

Prepare for brazing aluminium samples by ultrasonic cleaning

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Abstract. Due to its properties, aluminum and its alloys are one of the most widespread materials in the industry, surpassing classical materials. From the economic point of view, with the introduction of these materials, it was also necessary to create technologies for the repair and refurbishment of the parts and subassemblies. Due to the relatively low melting temperature of the aluminum, the welding refurbishing operation faces some difficulties. Therefore, one of the most used aluminum refurbishing processes is the brazing operation. The difficulty of this operation is how to clean the surfaces to be contacted. Aluminum oxide on the surface is the protective layer on the anodized aluminum. The aluminum oxide on the surface is like the protective coating on anodized aluminum. The large differences between the melting point of the aluminum and the melting point of the aluminum oxide lead to defects in the brazing operation, unless proper preparation of the surfaces by the removal of the oxides is achieved. This paper aims to improve the preparation of the surfaces to be assembled by setting the parameters of the ultrasonic cleaning regime.

1. Introduction

One of the technologies by which the aluminum samples are combined is the oxy-acetylene manual brazing.

A very important operation for achieving a good quality joint is the preparation of the surfaces to be assembled.

For this stage, we used the ultrasonic cleaning bath with transducer because it has superior benefits to conventional mechanical cleaning or pressure cleaning methods.

The principle underlying the ultrasonic cleaning bath method is as follows: the ultrasonic generator emits a sinusoidal signal to the piezoelectric / magnetostrictive transducer, which generates a mechanical work of the tank walls, which further generates a pressure - depression in the mass of the liquid with a frequency of $28000 \div 40000$ times/s. The speed of movement and the pressure of the cleaning fluid molecules cause them to penetrate the smallest holes and cavities, inaccessible places in the case of handwashing or under pressure. The basic scheme is shown in figure 1. At the base of removal of impurities and aluminum oxides, there are two phenomena: the alternating pressure - depression generated on the surface of the piece and the acoustic cavitation.



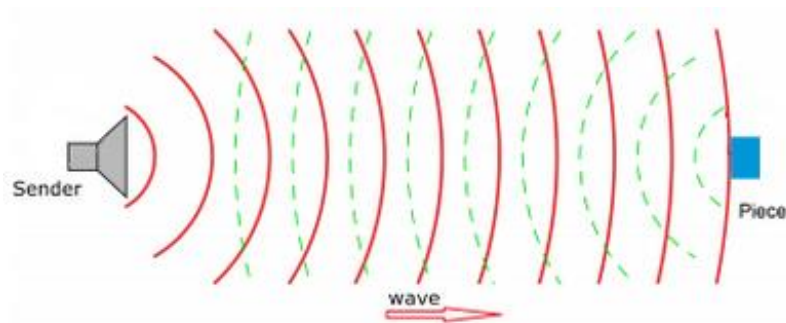


Figure 1. Scheme of ultrasonic cleaning [1].

Acoustic cavitation is a phenomenon of implosion of gas bubbles created by lowering static fluid pressure. The gas bubble implosion generates strong shocks on the surface of the aluminum samples that cause the displacement of impurities and oxides.

Ultrasonic oscillator cleaning in the tank is an improved '3xSweep' cleaning system that includes a frequency oscillator of $\pm 1\text{kHz}$ for a uniform distribution of ultrasonic waves in the mass of the washing fluid and a better penetration of the waves. The schematic diagram of the frequency sweep is shown in figure 2.

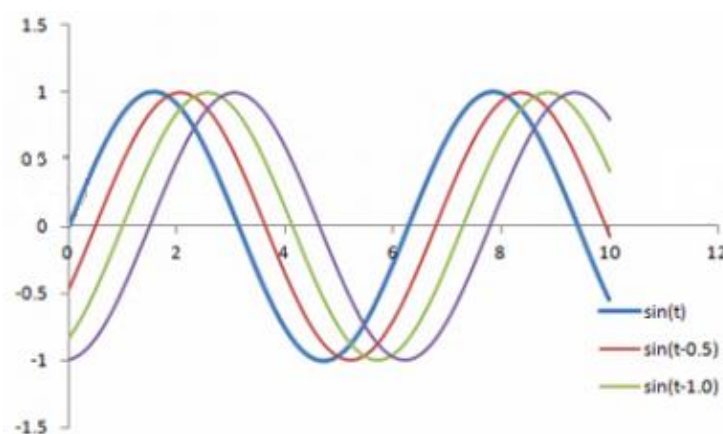


Figure 2. Schematic diagram of the frequency sweep [2].

