January 2011

DVS – DEUTSCHER VERBAND FÜR SCHWEISSEN UND VERWANDTE VERFAHREN E.V.	Adhesive bonding of thermoplastics	DVS Technical Code DVS 2204-1

Adhesive bonding of thermoplastics

Contents:

1 Scope of application

This technical code deals with the structural adhesive bonding of thermoplastics exhibiting different chemical compositions with themselves or in combination with other thermoplastics. Other regulations and instructions are not restricted by this technical code.

As the main focal point, this technical code is oriented to both manual and mechanical processing. The continuous manufacture of adhesive-bonded joints (such as large-area coating, composite film manufacture, series fabrication operations and the adhesive bonding of foams) is not the subject of this technical code.

2 Materials

The base materials are polymers, copolymers as well as their blends. A list of the materials to be joined, with information about the adhesive bondability, can be found in Annex 1.

Copolymers and their blends exhibit altered or, to be more exact, improved properties, e.g. increased impact strength, thermal endurance or weathering and media resistance. The materials are utilised in mouldings and as semi-finished products such as panels, pipes, sections or films.

3 State of the art

Adhesive bonding technology is becoming ever more significant in industrial fabrication and in the skilled trades. In the meantime, adhesive-bonded joints can be found in all sectors. A wide selection of adhesives are available for this purpose.

With regard to the adhesive bonding of plastics, the surface energy (polarity) is a decisive variable. It is responsible for the degree of wetting by the adhesive and can be influenced by corresponding pretreatment methods.

However, surface pretreatments are often not so effective. Therefore, no significant improvement in the adhesive-bonded joint is obtained. Moreover, the effectiveness of the pretreatment is often only temporary, depending on the material and the method. In the field of the plastics which are easy to adhesive-bond (such as PVC and ABS), the good solubility of the polymers is exploited and solvents or solvent-based adhesives are used. The solvents penetrate into the joining face, trigger molecular movements and, after escaping, lead to strong, permanent joints. It must be borne in mind that the solvents may influence the polymer structure and the composition depending on (for example) the polymer, the time and the temperature. Components with residual stress are particularly susceptible here and corresponding measures (e.g. tempering) must be taken.

Polymers with increased polar proportions like ABS can also be joined using adhesives with a purely adhesive effect. Adhesives which are intended for polyolefins (PE/PP) and achieve notable strengths also without any special pretreatment of the adhesive bonding faces have even been launched on to the market in recent times.

The selection of suitable adhesives is determined by the application and the materials and, as a rule, is made in cooperation with the adhesive supplier or on the basis of a recommendation in a so-called adhesive table.

Since the base materials may be very different because of the variation of the components and the mouldings contain additives such as lubricants, preliminary tests are required in addition in most cases when selecting the adhesive system.

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4 Adhesives

According to DIN EN 923, any non-metallic substance which can join materials, by means of surface bonding (adhesion = bonding forces at the interface to the substrate to be adhesive-bonded), in such a way that the joint has an adequate internal strength (cohesion = bonding forces of the adhesive constituents amongst themselves) is regarded as an adhesive.

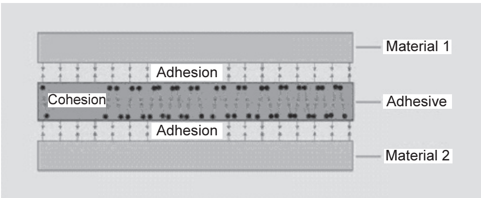

Figure 1. Structure of an adhesive-bonded layer.

The basic prerequisites for adhesive bonding are that the adhesive must be liquid or pasty in the application condition and solid in the final condition and that the joining parts are wettable with the adhesive. The surface energy of the adhesive must be at least lower than or equal to the surface energy of the material. Ideal wetting is obtained when the surface energy of the adhesive is a great deal lower than that of the material.

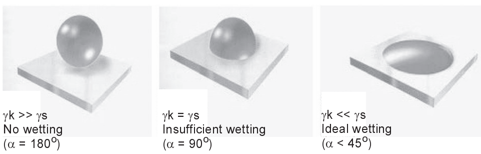

Figure 2. Different wetting.

