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Principle and realization of an electromagnetic pulse welding system with a dual-stage coil

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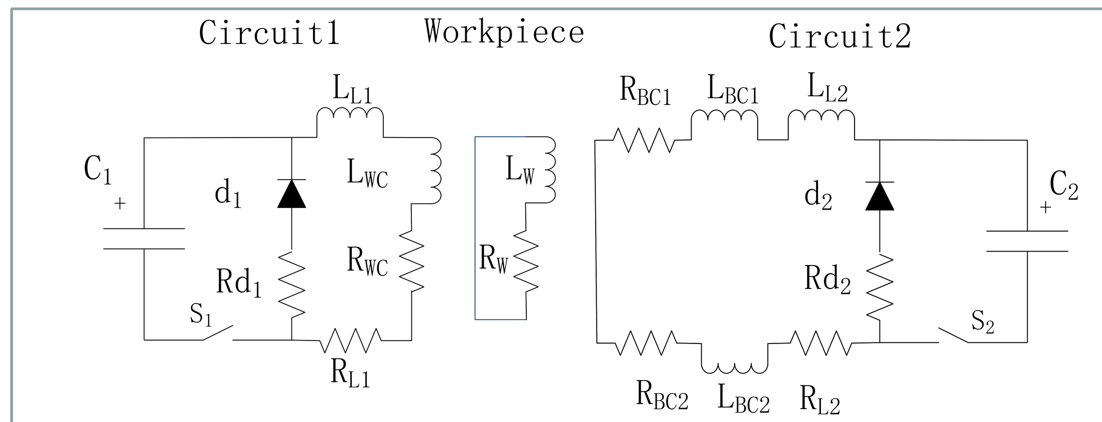
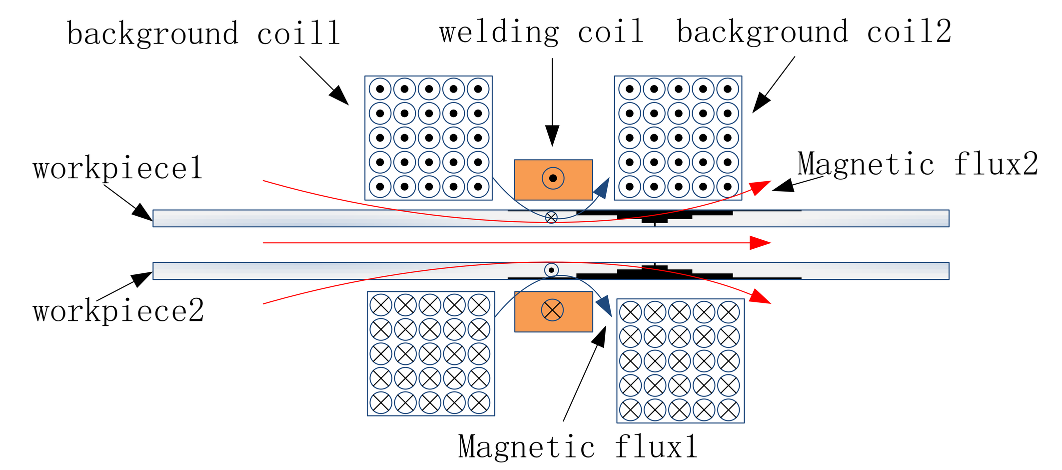
I Introduction

Electromagnetic pulse welding (EPW) is an effective way to realize the connection of two different kinds of metal materials via pulsed electromagnetic forces. To improve the welding performance, a new EPW process with a dual-stage coil system was proposed for joining aluminum sheets in this paper, in which one coil is used to generate a pulsed magnetic field with a short pulse width for inducing an eddy current in the aluminum sheet, while the other one is app-lied to generate a background magnetic field with a relatively long pulse width for increasing electromagnetic force acting on the aluminum sheet. The EPW system has been designed and implemented based on the simulation results using the finite element method, with considering the effects of the coil shape, the number of coil turns and the discharge parameters. Finally, experiments are carried out to validate the feasibility of the EPW system, and the microstructure observations of the interfaces show that the welding quality can be effectively improved.

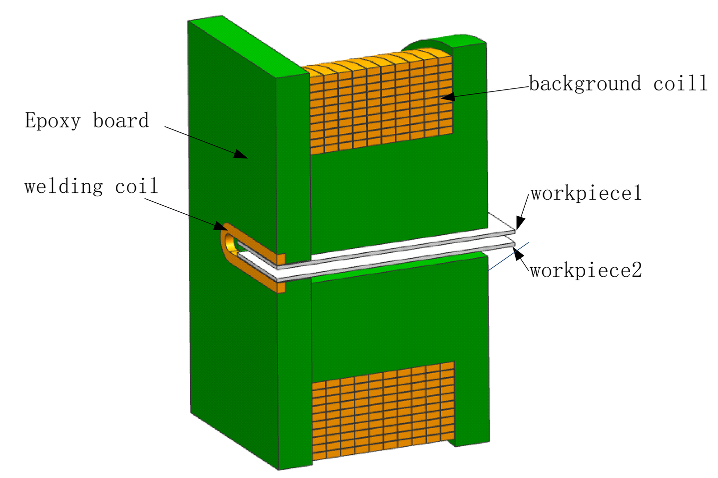
II Principles , design ,simulation and experiment



