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Unidirectional Friction Stir Welding of Similar and Dissimilar Metals by using EN19 Diamond and Square Tool Profile

Ch. Ranga Rao[1], B Srinivasulu[2]

Associate Professor[1], Research Scholar[2]

St. Martin's Engineering College[1], Sri Satya Sai University of Technology & Medical Sciences[2]

***Corresponding Authors' email id**: raochundru2004@gmail.com*

Abstract

Development of light materials is challenging. Numerous applications has been developed for creating light weight materials which can be used in Aircraft industry, automobile industry, satellite launching, mobile assembly applications. This can be achieved by Friction Stir Welding is a solid state joining process. In this process a rotating tool is plunged in to the work piece, because of the friction between tool and work piece a considerable heat is developed which is sufficient to melt the metal and join which is free from fumes, gases or oxides. An experiment has been conducted on a conventional milling machine for joining of Aluminum(6061-T6) with Brass and welded samples are tested found that Square profile has given better Tensile Strength and Yield Strength but Diamond profile has given better Hardness

Keywords: *Friction stir welding (FSW),EN 19 Tool, Diamond and Square profile*

INTRODUCTION

Friction Stir Welding is a solid state joining process which was invented and patented by The Welding Institute, UK in 1991. Several experiments has been conducted since then, till date the process is not commercialized at a low cost. The cost of the FSW machines are prohibit to reach to MSME sector. In our experiment we are using a Conventional Milling machine and Tool is made of EN19 which is commercially available at affordable cost. There are several joining process are already available for joining of dissimilar

metals viz Laser Welding, Resistance Welding etc which are either costly or not serving the purpose of MSME sector. Friction Stir Welding serves this purpose. This technique is used by NASA for joining aluminum-lithium alloy which is light weight, for welding of liquid oxygen tank. It is also successful for joining of aluminum and steel, aluminum to magnesium, copper to stainless steel, nickel alloy to steel. Petronos in Malasya demonstated this technique for joining of Nylon sheet 6 mm to 16 mm thick. Friction stir welding applications are endless which includes ships, cars, heavy tricks, military vehicles, airplanes, space craft applications, Parts of imac Apple company etc. Fig(1) shows the schematic diagram of Friction Stir Welding.

TOOL DESIGN

The design of the tool is a important part as a fine tool can improve both the eminence of the weld and the utmost probable welding speed. The tool material is made up of tough , thermal resistance and wear resistance. We have designed Diamond Profile Tool and Square profile tool in CATIA. The final dimensions of the tool are described in Fig(2) and Fig(3)

