



## Friction stir welded joint aluminum alloy H20-H20 with different type of tools Mechanical properties

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**Abstract** :In this project we will using three type of tools, straight cylindrical, taper cylindrical and triangular tool all made of High speed steel (Wc-Co) for the friction stir welding (FSW) aluminum alloy H20 –H20 and test the mechanical properties of the welded joint by tensile test and vicker hardness test finally compare mentioned mechanical properties and make conclusion. the result will help choosing the welding parameter or welding parameter optimization in different type of process and materials and different applications.[*J Am Sci* 2021;17(3):64-79].(ISSN):<http://www.jofamericanscience.org>.8. doi: [10.7537/marsjas170321.08](https://doi.org/10.7537/marsjas170321.08).

**Keywords:** friction stir welding(FSW), tool, CNC milling machine, aluminum alloy H20, Vickers hardness test, Tensile test, straight cylindrical tool, taper cylindrical tool, triangular tool.

### 1. Introduction

Friction stir welding is a welding process recently developed in 1991 using for Al, Mg, Cu, Ti, for work pieces that could not welded by conventional types of welding and recently develop too much in different application because of economical and quality consideration [1].modern types of tool developed recently for harder typed of materials work pieces like different type of steels [2].also different types of machines developed for this purpose.FSW can done by an ordinary CNC milling machine for small work pieces to professional single purpose robotic machine in orbital FSW in steel pipes welding in oil industries [3].the schematic of friction stir process shown in figure 1.

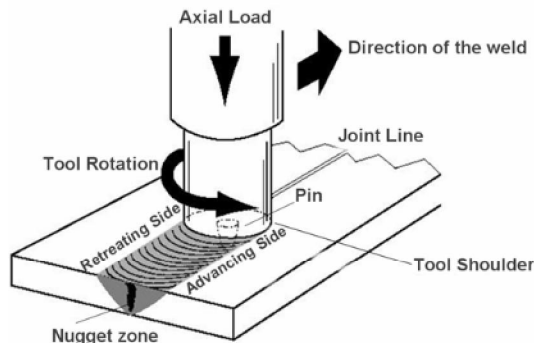


Figure 1: Schematic of friction stir process.

### 2. Material and Methods

We are using the CNC milling machine BMV 45 with aluminum alloy work piece H20 and rotational speed 1000RPM feed 20 mm and travel speed 20mm/m in this project the CNC milling machine specification as following :



Figure 2. CNC milling machine BMV 45

Table 1. specification of CNC milling machine BMV 45

No	Part name	Specification
1	3-axis machine center	Spinner
2	Model	BFW45
3	Spindle driver	Servo motor
4	Spindle range	10-6000 RPM
5	Tool holder	ISO 40
6	Cutting fluid	NR
7	Tool	HSS
8	Work piece	<b>Aluminum Alloy H20</b>
9	Movement	610*450
10	Bed size	800*500

#### 2.1 Aluminum Alloy H20 and H20

Because of suitable corrosion Resistance, strength properties, machinability and control in grain structure aluminum alloy H20 is a good material in friction stir welding[4]. Also we used

aluminum alloy H20 successfully in previous investigations with the same CNC milling machine BMV45.



Figure 3. Aluminum alloy H20 work piece

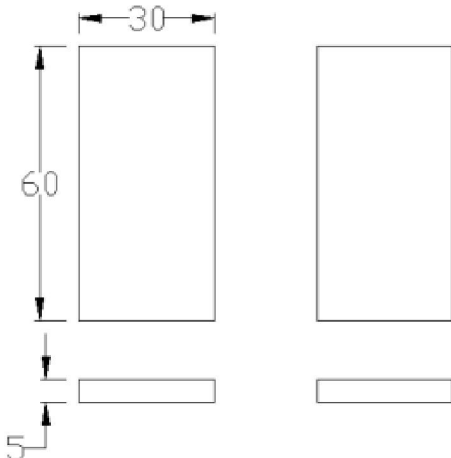


Figure 4. work piece Dimension (conventional joint)