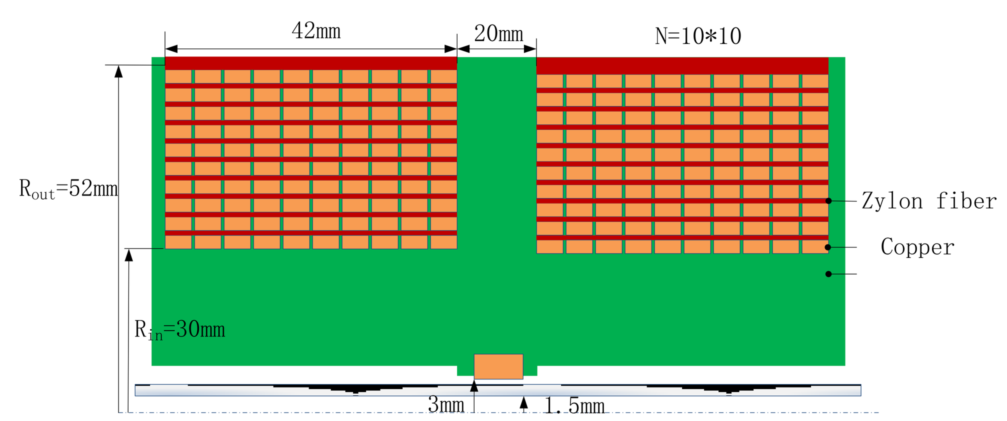
Four coils exist in the systems, including two background coils ,one welding coil and one coil replacing the workpiece.



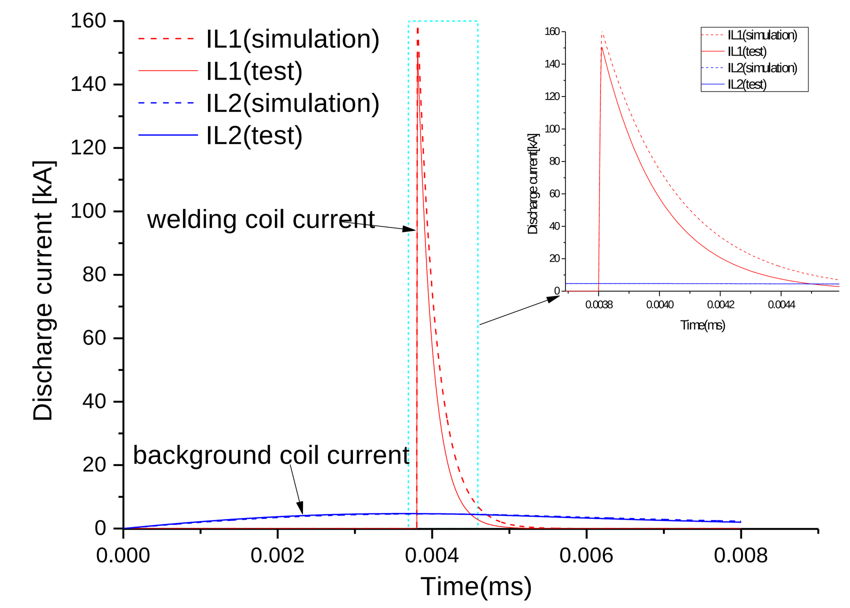
The background magnetic field is generated by two background coils with the same direction of filed as the magnetic flux2 showed in the Fig. The circuit1 will discharge when the current of the circuit2 reaches to the maximum. The welding coil forms rapidly changing magnetic field near the metal plate.



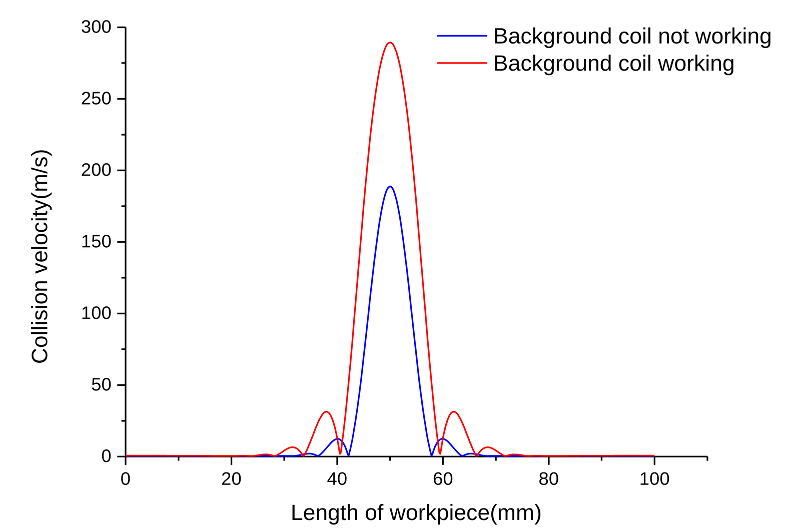
In this paper, the background coils were designed to be round for fabricating and increasing the strength of coil. The welding coil is made into a rectangle single-loop coil.



