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DEVELOPMENT OF A ROBOTED DEVICE FOR FAIRING THE BOARD OF THE SHIP WHILE PASSAGE

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Introduction. During the passage of a vessel in areas with difficult weather conditions, passing narrow passages and restricted waters, unsuccessful mooring, partial damage of the vessel's side between the rings in the form of deformations that affect her stability and speed and maneuverability are possible (Fig. 1) [1–5]. The situation may be aggravated by the fact that companies that are able to carry out regular repairs of vessels located over long distances, as well as the fact that the cargo must be delivered to the appropriate contract term.

Fig. 1 – Typical minor damage of the ship's surface

In this regard, to ensure the integrity of the vessel's surface, it is necessary to have auxiliary repair devices that will have to carry out repair work without changing the trajectory and speed of the ship at sea.

Problem statement. The technical solution that will allow performing repairs to ensure the reverse deformation of the metal surfaces of the boards of the vessel will make it possible to significantly reduce the time for performing simple but important operations without affecting the transition time.

The peculiarity of the technical solution is that it should be designed by a robotic device capable of locally identifying the deformation, taking a decision to eliminate it, and determining the repair tools even when deformation is widespread along the board (Fig. 2).

For the maritime industry, in the well-known literature, there are currently no analogs that perform autonomous work related to initial distortion, but in the field of automotive industry, on-site stations are used and carry out a vacuum cleaner. An overview of existing technical solutions in the automotive industry does not allow the use of developed devices for the current repair of maritime transport and requires the development of special devices.

Problem statement. The purpose of the work is to maximally reduce the terms of automated repair of form-changing surfaces of the ship by creating an automated reverse deformation device.

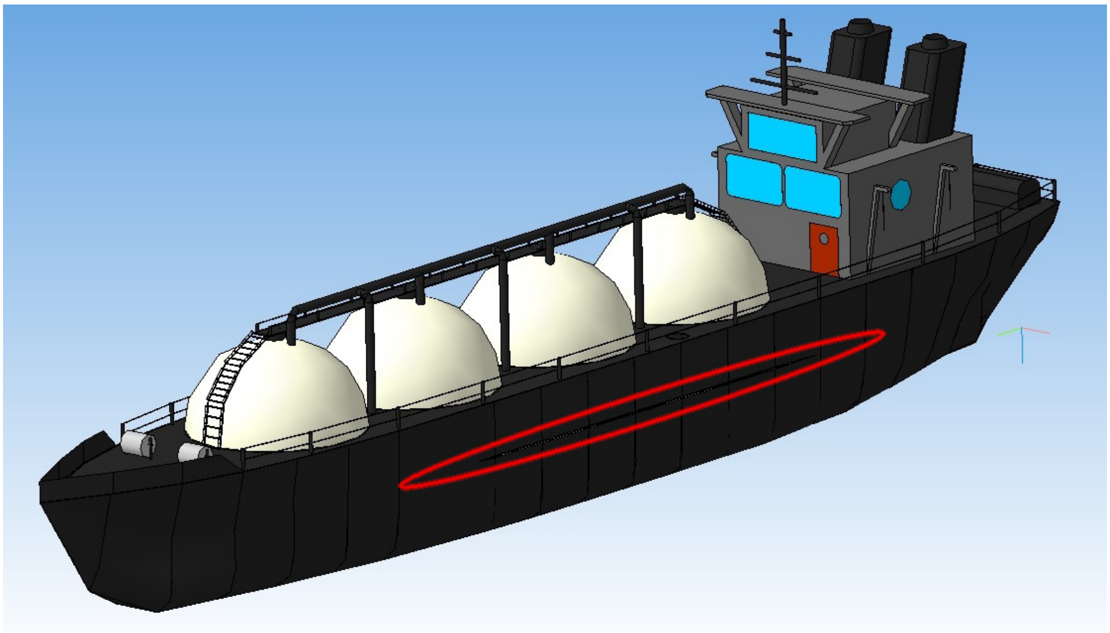


Fig. 2 – Longitudinal damage of the ship's board

For our time, the leveling of the surface of the vessel has its disadvantages, welding is most often used, so it is not possible to get rid of dents without damaging the surface or processing it beforehand [6]. To eliminate damages with magnets they are used with great force to break. Alternatively, additional heating of the surface may be used.

For the development of an automated device, two methods for restoring surface damage were taken as a basis for this elimination of magnet damage and special equipment for their improvement.

At the heart of the device design there are elements that can be found on 3-D scanners and 3-D printers (Fig 3 a, b) [7, 8]. The functions of these devices are combined because the reverse deformation process takes place in two stages: scanning the deformed surface and its alignment (Fig. 4).

