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Phase Identification of Inconel 738 Lc Superalloy Byactive Bazing Alloy of (28 Ni 72 Ti)

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Abstract:

In this study, Inconel 738LC super alloy brazed by 28Ni72Ti which was used as an active filler alloy at temperature 985ºC for (15min). The process achieved in a furnace brazing under high purity of a protective 99.999% Argon gas to ensure that joints are free from oxidation and contamination. The XRD and microstructure analysis were implemented to investigate the bonding morphology and the bonding strength was estimated from shear test. The results show that the highest shear strength was 29 MPa and morphologically the strength of bonding was inclined by the creation of reaction layers that cross over in the center of the brazing area due to the inter diffusion effects of several constituents from base metal 738 super alloy and active brazed metal 28Ni72Ti.

Keywords: Super alloy, Brazing, Active Filler Alloy, Inconel 738, Shear Strength.

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1. INTRODUCTION

The term of brazing refers to the process that produces coalescence of materials by heating them to the temperature called brazing temperature in the presence of an active filler metal which must have liquids above 450ºC and below the solidus of the base metal [1]. In the manufacturing industry particularly in joining process, brazing was applied to join two materials via capillary action by heating them to the melting point of the filler metal in order to ensure that filler metal flows via capillary action between two mating surfaces [2]. Inconel 738 super alloy has a low coefficient of thermal expansion (CTE) was developed for the gas turbine Industry [3]. This alloy is useful strengthened by a precipitation- hardening heat treatment by additions of niobium and aluminum [4]. At high temperatures the aluminum content provides excellent resistance to oxidation. This alloy could be used in gas turbine and steam turbine components due to low expansion, high strength and excellent resistance to oxidation [3, 5].

2. EXPERIMENTAL PROCEDURE

Inconel 738LC super alloy (first stage gas turbine blade) was used in this study as a base metal. The sample was prepared by cutting it with wire cut machine to cubic shape with dimension of 10 mm^3. The brazing process was carried out in an electrical furnace under protective atmosphere (high purity Argon gas 99.999%) to ensure that the brazed samples are free from undesirable contaminants between the mating materials. The past filler metals were prepared by weighting a suitable amount of metal powder alloy and mixed with a drops of glycerin to form a filler metal paste which in suitable for one joint.

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3. RESULTS and DISCUSSION

3.1. Microstructures of the Brazed Joint

The microstructures investigated by the optical microscope were shown in Figure 1 at different magnification. It was perceived continued morphology structures in the joint microstructure, it can be detected that a good metallurgical bond, unbroken connection was originated in the Inconel 738 LC joint, demonstrating good wettability.

The metal diffused by capillary action, seals the joint clearance and negated potential voids at the interface between the two surfaces. The capillary force requires an interaction between the base metal and the filler metal; the termination of some base metal does takes place due to inter diffusion between the filler metal and base metals [2], as shown in Figure 2.

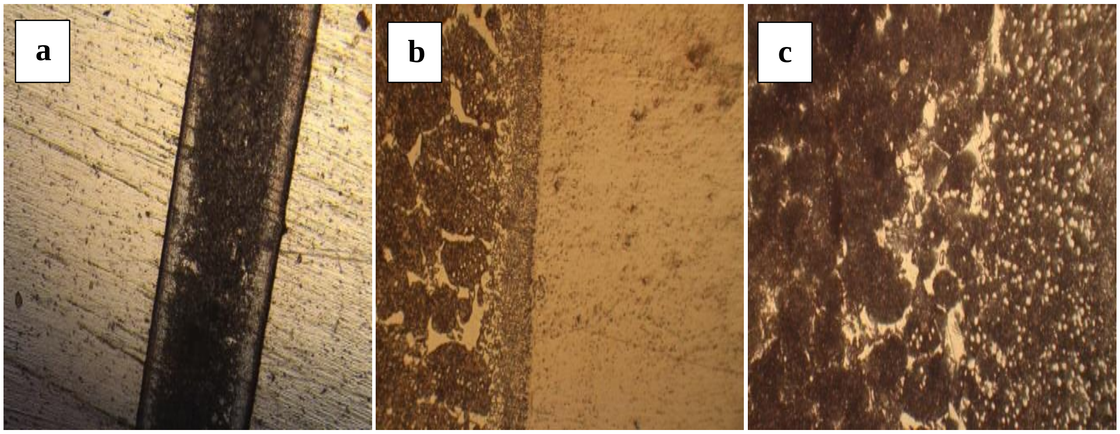

Figure 1. Optical micrograph image of samples bonded by 28Ni 72Ti filler alloy at different magnification **a.** 20x, **b.** 40x **c.**40x.