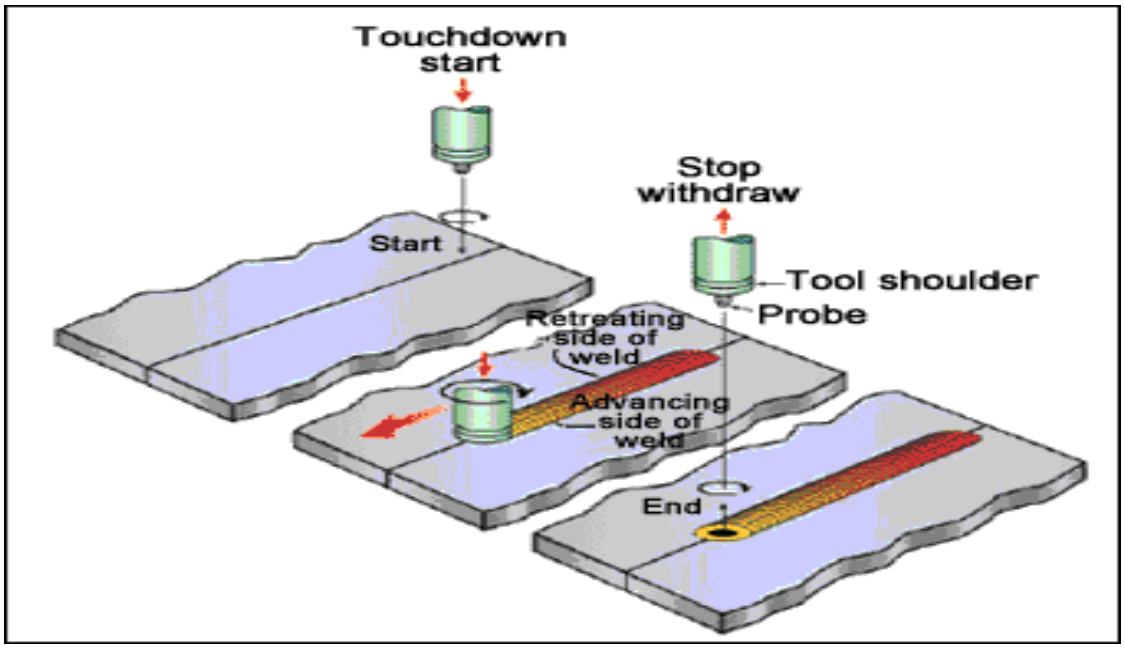


Fig1: Friction Stir Welding

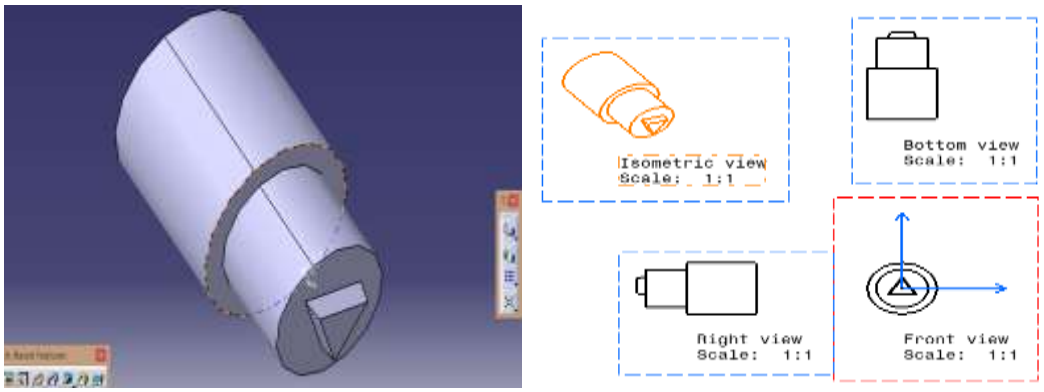


Fig2: Diamond Profile Tool

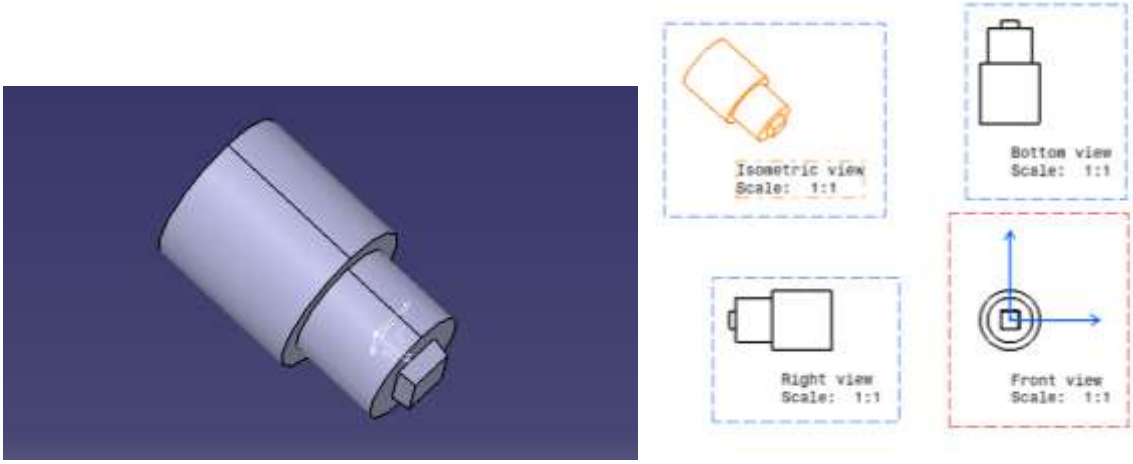


Fig3: Square Profile Tool

The shape of the shoulder outer surface (square or diamond) has an insignificant influence on the welding quality because the shoulder plunge depth is very small. This simple shape is easy to machine and can produce sound welds.The final fabricated tool are depicted in Fig(4) and Fig(5)