This paper proposes aluminum 6061 ultrasonic oscillator cleaning procedure in the bath by establishing the time parameters for maintaining the parts in the bathroom and the bath temperature to values that give the brazing joint outstanding qualities.

2. Used materials

The materials that will be uncounted is aluminum alloys 6061, which has a wide spread in all industries: aerospace, machine building, food, pharmaceutical and medical, but also in the chemical and petrochemical industry. Thanks to its wide range of applications, the aluminum alloy brazing technology has been developed since 1985. [3]

It is known that parts made of aluminum alloys are characterized by an effect that makes the brazing operation more difficult, namely instantaneous oxidation of the surface. Various surface cleaning technologies to be assembled by brazing are known in the literature.

The chemical element that causes the biggest problems is Silicon, which, if it exceeds 0.6%, makes application of brazing technology more difficult. As this percentage is not limited, as is the case for

the aluminum alloy 3103 for example, it is necessary to introduce a surface preparation technology [4].

The new surface preparation technology consists in ultrasonic cleaning of aluminum parts and degreasing them with dimethyl ketone or propanone solution (C₃H₆O).

This simplicity allows rapid implementation of the surface preparation process in the industries using aluminum alloys 6061 and due to the very low degree of pollution. This way, classical surface preparation technologies such as baths in Aloclone 100 or Deoxidizer solutions can be successfully replaced.

To perform the ultrasonic oscillator cleaning operation in the bath, we used a cleaner EMMI-40 HC with the following features:

- the dimensions of the tank (LxHXH): 300x155x100 mm;
- the capacity of the tank: 4,0 l;
- power of the installation: 250 W;
- power in the tank: 240 W.

Due to the first two characteristics of the tank size and the amount of cleaning fluid, the appliance has the disadvantage of limiting sample sizes.

Parameters that can be varied during the cleaning process are: bath temperature, appliance power, time to maintain parts.

As the cleaning solution we used EM 404 with the following chemical composition: non-ionic tensides, citric acid, anti-corrosion protection, phosphate-free PH-value 3.0 at 1% in a concentration of 25%.

Parameters that can influence the quality of cleaning the surfaces to be brazed are the temperature and the time of maintaining the parts in the tank.

Power cannot be considered as a parameter that needs to be varied because it directly influences the maintaining time. Thus, the power of the apparatus was chosen 100%.

For this purpose, a series of experimental samples were performed, the parameters of which vary according to table 1.

Table 1. Variation of ultrasonic cleaning parameters in experimental samples.

No.	Sample marking	Temperature [°C]	Time [min]
1	7	35	10
2	8	45	10
3	9	55	10
4	11	35	15
5	12	45	15
6	13	55	15
7	23	35	20
8	24	45	20
9	25	55	20
10	29	35	30
11	30	45	30
12	31	55	30

After this step, the markers were degreased with dimethyl ketone solution and brazed using a neutral oxy-acetylene flame and depositing the filler material on both surfaces of the base material, as can be seen from figure 3.



Figure 3. Characteristics of brazing technology parameters
 a. Filler material deposition on both sides of the base material,
 b. the use of a neutral oxyacetylene flame.

It is worth mentioning that a part of the ultrasonically cleaned samples was degraded in the brazing process, which required the restoration of the experimental samples. From the all the samples performed, the most representative ones are shown in figure 4.