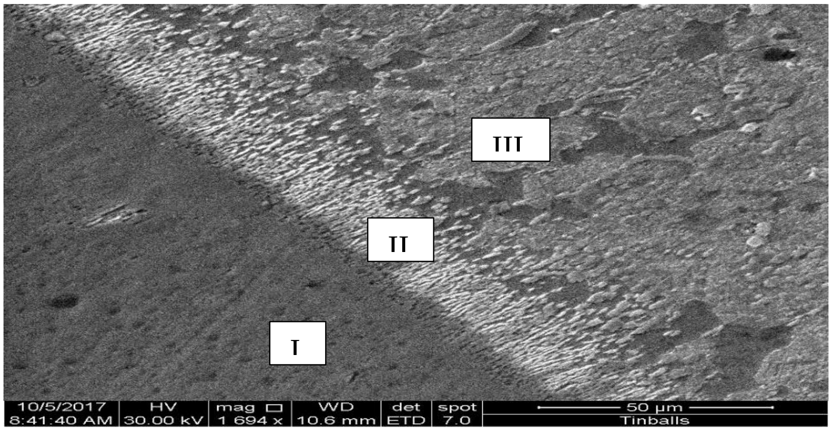

Figure 2. SEM images for joint sample at magnification 1694x.

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3.2. Interface Characteristics

The interface zone (substrate \ filler) microstructure begin to differ during proceeds towards the metallic support manufacture region known as a transition zone, this region molded when the base metal dissolution take place by the filler alloy. The inter-diffusion between the active filler elements and substrate happened, as soon as the alloying elements such as Cr, W, and Co diffused into the molten filler alloy, and contrarily Ti, Ni and Al migrate towards the substrate. The diffusion affected zone (DAZ) or transition zone were shaped to adjacent the substrate, it can be noticed clearly with the thickness of (12.63µm) for the sample bonded by 28Ni-72Ti% as in Figure 3.

The distribution of the elements in this region was described by EDX in Figure 4. It was observed that the DAZ layer rich with Ni, Cr and Co with noticeable amount of Ti for sample bonded by 28Ni-72Ti%.

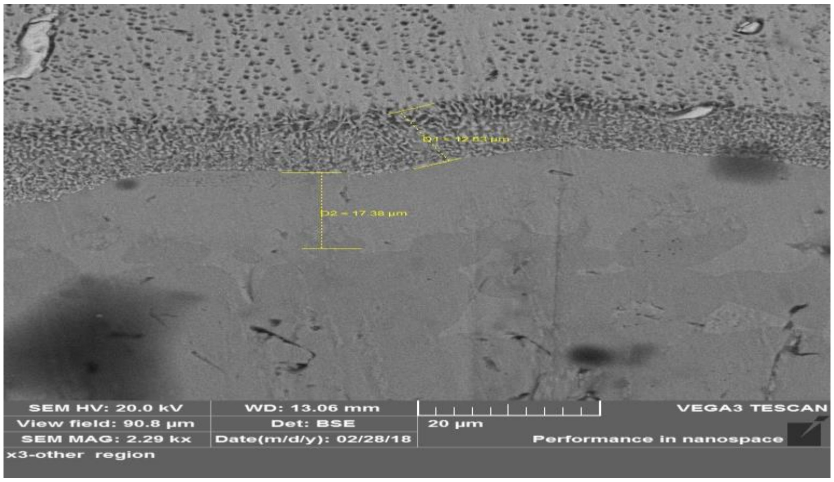

Figure 3. Diffusion Zone Thickness for sample bonded by 28Ni 72Tiwt. %.