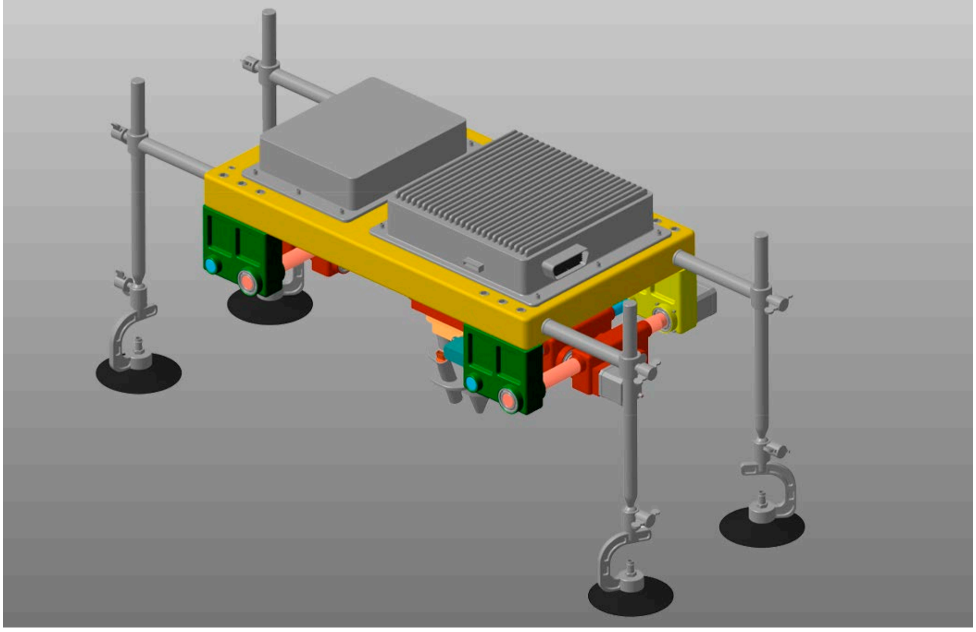


Fig. 3a – Reverse deformation device (top position)

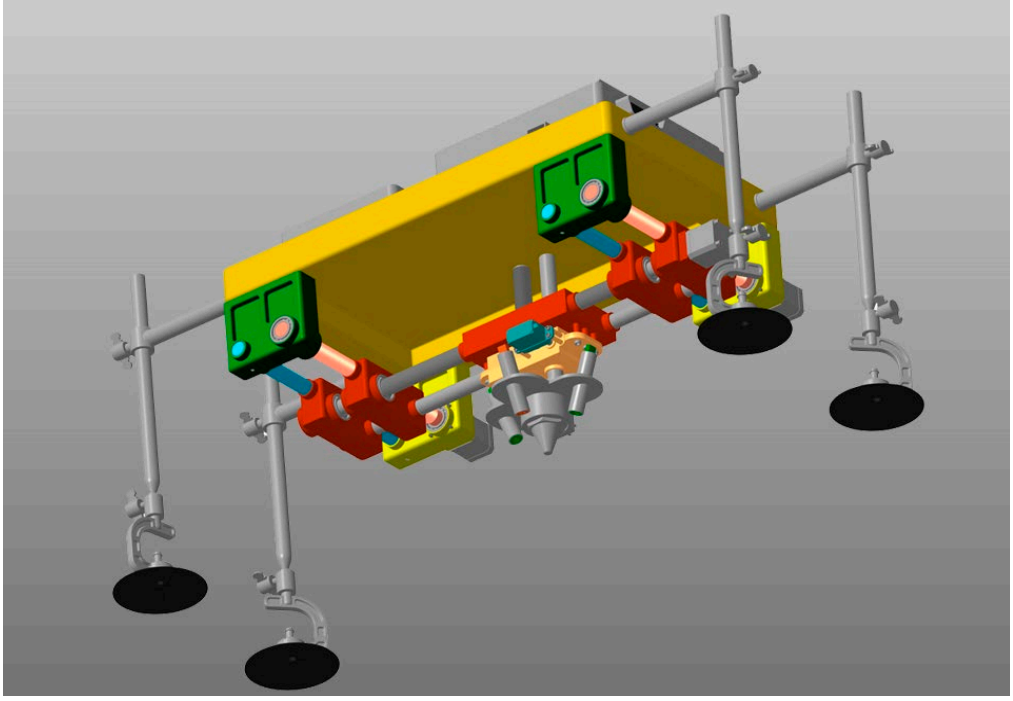


Fig 3b – Reverse deformation device (bottom position)

