THE DETERMINATION METHOD OF THE COMBAT POSSIBILITIES OF MILITARY UNIT

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Abstract: *in the paper, by using of the known factor of military unit combat power the problem of its combat possibilities calculation has been considered. By using of these estimations the method of tactical operation calculation of the task implementation possibility, the factor of battle parties losses and the attack movement rate has been offered.*

Keywords: combat power, task implementation probability, losses, attack rate, interpolation.

1. INTRODUCTION

The assessment methods of combat possibilities have especial position among the support systems of the process of military decision-making (Smith: 2011). The correct decision-making of combat activities and the impartially assessment of combat possibilities of the battle both sides for define of combat tasks have much significance. For lack of reliable methods in this area the commanders are reluctant to make intuitive decision based only on the own practical experience.

The assessment of combat possibilities is not new problem (Aliev & Bayramov: 2018) and in this area many investigations are carried out (Bobrikov: 2009; Buravlev & Rusanov: 2009). However, for practical calculation of combat possibilities in the various offered methods the fire, blow and maneuver possibilities are defined on the basis of various methods, and the quantity describing the common combat possibility of unit is not calculated. It complicates to implement of tactical operational calculations on its basis.

In the paper, on the basis of dynamic power of the military unit (Demenkov: 1993) described its combat possibilities the tactical operational calculations implementation method has been offered.

2. CALCULATION OF ELATIVELY COMBAT POWER AND PROBABILITY OF TASKS IMPLEMENTATION

For the purpose of assessment of expected battle victory we can calculate a combat power ratio of battle both sides (both for attack and defence sides) (Demenkov: 1993):

$$GN_h = \frac{G_D^h}{G_D^m}\,;\ GN_m = \frac{G_D^m}{G_D^h} \qquad (1)$$

Here: GN_h – is a combat power ratio for the attack side, G_D^h – is a combat dynamic power for the attack side, GN_m – is a combat power ratio for the defence side, G_D^m – is a combat dynamic power for the defence side.

If GN_h >1 then it is means that a attack side will has a reliable victory and the propability of its success P_T is directly proportional to value of GN_h (Demenkov: 1993).

During attack some of time after beginning, the content of attacking troop for utter defeat of the enemy is defined by the level of possible losses of the sides. The dependence between the combat power ratio of sides (*GN*) and the possible losses is determined by below formula (Demenkov: 1993):

$$\dot{I}_h = 1 - \sqrt{1 - GN_m^2 \times \dot{I}_m \times (2 - \dot{I}_m)} \quad (2)$$

$$\dot{I}_m = 1 - \sqrt{1 - GN_h^2 \times \dot{I}_h \times (2 - \dot{I}_h)} \quad (3)$$

Here: $\dot{I}_h$ – is a losses factor of attacking side, $\dot{I}_m$ – is a losses factor of defending. Its quantities change between (0÷1) range.

The wars' expirience has shown if an attacking side has 30-50% losess ($\dot{I}_h = 0{,}3 \div 0{,}5$) then it gives up the attack or it must organize a new attack. If an attacking side has more 50% losess, in this case the continuation of attack is not possible. If a defending side has 50-70% losess then its combat possibilities decrease much, and it must organize a defence over again. If a defending side has more 70% losess, in this case it cannot defend itself at all (Demenkov: 1993).

If the losesses for an attacking side are 30-50% and for a defending side are 50-70% the these losesses are called critical. From this we can calculate a combat critical power ration for battle both sides. If $GN_h = GN_{h.critic}$ and $GN_m = GN_{m.critic}$, then after battle beginning, at the same time, both sides losess are begun critical, and in this case the combat tasks implementation possiilities for both sides are equal. If, $GN_h < GN_{h.critic}$ and $GN_m > GN_{m.critic}$, then a defending side will obtain rather critical losess and for an attacking side the combat tasks implementation possiilities will more much. Below formulas can be used for calculation of both sides critical ratio (Demenkov: 1993):

$$GN_{h,critic} = \sqrt{\frac{(2 \times \dot{I}_m - \dot{I}_m^2)}{(2 \times \dot{I}_h - \dot{I}_h^2)}} \quad (4)$$

$$GN_{m,critic} = \sqrt{\frac{(2 \times \dot{I}_h - \dot{I}_h^2)}{(2 \times \dot{I}_m - \dot{I}_m^2)}} \quad (5)$$

There have been shown below in table 1 the calculated values of critical ratio of the combat power for both attacking ($GN_{h.critic}$ in denominator) and defending sides ($GN_{m.critic}$ in denominator).

