WELDING OF PLASTIC MASS BY MEANS OF INFRARED HEATING

Mircea-Petru URSU, Traian BUIDOS
University of Oradea (mpursu@uoradea.ro, tbuidos@uoradea.ro)

Abstract: This paper presents new possibilities of plastic pipes welding, which are used in special hygiene conditions (medical and pharmaceutical industries etc.), IR (infrared) machines and possibilities of weld quality control.

1. INTRODUCTION

Plastic has become preferred for a wide variety of pipes required in various domains. The plants are concentrating their investments in innovative solutions, customer-oriented. Papers [1, 2, 3, 4] show the technologies of electrofusion, polyfusion and butt-welding of plastic pipes.

For plastic components, IR welding can successfully replace some more traditional applications using heated plates or vibration. Using a controlled IR source, with precise time and temperature settings, allows a more accurate control of the plastic components welding process.

Different heating levels for various welding conditions can be obtained with a single device. The possibility of placing the IR emitters in various positions makes possible the welding of multiple surfaces in one configuration. The process is much cleaner because the IR heaters don't touch the components to be welded. Unlike the heated plate process, the plastic components don't stick to the IR heaters.

The delays caused by cleaning and replacing of the heated plate for 2-3 times per cycle are eliminated. Due to the IR heaters functioning in rating immediately after turning on, there is no more wasted time for the working device to heat up. Changing to a new configuration is faster because there is no need to wait for the devices to cool down, as in the case of heated plate.

Other advantages of this method are:

- less frequent maintenance;
- the faces of the parts to be welded do not touch the heaters;
- there is no more need of backup tools;
- instantaneous on/off and more accurate part temperature control;
- smaller dimensions of the machines;
- lower tool costs;
- hermetical sealing of the welded parts;
- low power consumption;
- the no-contact processing assures higher surface quality.

2. PIPES JOINING TECHNOLOGY BY MEANS OF IR HEATING

Basically, the steps of this welding process are the following: the components to be welded are brought face to face and are planned in parallel on the front sides (fig.1).

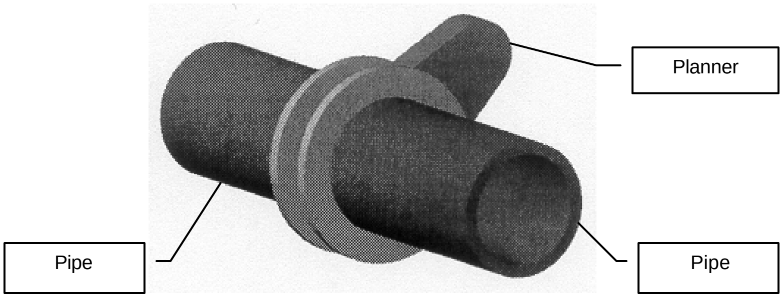

Fig.1. Paralel planing of the pipes ends.

Then, the faces are heated and melted *without contact* under a specific gap-time ratio (fig.2).

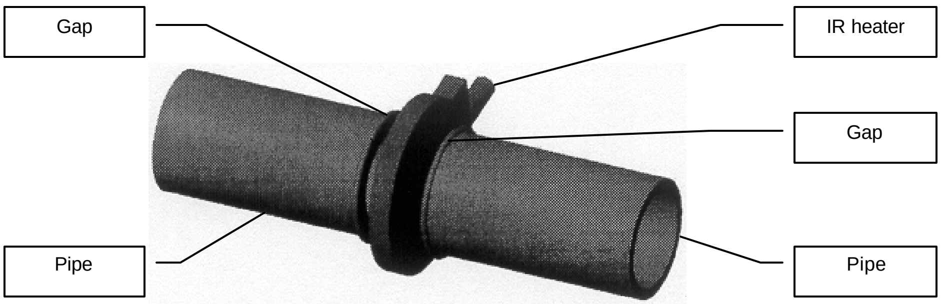

Fig.2. No-contact IR heating of the pipes ends.

