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MODIFIED ALGORITHM OF AUTOMATIC LAUNCHING OF THE MG-20 BRIDGE SPAN

Abstract. The MG-20 assault bridge has three modes of launching over an obstacle: emergency, manual and automatic. The article discusses the results of the changes made in the existing algorithm of the operation of the control system supervising the process of automatic launching of the MG-20 bridge span over an obstacle. The reasons of modifying the current algorithm are described. Modifications were made in the sensor system to enable control of additional parameters. Charts show the individual stages of span launching depicted on the display panel. The results obtained and advantages of the modifications are summarized in conclusions.

Keywords: MG-20 assault bridge, terrain obstacle, PM-20 span, span launching, span retrieval, automatic span launching.

1. INTRODUCTION

Since 2003 the Research and Development Centre for Mechanical Devices "OBRUM" is implementing a programme to develop military self-propelled bridges on wheeled and tracked chassis for the needs of the Polish Armed Forces. The bridge programme was codenamed Daglezja (*Douglas fir*) and it included a family of bridges:

- MS-20 support bridge [1] on wheeled chassis (Daglezja);
- MG-20 assault bridge [2] on tracked chassis (Daglezja G);
- MS-40 folding bridge [3] on wheeled chassis (Daglezja-S).

The basic distinguishing feature of these bridges is the type of application dependent on the environmental conditions (conducted war operations) and the nature and size of the terrain obstacle over which the bridge span needs to be extended.

These variants of the bridge are now at different stages of product development:

- MS-20 – series production;
- MG-20 – trial batch;
- MS-40 – tested prototype.

1.1 MS-20 support bridge on wheeled chassis

This bridge, developed and manufactured at OBRUM, allows the PM-20 bridge span to be launched within a few minutes over an obstacle up to 20 m wide. This bridge can be crossed by MLC70/110 class vehicles [4] (acc. to STANAG 2021 standard). This version of the bridge allows the span to be launched and retrieved when there is no direct warfare in the area. The process of launching and retrieving the span is controlled from a portable control panel by an operator outside the vehicle, who controls the process while observing it. The portable control panel can also be connected inside the cab. Such connection also enables viewing the operating parameters of the traction drive on the portable control panel.

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Fig. 1. Launching the MS-20 bridge span in open terrain [14]

The use of this type of equipment, a truck-mounted bridge, enables quick and effective help also in rescue operations during natural disasters. The bridge semi-trailer is equipped with additional hydraulic drives that improve traction properties and enables moving in rough, e.g. hilly, terrain. Special design of the semi-trailer enables changing the width of the span from the transport arrangement to the working arrangement and vice versa. Due to this, the span in the transport arrangement and the entire MS-20 bridge can move on public roads without additional approvals (pilot, route arrangements, etc.), because they meet the requirements of traffic regulations.

1.2. MG-20 assault bridge on tracked chassis

The MG-20 bridge is an extension of the MS-20 bridge structure. The design requirement was to use the same PM-20 span, which was made possible by the specially designed structure of the bridge layer - compatible in terms of the span mounting. The distinguishing feature of both carriers (wheeled chassis and tracked chassis) is the possibility of launching the PM-20 span over an obstacle by means of the tracked vehicle and retrieving the span by means of the wheeled vehicle and vice versa. Operating the MG-20 bridge in full automatic mode is a very important feature that enables the span to be launched during war operations (passage of troops) and the span to be retrieved under different conditions, e.g. by the wheeled vehicle. The MG-20 span is shown in Fig. 2.

Fig 2. MG-20 bridge [14]

The MG-20 assault bridge is designed for engineering subunits, which are part of the units and higher tactical units that include tanks. MG-20 can operate under rough field conditions, during warfare, also in chemically contaminated areas. The MG-20 bridge is highly mobile, its launching time is short and it can provide maximum crew protection.
The requirements set out in document [2] include, among others, the requirement for the crew to be able to launch the bridge span over an obstacle and to retrieve it without leaving the interior of the base vehicle (tracked chassis) when the difference in elevation of opposite banks of the obstacle is as large as 2m. This is a particularly tough requirement due to the crew being unable to observe directly the launching process. The structure of the MG-20 bridge developed at OBRUM allows all three modes of operation (emergency, manual, automatic). The entire launching process is supervised by a control system which includes a programmable controller [5] that acts according to a defined algorithm. Actuating systems with built-in sensors are able to perform the entire procedure of launching the bridge, including automatic disconnection of hydraulic and electric lines connected to the bridge span, without the crew leaving the vehicle.

