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FSW of Contradictory Ingredients among Alloy Mixtures and Copper

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Abstract— Friction Stir Welding (FSW) is a compact national Welding procedure used for Welding like and unlike materials. The procedure is widely used because it produces wide-ranging joins and does not have common problems such as solidification and liquefact cracking associated with the fusion Welding techniques. The FSW of ALUMINIUM and its compounds has been commercialized; and new interest is concentrated on linking unlike materials. However, In order to commercialize the process, investigation educations are required to characterize and establish procedure windows. In particular, FSW has inspired investigators to attempt linking unlike materials such as ALUMINIUM to COPPER which differ In things and wide-ranging joins with none or limited intermetallic mixtures has been produced. In This paper, we review the present investigation national of FSW among ALUMINIUM and COPPER with a focus on the resultant combined microstructure, machine-driven challenging and the utensils hired to harvest the joins and also an insight into upcoming investigation in this field of study.

Keywords— Aluminium, Copper, Unlike Materials, Intermetallic Compounds, Microstructure.

I. INTRODUCTION

Now a day, investigators have been focvia on rising fast and recyclable processes. In manufacturing and this include Friction Stir Welding (FSW) and Handling (FSP). Friction Stir Welding (FSW) is a solid–national linking method invented and patented by The Welding Institute (TWI) in 1991 for butt and lap welding of ferrous and non–ferrous metals and plastics. FSW is a nonstop procedure that involves plunging a share of a specially shaped circling tool among the butting faces of the joint. The relative motion among the tool and the substrate gene charges Frictional hotness that creates a plasticized part around the immersed share of the tool.

Friction Stir Welding procedure uses a non-consumable circling tool containing of a pin extending belittle a carry that is forced into the adjacent mating edges of the effort bits as demonstrated in Fig. 1. The hotness input, the forging act and the Stirring act of the tool induces an elastic flow in the material, forming a solid state weld.

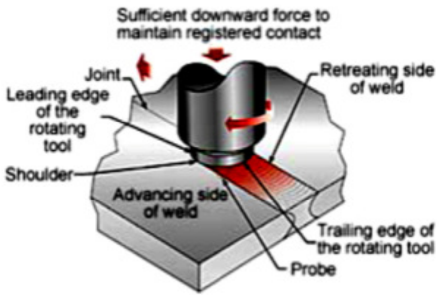

Fig.1. Schematic diagram of the Friction Stir Welding procedure

It was realized in the growth of the FSW procedure that the tool plan is critical in making wide-ranging joins. A basic and unoriginal plan for a FSW tool is shown In Fig. 2 which consists of a threaded pin and a curved in shoulder. FSW utensils follittle the same basic trends In terms of their figures and geometries. They are normally comprised of three generic features including a shoulder, a probe also known as a pin and external features on the probe.

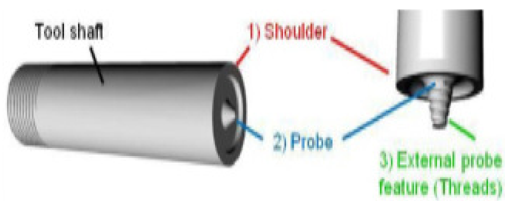

Fig.2. a Schematic view of FSW tool (Timothy)

FSW links usually consist of changed areas as demonstrated in Fig. 3 following the terminologies used by thread gill which include; the un Pretentious material or parent metal, the Heat-Pretentious part (HAZ), the Thermo mechanically Pretentious part (TMAZ) and the combined nugget.

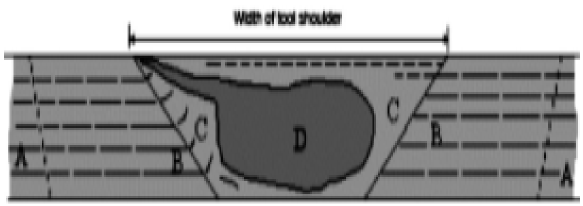

Fig.3. Illustration of changed microstructural areas in the transverse cross section of a Friction Stir joined material. A parent metal or UN Pretentious material; B, heat-Pretentious zone; C, thermo mechanically pretentious zone; D, combined bit.

