POLYMERIC COMPOSITES BASED ON AL_2O_3 REINFORCING PARTICLES

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Abstract. Material research and development of new materials are the base of the human activity branches growth. The basic knowledge of the material characterizations and their behavior at the same time are the basic presumptions for an optimum choice of applied materials. The subject of carried out experiments was the polymeric particle composite the united phase of which was in the form of two-component epoxy adhesive and non-united phase (the reinforcing particle) were particles of Al_2O_3. The polymeric composites combine synergic of the mechanical properties of the filler with the suitable properties of the matrix enabling to spread the utility qualities when applying adhesives not only for the bonding, but also for the renovation of worn parts. Polymeric composite systems get into the agriculture production these days. It comes to an intensive development of enough wear – resistant systems. The tested composite systems showed the linear increase of the resistance against the relative abrasive wear and linear increase of the hardness with the increasing filler concentration. The plus of the above mentioned composite systems is the decrease of the soil adhesivity, connected decrease of the energy demand and the corrosion elimination.

Keywords: Al_2O_3, hardening, mechanical properties, particle polymeric composite, wear.

Introduction

The plastic materials and materials developed on their basis are without question the dynamic developing materials group [1-4]. The soil adhesivity to the working equipment and connected decrease of the energy demand are minimized due to chemical and physical properties when applying polymeric composites.

In this group the polymeric particle composites can be included. They combine synergic of the mechanical properties of the filler with the suitable properties of the matrix [5]. Cementing is the primary determination of these material systems, where the static and dynamic stress can be supposed.

Composite materials represent the group which asserts oneself increasingly in many fields of human activity and knowledge. By the synergic effect these materials connect the properties of single phases and in this way they enable to reach better properties than it is given by their simple sum [5]. On this effect the production philosophy and these materials use are based. Experimental measuring was intended to demonstrate the definite dependences between "particle" composites of different filler phase part by volume and their properties. The substantial change of mechanical properties can be reached by addition of optimal filler content in adhesive. In this way the polymeric particle composite of specific properties comes into being. The optimal usable properties of these composites are limited above all by the risk of the cohesion failure, which is caused by the filler unsuitable concentration and material.

Composite materials can include fillers of various sizes. In engineering such micro-composite materials are of the greatest importance, the maximum cross size of which usually does not exceed 10 μm [6]. Concentration is generally considered to be one of substantial parameters influencing the whole composite properties [7]. The important criterion for the multiphase material system submission among composites is the content of minimal 5 % filler content [8]. Other multi-component systems, which do not fulfill the mentioned criterion, cannot be considered to be composite materials [8]. In particle composites the fillers from hard and thermodynamic stable compounds are used. The silicon carbide (SiC) and the aluminum carbide (Al_2O_3) are the most significant, both in form of irregular particles [9].

The main task of the matrix is to interconnect the discontinued filler phase. This task should be kept also after first failures. This demand is met above all by metal and polymer matrix [10]. The subject of the carried out experiments was the polymeric particle composite, the continuous phase of what was in the form of two-component epoxy adhesive and discontinuous phase of corundum (Al_2O_3). By experiments the abrasive wear and hardening SHORE D to the filler part by volume were determined.

The research of the given problems proposes the deeper knowledge of the dependence between the two-component epoxy adhesive and the filler in the form of Al_2O_3.

The aim of the given issue research is to find out the influence of composite systems based on Al_2O_3 on the abrasive wear. The tested systems are compared with the steel secondarily. The research aim is to obtain such polymeric particle composite the properties of which are optimum and stable with regard to competitive systems of similar base offered on the market.

Materials and methods

The particle composite was made from two basic phases. The two-component epoxy adhesive LEPOX UNIVERSAL P11 ECO was the matrix, the abrasive corundum micro grains Al_2O_3, grit F 600 (grain size 9.3 µm), F 800 (grain size 6.5 µm) or F 1200 (grain size 3.0 µm) were the filler [11]. The corundum hardness is 1800 till 2000 HV.