The heater is removed (change-over time) and the components are pressed together under pressure (fig.3) for a defined time (welding time).

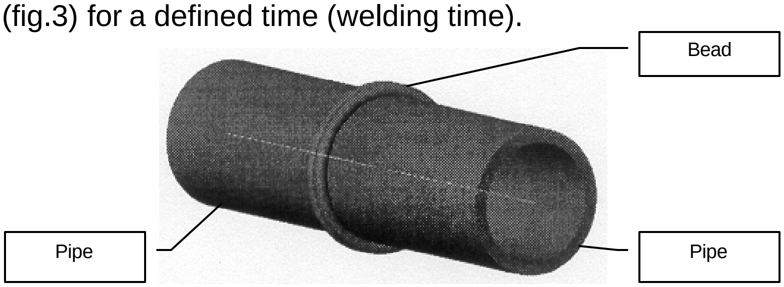

Fig.3. The welded pipes.

The necessary parameters (temperature, pressure and time) vary upon materials and surfaces to be welded.

Besides the butt-welding, pipes may also be assembled by means of sockets and fittings; in special cases (medical or pharmaceutical parts etc), the components are separately injected and then IR welded together, by means of special modules.

3. INSTALLATIONS USED FOR JOINING PIPES BY MEANS OF IR HEATING

Fig.4 shows is a manual welding machine for touchless welding of pipes and fittings of OD 20 up to OD 63, based on infrared radiation and heating element butt welding by means of easy mountable anti-stick coated top plates. For the exact preparation of the weld and for the calibration of the radiation, a planer is mounted on the machine. All movements of the machine are performed manually, are supported by a high precision linear guide way and also provided with guidance in order to avoid collision. With respect to specific requirements in the cleanroom area, all surfaces are scuff-resistant nickel-plated, in anodized or high quality steel version. The temperature range of the heating element is electronically continuously variable up to 500°C. For that reason, in combination with a very good radiating, abrasion free surface coating, the heating element is suitable for the infrared welding of all common fluorine plastics and polyolefines. Due to a specific arrangement, the current welding pressure is shown in Newton on the separate, portable control unit without being influenced by the drag force. For the optimal alignment of the pipes, a horizontal and vertical offset compensation is provided for an offset-free welding.

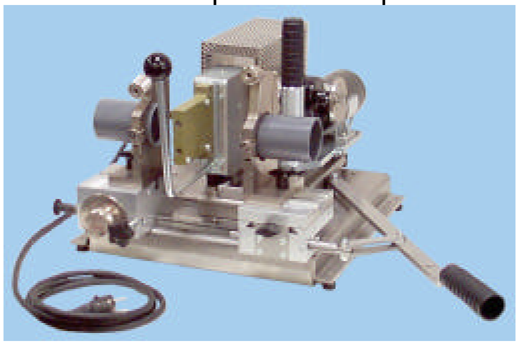

Fig.4. Manual welding machine.

Fig.5 shows a program controlled welding machine with servo drives for welding workpieces, pipes and fittings made out of PP, PVDF and PFA, as well as other suitable materials by means of infrared radiation. Besides the standard welding machines available on the market working either with force control or with limitation of the jointing way, this machine has servo controlled drives offering new potentialities concerning precision and number of possible processes. The combination of a high-quality drive unit and the latest drive technology sets the standard for speed, exact positions and force control. Due to this combination, welding methods are possible with either limitation of the joining way or with force control as well as with a special combination of both techniques. This method is very interesting for all applications of the plastic welding technology. Particularly when welding plastic pipes with a high MFR, a stress-free cooling with a concerted residual melt can be reached at the same time.

