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WELDING TECHNOLOGY APPLICATIONS IN AUTOMOTIVE INDUSTRY

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ABSTRACT

Basically, welding is used to obtain permanent joint of two metals through localized application of suitable combination of temperature, pressure and metallurgical conditions. A wide variety of welding processes have been developed by different combinations of temperature and pressure. Welding is the principal means of fabricating and repairing of metal products and is used in every industry. Amongst the major areas of applications, welding is extensively used in automotive industries. Welding is invariably used in the automotive industries for joining variety of structural components and engine parts. The constant demand for new improved material requirement for automotive applications necessitates the development of innovative joining techniques. In this paper, the welding techniques commonly adapted in the automotive industries are discussed. Illustrative diagrams and specific automotive applications are included in the paper. The novel technique of joining dissimilar metals viz., magnetic pulse welding is also discussed. The latest update on medium frequency welding method used by auto manufacturers is also presented with its technical and operational merits.

Keywords: Automotive Applications, Magnetic Pulse Welding, Medium Frequency Welding, Welding

I. INTRODUCTION

Basically, welding is used to obtain permanent joint of two metals through localized application of suitable combination of temperature, pressure and metallurgical conditions. A wide variety of welding processes have been developed by different combinations of temperature and pressure. Welding is the principal means of fabricating and repairing of metal products and is used in every industry [1]. Amongst the major areas of applications, welding is extensively used in automotive industries. The most commonly used welding methods for automotive applications include resistance spot welding (RSW), resistance seam welding (RSEW), metal inert gas (MIG) welding, tungsten inert gas (TIG) welding, laser beam welding (LBW), friction welding (FW) and plasma arc welding (PAW). The advanced welding processes for automotive applications have been developed envisaging reduction in vehicle weight and increase in fuel efficiency [2]. In conventional welding methods, an additional material is always added to the weld joint that flows into the materials to be joined to produce an extremely strong bond. The added metal at each weld increases the vehicle weight which in turn

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decreases fuel economy. In this paper, welding techniques used in automotive applications viz., RSW, RSEM, FW, LBW are discussed. The advanced technique viz., magnetic pulse welding (MPW) process used to produce lighter weld components is also presented. The latest welding technology i.e. medium frequency welding (MFW) used in the automotive industries is also discussed in this paper.

II. AUTOMOTIVE APPLICATIONS OF WELDING

A wide variety of automobile body components are joined together using welding techniques. The necessity for development of new welding techniques for automotive applications is ever growing to meet the new material combinations for auto body parts. The requirement for innovative welding processes is felt strongly in the recent days with automotive manufactures focusing on lighter yet strong and fuel efficient vehicles employing light weight alternative materials. The most commonly used welding techniques in automotives applications are explained in the following sections.

2.1 Resistance spot welding

The conventional steel body of a car, on an average, contains 4500 spot weld joints. Resistance spot welding is the principle joining method used in automotive industries and has been for many years. In this method the joint is produced by the heat generated due to the resistance of work pieces to the flow of current and application of pressure [3]. The weld is limited to the spots on overlapped work pieces and hence not continuous. The pointed copper electrodes conduct the welding current to the work spot and also serve to apply pressure to form the strong joint as shown in the Fig. 1.

