

**Review Article**

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# Production Methods of Laminated Al Alloy Composites

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**\*Corresponding author:** Yalun Sun, Beijing Institute of Technology, China.**Received Date:** July 05, 2019**Published Date:** July 19, 2019**Abstract**

Al alloy is widely used because of its versatility. Al can alloy with a variety of elements and produce materials with different properties. Efforts have been made to join two kinds of Al alloys together. This combination can take both materials' advantages and may even have superior property over both starting materials. Researches showed that the combination of certain alloys can help improve the corresponding property, such as mechanical strength and thermal/electrical conductivity. Another practical use is to reduce the overall price while remaining acceptable properties. In this paper, 6 different methods for producing laminated metal composites (LMCs) were briefly reviewed.

**Keywords:** Al alloy; laminated metal composites; Bonding**Introduction**

Aluminium (Al) is the third most abundant element, after oxygen and silicon, in the Earth's crust. It is remarkably light its density is only around 1/3 that of Fe, giving it advantage in applications in vehicles and aircrafts/spacecrafts. Although Al is highly reductive, it can resist environmental oxidation and corrosion due to a dense layer of  $Al_2O_3$  which naturally forms on the surface. The oxide layer is only a few micrometers thick, so it does not have a huge influence on the purity, meanwhile, it is highly effective in protecting the inner Al from contact with the oxidizer in the environment [1]. Al is almost always alloyed to improve the mechanical properties. Even the industrial pure Al can be considered as an alloy with Fe and Si. Al alloys can be divided into two major categories: casting compositions and wrought compositions [2]. While the Al melts during casting, wrought alloy remains solid during the processing. All kinds of efforts have been made to improve the mechanical strength of the alloy. One way to improve the mechanical properties is to alter the microstructure of the alloy. Research shows that the crack growth in ultrafine and coarse grain Al alloys will be different. It is possible that the grain boundaries in the ultrafine grain Al alloy can capture the crack and hinder its further growth [3]. Another way is to dope the alloy. Researches show that doping with Nb helps improve the thermal stability [4] while doping with SiC,  $Al_2O_3$ , and MgO can improve the alloy's yield strength, ultimate tensile strength (UTS), hardness, and decreased elongation (ductility) [5-7]. Despite the promising results, the improvement of performance is always accompanied with an increase in price. However, producing Al alloy

LMCs may help with obtaining both reasonable price and desired properties.

**Methods for Joining Alloys**

A variety of methods have been developed to join different metals and they have their own strength and limitations. The main idea of the joining methods is to form a transition area at the interface. The produced composite can be a good combination of different properties [8,9].

**Roll bonding**

Roll welding is a type of pressure welding or solid-state welding techniques where bonding is established by joint plastic deformation of the metals to be bonded [10]. It is the establishment of an atom-to-atom bond between two pieces to be joined through intimate contact between contaminant free areas [11]. In roll bonding, a threshold degree of deformation has to be reached to achieve the bonding. Roll bonding can be split into warm/hot roll bonding and cold roll bonding, and the difference lies in the operation temperature. While hot roll bonding may require 700–1000°C, cold roll bonding can happen in room temperature [12]. Parameters including the amount of deformation [13-18], the metal under consideration [19], the temperature of welding [20-22], etc. will influence the properties of the obtained material. All these parameters will have similar influence on samples prepared by similar process. The manufacture procedure of roll bonding has

been well established, which brings down the price. However, roll bonding, especially cold roll bonding, requires high purity of the metal's surface [23].

### Diffusion bonding

Diffusion bonding is useful in joining metals that has initial oxide layer and/or forms brittle intermetallic in the bonding region, because diffusion bonding requires more smoothness than the composition of the bonding surfaces. The point of diffusion bonding is to provide a greater contact area, in order to increase the atomic diffusion paths [24]. Since no surface is absolutely flat, the workpiece to be bonded should be plastically deformed locally through an applied stress. If the flow stress of the material is high, the applied stress will not be enough to cause local plastic deformation of this material. Then many voids and pores will remain at the interface after diffusion bonding. In this case, a good joint cannot be achieved, and the bonding quality will be degraded. Although higher pressure or longer heating time could improve the bonding effect for these high strength materials [25-27], the manufacturing cost will be increased [24,28].

The predominant process parameters in diffusion bonding process are bonding temperature, bonding pressure and holding time [29-33].

### Explosion welding

Explosion welding (EXW) is a solid-state metal-joining process that uses explosive to create an electron-sharing metallurgical bond between two metal components. It has successful joint all kinds materials [34-40]. Although the explosive detonation generates considerable heat, there is not time for heat transfer to the component metals; therefore, there is no appreciable temperature increase in the metals [41]. To achieve a good weld result, some conditions need to be met, which is called as a weldability window or criteria. A weldability criterion based on the collision point velocity ( $V_c$ ) and on the collision angle ( $\beta$ ) is the most used today [42]. The advantage of EXW is that it can join different kinds of materials. It also has no restrictions on the size or surface condition of the material because the detonation wave can help remove the oxides or contaminations on the surface. However, because it is based on explosion, the obtained materials always need some post process. Also, this method performs better on thick plates.

### Friction stir welding

Friction stir welding (FSW) uses simple and special designed tool with a shoulder and a pin (or probe) which causes thermomechanical action for joining the materials [43]. It is efficient in joining soft and low melting point alloys; therefore, a large amount of Al and Mg alloys have been clad using this method [44-49]. FSW is suitable for some critical applications such as welding of high strength pipelines, but the width and depth of the alloys that can be joint are restricted by the size of the pin.

### Hot pressing

Hot pressing has been applied on bonding Mg and Al [50,51]. In this case, powdery solder is needed. In the mentioned reference,

Mg-Al eutectic alloy was used as the solder for joining Mg and Al, and it was operated under 400–500°C. This method used to require a duration of high temperature and pressure of 2h [50], but the more recent modification of this method shortened the duration to no more than 1 min [51].

### Direct-chill casting

Direct-chill (DC) casting is the major production route for wrought aluminium and magnesium alloys that are later deformed (rolled, extruded, forged) to the final products [52,53]. Using a double-stream-pouring in direct-chill casting gives the possibility of producing a bi-metal or sandwich structured slabs [54-56].

### Conclusion

In conclusion, the above-mentioned methods are suitable for joining two alloy slabs. However, problems such as the oxidation during production may result in a weak bonding between different components. Therefore, further improvements are still in need to satisfy the requirements for Al alloy LMCs.

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### Conflict of Interest

No conflict of interest.

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