The Unpretentious material or parent material is the material remote since the combined that has not been deformed. The Hotness Pretentious Part (HAZ) is the region, which lies closer to the weld-center; the material has experienced a thermal cycle that has modified the micro construction and/or the machine-driven properties. However, no elastic decreation occurs in this area. The Thermo Mechanically Pretentious Part (TMAZ) is the part in which the FSW tool has plastically designed the material, and the hotness since the procedure has also exerted some influence on the material. In the case of aluminum, It is probable to obtain significant elastic strain without recrystallization In This region; and there is normally A separate border among the recrystallized part (combined nugget) and the designed regions of the TMAZ; and the Combined bit is the completely recrystallized area, sometimes called the Stir Part (SZ) or Stir Bit (SN), It refers to the part before occupied by the tool pin.

Prior to the growth of FSW, unoriginal fusion Welding processes were used to join like and unlike materials. Friction Stir Welding of unlike materials remains not completely researched. Friction Stir Welding of unlike materials such as ALUMINIUM to COPPER In specific need to be completely understood due to their changed melting temperatures. The tall substance affinity of together base materials promotes the creation of tough intermetallic Al/Cu phases, which still require extensive investigation. Furthermore, ALUMINIUM and COPPER are problematic to combine with unoriginal Welding processes due to their tall reflectivity and thermal conductivity. Tough intermetallic stages develop in the combined part since COPPER and ALUMINIUM are not exact soluble in one an additional in the compact state. These intermetallic stages lesser the toughness of the combined and lead to cracks during and after the Welding.

Moreover, ALUMINIUM to COPPER Welding is increasingly used in some practical uses such as hotness transfer equipment's, wiring, electrical and electronics industries, and aesthetical applications. Furthermore, ALUMINIUM compounds are widely used to harvest aerospace constituents with tall specific strength. However, Di Paola et Al delivered that when traditional Welding processes are applied to these ALUMINIUM alloys, They often entail disadvantages that have sometimes discourage the use of joined components.

Many investigators have delivered reviews on Friction Stir Welding and handling focvia on the utensils hired, Friction Stir handling, unlike compounds and on ALUMINIUM compounds. To the best of our knowledge, no review focvia on Friction Stir Welding of ALUMINIUM to COPPER has been published. Therefore, this paper critically revised the existing delivered literature by focvia on the new effort done on Friction Stir Welding of ALUMINIUM COPPER alloys. The rest of the paper is concentrated on the resultant microstructural evolution, the machine-driven things characterization and the utensils hired to harvest the joins among ALUMINIUM and copper.