Fig 4 & Fig 5 : Final Fabricated Tools

3. TOOL MATERIAL CHARACTERISTICS

Tool material characteristics can be critical for anti clock wise direction of friction stir welding. The tool material depends on the work-piece and tool life.

EN 19 Tool Specification

EN 19 also known as 709M40 is a high eminence alloy steel, its good ductility and shock resistant and wear resistance and also widely used in the industries of FSW tool including an additional use EN 19 is usually supplied as high tensile grades. EN 19T (709M40T) OR EN 19U. The typical composition of EN19 are described in Table (1)

Table: 1 EN 19 COMPOSITION

Carobon	Silicon	Manganese	Sulphur	Phonsphorous	Chromium	Molybdenum
0.36-0.44%	0.1-0.44%	0.7-0.44%	0.44% Max	0.35 Max	0.9-1.2%	0.25-0.35%

4. PROCESS VARIABLESFOR FRICTION STIR WELDING ARE

Tool design

Rotational speed of tool

Welding feed speed

Main anti clock wise direction for FSW process

Table 2: Input Parameters

Tool design variables	**Machine variables**	**Other variables**
Shoulder and pin materials	Welding speed	Anvil material
Shoulder diameter	Spindle speed	Anvil size
Pin diameter	Plunge force or depth	Work-piece size
Pin length	Tool tilt angle	Work-piece properties
Thread pitch		
Feature geometry		

Table 3: Process Variables Selected

Parameters	**1**	**2**
Rotational speed(rpm)	900	900
Feed(mm/min)	31.5	31.5

Depth of cut(mm)	2.8	2.8
Tilt angle(degrees)	0.5	0.5
Tool profile	Square	Diamond

5. EXPRTIMNETAL SETUP

FSW performed on vertical milling machine. The input parameters as mention before be taken for machine process parameters. We have machined our Al 6061& Brass plates in the size of 100*55mm and 2mm thickness by automatic showing cutter. After Table(3) shows the final results of the experiment.