The following parts and structural elements are used in the design of the device: axle guides or AISI 304 steel shafts; the DSTU analogue is steel grades 08X18H10T (low carbon stainless steel is acid-proof and withstand a short-term rise in temperature to 900 degrees Celsius, also due to small the carbon content of the metal has anti-ferromagnetic properties and high strength); step engines use the NEMA17 brand with a minimum step of 1.8°; digital servo Anderson Brushless Digital High Voltage Servo 140 kg (servo made in an aluminum case with a metal reducing gearbox at an output speed of 0.062 sec / 60°); reverse electromagnet. In the electronic control unit, the most commonly used elements in 3D printers are: the main or motherboard; stepper engine controllers and servo controller; Industrial linear laser 1 mw, 635 nm with thickness of line 3 mm; Viatek Cylindrical Camcorder Brand VC-26S with Infrared Detection, which allows scanning the surface of the wing even in poor lighting conditions; Vacuum suction cups TJG TAIWAN with professional loading capacities more than 150 kg or neodymium magnets over 500 kg.

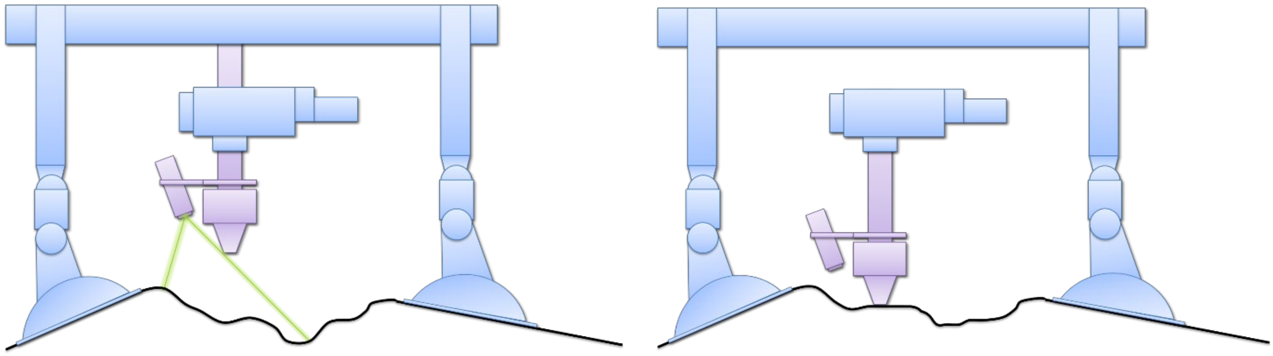
All components and elements are located on a supporting metal plate with a porous structure inside to reduce the weight of the device and allow it to be fixed on board the vessel without any additional stands and adaptations.

The device is reversed by means of an electronic control unit connected to the computer via the WiFi module.

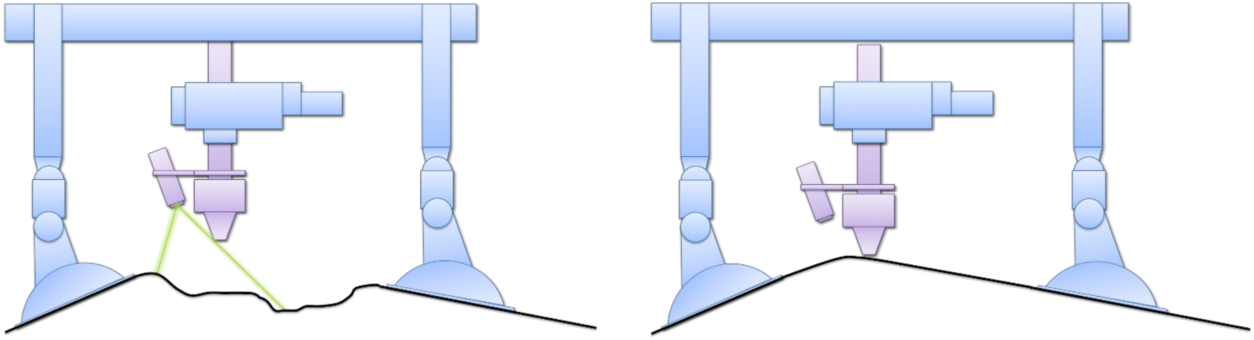
Research results. The reverse deformation of the surface occurs in several passes, depending on the depth and size of the damages. The process takes place in several passes and due to the fact that the metal surface during the reverse deformation will change its form and for the correct operation of the device and high enough quality of work it is necessary to make real-time corrections to the surface, after which the program evenly distributes the load to the corresponding points of the surface.

The repair is divided into two stages. The first stage is laser scanning of the surface. In the first stage of the device, the program loads a 3-dimensional image of damage, then automatically relying on the base points of the surface complements the phantom image close to the reference form. The phantom image is translated into a point cloud with coordinates that look like machine commands for stepper engines, servo drive and electromagnet controller.

