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Reduction of Defects in Al-6061 Friction Stir Welding and Verified by Radiography

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Abstract. Friction Stir Welding is a new innovating process of joining of two work pieces. It is an relatively a new joining process and highly useful in welding method, which can produce high strength weld without using any toxic materials like electrodes. In this method, weld is obtained by frictional produced between shoulder and work piece [1, 2]. Main parameters which are to be considered for FSW are spindle speed and feed rate. By providing suitable parameter during welding defects will not be occurring. Also, FSW is an eco-friendly process because there is no fumes production and no filler material. To get high quality of weld, then high heat should be generated. In this paper, Al-6061 material is welded by H-13 tool with different parameters and quality of weld is examined by using a non destructive testing method called Radiography.

1. Introduction

Friction Stir Welding is a process of joining two surfaces using a third body tool. Friction Stir welding process was invented and experimentally proved by The Welding Institute (TWI) UK in December 1991. TWI filed successfully patents in Europe, USA, Japan and Australia. Since, FSW invention has received worldwide new attention. FSW has been proved to be an effective process for welding aluminium, brass, copper and also for other metals which are having low melting temperature materials. The latest study in FSW has been targeted to at expanding the usefulness of this procedure in the metals having high melting temperature materials also like carbon and stainless steels. Major parameters which affect the weld quality are spindle speed and tool feed rate [3]. These parameters are responsible for heat generation and intermixing of work pieces. Internal defects produced due to improper welding are not verified by normal method. These defects can be detected by a special method called radiography. Radiography is one of the non-destructive techniques which can find defects without creating any damage. It is a technique used to view internal structure of a material [4]. Aim of this paper is to prove that by proper spindle speed and feed rate. Thus, the defect can be reduced.

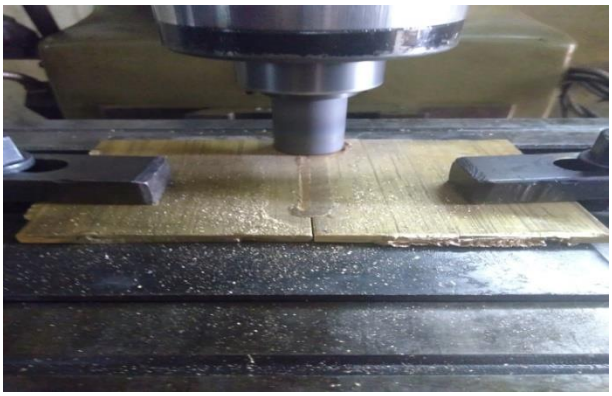


Figure 1. Friction stir welding

2. Material

2.1 Material

Al-6061 has good strength, good weldability and excellent corrosion resistance to atmospheric conditions and salt. Used for marine fittings, electrical fittings, valves and cycle parts. Known for its high tensile strength and intensive texture. It has very good corrosion resistance and very good weldability even though decreased strength in the weld area . Hence it not preferred for very complex cross sections. Al-6061 is generally utilized as a part of designing structures and segments where light weight or erosion resistance is required.

Table 1. Physical property of Al- 6061

Physical Property	Value
Density	2.7 gm / cm^3
Melting Point	Approximately 580^0C
Modulus of Elasticity	70 – 80 GPa
Poisson's Ratio	0.33

2.2.Microstructure of Al-6061

The microstructure shows the grains of Mg_2Si in aluminium solid solution. The sample is in the longitudinal direction as it is evident from the parallel grain flow. The grains size of the particles is ranging from 10 – 15 microns. Some direction of forming and its grain size is ranging from 30 to 40 microns [5, 6].

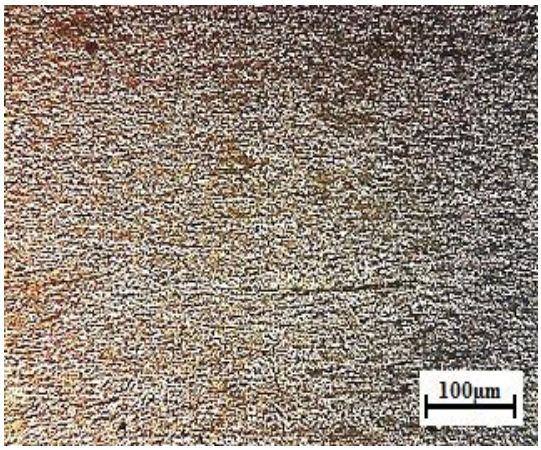


Figure 2. Microstructure of Al-6061

3.Experimentation

Friction Stir weld between two Al-6061 material with the dimensions of 300 X 100 X 3 mm were successfully produced in vertical milling machine. To weld these aluminium work pieces, H-13 tool with cylindrical probe with diameter 3 mm and with shoulder diameter of 10 mm was used. Friction Stir welds were produced by varying the rotational speed between 1000 and 2000 rpm and feed rate of 15 and 20 mm/min. Tool speed 1000, 1400 and 2000 rpm were employed while 15 and 20 mm/min were the feed rates. These feed rates were considered as representing the low high setting feed rates respectively [7]. To get high hardness for a tool, it is subjected to nitriding before weld. After weld,

the material was inspected by X-ray radiography. Different weld parameters were used in this method is given in table 2.

