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Research Article

THE INFLUENCE OF CURRANT MMA WELDING ON THE TENSILE STRENGHT OF JOINT

Piotr Penkała[1]**, Beata Płowaś**[2]

[1] Institute of Technical Sciences and Aviation, The State School of Higher Education in Chełm, Pocztowa 54, 22-100 Chełm, Poland, e-mal: ppenkala@pwsz.chelm.pl

[2] Institute of Technical Sciences and Aviation, The State School of Higher Education in Chełm, Pocztowa 54, 22-100 Chełm, Poland, e-mal: bplowas@pwsz.chelm.pl

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ABSTRACT
Welding with coated electrodes is still growing method of joining metals in construction machinery. If the electrodes are properly selected and current welding can weld materials in a wide range of geometric dimensions and species. With carefully selected ingredients one can introduce additional elements to the welded material and the joint during welding. An important issue in the electric welding is a welding current selection, depending on the thickness of the electrode and material thickness. The use of too low operating current cause instability and inadequate mechanical properties of the weld, resulting from insufficient melting of the material combined. Too high operating current results in the weld metal spraying and thermal overload of the electrode. For welding samples that were used to test the strength of the electrode used ESAB OK. 46.00 a diameter of 3.2 mm. Product of the company will provide a range of welding current ranging from 80 A to 150 A. The samples were welded currents amounting to 90 A, 115 A and 150 A. Due to problems with arc ignition and its instability is not made of welded samples current of 80 A.

Keywords: MMA welding, welding current, welded joint, tensile strength.

INTRODUCTION

The method MMA electrode coating is used, which consists of a metal core coated with compressed wrapper. Between the end of the electrode and the workpiece is produced electric arc. Arc ignition is a contact through the end of the electrode to the workpiece. The electrode melts and drops of molten metal electrodes are transferred through the arc to the molten weld metal welded to form a weld after solidification. Approaches welder electrode as its fusion to the workpiece so as to maintain a constant arc length, and at the same time moves the end of the melt, along the welding line. Melting electrode coating releases gases that protect the molten metal from the atmosphere and then solidifies and forms a puddle on the surface of the slag, which protects the solidifying weld metal from the influence of the environment. After laying a bead slag must be mechanically removed.

Electrode welding is used in all conditions and is, therefore, the most universal method throughout the welding industry. MMA method is a universal method because of the grade welded steel construction, position and place of welding. The main application is the welding of steel structures in shipbuilding and in most manufacturing industries, welding of pipelines, installation work on the construction sites, welding in the field and at altitudes and in areas with difficult access.

Welding design of machine elements is the most popular connection inseparable because they are cheap, simple and enable the achievement of significant savings in comparison with other design solutions. Welded joints replace items with large dimensions, casting or forging which is problematic for technological reasons. As compared to cast iron weight is obtained by using the structure of thinner walls, the materials of higher strength, less machining excess material.

WELDING PROCESS PARAMETERS BY MMA

Electrode welding, despite its huge popularity, is a method that requires considerable skills of the welder. Although manufacturers of power sources and additional materials through continuous improvement of its products, constantly striving to improve the ergonomics of welding, but the proper conduct of the welding process requires a combination of welder‘s experience and appropriately selected welding parameters. The basic parameters of manual welding with coated electrodes are [1–6]:

- the type and intensity of the welding current,
- arc voltage,
- arc length,
- welding speed,
- diameter of the electrode,
- slope of the electrode.

Welding current is a parameter that extent determines the amount of heat input to the weld and the speed of melting of the electrode to the greatest. In terms of the welding electrode, welding can be performed with:

- direct current (DC):
  - positive polarity (positive pole connected to the terminal electrodes, DC +),
  - negative polarity (negative pole connected to terminal electrodes, DC),
- alternating current (AC).

Type of welding current flows on the stability of arc, moving in the liquid metal droplets, the shape of the weld bead and the depth of submergence. Direct current arc provides a more stable and uniform distribution of the liquid metal in the arc, limiting the number of splashing even at low currents. Furthermore, with higher melting of the edges of the joined materials and tendency to shorten the circuit arc is lower. Some types of electrodes (mainly alkaline electrode designed for welding high-strength and high-alloy steels) require a very good arc stability, which can provide welding with positive polarity. In this configuration, the depth of fusion is increased, in comparison to the welding process with a negative polarity. AC welding is used rarely, but rather under "home" because of low cost of the device (welding transformer). Current value is selected depending on the type of material being welded, the thickness, the diameter of the electrode and the welding position. When welding current should be kept constant, stable value, which does not depend on the length of the electric arc. For this reason, it is recommended to steeply slope the characteristics static power sources, what ensures the maintenance of a constant current as a function of voltage (Figure 1). The steeper the current – voltage characteristics of the source the lower the change in current (I) when changing arc length (resulting in a change of the voltage U). For position welding a source of gently sloping characteristics may be used to adjust the length of the arc current.

