# Interrelationships Between Welding Parameters of Hot-Gas Welding: Review

**[1]A.S.Khedvan, [2]Dr. K.P. Kolhe**
[1]PG student, [2]Professor,
Departmernt of Mechanical Engineering,
JSPM's ICOER, Wagholi, Pune, India.

***Abstract*— Current paper presents review of Interrelationships between Welding Parameters of Hot-Gas Welding. Today, joining of thermoplastic composite structures is gaining more importance since thermoplastic composite materials are increasingly being used to replace metallic and thermoset composite to better withstand static and fatigue loads in aerospace, automotive, and marine industries.Plastic welding is described in ISO 472 as a process of uniting softened surfaces of materials, generally with the help of heat (except solvent welding). Hot gas welding is one of the external heating methods. In case of hot-gas welding the parameters of welding such as welding temperature, flow rate, welding speed, welding force,gas,angle,filler rod, Pressure of hot air/gas, Gap distance and shoe influence the strength of the welded joint.This article has studied various literature presenting properties of various polymers, different techniques for plastic welding, comparative study of different techniques, effect of various process parameters on strength and quality of welded joint.**

***Index Terms*—Plastic,Polymers, Plastic Welding, Hot gas welding, Welding parameters.**

---

## I. INTRODUCTION

**Plastic:**

The word plastic is derived from the word (plastikos) meaning capable of being shaped or molded. Plastic is a material comprising of a wide range of semi-synthetic or synthetic organics that are malleable and can be molded into solid objects of different shapes. Plastics are typically organic polymers of high molecular mass, but they many a times contain other substances. They are generally synthetic, most commonly derived from petrochemicals, but many are partly natural. Plasticity is the common property of all materials that are able to irreversibly deform without breaking, but this occurs to a degree with this class of moldable polymers that their name is an emphasis on this ability.

Today, joining of thermoplastic composite structures is becoming more significant since thermoplastic composite materials are being used to replace metallic or thermoset composite material to better withstand various loads in automotive, aerospace, and marine industries. Many joining techniques have been developed to weld thermoplastic polymers typically organic polymers with greater high molecular mass, but they often comprised of other substances. They are usually synthetic, mostly derived from petrochemicals, but many are partially natural. Plasticity is the general property of all materials that are able to deform without breaking, but this occurs to such a degree with this class of moldable polymers that their name is an emphasis on this ability.Today, joining of thermoplastic composite structures is becoming more important since thermoplastic composite materials are increasingly being used to replace metallic or thermoset composite materials to better withstand various loads in aerospace, automotive, and marine industries. Many joining techniques have been developed to weld thermoplastic polymers in figure 1.

