International Journal on
"Technical and Physical Problems of Engineering"
(IJTPE)
Published by International Organization on TPE (IOTPE)

ISSN 2077-3528
IJTPE Journal
www.iotpe.com
ijtpe@iotpe.com

March 2011	Issue 6	Volume 3	Number 1	Pages 38-44

METHOD FOR DETERMINATION OF VEHICLE TRAVEL SPEED ON THE BASIS OF STOCHASTIC UNCERTAINTIES

A.A. Allahverdiyev

Azerbaijan Technical University, Baku, Azerbaijan, afik_allahverdiev@mail.ru

Abstract- The present research represents an analysis of the method for determination of automobile travel speed on the basis of stochastic uncertainties. As is known, it is impossible to solve such tasks using traditional methods of classical mathematics, while the proposed method provides an easy solution to this complex problem.

Keywords: Transportation, Automobile Travel Speed, Probability, Fuzzy Set.

I. INTRODUCTION

Due to a transition to the market-driven economy, timely delivery of cargo to the consumer is assuming great importance. Solution of this problem to a large extent depends on the technical speed of a motor vehicle. The currently used methods for determination of a motor vehicle's technical speed have a number of drawbacks:

- The normative travel speeds are not differentiated from the standpoint of design parameters of modern motor vehicles and do not correspond to their traction capabilities;
- The average technical speeds established on the basis of natural and statistical researches are valid only for observation conditions. They do not take into consideration random disturbance and require a lot of time for the processing of statistical data;
- Dynamic characteristics do not lead to the output of specific numerical values of a motor vehicle's average speeds on the basis of random factors, because the speed is determined in strictly fixed and almost ideal conditions. The methods for the calculation of maximum allowable travel speeds are particularly convenient when assessing the impact of permanent parameters of roads on the mode of motion.

Therefore, the deterministic approach to the establishment of a travel speed leads to inadequate models of a real situation.

II. PROBLEM STATEMENT

The analysis of literary sources has revealed that unfortunately unified regulations for the calculation of motion speed, which would take into consideration the road, atmospheric, climatic and transport conditions, have yet to be developed in vehicular transportation [3].

As is evident from the analysis of the problem status, the standardization of average speeds on road freight transport is not being used properly at present. As a result, this important indicator is mostly determined by the driver not on the basis of technical capacities of a motor vehicle or specific service conditions, but using intuition and experience. This can partly be explained by the fact that the existing methods do not allow the determination of average speeds determined by capacities of a motor vehicle on the basis of the whole range of objective and subjective factors affecting the motion of a vehicle.

Consequently, the need has emerged to develop a method for the calculation of average speeds on the basis of technical capacities of a motor vehicle and uncertainties, as well as randomly changing real factors. The development and practical use of the method, which is intended to attain end results through extensive application of computers, is one of the priority tasks in the development and enhancement of motor transport.

Standardization of motion speeds using computers represents tremendous interest. This requires, along with the design of this method, development of software using computer facilities for prompt determination of the average speed of a motor vehicle.

III. METHOD OF SOLUTION

To determine an average motion speed, every route is divided in sections with characteristic indicators: type and evenness of the road surface, condition of the road surface, slopes of sections, coefficient of rolling resistance and tire grip on the road, plan and profile indicators, availability of traffic management signs, intensity of traffic, etc.

Solution of the tasks is determined by the possibility to highlighting the route sections which are covered in a certain transmission. This is achieved by comparing specific external resistance with traction capacities of a motor vehicle in a certain transmission.

The analysis held has shown that at every section of the route the speed of a motor vehicle represents a function of permanent and random factors. Therefore, the value of speed can be described by a distribution law. The difficulty is that laws which could help record changes in motion factors are not established. Due to the random nature of these factors they can only be probabilistic.

It is known that random factors are described by probability theory laws sufficiently well. The distribution laws discovered can be successfully used to create methodologies for the calculation of average speeds. As the case with any random variable, speed will be characterized by average value. It is worth mentioning that in essence speed represents a whole set of characteristics, including qualitative.

