Plasma and electric arc thermal spraying - achievements and perspectives

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Keywords

Plasma and electric arc thermal spraying, plasma jet arc, applications

1. Introduction

Plasma thermal spraying method uses as fillers materials powders of different grain sizes. In order to supply the plasma jet with powder it is necessary to use supply dispensers of high complexity due to the process of powders compaction.

The use of filler material in wire form is limited by the fact that the temperature of the plasma jet decreases significantly reduced at a reduced movement to the axis of the plasma jet, and the filler material passes along the plasma jet and is not melted the plasma jet.

The cost price of the filler material in powder form is much higher compared to the cost price of the filler material in the wire form.

At ISIM Timişoara has been developed the method of plasma and electric arc thermal spraying (PLASMA JET ARC) using as filler materials in the form of wire. Figure 1 shows the schematic diagram of this process.

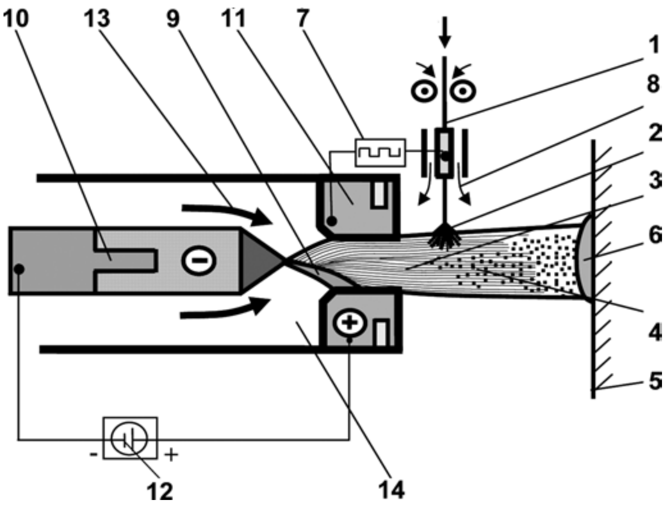

Figure 1. Schematic diagram of the process.

The plasma generator (14) produces a plasma jet (3), by means of the electric arc (9), which burns between the non-consumable electrode (10) and the nozzle (11) intensively cooled with water and the plasma gas (13). Plasma arc is powered by the power source (12).

In the plasma jet (3) is inserted the electrode wire (1) and produces an electrical arc (2) in the tip of the wire electrode and the plasma jet. The electric arc (2) is powered by a power source (7) and is protected by the protective gas (8).

The wire electrode is melted in the electric arc (2) and the plasma jet (3) and the molten particles (4) derived from the electrode wire are driven by the plasma jet and sprayed at high speed on the support materials (5). The electric arc (2) that burns between the tip of the wire electrode (1) and plasma jet (3) is not a usual welding arc. The arc's tension is very low and the current is limited at a certain value. The role of the arc (2) in the process is not only to melt the wire electrodes but rather to guide the molten particles of the wire electrode to the axis of the plasma jet.

The process of plasma and electric arc thermal spraying (PLASMA JET ARC) provides the highest rate of deposition of all thermal spraying processes, the deposition rate is comparable with the processes of MIG/MAG. The porosity of the material is very low and the parts realized through thermal spraying are weldable [1-3].

2. Experimental procedure

2.1. Deposition of stainless steel on carbon steel substrate

In this experimental research were deposited stainless steel layers through thermal spraying on a carbon steel pipe.

The deposition parameters were:

- Plasma gas: Ar + 6% H2
- Plasma gas pressure: 8 bar.
- The current type, plasma, polarity: CC-
- Plasma Current: 650 A
- Plasma voltage: 65 V
- Cooling water pressure: 10 bar.
- Arc current: 60A
- Arc voltage: 4V
- Wire feed speed of 9 m / min.
- Shielding gas Ar (I1/SR EN ISO 14175)
- Protective gas flow: 10 l / min.
- Type arc current, polarity: DC +
- the distance between plasma nozzle-electric arc: 15 mm
- Spraying distance: 200 mm
- Spray angle: perpendicular

Figure 3 a, b presents the macroscopic aspect of the steel pipe that was thermally sprayed with stainless steel layers.

