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Reconstruction of Armoured Bridge Layer MT-72

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Abstract:

The paper contains constructional scheme of a vehicle and its individual aggregates, systems and subgroups. It gives constructional overview of the MT-72 vehicle. The designed conception solves re-construction shape of the vehicle hull, which makes it possible to create the compartments of driver and commander in the front of the vehicle next to each other. The transmission is also modified and adapted to enable intake of required performance for the pump drives of the vehicle's extension. In this re-constructed bridge layer i.e. MT-72 M2 is installed new air-conditioning unit, new fire-fighting equipment by Co. DEUGRA and engine with more efficient air cleaner, too. Laying mechanism controlled by the linear hydraulic cylinder, suspensory consoles and compatibility of the bridge layer MT-72 M2 with MT-55A bridge system to simplify the user's logistics was well-preserved.

Keywords:

Bridge, bridge layer, bridge position, construction nodes, MT-72, transmission, stability

1. Introduction

According to the demands of a submitter, detailed constructional scheme of the MT-72 was elaborated. It was necessary to realize modernisation of the basic tank MT-72 taking into account present demands for the technology of this kind, as well as accepting the requirements of the submitter.

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The MT-72 Project documents all crucial construction nodes (units) of an extension in term of issue relevant for technical decision.

2. General Requirements

The aim of development of the new MT-72 M2 is to design, develop and verify modernized bridge tank with the original Slovak T-72 M1 running gear supplemented by these upgraded elements:

- fixation of the seats of a driver and a commander,
- engine 638 kW (850 hp) with upgraded air cleaner,
- air-conditioning,
- fire-fighting equipment by Co. DEUGRA.

The armoured bridge-layer is designed to provide movement of troops equipped by tracked vehicles when overcoming narrow obstacles on the battlefield. When solving the bridge-layer development, it is necessary to keep possible unification of nodes and aggregates with the T-72 M1 tank, as well as national standards and unification at maximum. During the bridge-layer development, the tactical and technical demands can be refined or supplemented, but only after agreement between the submitter and the constructor [1].

3. Requirements

3.1. Operation and Tactical Requirements

The bridge tank shall provide laying of one-section (ramp) bridge through natural and man-made obstacles in short time, under firing without the crew getting out, during both night and day. The bridge construction shall also provide laying of two-section (ramp) bridge and adjustment of combined bridge crossing together with standardized transport bridge equipment. The bridge tank shall provide transport, laying and loading of the bridge over the obstacle from both starting and opposite banks.

The bridge tank shall contain the equipment necessary to perform deep fording operations unified with the machine of the basic tank that provides fording, in the same depth and velocity of flow. The bridge tank shall enable installation and operation of the device for self-entrenching. The bridge tank construction must enable its transport by rail, sea and air. The transport of the bridge and running gear separately is possible. Crew of the bridge tank comprises two members [2].

3.2. Technical Requirements

Technical parameters of the bridge tank:

- weight: 41 500 kg + 2%
- dimensions in march position shall not be more than:
  - length 10 700 mm
  - width 3 300 mm
  - height 3 800 mm

Technical parameters of the bridge:

- length 20 m
- load-carrying capacity: for tracked vehicles 50 t
  for wheeled vehicles 50 t
  max. pressure for one axle 12.5 t

- clear width 3.3 m
- distance between rails max. 1.15 m
- speed allowed on the bridge max. 15 km/h

Time needed for laying bridge over obstacle:
- one-ramp bridge max. 3 min

Time needed for loading bridge from obstacle:
- one-ramp bridge max. 3÷8 min

Time needed for laying and loading the bridge over obstacle during night can be 1.5 times longer (in doing so, the crew is allowed to get out of the tank).

Bridge construction shall allow leaning of the bridge against ground at any bridge span and it guarantees access (crossing) with sufficient visibility aiming to ensure safe transport at given speed. The bridge layer stability when moving on the slopes shall not be much different from the stability of the basic tank.

4. Vehicle Design

The following design of MT-72 was elaborated in the final MT-72 Projects taking into account requirements for development of the MT-72 and results of the final tests using functional pattern:

- reconstructed shape of tank hull of the basic vehicle enables to create compartments of driver and commander in the front of the vehicle next to each other, installation of the trackway equipment and carrying of the bridge in transport position – trackway equipment controlled by hydraulic cylinder, placed in the front of the tank hull
- transmission adapted so that the intake of the required performance for the pump drives of the vehicle is possible.

4.1. Vehicle Layout

Conceptual arrangement of the MT-72 is shown in Figs 6, 7, 8 and 9.

