Research on the process in MIG welding of 5A02 aluminum alloy plate

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Abstract. 10mm thick aluminum alloys 5A02 plates were welded using MIG beam in this paper.The MIG weld formation and microstructure morphology were studied,the hardness in the weld were measured, the tensile test were made.The test result shows that the cooperation of welding current,speed and root gap can lead to perfect welds.There are equiaxed grain in the central welds and cloumnar grain structure near the fusion line.The maximum hardness is in the fusion zone of joints,and the minimum is in the softening zone.

Introduction

5A02 is Al - Mg based non-heat-treatment reinforced aluminum alloy , has high fatigue strength, plasticity and corrosion resistance, and good formability,and widely used in pressure containers, ships, vehicles, etc[1]. This study was carried out on the 10 mm thick 5A02 aluminum alloy automatic MIG welding process , the analysis of the effect of MIG welding process parameters on the weld, testing the mechanical properties of welded joint. This will provide reference for 5 how a02 aluminum alloy MIG welding process.

Material and Experimental Process

The 5A02 plates with a thickness of 10mm was used as base material in this study,its nominal chemical composition is shown in Table1.Filler wire used in the test is 4043 with ta diameter of 1.2mm, the chemical composition of welding wire is shown in Table 2.

Table 1 chemical composition of 5A02（%）

Cu	Mg	Mn	Fe	Si	Ti	Fe+Si	Al
0.10	2.0～2.8	0.15～0.4	0.4	0.4	0.15	0.6	rest

Table 2 chemical composition of 4043（%）

Si	Fe	Cu	Mn	Mg	Zn	Ti	Al
4.5～6.0	≤0.8	≤0.30	≤0.05	≤0.05	≤0.10	≤0.20	rest

The power supply is DCRP, voltage is 22V, protective gas is 99.99% purity of argon, nozzle diameter is 20mm, the gas flow rate of is 15L/min.Test using I-butt with the root gap from 0 to 3mm. Wire extension length is 15mm.The first to use mechanical cleaning to remove the oxide on the surface of the weld and impurities, and then swab with acetone, strive for the welding within 12 hours.

Test using a single parameter change control method. The experimental parameters are changed current, welding speed, welding of the root gap, the changes as shown in Table3 to Table4. In the direction perpendicular to the weld specimens cut performance testing and microstructure observation. Etchant selection Keller reagents.

Table 3 Change the parameters of one-side welding

Serial number	Current (A)	Voltage (V)	Welding Speed （mm/s）	Gas Flow （L/min）	Root Gap (mm)
1-1	170	22	8	15	1
1-2	190	22	8	15	1
1-3	210	22	8	15	1
2-1	220	22	6	15	1
2-2	220	22	7	15	1
2-3	220	22	8	15	1
3-1	220	22	8	15	0
3-2	220	22	8	15	0
3-3	220	22	8	15	2

Table 4 Change the reverse current

Serial number	reverse current （A）	Positive current（A）	Voltage (V)	Gas Flow （L/min）	Root Gap (mm)	welding speed （mm/s）
4-1	160					
4-2	180	140	22	15	2	8
4-3	200					

Experimental results and analysis

The weld penetration is as a finger shown in Fig1. From the macro we can distinguish the weld defects, such as incomplete penetration in sample 1-1,a big hole in at weld edge in 1-3,no fusion phenomenon in 4-1 and 4-3.

There are equiaxed grains in the middle of the joint,and columnar crystal near the fusion line as shown in Fig2.The main structure of the joint is α (Al) + β (Al_3Mg_2), containing a small amount of Mg_2Si on the grain boundary.From 1-1, 1-3 and 2-2 can be seen the line of energy will increase, whether increases the current or decreases the welding speed.It keep the molten pool at high temperature for a long time and slow to cool the weld area[2].

Known from the Al-Mg two element alloy phase diagram, when the temperature reaches the liquidus α-solid solution is precipitated, and will continue to increase until all crystallized.When the temperature down to solid solution line, the solubility of alpha solid solution is reduced, until the Mg saturated in the alpha solid solution. Redundant Mg will precipitate from the alpha solid solution as beta (Al_3Mg_2)[3].

As can be seen from Figure 2, and their microstructure has not changed much, but there are significant changes in grain size.The organization of sample1-3 is more uniform and fine than several others,followed by 3-3.This is because the change in parameters only root gap and swing frequency, the heat input and line energy has not changed, it will only change the weld penetration, weld width and remaining high, forming a significant effect on the surface.