The microscopic structure of the deposited layers is presented in Figure 3. and consists of austenitic structure with complex carbides. Also, are not observed defects such as microcracks.

The deposited layers were submitted to HV5 Vickers hardness test and were obtained values ranging between 219-229 HV5.

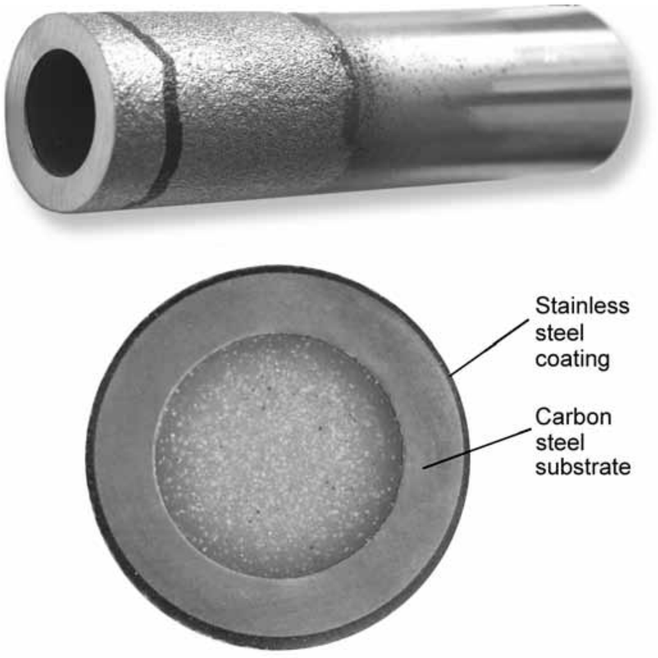

Figure 2. Macroscopic aspect:
a) The deposited pipe; b) cross section of the pipe.

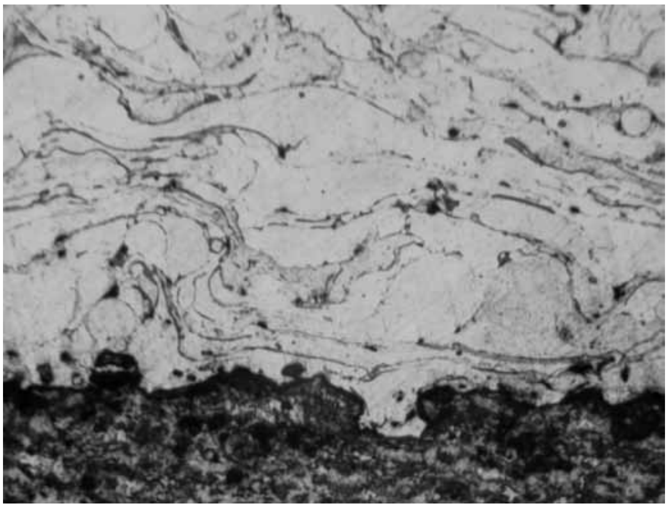

Figure 3. The microstructure of the deposited layers.

2.2. Deposition of copper layers on aluminum substrate

In this experimental research were deposited by thermal spraying copper layers on carbon steel pipe.

The deposition parameters were:

- Plasma gas: Ar +6% H2
- Plasma gas pressure: 9 bar
- Type of plasma current, polarity: CC-
- Plasma Current: 750 A
- Plasma voltage: 75 V
- Pressure of the cooling water: 10 bar.
- Arc current: 70 A
- Arc voltage 5 V
- Wire feed speed: 6 m / min.
- Shielding gas: Ar (I1/SR EN ISO 14175)
- Protective gas flow: 12 l / min.
- Type of arc current, polarity: CC-
- The distance plasma nozzle - plasma jet: 25 mm
- spraying distance: 150 mm
- spraying angle: perpendicular

Figures 4 and 5 present the macro and microscopic aspect of these depositions.

