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EQUIPMENT FOR MECHANISING THE SUBMERGED ARC WELDING PROCESS

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Abstract: Flux welding is a notable, reliable, and adaptable method of combining metals among other welding techniques. Flux welding is an arc welding technique that employs a substance known as "flux" to shield the weld pool from any chemical reactions with atmospheric constituents while welding. Flux materials often comprise borax, hydrochloric acid, or zinc chloride. In the process of flux welding, a joint is covered with a layer of flux, or alternatively, a flux-coated or flux-cored electrode is employed. Upon the formation of the weld pool, the flux undergoes melting and adheres to the pool, thus safeguarding it against any potential reaction with air constituents. This manuscript describes equipment used in mechanized flux welding process in order to improve its performance. Lincoln Electric NA-3N submerged arc welding equipment on a universal lathe longitudinal carriage was designed. The equipment was mounted on a carriage with a maximum longitudinal travel of 2380 mm and a maximum transverse stroke of 410 mm. This carriage moves the welding equipment. The longitudinal advance allows longitudinal and transverse welding on this system.
Key words: flux welding, universal lathe, mechanized system.

1. INTRODUCTION

Flux welding is a method of welding that involves the use of a material called flux to protect the weld area from oxidation and contamination. Flux is a chemical substance that is applied to the welding surface before the actual welding process begins. Flux melts under the heat produced by welding and forms a protective layer over the weld area, preventing defects such as porosity or cracks from forming.
Flux cored welding is used in various fields such as the shipbuilding industry, pipeline construction or the production of components for drilling equipment. This method of welding can be carried out using various types of welding, such as electric arc underflow welding, gas underflow welding or laser underflow welding.
Flux-cored arc welding is a highly productive process and to date is the most economical of the fusion welding processes. It also has the advantage of being easily automated. The arc is formed between the workpiece and the uncoated wire under the flux-coated layer. The arc melts the wire together with the edges of the workpiece and some flux in the immediate vicinity of the weld area. The metal of the weld pool cools as the arc moves, forming the seam, covered with a layer of slag, which is gently removed after cooling. The coated wire is wound on a drum and is inserted into the arc by means of a roller driven by an electric motor. The flux is brought above the weld joint through a tube which may be placed before the electrode or enclose the electrode, [1]. Figure 1 shows the scheme of arc welding under the flux coat.
The root of the seam is sometimes protected by a copper strip as opposed to electric welding with coated electrodes. The flux-cored welding process has a number of advantages over other welding processes, such as:
- Providing high protection against the penetration of various gases from the atmosphere into the arc zone due to the intense vaporisation of components inside the flux;
- Good penetration due to high current density and high heat concentration coefficient;
- High melting speed ensures high productivity;
- Good calorie yield;
- Lower probability of defects forming;
- Due to the development of heat in a confined space and the high current density, the process allows deep penetration, which eliminates the need for machining the part after welding;
- The quality of the weld produced is not influenced by the qualification of the welder and can be said to remain constant if the welding regime parameters have been calculated correctly;

•Lack of ultraviolet and infrared radiation and amount of smoke;
In addition to these advantages, flux cored welding also has some drawbacks:
•Increased claims on the cleanliness of the rostrum;
•Increasing trends in stresses and strains;
•The cost of equipment is high;
•Welding can only be done on horizontally positioned parts or on cylindrical parts.

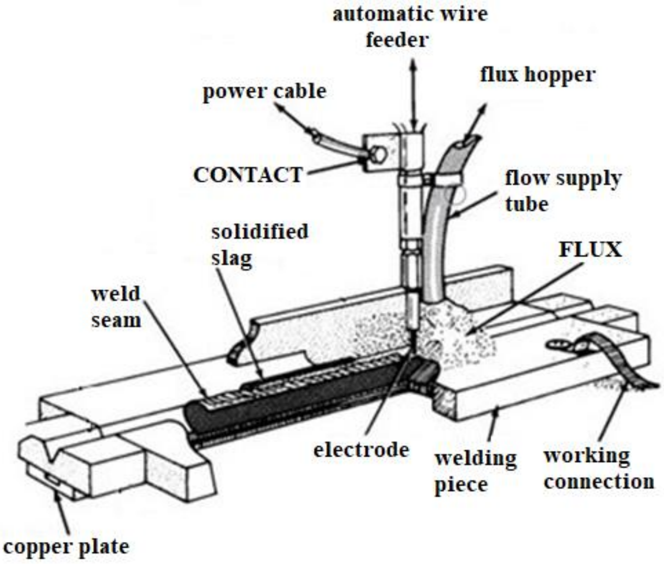

Fig. 1. Schematic of flux cored welding, [2].

