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ANALYSIS OF TECHNOLOGICAL PROCEDURES AND METHODS USED FOR WELDING PLASTIC PIPES USED FOR TRANSPORTING NATURAL GASES

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1. SYNOPSIS

Thermoplastics, such as polypropylene (PP), polyvinylchloride (PVC), polyethylene (PE) and polyvinylidenefluoride (PVDF) are being used more and more for the storage and transportation of many hazardous chemicals due to their excellent chemical resistance. This paper describes the various techniques that are used for welding thermoplastic tanks and pipelines.

2. INTRODUCTION

As the use of plastics in more structurally demanding applications increases so does the need for rapid, reliable and high-quality welding techniques. For this reason, a wide variety of welding techniques have been developed and improved over many years to satisfy these requirements. The main welding techniques used for fabricating thermoplastic tanks and pipe systems are described below.

3. WELDING TECHNIQUES USED IN THE FABRICATION OF THERMOPLASTIC PIPE SYSTEMS

3.1. HOT GAS WELDING

Hot gas welding is mainly used for joining thin (< 6mm) sheets of PP, PVC, PE and PVDF to themselves and also to pipes. The welding equipment is a hand-held welding gun consisting of an integral blower, a heating element with thermostat and a set of interchangeable nozzles for directing hot gas at the workpiece. A filler rod is used and this is made from the same polymer as the parts to be welded.Usually, the gun is fed with air although for some applications nitrogen gas is used. The temperature of the hot gas stream is typically in the range 200-400°C, depending on the polymer being welded. With the heated gas directed towards the joint, local melting or softening of the components and filler rod take place (*Fig.1*). A weld is formed when the joint region and filler rod fuse and then cool to ambient temperature

Fig.1. Hot gas welding

Since hot gas welding is a manual rocess,its success depends greatly on operator skill.

3.2. EXTRUSION WELDING

1.3 Extrusion welding

Extrusion welding is mainly used for joining thick (> 6mm) sheets of PP and PE to themselves and also to pipes. The process involves continuously extruding molten thermoplastic material into a weld preparation on the plastic structure being joined. The equipment (*Fig.2*) is based on an electric drill with a mini extrusion barrel attached to the front. The extrusion barrel is heated along its length, either by cartridge heaters or hot air. A thermoplastic rod or granule feedstock is fed into the rear of the extrusion barrel and the material is heated as it is drawn through the barrel by the rotating extruder screw.

Molten thermoplastic is continuously ejected through a PTFE shoe attached to the front of the extrusion barrel. The PTFE shoe is shaped to match the profile being welded, and defines the shape and size of the final weld. At the leading edge of the PTFE shoe, hot gas is used to heat the substrate material in front of the area where the molten bead is to be laid. This ensures that there is sufficient heat in the substrate material to form the weld. Typical welding speeds are 0.5-1.0 m/min. Again, since extrusion welding is a manual process, weld quality is dependent on the skill of the operator.

3.3. BUTT FUSION WELDING

The butt fusion welding technique (also known as hot plate welding, butt welding, mirror welding or platen welding) is primarily used for joining PE pipes for the water and gas industries, and PP and PVDF pipes for the chemical industry. It can be carried out on a wide range of pipe sizes, typically between 63 and 1600mm outside diameter (OD).

Fig.3. Butt fusion welding

The welding equipment (*Fig.3*) consists of a system for clamping the two pipes to be welded and allowing them to move co-axially, a trimming unit to ensure that the pipe ends are flat and square prior to welding and a heated metal plate. The welding sequence begins when the hot plate, at a preset temperature, is positioned between the two pipe ends. The pipes are pushed towards each other until the pipe ends come into contact with the hot plate and the pressure is increased to give good thermal contact. The pipe ends melt and the interface pressure forces the molten material outwards to form 'weld beads' at the outside and inside pipe surfaces; hence the term 'bead-up' stage. At the end of this stage, the pressure is reduced to a value sufficient only to maintain the pipe in contact with the hot plate. This allows the melt depth to increase without increasing the size of the weld beads. At the end of this 'heat soak' stage, the pipe ends are pulled away from the hot plate. The hot plate is removed, and the two molten pipe ends are pushed together at the same pressure as used during the initial bead-up stage. This causes further growth of the weld bead and is called the 'bead roll over' stage. The pressure is maintained until the weld is fully cooled.

3.4. SOCKET FUSION WELDING

The socket fusion technique is mainly used for welding pipes made from PE, PP and PVDF for chemical pipework. The process operation is generally manual and can either be carried out by hand (for pipe sizes up to 50mm OD) or on a manual machine for pipe sizes typically between 63mm and 150mm OD. A socket mounted on a hot plate is used to heat the outside surface of the pipe being welded. On the opposite side of the hot plate, a spigot is used to heat the inside surface of an injection moulded fitting (*Fig.4*). Both the fitting and the pipe are heated for a set period, known as the heating time. When the heating time is complete, the heated pipe and fitting are removed from the socket and spigot, and the pipe is pushed inside the fitting, producing the weld.

Fig.4. Socket fusion welding

3.5. ELECTROFUSION WELDING

The electrofusion (EF) technique is mainly used for welding pipes made from PE, for the water and gas utilities, although PP and PVDF can also be EF welded. This technique permits joining of pre-assembled pipes and fittings to be carried out with minimum equipment. It also offers a number of practical advantages to the installer; it is easy to use for repairs and where the available space and pipe movement is limited. The EF welding process involves the use of a fitting (*Fig.5*), which is basically an outer sleeve with a coil of electrical resistance wire at the bore, which the two pipe ends slide into. An internal stop prevents the pipe ends from meeting. EF fittings are typically available in sizes from 16mm to 500mm. However, sizes up to 710mm are available. Before welding, the pipe ends are cut square, the pipe surfaces to be joined are scraped to reveal uncontaminated material and the pipes are clamped to eliminate movement between the pipes and fitting. The welding process, where a current is passed through the coil to heat it to a temperature above the melting point of the surrounding polymer, can be divided into three stages: i) initial heating and fitting expansion, ii) heat soak to create the joint and finally iii) joint cooling. The duration of stages i) and ii) is commonly termed the 'fusion time'.

Fig.5. Electrofusion welding

3.6. INFRARED WELDING

The infrared (IR) technique is used primarily for welding pipes made from PP and PVDF for the semiconductor, pharmaceutical and chemical process industries. It can be carried out on pipe sizes typically between 20 and 225mm. The technique uses an electrically heated metal plate, which is typically at a temperature between 320 and 530°C, depending on the material and size of pipe to be welded. The pipes to be welded are brought into close proximity to the hot plate (typically 1.5-2.0mm) but without touching it and heat up due to radiation and convection. When the pipe ends become molten, the plate is withdrawn and the pipes are forced together to form a weld. The resulting joints have smaller weld beads compared with butt fusion joints because there is no 'bead-up' stage.

3.7. BCF WELDING

The bead and crevice free (BCF) welding technique is used for joining small diameter (20-63mm) PVDF piping systems for the semiconductor, biotechnology, pharmaceutical, food and beverage industries. The BCF welding technique is based on the use of a rubber inflatable bladder, which is placed at the joint line inside the pipes, before welding commences. The pipes are clamped remote from the joint, and a heated metal collar surrounds the pipes at the joint line. As the polymer around the joint melts, it cannot deform outwards because it is constrained by the collar nor inwards because it is constrained by the bladder. After a predetermined time period, the heat supply to the collar is switched off and the joint cools. Welds produced in this way exhibit no weld bead, which means that there are no crevices inside the pipe in which bacteria might grow.

3.8. REFERENCES

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