During the second stage, the device begins "rough" correction with an electromagnet of reverse action. For greater practicality, splice heads of different diameters are used. With the aid of an electromagnet, the deformation is gradually extended. After the first pass, the device makes a new surface scan, the program builds a new phantom image of the surface with greater accuracy, setting as many reference points as possible. This is necessary to achieve maximum approximation to the initial shape when correcting the damaged surface (Fig. 4).



Initial scan Rough pulling of surface



Secondary scan Pure pulling

Fig. 4 – Stages of the work of the automated reverse deformation device

After scanning and calculating the coordinate program, the magnetic head begins to "clean" the stage of reverse deformation, but the speed of lifting the head at this stage differs from the previous stage by 2 times (slower), which provides greater accuracy and smoothness of the surface, also during the second stage, scanning the surface in real time, making adjustments to the phantom image and the coordinates of the reference points by adding them or subtracting them (Fig. 5).

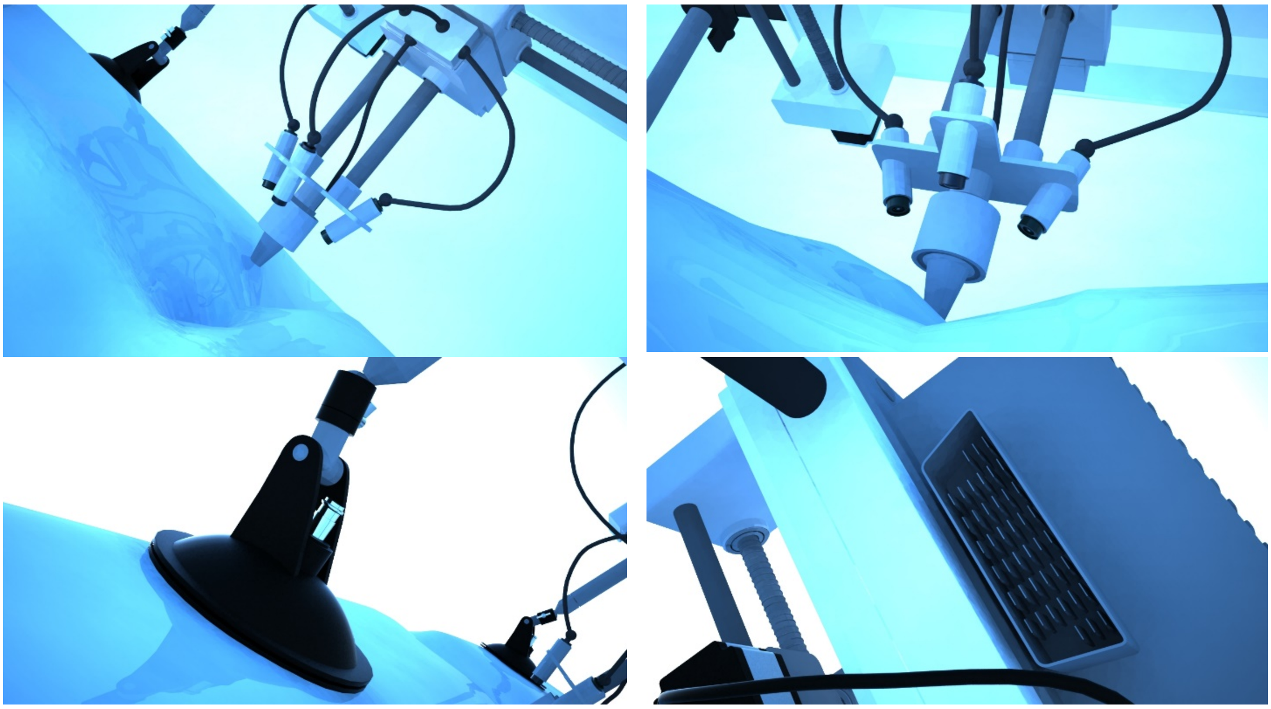


Fig. 5 – Schematic image of the device work

For the purpose of faster deformation on the front and / or the reverse side of the board, additional heating elements may be placed at the site of the damage. However, it should be borne in mind that when heated to 768 ° (Curie point), iron loses its magnetic properties, although its lattice does not change [9]. Thus, the temperature sensors should be located along the deformation circuit and the temperature fields of heat propagation should be taken into account in the middle of the fragment of the ship's metal board in order not to exceed the Curie point. In addition, during heating the rubber sucker should be replaced with powerful magnets with a corrugated surface.

Conclusions. Thus, the designed reverse deformation device will allow to automate the implementation of a complex parametric type of activity to correct the deformed surface of the ship from the sheet material. 3D simulation of the reverse deformation process makes it possible to assert that the principle of operation and design of the device has an objective function for carrying out repair work on the maritime transport.

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