A welding head is used to feed the arc with wire, bring current to the wire and transport the flux cored hopper. The welding head can be mounted on a carriage that can move right on the weld product or on a separate guide. This assembly is called a welding tractor. The tractor can also be fixed in position; the movement being performed by the product. The automatic welding process is used for welding long, straight or circular seams. For short seams and curved seams, semi-automatic welding is recommended. In this case the arc is guided along the weld by hand and only the wire feed is done automatically, [1].

2. EQUIPMENT USED IN FLUX CORED WELDING

Welding machines differ in the way they regulate the welding process. There are automatic machines with constant wire feed speeds and automatic machines in which the feed speed is automatically adjusted according to the arc voltage.
Constant feed rate machines are simple. The feed speed steps are changed by changing gear groups. Within the same setting step, the change in feed rate is achieved due to the slightly decreasing characteristic of the power supply. If for some reason the wire melting speed has increased, the spring lengthens. This causes an increase in the resistance of the spring, a decrease in the current, which causes the melting speed of the wire to decrease and in this way the balance is restored. In automatic machines where the wire feed speed is automatically adjusted, the speed of the wire drive motor depends on the arc voltage. If this increases, because the spring has become longer, the motor speed also increases and so the spring tension returns to its original value again, [1].
The assembly of the automatic flux cored welding plant in figure 2.

2.1. Formation of the welded seam under the flux coat

The flux coat is a granular fusible material with a chemical composition close to the electrode coating of manual arc welding.
The electrode is a continuous wire wound in a cage and driven by a roller mechanism passing through a bushing which is in electrical contact with the welding circuit. Under the action of the electric arc, the base metal, the electrode and part of the flux melt at the same time, forming a gas zone which, together with the molten metal particles, forms a liquid bath covered with slag and supported on the root side by a copper or steel part. The welded seam formed as a result of the solidification of the liquid bath is covered by the solidified slag, [4].

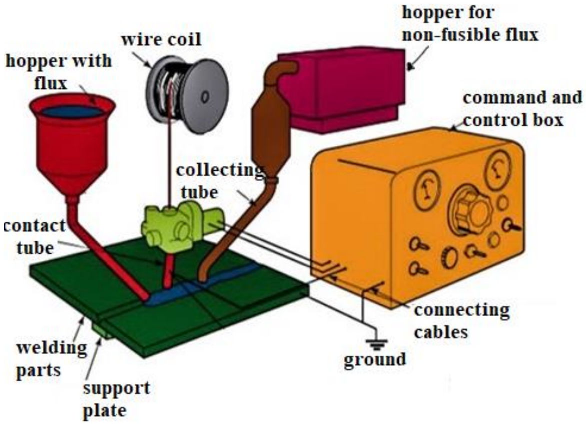

Fig. 2. Mechanized flux cored welding plant, [3]

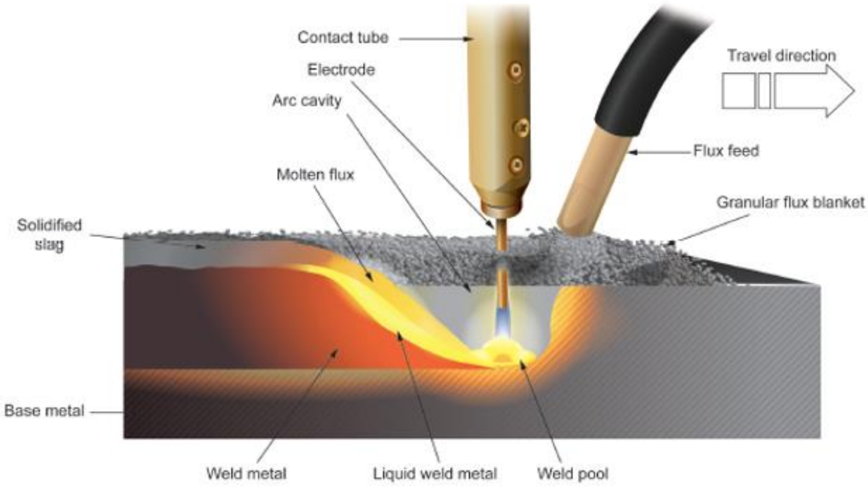

Fig. 3. Schematic of welded seam formation under flux cored, [5]