Vehicle interior is divided into two parts:
- engine compartment,
- fighting compartment.

The engine compartment is in the back of the vehicle and is the same as in the basic vehicle with air-conditioning. The only important change is a lead of torsion moment from drive axle to hydroelectric generator and corresponding modification of engine bulkhead. The change enforced a modification of the bottom of an air cleaner and cooling air supply to a compressor.

The fighting compartment is in the front of the vehicle and is separated from the engine compartment by a sealed wall. The tank hull is designed to enable creating of the space for the commander and the driver sitting in the front of the vehicle next to each other, as well as to enable installation of internal equipment of the vehicle through the hatch. The hatch is placed in the back and is covered. The driver's compartment is on the left in the front, 600 mm from the vehicle longitudinal axis. In terms of ergonomics of the vehicle handling, the driver's compartment is similar to the basic vehicle. However, the location of driver's equipment is different. The driver's instrument panel including fuse box is on the right and it separates the driver's compartment from the commander's compartment. Under the driver's panel is a panel for handling of the extension. On the right in the front is some security device (P-11, B-2, D-11) and on the driver's left is B1 equipment. Commander's compartment is on the right 660 mm from the vehicle longitudinal axis. On the commander's left on the back of the driver's panel is BV-34 internal communication device, BA-20 equipment, KDS equipment, and further down and in the front is R-173 radio station with KUV-11 equipment above. In the front on the right is fire-fighting equipment. Between driver and commander is placed A/C evaporator that leads cool air to the driver's and commander's compartment.

The driver and the commander sit on the same seats fixed to the top, sidewall and front panel. The commander's hatch is an improved hatch of the basic tank – outer matrix has been removed. Behind the driver are the accumulators for the vehicle and above them are electric control units and units of fuel supply system. Behind the emergency hatch, between the driver and the commander, is hydraulic distributor of extension that provides also manual control of individual movements from the position of the driver as well as the commander. On the right of the fighting compartment behind the commander's seat are FVZ, heater and fire extinguishers.

In the back of the fighting compartment are fuel tanks on the left side, oil canister on the right of longitudinal axis and drive of hydroelectric generator on the right side. Therefore, there is a space in the back that enables access to oil canister, drive of hydroelectric generator or possible emergency carrying of one or two people without dismantling of the hatch.

Placement of aggregates and equipment in the vehicle is similar to the original one. Laying mechanism of the bridge is placed in the front of the hull and is attached to the console. Its movement is controlled by hydraulic cylinders. Under the front bottom armour is recessing device that is identical to the recessing device of the basic vehicle, too. Except the recessing, this device can also serve for eventual adaptation of the ground for laying the vehicle's bridge (only occasionally). In the back of the vehicle is back console that together with hydraulic arm and middle consoles secures transport of the bridge. When transporting, the bridge is in the back console secured by hydraulic cylinders and centric cones. There is a condenser or air-conditioning in the armoured cover behind the left middle console. Fuel tanks, containers and boxes for equipment are placed identically as in the basic vehicle, and the last fuel tank and last box are modified as a result of placement of the back console. The equipment of bridge vehicle is placed on the back cover and above the left track guard.

4.2. Operating Modes

The crucial operating mode is transport, laying and loading of the bridge over obstacles. In Figures 6, 7, 8 and 9 working possibilities of the MT-72 when laying the bridge are shown. The MT-72 tank is able to lay and load bridges on the slope ±15° of transversal slope ±6°. The bridge construction for trackway equipment is designed so that the MT-72 can lay few bridges (max. 2 bays) one on another and is able to overcome obstacle 31.5 m long and 3 m deep.

Except this basic function, the vehicle is similarly to the T-72 able to dig or adjust ground for the bridge laying using the recessing device (on occasional circumstances, if the bridge exceeds the MT-72 working abilities) and in emergency it is able to pull damaged machinery using towing rope during which time bridge does not have to be removed from the MT-72.

4.3. Determination of the Centre of Gravity

Determination of the centre of gravity has resulted from the measurements and calculations using a functional pattern while requirements for the MT-72 were taken into account.

