Research Article

Chracterization of Brazed Joints in Titaniumtostainless Steel Using (Ni-Cu-Ag_Pb) Composite Filler .

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Abstract:
Diffusion brazing was performed between Stainless Steel (304L)and pure titaium using a filler alloy (Ni-Cu-Ag-Pb) system at temerature range of (750,850,950,1050)°C for 30 minutes with a vaccum furnace of 10^{-3} pa technique. The results show that the diffusion brazing temperature is a critical Factor controlling the microstructure of specimens. The microstructure was investigated using light microscop and scanning electron microscope equipped with an energy dispersive X- ray system(EDX). The best results of microstructure investigation was a chived for joint brazed at 950°C for 30 minutes.Above this temperature at 1050°C showed that the craks propagates noticeably wih increased temperature. The joint Sections analyzed by using SEM and Edx to observe the produced phases. The major phases of brazed joints using filler alloy gives (α –Ni) (Ni-Cu)and (Ni-Cu-Ag)Phases

Keywords: Stainless steel ,Titanium ,Intermetallic ,Diffusion brazin ,Microstructure properties

Introduction :

Titanium is alightweight metal with the highest strength to weight ratio of any metal and un excellent corrosion resistance [1,2].The extensive use of titanium and its alloys in various sectors such as nuclear industry ,aeropace transportation and power generation ,requires them to be joinied to other materials for fabrication of different compoinets [3,4]. The strong Ti -Stainless Steel welding is so difficult due to the very low solubility of iron in alph titanium at room temperature [4].

This Ti –St. St joints work has been limited due to lack of metallurgical compatibility that leads to the formation of brittle intermetallic compounds between these materials.[5]. Areview of the literature revealts that the existing methods of joining Ti and its alloys to St.St include fusion welding laser joining and explosion welding have not been a good choice ,since it needs to be performed in inert atmosphere due to the reactive nature of Ti and the signifacantdifferance in physico-chemical propertips of the material [6].

Against this background ,the present article reports ,we Round a vacuum brazing technique is successful joint method between Ti to St.St by using anew prepared filler brazing alloy type (Ni-Cu-Ag-pb) system.

Experimental procedure:

The base materials used in the experiments were plates of stainless steel (304L) and pure titanium .The nominal compositions of these materials are given in Table (1). High purity powdered metals of Ni (60wt%)Cu (30wt%),Ag (5wt%) and pb(5wt%) were used to prepare the filler alloy ,through compacting the mixed powders and alloying them in a vacuum furance with Nitrogen atmosphere of 850°C for 15minuts. This filler alloy was in between butt plate of Ti-St.St as an sandwich form .Asteel fixture was used to hold the assembly in middle of vacuum tube furnace type(SAFTherm). The suitableoperated vacuum condition of 10^{-3} pa with the brazing temperature of 950°C for 30 minut used to achieve the joining process. All joint specimens were cleaned ultrasonically in acetone and dried rapidlly in air. The brazed samples were cut and polished to exam the microstuctuies occurred after brazing diffusion process using alight microscope (optikeMicRoscop ES ITALY)**.** A scanning electrone microscope (SEM) type (JEOL.JMS_540L)used to obtain finer structure details .the energy dispersive X-ray spectrometer EDX. attached to the (SEM) to analyze the real and impurity elements occure after brazing diffusion.

Shimadzu Powder X-ray diffrastion (XRD) Patterns were recorded operating with Cụ kα radiation (40 KV,45mA λ=1.542 Å) for phase and Structure analysis of brazing filler alloys.

Results and Disscssion :

Table (1) chemical composition of the base materials used with brazing filler alloy used.

Materials	Chemical Composition Wt%
Pure Titanium (Grad 2) St.st (304L) Brazing Filler Metals	Ti: 99.70, Fe: 0.17 , C: 0.03 C: 0.02 , Mn : 1.5 , Si : 0.52 , Ni: 10.5, Cr: 19.1 , Fe : Rem Ni:60 , Cu: 30 , Ag:5 , Pb:5

Brazing Filler Types	Chemical Composition Wt%
F1	Ni:70 , Cu:10 , Ag :10 , Pb :10
F2	Ni:50 , Cu:20 , Ag:20 , Pb: 10
F3	Ni: 60 , Cu:30, Ag:5 , Pb:5
F4	Ni:65 , Cu:25 , Ag:10 , Pb: 0

Four diffrent filler alloys used to Join brazing of St. St (304L) to pure Ti metals as shown in Table(2). The results of brazing fouund that the filler alley type No (F3) is ideal alloy with Nickell 60% and Copper 30% to maintain the superiar bonding strength in this study.