The determination of component parts concentration was expressed by means of volume percentage. Composites were prepared using from 5 to 25 volume percentage of filler (gradation 5 %). By mixing of the matrix and filler phases the specific composite was created.

The form and size of moulds meet the corresponding standards. The moulds for casting were made of the material Lukapren N using models. The composite mixture injection in the moulds was carried out using syringe of 20 ml capacity. A required amount of the composite was injected into the form. A steel shim of sizes 25×25×7 mm was inserted into the form secondarily. Inserting the steel shim should simulate the "real application", that means the adhesive forces regarding. The tested specimen final size was 25×25×17 mm – Fig. 1.

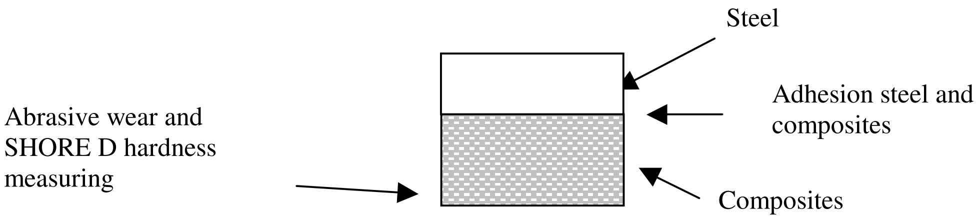

Fig. 1. **Tested specimen for testing abrasive wear and SHORE D hardness**

The abrasive wear tests were carried out on the equipment with an abrasive cloth distinguished for the high abrasiveness coming from the standard ČSN 01 5084. The testing equipment with the abrasive cloth consists of a uniformly rotating horizontal plate on which the abrasive cloth is fixed – Fig. 2.

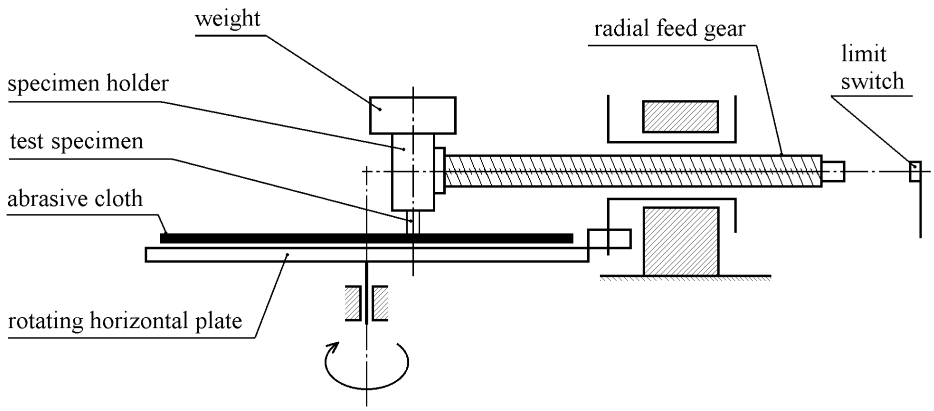

Fig. 2. **Scheme of equipment for testing abrasive wear [15]**

The tested specimen of size 25×25×17 mm is held by a pulling head and is pressed to the abrasive cloth of the grit F 220 by the force which is induced by a set of weight of the total mass 2.35 kg. The tested specimen is shifted from the edge to the center of the abrasive cloth during the test and it is still contacted to the unused abrasive cloth by a part of its surface. The polymer – resin LEPOX UNIVERSAL P11 ECO was used as the etalon. As the second step the comparison with the steel etalon – steel 12 014 of an average hardness 100±2 HV – was carried out. The test principle corresponds to the two body abrasion where bonded hard particles penetrate the surface and harder particles wear the softer material in the mutual motion. This process leads to the material separation and to the material mass and volume losses.

The mass decreases were weighed on the digital analytical scales weighing for 0.0001 g. The measurements were carried out repeatable for the inaccuracy decreasing and afterwards they were statistically evaluated.

The relative wear was calculated according to the equation (1).

$$\psi_h = \frac{W_{hZ}}{W_{hPZ}} \tag{1}$$

where ψ_h – relative abrasive wear;
W_{hZ} – mass decrease of etalon, g;
W_{hPZ} – mass decrease of tested specimen, g.