2.2. Choice of welding regime parameters under flux cored welding

For the execution of a welded joint under flux cored, the basic parameters are as follows: current intensity I_s; wire diameter d_e; arc voltage U_a; welding speed V_s; number of layers n_s.

The current intensity is determined by the thickness of the workpiece, the way the weld is made (one layer or several layers), the type of joint, the support of the bath, the flux mark, the composition of the base metal. Current values are usually taken from tables.

The wire diameter is chosen according to the machine of the device, the composition of the base metal. The choice of spring tension is made taking into account that a certain seam shape coefficient must be obtained and that the spring must burn smoothly. The welding speed is chosen according to the capabilities of the machine, the type of flux and the quality of the weld metal.

Multi-layer welding is used when the machine does not have the necessary intensity for large thicknesses, or when the base metal does not support certain intense welding regimes, [1].

The diameter of the electrode wire, d_e is chosen from the tables according to the thickness of the parts to be welded.

The height of each layer of deposited metal, H_s for one-sided welding is calculated with relation (1).

$$H_s = K \cdot s, \text{ [mm]} \quad (1)$$

Where K is a coefficient that differs according to the type of flux cored welding: on flux cushion K=(1.05-1.1) and K=(0.75-0.9) when welding without flux cushion, s represents the thickness of the sheet.

The welding current, I_s is calculated according to the diameter of the electrode wire used.

$$I_{s\ min} = 162.5 \cdot d_e - 190, \text{ [A]} \quad (2)$$

$$I = 13 \cdot d + 147 \cdot d_{s\,maxe}{}^{2}{}_{e} - 87, [A] \quad (3)$$

$$I_{s\,med} = (I + I_{s\,mins\,max})/2, [A] \quad (4)$$

The welding speed, V_s has a direct influence on both the welding productivity and the shape of the welded seam in the sense that lowering the welding speed leads to a larger seam width. It can be calculated with relation (5).

$$V = 100 \cdot A/6 \cdot F_{sdt} \cdot \rho, [cm/min] \quad (5)$$

F_t is the cross section of a pass [cm^2], A_d is the deposition rate, ρ is the density of the material.

$$A_d = 5.28 \cdot 10 \cdot I^{-3}{}_{s} + 3.28 \cdot 10 \cdot I / d^{-5}{}_{s}{}^{2}{}_{e}, [kg/hour] \quad (6)$$

The arc voltage, U_a is calculated as a function of the welding current.

$$U_a = 22 + 0.22 \cdot I_s, [V] \quad (7)$$

To weld two tables with dimensions s=10, L=2690, l=215 mm, according to the tables the following values of welding parameters were chosen, [1]: I_s =500, [A]; d_e =4, [mm]; U_a =30, [V]; V_s =50, [cm/min]; n_s =2.
The correct choice of the shape and dimensions of welded joints and the appropriate joints is of particular importance for ensuring the quality of welded seams.

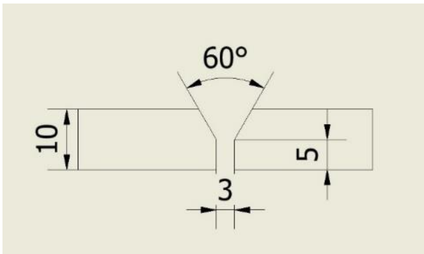

Fig. 4. Weld joint, [mm]

The basic material used to weld the sub-assembly of the part is a steel blank SR EN 10025-1:2005, and has the chemical composition and mechanical properties as are presented in table 1.