Table (2): The Filler Compositions used in the joints brazing St.St (304L) Ti at 950°C For 30min.
The resalts also reported that interface rises with the increasing in temperature of 950 °C /30 min by using this filler alloy no (F3) under vacuum furnace as shown In Figure (1). The results show that the Vacuum level used for our brazing process in the range of 10^{-3} - 10^{-5} Pa with nitrogen atomspheres is enough to reduce the formation of surface oxides during brazing experimentts [6].
The microstructure of diffusion brazed jonts revealed by the light microscope are shown in Figure 2 (a – b). The results Show that diffuson interface with mutual dissolution of filler metals in awave form are clearlY visible. This may be explained by the solubility of filler elements in St. St (304L- Ti) substrates as shown in Figure (2a); for brazing temperature at 950 °C /30 min [7]. Also this Figure (2 a) adark Points werreabserved in the braze joint , this may refer to the formation due to the bonding mechanism by active filler metals used [7].

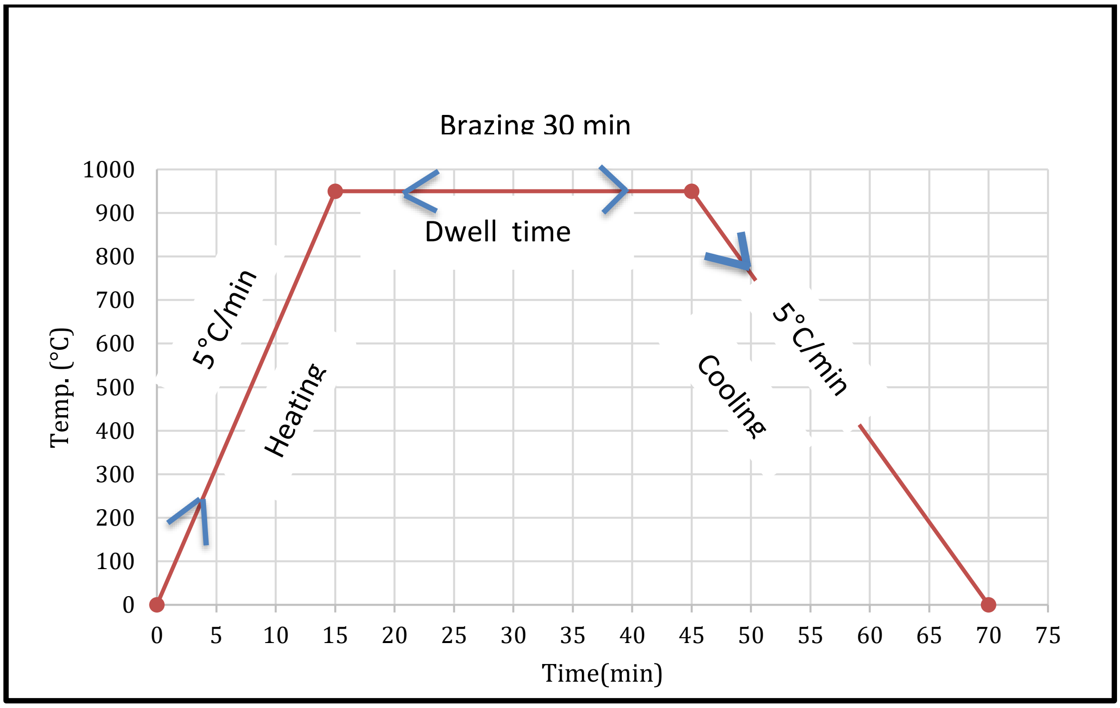

Figure (1): Tlime - Temperature plot showing the brazing St.St to Ti using filler alloy(Ni – Cu – Ag – Pb)system

At brazing temperature 1050°c / 30 min Figure (2b), shows a distinet layer separated from the St.St-Ti substrates due to the weak bonding strength including som cracks with bores [8], which means that the brazing temperature at 1050°c /30 min is not Suitable for brazwng layer [9].