II. RELATED EDUCATIONS ON FRICTION STIR WELDING AMONG ALUMINIUM AND COPPER COMPOUNDS

A. *MICROSTRUCTURAL PROGRESS and X-RAY DIFFRACT ANALYSES*

The growth of laboratory effort on the Friction Stir Welding of unlike materials will distribute a respectable insight on their probable manufacturing application and therefore improve manufacturing development. Liu et Al observed though Welding COPPER (T2) to AA 5A06 that the delivery among the COPPER (Cu) and ALUMINIUM (Al) has an unmistakable border and the material in the stir part shows obvious elastic grouping of together materials. Furthermore, they observed visibly an onion ring construction in the stir part indicating respectable material flow. Additionally, they specified that the metal Cu and Al close to the COPPER side in the combined bit (WN) part showed a lamellar alternating construction typical. However, a varied construction typical of Cu and Al existed in the ALUMINIUM side of the combined bit (WN) zone. The stir act of the tool, Frictional hotness and hotness conductivity of Cu and Al could have induced the changed structures of together sides in the combined bit zone. The X-ray diffracts (XRD) analysis showed that there were no new Cu–Al intermetallic in the combined bit zone. Consequently, the construction of the combined bit part was largely elastic dissemination grouping of Cu and Al. However, Xue et Al effectively joined AA1060 and 99.9% clean commercial COPPER (annealed), they showed XRD analysis and their marks exposed the existence of separate typical diffract mountains of Al_2Cu and Al_4Cu_9. Hence, they specified that the Al_2Cu and Al_4Cu_9 were made around the larger Cu particles, and for the smaller Cu elements extreme of the COPPER were trans designed into these two intermetallic (imcs). However, the microstructures of the bit part contained of a mixture of the ALUMINIUM ground and Cu particles. The delivery of the Cu elements with unequal figures and many dimensions was inhomogeneous in the bit part and a particles-rich part (PRZ) was designed near the end of the combined. Furthermore, they examined the attendance of the elements In the ALUMINIUM ground of the bit part and qualified that to the stirring act of the tool pin that worn out the Cu bits since the bulk copper, breaking up and scattering them during the FSW procedure.

AA5083 and commercially clean COPPER were combined via FSW by Bisadi et Al. They observed that an exact little Welding high temperature led to some faults like channels that showed up at a part near the sheets line particularly in the Cu sheet. Also, extremely tall procedure high temperature leads to some cavities look at the line of the diffused ALUMINIUM elements and the COPPER sheet material. Additionally, they establish that growing the procedure high temperature reportedly leads to higher quantities of COPPER elements dissemination to the ALUMINIUM sheet, rise in the intermetallic compositions and a number of micro cracks were present.

On the additional hand, Xue et Al joined AA 1060 ALUMINIUM to commercially clean copper. They identified many faults in the bit part at the lesser cycle hurry of 400 rpm considered; whereas at higher cycle hurries of 800 and 1000 rpm, respectable metallurgical attachment among the Cu bits and Al ground was achieved. Furthermore, a large volume fault was observed when the soft Al platter was located at the proceeding side. They qualified that to the tough COPPER bulk material which was tough to vehicle to the proceeding side during FS Welding. Esmaeili et Al combined AA 1050 and 70%Cu–30% Zn brass, the marks showed that the construction of the wide-ranging combined at the bit part of ALUMINIUM is made up of a complex structure, containing of intermetallic and brass particles, commonly at the higher part of the combined cross section. Furthermore, a multilayer intermetallic multiple was designed at the line at turning hurries higher than 450 rpm. This layer is commonly composed of cuzn, cual2 and Cu9Al4. The distribution, shape and size of the elements are unequal and inhomogeneous in the bit part of ALUMINIUM .

Ouyang et Al also showed unlike fsjoins via AA 6061(T6) to copper. They verified that the direct FSW of AA 6061 to COPPER has been problematic due to the tough nature of the intermetallic mixtures designed in the combined nugget. Moreover, the Mechanically varied part In the unlike AA 6061 to COPPER combined contained commonly of several intermetallic mixtures such as cual2, cual, and Cu9Al4 together with small quantities of α-Al and a face centered cubic compact solution of Al in Cu .

Abdollah-Zadeh et Al Friction Stir joined AA 1060 to a commercially clean copper. They observed intermetallic mixtures of Al4Cu9, alcu and Al2Cu near the Al/Cu interface, where the crack can be started and propagated preferentially during the workable tests. They also observed that higher turning hurries enlarged the quantity of intermetallic mixtures designed at the ALUMINIUM / COPPER line though little turning hurry ensued in imperfect joints.

Saeid et Al specified that the line in the central part moved significantly into the end platter though linking 1060 ALUMINIUM multiple to commercially clean copper. The perpendicular vehicle of the line is qualified to the ring-vortex flittle of materials created by the tool pin threads . At higher Welding speeds, less perpendicular vehicle of the line was observed on the retreating side.