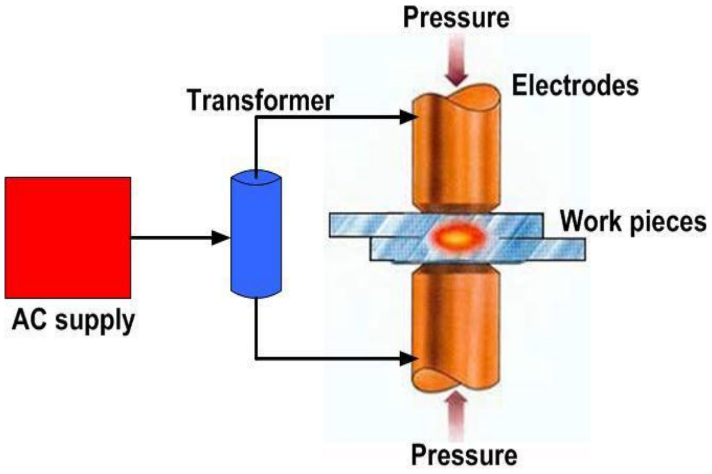

Fig. 1 Resistance spot welding

RSW is automated and used in the form of robotic spot welding in automotive industries to weld the sheet metals to form car body. Industrial robots spot welding the car body in production line is shown in the photograph given in Fig. 2.

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Fig. 2 Industrial robots welding car body (Source: Rexroth- Bosh group) [4]

2.2 Resistance seam welding

In this type of resistance welding, the joint is produced progressively along the length of the weld. This gives a continuous and leak tight joint in sheet metals. The weld may be made with overlapping or continuous work pieces. In automobile industries, this welding process is used to produce leak proof fuel tanks. The principle of RSEW is depicted in the Fig. 3. This process provides high welding speeds, but its applicability is limited by component shape and wheel access. A seam welding process in operation is shown in Fig. 4.

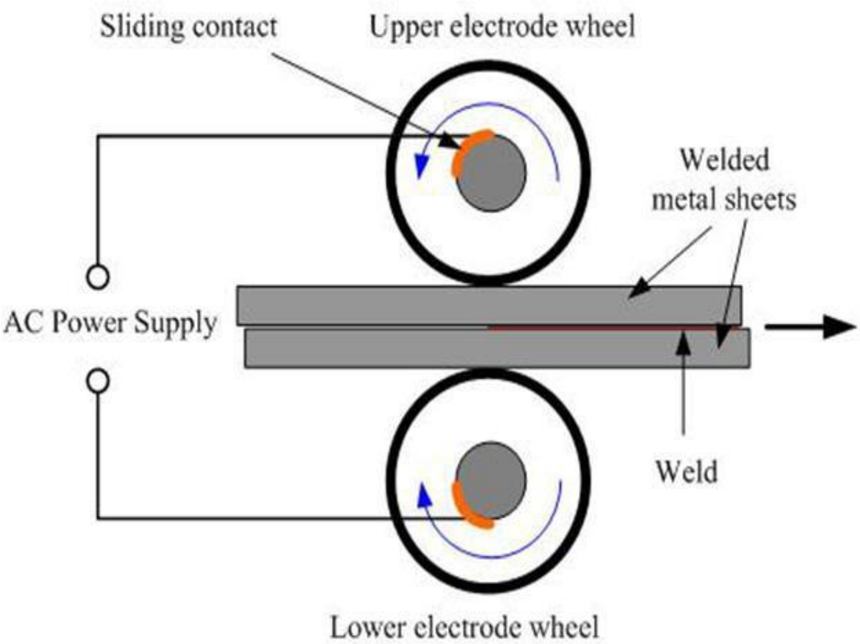

Fig. 3 Principle of resistance seam welding

Fig. 4 RSEW producing continuous joint

2.3 Friction welding

In solid state welding the joint is produced by the application of pressure without significant melting any of the work parts. Friction welding is a form of solid state welding where the heat is obtained from the mechanically induced sliding motion between the parts to be welded [5]. The weld parts are held together under pressure. Generally, the frictional heat is generated by rotating one part against the other. When certain temperature is reached, the rotational motion is seized and the pressure applied welds the parts together. The two shafts joined by FW process is depicted in Fig. 5. This welding process can be controlled by regulating the time, rotational speed and pressure.