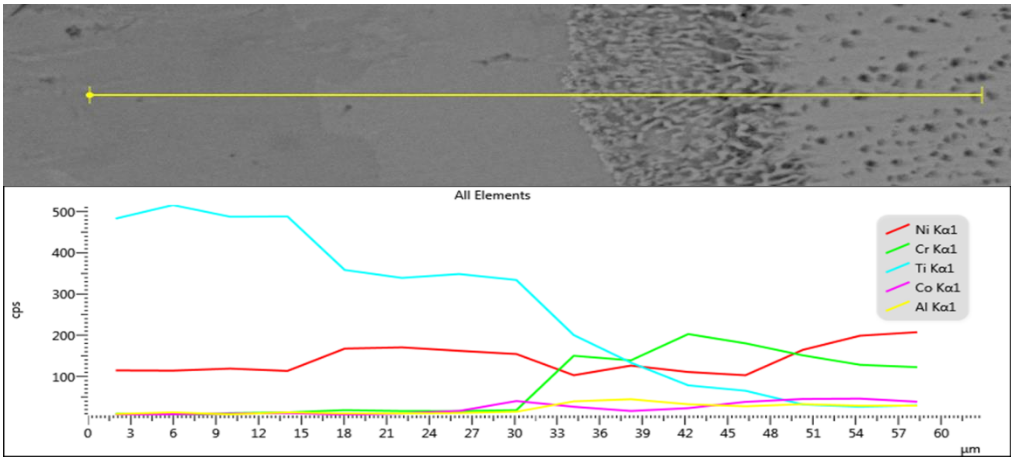

Figure 4. Energy Dispersive Spectroscopy EDS for samples bonded by 28Ni72Ti.

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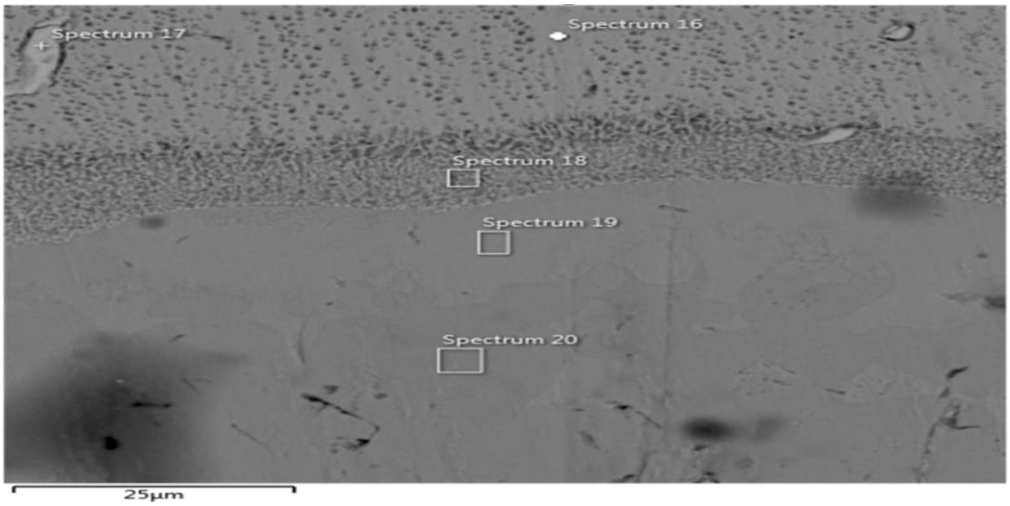

Figure 5. EDX points for sample bonded by 28Ni 72Ti .

Table 1. EDX analysis for sample bonded by 28Ni72Ti%.

Point No.	Elements Wt.%							
	Ni	Ti	Cr	Co	Al	W	Ta	Nb
16	59.3	2.8	20.0	9.0	3.5	5.4	-	-
17	3.0	23.4	1.5	17.4	-	7.8	34.7	12.2
18	41.0	14.0	28.8	4.8	3.3	8.1	-	-
19	50.6	43.6	1.5	4.3	-	-	-	-
20	35.0	60.0	1.2	3.8	-	-	-	-

3.3. Bonding Zone Analysis (Brazing Region)

Figure 5 shows the EDX points for sample bonded by 28Ni-72Ti% and Table 1 shows the chemical composition for detected phases in the bond region and structural profile through the bond we used in this investigation EDX, the results exposed intermediate phases like Ni-rich, and Ti-rich.