Main Dimensions:

Designed main dimensions of MT-72 with a bridge in transport position are following:

- length		10 640 mm
- maximum width		3 515 mm
- maximum height		3 830 mm
- minimum clearance		350 mm
- minimum angle of raid	- forwards	41°
	- backwards	26°
- distance between tracks		2 780 mm (R)

Weight Data:

The following data were measured by the weighting of a MT–72 functional pattern:

- gross weight	G_c =	41 633 kg
- weight of vehicle without bridge	G_v =	35 600 kg
- weight of bridge	G_M =	6 033 kg
- weight of trackway equipment	G_{PM} =	1 150 kg
- weight of hydraulic cylinders	G_{PCM} =	1 280 kg
- weight of tank bogie (without G_{PM} a G_{PCM})	G =	33 170 kg
- load of left track	G_L =	20 967 kg
		(17 950 kg from G_V)
- load of right track	G_P =	20 666 kg
		(17 650 kg from G_V)

5. Drive Units and Specific Purpose Equipment

5.1. The Laying Mechanism

The new material of the mechanism is now E 460 TS.9 and the thickness of the tie bands in parts subjected to stress / on the dipper and arm / rose from 6 to 8 mm.

5.2. The Bridge

A unit measuring the number of car crossings with a particular minimum weight proved to be important to install. The construction is affected by 35, 000 kg and more. That is why we used this load to be prevailing for crossings calculations. When the bridge is exposed to a load, it bends. Bending is proportional to the weight of the crossing carriage. If we scan these bendings, we come to a number of crossing carriages of a particular weight. Using this assumption we designed a mechanic scanner to get the number of crossings. There is a bridge-deck beam in the internal part of the bridge deck which is exposed to no external forces, a so-called rigid beam. It stands on two posts at both ends of the deck.

5.3. The Hydraulic System

The new linear fluid motors /LFM/ and pintle distributors enable us to increase the operating pressure to 32 MPa and to improve operating reliability using gaskets made by MERKEL.

The system contains four AC 2802.L hydrogenerators.

- The first one feeds the LFM 1 circuit, which is protected by one of the main safety valves with the help of a control valve.
- The second one is the source of auxiliary pressure to make electrohydraulic operating of the LFM 1, 2 and 3 movements possible. To regulate the amount of pressure, use a throttle valve.
- Numbers 3 and 4 feed the LFM 2 and LFM 3 circuits. The circuit is protected by the main safety valve and corresponding control valves (a low-pressure valve for the mechanism and a high-pressure valve for the bridge).

Apart from this, each of the hydrogenerators' circuits has another safety valve in front of reverse valves.

The hydraulic system preserves all good qualities of the former MT-55 A type and modifying the key elements helped us to:

- increase operating pressure to 32 MPa,
- improve operating reliability using gaskets with pressure tolerancy of 40 MPa,
- maintain the original space conditions,
- raise the reliability and working life of hydrogenerators / pressure capacity of 35 MPa,
- make the use of filter beds longer,
- protect the environment by blocking the hydrogenerator gear after oil level sinking to the sensor level, in case of a leak in the connecting pipe.

6. Coordinates of the Centre of Gravity

Coordinates of the centre of gravity of MT-72, MT-72 without bridge and tank bogie MT-72 without bridge, trackway equipment and hydraulic cylinders were taken by weighting of functional pattern MT-72, as well as by calculation.

6.1. Determination of Transverse Position of the Centre of Gravity

a) MT-72 tank bogie without bridge:

$$y_v = \frac{G_L R}{G_v} = \frac{17\,950 \times 2\,780}{35\,600} = 1\,402\ \text{mm} \tag{1}$$

$$y_v^` = R - y_v = 2\,780 - 1\,402 = 1\,378\ \text{mm} \tag{2}$$

Displacement of the centre of gravity out of the longitudinal axis of tank:

$$\delta y_v = \frac{R}{2} - y_v^` = \frac{2\,780}{2} - 1\,378 = 12\ \text{mm} \tag{3}$$

(left from the tank axis).

b) MT–72 (with bridge):

$$y_C = \frac{G_L R}{G_C} = \frac{20\,966 \times 2\,780}{41\,633} = 1\,400\ \text{mm} \tag{4}$$

$$y_C^{'} = R - y_C = 2\,780 - 1\,400 = 1\,380\ \text{mm} \qquad (5)$$

Displacement of the centre of gravity out of the longitudinal axis of a vehicle:

$$\delta y_C = \frac{R}{2} - y_C^{'} = \frac{2\,780}{2} - 1\,380 = 10\ \text{mm} \qquad (6)$$

(left from the tank axis).

