RESISTANCE WELDING MANUAL

Revised Fourth Edition

RWMA®

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1

Fundamentals Of Resistance Welding

INTRODUCTION

Welding consists of the joining of two or more pieces of metal by the application of heat and sometimes of pressure.

Resistance welding embraces that branch of the welding art in which the welding heat in the parts to be welded is generated by the resistance offered by these parts to the passage of an electrical current. It differs from other forms of welding in that no extraneous materials, such as fluxes, filler rods, etc. are used; therefore, the metallography of the weld is not complicated by the addition of these materials. Resistance welding further differs from the fusion welding processes, by utilizing the application of mechanical force to forge the heated parts together. The effect of the force is to refine the grain structure, thus producing a weld with physical properties, in most cases, equal to the parent metal, and sometimes even superior.

Resistance welding machines and their operation often appear mysterious to the layman when he sees good welds being made quickly and easily. The same characteristics may lead the beginner to believe the process more simple, or more generally applicable, than is true. It is the aim of this introductory discussion to review the fundamentals of the process and to discuss some of the more basic details.

Welding is really a metallurgical process. Ordinary iron has been described as a suspension of ferrite crystals of variable compositions in a matrix of its own impurities. It is this matrix of impurities that increases the electrical resistance of all metals which is of real importance in electrical resistance welding.

RESISTANCE WELDING PROCESSES

Figure 1.1 illustrates, in graphic form, the resistance welding processes[1] and their relation to one another. It should be noted from this chart that the general subject of resistance welding may be broken into two general classifications according to the method of joining the parts. (The same classifications may also be applied to other welding processes).

1 See also the latest revision of *Standard Welding Terms and Definitions*, an American Welding Society (AWS) publication.

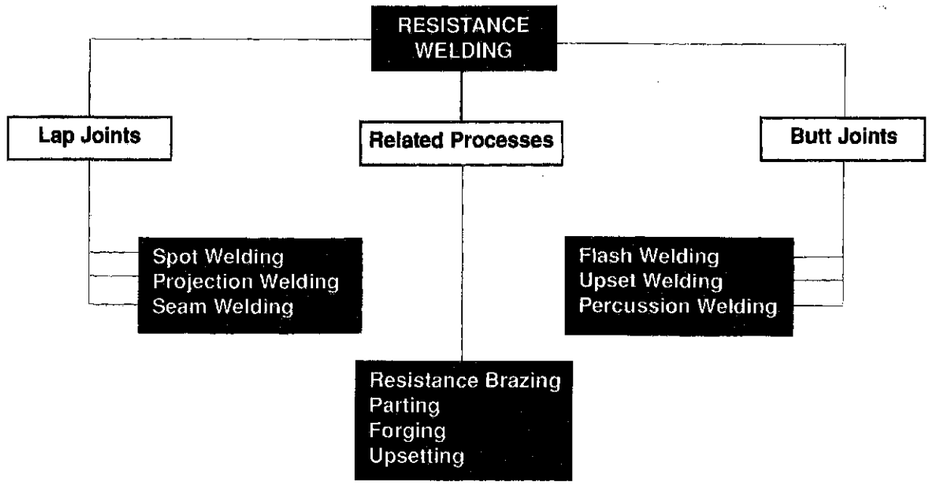

Fig. 1.1 - Resistance Welding Processes

Lap Joining. This is a method whereby the electrodes conduct the welding current and at the same time apply the welding force. This method includes not only any kind of lap joint but also any joint in sheets, plates, rods and bars in which the weld is not made end-to-end or edge-to-edge.

Spot Welding. Spot welding is the most widely used example of lap joining, and it is accomplished with shaped electrodes held essentially stationary while the weld is made.

Projection Welding. By forming projections in one or both of the workpieces, the current path is localized at the projections. This permits the use of flat electrodes, thus producing projection welds.

Pulsation Welding. Normally a spot or projection weld is made with a single application or impulse of current. If, however, the flow of current is interrupted and reapplied one or more times without release of electrode force, a pulsation weld results.

Seam Welding. Seam welding is quite similar to spot welding, but the electrodes revolve and are actually in motion while the weld is being made.

Roll Spot Welding. If interrupted current is used—regardless of whether the wheels rotate continuously or intermittently—and if the timing is such that the welds do not overlap, the resulting joint is called a roll spot weld.