For instance, it is known that no road surface can be absolutely even. Even the latest asphalt concrete surfaces have bumps up to 1 cm high. Such roughness creates additional resistance to motion. The form of bumps, their sizes and location have a random nature and defy analytical calculations. Therefore, the evenness of a surface is determined in an experimental manner.

According to the methodology developed, the route is divided in consecutive sections with a length of $l_1, l_2, ..., l_m$ with slopes $\alpha_1, \alpha_2, ..., \alpha_m$, coefficients of rolling resistance and coefficients of adhesion with due consideration for road and climate conditions. On every section the motor vehicle with have a designed speed of motion of v_{ij}, which will depend, besides the said climate and organizational conditions, on the use of carrying capacity of the motor vehicle.

Solution of this task involves major difficulties because it is necessary to take into consideration a multitude of factors possessing random values associated, to a certain degree, with uncertainty and preconditioned by: impossibility to obtain information of the required degree of reliability, impossibility to formalize a number of factors.

During the transportation of a specific cargo along a route selected for a motor vehicle, the following manifest themselves as uncertain parameters: technical speed of motion, coefficients of rolling resistance and coefficients of adhesion. The known methods cannot be recommended for practical calculation of the average speed on the route.

To solve the problem, the proposal is to determine the coefficient of adhesion under the impact of climate conditions by the method of membership function formation in term values. The formalization of uncertainties will serve to increase the adequacy of calculations with real conditions of motor vehicle functioning.

The problem is solved on the basis of the following algorithm:

1. On this section the motor vehicle is to travel in a high transmission with maximum speed. To confirm supposition, relevant indicators are determined, namely: $N_{v\max}, n_{v\max}, M_{v\max}, P_{\psi}, P_w, N_{\psi}, N_w, k_N, D_{v\max}, \psi_{\alpha,v\max}$

2. Verifying whether the motor vehicle is capable of moving in the given road conditions in a high transmission with maximum speed. If yes, it is checked whether the motor vehicle can move without skidding. If it can, then the total road resistance coefficient is conditionally taken as being equal to the dynamic factor value as maximum, i.e. $D_{v\max} = \psi_c$

3. By comparing the dynamic factor and the total motion resistance coefficient values with due consideration for length of road sections, the average speed in each transmission and the time of motion in these transmissions are determined.

It is worth indicating that transmission shift into a lower gear is carried out if there is inequality afterwards. Apparently, to obtain a higher travel speed, the driver has to be well familiar with peculiarities of the route, i.e. the indicators of its characteristic sections, namely: $\alpha, f_0, \Psi, \phi, l_y, R_n, R_b, R_{boz}, S_b, \beta$ and allowable travel speeds in certain gears, moments when transmission has to be shifted. In all cases when road resistance coefficient is higher than one that can be covered in a given gear, transmission must be shifted and the maximum speed of a lower gear taken.

The travel speed for a motor vehicle is determined on the basis of its design parameters. In doing so, it is necessary to consider the speed limits established by rules of the road, operating capacities of a motor vehicle, road and climate conditions, and intensity of traffic.

The method for the calculation of average speed being developed in based on studying the impact of different factors, comparing the capabilities of a motor vehicle with resistance values, road surfaces which are characterized by resistance to motion. However, it must be pointed out that the speed of a motor vehicle on a given section is mainly determined by the capacities of the gear in which the section is being covered. The total time of motion on a route being considered will represent the total time of coverage of different sections.

Therefore, the total time in motion and the average speed of motion will depend on the time of motion in each gear. Thus, the average speed is mainly determined by the possibility of highlighting sections of the route covered in a certain gear. Obviously, this can be done by comparing specific external resistance with traction capacities of a motor vehicle in a certain gear. In other words, motion occurs in the first gear if the following condition is met: $D_{i+1} \le \Psi < D_i$.