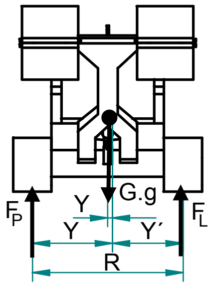

Fig. 1 Determination of transverse position of the centre of gravity

6.2. Determination of Longitudinal Position of the Centre of Gravity

a) MT-72 tank bogie without bridge:

$\underline{F}$ = 160 807 N (from three measurements),

a = 150 mm,

l = 5 550 mm.

$$x_v = \frac{\underline{F}\, l}{G_V\, g} + a = \frac{160\,807 \times 5\,550}{35\,600 \times 9.81} + 150 = 2705.5\ \text{mm} \qquad (7)$$

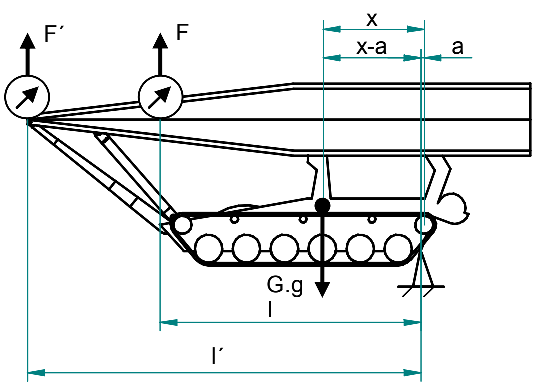

Fig. 2 Determination of longitudinal position of the centre of gravity

b) MT–72 (with a bridge):

$\underline{F}^{'}$ = 133 543 N (from three measurements),

a = 150 mm,

$l^{'}$ = 7 370 mm.

$$x_C = \frac{F\,l'}{G_C g} + a = \frac{13\,3543 \times 7\,370}{41\,633 \times 9.81} + 150 = 2\,560\ \text{mm} \tag{8}$$

c) MT-72 tank bogie without bridge, trackway equipment and hydraulic cylinders:

$$G_1 = G_{PM} + G_{PCH} = 2\,430\ \text{kg} \tag{9}$$

$$l_3 = 4\,900 + 600 + 850 = 6\,350\ \text{mm} \tag{10}$$

$$x = \frac{G_V . x_V - G_1 l_3}{G} = \frac{35600 \times 27\,055 - 2\,430 \times 6\,350}{33\,170} = 2\,438.5\ \text{mm} \tag{11}$$

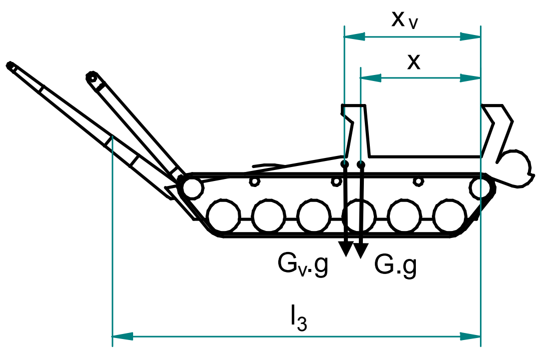

Fig. 3 Determination of longitudinal position of the centre of gravity without bridge

6.3. Determination of a Vertical Position of the Centre of Gravity

a) MT-72 tank bogie without bridge:

G_V = 35 600 kg,
x_V = 2 705.5 mm,
l = 5 550 mm,
v = 300 mm,
h = 400 mm,
a = 150 mm.

Tab. 1 Data from measurement when determining vertical position of the centre of gravity

Measurement No.	Depression angle α	Force F [kN]
1	15°37’	155.76
2	17°14’	155.59
3	19°55’	153.50

$$\underline{z}' = \frac{F}{Gg \sin\alpha}(v \sin\alpha - l \cos\alpha) + 2555.5 \cot an\,\alpha\ \ [\text{mm}] \tag{12}$$

Average from the measurements (see Table 1) is $\underline{z}' = 431\,\text{mm}$.

$$z_V = \underline{z}' + h = 431 + 400 = 831\,\text{mm} \tag{13}$$

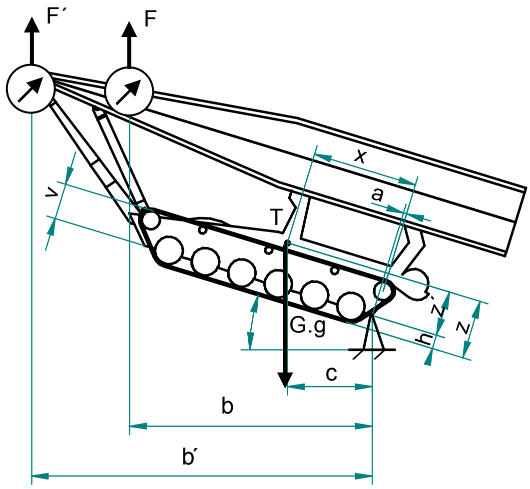

Fig. 4 Determination of a vertical position of the centre of gravity

b) MT–72 (with a bridge):

G_C = 41 633 kg,
x_C = 2 560 mm,
l' = 7 370 mm,
v' = 2 088 mm,
h = 353 mm.