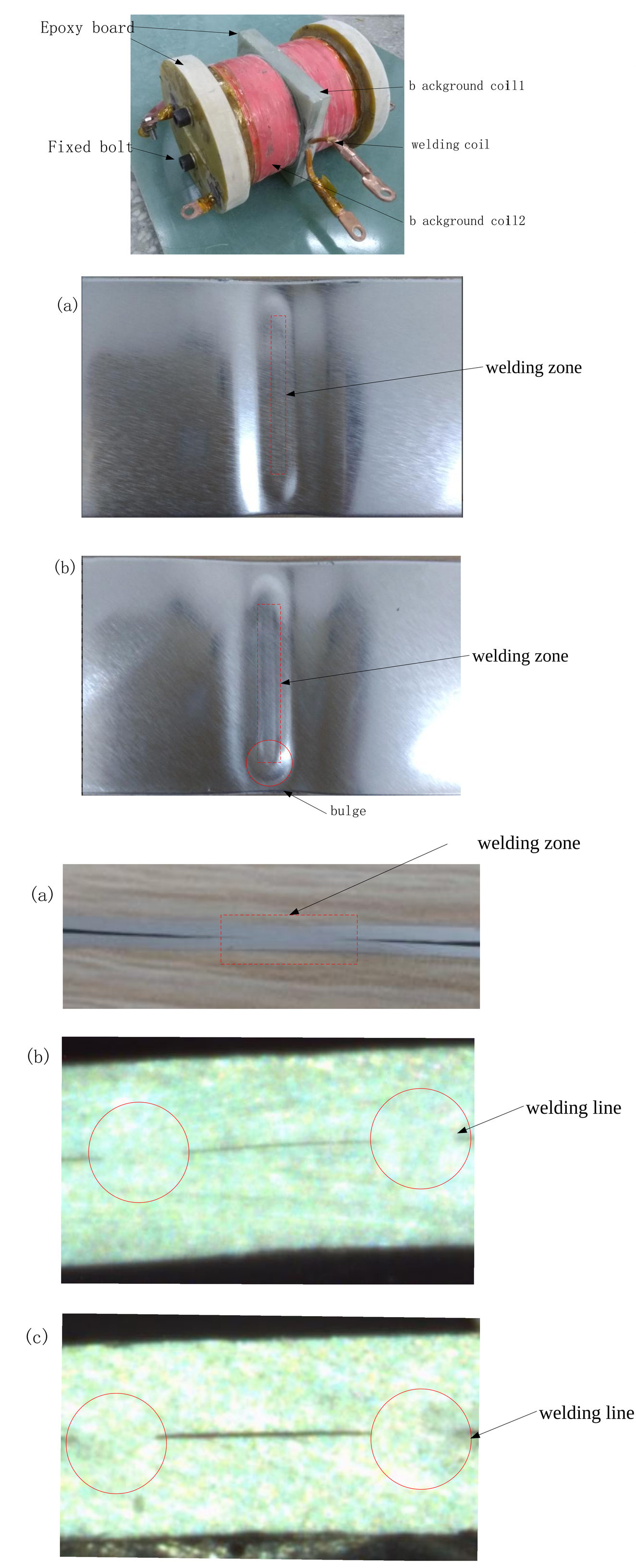
The background coil has 10 layers and 10 turns of copper wire. The Zylon fiber composite is applied to decrease the stress in copper wires and ensure long coil performance life. The welding coil is made of a 3mmx5mm flat copper. The Coil shape can make the coil close enough to the workpiece to improve the intensity of the magnetic field near the workpiece.



This picture shows that the current rising time of the background magnetic filed coil is about 3.8 ms, and the maximum current is about 4.6 kA. The welding coil circuit discharges at 3.8 ms and rises to the maximum 146kA after 11us.



This picture shows the different ratios of the workpieces with the background coil working and not working.



A luminum plates (1060) with thickness of 1mm have been adopted to make a series of experiments. Picture shows the welding section appearance when the weld coils discharge voltage is 12kV and the background coils are not working or discharging with 5kV.

Figure shows the micro structure when the weld coil discharges with voltage of 12kV while the background coils are not working or discharging with 5kV. It is found that the joined sections are two lines along the welding seam. The difference with the two welding methods is that the width of the welding line is larger when the background field is applied. The welding will be more reliable with the wider weld lines.

III Conclusion

It is obvious that this method can improve the welding quality via the numerical simulation and experimental results. This method is very useful when the plate is thick and the single coil does not complete the welding process. This welding method can also be applied to the welding of pipes. When the need of the background field intensity is not strong, the background field can be replaced by permanent magnets.

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