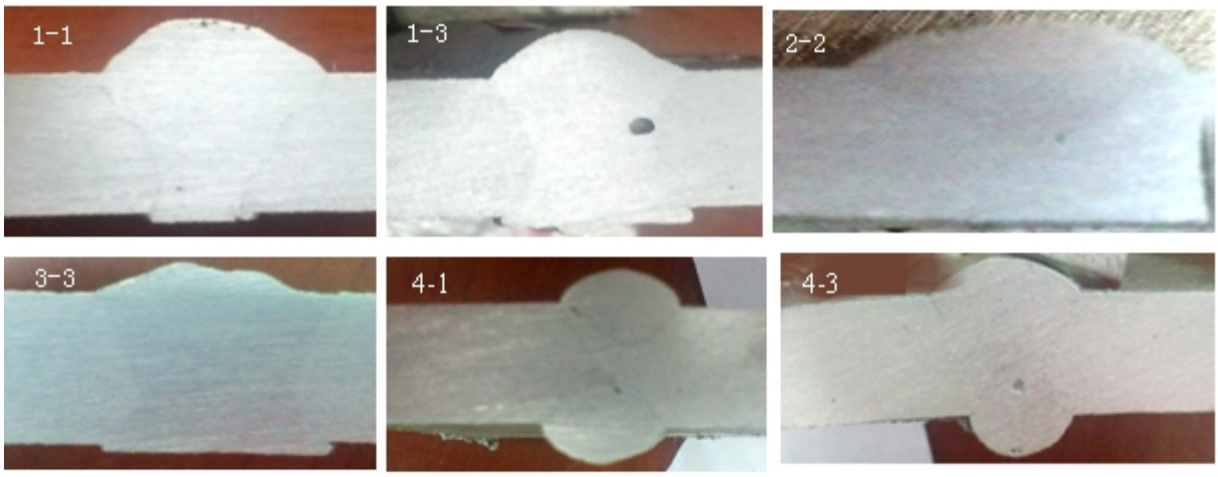

Fig 1 Macro-morphology of the cross section of the weld

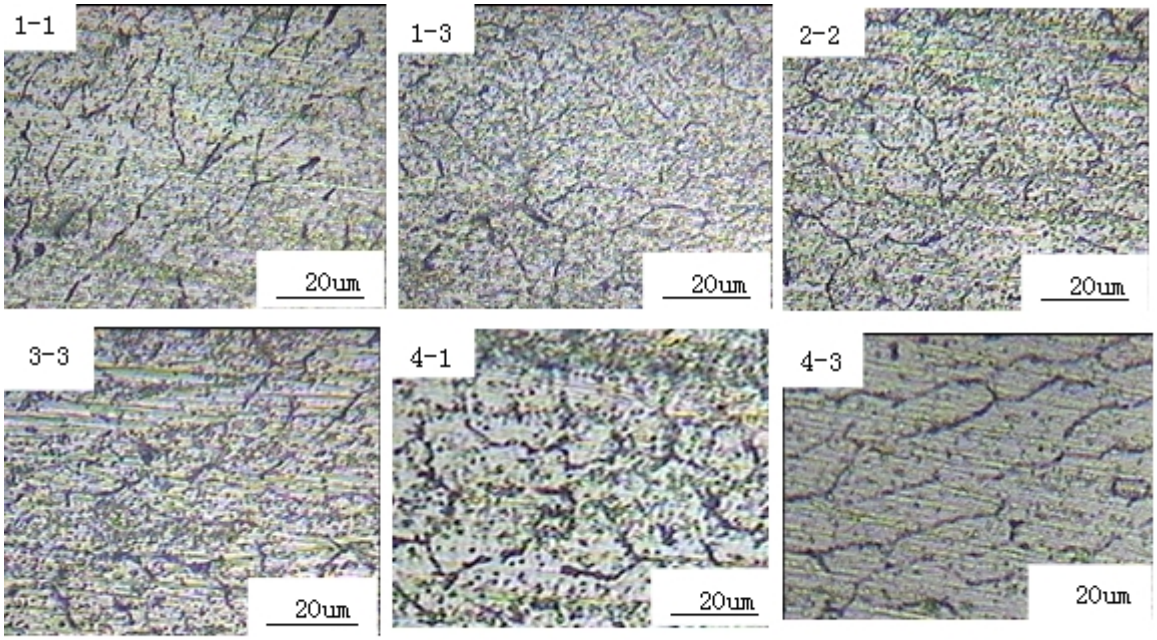

Fig 2 weld microstructure

The sample 4-1, 4-3 used double-side welding, 4-1 for equiaxial crystal grain and 4-3 for dendrite.The main weld microstructure is alpha (Al) solid solution and a small amount of Mg2Si.