The Scancanning. Electron Microscopy (SEM) investigation of the joints was Perfermed in order to reveal more details in the reaction layers of the joint SEM images of the diffusion brazed joints shown in Figure 3 (a-b). Figure 3 (a) is braze joning conditions optained at 950 °C/ 30 min , that Produced successfully weld brazingbonded between the dissimllar joints of St-St (304L) to Ti, giving well pressed to the Nickel base filler metals. No Craks and voids were observed on the interface between the brazed materials. Above 950 °C at 1050 °C brazing temperature , at the Same time of brazing, the craks and surface defects appear noticeably with in creased temperature.

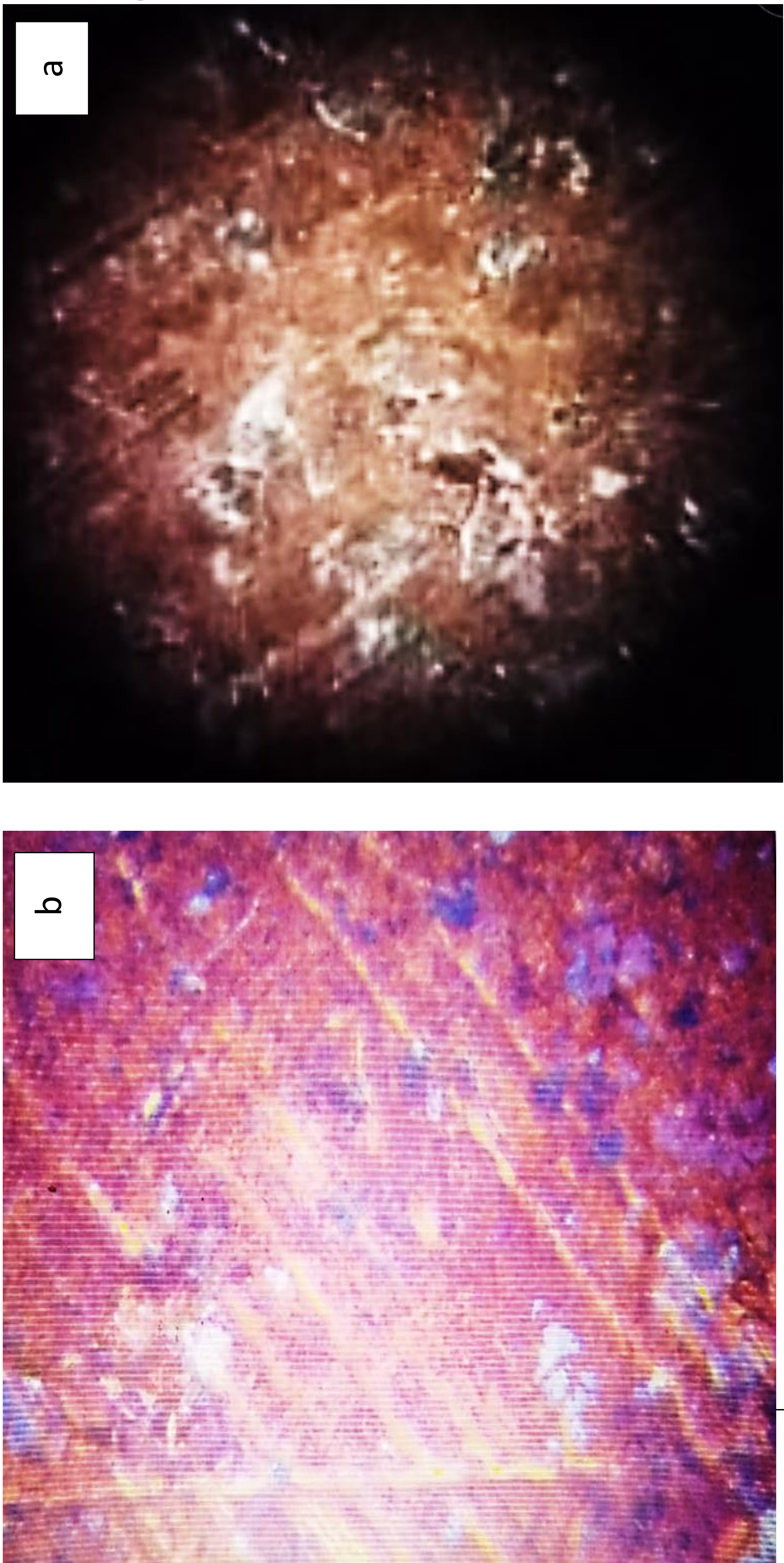

Figure 2: Light microscope microstructure of brazing filler (X=1000) at:

1. 950 °C/30 min
2. 1050 °C/30 min

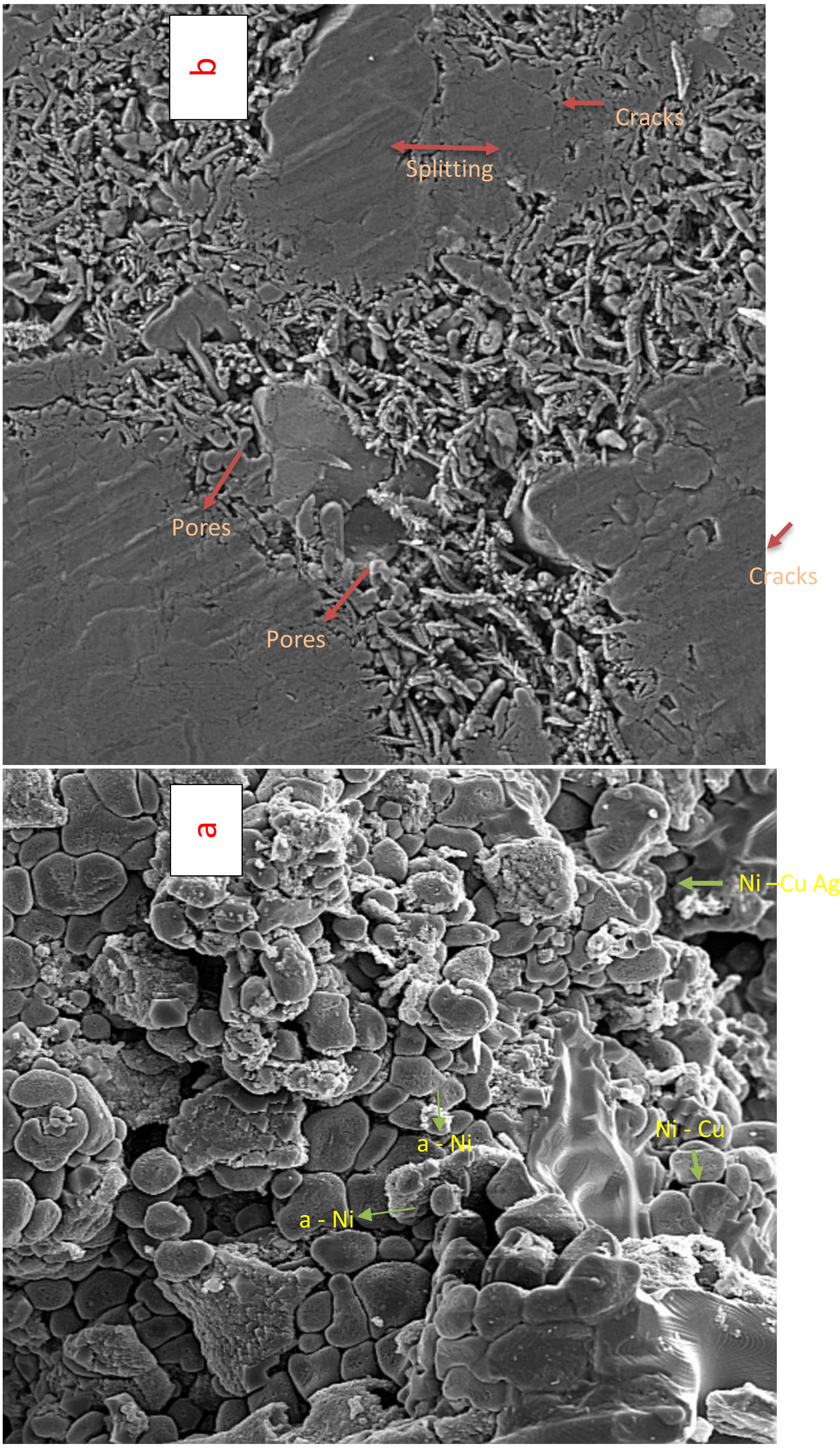

Figure 3– SEM results of brazing temperature at:

1. 950°C /30 min
2. 1050 °C /30 min

This is probably due to the presence of the brittle intermetallic phases as shown in Figure 3(b). [10]. This high temperature actually melted all metals of braze alleY, leading themto the liquid phase diffusion due to their high solubility whish are rejected joing with pothSt.St (304L) to Ti substrates [11]. Additionally Some studies explain the Craks originated from slip occurs a long Some structural directions over a certain temperatures [11,12]. The X- ray diffraction(XRD) results of atypical region of the brazing alloy filler (Ni-Cu-Ag- Pb) used at brazing temperature of 950°C is shown in Figure (4a-b) and Table(3).