Table 1. Chemical composition and mechanical properties of steel blank SR EN 10025-1:2005

Basic material	Chemical composition [%]							
	C	Yes	Mn	S	P	Cr	Ni	At
C45	0.42	-	0.80	0.035	0.04	-	-	-

Basic material	Mechanical characteristics [%]			
	Rp0.2 min [N/ mm]^2	Rm [N/ mm]^2	A, min [%]	Resilience KV, min [J]
C45	480	700 - 840	14	+ 20°C

3. DESIGN OF A WELDING ASSEMBLY WITH MECHANIZED WELDING TABLE FIXATION

The paper aims to present the design and realization of a mechanization equipment for the flux cored welding process.
The design was for a Lincoln Electric NA-3N flux cored welding equipment that is mounted on the longitudinal carriage of a universal lathe. The welding movement is achieved by longitudinal or transverse feed of the carriage on which the equipment is mounted, the maximum longitudinal travel of the carriage is 2380 mm and the maximum transverse feed travel is 410 mm. On this installation it is possible to weld in the longitudinal direction using the longitudinal feed as well as in the transverse direction.
The Lincoln Electric NA-3N is a power source for welding. It is a constant voltage (DC) DC welding machine commonly used for arc welding processes such as coated electrode welding (SMAW) and flux cored arc welding (FCAW). The NA-3N is designed for industrial applications and offers features such as adjustable voltage and

current settings, reliable arc control and durability. The equipment features a suspended welding head. It consists of weld head body (1), command and control box (2), flux hopper (3), contact assembly (4), head mounting piece (5), wire guide tube (6), wire coil (7), coil mounting shaft (8), cross seam adjustment (9).
The electrode wire feed speed is regulated by varying the speed of the drive motor with commutator on small machines, and by friction variable speed drives on medium power machines [6].
For the positioning and orientation of the welded parts, a mechanized table assembly with pneumatic clamps was designed, figure 6. The table is designed from 40x40x2 mm square pipe, it is made by welding with dimensions of 2600x720x400 mm, these dimensions are adapted according to the maximum strokes of the plant on which the equipment is mounted.

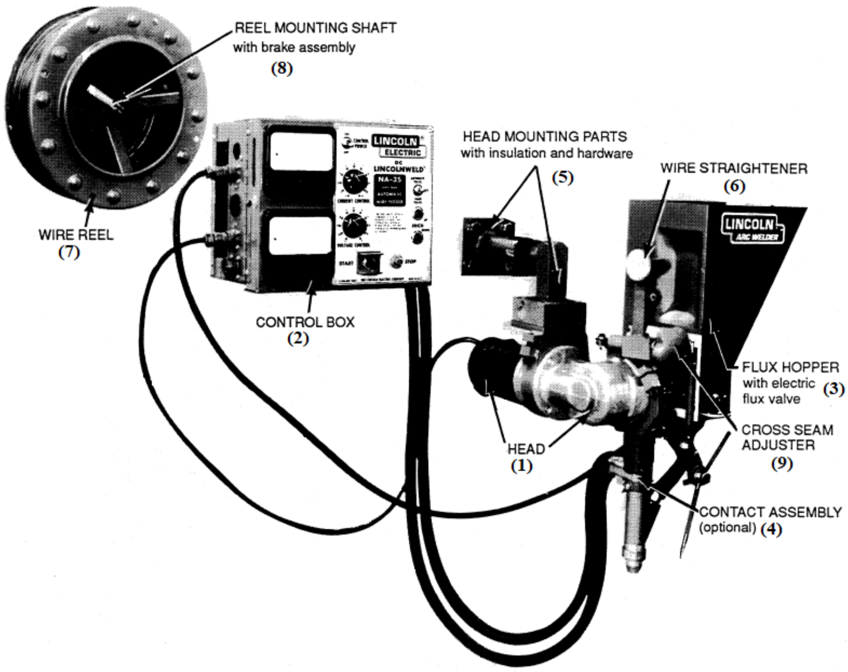

Fig. 5. Welding equipment assembly, [7]

In figure 5 shows the determination of the clamping force S as a function of the orientation size of the forces G (weight) and T (technological force) and the position of the bearings. Incorrect application of the clamping force can have undesirable consequences, e.g. displacement of the workpiece, deformation of the workpiece, or local damage to the workpiece surface.