Figure 4. Macroscopic aspect

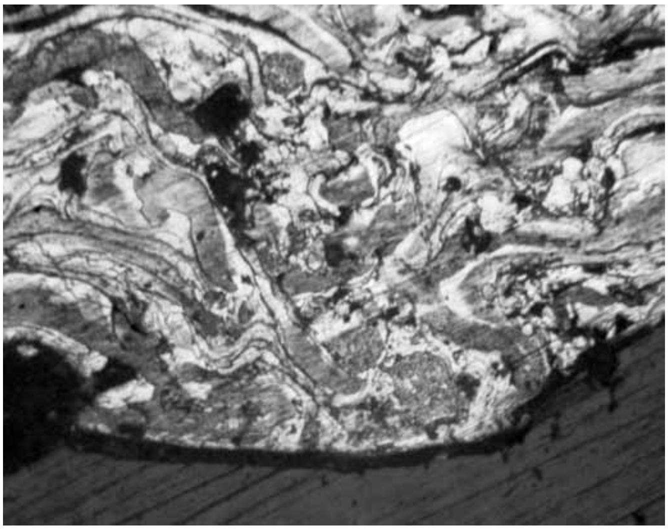

Figure 5. Microscopic structure of the depositions

This technology can be applied to realize electrical contact between copper and aluminum.

2.3. Deposition of bronze on ceramic substrates

In this experimental research were deposited bronze-based layers through thermal spraying on ceramic substrates:

Support materials: ceramic tube ø 15 mm, ceramic plates 30 x 20 x 5 mm

Deposition layers: aluminum bronze, ø 1,6 mm, ER Cu Al-A2 (AWS.SFA-5.28) on ceramic tubes and tin bronze ø 1,6 mm, ER Cu Sn-A (AWS A 5.7) on ceramic plates

The deposition parameters were:

- Plasma gas: Ar + 6% H2
- Plasma gas pressure: 8 bar
- Type of plasma current, polarity: CC-
- Plasma current: 700 A

- Plasma power: 70 A
- pressure of cooling water: 10 bar.
- Arc current: 75 A
- Arc voltage: 6A
- Wire feed speed: 5 m / min.
- Protective gas: no
- Type of arc current, polarity: DC +
- distance between plasma nozzle – electric arc: 20 mm
- Spraying distance: 200 mm
- Spraying angle: normal

Figure 6, 7 present the macro and microstructures of aluminum bronze coatings on ceramic tube.

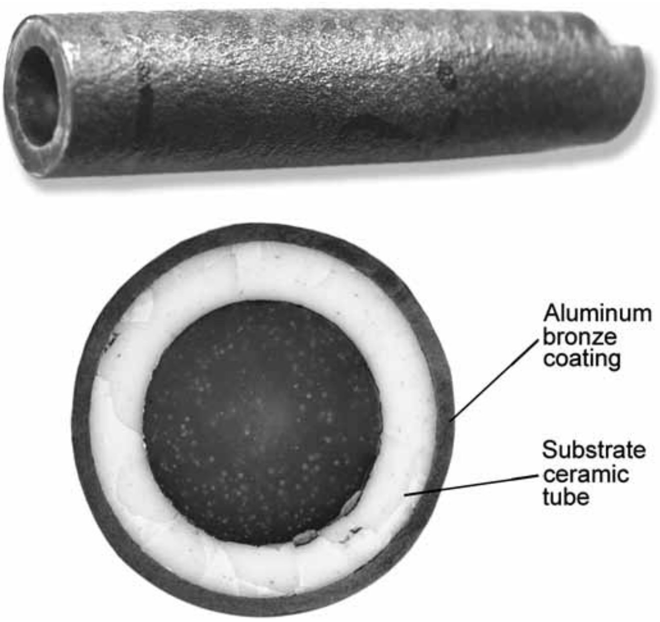

Figure 6. Macroscopic aspect of aluminum bronze coatings on ceramic tube.

