MACHINES FOR FLASH-BUTT WELDING OF BAND SAWS, RODS, WIRES AND BARS

Flash-butt welding of band saws has its own features associated with geometrical shape of cross-section of the saw (width is much larger than thickness). During resistance welding the random character of contacting areas location in the butt and, as a result of that, the non-uniformity of heating of these areas is a great problem. The heat, generated at the contacting areas, causes a rapid growth in temperature, which is maintained even after the disappearing of contact resistance up to the welding cycle end. This leads to the overheating the metal at the mentioned areas with all the coming consequences like grain growth, accumulation of impurities along the grain boundaries, etc. The ductile and strength properties of metal of this area are reduced, and it is impossible to improve them by high tempering used in FBW. Furthermore, a high current density necessary for resistance heating (much higher than in flash heating) leads to splashes of metal during heating and oxides formation in the joint zone. Therefore, welded joints of band saws produced using resistance welding do not have a high and, most important, stable quality. In FBW of band saws the single contacts are uniformly distributed in the flashing area over the entire cross-section of the butt, which provides its uniform heating and obtaining the more stable properties of the welded joints.

For joining the band saws the world industry produces machines both for resistance as well as FBW.

The machines for resistance welding of all the manufacturers (FULGOR, GRIGGIO, IDEAL) are designed almost identically and adequately handle welding of saws of up to 20 mm width. In order to increase the demand their technological capabilities were expanded by modification with clamps for mounting the band of 40 mm width, and in some machines of up to 60 mm width. In such a situation a stable and reliable welding cannot be even a question.

Machines for FBWof band saws offered in the market, like IDEAL BAS-050 or IDEAL BAS-060 (Germany), FULGOR FW400 (Italy), FL50 (China) are produced according to the traditional scheme of the same type and are differed from each other mainly by capacity and appearance. Machines of Ukrainian manufacturers G-22 and its copy MS4 with improved appearance but deteriorated as to the components and rigidity of its design are heavy, unreliable and out-of-date designs.

The most successful and, therefore, popular are the machines of IDEAL company. These machines can be equipped with pyrometers and allow obtaining a stable quality of welding. For this purpose the manufacturer recommends to remove the current-carrying jaws from the machine and perform their grinding every 10–20 welds (depending on width of bands to be welded). This requires the availability of grinding machine, which, for obvious reasons, is expensive.

The flashing process is accompanied with release of a large number of metal particles in the form of splashes and aerosol. Therefore, in all the welding machines the bearings of carriage of a moving clamp and the contact surfaces of clamps are extremely vulnerable.

The essential resource in improving the quality of welded joints of band saws in FBW is the increase in speed of closing of the spark gap. The increase in speed will reduce the oxidation of molten metal, increase the deformation rate of joint area and provide the finer grain structure of weld metal. However, the significant increase in the upsetting rate during welding in the existing equipment is complicated because the great upsetting forces result in loss of stability of the band ends, and large inertial masses of mobile clamps are determined by the design of machines and cannot be changed. A particularly low upsetting rate is observed in welding of sections, which are minimum for welding machine, traditionally evidenced by a poor quality of produced welded joints. In welding of spring and high-speed cutting steels, of which the bimetallic saw blades are manufactured, the increase in upsetting rate is also very desirable, as far as it is known that obtaining a stable quality of welding of bimetallic saw blades in the available machines is a difficult task.

In FBW to provide a stable flashing the transformers with 3 or 5 times power margin is used. At high power even a short break in flashing with transition to resistance heating (short-period short circuit) leads to a sharp increase in current in the parts to be welded and overheating of

metal in the joining zone. This is caused by the peculiarity that the voltages required for stable flashing are approximately 1.5 times higher than the voltages required for resistance heating. Therefore, designing of new welding machines with a lower electric power margin, providing high and stable quality of joints, is very relevant.

The main drawback in the design of almost all manual clamps of FBW machines is that they are not fully opened after each welding for cleaning of current-carrying electrodes, and the clamping force is not controlled in them. The clamping force of thin and narrow bands should be reduced as far as clamping of narrow bands the saw can deform the current-carrying electrode. Moreover, there is no need in a strong clamping, since the upsetting force is low and the probability of saw slipping in the clamps of the machine is also low. In connection with that, the rational is such design of clamps, where the above-mentioned problems will be solved.

The quality control of joints of band saws, rods and wires is an important part of welding technology. The control is carried out mainly by visual inspection and testing for number of bends at 180°. The tests for number of bends allow evaluating both strength as well as ductile properties of welded joints, but they provide only consulting information. Such tests are carried out after each readjustment of the machine to the other welding mode. Therefore, it is highly desirable to have a parameter, according to which the quality of the produced joint can be evaluated without its destruction. Such a parameter may be the amount of butt deformation during upsetting. At a low upsetting value in the joint area the oxide films and lacks of penetration are observed, a large value may indicate the overheating of metal. Therefore, the development of a method for control of the upsetting value represents the interest.