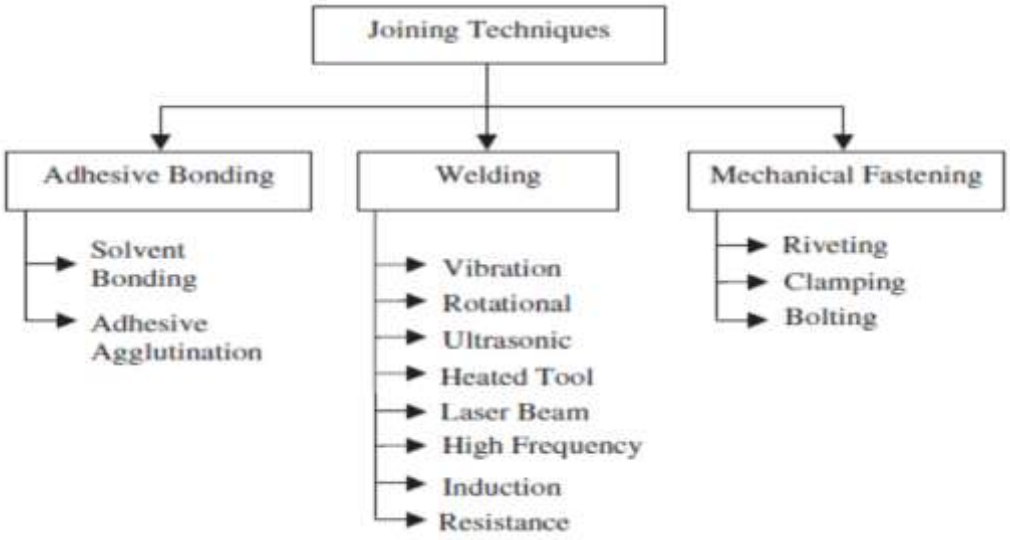


Fig1 Plastic Joining Techniques

**Plastic welding**:

Plastic welding i.e. welding for semi-finished plastic materials is reported in ISO 472 as a process of joining softened surfaces of materials, generally with the help of heat (except solvent welding). Welding of thermoplastics is accomplished in three sequential stages, preparation of surface, heat and pressure application,cooling. Numerous welding methods have been developed for the joining of semi-finished plastic materials. Classification of plastic welding is depicted in fig 2.

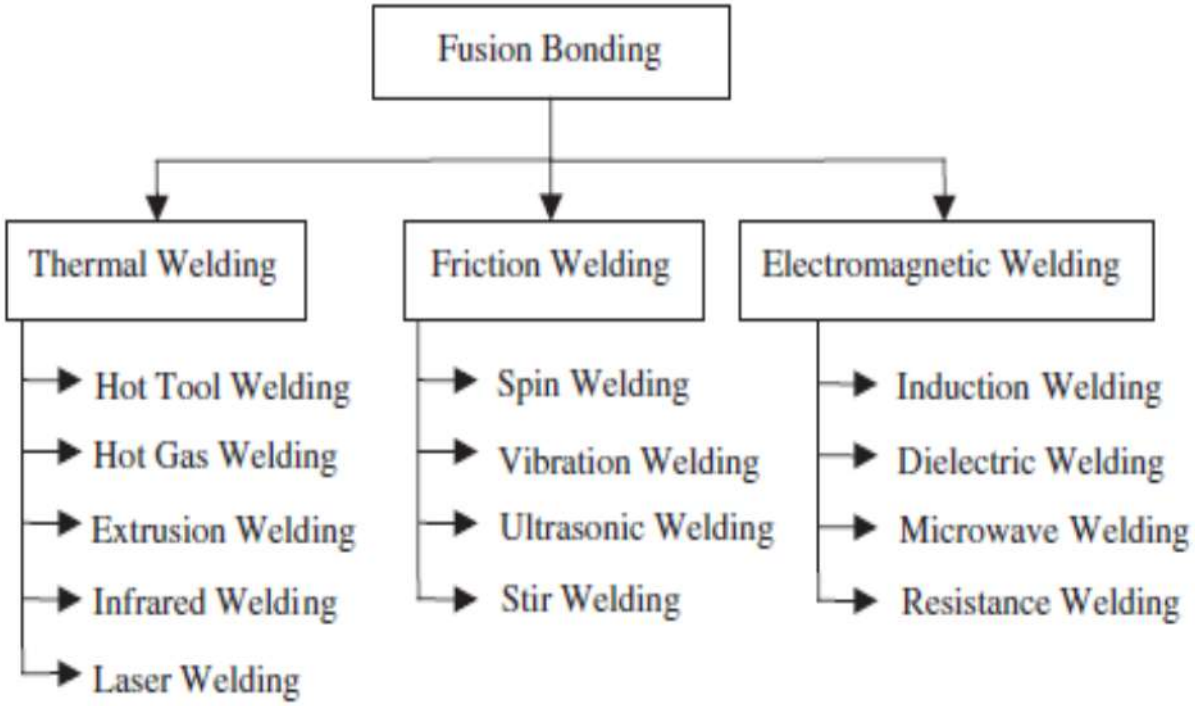


Fig 2 Classification of plastic welding

**Hot gas welding:**

Hot gas welding is one of the external heating methods, and it was patented by Reinhardt in 1940. In this method, a weld groove and a welding rod were heated with hot gas stream until they become soft sufficiently to fuse; then, the welding rod is pressed into the weld groove. It is very simple, portable, economical, and the most suitable process in the more complex and "one-off" fabrications, and hence it is employed wildely to fit plastic constructions. It is used in the fabrication of chemical containers, the sealing of roof or floor membranes for coverage, and the repair of large injection molded components. Hot gas welding process is portrayed in figure 3.