Table 1. The critical ratio of the combat power for both sides (GN).

		Losess of attacking side				
		30%	35%	40%	45%	50%
The losess of defending side	50%	<u>1.213</u> 0.821	<u>1.140</u> 0.878	<u>1.083</u> 0.924	<u>1.037</u> 0.964	<u>1.000</u> 1.000
	55%	<u>1.251</u> 0.800	<u>1.175</u> 0.851	<u>1.116</u> 0.900	<u>1.069</u> 0.935	<u>1.031</u> 0.970
	60%	<u>1.283</u> 0.779	<u>1.206</u> 0.829	<u>1.146</u> 0.873	<u>1.097</u> 0.913	<u>1.058</u> 0.945
	65%	<u>1.312</u> 0.762	<u>1.233</u> 0.811	<u>1.171</u> 0.854	<u>1.122</u> 0.892	<u>1.082</u> 0.925
	70%	<u>1.336</u> 0.749	<u>1.255</u> 0.797	<u>1.192</u> 0.839	<u>1.142</u> 0.876	<u>1.102</u> 0.908

For the pupose of break open and exploit an attack deep in the enemy defense for the retention of combat possibilities the attacking side losess must be less 30% ($\dot{I}_h \leq 0.3$). In this case, the defending side will has the minimum 70% losess ($\dot{I}_m \geq 0.7$) and will crushed. For such losess the appropriate relative combat power of attaking side is called full one (a full superiority) (Demenkov: 1993). By using formula (4) let us calculate its value:

$$GN_{h.full} = \sqrt{\frac{2 \times 0.7 - 0.7^2}{2 \times 0.3 - 0.3^2}} = 1.34$$

Therefore, if $GN_h \geq GN_{h.full}$ then the attacking side has much probability to implement combat task. By analogy, the defending side losess must be less 50% ($\dot{I}_m \leq 0.5$) that to provide defence capability. In this case the attacking side must to has more 50% losess ($\dot{I}_h \geq 0.5$). For such losess the appropriate relative combat power of defending side is called full one (a full superiority). By using formula (5) let us calculate its value:

$$GN_{m.full} = \sqrt{\frac{2 \times 0.5 - 0.5^2}{2 \times 0.5 - 0.5^2}} = 1$$

Therefore, if $GN_m \geq GN_{m.full}$ then the defending side has much probability to implement combat task.

In (Trosenko: 2008) the dependence of combat task implementation probability on some values of relatively combat power and the method of probability calculation have been presented. However, thre are the inverse tasks in many practical problems: for given probability of task implementaton the necessary relatively combat power should be determine. For this porpuse let us determine $P_T = F_P(GN_h)$ and $GN_h = F_G(P_T)$ functions by using of coefficients given in table 2.

Table 2. The probability of task implementaton and the dependence of relatively combat power.

Given $F_P(GN_h)$	GN_h	2.18	1.81	1.59	1.44	1.34	1.26	1
	P_T	0.71	0.65	0.6	0.56	0.54	0.51	0.5
Calculated by interpolation $F_P(GN_h)$	P_T	0.71	0.65	0.60	0.56	0.54	0.52	0.50
	Error	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Calculated by interpolation $F_G(P_T)$	GN_h	2.18	1.76	1.59	1.45	1.34	1.10	1.00
	Error	0.00	0.05	0.00	0.01	0.00	0.16	0.00

For determination these functions let us use Newton's interpolation formula:

$$P_n(x) = a_0 + a_1 \times (x - x_0) + a_2 \times (x - x_0) \times (x - x_1) + \cdots + a_n \times (x - x_0) \times (x - x_1) \times \ldots \times (x - x_n) = a_0 + \sum_{i=1,n} a_i \times \prod_{j=0,i-1} (x - x_i) \quad (6)$$

a_0 is obtained from $P_n(x_i) = y_i$. If *i=0*, $a_0 = y_0$; *i=1* then $a_0 + a_1 \times (x_1 - x_0) = y_0$, From here $a_1 = (y_1 - y_0)/(x_1 - x_0)$.

By analogy, the another factors can be calculated.