To achieve the put aim , i.e. the development of new welding machines, deprived of the abovementioned disadvantages, the following tasks were solved:

- reduction of weight of moving parts of the machine, that improved the quality of welding the sections, which are minimal for the welding machine;
- moving carriage is designed so that it has no friction parts like guides, bearings and other traditional elements and connections. It is suspended in the space on springs, which provide rigidity in vertical and flexibility in horizontal directions during movement of the carriage. Due to such a design, the maintenance of the carriage during operation of the machine is no longer required;
- transformer is designed to provide stable flashing at the minimum power margin, the power losses from magnetic currents are minimized;
- approach to evaluation of quality of the produced welded joints as to the upsetting value was offered. In the version of the machine with microprocessor control the actual value of the obtained upsetting is measured and appears on the display;
- clamps with symmetrical arrangement of bands are designed in relation to the axis of welding transformer (they provide uniform heating of bands, since electromagnetic field of the transformer does not displace the current line). The design of clamps provides access to the current-carrying electrodes after each welding, the controlled compressing force is proportional to its thickness, the easy and comprehensible adjustment of uniform distribution of clamping force (and correspondingly uniform heating) across the width of the band. The grinding of electrodes is carried out without their removal from the welding machine.

The technical data of FBW machines CHAJKA are given below.

The designed equipment is patented, has a high reliability and provides a stable quality of welded joints of both saw bands as well as rods and wires.

Today the two new models of welding machines are produced. The first machine is with a manual start, and the second one is a fully automatic with electric flashing drive controlled by a microcontroller. The machine is controlled by a single lever or a joystick (there are no control buttons).

In the first model the designed hydraulic drive of flashing with self-regulation of flashing rate is applied. The self-regulation is performed as follows. At the break of flashing at any reason (oxidized ends, mains voltage drop, etc.) the bands heating is transferred from flashing process to the process of resistance heating. At the same time, the solid layers of metal of the flashed ends contact each other (lean against each other) and the fluid pressure in the hydraulic cylinder decreases. The speed of piston movement is reduced and, accordingly, the rate of flashing is automatically reduced. The machine comes out of the crisis (flashing is stabilized) without loss of quality of the welded joint. The peculiarity of the machine is that welding time is not constant due

Technical characteristics of FBW machines CHAJKA

Parameters	MKSSO-40	MKSSO-60
Primary mains voltage, V	380	380
Maximum primary current (in welding), A	10	15
Width/thickness of bands to be welded, mm	10–40/0.6–1.3	20–60/0.7–1.3
Diameters of low-carbon steel wires and bars to be welded, mm	1.0–8.0	1.5–9.0
Number of welds (bands) per hour	30–40	30–40
Welding time, s	0.9–2	1–2
Welding voltage, V	2.8–3.2	2.8–3.4
Cooling	Water, autonomous	
Upsetting force, N	200–400	200–800
Heat treatment regulation	Manual	Manual/Automatic
Dimensions, mm	250×500×400	250×500×400
Weight, kg	85	85

to self-regulation of flashing rate. To control the welding time the indication is provided.

The second model of welding machine is automatic and controlled by a microcontroller. This peculiarity simplified the design of mechanical part of the machine and the choice of optimal acceleration during flashing, welding time and accurate dosing of heat generation during upsetting. The latter is provided by a rough dosing of number of current pulses and their power passing through the butt after upsetting is switched-on. To evaluate the quality of the produced joints after each welding the measurement of the actual upsetting value is performed and this value is shown on the display.

On the machine the designed clamps are installed, which are fully opened after each welding for cleaning the contact surfaces of the upper jaws and the current-carrying electrodes (Figure 1). In these clamps, regardless of force on the cam closing the clamp, the pressing force of the upper jaw band against the electrode is proportional to the thickness of the clamped band.

The uniform distribution of clamping force across the width of the band and, accordingly, the uniform heating are provided by a preliminary presetting the value of welded band thickness on the clamping scale.

Due to the specially developed algorithm the control of welding machine is performed by a one four-position joystick, by which both the selection of preliminary presetting of welding, as well as start of welding itself and heat treatment are carried out. The support frame regulating the protrusion of the tooth from the clamps of the machine providing rectilinear welding of bands, is made common for both clamps, has a facilitated setting and can provide supporting of the saw both along the tooth, as well as along the «back» (Figure 2).

The software of the welding device allows updating the built-in program by the user himself, which allows reacting promptly to the requests of the operator for adjustment of the operation algorithm. The multilingual interface facilitates the use of the machine in different countries. The

