RESEARCH IN MECHANICAL PROPERTIES OF ADHESIVE CONTAMINATED WITH DUSTY MICRO-PARTICLES FROM PRODUCTION PROCESS

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Abstract. Adhesive bonding technology is effectively used in various production companies. It is not always possible to eliminate contamination of an adhesive with environment at the technological process of production at the application of the adhesive bonding technology. The research was focused on evaluation of the influence of dusty micro-particles contamination of a two-component epoxy adhesive at the hardening process. The dusty micro-particles were gained from filtering equipment used in a production hall. The tensile strength and impact strength were watched within the research. Moulds for casting of the test specimens were made from material Lukapren N using prepared models. The shape and sizes of moulds meet the corresponding standards CSN EN ISO 527-1, CSN EN ISO 3167 and CSN 64 0611. The contamination of the adhesive with dusty micro-particles increases dispersion variance of the results. It is obvious from the results that the dusty micro-particles lower the mechanical properties of the adhesive.

Keywords: adhesive bond, dusty micro-particles, tensile strength, impact strength.

Introduction

The adhesive bonding technology is effectively used in various production companies. It is not always possible to eliminate contamination of an adhesive with an environment at the technological process of production at an application of the adhesive bonding technology.

Many research projects dealt with preparation of adhesive bonds, logistic, degradation aspects etc. [1-3]. An area, which has not been properly investigated at present, is the influence of contamination of the adhesive bonds by dusty micro-particles, e. g., from ventilation of assembly shops, production hall etc.

During hardening, e.g., of two-component epoxy adhesives the epoxy resins react with hardeners and they create macro-molecules [4]. The polymeration process influences the resultant strength of the adhesive bond [5-7]. It can be supposed that it comes to lowering of the resultant adhesive bond strength at the adhesive bond contamination during the hardening process (the polymeration).

In the past many studies focused on evaluation of the environment in various buildings were performed [8; 9]. Also spaces in which people are moving at doing various activities were investigated [10-12]. It was ascertained that there is a huge amount of dusty contaminants in different buildings [13].

The research was focused on evaluation of the influence of dusty micro-particle contamination of the two-component epoxy adhesive at the hardening process. The dusty micro-particles were gained from the filtering equipment used in the production hall.

It is not a composite material. The aim of the research was practical utilization of adhesives at suggesting constructional adhesive bonds in spaces with increased dusty contamination or in places where it is hardly possible to reach a clean working environment, e.g., some production halls or agricultural (farming) buildings for breeding animals.

Materials and methods

Impurities from the filtering equipment in the production hall were analysed by means of a sieve analysis. Sieves of dimensions 315 µm, 250 µm, 160 µm and 90 µm were used. These impurities from the filtering equipment were subsequently mixed into the adhesive in a given ratio (Fig. 1). Two-component constructional epoxy adhesive GlueEpox Rapid was used. The impurities from the filtering equipment were added in the following ratio: 100 000 mg of the two-component adhesive (parts A and B): 250 mg, 500 mg, 750 mg and 1 000 mg of the impurities of different particle size. Particles below 90 µm were not used. The reason was the heterogeneity of a fraction caused by the impossibility of separation on sieves.

Impurities gained from the filtering equipment, respectively common dust which can be found in the air all around us, were used in this research. This dust consists generally of human skin cells, vegetable pollen, human and animal hairs, textile fibres, paper fibres etc.

Tensile test. The test specimens for the tensile properties determination according to the standard CSN EN ISO 527-1 (Plastics – Determination of tensile properties – Part 1: General principles) were prepared according to the standard CSN EN ISO 3167 (Plastics – Multipurpose test specimens). By the destructive testing the tensile strength was determined.

The moulds for casting of the test specimens were made from the material Lukapren N using the prepared models. The shape and sizes of moulds meet the corresponding standards.

The mould consisted of two parts in order to reach an even surface on both sides of the test specimens.