If total resistance is higher than the maximum dynamic factor D_i, it is necessary to engage a lower (e.g. first) gear. If possible, the driver tries to engage a higher gear. Researchers conducted to this date have established that speed distribution curves in intense traffics have bell-shaped contours and correspond to the Laplace-Gauss normal distribution curve. The above leads to the conclusion that when a motor vehicle travels in first gear, the speed will be governed by the normal distribution law.

The mode of motion is significantly affected by such transportation and operational characteristics as evenness and surface adhesion coefficient. Resistance of motion depends on: type, slopes and the condition of highway structure, intensity and make-up of traffic, climate conditions, etc.

Changes in each of the factors on route sections are random from the driver's standpoint. For this reason, it is impossible to establish their exact impact on the speed of motor vehicles. The above factors have an impact on the condition of roads and motor vehicles, change the way the driver perceives traffic conditions, dangerously increase reaction time and distract the driver's attention. The greatest impact on the speed of motion is made by factors determining resistance of motion, such as motor car and highway structure.

In conducting practical calculations to determine traction and speed properties of a vehicle, the value of the coefficient of rolling resistance may mainly depend on the type of the road surface. The values of the coefficient of rolling resistance for different road surfaces have been determined and provided in many researches [2]. The value of the coefficient of rolling resistance changes in a sufficiently wide range for all road types. Also, the value of the coefficient of rolling resistance depends on the speed of a vehicle.

The real value of the average speed of motion obtained as a result of calculations first of all depends on whether the variable resistance of the road to motion is considered. The existing methodologies establish the speed on an ideal road with permanent resistance and without consideration of uncertainties and randomness, which is not sufficient because it is impossible to consider a number of real peculiarities of traffic.

The baseline data for the determination of average motion speeds of a motor vehicle are the permanent and variable data on the traffic route and the motor vehicle. Permanent data include: length of the route, number of route legs, type and condition of permanent parameters of the road surface, type and nature of the cargo being transported; type of a motor vehicle, carrying capacity and cargo load factor. Variable parameters include: coefficient of rolling resistance, slope ratio, weather and climate conditions and coefficient of wheel adhesion with the road bed, etc.

The mentioned indicators cannot be directly used to assess the effectiveness of motor vehicles. It is worth mentioning that standardization of average motor vehicle speeds using computers is not being used at present. The existing calculation methods do not produce the values of average speeds determined by a motor vehicle's capacities on the basis of all objective and subjective factors affecting its motion.

In general, the speed of motion must be calculated by the following formula:

$$v_t = \sum_{i=1}^{n} l_i / \sum_{i=1}^{n} (l_i / v_i) \tag{1}$$

where l_i is length of i section of road in km and v_i is technical speed of motion on i leg of the route in km/h.

For given road conditions it is necessary to determine which gear and at which speed motor vehicles can move. As a result, the average speed of motion and the hourly fuel consumption of a motor vehicle is determined by the formula:

$$Q_T\left(G_a, L, \overline{U}\right) = g\left(9.81\, G_a \varphi_{(v,\alpha)} + KF\overline{U}_2 / 12.96\right) / \left(36000\, \eta_{TP}\, \rho_T\right) \tag{2}$$

where

$$\overline{U}_i = f\begin{pmatrix} N_{\max}, M_{\max}, \Pi_N, \Pi_M, a, b, c, V_{\max}, \eta_{NT}, K, F, V_B, V_O, \\ r_k, i_k, i_o, G_a, G_c, G_{2T}, G_{2N}, l_1, l_2, l, q_H, j_c, f_\alpha, \alpha, \varphi \end{pmatrix}$$

