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**O. Verlamov**

**V. Kletz**

**I. Shtogrin**

*Military Academy (Odessa), Ukraine*

## **FEATURES OF VEHICLES' OPERATION IN WINTER**

*The paper presents the features of preparation and operation of engines of armored vehicles in the winter. Influence of coolant temperature on the wear of cylinder sleeves Organization of transfer to winter operating machinery. Preparation of lubrication system, cooling system and engine armored wheeled vehicles. Maintain vehicles in readiness for use.*

**Keywords:** *crankshaft; electrolyte; sulfuric acid; corrosion-resistant cast iron; nozzle; heater; oil inject pump; antifreezes.*

### **Statement of the problem**

The features of winter period are low ambient air temperature, the presence of snow cover and, in some areas, strong winds. The average temperature in January and February reaches  $-20^{\circ}\text{C}$ .

Extreme cold locks up ponds, swamps, rivers. They are passable for tracked vehicles. However, in many areas the presence of snow cover limits the movement of machinery. In middle zone in open area the depth of snow cover reaches 0,8-1,0m, and in the woods - 1,5m. The deep snow cover not only increases the resistance of movement, but also hides various obstacles. Naturally, in such conditions, lest get stuck, cars can move only on the roads.

### **Analysis of recent achievements and publications**

In north-eastern areas the wind speed reaches 30 m/s. Low temperatures, the presence of snow cover and strong winds reduce the combat capabilities of vehicles because of prevention of engine starting and maintain it in readiness for immediate use; driving conditions and survey the terrain are complicated; increasing the duration of maintenance of vehicles, because of the deteriorating conditions of the crew and its efficiency reduces.

Moreover, poor knowledge and noncompliance in operating vehicles in winter can lead to breakdowns and accidents.

### **Statement of the problem and its solution**

The combat readiness of vehicles in many respects depends on the ambient air temperature. The lower is the ambient air temperature, the more time you need to prepare the machine for operation. First of all, it prevents the engine starting. This happens because of the following reasons:

- It deteriorates the spontaneous combustion of fuel;
- It increases the resistance to rotation of the engine crankshaft;
- It prevents the creation of the necessary of oil pressure in friction.

### **The main material research and complete explanation of scientific results**

Deterioration of spontaneous combustion of diesel fuel is caused by two reasons. First of all, with a decrease in temperature increases the viscosity of diesel fuel. Therefore, use only winter diesel fuel in winter, and in some areas - Arctic. Besides that, to ignite the fuel it is necessary that the temperature at the end of

compression stroke should be not below + 350°C. The lower is the temperature, the lower will be the temperature  $T_c$  at the end of compression stroke:

$$T_c = T_a \left( \frac{P_c}{P_a} \right)^{\frac{n-1}{n}},$$

where  $T$  – the temperature of the air intake, °C;

$P_c$  – a pressure at the end of compression stroke, kg/cm<sup>2</sup>;

$P_a$  – the air pressure in the suction, kg/cm<sup>2</sup>;

$n$  – a polytropic index of compression.

The value of  $n$  is smaller than the lower is the temperature of the air intake and the speed of rotation of the crankshaft (at low rotation speed the loss of compressed air increase due to the gaps between the sleeve and piston rings and more heat is given to the cold parts).

Rising of the air intake temperatures improves conditions of the fuel ignition. This is achieved by heating of the engine. The heating of coolant by heater should be the higher the lower is the temperature of the ambient air.

In all cases, the temperature at the end of compression stroke is the higher, the greater is the speed of rotation of the crankshaft. So to start the engine at low temperatures it should rotate the crankshaft at high velocities. But in reality, at low temperatures the starting speed decrease because of greatly increases the moment of resistance of the crankshaft turn mainly due to increase of oil viscosity.

With decreasing of the air temperature the oil viscosity increases to tens or hundreds of times. For example, if the temperature drops from 50 to 0 ° C, the oil viscosity MT-16P increases to 40 times. A further decrease in temperature from 0 to -20 ° C leads to an increase of viscosity more than to 450 times. In consequence, sharply increases the required time for the rotation of the crankshaft of the engine and movement of the pistons in the cylinders.

The resistance of crankshaft rotation increases also due to the difference in the coefficient of linear expansion of various metals the gaps reduce in bearings and their shape is distorted.

The moment of resistance of crankshaft rotation  $M_c$  is the sum of several components:

$$M_c = M_K + M_{in} + M_{tr},$$

where  $M_K$  – a moment of resistance caused by compression, kg/m;

$M_{in}$  – a moment of inertia, kg/m;

$M_{tr}$  - a required moment to overcome the friction forces, kg/m.