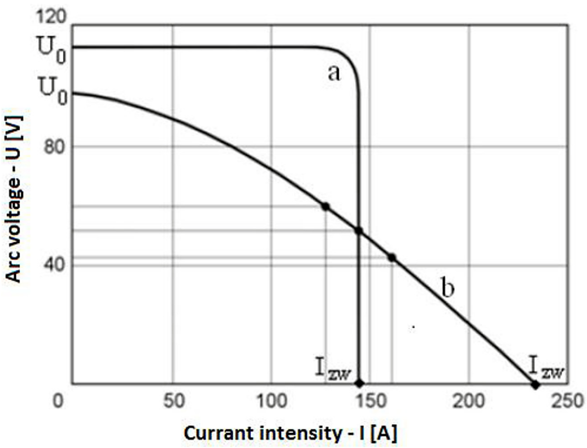

Fig. 1. Static current – voltage characteristics of sources for manual welding with coated electrodes: a – steeply sloping, b – gently sloping [1]

RESEARCH OF WELDED JOINTS

Research welds were carried out by destructive or non-destructive methods. In destructive tests a part of construction is destroyed in order to obtain a sample for testing. Destructive testing is used mainly in order to obtain information about the structure and mechanical properties of the joint. It is carried out on the samples whose dimensions and the research methodology are given in the relevant standards.

Non-destructive testing methods include those, which enclose the state of the object. They are made without prejudice to its consistency, or degradation of performance or functional characteristics. Non-destructive testing can be carried out at various stages of manufacture of welded joints: before, during and after welding [7].

The group of non-destructive tests enclose:
- visual,
- penetration,
- magnetic particle,
- radiographic,
- ultrasonic,
- tightness,
- eddy currents.

Destructive testing of welded joints are divided into:
- tensile test,
- hardness,
- impact,
- bending
- technological tests.

MECHANICAL PROPERTIES RESEARCH

The study of mechanical properties are an important group of tests that can be used for basic materials, additional and bonded joints. The study behaviour of the structure obtained on samples with specific dimensions, welded in the laboratory, may give different results than the whole structure under the actual load and the actual ambient conditions (temperature, humidity, pressure, etc.). It is also difficult to model the actual state of internal stress (welding) in the actual construction, resulting from subjecting its overlapping welding thermal cycles. The problem is also taken into account during the study of heterogeneity of a metallurgical bonded in the same joints, such as the heat – affected zone, face or ridge seam. Destructive tests can be used to determine the characteristics of the entire connection or a selected zone. The destructive methods for testing the mechanical properties are used to control:
- basic materials,
- additional materials,
- welded joints most commonly conducted on samples taken from the control joints made of the possible behaviour of the faithful implementation of a particular method of welding,
- test joints made during the development of new bonding technology, determine the welding conditions, the use of new materials, the fabrication of prototype,
- qualifying welders.

STATIC STRETCHING MATERIAL TESTING AND JOINTS

Static tensile test metal is included PN-EN 10002-1 and consists of subjecting the sample to a suitably shaped tensile force in the axial direction until the break. It is performed on samples of square, round, rectangular or annular depending on the shape and dimensions of metal, weld at ambient temperature of about (23 ± 5) °C. The basic tensile test is called static testing, although the load slowly increases at a predetermined speed. It is assumed, however, that corresponding to the specified deformation stresses appear immediately after operation of the load, that there is at any time able to balance stress of deformation. To a large extent this is true for elastic deformation, but in terms of plastic strain for many materials, such an assumption is inconsistent with reality. The standards provide for the limitation of the maximum speed of stretching. Maximal increase of stress in the elastic deformation range should not exceed 30 MPa/s. The growing burden should be slow and continuous for its maximum value.

Tensile testing is the basic and most common strain test, but one should keep in mind that the size of the characteristic obtained under tensile samples may not reflect the overall behaviour of the structure under load. For these reasons, some elements whose work load is mostly stretching, is subjected to a tensile test as a whole; for example: ropes, chains, wires, some of riveted joints or welded. Using tensile tests determined the following mechanical properties:
- tensile strength Rm [MPa],
- yield point Re [MPa],
- elongation at fracture A [%],
- sectional narrowing rates after fracture Z [%].

Static test of transverse stretching butt welded joints is the basic tensile test used in clinical properties of welded joints according to standard EN 895. It is performed to determine the tensile strength and the position of a breakthrough in the welded butt joints. The welded joint is heterogeneous in terms of ownership, and therefore does not specify the yield point and elongation of the sample, but only the tensile strength.