2. OPERATION OF THE MG – 20 BRIDGE LAYER

During tests and trials of the bridge aimed at checking the correctness of all variants of operation of the MG-20 bridge layer, particularly in the automatic mode, the element of special concern turned out to be the launching of the bridge over an obstacle the two opposite banks of which were at different elevations. The requirements covered both the case when the opposite bank level was above (Fig. 3) that of the vehicle and bridge layer, as well as the opposite case (Fig. 4).

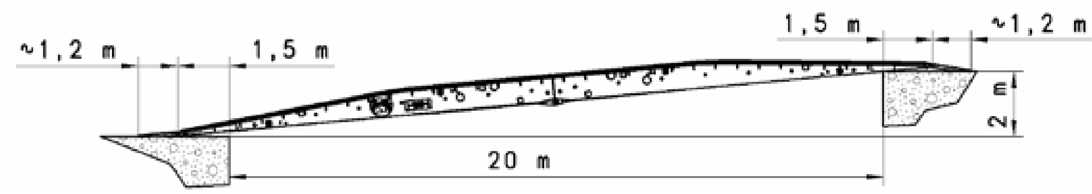


Fig. 3. Opposite bank higher than the position of the bridge layer [10]

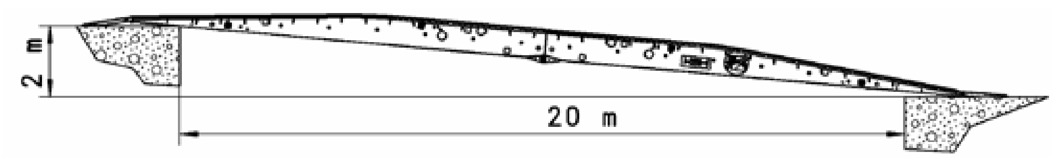


Fig. 4. Opposite bank lower than the position of the bridge layer [10]

The observations made and the experience gained during prototype testing enabled the development/writing of modified software that included additional safeguards against improper operation of the hydraulic system that would preclude proper launching of the bridge span. A new function included in the automatic span launching program calculates the ratio of the span unfolding distance to the extension of the LS2 actuator (Fig. 5). It not only allows the bridge span to be launched at an appropriate height, but also protects against improper operation of the LS2 actuator (Fig. 5) and of the span unfolding actuators integral with the span. The effects of an erroneous algorithm without these safeguards could include: too rapid unfolding of the span and overturning of the bridge or striking against the ground of an unfolded span and its damage.

Two other points in the unfolding procedure were of key importance for the control system software. One was the difficulty to detect (depending on the bank slope on which the MG-20 assault bridge was located) the point where the bridge span, being still unfolded, was a few degrees away from the vertical position in relation to the ground. Detection of this point enables proper start of the span unfolding procedure. The other key moment was the detection of the resting of the span, already unfolded, against the opposite bank of the obstacle. Modification of the bridge layer functions required the adding of extra sensors to the control system, these sensors being installed in the actuators responsible for detecting the pressure jump in the situations described above in the LS1 and LS2 actuators (Fig. 5). The operation of the actuators is managed by Trafag CMP pressure sensors [6] and Balluff BTL5 position sensors [7].

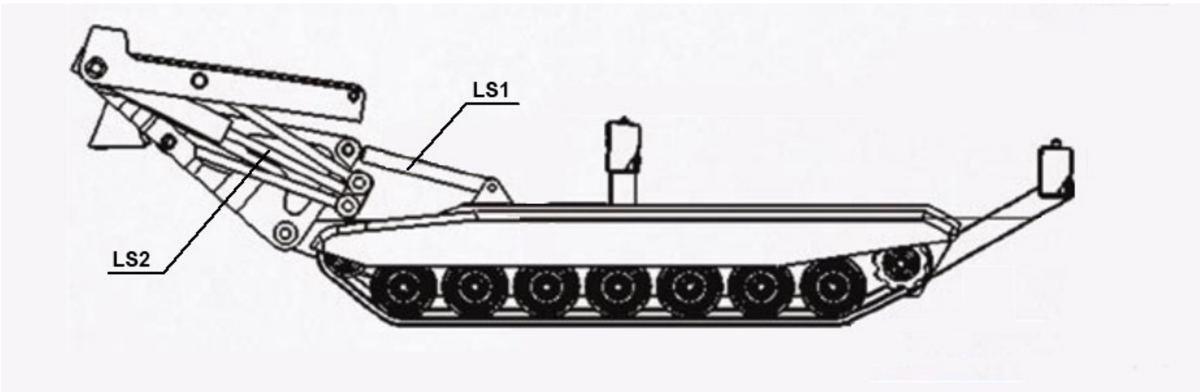


Fig. 5. Bridge layer actuators – LS1 and LS2 [9]