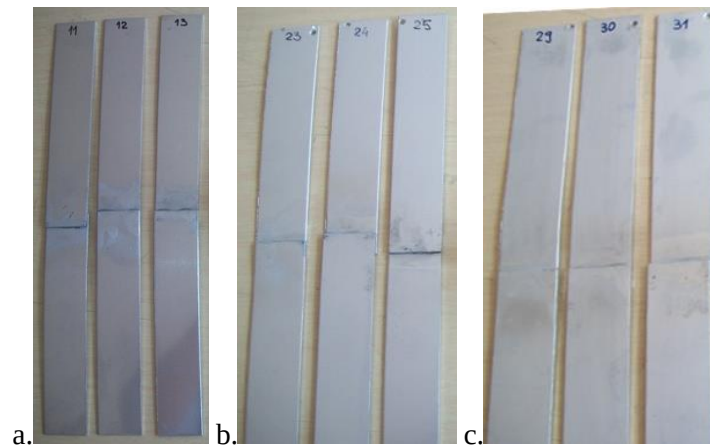


Figure 4. Representative sample sets obtained by varying the ultrasonic cleaning parameters:
 a. temperature - 35, 45, 55 [°C], time – 15 [min],
 b. temperature - 35, 45, 55 [°C], time – 20 [min],
 c. temperature - 35, 45, 55 [°C], time – 30 [min].

3. Non-destructive tests

Following the optical-visual examinations, it was found that the sample with symbol 25 was not defective.

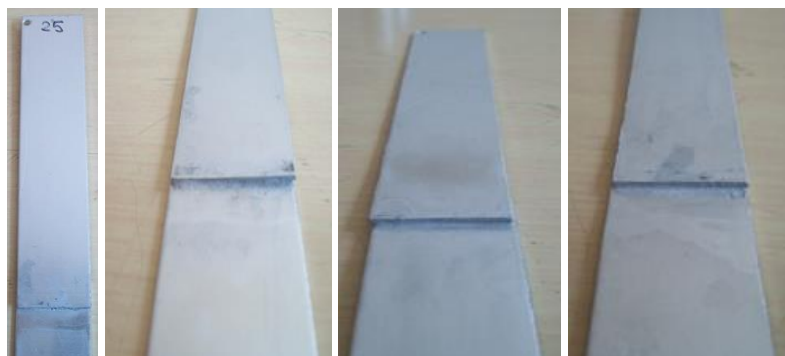


Figure 5. Sample 25 examined optically-visual.

Figure 6 shows penetrating fluid examination, penetration and development steps using KD-Check-RDP1 Red Ink Penetrant according to EN ISO 3452 9901 and KD-Check-SD1-compliant wet-developer according to EN ISO 3452 and DIN 54152- 9903.

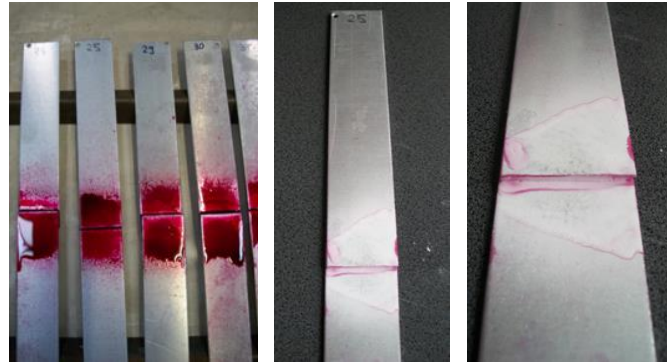


Figure 6. Sample 25 examined with penetrating liquids.

This examination method, which reveals surface discontinuities or communicates with the surface, has not found defects in sample 25.

To highlight potential discontinuities from inside, we will use the immersion ultrasound examination method shown in figure 7a. and 7b.