Full weight of a motor vehicle with cargo:

$$G_a = G_C + q_H\, j_C \tag{3}$$

Maximum capacity of a motor vehicle:

$$N_{v\max} = V_{\max}\, i_n\, i_o / \left(0.377\, r_k\right) \tag{4}$$

Speed of a motor vehicle in a given gear:

$$V_e = 0.377\, N_e\, r_k / \left(i_k\, i_o\right) \tag{5}$$

Towing capacity on traction wheels:

$$P_T = M_{\max}\, i_k\, i_o\, \eta_{TP} / r_k \tag{6}$$

Air resistance power P_W at a given speed:

$$P_W = K_F\left(V \pm V_W\right) / 12.96 \tag{7}$$

Dynamic factor:

$$D = \left(P_T - P_W\right) / \left(G_C + q_H\, j_C\right) \tag{8}$$

at $\alpha_H \le \alpha \le \alpha_B$ and Slope distribution density:

$$f(\alpha) = \frac{1}{\sigma_\alpha \sqrt{2\tilde{n}}}\, e^{\frac{-(\alpha - m_\alpha)}{2\sigma_\alpha^2}} \tag{9}$$

where m_α is mathematical expectation of slopes on a given route and σ_α is average mathematical deviation of slopes from mathematical expectation.

Road resistance distribution density

$$f(\psi) = \frac{1}{\sigma_\psi \sqrt{2\tilde{n}}}\, e^{\frac{-(\psi - m_\psi)}{2\sigma_\psi^2}} \tag{10}$$

where

$$m_\psi = m_\alpha\left(0.0174 - f_0\, 1.52\, 10^{-4}\right) + f_0$$
$$\sigma_\psi = \sigma_\alpha\left(0.0174 - f_C\, 1.52\, 10^{-4}\right) \tag{11}$$

at α = const. Total road resistance considering speed of motion

$$\varphi_{(v,2)} = f_0\left(1 + 4.5\ 10^{-5}\ V^2\right)\left(1 - 1.52\ 10^{-4}\ \alpha^2\right) + 0.0174\alpha \tag{12}$$

where

$$P_C = \left(G_{2T} + G_{2N} + q_H\, j_C\, l_2\right) / \left(1 - 1.52\, 10^{-4} \alpha^2\right) \cdot \left[\varphi + f_0\left(1 + 4.5\, 10^{-5}\, V^2\right)\right]$$

Length of section S_j where gear i is engaged:

$$S_j = l_j / L,\ l_j = L\, P\left(D_{i+1} \le \psi < D_i\right) \tag{13}$$

Relative path in gear i:

$$S_j = \int_{D_{i+1}}^{D_i} f^i(\psi)\, d\psi \tag{14}$$

Using the normal distribution function

$$S_j = \varphi^*\left(\frac{D_i - m_\psi}{\sigma_\psi}\right) - \varphi^*\left(\frac{D_{i+1} - m_\psi}{\sigma_\psi}\right) \tag{15}$$

Average speed of a motor vehicle in gear *i*

$$\overline{U}_i = \int_{v_i - 1}^{v_i} V f_i(V)\, dv \qquad (16)$$

The average speed of a motor vehicle in gear *i*

$$\overline{U}_i = 0.5\left(V_i + V_{i-1}\right) \qquad (17)$$

Standard conditions may be recorded as:

$$L = \sum_{i=1}^{N} l_i \qquad t = \sum_{i=1}^{N} t_i \qquad L = \sum_{i=1}^{N} \overline{U}_i t_i \qquad (18)$$

$$g = g_{e_{N_{\max}}} K_{\Pi} K_n \qquad (19)$$

$$K_n = f(n),$$

$$K_n = 1.23 - 0.792\left(\Pi_{\overline{U}} / \Pi_{\max}\right) + 0.56\left(\Pi_{\overline{U}} / \Pi_{\max}\right)^2$$

It is worth mentioning that when determining the average speed of motion using given parameters, formulas (9) and (10) are not used. When calculating randomly changing parameters, such as slopes, total road resistance, formulas (9) and (10) are used.

