# METALLOGRAPHIC RESEARCHES ON WELDED CONSTRUCTION OF THE TELECOMMUNICATION ANTENNAE

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**Abstract.** Modern telecommunications antennas are made in welded steel pipes. Constructive complexity, functional, parametric and resistance require special materials and a blend of modern technology. The paper presents a welded construction made of telecom antennas welded pipes using welding manual process and "very short arc spray" process. Two welding processes of metallographic samples taken are presented: welding with a metal coated electrodes made by MAG and by "very short arc spray". The structures were compared using microscopic examination, resulting in the conclusion of the joining process.

**Keywords:** metallographic samples, welded construction, telecommunication antennae

## 1. Constructive types of antennas

Telecommunication antennas are a basic component of modern telecommunication infrastructure systems. Construction and positioning are requesting special conditions because of their location requirements for strength, height, loading and external agents acting on them.

Starting from an pillar antenna made using tube welding construction metallographic analysis of samples taken from the antenna structure are presented in the paper using electrode manual welding or automatic MAG welding [1].

The antenna tower is formed by modules built in welded metal structure from bars, lattices and apertures.

The category of tower-shaped buildings and pillars contains: radio and television towers, radio pillars, lighthouses, some high derricks, chimneys, towers of power transmission lines and others.

Constructions having the form of telecommunication tower are usually embedded in foundations (figure 1).

Towers and pillars are spatially made of lattices and bars having the form of a cone trunk or pyramid trunk. Cross section can be square, triangular or round.

Taking into account a tower antennae build using tube welding technology construction, the technology and tests procedure are presented below.

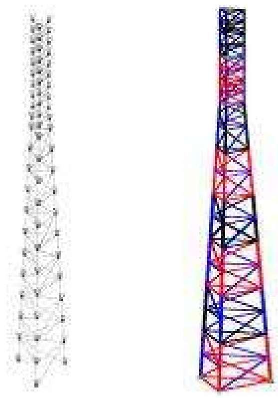


Figure 1. Telecommunication tower

## 2. Welding technology of telecommunication antennas

The process is characterized by a better penetration of the weld, an advantage that can be used in the root layer formation, the reduction of joint volume or increasing the welding speed. The welding arc is strangled and shorter than the one usually used. This is reflected in the fact that the arc tension decreases sharply with 2 to 3 V and current intensity is about 20 A higher than the values commonly used. An arc so short and with high enough power, together with good welding properties was used only after the emergence on large scale of the welding power sources with inverters and after the occurrence of the possibility of data digital transmission to a power source. For the seam protection, gas mixtures are used, a typical possibility is argon with 8% carbon and dioxide in addition [2].

The very short arc spray is created at current intensities of about 300 A and low levels of tension. It burns in a hollow produced by penetration under the action of plasma pressure.

Comparing to the “normal length spray arc”, the “very short spray arc” has the following advantages:

- The very short arc is extremely stable in preserving direction and is not diverted by the magnetic breath;
- Due to the small length of the arc and its directional stability, the nick moulding is impossible;
- Due to the high pressure plasma, the penetration depth is greater than that for the normal spray arc.

The properties listed above are permitting a significant increase in welding speed and thus increase the economic efficiency of the process.

The arc bottleneck caused by the magnetic field own pressure, concentrates the heat in the centre of the arc and thus, less heat is introduced in the base metal.

The latter property together with higher welding speed lead to a lower overheating and less deformation of the work piece.

Experiment samples were welded with the modern equipment DIGI@WAVE™ 400 - water cooling system: synergistic equipments with “multiple” current transfer and with the latest technology inverter. It has more than 120 synergistic curves included in memory and the possibility of memorizing 100 programs with a good numerically reproducibility, HOT START / SOFT START, a variety of transfer ways (Short Arc, Deep Arc, Speed Short Arc (SSA), Spray Arc, Pulsed, Silent Pulses (SSP), Cold Double Pulse, Spray-Modal TM, MIG brazing), 2T/4T, points. You can choose to operate in synergistic, semi-synergistic or manual version. Power supply: 400V - 3Ph. Current network frequency: 50/60Hz. Welding current adjustable voltage: 20A - 400A. Wire diameters used (Ø mm): 0.6 to 1.6 mm.

For MAG welding with very short spray arc wire, an electrode G3S1 was used, which was purchased from Tenzo, the main distributor of Bovax brand. They are delivered in the form of coils, with standard diameters in range of 0.8, 1.0, 1.2, 1.6 mm and correspond to SR EN 440 norm.

