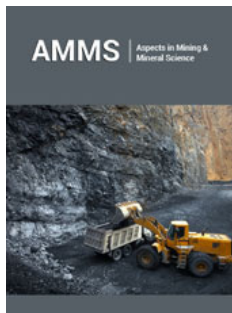


Application of Friction Welding in Electric Vehicle Construction

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Abstract

The massive electrification of vehicles is essential to achieve climate objectives. An electric vehicle emits significantly less greenhouse gases than a conventional thermal vehicle. Electric vehicles present unprecedented challenges that all car manufacturers must face. The autonomy and price of vehicles remain at the heart of consumers' concerns. Manufacturers must turn to new, and more efficient production methods. Friction welding is an assembly process that can meet these concerns. This process has several advantages such as reducing the weight of the car because it does not use a filler metal, which also reduces the cost of its production.

Keywords: Electric vehicle; Friction welding; Metals

Abbreviations: EVs: Electric vehicles; FSW: Friction Stir Welding; RFW: Rotary Friction Welding; LFW: Linear Friction Welding

Electric Vehicle

An electric vehicle is a car that runs entirely on electricity (Figure 1). This energy is stored in a rechargeable battery. One or more electric motors powered by the battery propel the vehicle. Of course, electric vehicles do not require fuel and do not emit exhaust gases, making them more environmentally friendly than cars with a combustion engine.



Figure 1: Electric vehicle.

Types of electric vehicles


Electric vehicles can be divided into two types :

- a. Type 1: 100% electric vehicles: are vehicles cars that run entirely on electricity stored in their battery.
- b. Type 2 : Hybrid vehicles are vehicles that combine a gasoline engine and an electric motor. The motors work in tandem to power the car.

According to economic statistics, sales of electric vehicles continue to grow. This is due to the technology, which is now mature and constantly improving. Another reason for this growth is that electric mobility now appears essential to reduce the impact of transport on the environment [1].

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Electric vehicles components

The main electric vehicle components or parts are:

- a. The Electric Motor: The electric motor is the heart of an electric car. It converts electrical energy into mechanical energy.
- b. The Battery to Power the Motor: Electric car batteries, which store electrical energy onboard, come in many shapes and sizes.
- c. Converter : It functions to change the Direct Current (DC) on the battery into an Alternating Current (AC) and then this alternating current is used by an electric motor.
- d. The Electrical Control Unit: The electrical control unit is the brains of an electric car. It is a small computer that receives data from sensors and other systems and then sends commands to the electric motor, battery, and charging system.

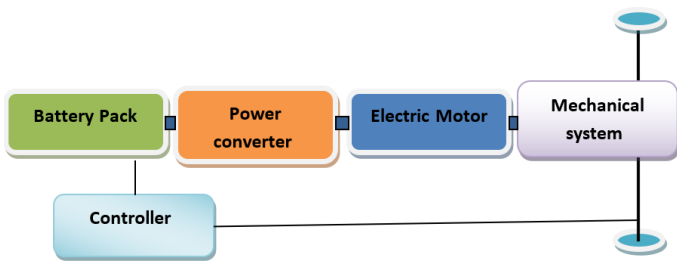


Figure 2: Components of electric vehicle.

- e. Mechanical System: It is the part that transfers mechanical power from the electric traction motor to drive the wheels [2]. Figure 2 gives an idea about the main components of electric vehicle.

Friction Welding Processes

Definition of friction welding

Friction welding is a category of solid-state welding. Friction welding is now well established as one of the most economical and productive methods of joining similar and dissimilar metals together. It is widely used in automotive and aerospace industry applications. Friction welding is often the only viable alternative in this area to overcome the difficulties encountered when assembling materials with very different physical characteristics. This process uses a machine designed to convert mechanical energy into heat at the weld joint using the relative movement between the parts, without using electrical energy or heat from other [3].

Types of friction welding processes

Generally, friction welding is divided into three types:

Rotary friction welding (RFW): The RFW process involves rotating one component at high speed while the other remains stationary. When the rotating component is pressed against the immobile component, frictional heat is generated (Figure 3a). Once the desired temperature is reached, the rotation stops, and additional pressure is applied to join the parts. This method is widely used for joining cylindrical components, such as drill pipes and drive shafts [4].

Linear friction welding (LFW): The two materials to be welded are forged using friction heat through the controlled reciprocal linear oscillation movement of two components under high contact load (Figure 3b), [5].

