STATE-OF-THE-ART IN RIGID P.V.C. PLASTIC WELDING BY HOT AIR TECHNIQUE

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Abstract: This paper presents the state-of-the-art in the field of plastic welding to assist in the future developments in this field. Various important P.V.C. plastics welding parameters such as welding techniques in common use, equipments requirement and the effect of variables on the weld bead shape, have been discussed. Problem associated with plastic welding and applications have also been outlined.

Keywords: Poly vinyl chloride, P.V.C. welding, hot air technique, High-density polyethylene, linear low density polyethylene.

INTRODUCTION

Now a day’s plastics are used in everyday life from manufacture of toys, to utensil to complicated part such as heart valve etc. In many industry fields plastic part are frequently used [2]. Very demanding criteria must now be fulfilled by parts made of polymeric materials and polymeric composites [2]. Plastics have excellent strength to weight ratio, good corrosion resistance and ability to take good finish. Plastics can be categorized as thermosets and thermoplastics. Among these two only the thermoplastic is weldable. In case of thermosets resin, a chemical reaction occurs during processing and curing, that is, as a result of irreversible cross-linking reaction in the mold [3]. Both molded thermosets and vulcanized elastomer components cannot be reshaped by means of heating, because of the irreversible reaction that occur [3]. So in this case joining can be obtained by adhesive bonding and mechanical fastening only. On the other hand, thermoplastic can be softened and can be remolded by the application of heat, and can fusion welded. Thermoplastics can therefore be welded by three methods (a) Thermal, (b) Friction (c) Electromagnetic.

We will mainly focus on thermal method of plastic welding which can be further classified as (a) Hot tool method (b) Hot air technique (c) Infrared heating (d) Laser beam heating

PVC plastics are different from other geomembrane like HDPE, LLDPE, and fPP because it is primarily amorphous while others are semi-crystalline [6]. When PVC is heated it will soften [5, 6], that allow a limited amount of chain entanglements to assure a strong bond.

HOT AIR TECHNIQUE

Hot air technique is an external heating method. In this method, a weld groove and a welding rod are simultaneously heated with a hot gas stream until they soften sufficiently to fuse together; the welding rod is then pressed into the weld groove to affect welding. A stream of hot air or gas (nitrogen, air, carbon dioxide, hydrogen, or oxygen) is directed toward the filler and the joint area using a torch. A filler rod or tap (of a similar composition as the polymer being joined) is gently pushed into the gap between the substrates (Fig 1). The filler rod has a round cross-section, but it is also available in oval, triangular and rectangular cross-section [7] during welding, the gas temperature can range from 200 to 600°C, depending upon polymer being joined [3]. Here is a list of plastic welding temperature (in centigrade) [10] for different type of plastics.

Table 1 different type of plastics with welding temperature

<table>
<thead>
<tr>
<th>Plastics</th>
<th>Welding temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acrylonitrile Butadiene styrene</td>
<td>350°C</td>
</tr>
<tr>
<td>Acrylic</td>
<td>350°C</td>
</tr>
<tr>
<td>Hard PVC</td>
<td>220 - 300°C</td>
</tr>
<tr>
<td>Hypalon</td>
<td>600°C</td>
</tr>
<tr>
<td>Polyethylene (Hard)</td>
<td>250 - 280°C</td>
</tr>
<tr>
<td>Polyethylene (Soft)</td>
<td>270 - 300°C</td>
</tr>
<tr>
<td>Polyisobutylene</td>
<td>600°C</td>
</tr>
</tbody>
</table>
The melting temperature of PVC is not well-defined, owing to the large distribution in crystalline particle size [8] this results broad melting range. Most thermo plastic can be joined via hot gas welding but PVC is the major material being assembled by this technique [5]. Apart from PVC, there are some more plastic which can be welded by this techniques are polyethylene, polypropylene, acrylics, polystyrene, and polycarbonate.