The tensile strength tests were performed using the universal tensile strength testing machine LABTest 5.50ST (sensing unit AST type KAF 50 kN, evaluating software Test&Motion). The speed of deformation corresponded to 6 mm·min^{-1}.

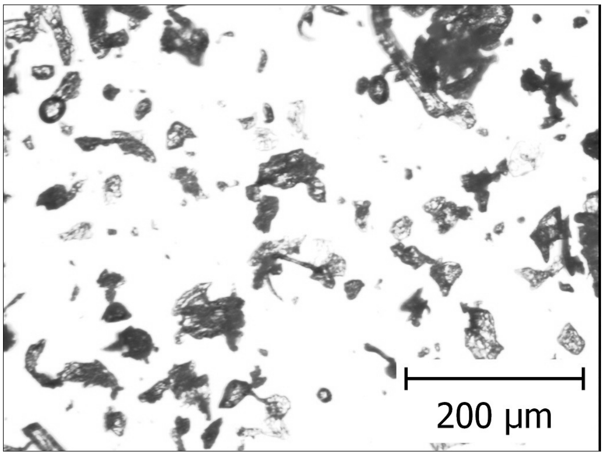

Fig. 1. **Impurities from filtering equipment**

Impact strength. The impact strength was set in an apparatus Dynstat determined for testing of plastics. The test specimen preparation and impact tests were performed according to the standard CSN 64 0611 (Determination of the impact resistance of rigid plastics by means of Dynstat apparatus). By the destructive testing the impact strength was determined.

The tested sets were mutually compared using the F-test in terms of the influence of various filler concentrations of the cast test specimens on the tensile strength and the impact strength. The zero hypothesis H_0 presents the state when there is no statistically significant difference ($p > 0.05$) among the tested sets of data from their mean values point of view.

Results and discussion

The strength results of the adhesive contaminated with the impurities from the filtering equipment ranged in the interval 32 to 76 MPa. The adhesive strength (without contamination with impurities) was 65.61 ± 6.84 MPa. From the results presented in Fig. 2 no explicit trend depending on the size or the concentration of the impurities is visible. However, a huge increase of a dispersion variance of the results is explicitly visible. This fact is considerably limiting for practical application of adhesives.

Fig. 3 shows the results of the impact strength. The results of the impact strength of the adhesive contaminated with impurities from the filtering equipment ranged in the interval from 0.89 to 2.12 kJ·m^{-2}. The impact strength (of the adhesive without contamination) was 2.13 ± 0.23 kJ·m^{-2}. From the results presented in Fig. 3 no explicit trend depending on the size of the impurities or their concentration is visible. Only the trend of decreasing the impact strength against the two-component epoxy adhesive without contaminating impurities is obvious.

The results of the F-test are in terms of the influence of the dusty particle concentration on the adhesive strength:

- Tensile strength: the hypothesis H_0 was confirmed at the size of the dusty particles 160 µm ($p = 0.3535$), so there is no difference among particular tested concentrations in the significance level 0.05. The hypothesis H_0 was not confirmed at other sizes of the dusty particles 315 µm ($p = 0.0071$), 250 µm ($p = 0.0150$) and 90 µm ($p = 0.0002$), so there is a difference among particular tested concentrations of the dusty particles in the significance level 0.05.
- Impact strength: the hypothesis H_0 was certified at no tested sizes of the dusty particles ($p = 0.0000$), so there is a difference among particular tested concentrations in the significance level 0.05.

Exposing of the adhesive bonds to various contaminants both during the production and at the application can influence the mechanical properties of the adhesive [14-18].