For interpolation by using data from table 2 (1, 3, 5, 7 columns) below factors have been obtained:

–for $F_P(GN_h)$ function: $a_0 = 1.15;\ a_1 = -1.53;\ a_2 = 1.11;\ a_3 = -0.23$

–for $F_G(P_T)$ function: $a_0 = 53.81, a_1 = 268.02;\ a_2 = -436{,}73;\ a_3 = 239.88$

From interpolation formula obtained $F_P(GN_h)$ and $F_G(P_T)$ values are given in table 1. The low errors allow to assert that factors are quite adequate. Let us write these dependences as:

$$P_T = 1.15 - 1.53 \times GN_h + 1.11 \times GN_h^2 - 0.23 \times GN_h^3 \quad (7)$$
$$GN_h = -53.81 + 268.02 \times P_T - 436{,}73 \times P_T^2 + 239.88 \times P_T^3 \quad (8)$$

During headquarter activities the operation-tactic target setting with necessary calculations can be various. However, there are three main parts for each tasks: the content of attacking side and its dynamic power G_D^h; the content of defending side and its dynamic power G_D^m; combat task and its implementation probability P_T. From this point of view there is a below classification of tasks:

I-st type task - G_D^h and G_D^m are given, P_T is found;

II-nd type task - G_D^h and P_T are given, G_D^m is found;

III-rd type task - G_D^m and P_T are given, G_D^h is found.

In I-st type task (7) formula can be applied for determination of probability of task implementation for both attacking and defending sides:

$$P_T^h = 1.1498 - 1.1498 \times \frac{G_D^h}{G_D^m} + 1.1104 \times (\frac{G_D^h}{G_D^m})^2 - 0.2298 \times (\frac{G_D^h}{G_D^m})^3 \quad (9)$$
$$P_T^m = 1.1498 - 1.1498 \times \frac{G_D^m}{G_D^h} + 1.1104 \times (\frac{G_D^m}{G_D^h})^2 - 0.2298 \times (\frac{G_D^m}{G_D^h})^3 \quad (10)$$

II-nd and III-rd type tasks have been solved usually combat task setting during atack (defence) planning. In this time if the unit's content and task implementation probability are known then (8) formula can be applied:

$$G_D^m = G_D^h/(-53.81 + 268.02 \times P_T^h - 436{,}73 \times (P_T^h)^2 + 239.88 \times (P_T^h)^3)$$
(11)
$$G_D^h = G_D^m \times (-53.81 + 268.02 \times P_T^m - 436{,}73 \times (P_T^m)^2 + 239.88 \times (P_T^m)^3)$$
(12)

3. CALCULATION OF LOSSES

For the purpose of losses calculation by using (1) and (2) equations the losses of one side must been known. However, in some time the both sides' losses must been known. For this purpose to combat power ratio of both attacking and defending sides appropriate the values based on the practical losses expirience can used (K.K.K.: YY-8: 1986). Let us determine a functional relationship between losses and relatively combat power by using of Newton's interpolation formula. For interpolation below factors have been obtained:

- in attack: a_0 = 2.4179; a_1 = -1.8032;
  a_2 = 0.5395; a_3 = -0.0524
- in defence: a_0 = 0.3086; a_1 = 0.0884;
  a_2 = 0.0417; a_3 = 0.0016.

Functional relationships between losses and relatively combat power for unit during 1 hour battle have been expressed as:

$$\dot{I}_h = 2.4179 - 1.8032 \times GN_h + 0.5395 \times GN_h^2 - 0.0524 \times GN_h^3 \quad (13)$$
$$\dot{I}_m = 0.3086 + 0.0884 \times GN_h + 0.0417 \times GN_h^2 + 0.0016 \times GN_h^3 \quad (14)$$

Calculated by interpolation equation and shown in figures 1 and 2 the dependnces between losses and relatively combat power allow to conclude that the results of interpolation are quite adequate.

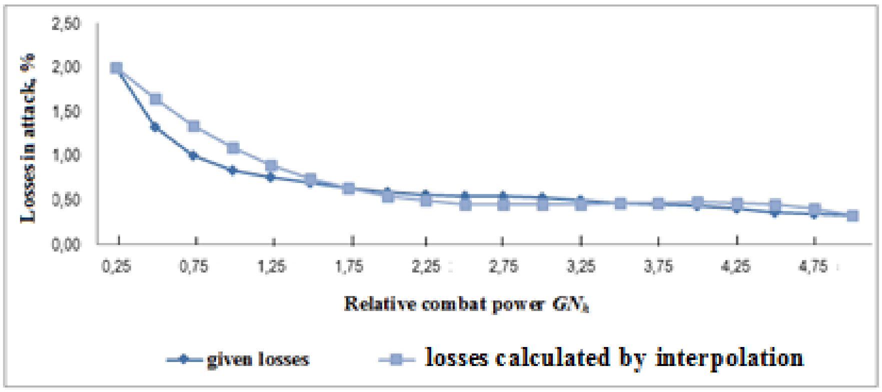

FIG. 1 The dependence of losses on relatively combat power in attack.