Tab. 2 Data from measurement when determining stability in side slope drive

Measurement No.	Depression angle α	Force F [kN]
1	17°43’	129.64
2	18°51’	129.23
3	21°50’	128.09

$$\underline{z}' = 889.3\,\text{mm}$$
$$z_C = \underline{z}' + h = 889.3 + 353 = 1\,242\,\text{mm} \tag{14}$$
$$z_V = 1\,242\,\text{mm}$$

6.4. MT-72 Stability

According to technical-tactical conditions, MT-72 should work in different modes. From stability point of view, only those the most disadvantageous ones have been investigated. Checking was done by a static way; data gained by taking measures of a functional pattern, as well as technical documentation, were used for calculations.

MT-72 Stability in Side Slope Drive

According to technical-tactical conditions, maximum angle of slope is $\alpha = 25°$ and wind speed $v = 18\ \mathrm{m \cdot s^{-1}}$.

$R = 2\,780$ mm,
$y_C = 10$ mm ($y = 1400$ mm),
$z_C = 1\,242$ mm,
$G_C = 41\,633$ kg,
$z_W = 2\,900$ mm,
$A = 11.76\ \mathrm{m^2}$ (side face of a bridge).

According to STN 270103 wind pressure is given:

$$w = \frac{v^2}{1.6} = \frac{18^2}{1.6} = 202.5\ \mathrm{Pa} \tag{15}$$

Force effect of wind:

$$F_W = Aw = 11.76 \times 202.5 = 2381\ \mathrm{N} \tag{16}$$

Reaction under upper chord F_P:

$$G_C g z_C \sin\alpha + F_W z_W + F_P R - G_C g y' \cos\alpha = 0. \tag{17}$$

From that:

$$F_P = \frac{G_C g y' \cos\alpha - G_C g z_C \sin\alpha - F_W z_W}{R}, \tag{18}$$

numerically:

$$F_P = \frac{41\,633 \times 9.81 \times 1.38 \times \cos 25° - 41\,633 \times 9.81 \times 1.242 \times \sin 25° - 2\,381 \times 2.9}{2.78} = 104\,148\ \mathrm{N}$$

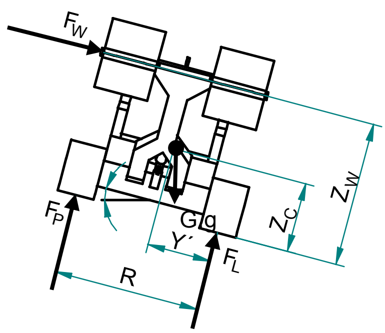

Fig. 5 Determination of stability in side slope drive

Degree of stability (for $F_P = 1$ N):

$$k = \frac{G_C g y' \cos\alpha}{G_C g z_C \sin\alpha + F_W z_W + F_P R}, \tag{19}$$

numerically:

$$k = \frac{41\,633 \times 9.81 \times 1.38 \times \cos 25°}{41\,633 \times 9.81 \times 1.242 \times \sin 25° + 2\,381 \times 2.9 + 1 \times 2.78} = 2.308$$

MT-72 Fording Capability

According to technical-tactical conditions, maximum water flow rate is v_v = 1 m·s^{-1}. During fording, MT-72 will be lightened by weight of water volume, which is the same as the vehicle one. The volume is approx. 13 m^3 including hull, trackway equipment, external fuel tanks, tool boxes, 4 hydraulic cylinders, bridge, etc.), that means gross vehicle weight of MT-72 under water is given:

$$G_{CV} = G_C - 13\,000 = 41\,633 - 13\,000 = 28\,633\ \text{kg} \tag{20}$$

and reactions under left and right chords are following:

G_{LV} = 14 525 kg,

G_{PV} = 14 100 kg.