IV. RESULTS

The simulation model developed ensures calculation of the motion speed of motor vehicles depending on different factors, namely those changing randomly. Separate results of research for Gaz 52-06 (with specific fuel consumption of 250 and specific weight of 0.72) are provided in the tables below. The travel speed of a motor vehicle and fuel consumption were calculated considering the resistance coefficient of carrying capacity, traffic resistance coefficient, ascending angle valuable of the road and intensity of traffic.

Table 1. Design parameters at f_0 = 0.020

f_0	U_K	D_{MAK}	V_{DM}	F_R	D_R	V_M	T_R	N_1	S_1	F_G
0.020	6.40	0.2424	2.34	0.020	0.242	7.8	0.85	6.40	0.65	0.2
0.020	3.09	0.1170	4.85	0.020	0.117	16.2	0.85	3.09	0.65	0.097
0.020	1.69	0.0639	8.88	0.020	0.064	29.6	0.85	1.69	0.65	0.053
0.020	1.00	0.0376	15.00	0.020	0.038	50.0	0.85	1.00	0.65	0.031

Table 2. Design parameters at f_0 = 0.050

f_0	U_K	D_{MAK}	V_{DM}	F_R	D_R	V_M	T_R	N_1	S_1	F_G
0.050	6.40	0.2424	2.34	0.023	0.242	7.8	0.85	6.40	0.65	0.2
0.050	3.09	0.1170	4.85	0.023	0.117	16.2	0.85	3.09	0.65	0.097
0.050	1.69	0.0639	8.88	0.023	0.064	29.6	0.85	1.69	0.65	0.053
0.050	1.00	Movement impossible								

Table 3. Design parameters at f_0 = 0.1000

f_0	U_K	D_{MAK}	V_{DM}	F_R	D_R	V_M	T_R	N_1	S_1	F_G
0.1000	6.40	0.2424	2.34	0.064	0.242	7.8	0.85	6.4	0.65	0.2
0.1000	3.09	Movement impossible								

Table 4. Calculations on a route equal to 10 and 20 km, with ascending angle of the road of 2 and 9 degrees

Calculations in operating conditions					Results of calculations					
l	γ_c	α	f_0	Z, before	$v_{\min}$	$v_{\max}$	v_{cp}	$G_{\min}$	$G_{\max}$	G_{cp}
10	0	2	0.02	0.25	31.5	50	40.8	16.8	16.9	16.9
20	0	9	0.02	0.25	12.5	41.7	27.1	18.2	19.5	18.5
10	1.0	2	0.02	0.25	30.7	50	40.3	36.9	37.2	37.15
20	1.0	9	0.02	0.25	10	33.2	21.6	39.1	42.8	40.3

Table 5. Calculations on a route equal to 40 km, with different values of the ascending angle

No, *n/n*	L	α	f_0	γ_c	Z	v_{cp}		G_{cp}		T_{cp}	
						km/h	%	liter	%	hour	%
1	40	0	0.02	1	0	50	100	41.2	100	0.8	100
2	40	0	0.02	0.5	0	50	100	30	72.8	0.8	100
3	40	0	0.02	0	0	50	100	18.7	45.4	0.8	100
4	40	5	0.02	1	0	30.7	100	36	100	1.3	100
5	40	5	0.02	0.5	0	33.1	108	25.9	71.9	1.2	92.6
6	40	5	0.02	0	0	37	120	16.9	46.9	1.08	82.9
7	40	0	0.04	1	0	50	100	82.5	100	0.8	100
8	40	0	0.04	0.5	0	50	100	60	72.7	0.8	100
9	40	0	0.04	0	0	50	100	37.5	45.5	0.8	100
10	40	0	0.02	1	1	45	100	40.2	100	0.89	100
11	40	0	0.02	0.5	1	45	100	29.7	72.8	0.89	100
12	40	0	0.02	0	1	45	100	18.6	45.6	0.89	100

Table 1 provides results of calculation of a vehicle speed depending on its design parameters. As is evident from the table, a vehicle can move in all gears. The maximum speed in the fourth gear is 50 km/h at f_0 equal to 0.02 and dynamic factor of 0.0376. As is evident from Table 2, with f_0 equal to 0.050, the motion of a vehicle in the fourth gear is impossible. It may move in the third gear at a speed of 29.6 km/h. Table 3 shows the results at f_0 equal to 0.1000.