Values of first two moments are not large, do not depend on temperature. With temperature decreasing the value of  $M_{tr}$  greatly increases. Even at -20°C for cranking the engine crankshaft B-2 it is necessary to overcome the resistance moment, similar to the moment that is developed by the engine.

The primary means of starting the engine is the starter. The principle of its operation is that with increasing of load the speed of rotation of the armature decreases. Therefore, the lower is the temperature, the slower is speed of crankshaft rotation. In addition, with the decrease in temperature the viscosity of the electrolyte increases and it gets not so well into the pores of the plates. The capacity of the battery is given back, and the moment that is developed by starter will drop. If moment that is developed by starter at + 20°C is taken as 100%, so at -20°C it will reduce to 70%. As a result, the scroll speed of engine crankshaft will decrease.

Reducing the moment of resistance caused by the increase in the oil viscosity is achieved by using a little viscous marks (e.g. oil MT-14p or other recommended by manuals) and heating of the engine before running by heaters. To significant reduction of resistance leads early injection of plastic thixotropic lubricant TPS-1 into the cylinders, prepared by mixing of little viscous oil MSU (90%) with thickener ceresin (10%).

It is necessary to warm up the engine by heater to such temperature to ensure a sufficient oil supply to the bearings. An indicator of normal heating is oil pressure before starting the engine. In case of insufficient oil supply (pressure is below norm) bearings will overheat and possibly fuse.

At low temperatures very important is also the support of optimum thermal condition of the engine. Work on low heat mode (when the coolant temperature is below +80-90°C) accompanied by high wear of cylinder sleeves and piston rings.

There is kept to 0.2% sulfur compounds in diesel fuel. By burning out, they are converted to sulfur oxides. Out of parts of these oxides and steam that appears from the combustion of fuel, sulfuric acid will form. Thus, it will form as much as lower is the temperature of the engine. Under the influence of the acid a corrosion of cylinder sleeves reinforces and they wear out faster. This is called corrosive wear. The lower is the temperature of the coolant, the more is wear of cylinder sleeves.

Particularly high wear of cylinder sleeves at starting and subsequent heating of the engine if it is not pre-heat. Even at an ambient air of temperature +15°C wear at starting and warming of engine is equivalent to the magnitude of wear, during operating the fully loaded engine at heat mode for 1-2 hours. When the air temperature is -10°C wear at starting and warming of engine is equivalent to the wear for 3-2 hours of normal work.

Low temperatures at less degree effect on engine wear of APC and vehicle, as cylinder sleeves of gasoline engines are made of corrosion-resistant cast iron to use of gasoline containing less active sulfur compounds. Use oil with additives also reduces corrosion. Starting wear of cars' cold engines equal to tens and hundreds of kilometers.

The influence of coolant temperature on the wear of cylinder sleeves.

The long work at low thermal conditions leads to tarring of diesel engines: on cylinder walls, especially in the area of piston rings and piston valves, deposited resin, very viscous products. They appear as a result of decomposition and oxidation of unburned fuel and oil that enters into the combustion chamber. Tarring aggravates mobility of piston rings in the grooves of pistons and causes a loss of compression. With strong tarring it can be valves hanging in the guide sleeve and even blocking of pistons in cylinders.

Low temperatures make difficulties to normal operation mechanisms of power transmission, chassis and drive control. Large oil viscosity in the mechanisms not only increases the resistance to rotation of parts, but is a cause of increasing details wear because of deteriorating lubrication of friction surfaces. Therefore, you should not move at high gear until the oil in the mechanisms will not warm up.

Organization of start to winter period operating vehicles.

The transition to winter time of the machine operation is similar to the previously considered preparation for summer time use. The required amount of work is provided in the action plan for the preparation of personnel, materiel and parks for use in winter, approved by the commander of the military unit.

Training of personnel is organized so as to inoculate practical habits of work to crews in the proper execution of work on transfer vehicles for winter use, rapid cars setting to combat readiness, to train crews technically correctly use and maintain the machine at low air temperatures.

After studying the influence of winter conditions on the job and combat readiness the driving rules are leant. Then at workshops is worked the technology of works that are carried out when transfer machinery for seasonal use. At the same time are worked actions of batteries installation, heaters starting etc.

At the expiration of training crew takes test for the rules of operation and driving in the winter. An admission orders to the crew's operating machinery is given over the military unit.