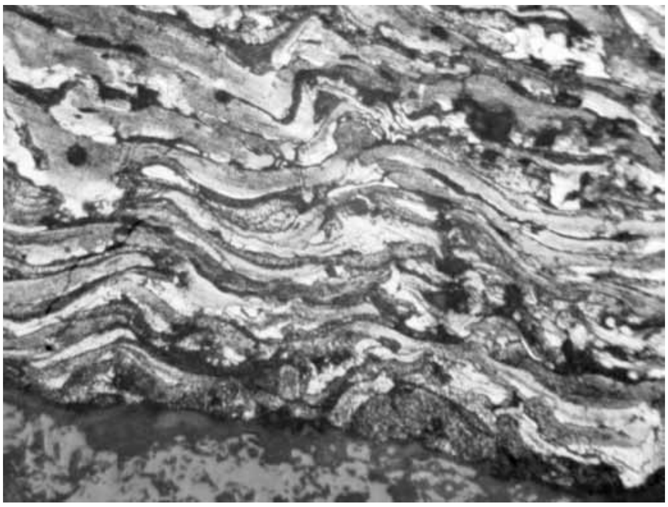

Figure 7. Microscopic structure of the depositions.

As it can be observed, the microstructure is composed of aluminum solid solution with Al-Sn precipitations.

Figures 8 and 9 present the macro and microscopic structures of tin bronze coatings on ceramic plates. The microstructures consists of α-solid solution with Cu-Sn fine particles.

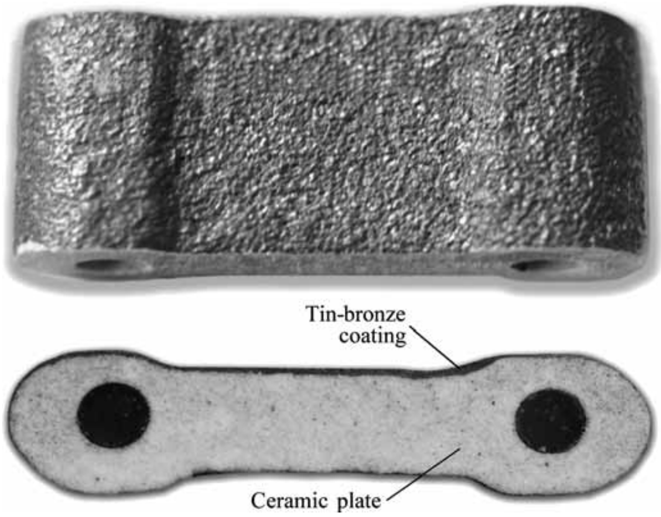

Figure 8. Macroscopic aspect of the coatings.

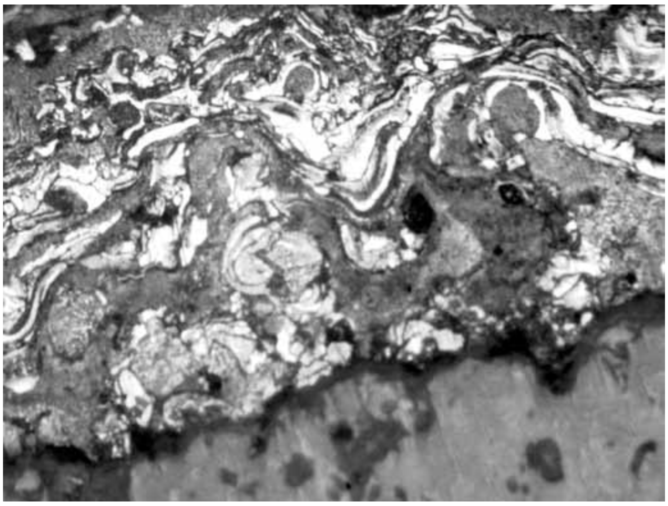

Figure 9. Microscopic aspect of the coating.

3. Conclusions

3.1. Plasma and electric arc thermal spraying method achieves equivalent productivity as MIG / MAG processes, being the method with the higher deposition rate of all thermal spraying processes

3.2. In this method it can be used as filler materials solid wire or cored wire.

3.3. By applying this technology it can be obtained electrical connectors copper-aluminum (copper joints).

3.4. In the process, the plasma jet can be fed with multiple wires from independent sources and multiple powders to obtain composite coatings or composite materials.

References

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