The various elements and phaseswere confirmed clearly in figure (4a). The onalysis results showed that the rich Cu Phase is almost bigger than other quantities without any oxide, metal Phase. This is' probably due acopper (Cu) is a good binary phasease with α-Ni as (Ni- Cu) phase [13] . No trace of any other eiement impurity noticed as shown in Table (3). Figure 4 (b) and Table (4) are analysis results confirmed for XRD at brazing temperature of 1050°C/30min Variousmetal oxides observed in the brazing process.

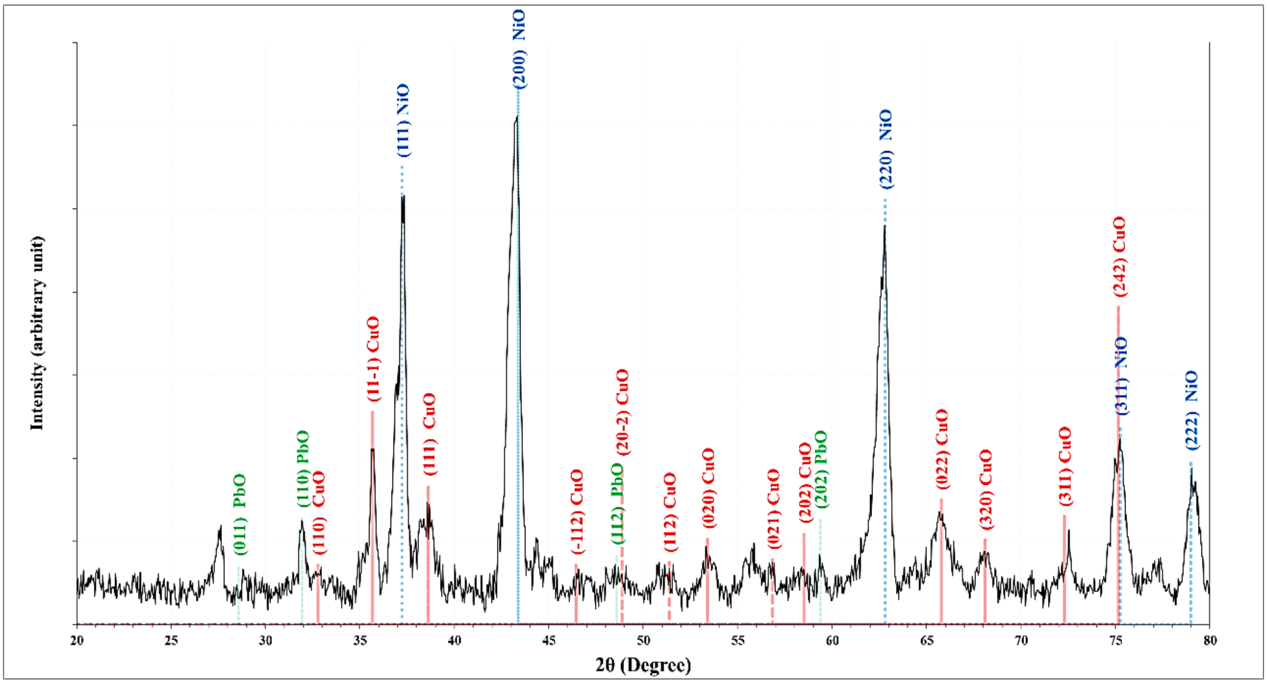

Figure 4 (a) : The XRD results for brazed (Ni – Cu – Ag – Pb) alloy at 950 ℃ /30 min

This results actuality are identical with SEM examination of the braze alloy layer Figure 3 (b), which shows that no enough intermetallis bond to form the boundaries of joined materials due tocracks and the pores and full of surface oxides [14] .

