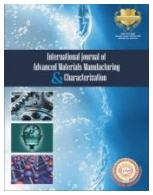

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Investigation of Effect to Mechanical Strength of Additive Powder Type into Adhesive

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ABSTRACT

The objective of this study is to investigate the capability of adhesive with adding aluminium powder and 63/37 Sn-Pb soft solder powder and copper powder to the epoxy to increase the mechanical strength of joints. The adhesive strength of the joints was determined by utilizing the single-lap shear test. Experimental results show that joints prepared by adhesive which was modified, adding 5 wt% 63/37 Sn-Pb powder have more mechanical strength than joints compared to ones which were prepared by adding aluminium powder and copper powder with ratio as 5 wt%.

Introduction

Adhesive bonding is frequently preferred method used for joining same or different materials. Adhesive is an engineering material and adhesive bonding technique is well accepted part of production. The adhesive materials have many different chemical types, physical forms and application methods. Some of the adhesives show binding feature at room temperature while some of the become so with the help of heat.

Today, adhesive bandings are used extensively in aviation, aerospace and automotive industries. Despite adhesives essential mission is making joints, they are also prefered due to seal or insulation properties.

The type of bonding material, surface preparing and using condition of bonded materials effect the success of processing directly. Bonding strength of joints being subjected to specified load is related with many factors. Generally, strength of adhesive bonding is related with size, thickness, geometry, elasticity modules, and bonding length of bonded parts, surface cleanliness of bonding area, bonding being sustained conditions, adhesive material and care that taken at adhesive bonding process.

As a course of their nature, adhesive materials' characteristic, working capability and strength are limited. For that reason, some changes on adhesive material have to be made to increase the mechanical strength properties over adhesive bondings.

The powder addition in the adhesive is widespread application to improve the mechanical strength, thermal and electrical conductivity [1-6]. Kilik and Davies [7]; made a series of mechanical tests to evaluate mechanical properties of epoxy material that 50, 75, and 100 μm aluminium and copper powders added into. While the powder added into adhesive is used at the ratio 5, 15, 30 and 50 wt% for tensile, shear and peeling tests; for impact and fatigue test the preferred ratio 1 and 5 % volume percents. They prove that powder proportion and type lead to some mechanical property changes. Evidences show that although adding powder into adhesive does not have an advantage on tensile strength and impact energy, it has good results on shear and t-peeling. When 5 wt% powder added into adhesive, the similar increases observed for shear strength for both powder types. Kahraman and et al. [8] searched effects of adhesive thickness and the amount of filler on mechanical performance at joints which bonded with epoxy material filled by aluminium powder. Bonding strength was obtained from single lap shear tests. While some joints were formed by pure adhesive, others were being formed by modified adhesive with different amounts (10, 25 and 50 wt%) of aluminium powders. Experimental results has showed that bonding strength increases by adding different amount of powders into adhesive.

Xian [9] get higher bend and impact strength at mechanical tests done by adding 4 wt% percent of 300 nm sized nano-TiO_2 powder into adhesive than by pure adhesive epoxy. While bend strength is about 110 MPa at pure epoxy, in TiO_2 added epoxy strength increases to 135 MPa. Also, impact strength increased from 25 MPa to 40 MPa by adding TiO_2 powder into adhesive.

Sancaktar and Gomatam [10] add different size and shape nickel powders into adhesive named Epon 830, and use this modified adhesive to join 1018 cold rolled steels. Results show that better wetting occurred with irregular shaped particles compared to spherical particles. The results of their work showed that the nature of the filler plays an important role on the strength and the conduction behavior of the joint.

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Filler materials in the adhesives are mostly copper, aluminium, nickel, short carbon fibers, ceramics, nano-TiO_2, nano- $CaCO_3$ and nano- SiO_2. In this study, 5 wt% amounts of 63/37 Sn-Pb solder, copper and aluminium powders added into epoxy as additive fillers. In experiments done with single lap joints, the effects of the type of powders added into adhesive on mechanical strengths are searched.

Experimental

Material and Method

In experiments, Permabond ESP110 named adhesive was used. Permabond ESP110 is an epoxy which is single component and being cured with heat. Filler materials are irregular 44~100 μm sized soft solder powder, spherical formed aluminium powder which is 60 μm in diameter and irregular formed copper powder which is 200 μm in diameter.

Erdemir 6112 (St 12) steel plate was chosen as an experimental material. In the selection of this material, wide usage of steel plate in the industry had been taken in account. Experimental material is used in home appliance and automative industry, widely.

Steel samples were prepared according to standart [11]. Samples shapes are shown in Figure 1. The chemical composition and mechanical properties of steel plate are given at Table 1 and 2, respectively. Also in Figure 2, tensile diagram of steel can be seen.