Force effect of water flow:

$$F_V = 1.6 A \frac{v_v^2}{2g}\sqrt{g} = 1.6 \times 11.76 \times \frac{1^2}{2 \times 9.81} \times \sqrt{9.81} = 9\,590\ \text{N} \tag{21}$$

Reaction under right chord:

$$F_V z_W + F_P R - G_{CV} g y' = 0 \tag{22}$$

From that

$$F_P = \frac{G_{CV} g y' - F_V z_W}{R} = \frac{28\,633 \times 9.81 \times 1.38 - 9\,590 \times 2.9}{2.78} = 129\,430\ \text{N} \tag{23}$$

Degree of stability (for F_P=1 N):

$$k = \frac{G_{CV} g y'}{F_V z_W + F_P R} = \frac{28\,633 \times 9.81 \times 1.38}{9\,590 \times 2.9 + 1 \times 2.78} = 13.9 \tag{24}$$

MT-72 Stability when Bridge Laying

From theoretically possible cases when crossing of obstacles given by TPP, the most disadvantageous ones for bridge laying were taken into account.

a) MT–72 stability when bridge laying on a longitudinal slope of gradient α = 15° (Fig. 6):

G = 33 170 kg,

G_M = 6 033 kg,

l_1 = 10 250 mm,

h_1 = 600 mm,

l_2 = 5 500 mm,

z_V = 831 mm.

Degree of stability:

$$k(G_M l_1 \cos\alpha + G_M h_1 \sin\alpha) = G l_2 \cos\alpha - G z_V \sin\alpha \tag{25}$$

From that:

$$k = \frac{G l_2 \cos\alpha - G z_V \sin\alpha}{G_M (l_1 \cos\alpha + h_1 \sin\alpha)} \tag{26}$$

and numerically

$$k = \frac{33\,170 \times 5.5 \cdot \cos 15° - 33\,170 \times 0.831 \times \sin 15°}{6\,033 \times (10.25 \times \cos 15° + 0.6 \times \sin 15°)} = 2.78$$

b) MT-72 stability when bridge laying from flat surface to a longitudinal slope of gradient α = 30° (Fig. 7):

G = 33 170 kg,
G_M = 6, 033 kg,
l_1 = 10, 250 mm,
l_2 = 4 560 mm.

Degree of stability:

$$kG_M l_1 = Gl_2 \tag{27}$$

From that:

$$k = \frac{Gl_2}{G_M l_1} = \frac{33\,170 \times 4.56}{6\,033 \times 10.25} = 2.44 \tag{28}$$

c) MT-72 stability when bridge laying from flat surface to a longitudinal slope of gradient α = 30° and wind speed 18 m·s^-1 (Fig. 8):

w = 202.5 Pa (wind pressure),
A = 23 m^2 (projection of bridge desks area in the wind direction),
G = 33 170 kg,
G_M = 6 033 kg,
l_1 = 10 250 mm,
l_2 = 4 560 mm.

Force effect of wind:

$$F_w = Aw = 23 \times 202.3 = 4\,657 \text{ N} \tag{29}$$

Degree of stability:

$$k(G_M g l_1 \cos 30° + F_W l_1 \sin 30°) = Ggl_2 \tag{30}$$

From that:

$$k = \frac{Ggl_2}{G_M g l_1 \cos 30° + F_W l_1 \sin 30°} \tag{31}$$

and numerically

$$k = \frac{33\,170 \times 9.81 \times 4.56}{6\,033 \times 9.81 \times 10.25 \times \cos 30° + 4\,657 \times 10.25 \times \sin 30°} = 2.7$$

d) MT–72 stability when bridge laying from the slope of gradient α = 15° to a flat surface (Fig. 7):

G = 33 170 kg,
G_M = 6 033 kg,
l_1 = 10 250 mm,
l_2 = 5 650 mm,
z_V = 831 mm,
z_P = 850 mm.

Degree of stability:

$$kG_M l_1 = Gl_2 \cos\alpha - G(z_V - z_P)\sin\alpha \tag{32}$$

From that:

$$k = \frac{Gl_2 \cos\alpha - G(z_V - z_P)\sin\alpha}{G_M l_1} \tag{33}$$

and numerically

$$k = \frac{33\,170 \times 5.65 \times \cos 15° - 33\,170 \times (0.831 - 0.85) \times \sin 15°}{6\,033 \times 10.25} = 2.93$$