Table 4 provides calculations of motion speed *V*, fuel consumption *G*, travel time *T* on a route *l* equal to 10 and 20 km, with ascending angle of the road of 2 and 9 degrees, with movement of a vehicle without cargo, coefficient of using carrying capacity taken as 0, and with cargo as 1. Table 5 contains calculations of motion speed *V*, fuel consumption *G*, travel time *T* on a route *l* equal to 40 km with different values of the ascending angle, coefficient of rolling resistance of wheels f_0, coefficient of using the vehicle's carrying capacity and intensity of traffic *Z*. To compare the results of calculations on different routes, fuel consumption in liters per 100 km of covered distance is conditionally taken as 100%.

The solution of the real problem of determining the speed requires consideration of uncertainties preconditioned by: impossibility to formalize a number of factors, necessary degree of reliability. Heuristic logic, heuristics, intuitive and approximate assessments, which are mainly qualitative intervals, serve as the basis for building them. To formalize, update and process such information, a special theory is used enabling the description of easy and fuzzy concepts and procedures. Their use enables rejection of "excessive" accuracy which is typical of traditional approaches to building models. At the same time, reasonable strictness is retained [4].

The application of the theory of fuzzy sets leads to formal methods to problems of rational choice and expert assessments. Real intervals of changes to a number of factors, e.g. coefficients of rolling resistance and tire grip on the road, are to a large extent fuzzy, which rules out mathematic interpretation of limits in the form of determinate inequalities. Due to this, the present problem is solved using the method of fuzzy sets.

Real intervals of change in these indistinct parameters are determined by ways of computer restoration of reasonable verbal proof summing decision-making by man in an indistinct and uncertain environment. To solve the problem, a model is designed on the basis of an indistinct system, which reflects dependence between variable indicators and coefficients of rolling resistance and tire grip on the road, which are expressed in the terms of linguistic rules. The indistinct linguistic model of motor vehicle has four inlets and two outlets.

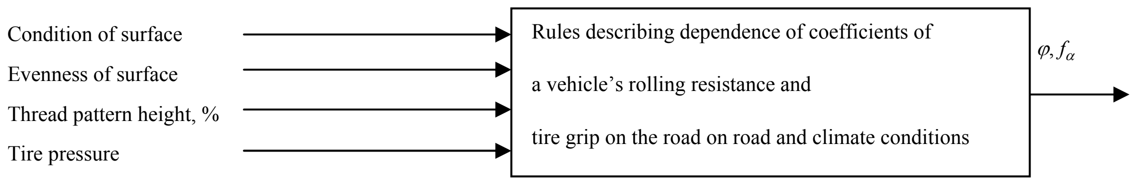

Figure 1. Coefficient dependence on road and climate parameters

Table 6. Fuzzy sets and linguistic variables

Indicators	Terms and fuzzy set support, F_i					
1. Condition of surface	QL, L, SS	O, SN	MU, PS	VQ	SQ	S
	0.05-0.2	0.2-0.3	0.3-0.45	0.45-0.5	0.5-0.7	0.7-0.8
2. Surface evenness, cm / km	Small (s)		Medium (m)			Large (l)
	0.2-0.3		0.3-0.5			0.7-0.8
3. Thread pattern height, %	Small (s) 0.15- 0.4		Medium (m) 0.4-0.41			Large (l) 0.41-0.43
4. Tire pressure, kg / cm2	Large (1.4-5)		Medium (m. 2-3)			Small (1.5-2)
	0.57-0.62		0.62-0.64			0.64-0.66