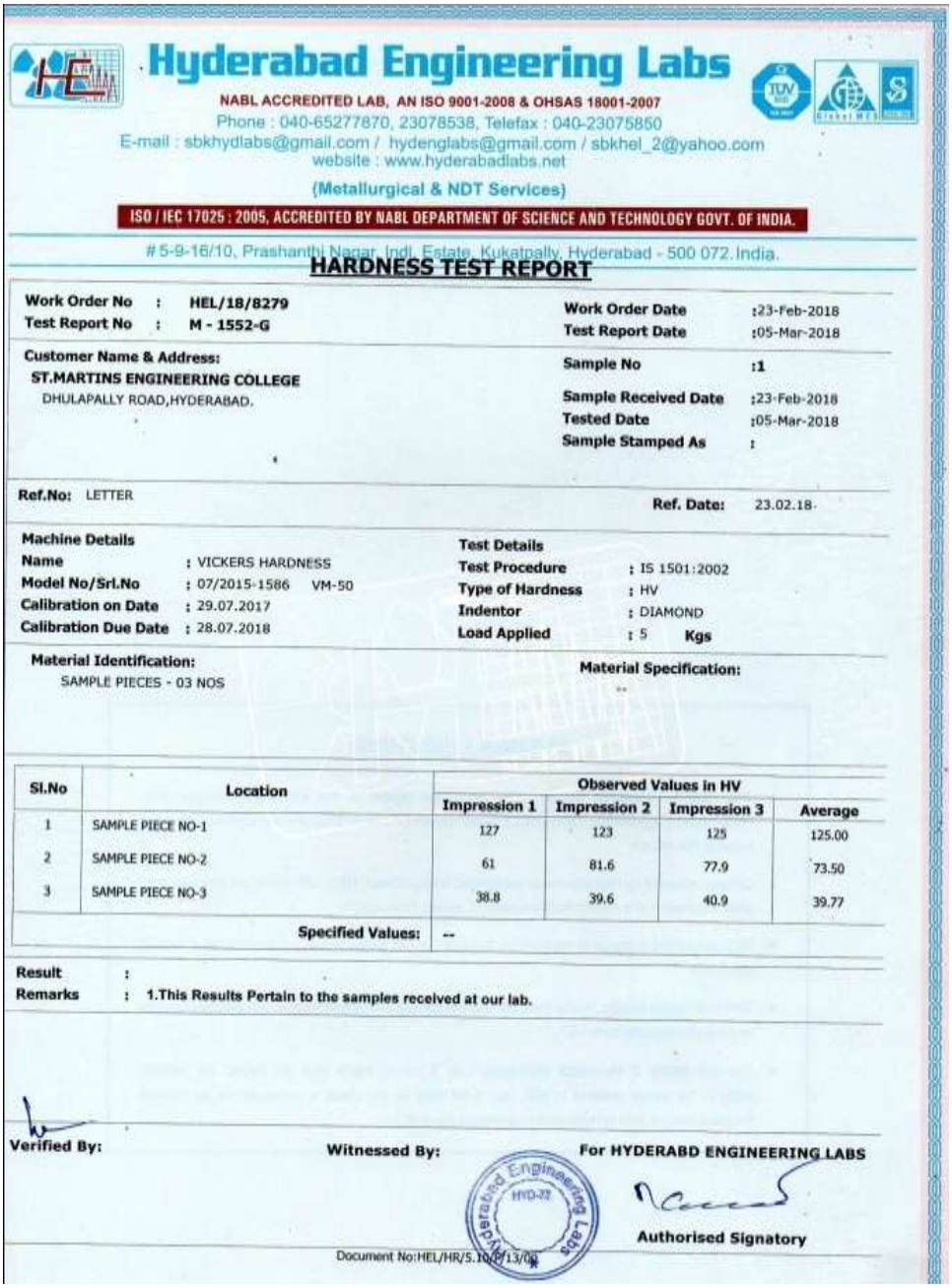
Fig 6: Experimental Setup in a Conventional Milling machine

RESULTS AND DISCUSSION

Friction Stir welding is conducted on a Vertical Milling machine. The Welding samples are tested on a Universal Testing Machine and Hardness is evaluated in Vickers Hardness machine. Fig(6) shows the final welded part by using Square Profile tool and Fig(7),8 shows the final welding part by using Diamond profile tool.

Fig7: Final Welding by using Square tool

Fig8: Final Welding by using Diamond tool



Hyderabad Engineering Labs

NABL ACCREDITED LAB, AN ISO 9001-2008 & OHSAS 18001-2007
Phone : 040-65277870, 23078538, Telefax : 040-23075850
E-mail : sbkhydlabs@gmail.com / hydenglabs@gmail.com / sbkhel_2@yahoo.com
website : www.hyderabadlabs.net
(Metallurgical & NDT Services)
ISO / IEC 17025 : 2005, ACCREDITED BY NABL DEPARTMENT OF SCIENCE AND TECHNOLOGY GOVT. OF INDIA.
5-9-16/10, Prashanthi Nagar, Indl. Estate, Kukatpally, Hyderabad - 500 072. India.

HARDNESS TEST REPORT

Work Order No : HEL/18/8279
Test Report No : M - 1552-G
Work Order Date :23-Feb-2018
Test Report Date :05-Mar-2018

Customer Name & Address:
ST.MARTINS ENGINEERING COLLEGE
DHULAPALLY ROAD,HYDERABAD.