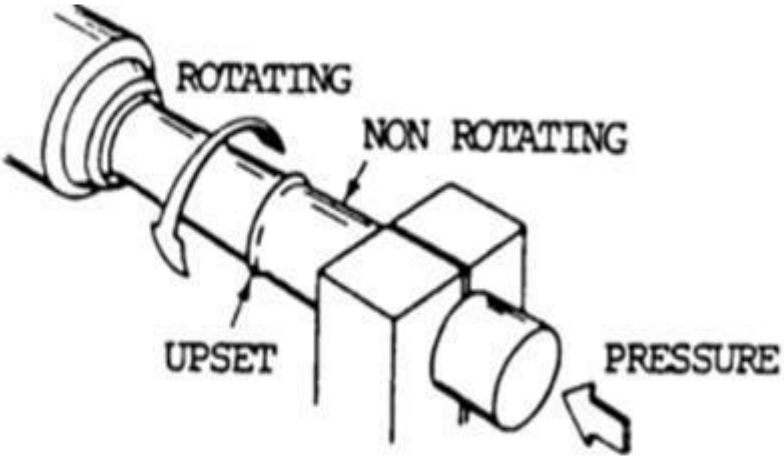

Fig. 5 Shafts joined by friction welding process

The metallic materials possessing certain degrees of plasticity at high temperature and thermal stability can easily be friction welded. Although all common engineering alloys can be friction welded, cast iron is an exception. In automotive industries, the FW is used to fabricate a wide range of components including half shafts, axle cases, steering columns, hydraulic cylinders, pistons rods and engine valves etc. The Fig. 6 shows few friction welded automotive components.

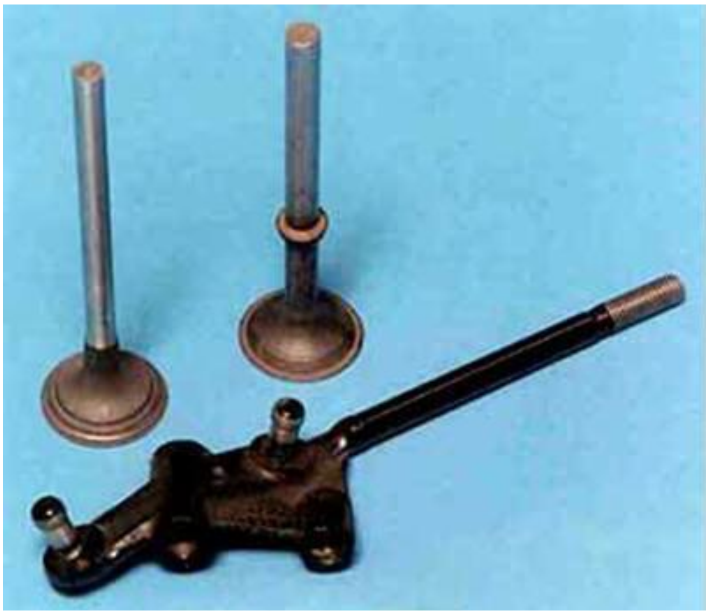

Fig. 6 Friction welded automotive components (Engine valves and tie rod)

2.4 Laser beam welding

The application of laser technology for welding the high volume automotive components has gained popularity because of its distinct advantages. The main benefits include good flexibility, improved productivity with substantial saving on maintenance and energy cost while producing a strong weld. The LBW process uses the heat generated when a focused laser beam impinges on the joint. Metal sheets having thickness in the range 0.2 to 6mm can easily be laser welded. Majority of the automotive industries employ cross flow CO2 laser system in the power range of 3 to 5 kW [6]. The schematic arrangement of components of a typical laser welding system is depicted in the Fig. 7.