### 2.2.type of tools

A wide variety of tools can use by friction stir process(FSP) in different geometry and different materials some of the most common type of tools are triangular, square and cylindrical that could be threaded or taper like threaded cylindrical (TH)and taper cylindrical (TC)also we have straight cylindrical (SC) that all consider as conventional tool types we have oval shape, paddle shape and many others that developed recently for different application and the displacement between threaded can be adjusted sometimes for different applications like changing spiral form and flared probe [5]. by the way the material also can be change from some conventional types like High speed steel (Wc-Co) in aluminum work piece in ordinary application to some tool made of cemented tungsten carbide with nickel and a AL2O3 surface coating made of cemented carbide comprising WC grains that is a kind of super abrasive tools suitable for hard steel work pieces friction stir welding(FSW) recently developed in Sweden [6].we will use straight cylindrical, taper cylindrical and triangular tools in this investigation for the mentioned work piece (mention dimension and materials)the tool material is High speed steel (Wc-Co).and the tool dimension are as following:

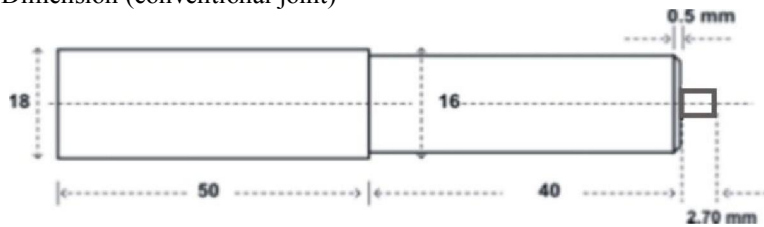


Figure 5. Friction stir welding straight cylindrical tool.

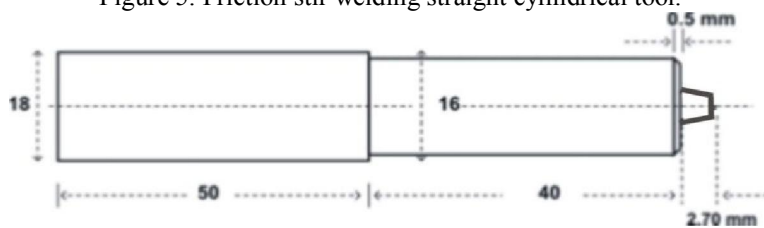


Figure 6. Friction stir welding taper cylindrical tool.

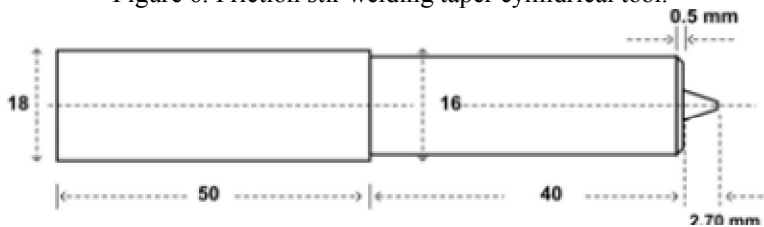


Figure 7. Friction stir welding triangular tool.

## 2.3. Weld Testing Procedures

### 2.3. A. Vickers Hardness Test

Diamond pyramid shape tool apply to the welded part, changing dimension parameter h and d will measure by a microscopic method and finally the Vickers hardness number (VHN) will calculate by following formula[7] :

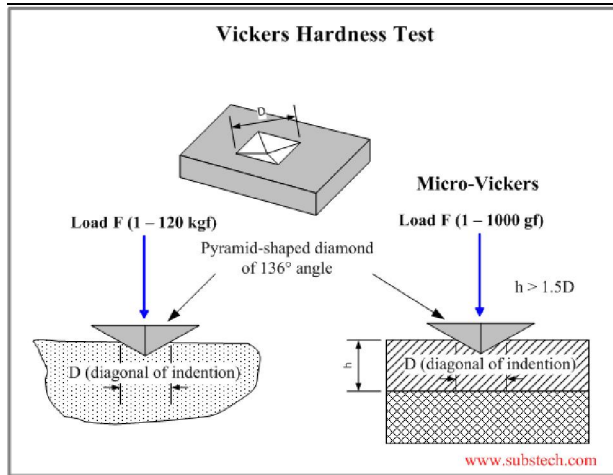


Figure 8. Vickers Hardness Test Terminology

$$DPH = \frac{2 P \sin (\theta / 2)}{L^2} = \frac{1.854 P}{L^2}$$

Where:

P - Applied load by Pyramid shape diamond ( kg).

L or D – area of indentation( mm).

