METAL COATED FIBERS FOR EMI SHIELDING COMPOSITES

Introduction

The tremendous growth and nearly universal application of engineering plastic housings in the computer and business equipment industry is frank testimony to the utility and broad appeal of these materials. They provide designers and engineers with combinations of aesthetics, physical strength, and design flexibility, virtually impossible to find in any other medium. A fundamental attraction of plastics is that they readily allow the integration of function, reducing or eliminating the need to incorporate subassemblies.

The new FCC regulations have highlighted perhaps the one thing that plastic housings cannot do and that is to shield electromagnetic interference (EMI). In their native state, plastics are transparent to radiofrequency signals. To remedy this deficiency, the last few years have seen a tremendous surge in efforts to produce composites of plastic resins and conductive fillers. While much progress has been made, considerable room for improvement still exists. This article will describe metal coated graphite fiber as a new, innovative conductive fiber which is commercially available to develop composite technology for EMI shielding.

Metal Coated Fiber Fundamentals

One of the most striking features of metal coated fibers (MCF) is that they are, themselves, a composite material. As such, the intention is to combine the desirable features of each component while minimizing less desirable properties. Currently available fibers include nickel coated graphite (NCG), which combines the high strength and low weight of a graphite fiber core with the conductivity and corrosion resistance of a plated nickel skin. Coatings of silver, gold, brass, copper, and other metals are also available. The retention of good contact resistance and relatively low cost makes nickel coatings the most likely choice for conductive composite shielding applications. MCF product forms include chopped fiber, non-woven mat, woven fabrics and upgraded products such as advanced composite materials (ACM). MCF advanced composite materials are eminently suitable for such applications as lightning strike and electrostatic discharge protection for aircraft. ACMs incorporating MCF provide high conductivity and excellent physical properties.

Fiber Dimensions

The effect of being a composite itself is readily observed in the NCG fiber specific gravity. Nickel has a specific gravity of 8.9 and graphite fiber has a specific gravity of 1.8 giving an NCG specific gravity of 3.2. Thus, an NCG fiber is only 36% as dense as a solid nickel metal fiber and only 40% as dense as steel. This is because the nickel coating only represents 23.4% of the total fiber volume. With a nickel thickness of about 0.5 microns, NCG fiber diameter is typically 8.0 microns.

The unusually high length to diameter ratio of MCF coupled with the low contact resistance of nickel allows for effective EMI shielding at low fiber loadings. Fiber L/D or aspect ratio is an important parameter for describing to what degree an effective microconductive fiber network can be created within the fiber/resin composite. A long fiber with high aspect ratio has a statistically better chance of constructively overlapping other fibers than a low aspect ratio fiber, resulting in a more extensive conductive path.

The interrelationship between fiber diameter and net specific gravity dramatically illustrates one of the distinct advantages of a metal coated fiber. In practical terms, the actual working parameter for fiber is length and total fiber length per pound is completely described by fiber diameter and specific gravity. In fact, total fiber length is inversely proportional to the specific gravity and inversely proportional to the diameter squared. Thus, the lower the specific gravity and/or the diameter of the fiber the greater the fiber length per pound. For example, NCG with a specific gravity of 3.2 and an 8.0 micron diameter yields 1754 miles of fiber per pound. A solid nickel fiber with an SG of 8.9 and the same diameter, however, would only yield 631 miles of fiber per pound. If you were to plate a typical glass fiber with a 0.5 micron coating of nickel, its ultimate diameter would be about 28 microns and the resulting specific gravity of 2.7 would yield only 172 miles of fiber per pound. The low specific gravity and the microscopically fine fiber diameter combine to contribute a multiplicity of conductive paths throughout a resin matrix.

Conductive NCG Composite Performance

The aspect ratio effect is evident when comparing loadings of various fillers in resin composites. A metal powder, being a sphere, has the lowest aspect ratio: its L/D is 1.0. A level of at least 50% by weight is needed to achieve 40 dB of shielding. Thermoplastic injection molded composites can achieve the same level of shielding with 10-20 weight percent of 1/4£ chopped NCG fibers. Thermoset composites (eg. BMC polyester) can attain similar shielding results with 1/2£ chopped NCG fibers at loadings as low as 3% by weight.

This difference between the performance of NCG fibers in thermoplastics and thermosets is largely due to the intensive compounding the thermoplastic composites undergo, causing the fibers to break and lose aspect ratio. Clearly, achieving the highest possible shielding effectiveness from a given loading of MCF in a thermoplastic matrix requires optimum compounding techniques. This includes low shear compounding equipment and downstream feeding. It is a characteristic of metal coated fibers that they disperse well in resin melts with a minimum of work.

Another advantage of composites is their high strength to weight ratio. This is evident both in the metal coated fibers and the MCF/resin composites. The thin metal coating allows practically full retention of the graphite fiber properties. With tensile strengths of up to 450 K psi and tensile modulus of 34 M psi, these are some of the strongest fibers known. When compounded into typical engineering thermoplastics at the 10 wt. % level, these properties translate into a doubling of the resin flexural modulus and a 40-50% increase in tensile strength. Coupled with the conductivity imparted by the metal coating, these composites present many new and unique approaches to the shielding effort.

In addition, many other products such as sealants, adhesives, coatings, inks, cable shields and gaskets can be fabricated to take advantage of the unique conductive characteristics of Metal Coated Fibers. Hopefully, the advent and proliferation of these fibers will spur many other imaginative uses of this versatile product.

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