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BONDING OF THERMOPLASTICS

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ABSTRACT
In technical praxis we often meet the problems of joining of various types of materials, eg. metals and polymers. Various methods of joining can be used successfully. These include welding, press-fitting, mechanical fastening and solvent and adhesive bonding. Choosing of the best method requires fundamentals knowledge of good point design and understanding of purpose of the joint, the type of material, the geometry and nature of components etc. This article describes principles of bonding methods and possible types of adhesives.

1. INTRODUCTION

1.1 Solvent bonding

Solvent bonding is a common technique used for joining injection molded components, especially injection molded components of amorphous thermoplastics. When the components are bonded with this technique, the solvent dissolves the surfaces of the two components and allows the material to flow together. After the solvent evaporates, it leaves a pure material-to-material bond. The components can be safely set aside to dry after 40-60s of hold time but full bond strength will not be achieved for 24 to 48 hours. In some cases it may be desirable to heat the assembly in an oven to drive of the excess solvent. Both point surfaces should be shallow to ovoid entrapment of excessive amounts of solvents. Locators pin or tongue and groove assemblies can help to provide good part matching as well as easy part location after the application of solvents.
Advantages of solvent bonding are good distributes stress over the bonded surface areas, can provide bond instead of bosses and the bond could be hermetic. Big disadvantages of solvent bonding are that Binder products cannot be disassembled, sufficient surface area must be available for proper joining, and solvent vapors released may be hazardous. Adequate ventilation has to always be provided to ovoid possible health hazards posed by the use of solvents. It is necessary to avoid direct contact with the solvents.
For many amorphous and some semicrystalline resins there is more than one solvent which can be used for bonding. Several polymers and various types of solvent for solvent bonding are given in the Table 1.

1.2 Adhesive bonding

Adhesive bonding is one of the most convenient methods of assembling thermoplastic parts or metal parts. Advantage of adhesive bonding is the possibility of joining of similar or dissimilar materials. Adhesives distribute stresses over the entire bonded surface area and can provide hermetic seal if needed.
Other advantages are seen in easiness of application using manual or automatic equipment, elasticity, low costs, easy of repair etc.
There are five major families of adhesives, each with a somewhat unique set of characteristics. The choise of properly type of adhesive, the cure time, cure temperature, temperature resistence, application area etc. have to be take in account.

1.2.1. Epoxy adhesives

Epoxy adhesives are know for their versatily. They bond strength, electrical conductivity, temperature resistence can be modified to fit almost any specific application needs. Epoxide are made both in one

and two part formulation. The two part system (2K) consist of a resin and a hardener that have to be mixed together in defined proportion to achieve required bond properties.
The one part epoxides (1K) require no mixing but they have to cure at elevated temperature. 2K systems are more widely used because they may be stored for long periods and will not activate until mixed.
Advantage of epoxides are good adhesion to bonded materials, high tensile and shear strength, good heat resistence and easy of cure, Disadvantage of this type of adhesive are brittles, low impact strength and relatively high cost.

Table 1. Solvent for solvent bonding of chosen thermoplastics

Polymer	Solvent
ABS	Acetone, Methylene, Chloride, Methyl ethylketone, Methyl isobuthyl Ketone, Tetrahydrofuran
PMMA	Methylene chloride, Ethylene dichloride, Trichloroethylene
Cellulosic	Acetone, Methylethyl ketone
Nylon PA	- místo Polyamid
Polycarbonate {PC}	Ethyleenedichloride, Methylene chlorid
Polystyrene {PS}	Ethylenedichloride, Methylene chloride, Ethylene ketone, Trichlorethylene, Toluene, Xylene
Polysulfone {PSU}	Methylene Chloride
PPO	Trichlorethylene, Ethylene dichloride, Methylenchlorid
PPE	Trichlorethylene, Ethylene dichloride, Methylenchlorid
PVC	Methyl ethyl Keton, Cyclohexan, Tetrahydrofuran, Dychlorobenzin

1.2.2. Urethane adhesives

Urethane (or polyuretane) adhesives are primarily used in applications that require both high strength and flexibility. Are available in 1K or 2K systems. 1K system require heat curing while 2K system may by cured at room temperature. Advantages of polyuretane adhesives are thoughness, flexibility, impact strength, good abrasion resistence and high peel strength. Disadvantages are mainly poor strength at higher temperature, sensitivity to some chemicals and moisture sensitivity in uncured state.