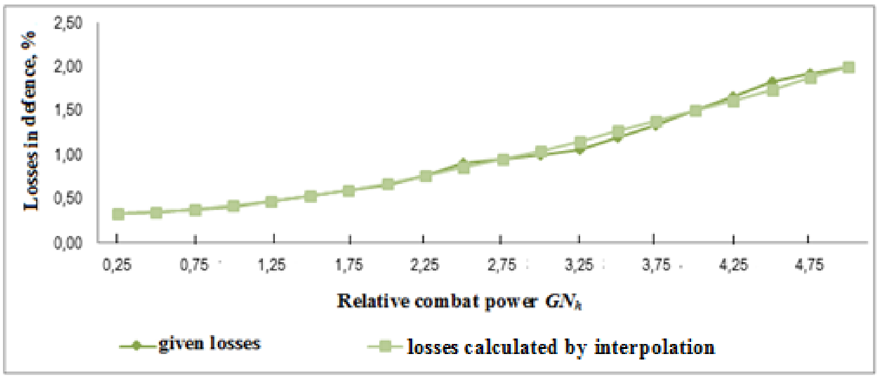

FIG. 2 The dependence of losses on relatively combat power in defence.

When the unit's losses have been determined then its should be divided on the categories of personal, weapons and military technics. İn this case the losses for various categories will different. It is conditioned by application properties on the battle area. The personal, weapons and military technics losses's factors given in (K.K.K.: YY-8: 1986). The losses of unit's weapons and military technics can calculated by below equation:

$$\dot{I}SH_j = \dot{I} \times N_j \times K_j, \quad j = I, II, \dots IX \qquad (15)$$

Here: $\dot{I}SH_j$ is a number of j weapon category losses, $\dot{I}$ is the factor of unit's common losses, N_j is a number of weapons of j category, K_j is a losses factor of j weapon category. For calculation of unit's personal losses balow equation is used:

$$\dot{I}ŞH = \sum_{j=I,\dots,IX} \dot{I}SH_j \times Ş_j \qquad (16)$$

Here: $\dot{I}SH_j$ is losses for each weapon's category; $Ş_j$ is a factor of personal losses for the same weapon's category.

4. CALCULATION OF ATTACK RATE

The unit's attack rate is depended on many factors: the type of unit, the conditions of terrain and weather, the disposition of defence and the engineering fortifications. The units of measurement of the attack rate are km/hour for (squad ÷ brigade) and km/day for (army's corps ÷ army). Here, km/day cannot displace to km/hour, because attack rate are not same in day and night, it is taken as average quantity.

First of all, let us consider attack rate during 1 hour. The war and military trainings expirience have shown that in dependence on the ratio of both sides combat power the attacking side rate is given in (K.K.K.: YY-8: 1986). For the pupose of determination of the functional dependence between ratio of combat power and attack rate let us use Newton's interpolation formula (6) and determine a_i factors. Taking into account of directly proportional smooth dependence between unit's attack rate and relatively combat power let us take this dependence as non-linear one of third degree. For interpolation below factors have been obtained: a_o = -1.0631; a_1 = 1.4952; a_2 = -0.4900; a_3=0.0579. The dependence of unit's progress common rate (km/hour) in attack on relatively combat power can calculated by below equation:

$$CHT_{hour} = -1.0631 + 1.4952 \times GN_h - 0.4900 \times GN_h^2 + 0.0579 \times GN_h^3 \quad (17)$$

The dependence of progres rate in km/hour on combat power (Fig.3) shows that interpolation results are adequate.

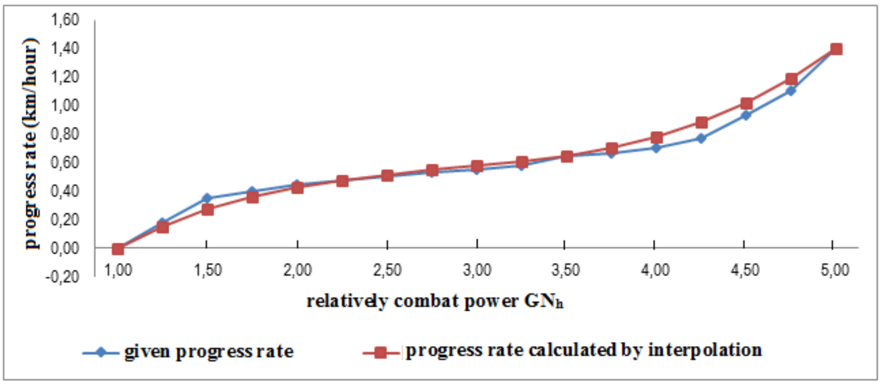

FIG. 3 The dependence of progress common rate in attack on relatively combat power.