The automation (control) system, including the installed sensors, work on the basis of the CAN bus [8], which allows modification of the system and introduction of subsequent sensors without having to make further deep changes. The differences in the wiring diagrams of the bridge layer illustrate how the CAN bus was modified (Fig. 6). The system has two additional pressure sensors and three solenoid valves for adjusting the height of the pins located on the extendable tubes supporting the span in the transport position.

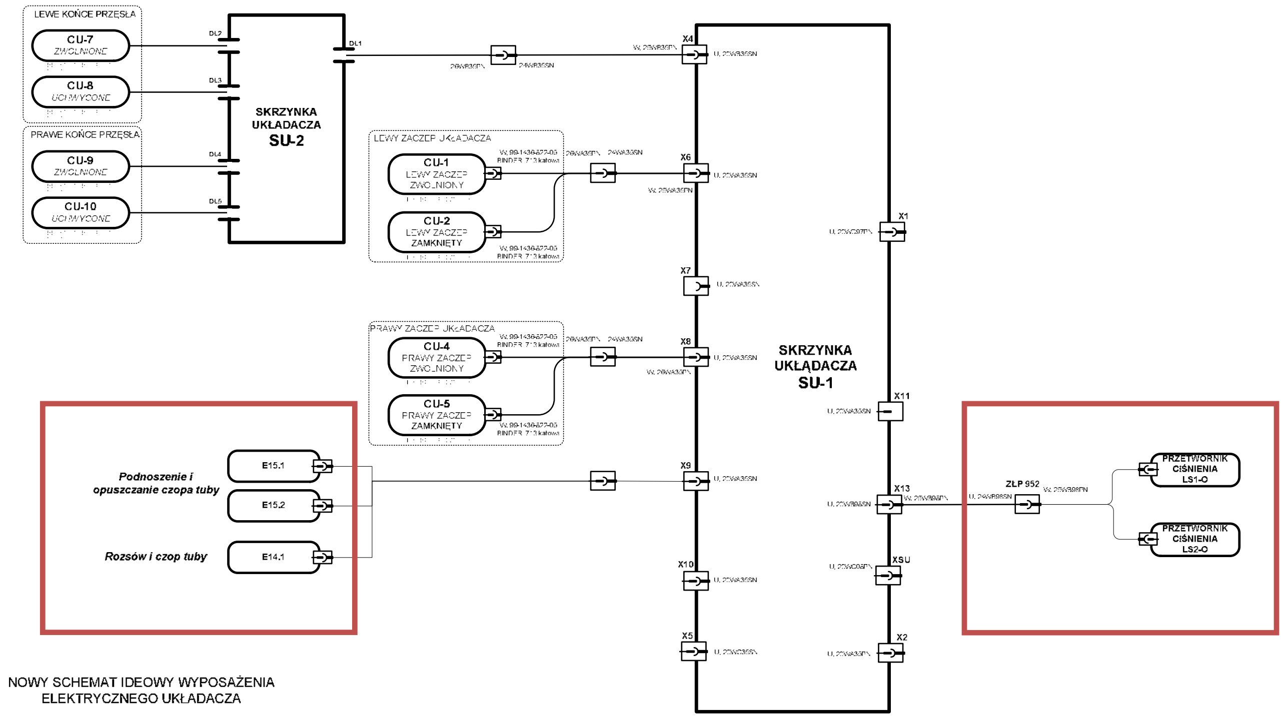


Fig. 6. Schematic diagram of the electrical equipment of the bridge layer with marked changes

3. MODIFICATION OF THE ALGORITHM

In order to eliminate possible irregularities in the process of launching the span, the algorithm of the bridge layer operation was modified.

3.1 Algorithm of MG-20 bridge layer operation

The new, modified bridge span launching algorithm was split into nine stages. The transitions between successive stages are smooth and imperceptible to the user. These stages/phases are described in Fig.7.