$\theta$  - angle between opposite faces of diamond =  $136^\circ$

### 2.3.B.TENSILE TEST PROCEDURE

universal testing machine (UTM) used to strength tensile test in MPA, if S = Cross-sectional area and F = maximum force then [8] :

tensile strength =  $R = F/S$  (MPA)

### 2.4.CNC PROGRAM

We use CNC program as following in our CNC milling machine BMV45[9]

00010(DIA 16.0EM 45 DEGEREE TIP CUTTER)

N01 (FRICTION STIR WELDING)

N02 (DATE 11-01-2010 TIME 20:15:08)

N03 G0G17G40G49G53G80G90

N04 G5.1Q1R10

N05 G91G28Z0

N06 M03S950

N07 G90G54X0.0Y0.0

N08 G43H6Z50

N09 G1Z2F800

N10 G1Z-3.8F16

N11 X170

N12 G0Z50.0M09

N13 M05

N14 G91G28Z0

N15 G5.1Q0

## 3. Results and Discussion

We weld the mention dimension aluminum alloy H20 conventional joint with the mentioned process parameter and CNC milling machine three times first with triangular tool after that with taper cylindrical tool and finally with straight cylindrical tool and then perform both vicker hardness and tensile strength test to the welded joints.compare the results and make conclusion.



Figure 9.friction stir welded aluminum alloy H20 triangular tool



Figure 10. friction stir welded aluminum alloy H20 taper cylindrical tool.



Figure 11. friction stir welded aluminum alloy H20 straight cylindrical tool.

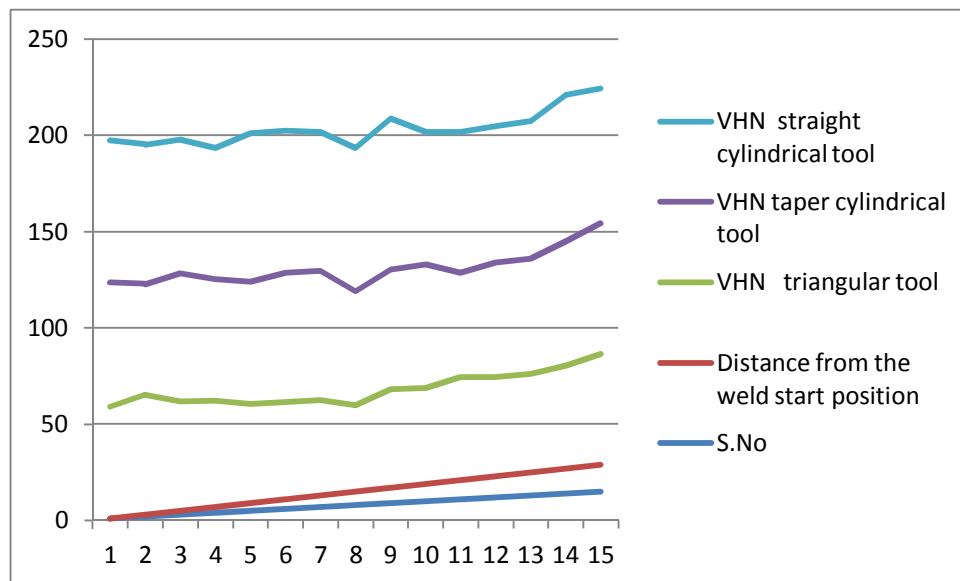
The Vickers hardness number of the welded joint varied by distance from the weld center the surface quality of the welded joint by triangular tool is better than the welded joint by taper cylindrical tool and the surface quality of welded joint by straight cylindrical tool was not satisfactory.

On the other hand the hardness characteristic of welded joint by straight cylindrical tool was the best. beside this the hardness characteristic of welded joint by taper cylindrical tool is better than welded joint by triangular tool.

Table 2. Friction stir welded joint aluminum alloy H20-H20 Vickers Hardness Number (VHN).

