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Application of Alternate Current for the Welding of Magnetized Details for Special Directs

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Introduction. Manual metal arc (MMA) welding by direct current (DC) with basic coated electrodes is a common method to produce permanent joints for details repair [1-4]. To provide a spatial and physical stability of the arc discharge, it is necessary to create conditions for eliminating magnetic blow. This elimination is the most difficult to provide in the case of residual magnetization of workpieces, which is caused by application of magnetic methods of inspection. The solution of this problem, as a rule, is carried out with the help of preliminary demagnetization of the workpieces. This approach involves the use of special equipment, the operation of which is characterized by a long process of preparation for work and low labor productivity and requires a highly skilled service personnel.

To eliminate these disadvantages an innovative solution to the problem of arc welding of magnetized workpieces was proposed. The solution is in using a square wave alternate current (AC), which polarity is changed at the moment of critical deflection of the arc from the axis of the coated electrode (Patent RU2245231). Such an algorithm of the welding current polarity switching helps to avoid arc extinction, to stabilize its spatial position and to ensure welding when the value of magnetic induction in the welding zone is up to 0.1 Tesla. To implement the solution, the IST-201 semiconductor inverter was designed. This inverter is to be included into a load circuit of a welding rectifier or a generator with constant current characteristic.

Research purpose is to confirm the suitability of square wave AC in arc welding with coated electrodes of magnetized details. It is necessary to determine the influence of the current type and magnetic flux density in the welding area on the properties of welded joints.

Experimental procedure. Pipes made of 17GSU steel grade were used as samples, which mechanical properties were presented in Table 1. Tube diameter was 1067 mm, wall thickness – 14 mm. Edge preparation (C17) was done according to the requirements of GOST 16037-80. Welding was performed for a pipe in non-rotational position in three passes. Welding parameters are presented in Table 2. Initial value of the magnetic flux density in the gap between the edges to be welded was set by an external inductor. In the absence of a magnetic field in the welding zone (magnetic flux density is equal to 0 mT), positive DC (electrode is connected to positive pole) was used, and if the initial value of the magnetic flux density was of 100 mT, then square wave AC was used.

Table 1 – Mechanical properties of 17GSU steel grade (GOST 10705-80)

Tensile strength, MPa	Yield strength, MPa	Elongation, %
490	343	20

Table 2 – Welding parameters

Welding conditions	Passes	Electrodes		Current value, A
		Name	Diameter, mm	
magnetized workpieces, square wave AC	Root	LB-52U	3.2	95…100
	Fill, Face	OK53.70	3	
demagnetized workpieces, DC electrode positive	Root	LB-52U	3.2	85…95
	Fill, Face	OK53.70	3	

Results and discussion. At first, the welded joints were inspected by visual and radiographical methods. This inspection did not reveal any defects.

Actual chemical composition of the base metal is presented in Table 3, and of the weld metal is given in Table 4. The results show a negligible influence of welding conditions on the content of alloying elements in the weld metal.

Table 3 – Chemical composition of the base metal (17GSU steel)

Chemical composition of the base metal, %									
C	Si	Mn	Cr	Ni	Co	Cu	Nb	Ti	V
0.13	0.42	1.46	0.12	0.08	0.01	0.15	0.05	0.01	0.06

Table 4 – Chemical composition of the weld metal

Welding conditions	Chemical composition of the weld metal, %							
	C	Si	Mn	Cr	Ni	Co	Cu	V
magnetized workpieces, square wave AC	0.12	0.3	1.07	0.02	0.01	—	0.07	0.01
demagnetized workpieces, DC electrode positive	0.12	0.3	1.20	0.04	0.02	0.01	0.04	0.02

To determine mechanical properties of the welded joints, the samples in accordance with the requirements of GOST 6996-66 were made.

The results of the static tensile tests (Table 5) showed that the failure of the samples occurred in the base metal regardless of the welding conditions. The results of tests on static bending strength (Table 6) showed that for bend angles up to 413 K the destruction of specimens was not observed.

