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Hot Plate Welding of Mouldings Made of Polyolefins (PE, PP) in Volume Production

Direction DVS 2215-2

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Contents:

1 Scope

These guidelines are valid for welding mouldings together using hot plate welding, and also for combinations of mouldings and semi-finished products made of Polyolefins, homopolymers and copolymers as well as blends of these (reinforced, filled, elastomer-modified, fire protected and special settings of these plastics).

The hot plate welding of pipes to fittings is not subject-matter of this specification. For this the specifications DVS 2207-11 and -15 are valid.

This specification is to discuss in connection with specification DVS 2215-1, which the general bases for "Hot plate welding thermoplastic mouldings in volume production" are described.

2 Description of process

See specification DVS 2215-1.

3 Short description of the materials PE, PP to be welded

Polyolefins are semi-crystalline plastics which are characterized by a very good behaviour for hot plate welding. Because of their wide melting range these plastics have versatile applications in the field of hot plate welding, especially in the processing of semi-finished products as well as in the volume production of mouldings. In nearly all special fields the polyolefines are processed by the hot plate welding procedure. The choice of the material or the type has to take place not only according to the profile of requirements of the later application field but also according the type-specific welding behaviour.

Crosslinked polyolefines are not resp. not much suitable for welding.

Material values as well as type-specific properties can be taken from producer data sheets as well as the data bases of the raw material producers and institutes.

3.1 Polyethylene (PE)

According to ISO 1872-1 (DIN 16 776-1) PE moulding compounds are thermoplastic moulding compounds on the basis of Ethylene-homopolymers and/or Ethylene-copolymers.If no supplementary specifications are made, they have the complete composition prior to processing. If necssary fillers and/or reinforcements can be included.

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3.1.1 Ethylene-Homopolymers

Polyethylenes are produced with different degree of branching depending on the conditions of polymerization. With decreasing branching of the molecules the crystalline parts and the density will increase.

The melting temperature and melting viscosity are higher with increasing density and mole mass. With increasing melting viscosity polyethylene can be welded easier because of the tendency to stick at the hot plate declines. Density and molecular weight influence the mechanical and thermal properties of the polyethylene too.

PE-LD (density 0.915 to 0.934 g/cm^3) is polymerized in the high-pressure process and has a long-chain branched structure. However the linear built-up PE-HD (density 0.935 to 0.97 g/cm^3) has higher stiffness, hardness, and deflection temperature. It is produced in the low-pressure process and has few short-chain branches.

With increasing mole mass -characterized by lower MVR/MFR-values – impact strength and resistance against stress cracking of PE increase; the latter increases additionally with increasing density, that means with increasing degree of branching.

Moreover the mole mass distribution (MMV) influences considerably the properties and manufacturing process. Small MMV supports impact strength and poorness of deformation, wide MMV supports resistance against stress cracking and as well as flowability.

3.1.2 Ethylene-Copolymers

Copolymerization of Ethylene leads to branched chain structures. By it the crystalline components are reduced and the melting temperature, density, and stiffness are decreased and the resistance against stress cracking lowered. With the low-pressure process only apolar co-monomers like I-Butadiene, I-Hexene, I-Octene are usable for this purpose. In this connection low density Polyethylenes are produced like PE-ULD, PE-VLD, and PE-LLD (density 0.88 to 0.93 g/cm^3) and PE-MD medium density (density 0.93 to 0.94 g/cm^3), which have a linear structure with short chain branching. The degree of branching and the flexibility increase with concentration of co-monomers.

With the high pressure process there are polar co-monomers like vinyl acetate (VA), acrylic acid (A), acrylates (EA), which have in addition to the flexibilizing effect other properties, for example higher adhesion to foreign materials.

The copolymers (EVA, EAA, EEA) are characterized apart from density and MVR/MFR*) supplementary by kind and amount of the co-monomers.

3.1.3 Polymer blends

Polymers blends are produced by mechanical recessing of other polymers (e.g. PA). Tests for establishing the weldability have to be performed, because of the quality, kind and concentration of the second component in the blend can influence the quality of the welded joints.

3.1.4 PE with additives

Polyethylenes contain the most different additives like stabilizers, colouring agents, antistatic agents, processing aids, fire protecting agents and partly fillers and/or reinforcements. The weldability has to be cleared up by tests, because the additives influence the welding properties.

3.2 Polypropylene (PP)

According to ISO 1873-1 (DIN 16 774-1) PP moulding compounds are thermoplastic moulding compounds on the basis of Propylene-homopolymers and/or Propylene-copolymers. There are homopolymers with high or low crystalline components, block copolymers, random copolymers, elastomer-modified as well as filled and/or reinforced types. Polypropylen provides good conditions for the hot plate welding. As with the joining of semi-finished products also good weld qualities are achieved.

3.2.1 Polypropylene-homopolymers

Mouldings made from homopolymers are characterized by high stiffness, hardness and deflection temperature. The range of melting temperature begins at 160°C. The decreasing of toughness at temperatures less than 5°C has to be taken into account. The different types are always characterized by its MVR/MFR-values.

3.2.2 Polypropylene-copolymers

At the copolymers there are block copolymers (PP-B) and random copolymers (PP-R). Copolymers have a better toughness than homopolymers with comparable MVR/MFR-values. At the block copolymers this is valid especially for temperatures less than about 5°C. Random copolymers have a better transparency and a reduced wider melting range.

The different types are always characterized by its MVR/MFR-values resp. by its toughness.

3.2.3 Elastomer-modified PP

The elastomer-modified PP-compounds contain mostly the elasticizer Ethylene-propylene-rubber (EPM, EPDM). They are characterized especially by good impact strength in the cold, sufficient stiffness in the warmth, they are good to blend with fillers and/or reinforcements and they show good processing possibilities.

3.2.4 PP with fillers and reinforcements

Glass fibre-, chalk- or talc-filled polymers show a higher stiffness, hardness and deflection temperature, but generally lower impact strength than the non filled materials.

Glass fibre reinforced types with chemical coupling show especially high strength, stiffness and deflection temperature. Orientations of the glass fibre in the final parts influence the properties and deformation. For this reason these types have to be checked concerning their weldability.

3.2.5 PP with additives

Additives like foreign polymers, colouring agents, stabilizers, antistatic agents, processing aids and fire protecting agents influence the properties of PP, especially if they are added in a great amount or if they change the crystalline structure. Therefore it is necessary to check the weldability.

4 Material-caused influences on the welding behaviour

4.1 Flow behaviour

The flow behaviour of melt of polyolefins is characterized by the melt flow rate (MFR) or melt volume rate (MVR) according to DIN 53 735 / ISO 1133. In the standard is defined the combination of mass and temperature, at which the melt flow rate has to be determined. It is only possible to compare such values with each other which were measured at the same test conditions (load weight and temperature).

The plastifying behaviour of the joining zone is decisively influenced by the molecular weight and so by the flow behaviour of the melt of the material to be welded.

General rules are:
Easy-flowing PE- and PP-types with high MFR plastify more quickly than tough-flowing types with low MFR which therefore tend towards adhesion of the melt on the hot plate more easier. This is valid especially for ethylene-copolymers. Reducing the hot plate temperature decreases the adhesion.

The following welding parameters have to be adjusted to meet certain criteria:

*) look 4.1