Effect of Some actors Controling The Cold Presc ire Brazing of Metals

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SUMMARY

The aim of the present investigation is to study the effect of some factors which control the cold pressure welding and brazing of aluminum. These factors are, the effect of weld percent deformation, the nature of the material used as brazing inserts, and the post heat treatment.

The base material, in the present work, was commercial purity aluminum, the braze materials used were copper and commercial lead strips.

A special butt welding apparatus was designed to perform the pressure welding process. Welding was carried out on a universal tensile compression testing machine of 5 tons capacity. Post heat treatment of welds was carried out in a resistance furnace where specimens were held verticaly by means of special fixture.

The post heat treatment temperatures were 100, 150, 200, 300, 400, 500 and 600 °C for Al-Al welds, while for Al-Cu-Al welds were 100, 200, 300, 400, 500 and 550 °C and for Al-Pb-Al welds were 50, 100, 150, 200,and 250 °C.

The tensile properties measured were the weld ultimate tensile strength and elongation percent (a measure of weld ductility).

The present experimental results led to the following conclusions :-

1. The welding started at about 115 % deformation for both Al-Al and Al-Cu-Al welds, while Al-Pb-Al started welding at about 18 %. The latter weld is thought to be a result of mechanical interlocking.

2. In the case of Al-Al welds, the strength increased rapidly with increasing deformation. The Al-Cu-Al welds showed a similar behaviour but the rate of increase was slower. In the case of Al-Pb-Al, the strength increased up to 200 % deformation and then levelled off after that.

3. In all cases the ductility of the welded joint increased with increasing the weld deformation.

4. The solubility of the brazing inserts in the parent metal was found to have no effect on the joint formation.

5. Al-Cu-Al welds with deformations below 170 % showed higher strengths than Al-Al welds for the same value of deformation. While the latter showed much higher strengths than the former above 170 %. The same behaviour was found for the percent elongation.

6. A post welding heat treatment of 45 minutes at 150 °C was found to give the best improvement in tensile strength at all deformations in the case of Al-Al welds.

7. For the Al-Al welds, the increase in post heat treatment temperature, led to an increase in weld ductility up to a cetain maximum temperature, above which the ductility decreased. The heating temperature at which the maximum elongation took place was found to be a function of weld deformation. The higher the weld deformation, the higher the temperature.

8. Post heat treatment of Al-Cu-Al welds led to a decrease in their strengths in all cases due to the formation of brittle intermetallic compound between Al and Cu. at the weld interface.

9. Post heat treatment of Al-Pb-Al welds, also, led to a decrease in their strength in all cases.

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INTRODUCTION

Pressure welding is undoubtedly the first welding process to be used by man. After temporary eclipse by fusion welding processes, it is beginning to be considered again. It lends itself to modern automatic methods of light assembly and has its main advantages in applications where low temperatures are necessary. A considerable amount of research has been carried out on the process during the last thirty years, trying to clarify the effect of these factors which controls the pressure welding process.

Pressure welding processes may be divided initially into those in which no heat is applied and those which employ some method of heating in order to assist the bonding. This heating may perform one or more of several functions-melting or evaporating surface contaminations, increasing the diffusion of atoms from one metal to the other and lowering the yield strength of parent metals.

Ruge defined the cold pressure welding process in its special sense as, "the joining of similar or dissimilar metals by pressing them together under compression with a temperature range lying under the lowest possible recrystallisation temperature ".

The pressure welding process, in both lap and butt welding was found to be affected by a number of factors.

One major factor, viz. the amount of deformation which the metal has to undergo under the applied pressure, was found to be the main creterion that controls a sound weld. The deformation amount calls for exteremely high pressures when carried out at room temperature while at elevated temperatures, the necessary pressure falls down considerably [(1) (2)]. This result indicates the possibility of its practical application. Recent investigations showed the possibility of getting sound welds at room temperature, with a corresponding low specific pressures, i.e. low deformation, by post heat treatment. The improved mechanical properties of post heat treated welds were found to occur at reasonable low temperatures and short heating time[(3)], a result which led to beneficial applications in industry.

When pressure welding dissimilar-metal combinations, the situation becomes further complicated. It is difficult to obtain a tangible pattern of behaviour from the literature on dissimilar-metal welding. But few investigations showed the possibility of getting enhanced bond by using intermediate inserts of metal foils which are dissimilar metals of mechanical properties different from the base metal.

The objective of this research is to study the effect of some factors which may affect the weld strength of commercial purity aluminum rods when butt welded. These factors are:

1. The effect of the amount of deformation, that the weld interface has undergone, on the weld strength of aluminum welded at room temperature, and without post heat treatment.