Appropriate fuzzy sets with their own support are built for linguistic variables being considered in Table 6. These are determined on the basis of expert assessments. Fuzzy set support implies totally $X*$, as in $X* = \{x / \mu_m(x) > 0, x \in X*\}$

On the next stage, using [1], a set of rules is built describing the dependence of a motor vehicle on different factors. If A = N, then B = M

With the aid of the built model and set of rules, the problem being considered has been solved. When developing a system of automatic calculation of the motion speed of a motor vehicle, particularly difficult is the stage of formalization of the problem and development of mathematic support. This problem is still poorly structured. It is characterized by the absence of strict mathematic dependences and algorithms for decision-making, which preconditions an important role of practical specialists.

In cases where formalization is possible, calculation and analytical methods are sed. An improved efficiency in determining the motion speed of a motor vehicle requires the development of a formalization method, which is very difficult to do.

The algorithm for solution of technological problems is often described with the aid of heuristic logic, which is formulated by experienced dispatchers on the basis of personal experience accumulated over many years of work in automobile transport. The nucleus of the proposed approach consists in an expert system capable of assessing and analyzing a wide range of situations, which cannot always be formalized.

At the preparatory stage, an expert verifies relationship between elements of a problem being considered and mainly communicates his heuristic assumptions, not accurate data. The knowledge an expert used in solving complex problems mainly accumulates in the process of many years of intense practice in a given area. Therefore, the development of a knowledge base is one of the biggest challenges in the creation of an expert system. The knowledge received from an expert is stored in a code form in a database. The product rules consist of the IF and THEN parts.

The research carried out has established that wide and diverse impact of meteorological conditions on the condition of the road surface and motion speed of a motor vehicle may be assessed by the coefficients of rolling resistance and adhesion.

The reasoning provided has preconditioned the use of the theory of fuzzy sets in determining the coefficients of rolling resistance and adhesion. The assessment of coefficients of rolling resistance and adhesion is described by indistinct equations and relationships. Besides, the theory enables us to supplement a posteriori measuring information with a priori information in the form of formalized experience and intuition of an expert.

We will consider as linguistic variables such model indicators as intensity of traffic, make-up of traffic, evenness of the road surface, assessment of the road condition in unfavorable weather conditions, assessment of meteorological phenomena and conditions, meteorological visibility, etc.

Both the said variables and the coefficient of rolling resistance of a motor vehicle are provided with the use of $(L-R)$ fuzzy numbers f for solving the problem of determining integral indicators which form the speed of a vehicle and the road surface adhesion coefficient φ. Analytically, the affiliation of every term is recorded in the following way:

Every object is characterized in the system by finite sequence (i, w, n, d, l), where i is the object index; w is the name of the object; n is the full title of the object; d is the nominal range of changes of w object; and l is the unit of measure.

The entry of knowledge into the ESPLAN occurs in the dialogue mode. As a result of the entry and interpretation of knowledge, a database of knowledge is formed. The key moment of the system is that it offers a wide range of opportunities for describing expert knowledge. To express his knowledge, the expert uses the rules provided in the following form: if (condition), then (conclusion), otherwise (conclusion). Let's examine the formation of the if … then …. otherwise ……. Rule.

The knowledge base of a dynamic expert system for the determination of the coefficient of rolling resistance of a wheel f and the tire grip on the road φ looks as follows (fragment).

If the surface is asphalt concrete and the road surface is gravel and intensity of rain is low or snow is dry and its height is considerable, then f will change in the range from 0.019 to 0.02 and φ changes in the range from 0.5 to 0.7.

If the road surface is asphalt concrete intensity of rain is medium and there is no snow and black frost, then f will change in the range from 0.014 to 0.018 and φ change in the range from 0.6 to 0.8.

After filling out the knowledge base, the dispatcher will be able, provided there is some baseline data, to receive a result from the system. It is worth pointing out that a justifiable determination of the motion speed largely preconditions the development of operational characteristics of a motor vehicle, namely fuel consumption and pollution of the environment.