Sample No :1
Sample Received Date :23-Feb-2018
Tested Date :05-Mar-2018
Sample Stamped As :

Ref.No: LETTER
Ref. Date: 23.02.18

Machine Details
Name : VICKERS HARDNESS
Model No/Srl.No : 07/2015-1586 VM-50
Calibration on Date : 29.07.2017
Calibration Due Date : 28.07.2018

Test Details
Test Procedure : IS 1501:2002
Type of Hardness : HV
Indentor : DIAMOND
Load Applied : 5 Kgs

Material Identification:
SAMPLE PIECES - 03 NOS

Material Specification:
--

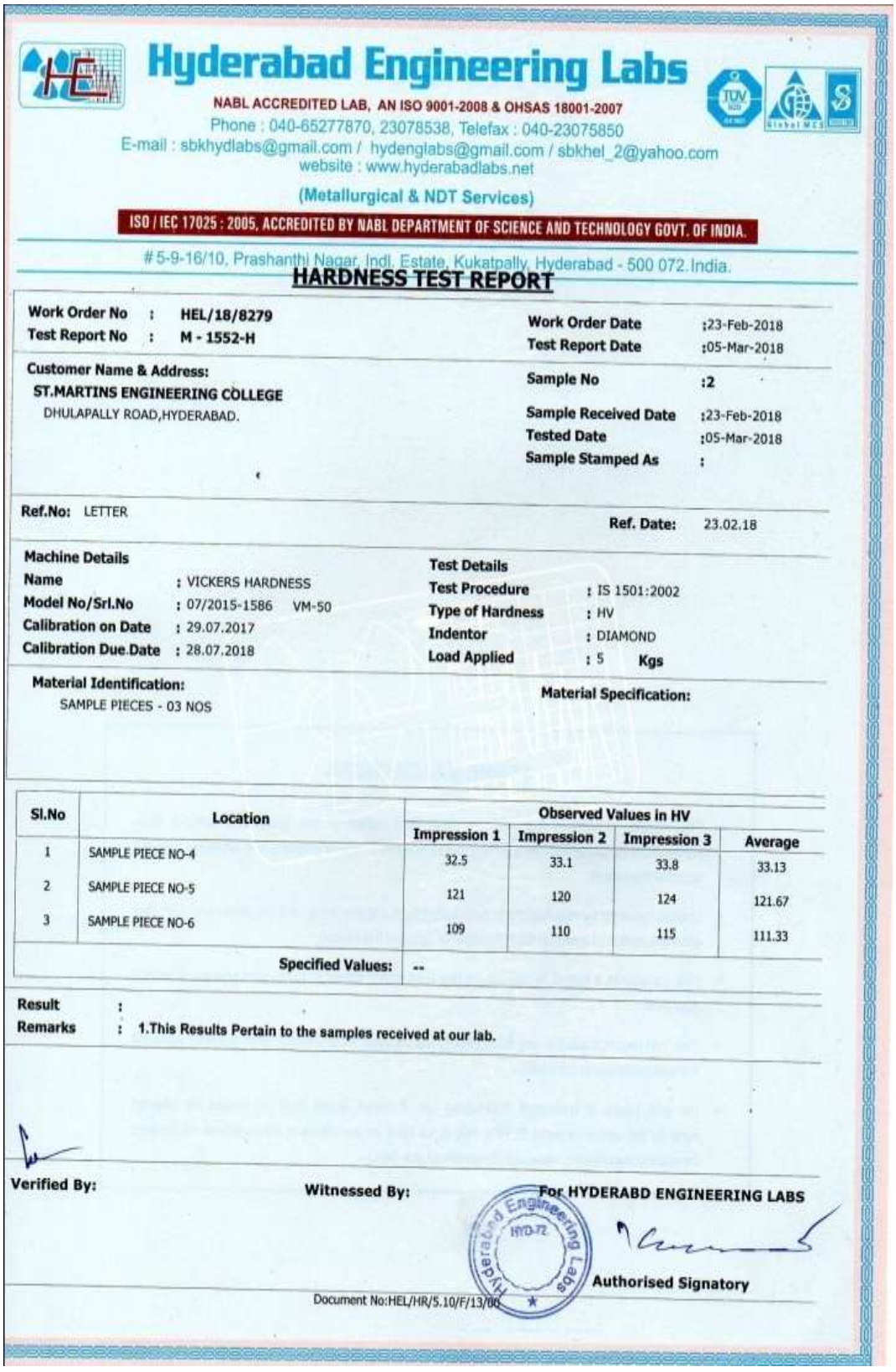
Sl.No	Location	Observed Values in HV			
		Impression 1	Impression 2	Impression 3	Average
1	SAMPLE PIECE NO-1	127	123	125	125.00
2	SAMPLE PIECE NO-2	61	81.6	77.9	73.50
3	SAMPLE PIECE NO-3	38.8	39.6	40.9	39.77
	Specified Values:	--			

