Development of a skid for manual contact welding with the machine movement in the working areas

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Abstract. There is represented the creation of a skid for manual contact welding. It consists of a metal structure of the skid itself and a movement carriage. Strength and stiffness calculations of the metal structure of the skid and of the carriage were performed. A full-scale sample of the skid assembly result is shown.

1. Introduction
In the process of assembling a panel, which consists of two stainless steel sheets by manual contact welding, there was a need to optimize the movement process of the manual contact welding machine (figure 1) along a given trajectory, without any preparation of a separate template for each panel [1]. It is also necessary to ensure the mobility of this skid and the ability to perform welding works in any suitable place.

![Figure 1. Machine for manual contact welding [1].](image)

To perform the specified work by manual contact welding, the platform must move in the horizontal plane with a certain, adjustable step.

Based on the above, the creation of an experimental skid for a manual contact welding machine is an urgent task. It would give the possibility to identify the specifics of the operation of all skid mechanisms, conduct field studies of its design and in case of necessity - to carry out its upgrading, including replacing the materials employed with other materials with higher physical mechanical characteristics.

2. Design model
The experimental skid for manual contact welding is a metal structure, along the guides of which the carriage moves. During the development process of the design of this skid, it is advisable to take metal
structures of belt conveyors [2-4] and roller conveyors [5-7], which are used in warehouses, as an analogue. In the process of an engineering research, it is also necessary to take into account the development of optimal design [8-13] of existing designs of other machines in relation to the metal structure of this skid.

The experimental skid would be designed for a manual contact welding machine by TECNA [1], the main characteristics of which are represented in table 1.

Table 1. Characteristics of the contact welding machine TECNA.

| №  | Device characteristics     | Value            |
|----|---------------------------|-----------------|
| 1  | Maximum current           | 5000 A          |
| 2  | Power                     | 13000 W         |
| 3  | Welder plank              | 4 mm            |
| 4  | Total welding sides       | two             |
| 5  | Compression drive          | manual          |
| 6  | Refrigerating system      | air             |
| 7  | Dimensions (LWH)          | 370x100x230 mm  |
| 8  | Mass                      | 11 kg           |
| 9  | Electrical stickout        | 125-500 mm      |

The creation process of an experimental skid for manual contact welding consists of several stages:
1. Calculation and design of the structure of the skid for contact resistance welding.
2. Creation of a 3D-model with subsequent strength and stiffness calculation in the SolidWorks IT system.
3. Assembling the skid based on the obtained results.

Design and calculation of the structure of the skid for manual contact welding. At the initial stage, a kinematic diagram of the carriage movement mechanism [14] with a central location of the gearbox between the running wheels was preliminarily adopted (figure 2).

![Figure 2. Kinematic diagram of the carriage movement mechanism: 1 - wheel, 2 - drive shaft, 3 - gearbox, 4 - electric motor.](image)

The main characteristics of the approved kinematic scheme are as follows:
- the number of carriage wheels - four;
- let us place the drive mechanism between the drive travel wheels;
- the carriage does not need a braking device;
- the running wheels connected to the drive are driving wheels, the rest wheels are idle.

Further, the values were determined, allowing the selection of mechanisms for the movement of the carriage.
The resistance $W$ to the movement of the carriage during the movement period, reduced to the wheel rim, consists of the friction force between the wheel rim and the surface of the angle $W_{fr} = W$. It is determined by the formula [14]

$$W = G_c + \frac{2\mu + f}{D} k_{pf},$$

(1)

$W_{fr}$ – frictional drag;
$G_c$ – carriage weight;
$\mu$ – coefficient of rolling friction of a wheel on a rail;
$f$ – reduced coefficient of sliding friction in wheel bearings;
$d_j$ – journal diameter;
$k_f$ – flange friction coefficient.

An electric motor was selected, depending on the value of the power $N$ [15].

$$N = \frac{W \nu_c}{\eta_{pr} \psi_{s, av}},$$

(2)

$\nu_c$ – carriage speed;
$\eta_{pr}$ – preliminary value of the efficiency of the mechanism;
$\psi_{s, av}$ – multiplicity of the average starting torque of the engine in relation to the nominal;

The choice of the gearbox was carried out according to the gear ratio [15]

$$i = \frac{n_m}{n_{rw}},$$

(3)

$n_m$ – motor shaft speed;
$n_{rw}$ – rotation frequency of carriage running wheels.

Wheel speed $n_{rw}$ [15]

$$n_{rw} = \frac{\nu_c}{\pi D_c},$$

(4)

$D_c$ – carriage running wheel diameter.

The 3D-model creation with subsequent strength and stiffness analysis in the SolidWorks software package. The usage of the complex metal structures requires preliminary experimental research and experimental design [17, 18]. Initially, a 3D-model of the skid for manual contact welding was designed in the SolidWorks software package [16] (figure 3), which consists of the skid metal structure and a carriage, moving along it.

![Figure 3. 3D-model of the skid for manual contact welding.](image)
Let us consider and analyze the carriage and metal structure separately. The constructed initial carriage model (figure 4) was subsequently transformed into a finite element model. The design scheme was formed on the basis this model (figure 5).

The metal structure of the carriage is under the load of 108 N from the contact welding machine acting on the plate. The welding machine is attached to this plate.

![Figure 4. Carriage 3D model.](image)

At the next stage, the stress-strain state of the carriage was calculated. The calculation results are shown in figure 6 [19].

![Figure 6. The result of calculating the carriage: (a) - stress distribution; (b) – strain distribution.](image)

Further, the initial model of the metal structure (figure 7) was transformed into a finite element model and the design scheme of the metal structure was obtained (figure 8).

![Figure 7. 3D-model of metal structure.](image)

![Figure 8. Design diagram of the metal structure: 1 - hard constraint; 2 - loads from the welded panel; 3 - loads from the carriage.](image)

As the places for fixing the metal structure of the skid, hard constraints (rigid supports), located at the base of racks 1 (figure 8), are taken. There are number of loads on the metal structure of the skid with the below values:

- load from the carriage to the running track - 153 N;
load from the welded panel - 80 N. Equal to the carriage, the calculation of the stress-strain state of the metal structure was carried done (figure 9).

![Figure 9](image)

**Figure 9.** The result of calculating the metal structure: (a) - stress distribution; (b) – strain distribution.

Assembling the skid based on the obtained results. The metal structure of the manual contact welding skid was made with the ability of a horizontal movement of the working body (figure 10, 11). It should be noted that before purchasing metal for the skid and starting work, it is necessary to study the physical and mechanical characteristics of the metal [20].

![Figure 10](image)

**Figure 10.** Elements of the skid for manual contact welding: (a) - carriage; (b) - skid metal structure.

![Figure 11](image)

**Figure 11.** Skid of the manual contact welding machine.

3. Results and discussions
The obtained values of stresses and strains of the carriage and metal structure of the manual contact welding skid are as follows:
- maximum carriage stresses - 16.6 MPa;
• maximum carriage strain - 0.1 mm;
• maximum stresses of the metal structure - 74.2 MPa;
• maximum strain of the metal structure - 0.2 mm.
These values fit the conditions of strength and stiffness.

4. Conclusions
Based of the calculated and projected 3D model, a prototype of the metal structure of the manual contact welding skid was made. Calculations of the stress-strain state of the model revealed an excess safety margin of the carriage and an allowable safety margin of the metal structure. In this regard, in the future, it is advisable to carry out the optimal design of the carriage and to analyses the new values of the stress-strain state of the skid metal structure.

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