## 3. Metallographic analysis and experimental results

To make the experimental program semi-drawn tubes, hot seamless from carbon steel were used. The pipes were cut to 1 meter with rates: Φ108x4.0 OLT 45 and Φ168.3x8.0 OLT 35, which were executed in welded joints in manual welding version with coated electrodes (ME) and environment protective gas welding (MAG “very short arc spray") [3].

Sample preparation was done in several steps: sampling, straightening, surface grinding preparation, finishing and natal attack.

Setting the sampling area was based on theoretical considerations (chemical in homogeneities, processing lines, superficial heat treatment, surface defects, cracks, broken parts, etc..), so that the sample to be representative for the studied material and suitable for the purpose research.

Sampling was done by cutting, using a proper cooling in order not to influence the structure. Samples were cut with abrasive wheels. After that, the sample was processed.

The preparation polishing was done with a series of papers grit increasingly finer. Finishing was done mechanically (using a very fine abrasive powder). In the polished sample, the structure is not directly highlighted. To study the macrostructure is primarily observed the fibre structure. Pores, cracks or structural issues can be seeing with different colour like gas inclusions etc.

The attack reagent used was the natal attack, which is a solution of 2 ... 3% nitric acid in alcohol and in contact with the polished surface of the sample reveals the microstructure of the sample. During the mechanical polishing, the surface of the sample forms a thin layer of highly distorted material (called Beilby's layer) which covers the inter-granular spaces, distorting the appearance of the microstructure. Due to the attack of the surface, this layer is removed, so the real aspect of the microstructure appears [4].

The differentiation of constituents through chemical attack is based on one of the following effects:

- Surface selective dissolution of various constituents;
- Colouring due to interface phenomena that occur in a transparent film formed on the surface of constituents;
- Deposit of a precipitate formed at the surface of a constituent by chemical reaction

Metallographic analysis of welded joints was conducted in accordance with STAS10952/1-97, the sampling mode is shown in figure 2.

For the experiments semi-drawn tubes, hot seamless made from steel carbon were used. The pipes were cut at 1 meter and have the rates: Φ108x4.0 OLT 45 and Φ168.3x8.0, OLT 35 [5].

Metallographic analysis was conducted of welded joints in manual welding with coated electrodes variant (ME) and environmental protective gas welding (MAG "very short arc spray").

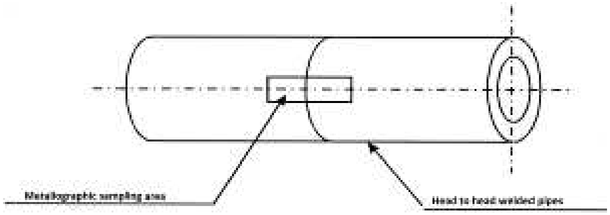



Figure 2. Metallographic sampling area

### 3.1. Structural features of pipe Φ108x4.0, OLT 45:

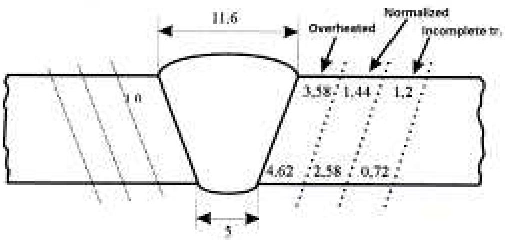



Figure 3. The thickness of welded area for pipe Φ108 x 4.0 -OLT 45

- In the cord, the root layer has overheating structure in exterior and through interior has annealing structure with small grain and the filling one has basalt grain;
- Superheated layer of thickness around 4.5 mm (figure 3) has the largest grain of all semi-manufactured welded products, the variation of the outer surface to the inner surface of the sample prepared metallographic is practically negligible;
- Overheated are is the largest of the sub-surface, with coarse structure Widmannstatten as a result of intense heat treatment for the thickness of the pipe;
- It is noted that at the transition from the cord to overheated area is a intermittent "frontier" that consists of ferrite grains put together head to head (figure 4);
- At the edge of the cords, it encounters a pore (at one of the metallographic samples) due to welding gas inclusions, and from it develops a crack.

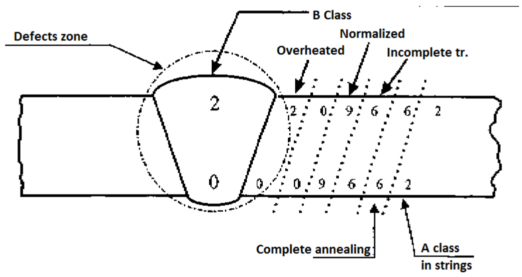



Figure 3. The thickness of grain for pipe Φ108x4 -OLT 45

It is very interesting that this two defects were formed in conditions that the welded semi-manufactured (the pipe) it is not submitted upon application.

