Assessment of resources of road machines working in the conditions of tropical climate

Vladimir Zorin\textsuperscript{1,*} and Le Tchong Tuan\textsuperscript{2}

\textsuperscript{1} Moscow automobile and road state technical university, Russia, Moscow
\textsuperscript{2} Moscow automobile and road state technical university, Russia, Moscow
* Email: madi-dm@list.ru

Abstract. In this article results of researches are considered, formulas full gamma percent resource $T_f,\gamma$ and a gamma percent resource before the first major repair of $T_r,\gamma$ (is developed for definition at $\gamma=80\%$) road-building machines, according to technical condition and operating conditions of the machine in the tropical climate of Vietnam. The corresponding values of resources of road-building machines in Vietnam were at the same time defined that formed a basis for exact planning terms of carrying out construction works, to make the reasonable diagram of maintenance and repair of machines for each climatic zone of Vietnam.

1. Introduction

Vietnam is developing country with the annual average speed of economic growth of 6-7\% [0]. In it, infrastructure and a transport network in particular are upgraded and extend more and more. As a result the great demand of the equipment in service of the national economy, including road machines forms.

Characteristic of operating conditions of road machines in Vietnam is the hot, humid tropical climate of the country located near the sea [0]. It is necessary to evaluate fallback resources of operability of machines as a basis of planning of operation, technical maintenance and repair for the purpose of increase in efficiency of use of the road-building equipment in climatic conditions of Vietnam.

2. Methods

The key resource indicators of road machines are full gamma percent resource $T_f,\gamma$ and a gamma percent resource before the first major repair of $T_r,\gamma$ (at $\gamma=80\%$), determined by a formula [0, 0]:

\begin{align*}
T_f,\gamma & = k_\gamma, T_d, T_a \\
T_r,\gamma & = T_f,\gamma / \sum_{i=1}^{n} C_i - 1.
\end{align*}

where

$T_d$ - depreciation service life, years;

$T_a$ - annual operating time of the machine;

$k_\gamma$ - the coefficient depending on a type of the distribution law of values of a resource, variation coefficient $\nu$ and probability values;

$C$ - the coefficient considering reduction of a between-repairs cycle after major repair of the machine;
n - number of between-repairs cycles.

This formula is used for calculation of resource indicators of the new road machines working in normal conditions of operation (the temperate climate characteristic of the Moscow region). In severe climatic conditions of Vietnam generally import road machines having a considerable operating time therefore for calculation of a residual resource it is necessary to consider coefficient of technical rigidity of climate and also machine utilization coefficient on time are used. In this case the formula (1) will be transformed as follows:

\[
\begin{aligned}
T_{f,y} &= k_y \cdot T_d \cdot T_a \cdot S_{ct} \cdot k_u, \\
T_{r,y} &= T_{f,y} / \sum_{i=1}^{n} c_i - 1
\end{aligned}
\]

where \( k_u \) - machine utilization coefficient on time (for the majority of road machines in Vietnam is accepted \( k_u \approx 0.8 \));

\( S_{ct} \) - coefficient of technical rigidity of a temperate climate (Moscow region);

\( S_{ctr} \) - coefficient of technical rigidity of tropical climate in Vietnam.

Coefficients \( S_{ct} \) and \( S_{ctr} \) it is calculated by the following formulas[0]:

\[
S_{ct} = (0.75 \cdot t_{min,c} + 0.25 \cdot t_{min,ac})(1 + 0.015 \cdot \sigma_c)(1 + 0.07 \cdot v_{ac})(1 + 0.26 \cdot \varphi_c)(1 + 0.014 \cdot n_{f,c})(1 + 0.022 \cdot \tau_{bz})
\]

and

\[
S_{ctr} = (0.55 \cdot t_{max,w} + 0.20 \cdot t_{max,aw})(1 + 0.01 \cdot Q_s)(1 + 0.0075 \cdot \sigma_w)(1 - 0.03 \cdot v_{sw})(1 + 0.026 \cdot \varphi_w)(1 + 0.009 \cdot n_r)(1 + 0.012 \cdot \tau_{az})
\]

where

\( t_{max,w}, t_{max,aw}, \sigma_w \) - respectively mean value of maxima of air temperature, mean value of an absolute maximum of air temperature and average non-periodic amplitude of daily fluctuations of air temperature in three warmest months, °C;

\( Q_s, v_{sw}, n_r \) - respectively mean value of the monthly sum of solar radiation, average speed of wind and a median number of days with rains in three warmest months;

\( \varphi_w, \varphi_c \) - mean value of relative air humidity in three warmest months and in three coldest months in unit shares;

\( \tau_{az} \) - action duration in months of average temperature of air is above zero.

\( t_{min,c}, t_{min,ac}, \sigma_c \) - respectively mean value of average minimum temperatures of air, mean value of an absolute minimum of air temperature and average non-periodic amplitude of daily fluctuations of air temperature in three coldest months, °C;

\( v_{ac} \) - average speed of wind in three coldest months, m/s;

\( n_{f,c} \) - mean value of number of days with fog and a blizzard in three coldest months, days;

\( \tau_{bz} \) - action duration in months of average temperature of air is below zero.