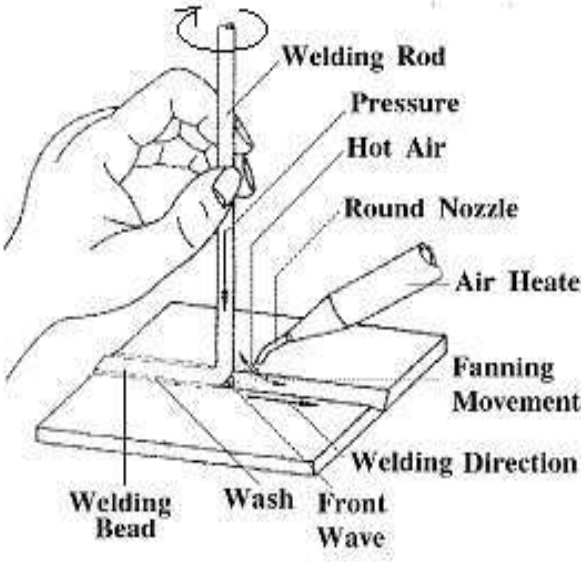


Fig 3 Hot gas welding process

## II. LITERATURE REVIEW:

This paper provides introduction to welding fundamentals followed by sections on a few welding processes that have had a significant developments or improvements over last few years, the processes that are discussed are, hot plate welding, ultrasonic welding, laser welding ,RF welding, hot gas welding, friction welding extrusion welding. Process parameters of each above mentioned plastic welding processes have been discussed. [1]

In this paper study of thermoplastic and thermosetting plastic has been carried out in detail. It provides characteristics of thermoplastic material such as acrylonitrile butadiene styrene (ABS) polycarbonate (pc) polyethylene (PE) polypropylene (PP) polyimide (PA) polybutylene terephthalate (PBT) polyurethane (PUR) polyvinyl chloride (PVC). Differences between thermoplastics and thermoset plastics has been discussed. Properties of above mentioned materials discussed are flexural strengths ,Normal operating temperatures, strength, rigidity, impact resistance, glass transition temperature ,scratch-resistance, melting point, chemical resistance, density, melt flow rate (MFR). Welding defects such as poor weld penetration, uneven weld bead width, charred weld, warping along with its causes are discussed. [2]

The focus of this paper is to review the various fusion-bonding methods for thermoplastic composite components such as Thermal Welding- Hot Tool Welding, Hot Gas Welding, Extrusion Welding, Infrared Welding, Laser Welding, Friction Welding- Spin Welding, Vibration Welding, Ultrasonic Welding, Stir Welding, Electromagnetic Welding- Dielectric Welding, Induction Welding Microwave Welding, Resistance Welding and present recent developments in this area. The various welding techniques and the manufacturing techniques, the necessary equipments, the effects of processing parameters on weld performance and quality, the advantages and limitations of each technique, and the applications are described. [3]

The aim of this paper is to investigate mechanical and morphological properties of hot gas welds on polypropylene (PP), polyethylene (PE), and polyvinyl chloride (PVC) sheets for different procedures, which are double and single V-welds with and without a welding shoe. Welding energy ($E_w$), which is transferred onto weld surfaces, was calculated to check weld quality. Morphology of welds was analyzed by stereo, polarized light and scanning electron microscopy. Polarized light microscopy results indicated that the heat-affected zone consists of welding rod core, deformed spherulitic zone and molten zone,. The results of various tests indicated that the weld strengths of PVC sheets are lower than weld strength of PE and PP sheets. When the welding shoe was used, weld strength increased significantly for each material due to the sufficient welding pressure and the effective heating on surfaces. [4]

This paper presents art in the field of plastic welding to assist in future developments in this field. Various important P.V.C. plastics welding factors such as welding techniques in common use, equipment 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. [5]