Akinlabi et Al investigated the micro construction of the combined line of AA 5754 and C11000 COPPER welds. The mingling of together materials was observed top to respectable metallurgical attachment at the combined interface. The ALUMINIUM rich part was black/silver though golden yellittle showed COPPER rich regions. Furthermore, Akinlabi, et Al observed a width discount in the combined line but respectable mingling was succeeded in the combined designed at a constant turning hurry of 600 rpm and feed charges of 50 and 150 mm/min. They qualified the discount in width at the combined interfacial areas to heavy showy observed during the Welding procedure. In addition, a respectable material mingling was succeeded in joins designed at lesser feed rate due to tall hotness made though the joins designed at tall feed charges ensued in worm hole fault creation. On the additional hand, Galvao, et Al observed that growing the hotness input, by performing joins under higher ω/v ratio, ensued in the creation of varied material regions with growing dimension and homogeneity. Furthermore, the morphology of the mingling regions and the type and quantity of the intermetallic phases, which they establish to result since a thermo mechanically induced compact national process, are also strongly dependent on the Welding parameters.

Galvao et Al Friction Stir joined oxygen free COPPER with tall phosphorous content (Cu-DHP, R240) and AA 5083-H111. They observed that the joins predesigned with the ALUMINIUM located at the proceeding side of the tool were morphologically exact irregular, being significantly thinner and exhibiting showy creation due to the expulsion of the ALUMINIUM since the combined area. Furthermore, the aluminum, which is expelled, gave rise to the showy showed for the joins predesigned with ALUMINIUM at the proceeding side. It was observed that when the ALUMINIUM platter is situated at the retreating side of the tool, the material was dragged by the carry to the proceeding side, where the harder COPPER platter is situated. In FSW of unlike metals, the pin offset is an exact main factor. Agarwal et Al combined AA 6063 and 99.9% clean commercially COPPER via FSW. They observed that as the pin offset is enlarged there is good mingling of the Al-Cu metals that ensued in the tunneling defect.

Singh et Al observed that there were changed micro construction features in the changed zones. At the combined center line, mix part of ALUMINIUM and COPPER were found. Small elements of ALUMINIUM and COPPER were distributed in the opposite side by the Stirring forces of the tool. The Thermo Mechanically Pretentious Part (TMAZ) is visibly obtained in COPPER

but it was not establish in aluminum. Thus, in together the metals, the Hotness Pretentious Part (HAZ) was not clear.
Ratnesh and pravin effectively combined AA 6061 and COPPER by FSW. They designed wide-ranging links by shifting the center line of the tool to the COPPER platter on the proceeding side. An attendance of a ‘‘changeover zone’’ was observed by Guerra et Al though Friction Stir Welding dense AA 6061 plates with a thin tall cleanliness COPPER foil. This changeover part was establish to be about twice as dense on the retreating side as it is on the proceeding side. They believed that the material in this part rotates, but its speed reductions since the turning speed of the pin at the inner edge of the changeover part to zero at its outer edge.

Xue et Al combined 1060 ALUMINIUM multiple and commercially clean COPPER with success through Friction Stir lap welds. They establish that the bit part contained of clean Al material and a complex construction in the higher and the lesser parts respectively. They establish that the Al/Cu line was branded by a thin, nonstop and uniform intermetallic layer, making a respectable line bonding. Furthermore, respectable metallurgical attachment was succeeded among the Al ground and the Cu elements in the complex construction due to the creation of a small number of intermetallic.
Akinlabi et Al observed that the combined interfaces are branded by varied coatings of ALUMINIUM and COPPER as unmistakable in the microstructures resultant since the hotness input into the joins by the Stirring act of the tool during the FSW process. Furthermore, they observed that the ratio decrease in the grain dimensions growths to the Stir regions of the welds.