Table 5 – The results of static tensile tests of welding joints

Welding conditions	Mechanical properties of welding joint			
	Tensile strength, MPa	Yield strength, MPa	Elongation, %	Contraction, %
magnetized workpieces, square wave AC	633–657 645	520–534 527	12.2–16 14.4	61.6–65 63,3
demagnetized workpieces, DC electrode positive	628–676 647	517–565 535	17–17,5 17.2	61.7–70 65

Table 6 – The results of tests on the static bending strength of welding joint

Welding conditions	Bend angle value; root layer displacement	
	on tensile	on compressive
magnetized workpieces, square wave AC	over 125°	over 125°
demagnetized workpieces, DC electrode positive	over 125°	over 125°

Analysis of the results of the welded joint impact strength tests (Table 7) showed that at the temperature of 293 K the value of the weld metal toughness did not substantially depend on the welding conditions. At a temperature of 233 K and other experimental conditions the value of weld metal toughness was 1.15...1.36 times greater, when square wave AC was used instead of DC. The positive influence of square wave AC application on the magnitude of impact toughness of the heat affected zone (HAZ) was revealed.

Table 7 – The impact toughness test results for zone of welding joint

Welding conditions	Stress raiser location	CVN $^{293\text{ K}}$, MJ/m^2	CVN $^{233\text{ K}}$, MJ/m^2
magnetized workpieces, square wave AC	Weld metal	105–143 122	28–64 34
	HAZ	168–272 204	188–258 227
	Base metal	181–194 191	191–248 216
demagnetized workpieces, DC electrode positive	Weld metal	105–142 117	23–56 25
	HAZ	217–265 220	64–241 196
	Base metal	162–278 228	156–224 207

In order to identify what caused increase in toughness of the weld metal and of the HAZ specimens obtained by magnetized workpiece welding with square wave AC, macro- and microstructure of the joint and distribution of microhardness were examined. The results of analysis show positive influence of square wave AC on the formed metal structure during welding of magnetized workpieces (see Fig. 1). This influence led to smaller grain size and decreased overheat zone dimensions. Furthermore, the microhardness distribution over width and height of the weld joint is more uniform in this case.

Conclusion. The results of the experimental studies support the use of alternating current in a rectangular arc welding with coated electrodes magnetized details, because it provided high quality and strength characteristics of permanent connections, and significantly simplifies the process of repair of details with residual magnetism.

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Material Processing in Space

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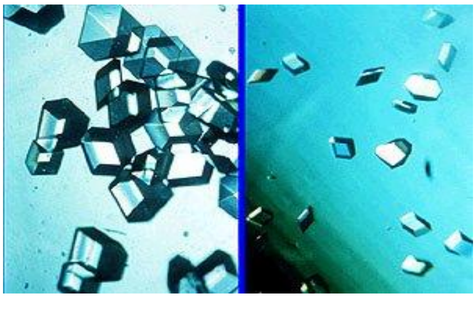
Materials processing is the science, which researches how ordinary and comparatively inexpensive raw materials can be made into useful crystals, chemicals, metals, ceramics, and other manufactured products with the necessary properties. Materials processing makes it possible to produce chemical and biological compounds for use in medicine, different types of plastics, alloys, ceramics for use in a variety of the goals [1].

Materials processing on Earth allow us to rise our spacecrafts into the Earth orbit. There the extended benefits of working in especial conditions have opened new and unique opportunities for the science of materials processing. In the microgravity environment of an orbiting spacecraft, scientists can make procedures that are impossible on surface of the Earth.

Materials processing in space (MPS) has been studied both theoretically and experimentally for over ¼ of a century. The experiments with the material processing in space were first realize relatively recently. In the USSR, the first technological experiments were carried out in 1969 on board the manned spacecraft "Soyuz-6". Cosmonaut Kubasov V. N. was working out different ways of welding metals using equipment called



Picture 1 - Comparison of insulin crystal growth inouter space (left) and on Earth (right)