V. CONCLUSIONS

The research carried out has established that wide and diverse impact of meteorological conditions on the road surface and vehicle speed may be assessed by coefficients of rolling resistance and adhesion.

The method developed enables modeling the calculation of average vehicle speed on a computer on the basis of random and indistinct parameters. In comparison with the existing methods, the proposed method enables us to thoroughly and effectively use the experience and intuition of specialists in calculating the speed both on different sections and on the entire route. This leads to the consideration of a known share of uncertainties.

NOMENCLATURES

The following symbols are used in the model:

V - average speed of motion on a route;
V_i - speed in gear;
t_i - time of coverage of section of the route;
t - time of coverage of the whole route;
N - number of gears;
Q_t - average fuel consumption per hour;
q_H - nominal carrying capacity of a vehicle;
j_c - cargo load factor of a motor vehicle;
f_α - coefficient of rolling resistance;
α - road slope;
φ - coefficient of tire grip on the road;
G_a - full weight of a motor vehicle with cargo;
G_c - unlade mass of a motor vehicle;
G_{2T} - weight on drive axle; and
l_1 - distance from center of gravity to the front axle;
l_2 - distance from center of gravity to the back axle;
l - motor vehicle base; L – route length;
$\bar{U}_i$ - average speed of a motor vehicle in gear i;
G - fuel consumption;
$\varphi_{(v,\alpha)}$ - total road resistance considering speed of motion;

K - wind shape coefficient;
F - front protection area;
$\bar{U}_2$ - average speed of a motor vehicle in gear i;
η_{TP} - total efficiency of engine and transmission;
ρ_T - specific fuel consumption;
$N_{\max}$ - maximum engine capacity;
$M_{\max}$ - maximum engine torque;
$\prod_N$ - turns corresponding to maximum engine capacity;
$\prod_M$ - turns corresponding to maximum engine torque;
a, b, c - engine type coefficient;
$V_{\max}$ - maximum motor vehicle speed;
V_B - radius;
r_k - rolling radius of a true;
i_k - ratio of transmission;
i_0 - main gear ratio;

The following symbols are used in the Table 6:
QL - even ice;
L - ice;
SS - dry snow;
O - frost-bitten surface;
SN - snow cover;
MU - wet conditions (rain);
PS - surface covered with snow,
VQ - moist dirt;
SQ - dry even;
S - dry clean and rough.

REFERENCES

[1] R.A. Aliyev and R.R. Aliyev, "Theory of Intellectual Systems", pp. 720, Baku, Azerbaijan, 2001.
[2] V.A. Illarionov, "Operational Properties of a Vehicle", Published by "Machine Building", pp. 280, Moscow, 1966.
[3] Vasilyev and M.I. Frimstein, "Management of Traffic on Highways", Published by "Transport", pp. 296, Moscow, 1979.
[4] A. Leonenkov, "Fuzzy Modeling in MATLAB and Fuzzy Tech", St. Petersburg, BHV-Petersburg, 2005 (in Russian).

BIOGRAPHY

Afiq (Allahverdi oglu) Allahverdiyev was born in Azerbaijan, 1937. He received the M.Sc. degree in the field of Operation Road Transport as Mechanical Engineer from Azerbaijan Polytechnic Institute (Baku, Azerbaijan) in 1960. He graduated to Ph.D. degree in automation of experimental research from Faculty Specials Retraining for New, Promising Areas of Science and Technology at the Moscow Automobile and Road Institute, Russian Academy of Sciences (Moscow, Russia) in 1985. Currently, he is the Associate Professor in the field of organization of road transport and road safety in Azerbaijan Technical University (Baku, Azerbaijan). He has authored 150 scientific papers. His research interests are in road transport of articles large-panel management, developing methods and models optimization in road transport logistics, and automation and process control and production.