LI et Al used clean COPPER and AA 1350 and effectively combined them through FSW with the pin offset technique. They establish that together COPPER and ALUMINIUM are greatly refined after FSW matched to the base materials. No intermetallic multiple was establish according to the XRD results. Esmaeili, et Al Friction Stir joined brass to AA 1050 at changed cycle speeds. At little cycle hurries and due to little stages of hotness inputs, no detectable intermetallic multiple was observed. As the cycle hurries increases, the gradual creation of intermetallic is started at the interface. Additionally, the rise in the turning hurry ensued in the thickening and growth of intermetallic layers.

Akinlabi showed XRD analysis on AA 5754 and C11000 FSW welds. It exposed the creation of intermetallic mixtures at the combined interfaces including Al_2Cu and Al_4Cu_9, though their concentrations in the joins were exact low.

Galvao et Al observed that the ALUMINIUM to COPPER unlike joins showed poor surface excellence and width discount commonly on those joins done with the ALUMINIUM in the proceeding side. The marks were matched to FSW of like materials joins which nevertheless showed respectable surface look with little showy and width discount. Avettand-Fenoe et Al observed Al_2Cu and c1-Al_4Cu_9 stages in the unlike AA 6082 (T6) to COPPER Friction Stir welds. Their creation is essentially governed by together the thermo machine-driven history and the local mingling of the substance species.
New investigation effort on the micro construction progress and XRD analyses has been reviewed. It can be summarized that In FSW of ALUMINIUM to copper; placing the COPPER platter which has a higher melting high temperature at the proceeding side yielded joins with respectable integrities. However, we noticed that extreme of the educations showed the attendance of intermetallic mixtures though Friction Stir Welding ALUMINIUM and copper, more analyses of these newly designed stages have to be showed In order to completely understand their impact in the elements. Optimization of the handling limits to reduce the creation of the intermetallic mixtures at the combined line also needs to be conducted.

B. MACHINE-DRIVEN CHARACTERIZATION

The information of the machine-driven things of the unlike Friction Stir joins among ALUMINIUM and COPPER is of significance to improve their use in the industries.

Investigation have establish that the extreme Final Workable Power succeeded in joins of ALUMINIUM and COPPER was about 296 MPA and It was obtained when the tool turning hurry is 950 rpm, and the travel hurry is 150 mm/min . Akinlabi also dignified the workable test via changed Welding parameters, the marks showed that the joins designed took combined efficiencies of among 73 and 86%, and can be acceptable for plan purposes.

Galvao et Al specified that the Welding condition, exactly the turning hurries and the traverse hurries that marks In obtaining joins with respectable surface look do not lead to the manufacture of wide-ranging unlike welds.

Furthermore, esmaeili et Al observed that the machine-driven behaviour of links is influenced as the turning hurry increases. They reported that the workable power of the combined designed growths due to the creation of a narrow interfacial intermetallic layer and a lamellar complex construction within the Stir zone. Then, the workable power reductions due to the dislike of complex construction and creation of faults In the Stir part. The width of the interfacial intermetallic multiple creation growths with a rise in the turning hurry which marks in the discount of the workable power of the joins designed.

Li et Al observed that the micro toughness standards dignified are higher At the COPPER side of the bit part than that At the ALUMINIUM side, This is expected as the UTS of COPPER is higher than that of the aluminum.

Additionally, they establish that the toughness at the end of the bit is normally higher than additional areas due to the Stirring act of the tool pin top to recrystallized grains. The UTS and the ratio elongation of the unlike links were 152 MPA and 6.3%, respectively, and the unlike links unsuccessful in A ductile-tough varied breakage mode.

Akinlabi and Akinlabi observed that there is an rise In the micro toughness standards At the combined interfaces of the joins resultant since strain hardening due to the Stirring of the tool pin and the carry before occupied by these areas during the Welding procedure though the tall mountains are due to the attendance of intermetallic mixtures resultant At the links interface.