Preparation of material for winter conditions include regular inspection and maintenance (in M-1 and M-2) and also some special work maintenance of vehicles, weapon systems, communication facilities that are marked in the manuals of each car's brand .

To help the crew with carrying out the weapons, communication facilities and removing inaccuracy the specialists of repair departments are involved.

Readiness of vehicles for use in winter is checked by commander of platoon, companies and deputy battalion commander in the technical part. At the expiration of all kinds of work the orders of the military vehicles readiness for use in the winter is given over the military unit.

Preparation of power supply unit. Operation of diesel engines in the autumn-winter period at +5°C and below in summer fuel due to the deterioration of its fuel spray and feeding can lead to reducing power and even stop the engine. So summer fuel is poured off from the fuel tanks, wash the fuel filters of fine and coarse cleaning and fill tanks up with winter diesel. Then run the engine at 3-5 minutes and burn up fuel, that is left, from the pump, piping and engine filters.

Preparation of the lubrication system.

In areas with extremely low temperatures oil MT-16P in the lubrication system tank engines is replaced to MT-14p. After pouring off the oil system and all filters are washed by oil MT-14p and then fill up with fresh oil MT-14p to norm. Lubrication systems of car engines and armored vehicles fill up with winter brand oils.

Preparation of the cooling system. Inspect the radiators, pipes and their junctions to prevent leakage, good condition of heater and heating system.

Duration of engine heating significantly depends on the amount of fuel that is supplied by nozzle. If it is given less than norm, the heater does not provide the estimated heat output. With the increased supply the fuel is not completely burned and on the walls of the boiler varnish is deposited, which prevents normal heat transfer to the cooling fluid. In order to all cars of unit could be prepared to move at the same time, the regulation of nozzles should be checked, measuring the amount of fuel that is supplied to the measure for a minute.

Purify heater boiler from varnish usually after removing the heater out and disjoining. Varnish is removed by special cleaning rod or wooden scraper. At the same time disjoint and wash nozzle in diesel fuel. Before assembling all parts are blown with compressed air. In areas with temperatures below -30°C in the case of heater reducer to liquefy lubricate CIATIM-201 fill up 25- 50l of diesel.

After preparing the heater in the cooling system fill up the antifreeze with mark 40 or for areas with temperatures below -35°C mark 65. The work of heating system is checked by heater running for 2-3 min.

If the system is not refueled, it is necessary to shed 5-6l of antifreeze to remove water and prevent it from freezing in the cooling system. In the absence of antifreezes fluid the crankshaft turn by starter two or three times without fuel. The draw-off tap, hole for poring off the coolant in the bottom shell and filling neck should leave open. The exact executions of these works examine officers.

In addition, pour off the water from the air-liquid cleaning system of observation devices.

In preparation IFV for the winter purifiers install in 3-5mm from the rim wheels and open air intake shutter "Winter-Summer" from ejector box to the air cleaner.

In all military vehicles summer headphones are replaced to winter headphones.

Firt of all, park preparation involves the preparation tools that provide rapid cars setting to combat readiness. One of such kind of work in units is checking of buffer groups of batteries, provide its heat insulation and install them on carts for transportation.

If the batteries are charging for weak currents, you should regularly monitor their condition.

There are car parks equipped with electric network to run heaters from an external source in some units. This allows running heaters to batteries set, due to less time preparing vehicles to move. In preparation for winter operation should verify the status of such networks.

While vehicles caring their system is not filled up in winter, antifreeze contain in additional cans or on vehicles or water-oil heater. In both cases, it is necessary to check operability of devices that are used to speeding-up the vehicles refueling.

Use and maintenance of vehicles in winter. Preparation the engine to start. The engine must warm up before running to the temperature of a cooling liquid, which are given in the operating manual. These temperatures are in the range from +75-80°C to +110-115°C. In order to reduce heat losses incoming and outgoing blinds need to close with tarpaulin or warm up with regular mats.

To avoid danger of bearings fusing at engine starting caused by oil inject pump should to create pressure in the lubrication system at least 2-3kg/cm<sup>2</sup>. To avoid overheating of the oil inject pump it is recommended to start it transitorily for 3-5s (for some vehicles time can be increased, but this must be given in the manual).

It is allowed a six-time start of pump. If the required pressure is not created, the crankshaft is turned by starter without fuel, simultaneously with oil inject pump. In the case of low oil pressure and when crankshaft is scrolling you should repeat heating of the engine.

By creating the necessary pressure at the working oil inject pump, turn the engine crankshaft by starter without fuel, and then run the engine.