RESULTS OF STATIC STRETCHING THE SPECIMENS JOINTS BUTT- WELDING CURRANT OF 90 A

Based on the results in Table 1 and in accordance with Figure 2 and also observing the specimens revealed substantial differences in the values of strength and elongation. The differences in the results were due to the poor quality of the weld. Observing the joint after fracture noted a large amount of slag around the ridge and the absence of melting the parent material. Discrepancies welded joint were caused by too low a welding current. A low welding current specimens hampered during the arc, with the result that the above-mentioned inconsistency created.

Table 1. The results of the tensile test specimens welded at 90 A

Current of welding	No of specimen	Cross-sectional area [mm^2]	Force (max) [N]	R_m [MPa]
90 A	1	100	18 520	185.20
	2	100	28 204	282.04
	3	100	40 204	402.04
Expectation value:		100	28 976	289.76

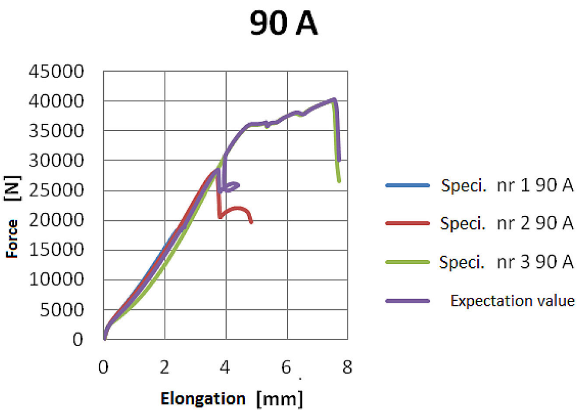

Fig. 2. Graph changes in the tensile test specimens welded current 90 A

RESULTS OF STATIC STRETCHING THE SPECIMENS JOINTS BUTT-WELDING CURRENT OF 115 A

Based on the results in Table 2 and Figure 3 one may conclude that a significant change of the force should be used to break the specimen. These values are considerably higher than in the previous study, that is welded to the current specimen 90 A. All three tested specimen were broken in the same place, i.e. at the site of the weld. After closer inspection of broken specimens we observed a small amount of slag and lack of fusion around the ridge. Such discrepancies could be due to problems with arc ignition in the surrounding ridge.

Table 2. The results of the tensile test specimens welded at 115 A

Current of welding	No of specimen	Cross-sectional area [mm]	Force (max) [N]	R_m [MPa]
115 A	1	100	34 333	343.33
	2	100	40 180	401.80
	3	100	44 684	446.84
Expectation value:		100	39 732.33	397.32

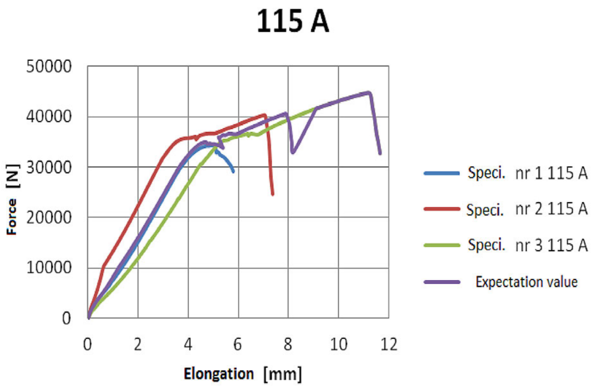

Fig. 3. Graph changes in the tensile specimens welded current 115 A

RESULTS OF STATIC STRETCHING THE SPECIMENS JOINTS BUTT-WELDING CURRANT OF 150 A

The data in table 3 and figure 4 show that a very significant amount of force is changed, which was to be used to break the specimen. These are significantly higher than previous attempts. The force required to break the three tested specimens is practically the same, the difference is just a few N, what is clearly showed in a graph in figure 4. In all three tested specimens there were local constrictions called the neck. The neck formed on both sides of the weld. Comparing the results it can be concluded that the strength of the weld made current 150 A is approximately equal to the strength of a solid material, as indicated by the results set out in table 4.