Butt Joining. Butt joining is that method in which the weld takes place on the ends of bars or the edges of sheets or plates. The electrodes introduce current to the two members being welded, and may or may not be used to transmit the upset force. If they are used to transmit the upset force, it is accomplished through the gripping action of the electrodes or clamp jaws; otherwise, upset force is provided by means of auxiliary clamp members or backup members.

Flash Welding. If two rods or bars, for example, are clamped end-to-end, with the abutting ends making light contact with one another when current is applied, a flashing action develops. As this flashing proceeds, metal is burned away, requiring one piece to be moved toward the other to maintain the flashing action. As this takes place the ends of the two pieces attain welding temperature, at which time an upset force is applied, thereby completing the weld.

Upset Welding. If two rods or bars, for example, are clamped end-to-end in electrodes, held in contact with one another as welding current and force is applied, the resultant joint is an upset weld.

Percussion Welding. This is usually classed as a resistance welding process, although it technically is not, since no heat is generated by the resistance of the workpieces. Instead, the welding heat is generated by an arc developed with the two pieces becoming spark-gap electrodes. Actually, it is a process wherein coalescence is produced simultaneously over the entire area of abutting surfaces. The heat is obtained from an arc produced by a rapid discharge of stored electrical energy, with force percussively applied during or immediately following the electrical discharge.

Figure 1.2 illustrates the principal types of resistance welds; they are: spot welds, seam welds, projection welds, upset welds and flash welds.

RELATED PROCESSES

In addition to welding, related applications or processes, such as resistance brazing, parting, forging and upsetting are included in this general subject. This is because the heat required for these processes is also generated by the resistance of the parts to the passage of electrical current.

Resistance Brazing. Some metals, such as copper, silver, tungsten, molybdenum, etc., are difficult or impossible to resistance weld, but are very readily resistance brazed. In this case, the brazing methods used are similar to gas or furnace brazing, except that the parts are placed between suitable electrodes in a resistance welding machine and held under light contact force while current is applied. If the electrodes are tungsten, molybdenum or similar material, the brazing temperature is generated by the resistance of the workpieces. If the electrodes are carbon or graphite, they become white hot and essentially all the brazing is obtained by conduction from these electrodes. This type of brazing is frequently termed *incandescent brazing* and is usually used for brazing large sections, such as electrical conductors, bus bars, etc.

Resistance Parting. This is the reverse of upset welding—a bar or cable is placed in the welding electrodes, a current and a force is applied to separate the workpiece midway between the electrodes. As the metal gets hot, it stretches and finally parts. In the case of a solid bar, each piece will have a pointed end. With a cable there will be some tapering down where the individual strands fused together.

Electro-Forging and Upsetting. If a solid bar is clamped and current applied, as in an upset weld, that metal between the electrodes reaches a forging temperature and upsets or forges if a force is applied, similar to an upset weld.

FUNDAMENTALS OF THE RESISTANCE WELDING PROCESS

General Principles

Weld. By definition, a weld is a localized coalescence of metal heated to a suitable temperature. This definition is all-inclusive and takes no cognizance of the method by which the weld is made, nor of the quality of the weld. Fusion welds which are made without the application of force require liquefaction and resolidification of the molten metal to consummate the weld. The result is a cast structure.

A resistance weld, on the other hand, is made under localized force which is maintained until the weld zone solidifies. The resultant grain structure is, therefore, of a higher order than that of the cast structure encountered with fusion welds.

In order to better understand the nature of resistance welding and how it is accomplished, it is best to consider a simple spot weld. The basic principles apply to all other resistance welding and heating methods except flash and percussion welding.

Generation Of Heat. A spot weld is made by pressing two or more overlapping pieces of metal together while an electrical current is passed through a localized contact area to heat the metal forming the weld nugget to the welding temperature.

One of the principles of resistance welding is to generate the heat energy in the weld zone very rapidly so that the minimum amount of heat will be dissipated by conduction to the cooler adjacent material. This requires a high rate of heat generation and is accomplished by passing a large value of current through the

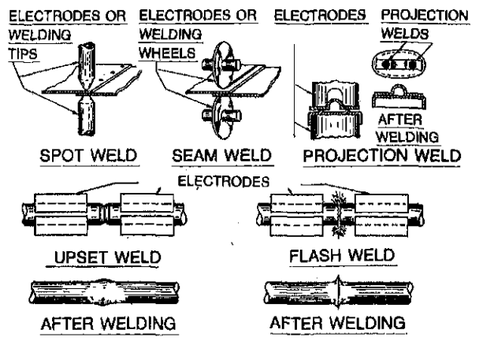

Fig. 1.2 - Principal Types Of Resistance Welds

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