However, Xue et Al verified that the FSW lap Al/Cu links unsuccessful In the HAZ of the Al side, and the workable trim load reached up to 2680 N when the Al platter was fixed on the proceeding side. The toughness enlarged visibly in the layered construction due to the strengthening effect of the Al/Cu intermetallic, which were commonly composed of Al4Cu9 stages.

The study showed by Xue et Al establish that the large workable specimen of the Al–Cu combined fractured At the HAZ of the Al side with A 13% elongation. The Final Workable Power (UTS) and the yield power were ~90% and ~80% of the Al base material respectively, and somewhat lesser than those of the Al base material due to annealing softening during the FSW procedure though the mini-specimen fractured At the particles-rich part (PRZ), and the UTS was about 210 MPA which was much higher than the Al BM.

Bisadi et Al establish that extreme toughness standards were dignified At the COPPER side of the combined at the combined SZ because of its fine grain size. In addition, although the grain size reductions, the toughness standards of the combined ALUMINIUM side SZ were significantly lesser than the ALUMINIUM base material which could be due to the manufacture of micro voids At This area.

Moreover, intermetallic mixtures were detected commonly at the tough breakage areas and all the final workable stresses decreased by growing the procedure high temperature. Poor workable things were succeeded at the exact large pin offsets and/or little cycle charges by Xue et Al which they suggested could be due to the insufficient react among the Cu bulk / bits and the Al matrix. Furthermore, respectable workable things were succeeded In the FSW Al–Cu links designed at higher cycle charges and good pin offsets of 2 and 2.5 mm due to sufficient react.

Marks since the effort of esmaeili et Al specified that the optimum final power of the wide-ranging combined was succeeded since A good material flittle and metallurgical attachment through A narrow intermetallic layer at the line in adding to crack detection by the occurrence of lamellar complex construction (onion rings) In the Stir part .

Ouyang et Al exactly establish that changed micro toughness stages ranging since 136 to 760 HV0.2 were designed in the combined bit corresponding too many microstructures, intermetallic and material little patterns.

Singh et Al establish that in the horizontal toughness profiles, the standards were establish to be about 110 HV and 106 HV for COPPER and for the ALUMINIUM base metals respectively. The toughness standards were stable for together metals In the HAZ and took tendency to rise in the bit part and this can be qualified to the creation of intermetallic compounds. The average workable things of the Friction Stir combined links of Cu/Al varied since 138.7 MPA to 135.5 MPA.

Shukla and Shah establish that the extreme workable power of Al/Cu combined was little (62.2 mpa) commonly due to the attendance of intermetallic compounds. The rise in the turning hurry ensued in lesser workable power commonly due to the rise in the quantity of the intermetallic mixtures designed At the Al/Cu line. Furthermore, In the Stir zone, the toughness was somewhat higher than the base metals also due to the creation of tough and tough intermetallic mixtures of cual2, cual and Cu9Al4 in the Stir part.

Saeid et Al succeeded extreme workable trim power of lap combined among aluminum and COPPER through FSW at Welding hurry of 95 mm/min. Due to the creation of tall quantity of micro cracks in the dark part At Welding hurries of 30 and 60 mm/min, the tolerable workable trim was lesser than that of 95 mm/min. Though At higher Welding hurries of 118 and 190 mm/min, the cavity faults were designed and again workable trim power decreased matched to 95 mm/min.

In adding to the workable challenging and micro hardness, Akinlabi et Al dignified the electrical resistivity of the welds. The marks ranged among 0.087 and 0.1 μΩ. It was observed that the joins with the highest electrical resistivity of 0,101 μΩ were dignified in those joins designed with tall hotness inputs.

In extreme of the above revised investigation outputs, Friction Stir Welding could be in the upcoming the extreme used linking method of unlike materials, though more investigation needs to be done to improve the machine-driven things of the welds.