3. Results

On the basis of the statistical data characterizing climatic conditions in a tropical zone (regions of Vietnam [0, 0]) and in a zone of a temperate climate (The Moscow region [0]), we can define coefficient of technical rigidity of climate, as shown in tab.1.

| City     | Hanoi | Vinh | Da Nang | Gia Lai | Vung Tau | Moscow |
|----------|-------|------|---------|--------|---------|--------|
| \( S_{ctr} \) or \( S_{ct} \) | 36.05 | 36.58 | 35.73   | 28.92  | 33.10   | 28.48  |

It agrees [0], we obtain the data necessary for calculation of resource indicators of some typical road machines (tab.2.).
Table 2. Values of parameters for calculation of resource indicators.

| Name of machines | Annual operating time of machine $T_a$ [h] | Depreciation service life of $T_a$, [years] | Number of between-repairs cycles $n$ | Coefficient variations $\nu$ | Coefficient $k_\gamma$ |
|------------------|------------------------------------------|-------------------------------------------|-------------------------------------|----------------------------|------------------------|
| Excavator SOLAR-140w | 2400                                      | 10                                        | 2                                   | 0.30                       | 0.74                   |
| Bulldozer T-140   | 2000                                      | 8                                         | 1                                   | 0.4                        | 0.64                   |
| Grader DZ-122     | 1600                                      | 8                                         | 1                                   | 0.20                       | 0.83                   |
| Wheel-loader WA350 | 1400                                      | 9                                         | 1                                   | 0.25                       | 0.78                   |

Substituting values of indicators from table 2 in a formula (2), we will receive values of a resource of road machines for operating conditions in tropical (Vietnam) and moderated (Moscow region) climatic zones (Figure 1).

![Figure 1. A gamma percent residual resource before the first major repair of $Tr_{r,\gamma}$ of the road machines working in tropical (Vietnam) and moderated (Moscow region) climatic zones.](image)

From the diagram it is visible that value of a residual resource of road machines during the work in tropical climatic conditions of Vietnam, it is much less, than during the work in moderate climatic conditions Moscow area. Values of a residual resource of road machines during the work in the city of Vinh are the smallest (less than 1.61 times), and in the city of Gia Lai - the highest (less than 1.27 times), in comparison with conditions of a temperate climate (Moscow region). Thus, for operating conditions of Vietnam mean value of resources of road machines is 1.5 times less, than the corresponding value under normal conditions operation.

4. Conclusion
Taking note of operating conditions and technical condition at assessment reliability of road machines in general [0-0, 0, 0-0] and definition of resource indicators, in particular, will allow to plan precisely terms of carrying out construction works, to make the reasonable diagram of maintenance and repair of machines for each climatic zone of Vietnam.

References
[1] Alferov A K and Petrov I V 1980 Ensuring operability of construction machines Stroyizdat,Moscow, 136
[2] Balovnev V I 2014 Determination of the optimal parameters and the choice of road-building machines by analyzing the fourth coordinate. Textbook: UDC 625.8.002.5, 180
[3] Balovnev V I 2010 Determination of the optimal parameters and the choice of earthmoving machinery, depending on operating conditions. Textbook: UDC 625.76.08, 132
[4] Climate of Vietnam - https://en.wikipedia.org/wiki/Climate_of_Vietnam
[5] Intensity of solar radiation in regions of Vietnam - https://solare.vn/blogs/news/cuong-do-buc-xa-nang-luong-mat-troi-tung-khu-vuc-tai-viet-nam
[6] Karnaukhov N N, Merdanov Sh M, Schaefer V V and Ivanov A A 2005 Operation of machines in construction Manual of UDC 625-08 Tyum of GNGU, 393
[7] Koch P I 1981 Climate and reliability of machines, Mechanical engineering, 175
[8] Kutuzov V V 2012 Increase in efficiency of operation of construction and road machines taking into account change of their technical condition. Thesis of Candidate of Technical Sciences: 05.05.04, 255
[9] Maksimenko A N, Makatsariya D Yu and Kutuzov V V 2006 Organization of operation of construction and road machines taking into account their technical condition Bulletin of the Belarusian-Russian university 4(13) 28-31
[10] Reliability of mechanical systems Textbook. M: INFRA-M, Moscow publishing house of 2015, 380
[11] Statistical data - General statistic office of Vietnam 2017 - https://www.gso.gov.vn/default.aspx?tabid=713
[12] Statistical data of social economic situation - General statistic office of Vietnam https://www.gso.gov.vn/default.aspx?tabid=621
[13] Statistical data: climatic Moscow - https://ru.wikipedia.org/wiki/Klimat_moskvy
[14] Zorin V A 1986 Bases of durability of construction and road machines, Mechanical engineering,Moscow, 245
[15] Zorin V A 2005 Bases of operability of technical systems Textbook: UDC 629 7 07, ISBN 5-902048-51-6, Magistr publishing house, 536