On vehicles without a heater or with a defective heater before starting the engine warm up with hot water. Heated to + 90-95 ° C water is poured into the cooling system when the draining tap is open. When the hot water flows from the tap, you should close it and fill the system up with water. When the air temperature is from -10 to -15°C after 10-15 minutes of keeping the water is drained, and the system is filled antifreezes coolant heated to + 90-95°C. When the air temperature is from -15 to -25°C through the engine shed two refueling of hot water, and at even lower temperatures to 5 fillings. Reliable start would be in that case if during the keeping for 10-15mins the water temperature does not drop below +30-35°C.

In order to trouble-free operation warm up engine, strictly following to established stepped speed mode. For example, engine B-2 and B-6 is heated first of all at 700-800 rev/min until the oil temperature is +10°C, then at 1400-1600 rev/min to the oil temperature + 30-40 ° C. Then gradually increase the revolutions to 1600-1800 rev/min. If oil pressure is not below 6 kg/cm<sup>2</sup>, it is allowed to start moving on a lower gear.

Normal engine operation at all operating modes is ensured by heating the water and oil to +55°C. To avoid tarring and increased wear of tank it is not recommended to use engines for a long time at a temperature of the cooling liquid below +65-70°C.

Warming up of the power transmission units. At low temperatures oil thickens in the mechanisms, increases the resistance of shaft rotation, as a result it is difficult to start an engine and move a car. In addition, the thick oil sprays badly, deteriorate conditions of its admission to the friction zone and, of course, the wear increases. For heating oil in the mechanisms, especially in cold weather, it should move on slow gears for 20-30mins.

Support vehicles in readiness for use.

When the situation demands that the vehicles should be in readiness to move, the engines periodically are heated by the heater. They are started to work at lower temperature of coolant to +30-40°C and off at the temperature + 80-90°C. The heat is stored in the vehicles better if they are put in shelter, close blinds, the warm up forceful separation of regular mats or cover the car with tarpaulin.

After using the vehicle, first of all, should assiduously to operate the engine. If it is filled with water, it is poured off at +50-70°C. The remaining water is removed from the system, first of all turn the engine crankshaft when the drain tap is open by starter for 3-5s, then shed 5-6l of antifreezes fluid through the system.

It should not allowed accumulation of snow at the bottom of the vehicle. When the vehicle runs a layer of snow is melting, and then stop the vehicle the water frosts and freezes the traction to the bottom.

Filling up vehicles with fuel and oil should exclude falling snow in the tanks. The water formed from it can freeze in the filter pipes or oil channels. Stopping the flow of oil in the bearings due to freezing water stoppers leads the engine down. Despite of these difficulties, experience shows that strictly following to established rules of use and maintenance of equipment the long trouble-free operation is provided and high combat readiness at any low temperatures.

Planning work of the transfer of military machinery armament (MMA) for seasonal operation should be performed with taking into account the number of vehicles, manhours for transfer on one vehicle on the seasonal operation mode and availability of logistical support are used in the works for military machinery armament

The commander of the military unit orders the transfer of military machinery armament to the seasonal operation mode. On the basis of the order over the military unit assistant of armament commander together with the chiefs of services, agreement with HQ make a plan of transfer of military machinery armament to the seasonal operation mode.

The plan includes:

- Training of personnel;
- Preparation of military machinery armament and facilities;
- Logistical support facilities maintenance departments;
- Order of works for transfer to seasonal operation mode;
- The timing and amount of work performed by specialized teams and posts;
- Equipping cars parking;
- The procedure for checking the quality by officials and committee of military unit;
- The procedure of documentation on the machine;
- The term of the draft order for the transfer of military machinery armament to the seasonal operation mode.

The plan is approved by the commander of military unit in 10-15 days before beginning of works on the vehicles.

Based on this plan assistant of armament commander of Battalion develops a schedule for the transfer military machinery armament to the seasonal operation mode. In 10-12 days before beginning of works on the vehicles commander of battalion present schedule to commander of military unit for approval.

In companies according to schedule of battalions in 8-10 days before beginning of works company commander develops a schedule of works in the company.

To perform work with MMA company develops process sheet for each sample, which is in service.

Before the work for the transfer military machinery armament to the seasonal operation mode is prepared and conducted technical conference with personnel of unit.

At the conference, experts of equipment operating share with personnel their experience in the operation and maintenance of MMA. Commanders summarize and analyze the operation for the past six months and also analysis of breakage and breakdowns caused by personnel in MMA.

Training of officers and warrant officers of unit realizes by two-day training, held in the unit before performing the transfer work to the seasonal operation mode.