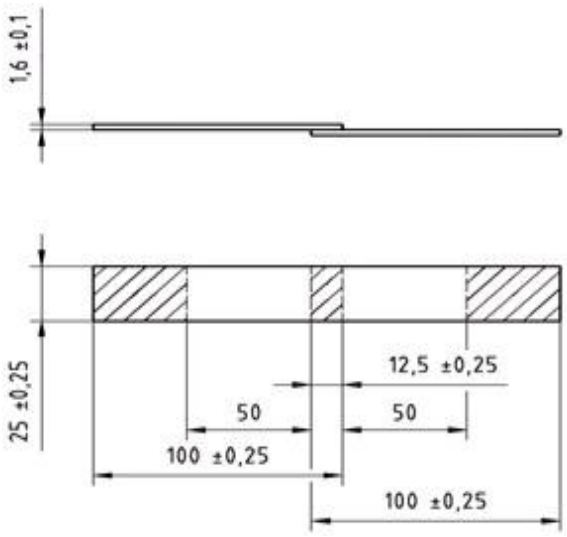

Fig. 1 Configuration and dimensions of lap shear bonded specimens

Table 1. Chemical composition of steel

Chemical composition wt %			
Carbon (C)	Phosphore (P)	Sulfur (S)	Manganese (Mn)
0.07	0.02	0.02	0.4

Table 2. Mechanical properties of steel

Yielding (kg/mm^2)	Tensile strength (kg/mm^2)	Elongation (%)
23.98	34.8	30.79

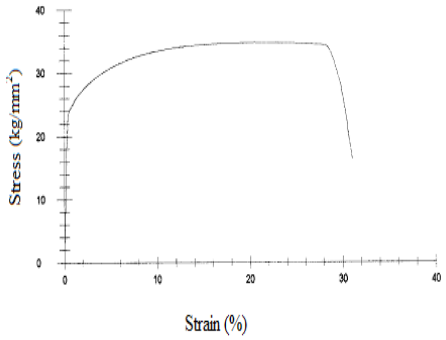

Fig. 2 The stress–strain curve of steel

In this study, mechanical abrasion (emery papers) was chosen to prepare joints surfaces. The bonding region of samples were abraded by 3M Diaped diamond abrasive. The abraded surface was cleaned with acetone and washed with distillate water. After drying with hot air for adhesion prosess, the samples were bonded. Adhesive material and filler powders were mixed in a plastic plate and then applied on the joint surfaces with the help of spatula. The mechanical pressure (about 50kPa) was applied on the samples' adhesion joints with the help of two metallic paper clips. That type of pressing method was used by some researchers [12,10,13]. All bonding processes were done at the 180 °C furnace temperature. At this temperature, 63/37 Sn-Pb solder alloy does not start to melt and powder in the adhesive is still kept as powder. Also copper and aliminium powder keep their initial shapes in the adhesive as powder shape.

Adhesion joints were cured by using Heraeus Oven Model T 5042 EK drying furnace

Results and discussions

Seven couples of adhesive bonded samples with Permabond ESP110 were prepared according to TS EN 1465standard [11] and then their shear tensile strengths were measured. 10-ton Zwick Z100 tensile measuring equipment was used for tensile tests. Tensile speed was 1mm/min and its speed was constant.

The shear strengths of joints which were prepared by soft solder and aluminium powder and copper powder (5 wt%) added into adhesive separately was measured. 5 wt% percent of additive is selected according to results of our previous studies [14]. For each amount of percent ratios, 5 samples were prepared and graphics were obtained by taking average of these 5 samples' shear strength values.

It can be seen from the Fig.3 that mechanical strengths of joint. Adding 5 %wt of soft soldering powder to Permabond ESP 110 gives best mechanical strength. Adding copper powder to

epoxy increases strength compared to aliminium powder but it causes decreasing of strength compared to pure epoxy.
Differences in shear strength between copper (as solder) and aluminium powders probably result from powder forms (shapes). Aluminium powder is in spherical form. Hence, powder surface easily seperated from adhesive at tensile-shear tests. It is conceivable that nonuniformed solder powder (as copper) cause joint mechanical strength to increase due to clamping with adhesive and delay of seperation from adhesive.

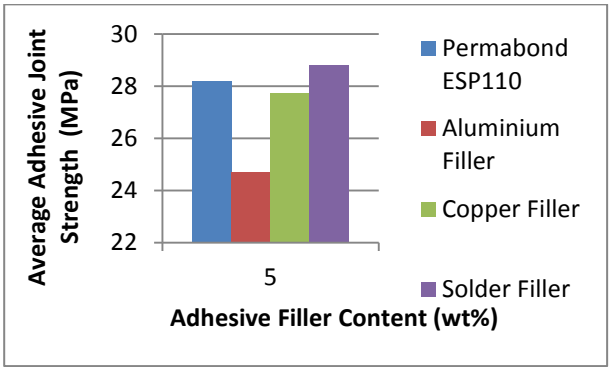

Fig. 3 Effect of powder additions on the lap shear strength of the adhesive joints

Remarks

Nowadays; various powders are used as an additive material into epoxy are with different forms. Effects on bonding of powders added into adhesives show differences with respect to powders sizes and shapes. Powders used in this study are about micron sized. However, it is thought that using same powders as nano sized will give better mechanical strength.

Conclusions

Results from this study given below.

- Adding 63/37 soldering powder into adhesive provides better mechanical strength than bonding with pure epoxy.
- The type and size of powder which gives the greatest improvements vary according to the mechanical property. 63/37 solder powder added adhesive bonded joints has more strength than aluminium powder and copper powder added ones.
- The experimental results show that solder powder can be used as an alternative filler material within the powders which are added into epoxy.

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