The base material has been in the preheating temperature when welding plank opposite,which makes the weld temperature at the peak time is longer, the cooling speed is slow, so the tissue morphology of equiaxed grain. On the grain size, 4-1 to 4-3 is increasing, the preheating current of sample 4-3 is larger than4-1,so the grain of 4-3 is more bulky than 4-1.

From Fig.3 we can see in addition to sample 3-3 fractured in the base metal , and the remaining few specimens were broken in the middle of the weld. On the specimen fracture were found incomplete penetration phenomenon, 4mm thick on 1-1, 3mm thick on 4-1, nearly 2mm thick on 4-3.This phenomenon will seriously affect the performance of joints. In this experiment, the yield strength reduced up to 52%, the tensile strength decreased by 68%, the elongation decreased by 77%.Under the microscope we also found some porosity on the specimen fracture of samples1-3,2-2 and4-2 ,which is also detrimental to the performance of the joint.

Figure 4 shows the hardness distribution of the joint. As can be seen, the fusion line is the highest hardness place of welding joint, heat affected zone is the place of the lowest hardness.

In this test the hardness of the sample with the root gap of 2mm is generally higher than the sample of 1mm, while the the hardness is not very obvious changed with different other parameters. The average hardness of the sample is 79HV, the hardness of the fusion zone is more than 90HV , the heat affected zone is between 56 ~ 76HV.

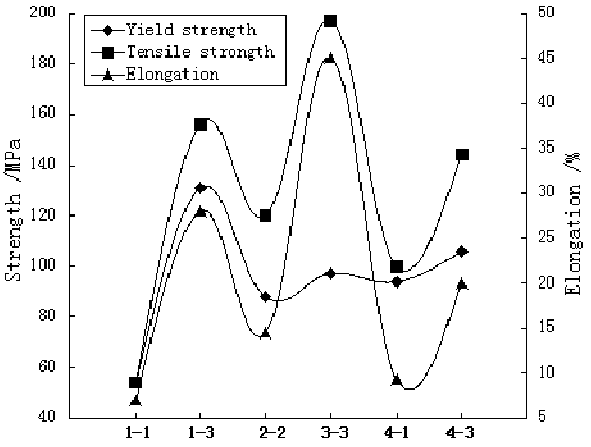

Fig.3 The mechanical properties of the joints

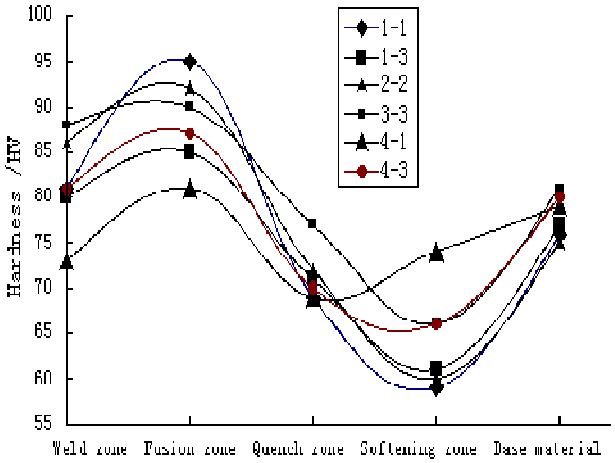

Fig.4 The hardness values of the joints

The hardness between the center of the joint and the parent metal is a little different. The hardness and strength of the material is proportional to the relationship.This reflects the “so strong” of aluminum alloy welded joint.And the softening phenomenon exists in the heat affected zone , which can be reduced or avoided by changing the welding process .

Conclusions

（1）The optimal parameters of one side welding: welding current is 210A, the root gap is 2mm, the welding speed is 8mm/s.

（2）When using double-sided welding I-butt, the front of the welding current should be at least 200A, reverse current should be greater than 200A. It can optimize the I-sided butt welding parameters to take root gap 2mm, SLR currents are taken as 200A.

（3）Distribution of hardness values can indirectly reflect the “so strong” between the center of the weld and base metal, overaged softening of HAZ,as well as hardness various trends of organizations in the joint .

（4）Line energy has the greatest influence on organizational . The organization has no obvious change with changing of the root gap, but the grain size has a slight change.

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