FRICTION STIR WELDING DISSIMILAR METALS BETWEEN PURE COPPER AND STAINLESS STEEL 316L (SS316L)

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Abstract
As a solid-state welding technology, friction stir welding (FSW) can join dissimilar materials with good mechanical properties. In this paper, friction stir welding between 304L stainless steel and commercially pure copper plates with thicknesses of 3 mm was performed. A number of FSW experiments were carried out to obtain the optimum mechanical properties by adjusting the rotational speed to 1000 rpm and welding speed in the range of 14-112 mm/min and with an adjustable offset of the pin location with respect to the butt line. Microstructural analyses have been done to check the weld quality. Cross-sectioning of the welds for metallographic analysis in planes perpendicular to the welding direction and parallel to the weld crown was also performed. The mechanical properties of the welds were determined using a combination of conventional microhardness and tensile testing. From this investigation it is found that the offset of the pin is an essential factor in producing defect free welds in friction stir welding of copperandsteel

I. Introduction

Welding is a joining procedure or sculptural process that joins materials, for the most part metals thermoplastics, by changing atoms into two materials. This is regularly done by warming the work pieces to an appropriate temperature and adding a filler material to shape a pool of liquid material (the weld pool) and subsequent to cooling solid bond happens. The procedure can be performed by applying heat or mechanical power, to deliver the weld. In any case, if there should arise an occurrence of binding and brazing, materials are warmed to a lower temperature to frame a bond between them, without softening the work pieces

A portion of the best known welding techniques include:

• "Shielded metal curve welding (SMAW) - otherwise called "stick welding", utilizes a cathode that has transition, around it. The terminal holder holds the anode as it gradually dissolves away. Slag shields the weld puddle from the outside space".

• Gas tungsten curve welding (GTAW) - otherwise called "TIG" (tungsten, dormant gas), which utilizes a non-consumable tungsten terminal to join two metals in weld. The softened range is shielded from climatic response by a dormant protecting gas, for example, "Argon or Helium".

• Gas metal curve welding (GMAW) - usually named as "MIG (metal, inactive gas"), utilizes a firearm through which wire is sustained at a flexible speed and splashes an "argon" based protecting gas or a blend of argon and carbon dioxide (CO_2) over the weld puddle to shield it from the outside world.

- "Flux-cored circular segment welding" (FCAW) – in this procedure a wire as tube which is loaded with transition is considere join the two work pieces; this should likewise be possible without protecting gas or within the sight of gas, contingent upon the filler.
- "Submerged circular segment welding" (SAW) – Flux gives as a layer of cover for ensuring the weld range.
- "Electroslag welding" (ESW) – It is a solitary pass welding utilized for work bits of sizes from 25.4 mm to 300mm in vertical position

A wide range of vitality sources can be utilized for welding, including a gas fire, an electric circular segment, a laser, an electron pillar, grating, and ultrasound. In enterprises welding was done under climatic conditions which incorporates air or submerged and so on Welding is a conceivably risky endeavor and safeguards are required to stay away from consumes, electric stun, vision harm, inward breath of noxious gasses and vapor, and introduction to extraordinary bright radiation.

II. Literature Review

1 A. Aghaei, K. Dehghan assessed the impacts turning and cross speeds on the microstructure and mechanical properties of Monel400 and stainless steel 316 joined by contact mix welding. Sound welds were gotten at the pivoting pace of 400 rpm with the welding rates of 50 to 100 mm/min, while a depression like deformity was framed when the cross speed surpassed 150 mm/min.

2. Athos Henrique Plaine and Nelson Guedes de Alcântara assessed the Joints which were created utilizing two devices and four mixes of particular parameters. The outcomes indicated intelligence between the pivotal power profiles and the low-amplification diagrams of the welded joints .

3. Basil Thomas and Cijo Mathew tested by joining two Al plates with various device materials, for example, SS304, SS316 and MS. They considered the microstructure of the welded joint and furthermore the mechanical properties, for example, elasticity, affect quality and tackle of the joints are inspected. SS316 gives high hardness, affect esteem and Tensile quality contrasted with other apparatus materials.

4. Faizal P Mȧ and Justin. Examined aluminum amalgam 6061 joint made by grinding mix welding; the instrument materials utilized were SS 304, SS 316 and MS. Elasticity of the delivered joints were tried and microstructures of weld zone of Friction blend welds were broke down utilizing checking electron magnifying instrument.

5. Yousef Imani, Mohammad Kazem Besharati Givi and Michel Guillot examined the rubbing blend welding between 304L stainless steel and monetarily unadulterated copper plates with thicknesses of 3 mm was performed. Various FSW tests were completed to get the ideal mechanical properties by altering the rotational speed to 1000 rpm.