Table (3): Shows all various elements and intermetallic phases for brazed (Ni – Cu – Ag – Pb) at 950℃/30 min

2θ (Deg.)	FWHM (Deg.)	dhkl Exp. (Å)	C.S (nm)	Phase	hkl	card No.
31.5065	0.1661	2.8373	49.7	Pb	(111)	96-901-3419
36.5836	0.2847	2.4543	29.4	Pb	(200)	96-901-3419
38.3155	0.2136	2.3473	39.4	Ag	(111)	96-901-2962
43.5350	0.2372	2.0772	36.1	Cu	(111)	96-901-2955
44.2230	0.2136	2.0464	40.1	Ag	(111)	96-901-2962
50.6287	0.2847	1.8015	30.9	Cu	(200)	96-901-2955
51.5065	0.2610	1.7729	33.8	Ni	(200)	96-901-3028
62.3725	0.4270	1.4876	21.7	Pb	(311)	96-901-3419
64.6738	0.4507	1.4401	20.9	Ag	(220)	96-901-2962
74.2823	0.3796	1.2758	26.3	Cu	(220)	96-901-2955
75.6821	0.3796	1.2556	26.5	Ni	(220)	96-901-3028
77.5801	0.3558	1.2296	28.6	Ag	(311)	96-901-2962

2θ (Degree)

Figure 4 (b) : The XRD results for brazed (Ni – Cu – Ag – Pb) alloyat 1050 ℃ /30 min

2θ (Deg.)	FWHM (Deg.)	dhkl Exp. (Å)	C.S (nm)	Phase	hkl	card No.
28.8134	0.4499	3.0960	18.2	PbO	(011)	96-101-0978
31.9100	0.3440	2.8023	24.0	PbO	(110)	96-101-0978
32.7834	0.4234	2.7296	19.6	CuO	(110)	96-101-1195
35.6683	0.3441	2.5152	24.3	CuO	(11-1)	96-101-1195
37.2298	0.5822	2.4132	14.4	NiO	(111)	96-432-0491
38.6590	0.7410	2.3272	11.4	CuO	(111)	96-101-1195
43.3172	0.6882	2.0871	12.4	NiO	(200)	96-432-0491
46.5726	0.4499	1.9485	19.2	CuO	(-112)	96-101-1195
48.5046	0.7411	1.8753	11.8	PbO	(112)	96-101-0978
51.2836	0.7146	1.7800	12.3	CuO	(112)	96-101-1195
53.3745	0.7411	1.7151	12.0	CuO	(020)	96-101-1195
56.7093	0.4235	1.6219	21.3	CuO	(021)	96-101-1195
58.3502	0.5822	1.5802	15.6	CuO	(202)	96-101-1195
59.3295	0.5558	1.5564	16.4	PbO	(202)	96-101-0978
62.7966	0.6617	1.4785	14.1	NiO	(220)	96-432-0491
65.7080	0.9792	1.4199	9.7	CuO	(022)	96-101-1195
68.0371	0.7146	1.3769	13.4	CuO	(320)	96-101-1195
72.5364	0.6087	1.3021	16.2	CuO	(311)	96-101-1195
75.2360	0.8734	1.2620	11.5	CuO	(242)	96-101-1195
79.1001	0.8470	1.2097	12.2	NiO	(222)	96-101-1195

Table (4) : Shows all various metal oxides phases for brazed (Ni – Cu – Ag – Pb) at 1050℃/30 min

AlsochemicalCompositions of filler brazing alloy Confirmed by EDX Spectroscopy analySis as shown in Figure (5) and Table (5).This results identified quantification around of 60.1% Ni, 30.05% Cu, 5.050% Ag and 4.79 % Pb without any trace of impurities. Various phases consisting α –Ni, Ni-Cu, and (Ni-Cu- Ag) are observed [15]. No trace of any α-Fe or α-Ti phase was noticed.

Element	Ni	Cu	Ag	Pb	O	Total Wt%	Possible phaso	Referens
Area 1	60.17	29.85	4.99	5.09	-	99.60	α-Ni Ni- Cu	[16]
Area 2	60.11	30.05	5.05	4.79	-	100	Ni- Cu – Ag - αNi	[17]