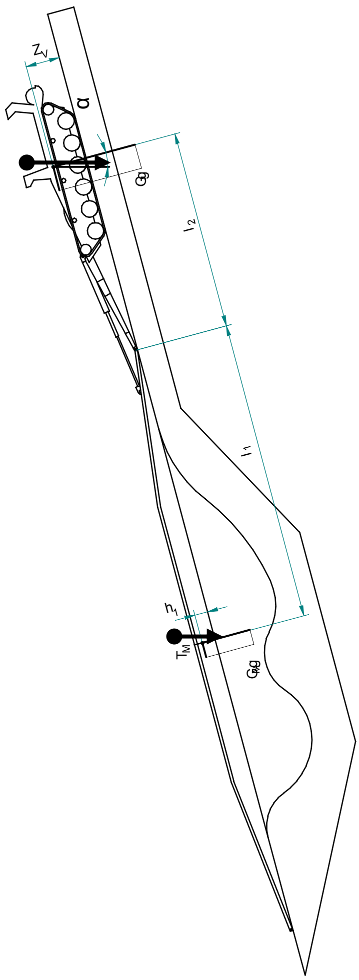

Fig. 6 Bridge laying on a longitudinal slope of gradient α = 15°

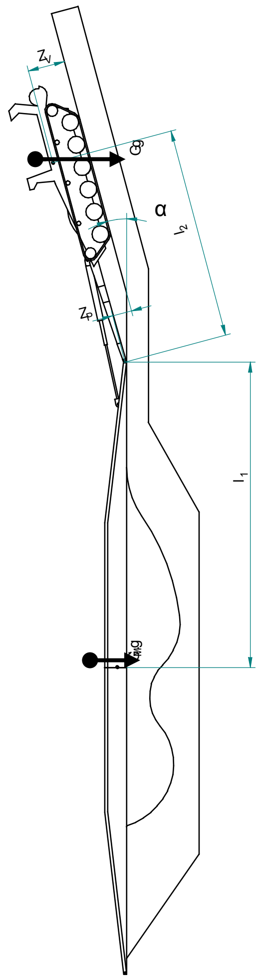

Fig. 7 Bridge laying from the slope of gradient α = 15°

e) MT-72 stability to avoid rotation in vertical axis direction when bridge laying in water of flow rate $v_v = 2\ m{\cdot}s^{-1}$ (Fig. 9):

G = 33 170 kg,
G_M = 6 033 kg,
l_1 = 10 250 mm,
l_2 = 2 800 mm,
l_3 = 2 460 mm,
L = 4 270 mm,
A = 11.76 m^2 (side face of bridge),
V = 11.2 m^3 (volume lifted by tank bogie),
V_M = 1.1 m^3 (volume lifted by tank bogie).

Weight of MT-72 tank bogie under water:

$$G^{'} = G - V\sqrt{g} = 33\,170 - 11.2 \times \sqrt{9.81} = 21\,970\ \text{N} \tag{34}$$

Bridge weight under water:

$$G_M^{'} = G_M - V_M\sqrt{g} = 6\,033 - 1.1 \times \sqrt{9.81} = 4\,933\ \text{N} \tag{35}$$

Force effect of water flow:

$$F_V = 1.6A\frac{v_V^2}{2g}\sqrt{g} = 1.6 \times 11.76 \times \frac{2^2}{2g} \times \sqrt{9.81} = 37\,632\ \text{N} \tag{36}$$

Reaction under chords of tank bogie:

$$G_M^{'} g l_1 - F_G^{'}(l_2 + l_3) = 0 \tag{37}$$

From that:

$$F_G^{'} = \frac{G_M g l_1}{l_2 + l_1} = \frac{4\,933 \times 9.81 \times 10.25}{2.8 + 2.46} = 94\,301\ \text{N} \tag{38}$$

Reaction under trackway equipment:

$$-G_H^{'} g + R_{PM} - F_G^{'} = 0 \tag{39}$$

From that:

$$R_{PM} = G_M^{'} g + F_G^{'} = 4\,933 \times 9.81 + 94\,301 = 142\,694\ \text{N} \tag{40}$$

Limit coefficient of resistance to rotation for the degree of stability $k = 1$:

$$\mu = \frac{F_V(l_1 + l_2 + L)}{F_G^{'} 0.5L + F_{PM}(l_2 + L)} \tag{41}$$

and numerically:

$$\mu = \frac{37\,632 \times (10.25 + 2.8 + 4.27)}{94\,301 \times 2.135 + 14\,2694 \times (2.8 + 4.27)} = 0.54$$

According to specialized literature, a value of the coefficient on sliding and soak soil is low, only 0.25 with negligible effect of cohesion, then limit velocity of water flow for $k = 1$ and $\mu = 0.25$ is:

$$F_V = \frac{\mu F_G^{'} 0{,}5L + \mu F_{PM}(l + L)}{l_1 + l_2 + L} \tag{42}$$

numerically

$$F_V = \frac{0.25 \times 94\,301 \times 2.135 + 0.25 \times 142\,694 \times (2.8 + 4.27)}{10.25 + 2.8 + 4.27} = 17\,468\ \text{N} \tag{43}$$

and

$$v_{\lim} = \sqrt{\frac{F_V 2g}{1.6A\sqrt{g}}} = \sqrt{\frac{17468 \times 2 \times 9.81}{1.6 \times 11.76 \times \sqrt{9.81}}} = 1.36\ \text{m} \cdot \text{s}^{-1} \tag{44}$$

