutral	0,5		
Not enough	0,25	Not good	0,4	Disadvantageous	
			0,3		
		Disadvantageous	0,2		
Bad	0	Bad	0,1	Very disadvantageous	min.
		Very bad	0		

3. EXPLOITATION DURABILITY OF A CAR

Exploitation durability in case of a mechanical object is a feature characterizing its ability to stay effective in use and operation till it reaches its stipulated fringe benefits.

Durability of a car means its ability to maintain to some normative qualities/values and some essential exploitation values in a generalized time. The durability, speaking in general, can be presented as:

$$T_w(t) = \varphi\ [(R(t)\ ,W(t)\ ,\ D(t)\ ] \tag{2}$$

where:

R(t) -reliability of a car as chance occurrences of its parts' fringe benefits,
W(t) -spectrum of extorted physical aging of a car,
D(t) -resistance of car parts to extortion.

Processes of aging that determine car parts' durability (crank-shafts, connecting rods, blocks, gear-wheels, bodies, etc.) are found in the surface layer, and the intensity of aging processes depends on extortion spectrum character, on material resistance to extortion and the production technology of the parts. Reliability as a general term is used to describe a car's preparedness and some factors such as non-impairment, operational ability, provided service.

Durability of a car part is understood as its ability of exploitation in conditions of proper technical service. It characterizes with: a period of work time, a number of rounds, amount of done work or length of covered distance by a vehicle from the beginning of its exploitation to the moment it reaches its fringe benefits.

4. RELIABILITY OF A CAR

Reliability of a car is its feature understood as its ability to fulfill all the requirements in some defined state of effectiveness and non-effectiveness in certain conditions and certain period of exploitation. In the normative sense, reliability is understood as probability requirements fulfillment in some defined quality limits of some essential exploitation quantities.

In reliability estimation a car is treated as a system of units and elements. There are two elementary systems of arrangement: in series and in parallel. The elements of a system are arranged in series in the sense of reliability if an impairment of one element causes the impairment of the whole system. Elements are arranged in parallel in the sense of reliability, on the other hand, if an impairment of a system equals the impairment of all the elements in the system.

A car being a system of elements forming infallible in series and in parallel structures remains efficient if at least k number of its n number of elements are efficient. Reliability of such an object can be presented by the expression:

$$R\frac{k}{n} = \Sigma(-1)^{i-k}\left(\frac{i-1}{i-k}\right)\Psi(R_1 \ldots\ldots R_n) \tag{3}$$

where:
$R_1...R_n$ – reliability of object elements,
$\psi(R_1...R_n)$ – the sum of products whose factors combine with $R_1...R_n$ after i eg for i=1, 2, 3, 4 and $n = 4(R_1...R_4,1) = R_1 + R_2 + R_3 + R_4$, $(R_1...R_4,2) = R_1R_2 + R_1R_3 + R_1R_4 + R_2R_5 + R_2R_4 + R_3R_4$, $(R_1...R_4, 3) = R_1R_2R_3 + R_1R_2R_4 + R_1R_3R_4 + R_2R_3R_4$, $(R_1...R_4,4) = R_1R_2R_3R_4$

In case of an object of engineering, forming an in series structure, reliability of the object built of n number of elements, (k=n) is:

$$R_{\frac{n}{n}} = \prod_{i=1}^{n} R_i \tag{4}$$

And as far as in parallel structure is concerned, in case of an efficient object where k=l, reliability equals:

$$R_{\frac{1}{n}} = 1 - \prod_{i=1}^{n} (1 - R_i) \tag{5}$$

One-circuit brake car system is an example of an in series structure element. It consists of a brake pump, lines, right and left front brakes and right and left back brakes. Each wheel's brake consists of brake jaws, a spring, a stretcher and brake drum. The efficiency of the system is dependent on the efficiency of its all structure parts.

The system of stoplights in a car is both in series and in parallel system. Its structure consists of two lights and a switch. The lights are arranged together in parallel while each of them is connected to the switch in series. Neither of the lights working means that the whole system is out of order. A single light working means that the system is efficient but not working properly.