All welding motions are drive n by a servo control. Manual work steps thus are not necessary. The reachable high speeds are smoothly accelerated so that shocks and impacts in the final positions are avoided. All displacement ways can be exactly positioned. The advantage is that the radiator and planning distances are not limited by fixed end stops and can be individually adjusted as required. This means for example that the best distance can be set for each wall thickness, which finally leads to a reduction of the heating time.

An access to the program is only possible by means of barcode legitimation. The card protects the welding process from unauthorized access. During the program the heating elements automatically move in and out. As a standard, the welding process conforms to the prescribed values of DVS regarding the welding area and material. Additionally it can be adjusted to individual user's requirements by means of a lab program. The welding process is only released if all requirements, desired values and work steps are met. If one programmed and desired value is out of tolerance, or if one work step is not fulfilled, the welding process is interrupted and an according error code is registered. All welding dates, actual and desired values as well as error messages are logged in the RAM of the control and on PCMCIA card with continuous number. The welder's identification, the project and the bead number, date and time as well as all relevant actual and desired values of the parameters pressure, time and temperature, are listed. Thus all the parameters are logged which are necessary for conclusions of the quality and the performance of the weld in order to ensure an optimum of production surveillance or systems of quality assurance.

Fig.5. CNC welding machine.

Tubular IR heaters (fig.6) can be used for industrial applications that require heating on extended areas.

Fig.6. IR emitters.

These are:

- *Infrared Halogen Emitters NIR:* halogen infrared emitters with a spectrum in the near-infrared region, a maximum power output of 1000 kW/m^2 and very fast response times;
- *Short Wave Infrared Emitters:* infrared emitters in the short wave region; twin tubes with lengths of up to 2.4m and high maximum power output of 150 kW/m^2;
- *Fast Response, Medium Wave Infrared Emitters:* emitters with an improved output in the medium wave (2÷4 µm); response times as fast as short wave, with a maximum power output of 120 kW/m^2 and lengths up to 6.3 m;
- *Medium Wave Infrared Emitters:* standard emitters with a medium wave spectrum, solid, flexible in construction, lengths (up to 6 m) and power output (max. 50 kW/m^2), especially suitable for continuous processes;
- *Carbon Infrared Emitters CIR:* CIR emitters combine a medium wave spectrum with fast response times and high power outputs; these emitters are produced as round tube or twin tube emitters, in lengths up to 3 m, with maximum power output of 100 kW/m^2 for round tube or 150 kW/m^2 for twin tube emitters.
- *Emitters for Targeted Heat:* meet all requirements in finishing processes, where only very small or curved faces, edges, borders or defined contours of the product need heating; for these cases, purpose built products such as contoured emitters, small surface emitters, Omega emitters and emitters for heating hot rivets can be made.

Common to all of these emitters is their focus in shape, size and spectrum to the desired process. Heat is produced in a targeted fashion exactly where it is needed. Consequently energy losses to the surrounding area are very small. Infrared emitters are produced as round tube or twin tube. Twin Tube Infrared Emitters have a high mechanical stability and can be produced in every required length up to 6.3 m. A gold reflector on the IR emitters reflects the IR radiation; the effective radiation onto the object is therefore roughly doubled.

Fig.7. IR modules.

IR modules (fig.7) comprise one or more infrared emitters mounted in a suitable housing and usually wired into a terminal box mounted on the back of the unit. System solutions comprise modules and a control panel designed to meet the requirements of the individual process.

Different heating and welding processes can be carried out by choosing the appropriate shapes and properties of the IR emitters (fig.8).