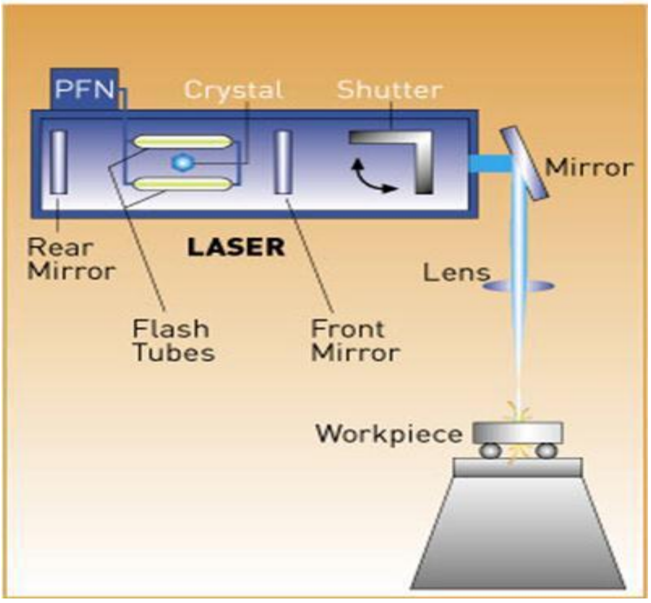

Fig. 7 Diagram of laser beam welding

The laser beam directed on the workstation is focused on the parts to be welded using the copper mirrors. It is a non contact process and well suited for automated applications. The process parameters such as laser power, speed and focused spot size determine the weld depth and width. A beam from one laser source can easily be switched to several workstations allowing optimum utilization of laser for different welding functions. This inherent flexibility of LBW satisfies high volume automotive production requirement for different part geometries without extensive set up. The Fig. 8 shows welding of low carbon steel sheet using CO2 laser system.

Fig. 8 Laser beam welding of low carbon steel sheet

Joining automatic transmission components found particularly suited for LBW. The components produced from powder metallurgy (PM) process are increasingly used in the automotives. The performance of PM components is characterized by combination of finished density, composition of alloying elements and part microstructure. These factors provide greater flexibility to determine weldability of PM components. The density is reported to have pronounced influence on performance and weldability [7]. The other automotive applications LBW include welding of roof to the side panels of car body structure. A continuous water tight joint with better accuracy can be obtained as less material is displaced. Also, post treatment of the weld is not necessary [8]. The evaluation of laser beam process for joining hinges to the reinforcement structure of car door is presented by Quintino et al., [9, 10]. The CO2 laser equipment giving output power of 6 kW was used in the evaluation. The surface finish of the parts affected porosity formation with LBW, hence improved surface finish can overcome this problem.

2.5 Medium frequency welding

The medium frequency welding is a type of resistance welding and latest offering from Bosch-Rexroth Ltd, Great Britain. The Fig. 9 depicts the basic working principle of MFW. In this welding process, the three- phase 50 Hz alternating current (AC) is rectified and supplied to an inverter. The inverter converts the current to a frequency of 1000 Hz (medium frequency) and is fed to a transformer, usually integrated into the welding gun [4]. Hence the welding current available is always direct current (DC). The technical and operational merits of MFW are listed in the Table 1.