Now, let us consider a progress rate during 1 day for brigade and bigger military formations in attack operations. Taking into account that in attacking operations during all day long the progress rate are different then 24x$CHT_{hour} \neq CHT_{day}$. The losses data during both 1 hour and 1 day have been taken from different sources (K.K.K.: YY-8: 1986; KKYY-190-7(A): 2001). Let us determine the functional dependence between relatively combat power and losses. By using of Newton's interpolation formula below interpolation factors have been obtained: a_0=1.4711; a_1=1.6067; a_2=0.8575; a_3 = -0.0895. In attack the dependence of unit's progress common rate (in km/day) on relatively combat power can expressed below equation:

$$CHT_{day} = 1.4711 + 1.6067 \times GN_h + 0.8575 \times GN_h^2 - 0.0895 \times GN_h^3 \quad (18)$$

The result of interpolation of the attacking progress rate in km/day are shown in Fig. 4.

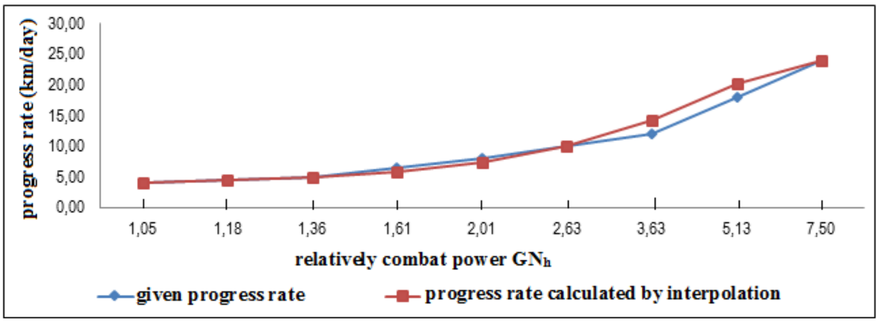

FIG. 4. The dependence of attacking progress rate on relatively combat power.

In attack the unit's really progress rate is depended on the type of unit, terrain and weather conditions, time of day (if rate is measered in km/hour) and the type of fortifications. These factors must be considered for calculation of attacking progress rate. These factors are given in (K.K.K.: YY-8: 1986; KKYY-190-7(A): 2001). Taking into account of these factors unit's attacking progress rate is expresses by next equation:

$$HT_{day} = CHT_{day} \times WC \times TC \times BT \times MS \times SV \quad (19)$$
$$HT_{day} = CHT_{day} \times WC \times TC \times BT \times MS \quad (20)$$

Here: *HT* is an attacking progress rate; *CHT* is a attacking progress common rate (9, 10); *WC* is weather influence factor; *TC* is terrain influence factor; *BT* is unit's type influence factor; *MS* is fortifications' density influence factor; *SV* is time of day influence factor.

During planning of military operations (tactic activities) the inverse problem can be often considered: the Staff determines an attacking progress rate and the unit's commander must determine necessary power ratio. Thereto, let us determine the dependence of combat power ratio on attacking rate. By using of Newton's interpolation formula below functional dependence's factors have been obtained: a_0 = -0.3424; a_1=0.3940; a_2 = -0.0131; a_3=0.0003.

By using of these factors the below functional dependence of attacking side's combat power ratio on the given attacking rate:

$$GN_h = -0.3424 + 0,3940 \times CHT_{day} - 0.0131 \times CHT_{day}^2 + 0.0003 \times CHT_{day}^3 \quad (21)$$

Taking into account of (21) equation the next formula is obtained:

$$GN_h = -0.3424 + 0,3940 \times \frac{HT_{day}}{WC \times TC \times BT \times MS} - 0.0131 \times \left(\frac{HT_{day}}{WC \times TC \times BT \times MS}\right)^2 + 0.0003 \times \left(\frac{HT_{day}}{WC \times TC \times BT \times MS}\right)^3$$

CONCLUSION

Therefore, the method of tactical operation calculation of the task implementation possibility has been developed and offered. On the basis of the unit's dynamic combat power the some factors defined combat capability are determined. There are relatively combat power, including critical and full, combat task implementation probability, both sides losses and attacking progress rate among these factors. The equations for calculation these factors have been obtainned.

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