Result :
Remarks : 1.This Results Pertain to the samples received at our lab.

Verified By: Witnessed By: For HYDERABD ENGINEERING LABS

Authorised Signatory

Document No:HEL/HR/5.10/13/03



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NABL ACCREDITED LAB, AN ISO 9001-2008 & OHSAS 18001-2007
Phone : 040-65277870, 23078538, Telefax : 040-23075850
E-mail : sbkhydlabs@gmail.com / hydenglabs@gmail.com / sbkhel_2@yahoo.com
website : www.hyderabadlabs.net
(Metallurgical & NDT Services)
ISO / IEC 17025 : 2005, ACCREDITED BY NABL DEPARTMENT OF SCIENCE AND TECHNOLOGY GOVT. OF INDIA.
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HARDNESS TEST REPORT

Work Order No : HEL/18/8279
Test Report No : M - 1552-H
Work Order Date :23-Feb-2018
Test Report Date :05-Mar-2018

Customer Name & Address:
ST.MARTINS ENGINEERING COLLEGE
DHULAPALLY ROAD,HYDERABAD.

Sample No :2
Sample Received Date :23-Feb-2018
Tested Date :05-Mar-2018
Sample Stamped As :

Ref.No: LETTER
Ref. Date: 23.02.18

Machine Details
Name : VICKERS HARDNESS
Model No/Srl.No : 07/2015-1586 VM-50
Calibration on Date : 29.07.2017
Calibration Due Date : 28.07.2018

Test Details
Test Procedure : IS 1501:2002
Type of Hardness : HV
Indentor : DIAMOND
Load Applied : 5 Kgs

Material Identification:
SAMPLE PIECES - 03 NOS

Material Specification:

Sl.No	Location	Observed Values in HV			
		Impression 1	Impression 2	Impression 3	Average
1	SAMPLE PIECE NO-4	32.5	33.1	33.8	33.13
2	SAMPLE PIECE NO-5	121	120	124	121.67
3	SAMPLE PIECE NO-6	109	110	115	111.33
	Specified Values:	--			

Result :
Remarks : 1.This Results Pertain to the samples received at our lab.

Verified By:
Witnessed By:
For HYDERABD ENGINEERING LABS
Authorised Signatory
Document No:HEL/HR/5.10/F/13/00

Fig9: Test report on Vicker's hardness

Table 4: The following are the final test results of the tested samples

S.NO	Sample	Tensile Strength N/mm2	Yield Strength N/mm2	Vickers Hardness HV	Tool Profile
1	Al-Al	101.72	82.19	39.77	Diomond
2.	Al-Al	85.24	82.007	33.13	Square
3	Brass-Brass	345.58	303.16	121.67	Diomond
4	Brass-Brass	383.32	324.78	111.33	Square
5	Al-Brass	63.34	59.21	125	Diomond
6	Al-Brass	47.28	41.37	73.5	Square

CONCLUSIONS:

Experiment has been conducted on various combinations of brass-brass, Al-Al and Al-Brass ,Brass-Brass with EN19 tool with Diamond and square profile tools, The welded samples are evaluated Tensile strength, Yield strength and Vickers Hardness. Compare with test sample, Brass-Brass with Square tool profile is strongest joint.

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