LOW COST ELECTROSTATIC DISCHARGE-PROOF PUMPS MANUFACTURED FROM CONDUCTIVE LOADED RESIN-BASED MATERIALS

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Abstract

Electrostatic discharge-proof pumps are formed of a conductive loaded resin-based material. The conductive loaded resin-based material comprises micron conductive powder(s), conductive fiber(s), or a combination of conductive powder and conductive fibers in a base resin host. The percentage by weight of the conductive powder(s), conductive fiber(s), or a combination thereof is between about 20% and 50% of the weight of the conductive loaded resin-based material. The micron conductive powders are metals or conductive non-metals or metal plated non-metals. The micron conductive fibers may be metal fiber or metal plated fiber. Further, the metal plated fiber may be formed by plating metal onto a metal fiber or by plating metal onto a non-metal fiber. Any platable fiber may be used as the core for a non-metal fiber. Superconductor metals may also be used as micron conductive fibers and/or as metal plating onto fibers in the present invention.
LOW COST ELECTROSTATIC DISCHARGE-PROOF PUMPS MANUFACTURED FROM CONDUCTIVE LOADED RESIN-BASED MATERIALS

RELATED PATENT APPLICATIONS


[0003] This Patent Application is a Continuation-in-Part of INT01-002CIPC, filed as U.S. patent application Ser. No. 10/877,092, filed on Jun. 25, 2004, which is a Continuation of INT01-002CIP, filed as U.S. patent application Ser. No. 10/309,429, filed on Dec. 4, 2002, now issued as U.S. Pat. No. 6,870,516, also incorporated by reference in its entirety, which is a Continuation-in-Part application of docket number INT01-002, filed as U.S. patent application Ser. No. 10/075,778, filed on Feb. 14, 2002, now issued as U.S. Pat. No. 6,741,221, which claimed priority to U.S. Provisional Patent Application Ser. No. 60/317,808, filed on Sep. 7, 2001, Ser. No. 60/269,414, filed on Feb. 16, 2001, and Ser. No. 60/268,822, filed on Feb. 15, 2001, all of which are incorporated by reference in their entirety.

BACKGROUND OF THE INVENTION

[0004] 1. Field of the Invention

[0005] This invention relates to electrostatic discharge-proof pumps and, more particularly, to electrostatic discharge-proof pumps molded of conductive loaded resin-based materials comprising micron conductive powders, micron conductive fibers, or a combination thereof, substantially homogenized within a base resin when molded. This manufacturing process yields a conductive part or material usable within the EMF, thermal, acoustic, or electronic spectrum(s).

[0006] 2. Description of the Prior Art

[0007] The transport of flammable liquids requires a pumping system that will ignite the material. For example, petroleum is pumped at several different stages of the oil production process. It is pumped from under the ground; it is pumped during the refining process; it is pumped onto and off from ships and/or trucks used for transport, and it is pumped through pipelines. Fuel such as automotive gasoline is another example of a flammable liquid which is routinely pumped. Such fuel is pumped at the refinery; it is pumped onto and off from trucks used for transport, and it is pumped into the end-use vehicle at the gas station. Aviation fuel and kerosene are pumped in a manner similar to gasoline. Hydrafuid is another flammable liquid which is routinely pumped. Hydraulic fluid is used for earth moving equipment and in many industrial machinery/equipment applications. In addition to liquids, flammable gas-phase fluids require pumping systems that will not ignite the fluid. These gas-phase fluids include oxygen and hydrogen. Oxygen may also be pumped as a liquid. In any situation where flammable fluids are pumped, it is vital that the pump itself not be a source of spark and potential combustion. In particular, the pump must be designed to dissipate any static charges to thereby avoid an electrostatic discharge (ESD) event that may ignite the flammable fluid. A primary object of the present invention is to provide for reliable pump for flammable fluids having a reduced risk of ignition due to electrostatic discharge.

[0008] Several prior art inventions relate to pumps and electrostatic discharge. U.S. Patent Publication US 2002/0006395 Al to Rohner teaches a method for measuring the operating parameters of a diaphragm pump by screen printing a conductive plastic loop on the diaphragm and connecting the loop to at least one bridge arm of a Wheatstone bridge. A time-dependent quantity is obtained from measuring voltage in the diagonal arm of the Wheatstone bridge and used for determining the condition of the diaphragm and its subsequent changing. U.S. patent Publication US 2003/0031560 Al to Blattmann teaches a centrifugal slurry pump. U.S. Patent Publication 2004/0071574 Al to Bezd et al teaches a piston machine for delivering gases that utilizes a diaphragm formed of a plastic material interspersed with magnetic particles, and magnetic means.

SUMMARY OF THE INVENTION

[0009] A principal object of the present invention is to provide an effective electrostatic discharge-proof pump.

[0010] A further object of the present invention is to provide a method to form an electrostatic discharge-proof pump.

[0011] A further object of the present invention is to provide an electrostatic discharge-proof pump molded of conductive loaded resin-based materials.

[0012] A further object of the present invention is to provide an electrostatic discharge-proof pump that is intrinsically or inherently safe with respect to static discharge.

[0013] A further object of the present invention is to provide an electrostatic discharge-proof pump with reduced weight.

[0014] A further object of the present invention is to provide an electrostatic discharge-proof pump with reduced manufacturing cost.

[0015] A further object of the present invention is to provide an electrostatic discharge-proof pump with excellent corrosion resistance and chemical impermeability.

[0016] A further object of the present invention is to provide an electrostatic discharge-proof pump with excellent thermal conductivity.

[0017] A further object of the present invention is to provide an electrostatic discharge-proof pump with excellent acoustical response and noise dampening.