After completing the training with officers and warrant officers the classes with personnel are organized and conducted.

On the classes with crew members, drivers every action of maintenance with performance of right working methods and the use of tools and accessories is studied and worked. After the finishing classes the

personnel takes a test in rules of operation, maintenance of MMA and precautions, fire safety, rules for using antifreezes fluid, heater start rules, order of engines running and their warming up signing in the list.

Logistical support as to transfer to seasonal operation mode must include the following measures:

- Calculating consumption of operational materials, fuels and lubricants, and special liquids and also spare parts and tools;

- Execution and applying request for receipt a needed number of parts and tools, operating materials, fuels and lubricants and organization of their maintenance;

- Inspection, repair and preparing of stationary and moving vehicles maintenance and repair.

- Logistical support must be completed in 3-5 days before starting works on the vehicles.

Park equipment used for the transfer of to seasonal operation mode is checked, if necessary, restored.

For work of posts and teams appropriate reserves of required materials are create. Special attention is paid to serviceability of tools and devices that will use.

In preparing the park and its equipment to the transfer of military machinery armament to seasonal operation mode measures to rapid ensure of military machinery armament to readiness for its intended use are carried out:

- Prepare water-oil heater;

- Prepare the elements of line maintenance;

- Check and prepare the backup buffer group of batteries;

- Check the communication and signaling system;

- Check of fire safety and freelance fire department.

The most complex operations with MMA perform specialized posts and teams according to schedule.

Works with MMA start with general formation of all personnel of park unit. The commander of military unit to hear a report of units' commanders about their readiness to perform work with MMA, specifies tasks to units and gives for performance, holds a general instructing of all personnel concerning precautions.

Battalion Commander specifies the tasks, conduct a general instructing of personnel on safety measures. Gives the order to the company commander for implementation the day planned activities.

The company commander holds the direct instructing in the workplace, reminds of the implementation technology of the planned activities for the day. Separate the personnel to workplaces and vehicles.

For performing the required scope of works with MMA the each day plan-task for vehicle is given to the crew. During the transfer of military machinery armament to seasonal operation mode it is forbidden to engage personnel for work that is not related to the performance of work with MMA.

The commanders of battalions, companies organize work with MMA, monitor the progress and quality of work that are planned in schedule.

The platoon commanders are in the park. Direct the work of personnel, teach it the rules of works in the transfer of military machinery armament to seasonal operation mode, check the quality of work, and personally inspect all armament and equipment of platoon.

### **Conclusions**

Timely and full implementation of armament maintenance, equipment for winter operation mode ensures trouble-free operation of armament and equipment in winter, its maintenance in combat readiness and prevent damage of armored arms and equipment.

### **Prospects for further research**

In the Armed Forces of Ukraine it is necessary planning and aggressively implement measures for the further development and introduction of new standardized all-season fuels and lubricants.

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**Reviewer:** Chief of the Department of combat use of armament and military equipment, Colonel V. Yarmolyuk, PhD, senior research worker, Military Academy, Odessa.

## ОСОБЛИВОСТІ ЕКСПЛУАТАЦІЇ МАШИН У ЗИМОВИЙ ПЕРІОД

О.М. Верламов, В.В. Клець, І.Д. Штогрін

*В статті приведені особливості підготовки та експлуатації двигунів бронетанкової техніки в зимовий період. Вплив температури охолоджуючої рідини на знос гільз циліндрів. Організація переходу на зимовий період експлуатації машин. Підготовка системи змащення, системи охолодження двигунів бронетанкової та колісної техніки. Підтримка машин у готовності до використання.*

**Ключові слова:** колінчатий вал; електроліт; сірчана кислота; корозійностійкий чавун; форсунка; підігрівач; маслозакачувальний насос; низькозамерзаюча рідина

## ОСОБЕННОСТИ ЕКСПЛУАТАЦИИ МАШИН В ЗИМНИЙ ПЕРИОД

А.М. Верламов, В.В. Клець, И.Д. Штогрин

*В статье приведены особенности подготовки и эксплуатации двигателей бронетанковой техники в зимний период. Влияние температуры охлаждающей жидкости на износ гильз цилиндров. Организация перевода на зимний период эксплуатации машин. Подготовка системы смазки, системы охлаждения двигателей бронетанковой техники. Поддержания машин в готовности к применению.*

**Ключевые слова:** коленчатый вал; электролит; серная кислота; коррозионностойкий чугун; форсунка; подогреватель; маслозакачивающий насос; низкозамерзающая жидкость.