The hardness SHORE D was measured according to the standard ČSN EN ISO 868 [17].

Results and discussion

The machine parts change the given size and shape as the consequence of the wear, the equipment becomes less efficient and less reliable and the marginal status can occur in a following use in which the equipment fails.

The tested composite systems showed the hardness linear increase according to the method SHORE D with the increasing filler concentration – Fig. 3. When adding 25 % of the filler the hardness increased on average of 5.6 till 9.7 % against the resin.

The tested composite systems showed the linear increase of the resistance against the relative abrasive wear with the increasing filler concentration – Fig. 4. The abrasive cloth, which was used for the surface abrasive wearing, has the main fraction specific grain size in the interval 63 till 75 μm of the abrasive cloth P220. The composites with lower granularity showed higher resistance that means with larger grain size. The composites based on the filler of granularity F800 and F1200 showed similar values, mainly when the concentration was 20 till 25 %.

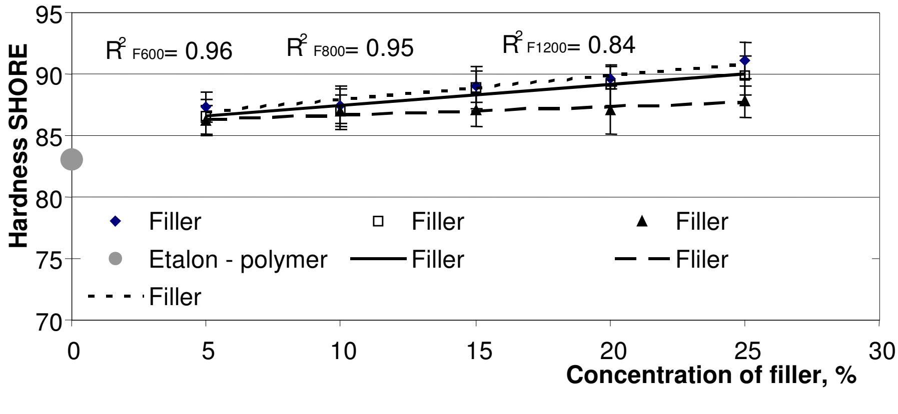

Fig. 3. **Influence of polymeric particle composite filler concentration and granularity to hardness**

The comparing test with the steel etalon was carried out for the possibility to replace the steel by composite surfaces – Fig. 5. The relative wear volume values had to be stated for increasing the declaring quality because of the different density of steel etalon 12 014 and polymeric composites. The steel etalon density was cca 7.85 g·cm^{-3}. The polymeric composites density was cca 1.30 g·cm^{-3}. The epoxy resin density was 1.15 g·cm^{-3}.

The composite materials and the epoxy resin showed lower values of the relative wear against the steel etalon. The found out results can be seen in Fig. 5. The results showed the trend of the granularity size influence which is essential for developing the composite materials resistant against the abrasive wear. The resistance against the wear decreases with the increasing granularity that means with the grain size decrease.