Friction stir welded joint with triangular tool	S.No	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
	Distance from the weld start position	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	14
	Vickers Hardness Number (VHN)	57.9	62.2	56.8	55.3	51.7	50.6	49.4	44.8	51.1	49.8	53.5	51.5	51	53.5	57.5	
Friction stir welded joint with taper cylindrical tool	S.No	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
	Distance from the weld start position	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	14
	Vickers Hardness Number (VHN)	64.7	57.6	66.6	62.9	63.2	67.1	67.1	59.3	62.1	64.3	54.2	59.4	60.1	64.3	67.9	
Friction stir welded joint with straight cylindrical tool	S.No	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
	Distance from the weld start position	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	14
	Vickers Hardness Number (VHN)	73.6	72.4	69.3	68.4	77.2	73.6	72.2	74.3	78.4	68.6	73.2	70.9	71.4	76.1	69.8	

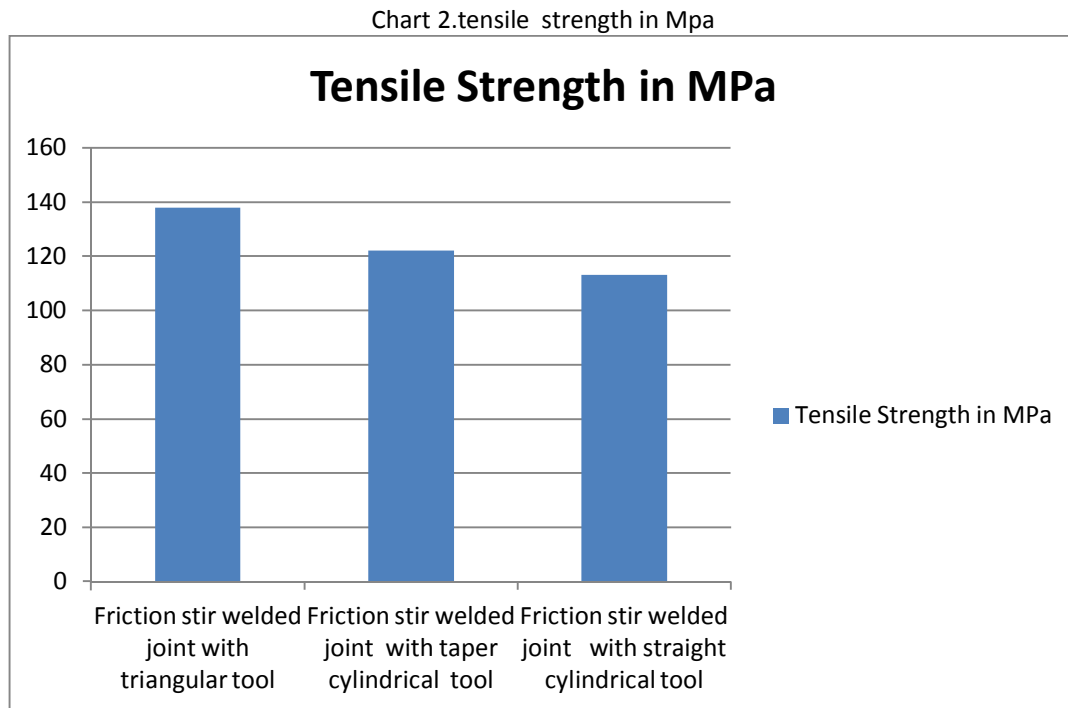
Chart 1. Vickers hardness numbers.



Also The results of the tensile testing shown in table 3.

Table 3. Friction stir welded joint aluminum alloy H20-H20 Tensile Strength in MPa

Type of Joint	Tensile Strength in MPa
Friction stir welded joint with triangular tool	138
Friction stir welded joint with taper cylindrical tool	122
Friction stir welded joint with straight cylindrical tool	113



The tensile strength characteristic of Friction stir welded joint with triangular tool is the best and the tensile strength of Friction stir welded joint with taper cylindrical tool is better than the tensile strength of Friction stir welded joint with straight cylindrical tool.

#### 4. Conclusion

Friction stir welding can be applied successfully for aluminum alloy H20-H20 by CNC milling machine. Friction stir welded joints with triangular tools have a good surface quality after welding and also have a good tensile strength. On the other hand, Friction stir welded joints with straight cylindrical tools have an excellent hardness characteristic but the surface quality is not satisfactory after welding and the welded joint usually needs some surface treatment processes. In conclusion, when the work piece is under hard vertical load, it is better to choose Friction stir welded joints with straight cylindrical tools, but when the work piece is under hard horizontal load, the Friction stir welded joint with triangular tool will be preferred in choosing FSW process parameters.

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