2. The effect of post heat treating temperatures, of aluminum rods welded at room temperature, on the weld strength.

3. The effect of metal foils used as inserts intermediate at the weld interface on the weld strength.

4. The effect of post heat treatment temperatures of cold pressure welds on the weld strength when using intermedite foils of dissimilar metals.

CHAPTER I

PHYSICAL FACTORS AFFECTING THE COLD PRESSURE WELDING PROCESS

The solid phase welding is the basic process in pressure welding, friction, wear, and powder metallurgy. The processes involved in the solid phase welding are many and it is not known to what extent each of the possible processes is important. Attempts have been made to find a "theory" of pressure welding[4] but, since welding can be carried out over a very large range of temperatures, pressures and deformations, no single comprehensive theory can be expected. At present, two theories are usually used to explain deformation welding.[2] [4] [5] The "film theory" proposes that, if two clean metal surfaces are brought into intimate contact, a weld will be created. Therefore, in deformation welding, the plastic flow serves to break up surface films and bring clean surfaces into contact.

The "energy-barrier theory" proposes that, even if clean surfaces are brought into intimate contact, no weld will result. The theory states that an "energy-barrier" exists that must be overcome before welding can take place. Deformation supplies this required energy. The energy-barrier hypothesis has not been developed in detail, so no quantitative comparison with experimental data is possible.

It is derived from a consideration of the variables that affect the threshold deformation. Thus, as will be seen later in this chapter, the variation of the thershold deformation with homologous temperature is consistant with the hypothesis. In fact, whatever the theory proposed to explain what the solid phase welding is, it was found that the process is affected by several factors, and what we can do now is to discuss the basic factors that can contribute something to it.

1.1. Attractive Forces

The surface of perfectly clean metal can be visualized as one half of a grain boundary. The lattice is perfectly right up to or nearly to the free surface. The surface atoms are probably in their lattice positions. However, they are not surounded by other atoms, as are the interior ones. They are thus capable of bonding to another piece of metal, that is, another aggregate of atoms. It is evident, then, that if we were to bring into contact two perfectly clean, atomically smooth surfaces of a metal, the resulting joint would be as strong as a grain boundary, i.e., stronger than the metal itself. Since the attractive forces between atoms is proportional to the inverse of the distance[6] fig. (1), the surfaces to be welded are to be brought close to a distance at which certain mutually attractive forces would take place. For copper, the

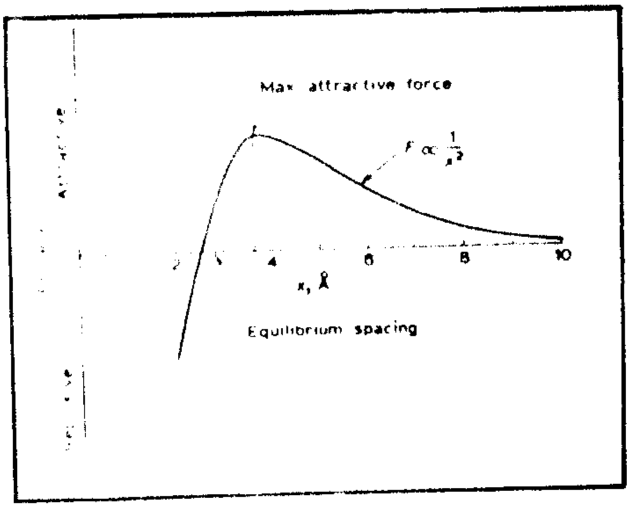

Fig.(1) Forces of attraction and repulsion
between copper atoms.

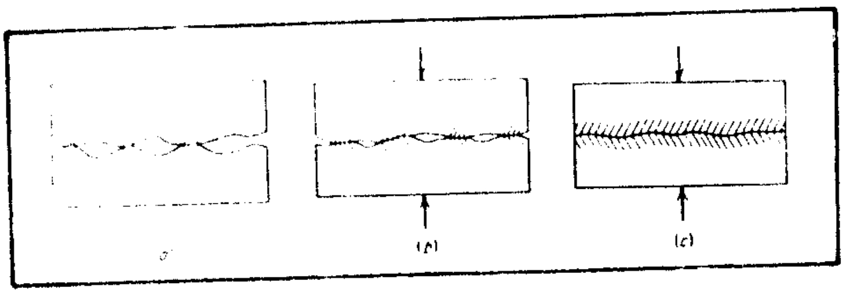

Fig.(2) Intimate contact between solids requires elastic and plastic flow.

a) When no pressure is applied, the surfaces contact only at asperities.

b) Under slight pressure, the contact area is increased by elastic and plastic deformation at the contact points.

c) When the pressure is sufficient to produce plastic flow over the entire surface, complete contact is ensured.