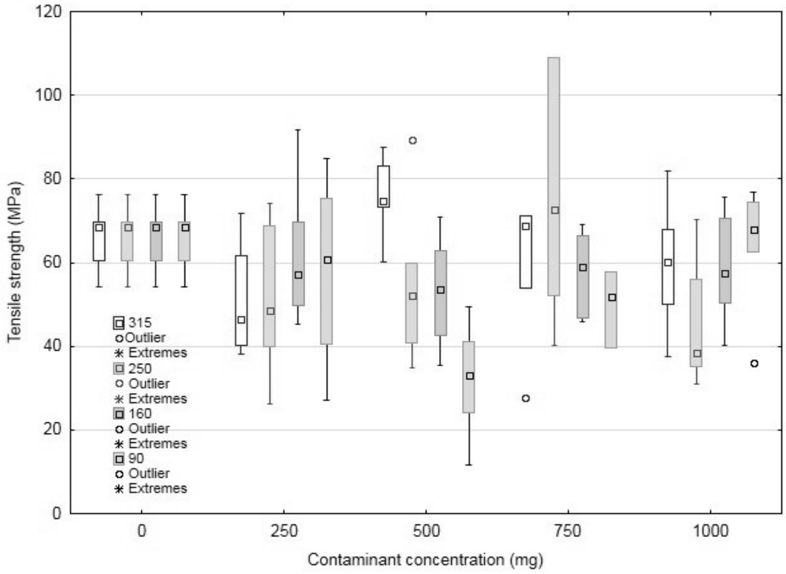

Fig. 2. **Influence of concentration and size of impurities on adhesive strength**

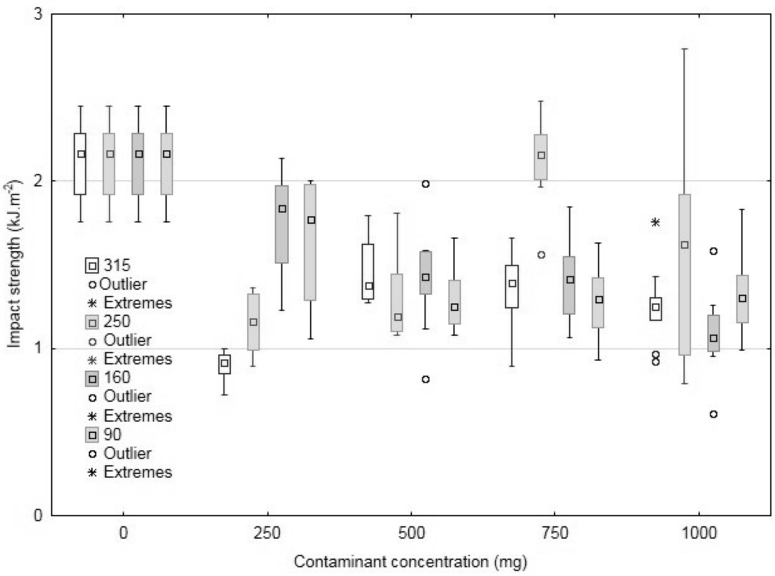

Fig. 3. **Influence of concentration and size of impurities on impact strength**

Conclusions

The following conclusions can be deduced from the research focused on the influence of contamination with dusty micro-particles from the filtering equipment on the tensile strength and the impact strength:

1. The change of the tensile strength caused by contamination with the dusty impurities ranged in the interval – 52 to 17 %. The tensile strength increased only at two tested sets (250 µm, concentration 750 mg – increase of 17 %, 316 µm, concentration 500 mg – increase of 16 %). The variation coefficient ranged among 10.1 to 35.6 % at the adhesive contaminated with impurities. The variation coefficient was 10 % at the adhesive without contaminants.
2. The fall of the impact strength caused by contamination with dusty impurities was in the interval 0 to 58 %. The variation coefficient ranged among 10.6 to 39.6 % at the adhesive contaminated with impurities. The variation coefficient was 10.5 % at the adhesive without contaminants.
3. Contamination of the adhesive with dusty micro-particles increases the dispersion variance of the results. This fact is considerably limiting for practical application of adhesives.

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