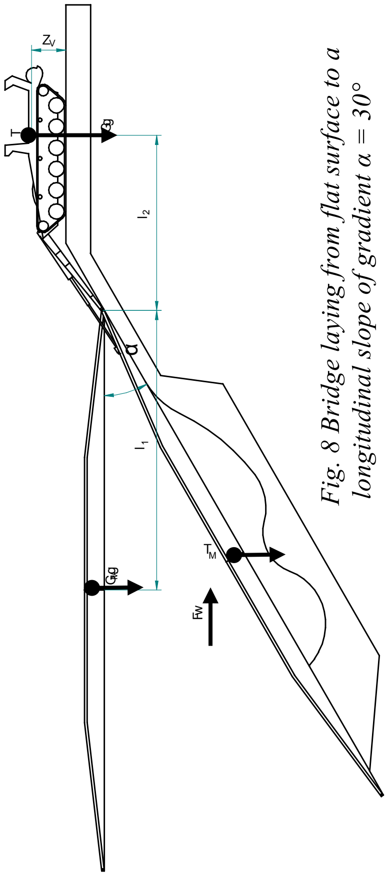

Fig. 8 Bridge laying from flat surface to a longitudinal slope of gradient α = 30°

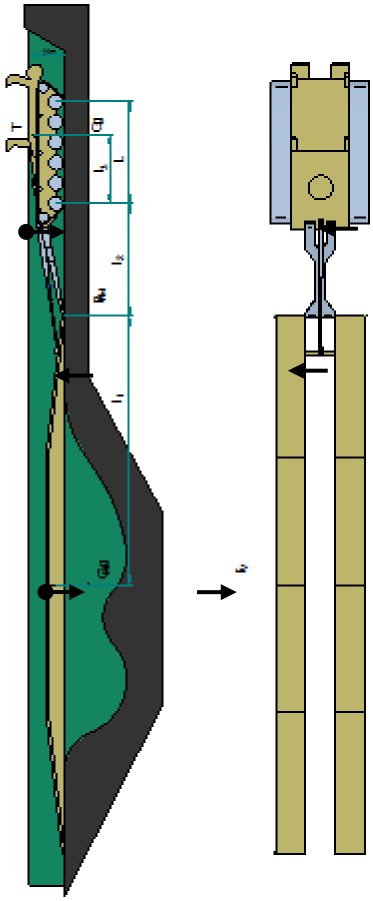

Fig. 9 Bridge laying in water of flow rate $v_v = 2\ m.s^{-1}$

7. Conclusion

As a result of rights incurred to solve the task within ‘final project’ phase, the design of the MT-72 is complete and with its parameters fulfils all required technical tactical parameters except distance measuring equipment.

The design of the MT-72 bridge-layer was elaborated in detail within ‘final project’ phase, resulting from technical-tactical conditions and functional pattern concept that were completed in line with requirements for modernisation of the basic vehicle.

The vehicle layout was specified and individual requirements for development of the MT-72 were considered. The MT-72 layout preserved the ‘scissor’ type of a bridge, exploitation of laying mechanism and hydraulic distributor of virtually identical construction though improved parameters compared to those of the MT-55A. This solution of the crucial aggregates together with the placement of the back console enables without any MT-72 aggregate changes also transport, laying and loading of the bridge of the MT-55A tank over obstacles. The same is applicable for the bridge of the MT-72 in relation to the MT-55A. However, this can be done only in emergency as exertion of the laying mechanism, hydraulic cylinders and pumping device shortens the bridge-layer period of service. The MT-72 bridge construction enables the bridge tank to overcome obstacles using two ramps though the combination of the ramps is possible, i.e. one ramp can be from the MT-72 and another from the MT-55A. This should be economically advantageous in areas where MT-55 A was exported.

This paper comprises final MT-72 construction design that results from technical-tactical conditions and from the knowledge attained when creating operational model of the vehicle and some of its aggregates (bridge, laying arm). The paper contains the construction design of the vehicle and its aggregates, systems and nodes. It offers constructional overview of the MT-72 vehicle and a good support for technical decision-making.

References

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