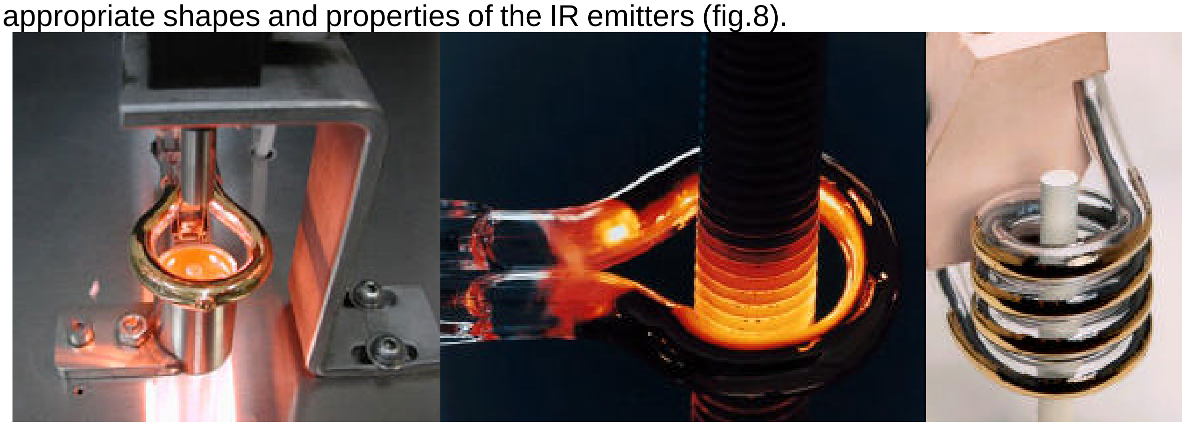

Fig.8. Special shaped IR emitters.

This joining method for plastic parts is cost-efficient and uses the concentrated IR energy to focus the heat on the plastic component to be welded. The demand for compressed air is low and the heat-sensible sides of the parts are not damaged because the heat is focused only where needed.

4. QUALITY CONTROL OF THE WELDED JOINTS

On site, the joints are checked by visual and non-destructive means, using ultrasounds and penetrating radiations, according to DVS2206 standards “Checking of Thermoplastic Components and Structures”. The non-destructive control is used only in special cases, because it is very demanding and costly.

The visual control must mark out the following aspects:

- the burr bottom must be above the pipes surfaces;
- the offset between the pipes outer surfaces must not exceed 5% of the pipe wall thickness;
- the burr width must be constant for the same pipe type (same diameters and wall thickness);
- there must not be any deteriorations on the pipes outer surfaces because of the fixing devices profiles;
- In the case of burr-removing, one must observe its constant width and the absence of impurities, cavities, offsets and other welding flaws, of which the most dangerous are the cracks and the non-melting.

The mechanical bending control is carried out according to DVS2203 standards, by sampling a defined number of test-specimens with the dimensions specified in these standards. Four antipodal test-specimens are sampled from pipes with nominal diameters under 90 mm, and six hexagonal placed test-specimens from those with nominal diameter above 90 mm. Half of the specimens are tested with the inner weld stretched and half with the inner weld compressed, observing that cracks should not appear at 90 degrees bends. If the results are not satisfactory, the testing is repeated on a doubled number of test-specimens. If the results are still not satisfactory, the welding is rejected, the weld operating conditions are double-checked and the process is reprogrammed.

The rupture under internal pressure control is carried out according to DIN16963 standards, by sampling test-specimens from the pipe of the following lengths:

- 400 mm for d_e = 75 mm;
- 600 mm for 90 mm = d_e = 225 mm;
- 1000 mm for d_e = 250 m m.

The testing is carried out at 80°C temperature and $0.6 \cdot P_N$ pressure for 1-type pipes and $0.8 \cdot P_N$ pressure for 2-type pipes, without failing in 170 hours; P_N is the nominal pressure for the tested pipe series.

5. CONCLUSIONS

IR welding can reduce the costs and the capital investments. The IR welding machines take less space than the conventional welding machines, and the electrical power consumption is much less. The injecting, modeling and processing costs can be reduced, and the welded components are mode solid and hermetic. The starting and stopping are instantaneous, and the no-contact processing provides higher surfaces quality and higher cleanliness of the process. Furthermore, IR welding can be carried out also in vacuum chambers in case of special applications.

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