In figure 5 were defined the research directions in the welded cord. OX – transverse direction, OY – radial direction and OZ – longitudinal direction.

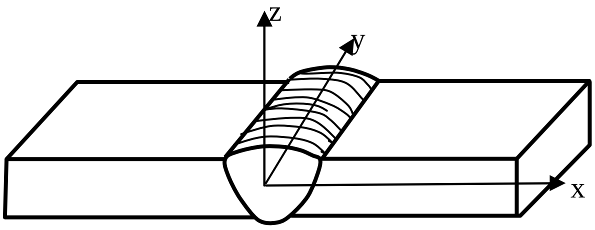



Figure 5. Research directions in the welded

Welded seam in a gas protective environment for Φ108x4.0 - OLT45.

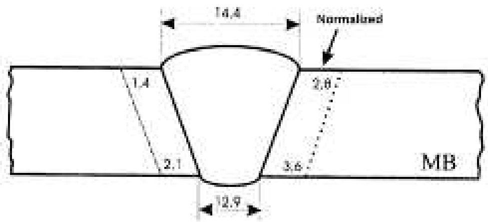



Figure 6. The width of the constituent sub HAZ pipe Φ108x4.0 - OLT45

The cord has a recrystallization annealing structure with homogeneous distribution of constituents that appears to limit grain, and the filling is ground ferrite grains. The heat-affected zone (HAZ) structure is very homogeneous, overheating zone disappears; base material has a fine structure with an aspect of restoration, without the band structures, figure 6.

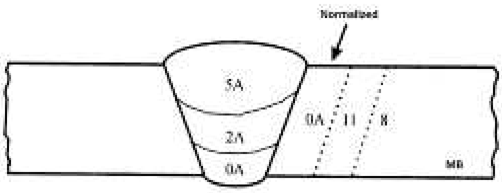
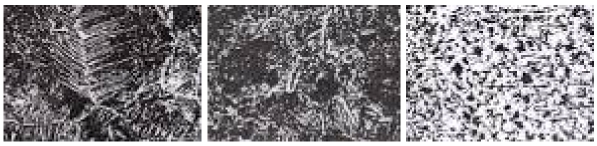


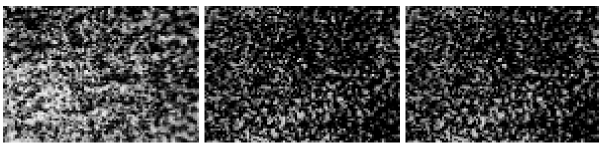

Figure 7 Metallographic grain size of seam welded pipe Φ108x4.0 - OLT45

Figure 8 shows the metallographic structure of the manual welding with coated electrode and figure 9 shows the metallographic structure of the protective environment of seam gas (MAG "very short arc spray"). WS – welded seam; HAZ – heat-affected zone; BM – base material [1].



WS HAZ BM

Figure 8. Metallographic structure of manually welded seam with coated electrode, the pipe Φ 108x4 OLT 45 (240:1)



WS HAZ BM

Figure 9. Metallographic structure of the welded seam in a gas protective environment (MAG with "very short spray arc") pipe Φ 108x4 OLT 45 (240:1)

**3.2. Structural features of pipe Φ168.3 x 8.0 - OLT35**

- The root layer is fully annealed;
- A possible force concentrator can be located at the intersection of seams with heat affected zone where three structures are found within only 0.5 mm;
- The annealed zone structure shows uniform and equi-axial grains;
- It appears a clear difference between primary base material (seamless pipe) and material of the welded joint that is formed pearlite globular;
- The overheated area of the fill layer is much smaller than it sample 1 (Φ108.0x4.0) and is also finer grain (figure 10).

Observation: Because of the higher thickness of the pipe an annealing treatment can be fulfilled, the thermal inertia of the welded pipe (the amount of heat stored) provides around the pipe seam annealing.

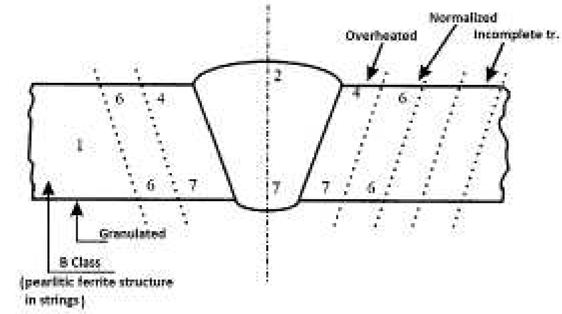



Figure 10. The size of the metallographic grain Φ168.3x8

In conclusion, the welded joint is structurally much more homogeneous than in the case of a pipe weld thickness less (compared to sample 1).