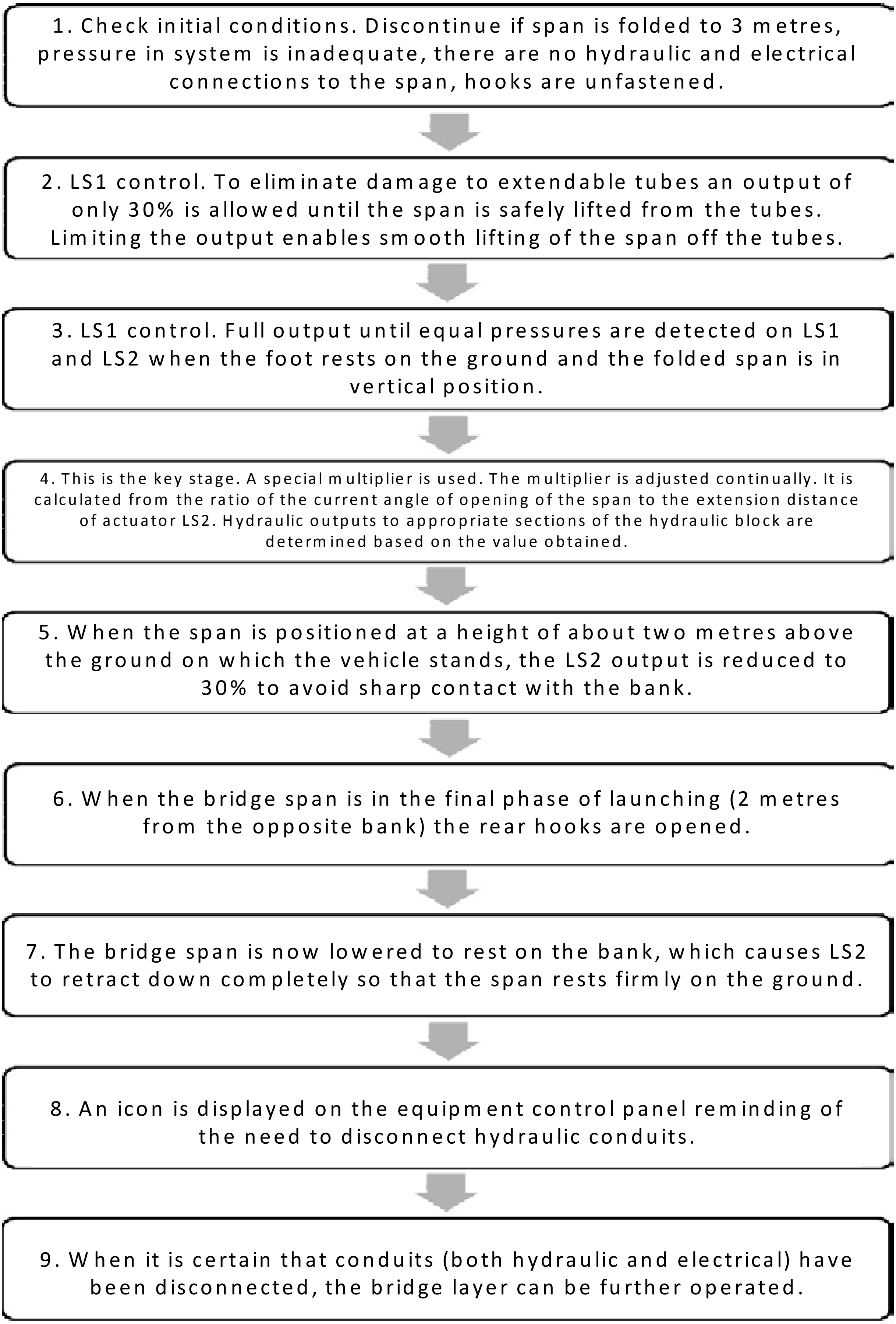


Fig. 7. Modified algorithm of MG-20 bridge layer operation

The modified algorithm shown in Fig. 7 was implemented in the controller [5] of the bridge layer. The individual phases are controlled during launching of the bridge in automatic mode by the operator on the display of the control panel [10]. All stages of span launching are displayed on the control panel screen (Fig. 8) which allows the operator to monitor the phases of the bridge layer operation.