A car, being a complex and repairable object, can be divided into functioning systems which are separate to some extend (Table 2). The systems are arranged in series from the perspective of reliability. Each system can be divided into subsystems and parts that can be of in series, in parallel or both in series and in parallel structure.

Reliability estimations of automotive vehicle execute on the base suitable balances, determined important levels car systems.
Arrangemented on the base [7] proper balances suitable systems and componenet of car.

Table 2

Functioning systems of car reliability [7]

Type systems	Component systems	% defect systems
ENGINE	Engine block Cylinder head Crankshaft Valve gear Oil pump, oil sump Oil filter Suction manifold, Exhaust manifold Exhaust silencer	8,41
FUEL SYSTEM	Air filter Carburettor Fuel pump Petrol tank	10,77
COOLING SYSTEM	Water pump Thermostat and cooling fan Water cooler	
CARRYING SYSTEM	Frame Suspension engine Rear axle Front axle and wheel hub front Wheels	3,8
SUSPENSION SYSTEM	Springs front Liquids springs Springs back	3,95
ELECTRICAL SYSTEM	Generator Current voltage regulator Starter Distributor, Ignition coil, sparks Electrical equipment	26,11
STEERING SYSTEM	Steering rood Steering mechanism	11,36
BREAKING SYSTEM	Compressor Breaking pump hydraulic Clutch pedal and break Breaking hydraulic Power brake mechanism Pressure regulating with safety valve Hand brake	7,26
MOTOR CAR BODY	Driver`s cab Open load carrying body	21,03

Table 3

Choice criterions of reliability cars and their elements

OBJECT LEVELS	OBJECT	Criteria reliability
1	Elements not repair of special high reliability	1. Maximum failure rate. 2. Maximum service life to exchange.
2	Elements (parts and component) car dependent exchange after first damage and not qualification to classes 1	1. Medium mileage to exchange. 2. Mileage gamma percentage to exchange. 3. Failure rate.
3	Parts, component and units, which in exploitation can have more then one damage, eliminate by regeneration, regulation, cleaning, washing, etc.	1. Medium mileage between damages. 2. Medium mileage to exchange. Mileage gamma percentage to exchange. 3. Medium laborious repair on all time of work.
4	Units and car sytems repairing,, composite from many elements	1. Medium mileage between damages. 2. Medium total mileage to major repair. 3. Mileage gamma percentage to major repair. 4. Parameter stream damages on mileage unit. 5. Medium laborious service or repair on mileage unit and for all time of work to major repair. 6. Medium costs service and repair on mileage unit and for all time of work to major repair.
5	Complete car	1. Parameter stream damages on mileage unit. 2. Medium total mileage to major repair. 3. Mileage gamma percentage to major repair. 4. Function service and repair car. 5. Medium laborious technical services and repairing. 6. Medium time standing in technical services and repairing. 7. Medium cost parts. 8. Medium cost technical services and repairing. 9. Coefficient technical ready.

Reliability can be described using the following factors: stream of impairment density (λ), average covered distance between impairment cases (L), distance covered before wrecking (R_k), a period of stop page in cases of inefficiency (T_N) and other.

The presented structural division makes it possible, after the elaboration of certain characteristics and reliability factors, to put all car elements in the hierarchical order which takes into consideration their influence on reliability and weak links evaluation. It should be marked here, that an element C which is the weakest link in Z subsystem or U system does not have to be the weakest link in the whole vehicle at the same time. It can be an element C_1 which in fact is the weakest link in the whole car itself and at the same time the weakest link in a subsystem Z_1 or a system U_1.

5. CONCLUSIONS

Quality measure being quantity of reliability and durability (given in numbers) determine certain car parts' quality and at the same time the whole vehicle's quality.

Exploitation quality of a car can be evaluated on the basis of exploitation characteristics quotients of a car which is a subject of research and an exemplary one.

Notion qualities is understood for evey man in different way in dependences from needs, tastes and economic consideration, because necessary is application standardized criterions estimation of quality.

Quality measures being with measures numerical reliabilities and durabilities, qualify quality each of elemnets automotive vehicle and in consequence also all car.

Exploitation quality of automotive vehicle one can estimate on rule creation quotient each exploitation characterizations car of considered and standard.

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