3.4. Layer-by-layer XRD Characterization of Microstructure

XRD analysis was accomplished for the reason that the limitation of EDX test; the joint cutting by wire parallel to the boundary between the base metal to three layers, the first layer cut to the distance near the bond zone about 0.5mm represent the base metal region and the results show the presence of Ni(Al,Ti) as a dominant phase. Second layer which is about 0.25mm near from the bond zone and it represents the inter diffusion region between the base metal and the filler alloy the dominated phases of Al 0.5C Ni3Ti 0.5, AlNi3 and AlTi3 and the last layer represent the bond zone (it's about the half of the bond zone), the dominated phase is Ni3Ti as shown in Figure 6. So we can say that typical brazed joint consist of three layers: (I) the base metal zone, (II) diffusion zone, and (III) bonding zone as shown in Figure 2. The bonding zone composed of (ASZ) which refers to A thermally Solidified Zone, this formed as a results of the remaining liquid solidifies in the joint when it cooling to the room temperature.

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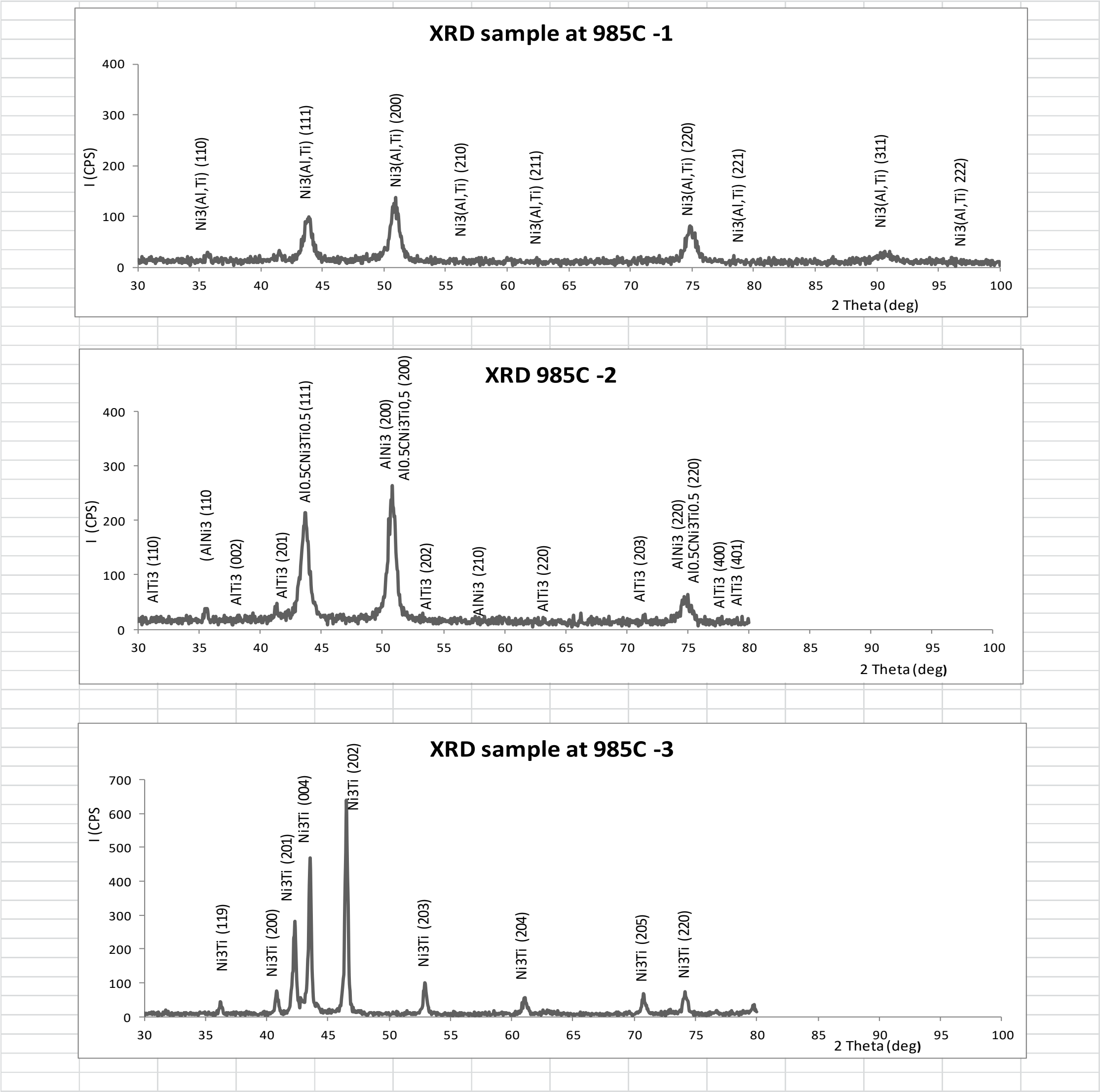

