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Composite adhesive joints of hardmetals with steel

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Newest developments in the field of gluing and processing of plastics permit obtaining adhesive materials with profitable properties: high mechanical parameters, increased thermal conductivity, low electrical resistivity, increased rigidity, limited residual stresses or reduced creep [1–2]. This is possible by composite structure of adhesives, i.e. binders enriched with filling materials – additional phases of different kind, grain size and fraction. In the paper, effect of reinforcing adhesive materials with continuous and powdery fillers on shear strength of adhesive joints is discussed. Presented are also results of electron microscopy examinations and EDX analysis.

Keywords: *hardmetals, adhesive composites, shear strength, microscopic examination, EDX analysis*

1. Characteristics of adhesive composites

Composites are defined as composite materials consisted of at lease two separate and mutually insoluble phases with different properties, offering a better set of properties and structural features coming from each of the materials separately [1–4]. Composites are externally monolithic materials, but have macroscopically visible boundaries between individual components.

Matrix of a composite is to bind the reinforcement and permit utilising its complete properties by effective conveyance of load from outside to the additional, reinforcing phase. Thanks to its flexibility, the matrix reduces stresses in composites and gives them specific operational, physical and chemical features [2]. The matrix facilitates forming composite bonds, affects their thermal properties and transmits stresses to the reinforcement.

Fillers can be divided into fibrous (continuous), used for manufacture of laminar materials, and powdery – spherical, irregular, flaky or in form of short cut fibres, see Figure 1 [1, 4]. Properties of composites depend on kind, size and fraction of filler, chemical and physical structure, as well as on adhesive abilities resulting from intermolecular distance of the couple matrix–reinforcement [1, 4]. A very important question is also proper orientation of fibres in individual layers of a composite or, in case of a powdery additional phase – its uniform distribution in the matrix. Besides reinforcing fillers, some chemically neutral additional phases are applied to reduce manufacturing costs of composites.

Usage of powdery fillers does not result in so large increase of mechanical parameters of composites as it is in the case of fibrous (continuous) fillers, but permits an improvement or even reaching some selected usable properties. Fraction of the reinforcement can even reach ca. 80 vol% in relation to the matrix, provided that the additional phase is well glue-wettable [1, 4–6]. Apart from size and shape of powdery fillers, important is also the relation between the grain length and cross dimension. From among the most frequently used inorganic fillers, the following should be distinguished: powders of metals and alloys, various oxides, nitrides and carbonates, glass, graphite and silicon compounds [1, 4–5].

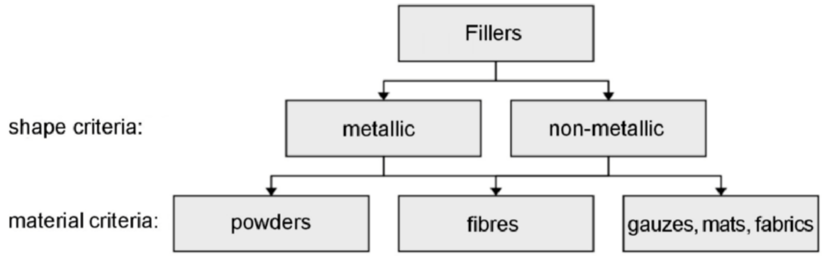

Fig. 1. Kinds of fillers depending on material and shape criteria [1]

2. Effect of fillers on properties of adhesive joints

Irrespective of their form, fillers are first of all used to eliminate the most significant shortcomings of adhesive joints, i.e. relatively low strength, irresistance to high temperatures, very low thermal and electrical conductivity. Properties of a composite are strictly related to kind and size of the particles, their volume fraction and distribution in the matrix [1, 4–5]. Unlike composites with plastic matrix, adhesives with composite structure include mostly powdery fillers as the additional phase. Maintaining suitable volume fraction guaranteeing profitable wettability, they increase mechanical strength of adhesive joints by improving forces of cohesive bonds. By selecting a suitable filler (chemical composition, granularity and shape), it is possible to design material properties which assume extreme values depending on forecast applications. A typical example is ability to conduct heat or electrical current. Adhesives of composite structure can demonstrate diametrically different characteristics – from typical insulators to materials with increased thermal conductivity coefficient or ohmic resistance corresponding to that of metallic conductors [1, 4, 7]. The other benefits resulting from applying adhesive bonds with composite structure are: improved impact strength, magnetic and processing properties, vibration damping ability, possibility of designing light but rigid structures, and resistance to unfavourable environmental conditions.

Generally, improvement of selected properties of adhesive bonds with composite structure is related to deterioration of other properties, so in fact the choice becomes a compromise solution. Nevertheless, the economical and operational benefits resulting from using such binders justify continuing research/development works in this field and predict its dynamic development.