On this pipe is noted that sub full annealing is about 25 mm, the area where the pearlite is globular, the ferrite has crumbled due to the heat. After 25 mm, the structure returns to its original appearance, ferrite and pearlite grain oriented along laminations (figure 11).

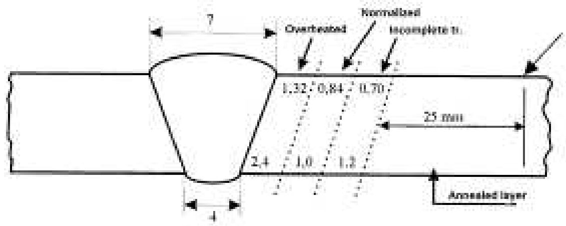



Figure 11. Welded Sub-seam width Φ 168.3x8.

Because the wall thickness is doubled, in this case the stored heat during welding has the same effect, so that the cord is partially restored, unlike the previous case, the cord is much more homogeneous and transformations were perfect filled the cord (figure 12).

Area is no longer overheating, resulting in a ductile behaviour in this area (figure 13).

The basic material is annealed structure.

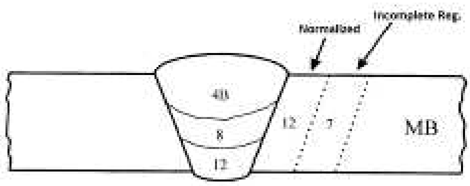



Figure 12. Metallographic grain size welded pipe Φ168.3x8 – OLT 35

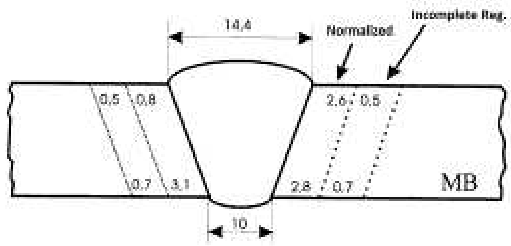
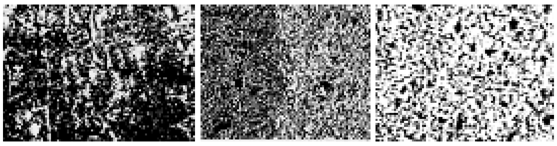


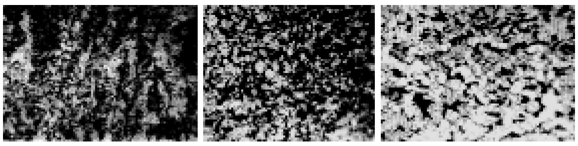

Figure 13. The width of the constituent sub Z.I.T. pipe Φ168.3x8 – OLT35

Figure 14 shows the metallographic structure of the manual welding with coated electrode and figure 15 shows the metallographic structure of the protective environment of seam gas (MAG “very short arc spray”). WS – welded seam; HAZ – heat-affected zone; BM – base material.



WS HAZ BM

Figure 14. Metallographic structure of manually welded seam with coated electrode at 168.3 Φ x8 OLT 35 (240:1)



WS HAZ BM

Figure 15. Metallographic structure of the welded seam in a gas protective environment (MAG with “very short spray arc”) Φ 168.3 x8 pipe OLT 35 (240:1)

## 4. Conclusions

Rolled mandrel for carbon steel manufacturing norms recommended annealing as a treatment of rolled product of removing defects that may occur from the strip or structures metal acid type of overheating Microstructure and restorer of Widmannstatten and prepare blank for welding.

Metallographic analysis of manual welding with coated electrodes has defects: cracks, inhomogeneous structural, pores, that may occur even in the conditions in which construction is not put into service.

Metallographic structure of the welded in protective environment of seam gas (MAG “very short arc spray”), gained homogeneous so that welded subareas appear in a small number because of seam recrystallization.

Root layer has fine structure and the normalized annealing has very fine and equi-axed grains.

The benefits of MAG process, with “very short arc spray” compared to manual welding with coated electrodes are higher productivity, better control of the welding heat input, inexpensive supplies, no slag, elimination of losses by changing the electrodes, no nicks are formed, penetration depth is higher, higher welding speed, less heat is inserted in the basic metal, less overheating and a lower deformation of the work piece.

The testing of new welding technologies of telecommunications antennae towers by taking micro and macro scopes samples and tests prove the welding area reliability and represents the authors contribution,

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