C. FSW UTENSILS USED FOR ALUMINIUM and COPPER

In extreme of the investigation effort showed On FSW among ALUMINIUM and copper, the tool geometry and plan is normally not completely exposed which may be due to proprietary reasons. Although tool geometry is an exact main feature for making wide-ranging welds. Rai et Al showed a review On FSW utensils but did not distribute much in creation On FSW utensils used for the linking of

ALUMINIUM and COPPER In particular. Nevertheless, few investigators exposed the utensils used in their educations to Friction Stir combined ALUMINIUM to copper. Akinlabi et Al effectively joined 5754 ALUMINIUM multiple and C11000 COPPER by employing the threaded pin and curved in carry tool machined since H13 tool strengthen and tough to 52 HRC.

Abdollah-Zadeh et Al combined ALUMINIUM multiple 1060 turned platter to commercially clean COPPER with thicknesses of 4 and 3 mm via A SPK satisfied and hardened tool strengthen and took a carry width of 15 mm with a threaded pin of 5 mm width and 6.5 mm long. Galvão et Al used conical and SC turned carry utensils to combined oxygen-free COPPER with tall phosphorous content (Cu-DHP, R 240) and AA 5083-H111. Whereas, esmaeili et Al used a hot working multiple strengthen which was tough to 45 HRC to combined AA 1050 to brass (cuzn30). The cited tool used was composed of A 15 mm width carry and a tapered slotted pin. Saeid et Al designed combined among turned plates of 1060 aluminum multiple and commercially clean COPPER by via a satisfied and hardened tool steel. The tool took a 15 mm width carry and A left-hand threaded pin (φ5mm×6.5 mm).

Furthermore, Li et Al used a tool with a concaved carry and A cone-threaded pin of 16 mm in width and 5.2 mm in width respectively. The tool pin was 2.75 mm in distance to combined clean COPPER and AA 1350.

Agarwal et Al used A tool made of AISI H13 tool strengthen and Tall Hurry Strengthen (HSS) and took A carry 18 mm and 15 mm In width and the tool pin 7 mm In width and 3.7 mm pin distance . The above cited tool was used to combine AA 6063 to commercially clean COPPER plates. Guerra et Al effectively combined AA 6061 with A thin tall cleanliness COPPER one-piece pin and carry since D2 tool strengthen hotness treated to HRC62. The nib was 6.3 mm width and 5.8 mm long with standard 0.25/20 right-hand threads and 19 mm width shoulder. FSW utensils are of significance in effectively linking like and unlike materials because utensils harvest the thermo machine-driven decreation and work piece Frictional heating essential for Friction Stirring. Therefore, it is essential to more improve the FSW tool geometry particularly for unlike materials to harvest tall excellence welds.

III. CONCLUSIONS AND UPCOMING INVESTIGATION

FSW procedure is a recyclable compact national linking method matched to the unoriginal Welding techniques. The linking of ALUMINIUM to COPPER via FSW has been revised to open an investigation window to investigators In order to expand the method to additional ALUMINIUM and COPPER compounds with the aim of achieving optimized limits thereby top to the commercialization of links among these materials. Investigation on Friction Stir Welding among ALUMINIUM and COPPER has not yet been thoroughly researched; much of the effort has been concentrated on joins characterizations and study of the material flow. There is however, a strong need in rising the manufacturing uses of FSW among ALUMINIUM and COPPER In the manufacturing sector for the enhancement of the industries. Thus, the use of the FSW method to join ALUMINIUM and COPPER compounds and material figures is of significance in the growth of their manufacturing applications.

In summary, the review of the Friction Stir Welding of unlike materials focvia On ALUMINIUM and COPPER has been effectively conducted. This will distribute a comprehensive insight for the present and also distribute the present national of investigation On FSW among ALUMINIUM and COPPER In order to fill the gaps with new investigation approaches and ideas. Furthermore, new educations On FSW among ALUMINIUM and COPPER with respect to the procedure optimization and selection of cost effective FSW utensils to harvest wide-ranging joins still needs to be developed.

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