Table 2. Weld Parameter

Work piece	Speed	Feed
1	1000	15
2	1000	20
3	1400	15
4	1400	20
5	2000	15
6	2000	20

4. Testing

4.1 Visual inspection

In order to reduce the defects on friction stir welding, we need to select the correct parameter. If the spindle speed increases, heat generated between tool and work piece get increased. This operation is done, in order to prove that quality of weld get increased if we increase the speed value and decrease feed value. During first process, spindle is made to rotate at 1000 rpm and tool is made to move at 15 mm/min. Since the tool speed is less, heat created between the tool and work piece is less. Therefore, due to in sufficient heat, the work piece could not obtain good weld. From the table, it is shown that friction stir welding at 1000 rpm and feed of 15 mm/min produced less quality weld, due to in sufficient heat produced. At 1400 rpm and feed 15 mm/min, tool speed is little high and heat created between the tool and work piece will get increase. As compare with before, tool speed increased and tool feed reduced. Hence, heat generation increased and quality of weld improved further. During welding of 2000 rpm and feed 15 mm/min, the tool and work piece is subjected to high friction to obtain good quality weld.

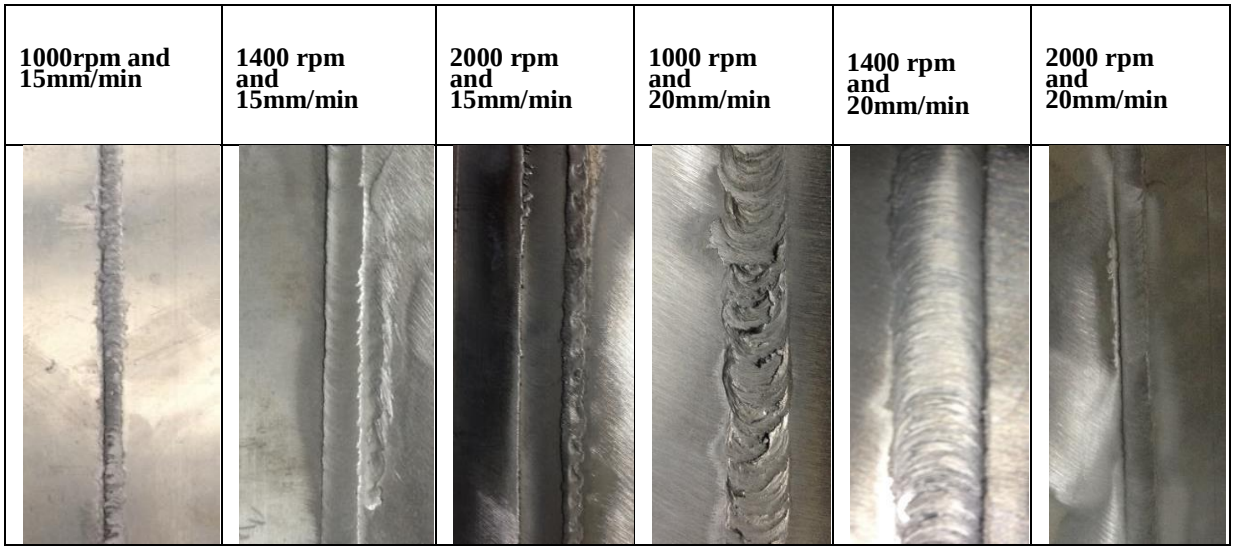
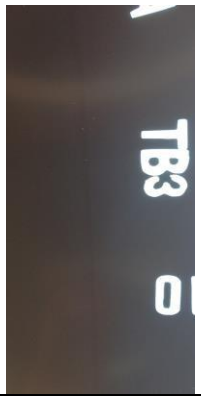
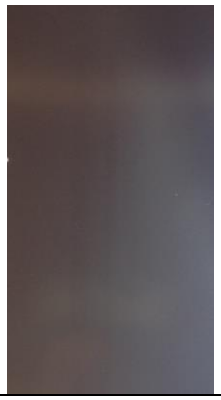


Figure 3. FSW Welded Region

4.2 Radiography inspection

Radiography is an imaging technique uses electromagnetic radiation other than visible light especially X-rays to view the internal structure of a non-uniformly composed and opaque object. To obtain the radiography image of the weld ,X-ray is projected toward the object. Internal defects which are not predicted by visual inspection can be obtained by using radiography method [9].

1400 rpm and feed 20 mm/min	2000 rpm and feed 15 mm/min	2000 rpm and feed 20 mm/min
		

5. Result

It is apparent that increasing the feed rate effectively increase the amounts of defects formed during welding, it can be attributed to the fact that less heat is generated at high feed rate which in turn is not enough to consolidate the weld with exception of the weld produced at 1000 rpm and 20 mm/min which can be interpreted that the high rotational speed at 2000 rpm compensated for the high feed rate of 20 mm/min and hence assisted in consolidating the weld produced at this setting. At 2000 rpm and 15 mm/min has been found to be the optimum tool rotational speed for defect free weld for Al-6061 work piece of 3 mm thickness.

6. Conclusion

Non Destructive testing techniques through X-ray radiography were successfully conducted on welds produced at various parameter combinations. With this testing result of various work piece it is found that, if the spindle speed increases more heat will produce on the work piece, which make the weld with good quality. Though, high speed available on the tool, increasing feed rate will compensate the heat generation. Hence, by selecting correct speed and feed rate we can reduce the defect produced during friction stir welding.

7. Reference

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