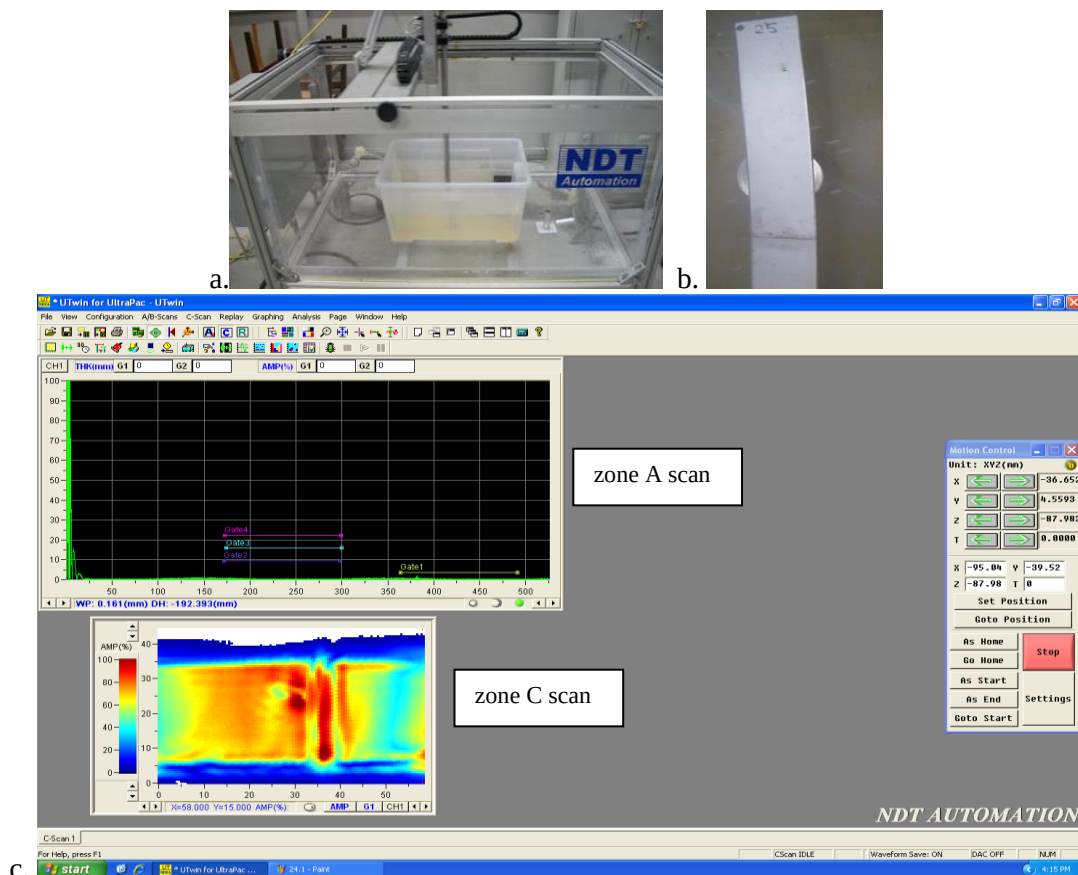


Figure 7. Ultrasound test in immersion
a. Ultrasound testing equipment in immersion,
b. Sample 25 positioned on the support,
c. Sample 25 examined with ultrasound immersion.

The gauge scans the entire sample after the coordinates entered, resulting in a map of possible defects presented by the C scan mode. The operator moves the touch probe into areas with possible defects to accurately check if there is a fault signal displayed in A scan mode. It is worth mentioning that the emission method is the one with repeated echoes. [5]

In figure 7c is the image in the C scan mode and A scan mode of the part and it has no internal defects.

4. Destructive tests

Figure 8 shows sample 25 subjected to a destructive test.

Destructive tests may be necessary to determine the effects of the brazing process or any subsequent heat treatment on the joint characteristics [6].

The most numerous brazing joints are designed with component parts in overlapping configuration. Because of the capillary phenomenon, most discontinuities generally occur in the joint area, having the main axes parallel to the joint plane.

Brazing joints are, in most cases, systematically designed to be shear resistant, and the joint dimensions influence the shear strength to a much greater extent than the tensile strength [7].

