

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

Mahmood Alam¹, (Dr.) M.I. Khan²

¹Asstt. Professor, department of Mechanical Engineering

²Professor, department of Mechanical Engineering
Integral University, Lucknow, India

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 (Fig1). 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 600⁰ 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

Plastics	Welding temperature
Acrylonitrile Butadiene styrene	350°C
Acrylic	350°C
Hard PVC	220 - 300°C
Hypalon	600°C
Polyethylene (Hard)	250 - 280°C
Polyethylene (Soft)	270 - 300°C
Polyisobutylene	600°C

Polypropylene	300°C
---------------	-------

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

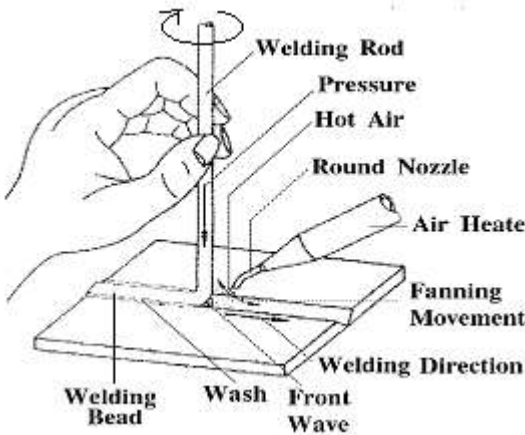


Fig. 1 Schematic of hot-gas welding, showing the correct position of torch and filler rod for different thermo-plastic.

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.

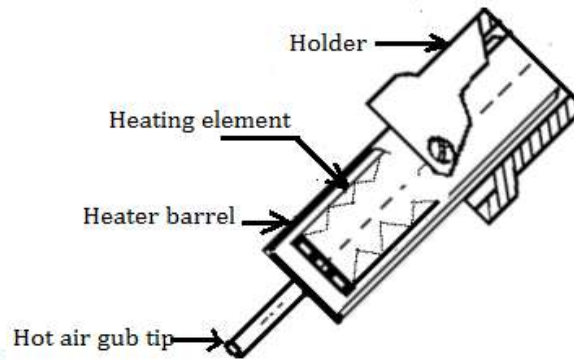


Fig.2 Basic elements of hot air gun

Table 2 Technical data of hot air gun

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

HOT AIR PVC WELDING PARAMETER.

The joining parameters of the hot air welding process are

Table 2 Process parameter for hot gas welding [7]

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

5. Weld force	Amount of force applied to the filler rod
6. Filler rod	Composition of filler rod
7. Gap distance	Distance between gas nozzle and workpiece
8. Weld joint	butt joint and double strap fillet joint.
9. Pressure of hot air/gas	Pressure of gas at which it coming out from nozzle
10. shoe	Design and size of welding nozzle

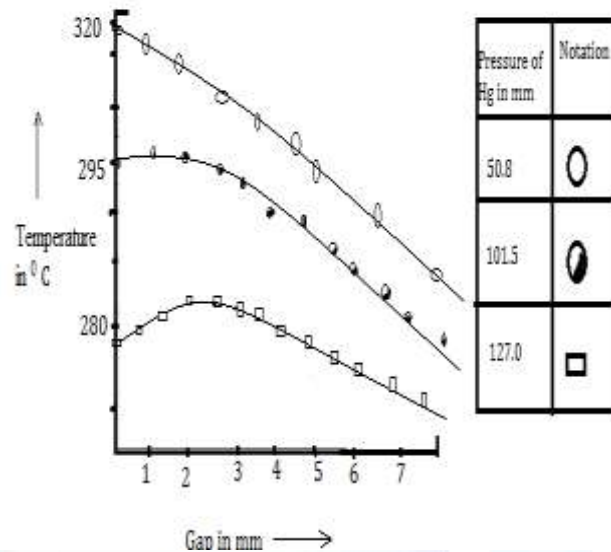


Fig. 2 Gap distance between torch and the job versus temperature of hot air [1]

- 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].
- Gas:** Generally gas used for welding is air or N [7].
- Angle:** Generally angle between the filler rod and weldment is taken as 90° and between gas nozzle and weldment is 45° [1]
- 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 measure by dividing the distance traveled of filler rod by time taken to travel this distance
- 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].
- Filler rod:** The composition of filler rod is must be similar to the polymer being welded [3].
- 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
- Welded joints:** generally two types of are used (a) butt joint (b) double strap fillet joint.
The sheet edges were cut to produce 60° single V-grooves and double V-grooves (X-grooves) [1, 4] shown in figure

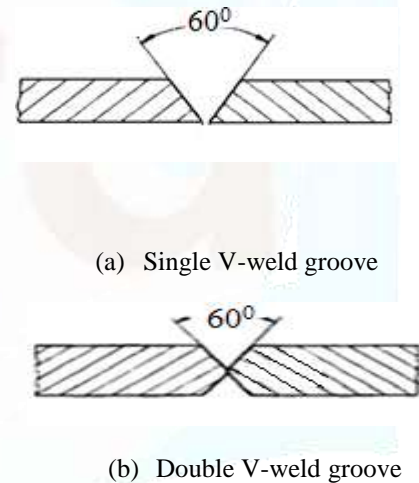


Fig. 3 Geometries of weld grooves

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)

[10] American Plastic Welding Technologies,
Hot Air Welding Guide For Plastic Repairs
www.bak-ag.com

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.

REFERENCES

- [1] Vijai Kumar, M.I. Khan
Development of Welding Procedure for Rigid P.V.C. Plastic by Hot air Technique
- [2] M. Rojek a, J. Stabik a,*, G. Muzia.
Thermography in Plastics Welding Processes
assessment VOLUME 41 ISSUES 1-2 July- August 2010
- [3] Thomas H.North and Geetha Ramarathnam,
University of Toranto Welding of Plastics
- [4] O. Balkan a,*, H. Demirer b, H. Yildirim c
Morphological and Mechanical Properties of Hot Gas Welded PE, PP and PVC sheets VOLUME 31 ISSUES 1 November 2008
- [5] W. S. Alley/ P. N. Baker
Chapter-2 Joining and Assembly of Plastics,
Volume-2 Identification, Testing and Recycling of Plastics, Handbook of plastic technology.
- [6] Thermally Bonded PVC seams Phase 1 "State- Of- The- Art & Preliminary Welding windows Tri/Environmental, INC, A Texas research international company
- [7] D. Grewell. A. Benatar
Agricultural and Biosystems Engineering. Iowa State University, Ames, IA, USA
Welding of plastic: Fundamentals and New developments
- [8] James D. Van de Ven, Arthur G Erdman,
Mechanical Engineering Department, University of Minnesota, Minnesota 55455 Hot Psin Welding of Thin Poly (vinyl Chloride) sheet
- [9] Stanley Graveline
Welding of Thermoplastic Roofing Membranes Subjected to Different Conditioning procedures
Journal of ASTM International, Vol.4, No.8 Paper ID JAI101018