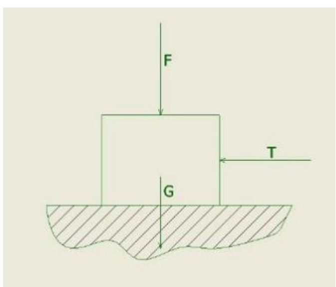

Fig. 6. Fixing scheme

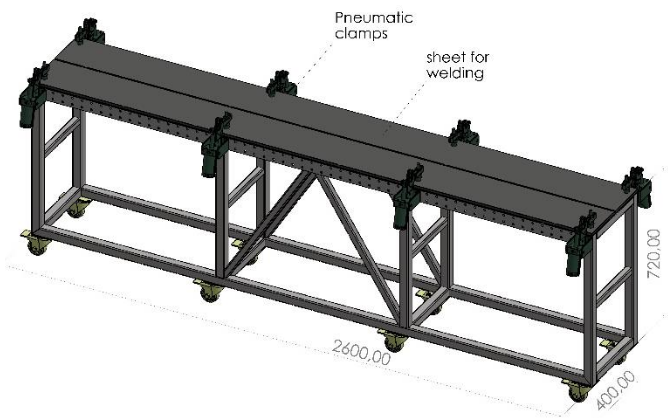

Fig. 7. Welding table assembly

The force required to fix the boards is calculated with the relation (8):

$$F=T/\mu-G \quad (8)$$

where μ is the coefficient of friction and for ordinary steels is between 0.1-0.8.
The flanges are fixed to the table on a specially provided plate, and can be positioned along the table with a 45 mm pitch.

Pneumatic clamps are devices used to secure or connect components or equipment using compressed air. They are often used in the automotive industry, in machine building or in general industrial applications.
The use of pneumatic bridles has a number of advantages, such as:

•Easily adjust to your needs by simply adjusting the air pressure in the pneumatic system;
•due to the pneumatic characteristics, the pneumatic clamp can exert a uniform pressure on the object to be clamped;
•The pneumatic clamp can be installed and removed quickly, saving time and effort in the fixing process;
•For use in a wide range of applications and industries, the pneumatic flange adapts to different needs and requirements;
•For use in applications requiring delicate and precise fastening, thanks to its uniform pressure and flexibility in adjustment, the pneumatic clamp can reduce the risk of damage or scratches to fastened objects.

In conclusion we can say that pneumatic clamps are a safe and modern clamping system, we chose this technology because it offers increased efficiency, precise adjustment, sufficient clamping force, versatility and safety. The overall drawing is shown in figure 7.

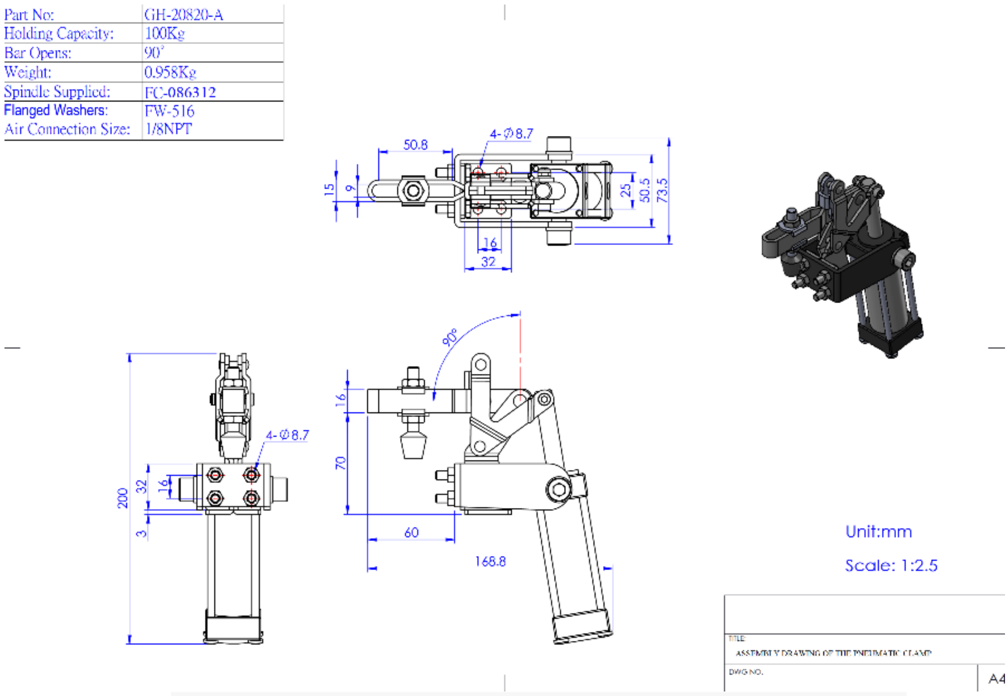

Fig. 8. Pneumatically actuated clamp with dual mounting for fastening, [8].