Table 3. The results of the tensile test specimens welded at 150 A

Current of welding	No of specimen	Cross-sectional area [mm]	Force (max) [N]	R_m [MPa]
150 A	1	100	50 579	505.79
	2	100	50 636	506.36
	3	100	50 565	505.65
Expectation value:		100	50 593.33	505.93

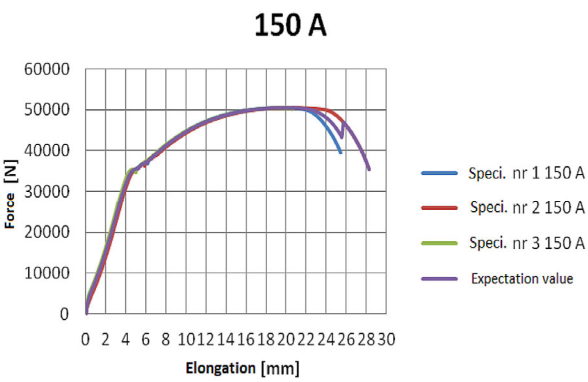

Fig. 4. Graph changes in the tensile specimens welded current 150 A

Table 4. The results of the tensile test specimens of solid material

Kind of specimen	No of specimen	Cross-sectional area [mm^2]	Force (max) [N]	R_m [MPa]
Solid material	1	100	50 579	505.79
	2	100	50 614	506.14
	3	100	50 636	506.36
Expectation value:		100	50 610	506.10

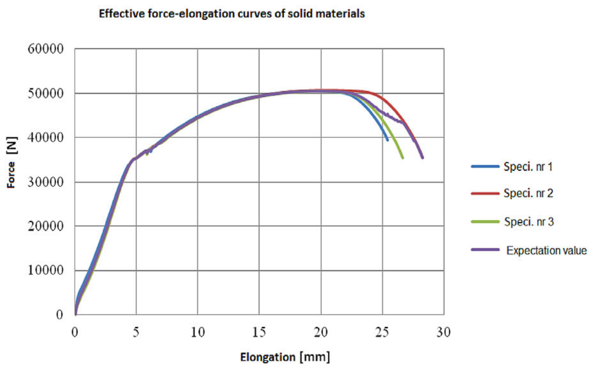

Fig. 5. Graph showing the relationship of strength and elongation for specimen of solid material

RESULTS OF STATIC STRETCHING THE SPECIMEN MATERIAL SOLID

Figure 5 and table 4 show linear increase in strain until a proportional limit. Then, after reaching the yield point the material enters the plastic state. Further increase of deformation tension caused non-linear growth until a noticeable narrowing of the neck called. Further stretching of the specimen caused its break under stress.

Table 5. Summary of the average results of the static tensile test

Kind of specimen	Cross-sectional area [mm^2]	Force (max) [N]	R_m [MPa]
Welded – 90 A	100	28 976	289.76
Welded – 115 A	100	39 732.33	397.32
Welded – 150 A	100	50 593.33	505.93
Solid material	100	50 610	506.10

SUMMARY OF RESULTS OF STATIC TESTS AVERAGED STRETCHING WELDED JOINTS WITH SOLID MATERIAL

Based on the results in table 5 and 6 we have stated that the strength of the welded specimen of 150 A current is equal to a very rough estimate of the strength of a solid material. This situation is well illustrated in figure 6, where the lines charts of the specimens tested through the remaining parts thereof, among other things, a linear increase of strain, the achievement of the yield point, the transition into a state of plasticity and the transition into a state of deformation practically coincide.

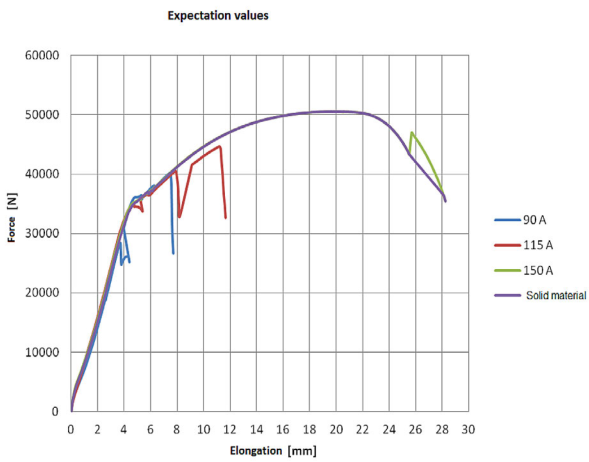

Fig. 6. Graph showing the dependence of strength and elongation for the results averaged

SUMMARY

Static tensile test confirms that the rupture of welded specimens a current of 90 A and 115 A, occurred at a much lower strength than welded current 150 A. After breaking the specimens welded current 90 A and 115 A a large amount of slag was observed in the root of the weld, and for sample welded current of 90 A as lack of fusion. In the case of welded specimens of current 150 A picked in the centre of the weld showed no abnormalities. The other two specimens were cut outside the weld, which indicates that the weld with properly chosen parameters has good strength properties.

Strength tests carried out showed that the welding current has a very significant impact on the strength and mechanical properties of welded joints. Non-conformities – welding slag around the ridge and the lack of penetration of the parent material were proved.

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