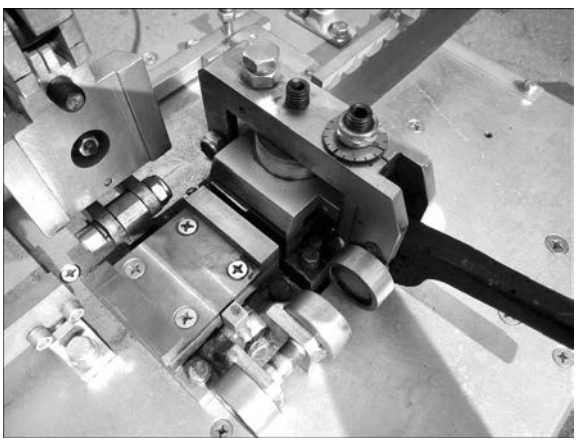

Figure 1. Clamps of FBW machine

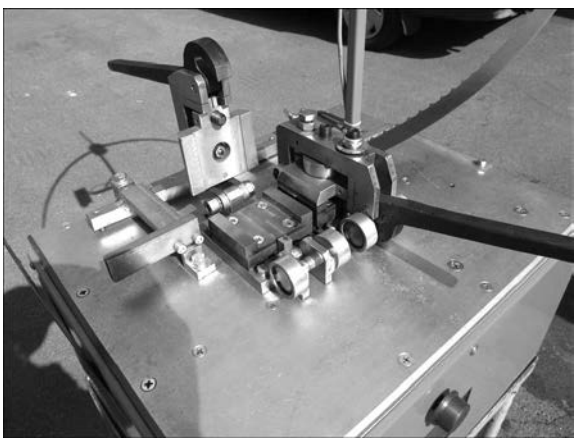

Figure 2. Saw support frame

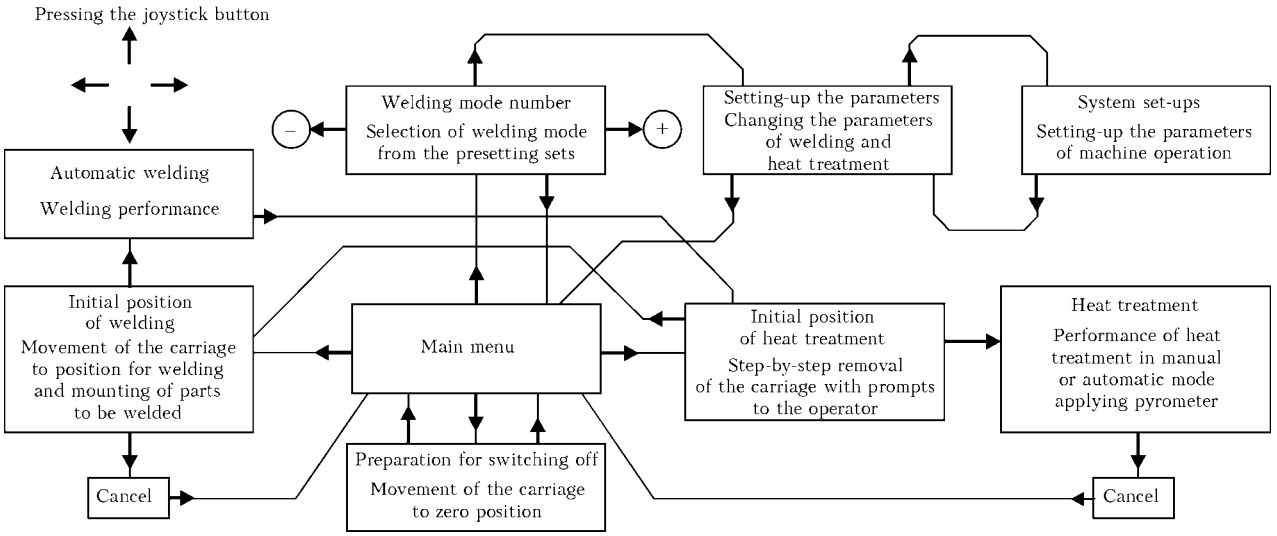

Figure 3. Block-diagram of the machine with microcontroller control system

block diagram of the machine with electronic control is shown in Figure 3.

The microcontroller control system allows facilitating the operation due to step-by-step prompts, appearing on the display. It remains for the operator only to select the type of a saw to be welded according to the program, mount it to the clamps and tilt the joystick to «Welding» position. Then the machine will perform the welding process automatically. After welding is performed, the measurement of upsetting value of the produced welded joint is automatically performed. The measured value is shown on the display. After the welding according to step-by-step instructions, on the display the heat treatment of the weld is carried out. The automatic heat treatment process runs without operator. The temperature of the weld is controlled by a pyrometer according to the program of the microcontroller of the welding machine. In case of using manual mode of heat treatment the operator needs to regulate the heating of butt himself using joystick being visually oriented by the brightness of incandescent metal. There are 20 preset modes of welding and heat treatment offered for different saws, knives and jigsaws.

The machine with microcontroller control system is characterized by very broad capabilities as to installation, adjustment and fulfillment of welding parameters with stabilization of heat generation in the butt during upsetting. For its use the special training of welding operator is not required.

In conclusion it should be noted that the presented FBW machines have the following operational advantages: the carriage has no friction parts (no bearings) and does not require maintenance during operation process, the controlled pressing force of bands, uniform heating across the width, stabilization of heat generation in the butt during upsetting, automatic heat treatment, full access to the electrodes after each welding, high and stable quality of welding including that of small sections and evaluation of quality of welded joints, produced without their destruction, are provided.

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