1.2.3. Aerylic adhesives

The aerylic adhesives used today provide of the same attributes as the epoxide and urethane adhesives. In addition, they also offer the advantage of rarely needing primers.
Acrylic adhesives are to disposal in 1K or 2K system. Acrylic bonds rapid cure at room temperature with a setting time of approximately to 2 min and full cure within 30 min or less. The application of heat may be used to reduce cure times.
The advantages of acrylies lays mainy in high strength, superior toughness, fast curing and in possibility to bond contamined surfaces. Big disadvantages of acrylic adhesives are strong and problems with flammability.

1.2.4 Anaerobic adhesives

Anaerobic adhesives are the 1K thermosetting adhesive family whose curing mechanisms is triggered by the absence of oxygen. This eliminate the problem of premature curing. Curing occurs at the room temperature and the higher curing temperature or ultraviolet radiation will increase the speed of the curing process. Anaerobic adhesives are excellent for critical sealing and bonding application where strength is not needed.
The advantages are mainly in good solvents resistence, bond flexibility and good impact strength. Anaerobics are highly sensitive to surface cleanliness.

1.2.5. Cyanoacrilate adhesives

The cyanoacrilate adhesives are 1K fast curing systems. With normal setting time of 2 to 3s and full cure time of about 24 h at room temperatre are these adhesives very popular in tacking and quick contact assembly operations. Curing is initiated by the presence of humidity in the air. Advantage of cyanoacrylates is high strength but bond is brittle and have only limited impact and peel strength.

Some types of adhesives suitable for bonding of themoplastics are given in Table 2.

Table 2. Some type of adhesives

POM	Epoxy, urethanes, rubber, cyanoacrylates
PA	Epoxy, urethane, cyanoacrylates
PET	Urethanes, epoxy, cyanoacrylates
TPE	Urethanes, cyanoacrylates
PC	2K Epoxy, 2K Urethanes
PPO	2K Epoxy, 2K Urethanes, 1K Urethanes
PBT	2K Epoxy, 1K Epoxy, 2K Urethanes
ABS	2K Epoxy, 2K Urethanes

2. EXPERIMENTAL

- Bonded parts / metals
  - steel
  - zincing steel

Bonding surfaces were prepared in the way to be able to fit required thickness of adhesives (Fig 1).

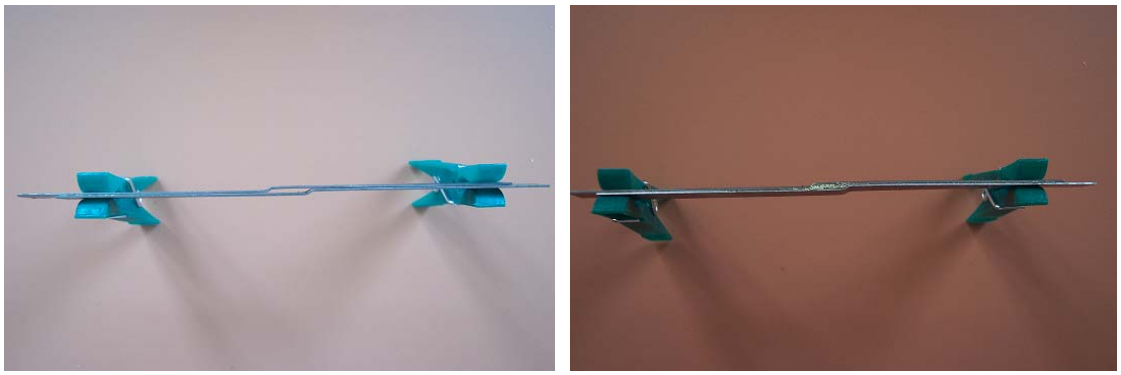

Fig 1. Testing sample before application of adhesives and after application of adhesives

- Adhesives
  - acrylic types SS 1515, SS315 Black, Mayer and Mayer, Austria
  - cyanoacrylic type CYANOFIX, Soudal
  - epoxy type LORD 310, Mayer and Mayer, Austria

- Testing equipment: Tensile strength machine ZWICK 145665

Comparison of various types of adhesives has been done. Some results of bond strength are given in following Fig 2 to Fig 6. In some cases the bond strength nearly reached the strength of basic (bonded) material (steel). Differences between pure steel and zincing steel have been observed.