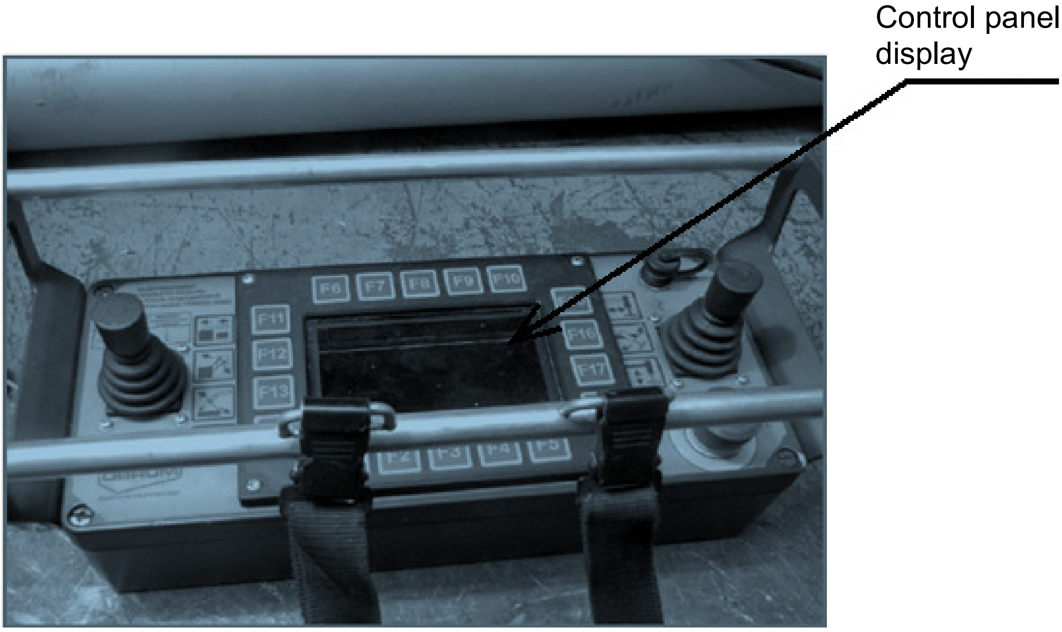


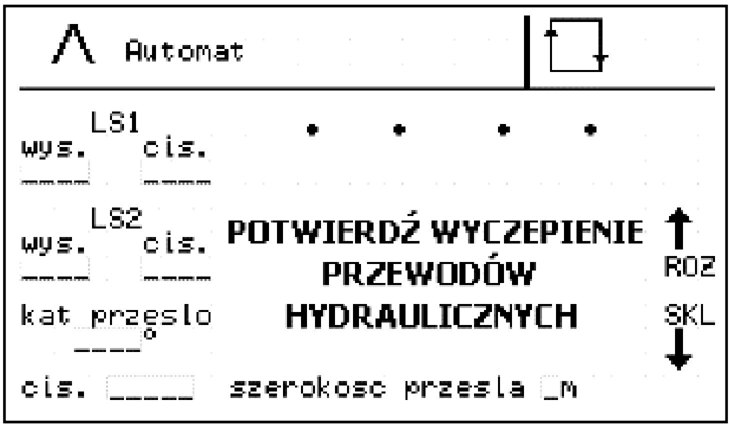
Fig. 8. Equipment control panel [8]

9.1. Bridge span in transport position – sequences 1-2

9.2. Span resting on support foot – sequence 3

9.3. Span unfolding – sequences 4-6

9.4. Span unfolding – sequence 7



9.5. Waiting for acknowledgement of cable disconnection – sequence 8

9.6. Span put off, folding bridge layer – sequence 9

9.7. Bridge layer in transport position. End of sequences

Fig. 9. Views of the screens of the bridge layer operating phases and displayed messages of bridge launching in automatic mode

3.2 Additional safety functions

While implementing modifications to the operational algorithm, several new additional safeguards were introduced.

The operation of the encoder is monitored continuously. Information on the failure or lack of communication with the encoder is displayed on the screen of the equipment control panel (Fig. 8). Such a message is shown in Fig. 10.