Table (5): Quantitative filler netalusi EDX in SEM

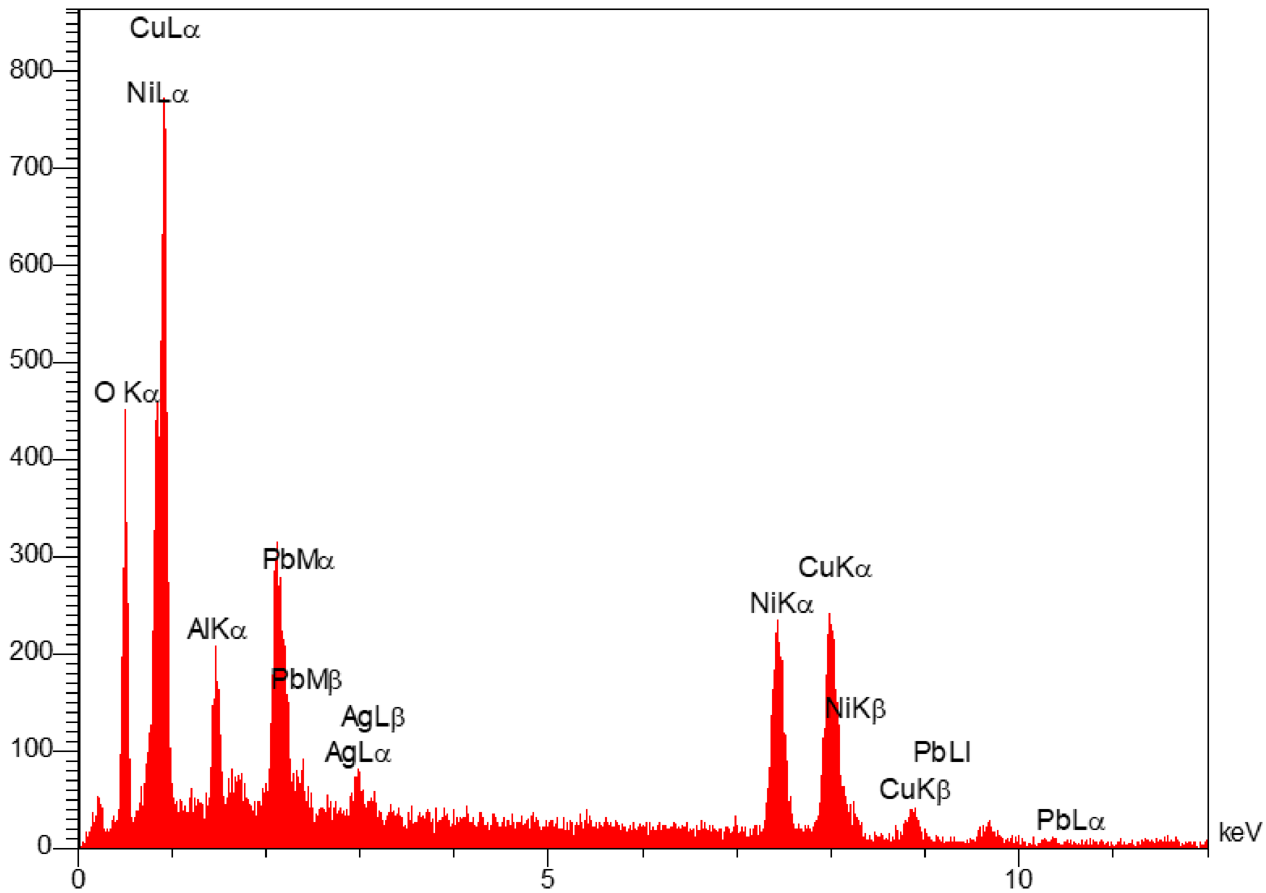

Figure (5) : EDX spectra of the brazed joint Prcessed at 950°C/30 min measured using SEM .

Conclusion:

Butt brazing of St-St (304L) with Pure Titanium plates are successfully welding by using vacuum brazing join process with Nickel base filler metal allay (Ni- Cu - Ag-Pb) system have been Performed.

The following Conclusions Can be drawn:

1- Themicrostructureproperties (SEM,EdX, X-ray) of the joint was investigated at different brazing temperature (750,850 ,950, 1050) °C /30 min.

2- The results show that the, bestbraze Joining conditions at 950°C/30 min improve the microstructure and joint strength .

3- Morpholog of the specimens were examined by SEM, Optical microscopy and X-ray investigate the phases present at 950 °C and 1050 °C. Successively Several solid phases observed refer to the solubility between the filler elements.

4- The results show ,when the brazing temperature reach to 1050°C/30 min Causes softening, craks and some pores, leading to decrease in the strong bonding.

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