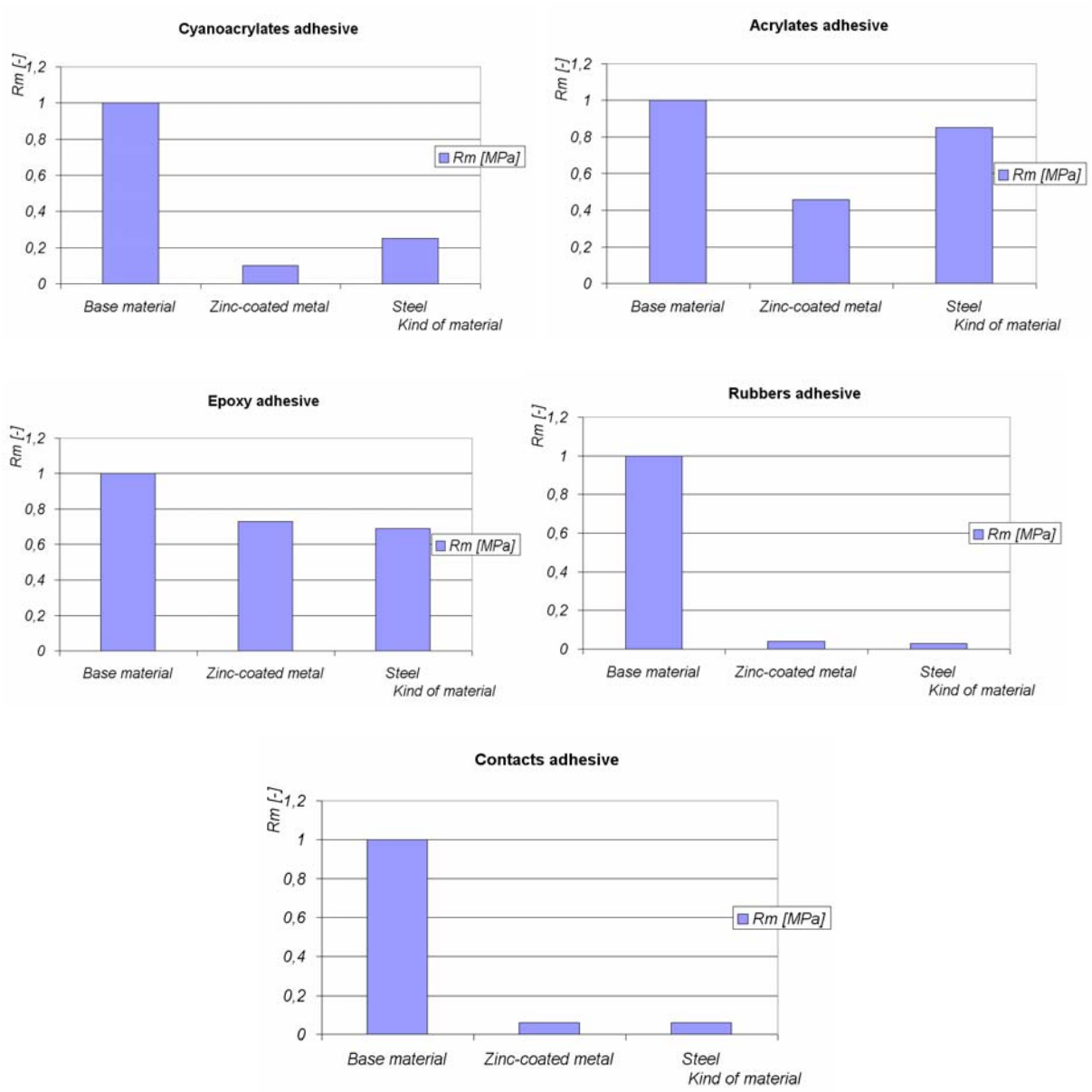

Fig 2-5. Comparison of maximum strain of basic material with bonded material

3. CONCLUSION

The most important factor in selecting an adhesive is the intended use of the product. Also requirement on strength heat resitence, chemical resitence or bond flexibility have to be taken in account.

4. ACKNOWLEDGEMENT

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