These clamps are used for repetitive fastening in production environments. Air from one inlet port engages the clamp and air from the other inlet port disengages it. The clamps maintain maximum clamping capacity even when air pressure drops. They have an open arm, so you can move the clamping screw to any position along the arm, the screw adjustment range is 50 mm.

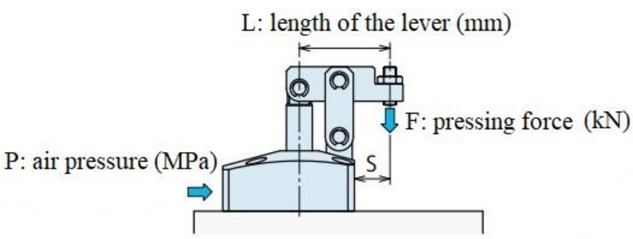

Fig. 9. Calculation scheme of the force required for fixing, [9]

For cylinder bore diameter *D=32*[mm] the force will be calculated with relation (9):

$$F = (14.11 \times P) / (L - 19.5) \quad (9)$$

An overview of the welding device mounted on the universal lathe is highlighted in figure 10.

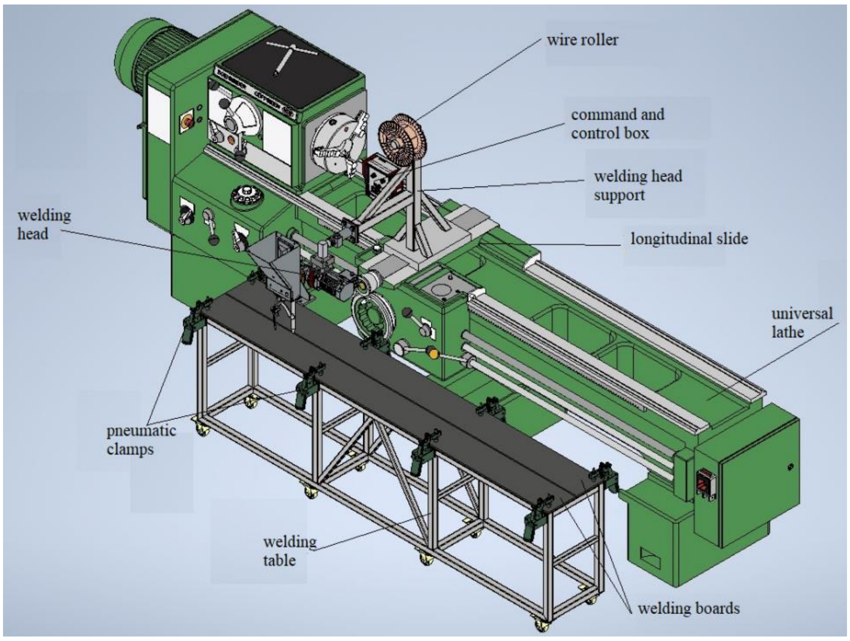

Fig. 10. Overview of the welding installation

4. CONCLUSIONS

Mechanized welding procedures are highly effective methods for enhancing welding efficiency, safety, and consistency, while simultaneously minimizing downtime and rejections. The strong demand for welders necessitates that sectors heavily reliant on welding aim to optimize the efficiency of their welding teams. To accomplish this objective, the most efficient approach is to convert repeated or high-volume manual welds into mechanized welding procedures, which yield considerably higher productivity and enhance workplace safety. The present study presents a viable solution for the mechanization of the welding process under the flux layer by using a universal lathe. Thus, through the careful setting of the process parameters and a proper grip of the welding device on the lathe, the chances of making quality welded joints are real. Of course, improvements can be made permanently so that work efficiency increases.

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