4.1 Influencing factors

For an optimum adhesive bonding result (i.e. a permanent, non-positive-locking joint), the following factors must be taken into consideration when selecting the adhesive:

- The application-related material selection must be made taking account of the mechanical, thermal and chemical requirements as well as the air humidity.
- The materials must be pretreated in a material-specific way.
- The adhesives are selected in relation to the application.
- The surfaces to be adhesive-bonded must be dirt/grease-free and dry.
- The adhesive bonding faces must be designed with the largest possible areas.
- Structures appropriate for the adhesive should serve to avoid any impermissible peeling loads and to reduce any stress peaks.
- The structure must be chosen in such a way that it preferably results in shear stresses.

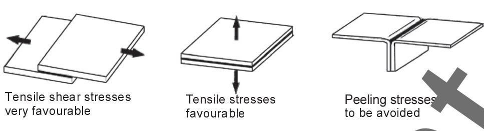

Figure 3. Types of stresses on the adhesive.

- A fit-up accuracy of the adhesive-bonded joint which is as high as possible and is adapted to the adhesive (according to the information from the manufacturer or to standards).
- Proper processing of the selected adhesive (pay attention to the instructions from the manufacturer).
- Loads on the adhesive-bonded joint only after the final strength or the utilisation strength has been achieved to a great extent (pay attention to the further processing instructions).

Furthermore, sequences in fabrication technology, questions relating to the economic viability and the latest occupational health and safety and safety stipulations must be borne in mind when selecting the adhesive.

5 Adhesive classification

From classical antiquity to the beginning of the 20th century, the adhesives were based on natural raw materials such as bone glue, casein or starch which dominated the market. Today, the adhesive market is characterised by the synthetic raw materials. Due to the variation possibilities resulting from these, the user has available a large number of most diverse adhesives which often exhibit distinctly different properties such as the processing, the strength, the temperature resistance and the media resistance.

A systematic, binding adhesive classification has not existed until today. The most common adhesive classification is based on the setting and curing mechanisms, Annex 2. A classification is made according to physically setting adhesives and chemically reacting adhesives. In the case of the chemically reacting systems, there are differentiations between one-component and two-component systems (1C/2C) as well as between cold-curing and hot-curing systems. The physically setting systems with chemical solidification, e.g. hot melt adhesives with PUR/EP post-curing should be regarded as a variant in this classification form. Another classification possibility is provided by the adhesive bonding forms, Annex 2.

5.1 Physically setting adhesives

They are defined by the fact that the setting process of the adhesive takes place physically (e.g. by means of drying, solidification from melts or diffusion processes) without any changes in the components in the chemical sense.

5.1.1 Contact adhesives

Contact adhesives are characterised by the fact that they contain high-molecular but chemically non-cross-linked polymeric components (e.g. polychloroprene) which, by adding solvent, are turned into a viscosity state which ensures the optimum wetting of the joining part surfaces.

Contact adhesives must be applied to both joining parts. The solidification process (solvent evaporation time) takes place by means of drying before they are joined together. The adhesive bonding layers must feel dry. The joining parts are then pressed together at a defined pressure within a certain period (contact adhesive bonding time). The level of the pressing pressure, not the pressing duration, is decisive for the strength.

During and after the pressing, an intermeshing process occurs between the adhesive layers on both sides and connects the joining parts with each other firmly. An improvement in the heat resistance and in the creep strength is achieved by utilising slowly acting hardeners which lead to spatially wide-meshed cross-linking in the course of a few days.

Because of the high solvent proportion (up to 80 %) of the classical contact adhesives, these are, if possible, replaced by so-called dispersion adhesives today. In this respect, the polymer (e.g. PU) is dispersed in water. The substantially longer drying process and slight initial adhesion are disadvantages in the case of the aqueous contact adhesives.

5.1.2 Dispersion adhesives

These are (synthetic) water-based adhesives on the basis of (for example) polyvinyl acetate dispersions (homopolymers/copolymers) in combination with acrylates or functional monomers. The utilisation field of these adhesives is primarily for the adhesive bonding of wood. As in the case of the hot melt adhesives, there is a chemically setting variant here as well, see Section 5.2.