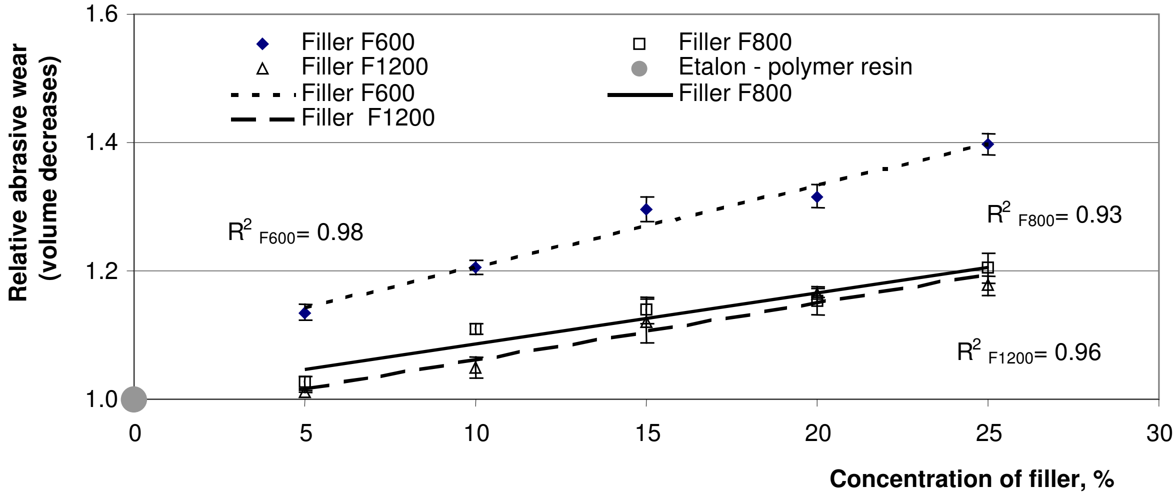

Fig. 4. **Influence of polymeric particle composite concentration and granularity to wear**

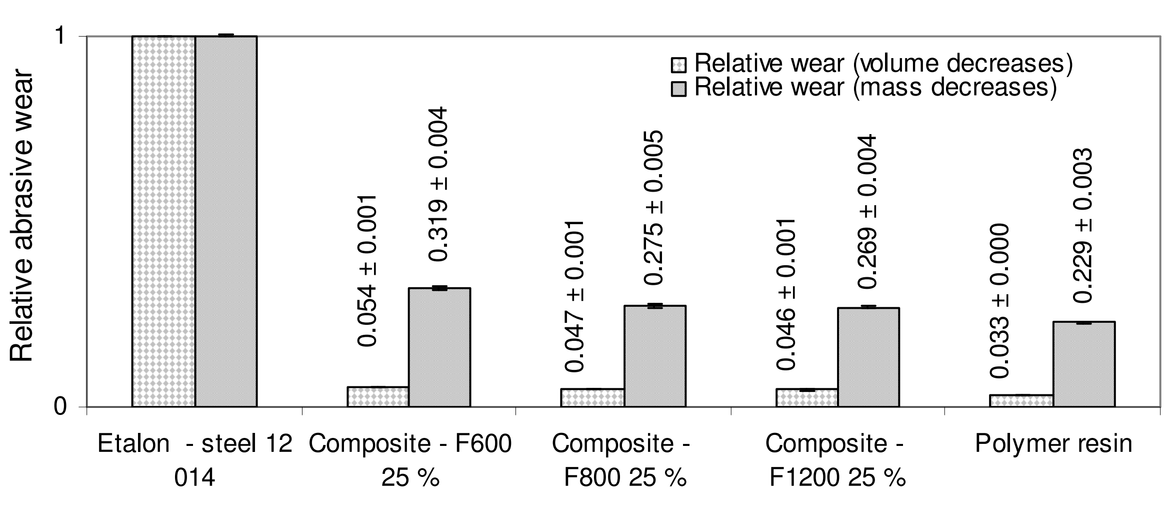

Fig. 5. **Comparison of resistance against abrasive wear**

Conclusions

Renewing of wearing parts and functional systems of agricultural machines will spread for higher number of single machines thanks to implementing new materials and new technologies.

Low input costs and easy preparation are the definite positive factors for the polymeric particle composite application possibility in the agriculture production.

The second essential plus of polymeric particle composites is the surface energy non-exceeding 50 $mN\cdot m^{-1}$. The surface energy of metals based on iron moves about 2000 $mN\cdot m^{-1}$. This presumption shows clearly the adhesivity elimination of the soil to working equipment and connected energy demand and the corrosion.

The wear was tested in the “high abrasive” surroundings of the bonded abrasive that means of the abrasive cloth. The resistance against the wear showed the linear increasing trend. This trend can be further researched. The “saturation” of the prepared composite mixture by the filler is the limit of this system. The linear increase of the resistance against the wear did not confirm the results of Sataphy and Bijwe stating the optimum filler volume as cca 15 %.

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