Figure 6. XRD Patterns **a.** first layer (base metal) **b.** second layer (inter diffusion layer) **c.** third layer (bonding).

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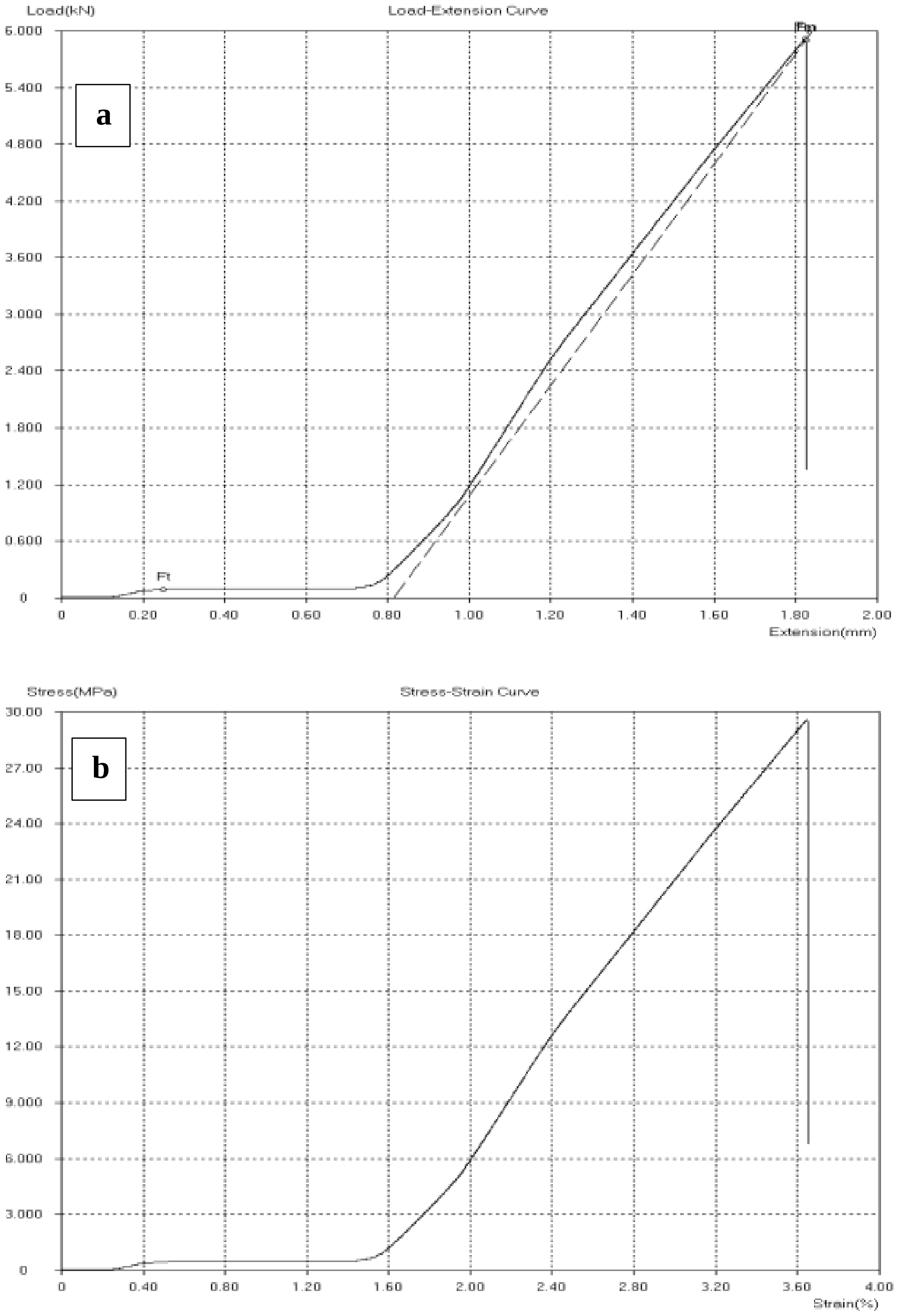