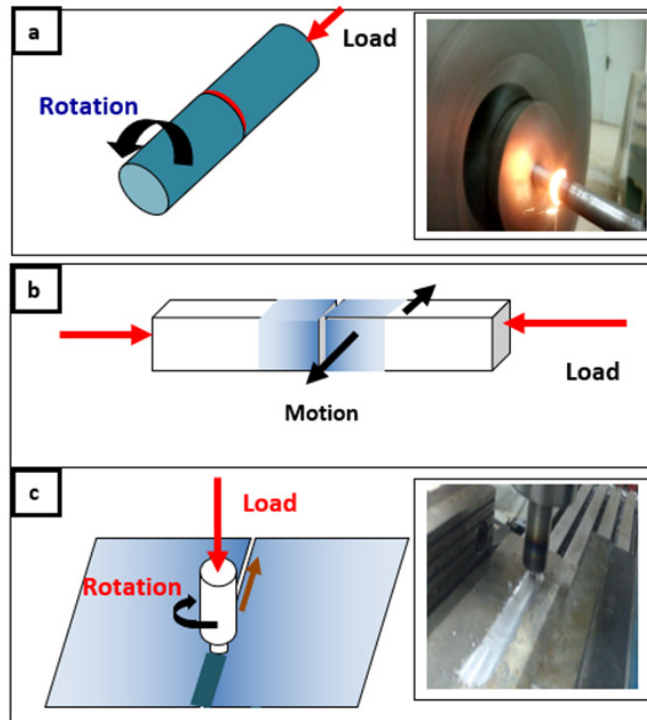


Figure 3: The three types of friction welding: (a): Rotary Friction Welding (RFW), (b): Linear Friction Welding, and (c): Friction Stir Welding (FSW).

Friction stir welding (FSW): In friction stir welding, a welding tool, consisting of a shoulder and a specially designed pin, is plunged into the plates to be welded, while rotating and advancing at a welding speed along the joint line until the plates are joined (Figure 3c), [6].

Friction Welding in Electric Vehicle Construction and Scientific Research

Friction welding in electric vehicle construction

Friction stir welding is considered a desirable process for the production of lighter, more energy efficient, safer and more durable vehicles. The FSW is used for the manufacturing these components of EVs:

- a. Stiffened panels
- b. Cast Aluminium Heat Exchangers
- c. Battery trays
- d. Engine Blocks
- e. Chargers for Electric Vehicles

In addition, the other two types of friction welding (Friction rotation and linear friction) are also used in the manufacturing of some parts of the electric car:

- i. Rotary friction welding is used to join aluminium alloys to copper alloys for electrical connectors.
- ii. Rotary friction welding is applied to join copper to aluminium for battery cables.
- iii. Linear friction welding is used to weld copper plates to aluminium plates for heat exchanger manufacturing [7].

Scientific research

It is important to mention that some research works have been devoted to the use of friction welding in the manufacturing of some components of the electric vehicle. For example, Akiyama et al. [8] investigated the friction welding of lightweight motor shafts for electric vehicles. To reduce both the weight of the shaft and the manufacturing cost, a hollow shaft structure was developed by these researchers. It was welded from a tube and solid parts by ultra-precise friction welding. Patel et al. [9] conducted a research work on the application of high welding speed in friction stir welding of lightweight battery trays in the electric vehicle industry. This welding technique produced a defect-free weld joint. Mypati et al. [10] attempted to join micro-thick copper (Cu) and aluminium (Al) sheets by friction stir welding. These materials are used as current collectors in lithium-ion (Li-ion) batteries, used in electric vehicles. They found that the welded samples achieved 9% lower electrical conductivity than base Cu and the corrosion resistance of the welded samples increased due to the formation of intermetallic compounds at the weld interface. Kim et al. [11] attempted to optimize the FSW welding parameters of fillet joints

in the production process of electric vehicle battery frames and improve the quality and mechanical performance of the product. Li et al. [12] performed Friction Stir Welding (FSW) of multilayer copper foils to obtain flexible copper connections. They studied the correlation between microhardness profiles, conductivity test data, weld morphology, and process parameters.

Conclusion

From this literature review about the application of friction welding in the manufacturing of electric vehicles, some conclusions can be deduced:

- a. The three types of friction welding (Stir, rotary, and linear) have been used in the manufacturing of some elements of the electric car.
- b. Friction welding allows joining dissimilar metals such as welding copper to aluminium for the manufacturing of electrical connections.

In addition, scientific research is needed to study the welding of other metals and metal alloys that can be useful in the manufacturing of electric vehicles in order to improve their performance.

Acknowledgement

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