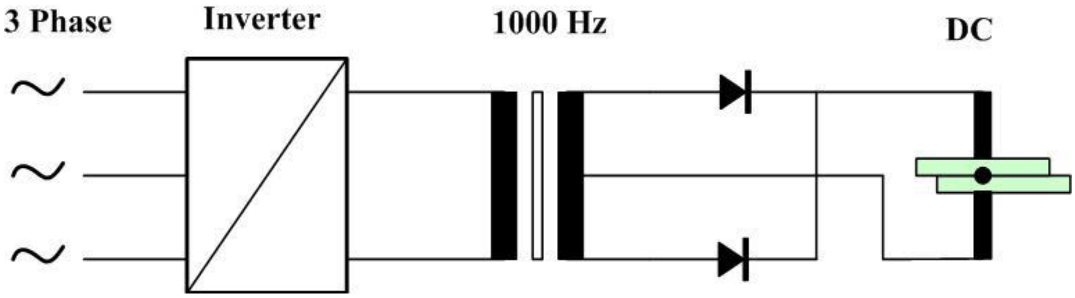

Fig. 9 working principle of MFW

Table 2 Technical and operational advantages of MFW

Sl. No.	Merit	Description
1	Reduced bill	It is less demanding on electrical distribution network since it draws current from all the three phases. This in turn results reduced electricity charges.
2	More tolerant	The welding current is supplied thorough an inverter and hence the process is more tolerant of mains disturbances.
3	Higher operating efficiency	As much as 25 % power savings can be achieved against single phase AC system. The transformers used are more compact and lighter. Most suitable for robotic applications. Hence robots can be made smaller and less power is expended in moving welding gun.
4	Faster welding	Due to reduced or no current fluctuations weld times are approximately 15 % shorter and can be controlled to millisecond. This gives 20 times more accuracy than 50 Hz AC supply. Since there is no resistance in the welding arm, the arm lengths and tip characteristics do not affect weld times. The enhanced tip life results in considerable savings on tip dressing and consumables.
5	Cleaner weld	It gives high quality weld with peak voltage is almost same as RMS voltage. No splash or sparks are present in the weld.
6	More material choices	The process is controllable to high accuracy. Difficult to weld materials such as high strength steel, aluminium, laminated steels, polymer composites, coated steels etc can be welded easily.

2.6 Magnetic pulse welding

The demand for lighter and fuel efficient vehicles has increased in the recent days. The automotive manufactures strive to produce lighter components. This helps to make existing cars more fuel efficient and meet the requirement of alternative fuel powered vehicles viz. fuel-cell powered cars and hybrid gas/electric vehicles. The use of lighter material like aluminum and development of new manufacturing processes using less steel in weld can help to achieve the above goal. The additional material deposited on weld joint as in conventional welding process increases the weight of the welded component. The MPW is a novel technology

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developed by Dana Corporation, USA for bonding aluminium and steel (dissimilar metals) without using additional metal at the weld joint [2]. In this method, the pre-shaped aluminum and steel tubular stock are subjected to high pressure using precision machined die cavities. This process is called hydro-forming and results in more precise fitting of structural components requiring very little fill material in the subsequent welding steps.

The hydro-formed components are then fitted together loosely. A rapidly switching magnetic field produced by an inductor (either internally or externally) causes one of the metallic components to form quickly and impact the other stationary metal part with sufficient velocity and force to create a weld. This requires high end machines to produce proper welds in complex geometric designs. The MPW process enhances manufacturing productivity due to reduction in production steps, materials, equipments and personnel expenses. The vehicle frame welded with MPW process is reported to be two–thirds lighter resulting in 8-10% improvement in fuel efficiency. This further reduces air pollution. The reduced energy consumption and shielded gases further aid to decrease air pollution. The MPW process is more efficiently used to produce automobile parts such as frames, side rails, cradles, stampings, space frames, and bumper reinforcements (Fig. 10).

Fig. 10 Automobile components (frames) produced by MPW process

With the commercialization of MPW process, it is possible to weld dissimilar metals (bimetallic welding) most effectively. This helps to design new geometries for automobile transmissions and undercarriage systems using different combinations of lighter materials to enhance fuel economy and cost savings.

III. CONCLUSIONS

The automotive application of permanent joining methods is discussed with illustrative diagrams. The resistance welding techniques namely spot and seam welding are presented with specific applications. The solid state welding method viz. the friction welding is also discussed. The need for innovative and cost effective welding methodologies to meet the growing requirement of lighter and fuel efficient vehicles is highlighted. The technological advancement in the metal joining in the context of auto industry is presented. The working aspect of medium frequency welding is briefed with its distinct merits. The magnetic pulse welding-a breakthrough in metal joining technique is also explained. The following points concluded from this above study.

- The automotive manufacturers focused on producing lighter yet strong and fuel efficient vehicles using new improved alternative materials. This necessitated most efficient welding techniques that produce lighter weld joints without adding additional material.
- The commercial implementation of magnetic pulse welding can prove advantageous for automotive industries to manufacture lighter and fuel efficient cars.
- The advancement in laser beam welding and medium frequency welding allows evolving new geometries for automobile transmissions and undercarriage systems using new combinations of materials, particularly made from powder metallurgy process.

IV. ACKNOWLEDGEMENTS

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