The objective of this work is carrying out preliminary studies comprising the assessment of welding parameters such as temperature, welding speed and welding-rod's feeding speed. Firstly, it was studied the actual temperature that acts on the welding rod and plate. After this, it was investigated the influence of the nozzle type on the welding bead. Since Hot-Gas is inherently a hand-carried process, the results were obtained from several welds, performed by three different welders. Thermocouples were used to measure temperatures at points related to the tool's terminal or nozzle. Sectioning, polishing and image analysis were used to study welding beads' shapes. Welding and feeding speeds were calculated using times assessed with a chronometer. The results show, for example, the suitable welding parameters range, and their effect on the welding bead. Temperatures at points of the nozzle related to the positions of welding rod and plate are significatively different from those selected at the tool. The nozzle type and the temperature greatly influence on the welding bead. Personal characteristics of the welders influence on welding parameters. [6]

The present work is done to observe the effect of mass flow rate of hot air, welding speed and welding current on stiffness of the PVC joint welded with hot gas welding technique. For design of experiment full factorial technique has been used. The effect of input parameter been evaluated on the output response stiffness of weld bead. The analysis and empirical modeling is done by ANOVA (analysis of variance). MINITAB 15 has been used to determine the best fit relation between response and input parameter. [7]

This paper presents examples of differential scanning analysis (DSC) and thermogravimetry analysis (TG) of selected plastics in an Argon protective atmosphere and also in an oxidative atmosphere of static air. Both measurements were performed on a Netzch STA 409 CD simultaneous Thermal Analysis Apparatus. The samples were tested under non-isothermal conditions at the same scanning rates of 10 K/min in two steps: heating and cooling. The temperature range of the measurements was from ambience temperature to 350 °C. The specimen, i.e., Polyamide66 (PA66) and High Density Polyethylene (HDPE) was measured in an inert atmosphere and also in an oxidizing atmosphere350 °C. The specimen, i.e., High Density Polyethylene (HDPE) and Polyamide66 (PA66) was measured in an inert atmosphere and also in an oxidizing atmosphere. [8]

## III. CONCLUSIONS

In manual hot-gas welding, the quality of the welded joint depends on the set values of the welding apparatus and, on the other hand, on the experience of the person performing the welding operation. The parameters of the hot-gas welding can be divided

into two subgroups: controllable and human-dependent parameters. It is concluded that effect all parameters, welding temperature, flow rate, welding speed, welding force,gas,angle,filler rod, pressure of hot air/gas, gap distance and shoe is significant and it affects the strength and quality of the welded joint.

**REFERENCES**

[1] Grewell, D., and A. Benatar. "Welding of plastics: fundamentals and new developments." International Polymer Processing 22.1 (2007): 43-60

[2] **S.**Harikannan, et. al., "Fabrication and Analysis of Thermo Plastics Welding", Vol. 4, Special Issue 6, 2347 - 6710 May 2015.

[3] Yousefpour, Ali, Mehdi Hojjati, and Jean-Pierre Immarigeon,"Fusion bonding/welding of thermoplastic composites", Journal of Thermoplastic Composite Materials 17.4 (2004): 303-341.

[4] Balkan, O., H. Demirer, and H. Yildirim, "Morphological and mechanical properties of hot gas welded PE, PP and PVC sheets", Journal of Achievements in Materials and Manufacturing Engineering 31.1 (2008): 60-70

[5] Alam, Mahmood, and M. I. Khan, "state-of-the-art in rigid pvc plastic welding by hot air", International Journal of Technical Research and Applications e-ISSN: 2320-8163,Volume 1, Issue 2 (may-june 2013), PP. 20-23.

[6] Júnior, Alberto Borges Vieira, "Bead-on-plate study of polycarbonate hot-gas welding", International Congress of Mechanical Engineering (Nov-2005).

[7] Alam, Mahmood, Reyaz Ur Rahim, and Mohd Suhail, "Empirical Modeling Relating Weld Current, Mass Flow Rate of Hot Air and Welding Speed to Stiffness of Hot Air Welded PVC Plastic", International Journal of Engineering Trends and Applications (IJETA) – Volume 2 Issue 1, Jan-Feb 2015

[8] Ondruška, Michal, et al., "optimizing the welding of plastics with the use of differential scanning calorimetry and thermogravimetric analysis", Acta Polytechnica 54.3 (2014): 221-224.