III EXPERIMENT AND METHODOLOGY

4.1 Selection Of Material

SS316L and Pure copper are chosen for remarkable execution in outrageous conditions. Both are disparate materials having distinctive physical properties, for example, warm conductivity. Joining of these two materials is extremely troublesome and faces the test in getting the reasonable properties of the acquired joint. The physical properties and substance creation of materials are appeared in Table

4.1, Table 4.2, Table 4.3 and Table 4.4 separately

Table 4.1 Typical physical properties for 316L review stainless steels.

Grade	Density (kg/m^3)	Elastic Modulus (GPa)	Mean Co-eff of Thermal Expansion (µm/m/°C)			Thermal Conductivity (W/m.K)		Specific Heat 0-100°C (J/kg.K)	Elec Resistivity (nΩ.m)
			0-100°C	0-315°C	0-538°C	At 100°C	At 500°C		
316/L/H	8000	193	15.9	16.2	17.5	16.3	21.5	500	740

Table 4.2 Typical physical properties for Pure copper

Melting point	**1084.62°C, 1984.32°F, 1357.77 K**
Boiling point	**2560°C, 4640°F, 2833 K**
Density (g cm^{-3})	**8.96**
Relative atomic mass	**63.546**
Key isotopes	**^{63}Cu**

Table 4.3 Chemical Composition of 316L review stainless steels.

Elements	C	Cr	Mo	Ni	P	Mn	S	Si
Composition	0.03	17.55	3.1	13.65	≤ 0.040	1.2	≤0.03	0.8
Filler Rod	0.03	17	3.0	12	≤ 0.03	1.2	≤0.03	0.65

Table 4.4 Chemical Composition of Pure Copper

Elements	Copper %	Other elements %
Composition	99.98	0.02

4.2 Design Of Tool

Instrument (Non-consumable): High speed steel

Apparatus measurements:

The non-consumable apparatus has a round segment with the exception of toward the end where there is a strung test or more entangled woodwind; the intersection between the tube shaped bit and the test is known as the shoulder. The test enters the work piece while the shoulder rubs with the best surface. The instrument has an end tap of 5mm measurement and a stature of 5mm the welding course. The plan of the stick and shoulder gathering assumes a noteworthy part on how the material moves amid the procedure.

Fig 4.1 Tool and apparatus tip

Table 4.5 Tool details

Parameter	**Length(mm)**
Total tool length	40
Tool diameter	20
Shoulder length	10
Shoulder diameter	18
Pin length	2.6

Pin diameter	5

Table 4.2: Tool particulars

4.3 Sample Preparation

Moved plates of 3mm in thickness were cut into the required size (150mm×75×3mm) by shearing machine. The tests were directed on the two arrangements of Pure copper and SS316L. in one case the weld was done precisely along the middle line of the butt joint of ss and copper plates and in other joint the welding was finished by taking the balance remove by 2mm towards the copper material which was taken because of the distinction between warm conductivities of copper and stainless steel. Prior to the grinding mix welding, the weld surface of the base material was cleaned. Plate edges to be weld were additionally arranged so they are completely parallel to each other. This is guarantee that there is no uneven hole between the plates which may not bring about sound welding. Besides surface readiness was likewise done as such that the surfaces of both the plates are of equivalent level and balance.

Fig 4.2 FSW Tool

4.3 Setup Of Milling Machine

In this undertaking for leading the examinations on unique materials, vertical processing machine was chosen with the accompanying particulars

Fig 4.3 Vertical Milling Machine

4.4 Experimental Work

Two plates of SS316L and Pure copper are brought with 150x75 mm measurements with 3mm thickness and cleaned before settling to the back plates as appeared in figure 4.4. in the wake of cleaning they were settled to the bed of vertical processing machine. The parameters chose as appeared in table 4.6

Table 4.6 Process Parameters

Axial Force	Speed (rpm)	Travel Speed (mm/min)	Tilt angle
5000N	1120	20	1degree

Examinations were performed in two ways. One is the device moves along the inside line of the butt joint as appeared in figure 4.4.Joint was shaped between two unique metals by applying a hub power of 5000N, with a rotational speed of 1120 rpm when the apparatus crosses at speed of 20mm for each min. the tilt edge was additionally used to get great contact between the surfaces of the instrument and work pieces

Fig.4.4 Joining of SS316L and Pure copper along the middle line

Second way is that the instrument made counterbalance by 2mm separation from the middle line of butt joint towards the copper material. With same parametric esteems, the trial was executed

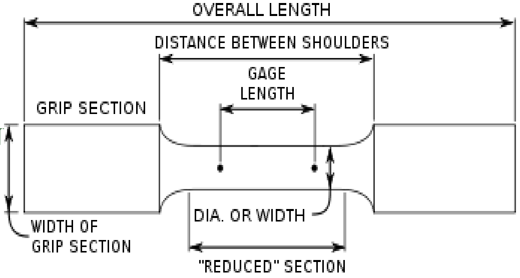
IV RESULTS AND DISCUSSION

5.1 Tensile test

Rigidity is the greatest anxiety where a material can withstand while being extended or pulled before necking, which is the point at which the example cross area begins to fundamentally contract. It is an exceptional property. It doesn't rely upon the measure of the test example. Likely it relies on the planning of the example, surface deformities, temperature of the test condition and material. Aside from this we are discovering effectiveness of grinding blend welded joints.