Figure 7. **a.** Load-Extension Curve and **b.** Stress-Strain Curve**.**

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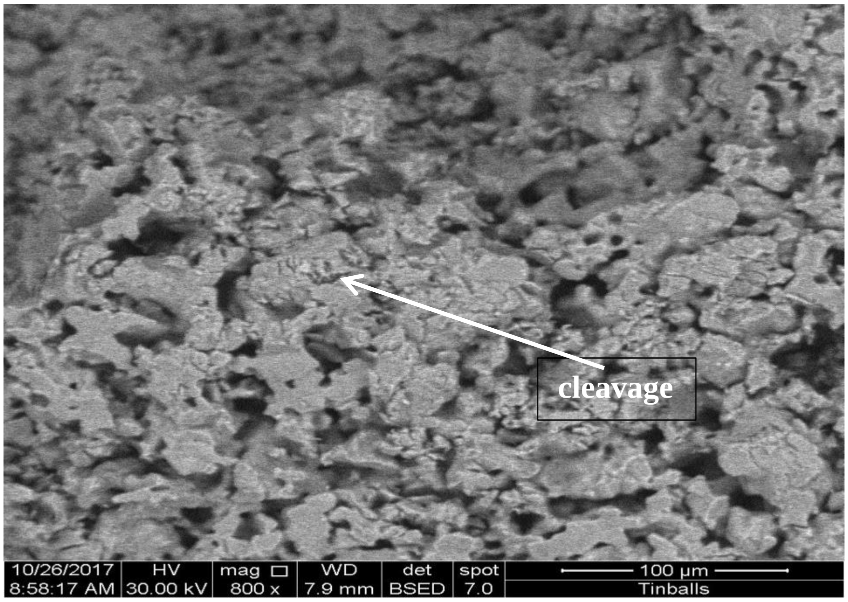

Figure 8. SEM images for sample after shear test at 800.

3.5. Shear Strength

The brazed sample shear test was accomplished at room temperature using the universal tensile test, with crosshead speed of 1mm/min. The results of the experiments show that shear strength is 29 MPa as shown in Figure 6. The sheared area was observed using SEM under 800x magnification, the results shown in the Figure 7. Figure 8 shows the SEM images for sample after shear test.

Figure 8 shows SEM images for sample after shear test it is observed that shearing happened in the middle of brazing zone. It can be observed from XRD that the reaction layer mainly consists of Ni and Ti. Thus we can propose that the significance of Ti content in brazing filler alloy effects of the shear strength. From the EDX, elements of Inconel 738 diffused and reacted with filler elements such as Ni Cr and Fe, so the bonding affected zone increase and Ni-Ti rich-phase condensed. Ni, Cr, and Co had a higher affinity to Ti contained within the brazing filler results to creation of the reaction layer crossing the center of brazing area this deal with Tuan Zaharinie and Frarazila Yousof results [2].

4. CONCLUSIONS

The filler alloy 28Ni72Ti represents a good wetting which can be observed from microstructure results, good metallurgical bond and continuous construction. The brazing time 15min was sufficient for the molten filler alloy 28Ni72Ti% to react with Inconel 738 at 985ºC and creating continuous bonding layer. XRD results exhibited that brazed joint involves of three region the base metal zone and the dominated phase is Ni3(Al,Ti) II-inter diffusion zone and the dominated phases are AlNi3, AlTi3 and Al 0.5C Ni3Ti 0.5 and III-bond zone and the dominated phase is Ni3Ti. Formation of the reaction layer which is crossed the center of the brazed area was affected by diffusion of some elements from Inconel 738LC with molten filler alloy 28Ni72Ti% during brazing process which significantly influenced the bonding strength of the brazing joint.

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