**Table 2 Technical data of hot air gun**

<table>
<thead>
<tr>
<th>Power input</th>
<th>230V / 50Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power consumption</td>
<td>550 W</td>
</tr>
<tr>
<td>Pump</td>
<td>Diaphragm Pump</td>
</tr>
<tr>
<td>Temperature</td>
<td>100°C - 480°C (rotary knob adjustment)</td>
</tr>
<tr>
<td>Air-flow-rate</td>
<td>Max. 23 l/min (setting)</td>
</tr>
</tbody>
</table>

**HOT AIR PVC WELDING PARAMETER.**

The joining parameters of the hot air welding process are

**Table 2 Process parameter for hot gas welding [7]**

<table>
<thead>
<tr>
<th>Process parameters</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Temperature</td>
<td>Temperature of hot gas</td>
</tr>
<tr>
<td>2. Gas</td>
<td>Composition of hot gas (air, carbon dioxide, hydrogen, oxygen or nitrogen)</td>
</tr>
<tr>
<td>3. Angle</td>
<td>Include angle between weldment and rod, angle between gas nozzle and weldment.</td>
</tr>
<tr>
<td>4. Travel speed</td>
<td>Rate at which weld is being deposited</td>
</tr>
</tbody>
</table>

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Fig. 1 Schematic of hot-gas welding, showing the correct position of torch and filler rod for different thermo-plastic.

**WELDING PROCEDURE IN COMMON USE.**

For hot air technique welding hot air gun is used. The gun consists of a main body which contain heating element. This is a non contact soldering for high requirements. The air volume and the temperature can be set or adjusted in a wide range; the nozzles can be easily replaced so that each component is soldered by using the suitable nozzle, air and temperature setting.
1. **Air/gas temperature**: Air temperature depends on the type of polymer being joined, and which determines the heating elements, nozzle dimension and gas/air flow rates that are used [3].

2. **Gas**: Generally gas used for welding is air or N₂ [7].

3. **Angle**: Generally angle between the filler rod and weldment is taken as 90° and between gas nozzle and weldment is 45° [1].

4. **Travel speed**: The difficulty in maintaining a constant desired traverse speed is overcome by using milling machine table traverse [1]. Or travel speed can be measured by dividing the distance traveled of filler rod by time taken to travel this distance.

5. **Weld force**: Best result attains when welding force applied on the weld in the range of 10-20 N when welding shoe is employed, however, it is approximately 5 N [4].

6. **Filler rod**: The composition of filler rod is must be similar to the polymer being welded [3].

7. **Gap distance**: There is effect seen on varying the gap distance between the gas nozzle and workpiece. A plot of gap distance versus temperature is obtained as shown in figure.

8. **Welded joints**: generally two types of are used (a) but joint (b) double strap fillet joint.

   The sheet edges were cut to produce 60° single V-grooves. 9. and double V-grooves (X-grooves) [1, 4] shown in figure.

**Pressure of hot gas/air**: pressure can be varied from 1.4 – 2.8 MPa when shoe is employed. However it is approximately 0.7 MPa [4]

**APPLICATIONS AND LIMITATIONS**

Plastic welding is used to repair polyolefin tank, container and welding of PVC, ABS, PE and PP pipe section [3]. Apart from this it is also used in automotive industry (repair of bumper) construction, sealing and packaging of material etc.
The biggest disadvantage of hot gas welding is that the temperature of gas is high as compared to the melting temperature of polymer being welded; therefore process is less energy efficiency, and degradation of the polymer substrate is possible unless care is taken [3]. Weld quality is depends on the operators skill [4], which is standardize by EN 13067 (European Norms).

CONCLUDING REMARKS

In plastic welding joining is adhesive and weld bead is weaker than parent material [4] that’s why plastic welding is not very popular. In the field of plastic welding by hot air technique immediate work is needed as study of effect of current and voltage, optimization of the process etc.

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