Fig 5.1 Drawing of elastic example

The examples are arranged independently to the norms, one for butt joint when two plates joined will be joined by rubbing mix welding when device moves along the inside line by wire cutting strategy as appeared in figure 5.2. furthermore, second



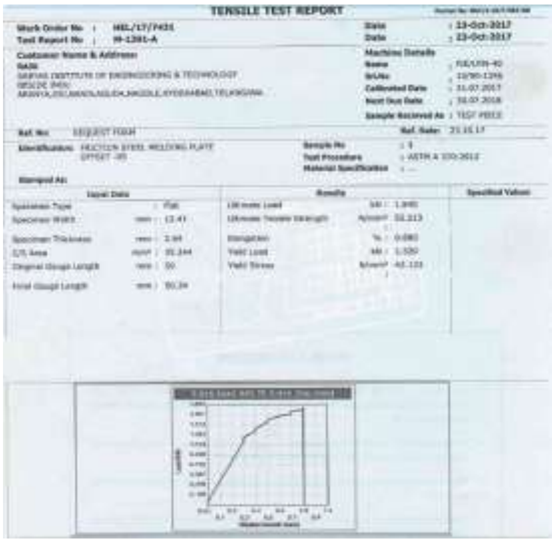
one for butt joint when two plates joined will be joined by rubbing mix welding when apparatus moves at counterbalance remove from focus line of weld as appeared in fig 5.3

Fig 5.2 Specimen of butt joint when two plates joined will be joined by rubbing mix welding when apparatus moves along the middle linefor Tensile Test

Fig 5.3 Specimen of butt joint when two plates joined will be joined by grating blend welding when instrument moves at off set separation from the inside line

OUTPUT DATA

Load at Yield : 5.07kN
Prolongation at Yield : 3.280mm
Yield stress : 98.848N/mm2
Load at peak : 6.00kN
CHT at peak : 4.00 mm
Malleable strength : 128.678N/mm2
Load at peak : 3.990kN
Stretching at Break : 3.9890 mm
%Elongation : 4.52%


TENSILE TEST REPORT

5.2 Micro basic examination: The principal endeavor at characterizing microstructures was made by P L Thread gill (Bulletin, walk 1997). This work was construct exclusively with respect to data accessible from aluminum amalgams. Nonetheless, it has turned out to be apparent from take a shot at different materials that the conduct of aluminum composites isn't run of the mill of most metallic materials, and hence the plan can't be widened to envelop all materials. It is subsequently recommended that the accompanying reconsidered conspire is utilized. The framework partitions the weldzoneintoparticular locales as takes after:

Unaffected material or parent metal: This is material remote from the weld, which has not been disfigured, and which in spite of the fact that it might have encountered a warm cycle from the weld isn't influenced by the warmth as far as smaller scale structure or mechanical properties.

Warmth influenced zone (HAZ): In this area, which will lie nearer to the weld focus, the material has encountered a warm cycle, which has adjusted, the microstructure as well as the mechanical properties. Be that as it may, there is no plastic twisting happening around there. In the past framework, this war alluded to as the "thermally influenced zone". The term warm influenced zone is presently favored, as this is an immediate parallel with the warmth influenced zone in other warm procedures, and there is little defense for a different name.

Thermo-Mechanically influenced zone (TMAZ): In this locale, the material has been plastically distorted by the grinding blend welding instrument, and the warmth from the procedure will likewise have applied some impact on the material.

Weld piece: The recrystallised territory in the TMAZ in aluminum composites has customarily been known as the chunk. Despite the fact that this term is illustrative, it isn't exceptionally logical. Notwithstanding, its utilization has turned out to be across the board, and as there is no word which is similarly basic with more noteworthy logical legitimacy, this term has been received. A schematic outline is appeared in the above figure which plainly recognizes the different areas. It has been recommended that the region instantly beneath the apparatus bear (which is plainly part of the TMAZ) ought to be given a different class, as the grain structure is regularly unique here. The microstructure here is dictated by rubbing by the back face of the shoulder, and the material may have cooled beneath its most extreme. It is recommended that this range is dealt with as a different sub-zone of the TMAZ.

CONCLUSIONS

The accompanying are the conclusions from the trials directed on two disparate materials which were joined by rubbing mix welding process

1. Joint with balance separate gives the Higher estimation of rigidity contrasted with joint when apparatus moved along focus line
2. The intermolecular structure was fine in specimen with balance separate
3. The hardness was observed to be High if there should be an occurrence of the joint because of the best possible warming of the materials because of erosion

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