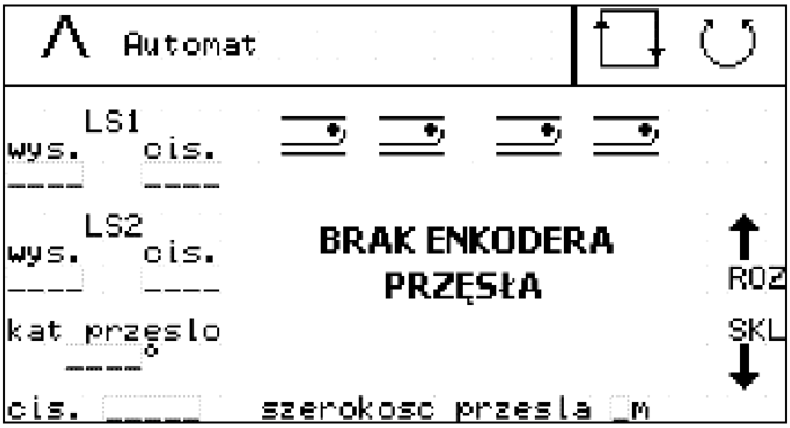


Fig. 10. Encoder operation monitoring

Another safety element is the monitoring of the deviation of the axis of symmetry of the span from the vertical plane passing through the axis of symmetry of the MS-20 bridge. This deviation can not be larger than 5 degrees.

When the vehicle is inclined, at first a sound signal is given, and then an icon appears in the upper right corner of the display informing about the situation. If in the course of automatic launching the vehicle inclination exceeds the permissible value, the process is interrupted and the bridge span can only be manipulated in manual mode.

In addition to safeguards against encoder malfunction and vehicle inclination, another safety feature is implemented to monitor the fastening of the hooks. As soon as the indication of a fastened hook in the danger zone (bridge layer angle angle between 15° and 170°) disappears on the display, a siren is activated and a special message appears on the equipment control panel (Fig. 11).

Fig. 11. Unfastened hook warning

Another important issue was to determine the moment at which span unfolding could be started.

The adopted operating conditions [2] allow the slope of the bank on which the MG-20 is positioned to be inclined at up to 20% (Fig. 12). Tests were performed to determine the optimal position of the support foot on an inclined bank. In this position, the pressures in the LS1 and LS2 actuators (Fig. 5) were equal. This observation was used in the described modification of the MG-20 bridge automatic launching algorithm.

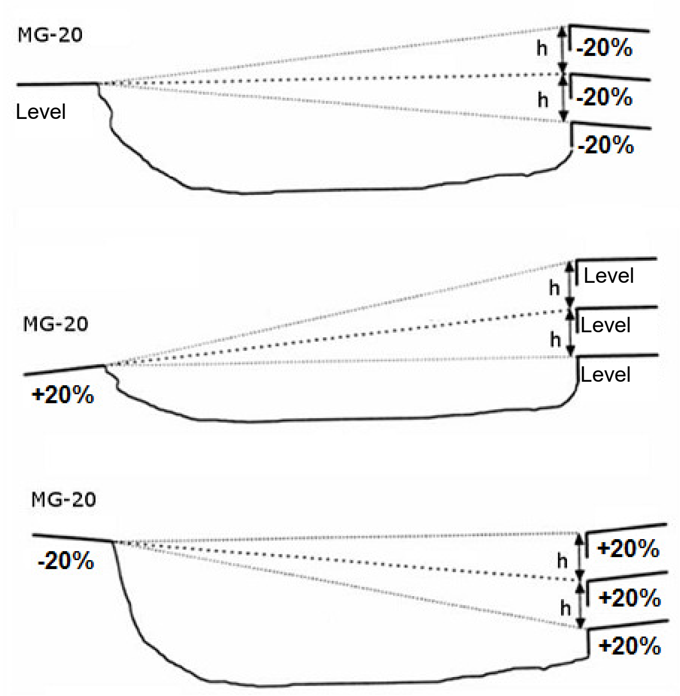


Fig. 12. Adverse cases of launching the MG-20 assault bridge [10]

The final modified software for controlling the bridge layer operation also has additional safeguards against thermal conditions and it also controls outputs in individual sections of the hydraulic system.

4. CONCLUSIONS

The experience gained during prototype testing and during trials and tests of a trial series product led to the changes made to the software. The modifications and corrections made in the algorithm had the following effects:

- bridge layer operation in automatic mode was improved;
- duration of the bridge span launching over an obstacle was shortened;
- completely safe launching of the span (under conditions as in Fig. 12) was ensured through the use of the LS2 actuator auto-correction function (Fig. 5);
- some additional operating parameters of the bridge layer could be controlled by the operator.

The changes made to the bridge layer algorithm improved the safety and reliability of using the MG-20 tracked bridge, especially when the bridge layer is operated in automatic mode, with the crew remaining inside the tracked vehicle.

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