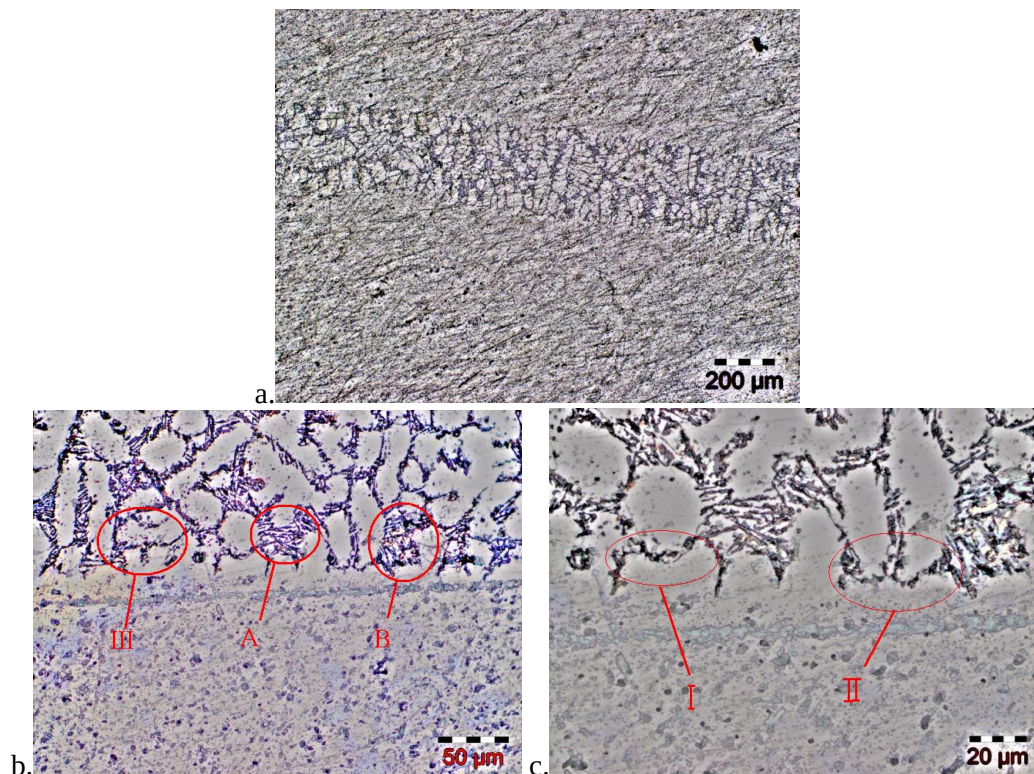


Figure 8. Sample 25 metallographically tested

- a. similar structure of the filler and base,
- b. no migration of oxides of the base material into the filler material is observed,
- c. the correct alloy between the filler material and the base material in the oxide-free zones I and II.

Analyzing figure 8a, sample 25 presents a normal brazing aspect without defects at the interfaces of the filler material with the base materials. Also, in figure 8b, in areas A and B can be observed that the base material oxides have not migrated to the interior of the filler material.

Analyzing figure 8a and 8b, sample 25 presents a normal brazing aspect without defects at interfaces or migrations of oxides towards the interior of the filler material.

In figure 8c, in zones I and II the filler material and the base material have been alloyed into a uniform structure, resulting in very good properties of the brazed joint. Similar areas can be seen in figure 8b zone III.

5. Conclusions

Following non-destructive tests, it can be noticed that the bath temperature and bathing time were well-chosen and there were no defects at macro-structure level due to uncleanness.

Power cannot be considered as a parameter that needs to be varied because it directly influences the maintaining time.

Because of the metallographic tests, there can be noticed no migration of the impurities in the filler material either at the first sintering, nor at the second sintering, respectively in the brazing. It can also be seen in figures 8b and 8c that there are no inclusions at the interfaces of the feed material with the base materials.

From this study, we can conclude that the surface cleaning technology for aluminum alloys 6061 is the following:

- Ultrasonic cleaning of surfaces with parameters: the power of the device 100%; heating temperature 550C; time of maintaining samples in the tank 20 minute; EM 404 ultrasonic cleaning solution in concentration 25%;
- Degreasing with dimethyl ketone solution of the surfaces.

The use of 6061 general purpose aluminum alloy cleaner technology does not show operator toxicity, and bio-degradable EM 404 cleaning solution, which is more than 90% dissipated, as can be seen of figure 9 which is the manufacturer's prospectus.

6. Information about ecology	
Information about disposal	
- Procedure	-
- Methods of analysis	-
- Degree of disposal	> 90% according to WRMG
- Valuation	bio – degradable
Additional information	Water danger class WGK 1. In accordance with the criteria of OECD tensides are easily bio – degradable

Figure 9. Manufacturer Features for EM 404 [8].

6. References

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