[0018] A further object of the present invention is to provide an electrostatic discharge-proof pump where the electrostatic dissipation effect is optimized based on the conductive loading.

[0019] A further object of the present invention is to provide components for an electrostatic discharge-proof pump.
A yet further object of the present invention is to provide an molded of conductive loaded resin-based mate
rial where the chemical, electrical, thermal, or acoustical characteristics can be altered or the visual characteristics can be altered by forming a metal layer over the conductive loaded resin-based material.

In accordance with the objects of this invention, an electrostatic discharge-proof pump device is achieved. The device comprises a housing. An inlet port is through the housing. An outlet port is through the housing. An impeller is in the housing and between the inlet and outlet ports. The impeller comprises a conductive loaded, resin-based material comprising conductive materials in a base resin host. The conductive loaded, resin-based material is molded into an electric motor device comprising a housing comprising the conductive loaded, resin-based material, an inlet port through the housing, an outlet port through the housing, and an impeller in the housing and between the inlet and outlet ports. The impeller comprises the conductive loaded, resin-based material.

In the accompanying drawings forming a material part of this description, there is shown:

FIG. 1 illustrates a first preferred embodiment of the present invention showing an electrostatic discharge-proof pump formed of conductive loaded resin-based material and, more particularly, illustrates a pump used for drilling applications.

FIG. 2 illustrates a first preferred embodiment of a conductive loaded resin-based material wherein the conductive materials comprise a powder.

FIG. 3 illustrates a second preferred embodiment of a conductive loaded resin-based material wherein the conductive materials comprise micron conductive fibers.

FIG. 4 illustrates a third preferred embodiment of a conductive loaded resin-based material wherein the conductive materials comprise both conductive powder and micron conductive fibers.

FIGS. 5a and 5b illustrate a fourth preferred embodiment wherein conductive fabric-like materials are formed from the conductive loaded resin-based material.

FIGS. 6a and 6b illustrate, in simplified schematic form, an injection molding apparatus and an extrusion molding apparatus that may be used to mold an electrostatic discharge-proof pump or pump component of a conductive loaded resin-based material.

FIG. 7 illustrates a second preferred embodiment of the present invention showing an electrostatic discharge-proof pump formed of conductive loaded resin-based material and, more particularly, illustrates a centrifugal pump utilizing a balanced impeller.

FIG. 8 illustrates a third preferred embodiment of the present invention showing an electrostatic discharge-proof pump formed of conductive loaded resin-based material and, more particularly, illustrates a centrifugal pump utilizing a balanced impeller.

FIG. 9 illustrates a fourth preferred embodiment of the present invention showing an electrostatic discharge-proof pump formed of conductive loaded resin-based material and, more particularly, illustrates a pump which utilizes an impeller.

FIG. 10 illustrates a fifth preferred embodiment of the present invention showing an electrostatic discharge-proof pump formed of conductive loaded resin-based material and, more particularly, illustrates a pump which utilizes a vane.

FIG. 11 illustrates a sixth preferred embodiment of the present invention showing an electrostatic discharge-proof pump formed of conductive loaded resin-based material and, more particularly, illustrates a pump in a vehicle fuel dispensing application.
DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0039] This invention relates to a molded conductive loaded resin-based materials comprising micron conductive powders, micron conductive fibers, or a combination thereof, substantially homogenized within a base resin when molded.

[0040] The conductive loaded resin-based materials of the invention are base resins loaded with conductive materials, which then makes any base resin a conductor rather than an insulator. The resins provide the structural integrity to the molded part. The micron conductive fibers, micron conductive powders, or a combination thereof, are substantially homogenized within the resin during the molding process, providing the electrical, thermal, and/or acoustical continuity.

[0041] The conductive loaded resin-based materials can be molded, extruded, or the like to provide almost any desired shape or size. The molded conductive loaded resin-based materials can also be cut, stamped, or vacuumed formed from an injection molded or extruded sheet or bar stock, over-molded, laminated, milled or the like to provide the desired shape and size. The thermal or electrical conductivity characteristics of electrostatic discharge-proof pumps fabricated using conductive loaded resin-based materials depend on the composition of the conductive loaded resin-based materials, of which the loading or doping parameters can be adjusted, to aid in achieving the desired structural, electrical or other physical characteristics of the material. The selected materials used to fabricate the pump devices are substantially homogenized together using molding techniques and or methods such as injection molding, over-molding, insert molding, thermo-set, protrusion, extraction, calendering, or the like. Characteristics related to 2D, 3D, 4D, and 5D designs, molding and electrical characteristics, include the physical and electrical advantages that can be achieved during the molding process of the actual parts and the polymer physics associated within the conductive networks within the molded part(s) or formed material(s).

[0042] In the conductive loaded resin-based material, electrons travel from point to point when under stress, following the path of least resistance. Most resin-based materials are insulators and represent a high resistance to electron passage. The doping of the conductive loading into the resin-based material alters the inherent resistance of the polymers. At a threshold concentration of conductive loading, the resistance through the combined mass is lowered enough to allow electron movement. Speed of electron movement depends on conductive loading concentration, that is, the separation between the conductive loading particles. Increasing conductive loading content reduces interparticle separation distance, and, at a critical distance known as the percolation point, resistance decreases dramatically and electrons move rapidly.

[0043] Resistivity is a material property that depends on the atomic bonding and on the microstructure of the material. The atomic microstructure material properties within the conductive loaded resin-based material are altered when molded into a structure. A substantially homogenized conductive microstructure of delocalized valance electrons is created. This microstructure provides sufficient charge carriers within the molded matrix structure. As a result, a low density, low resistivity, lightweight, durable, resin based polymer microstructure material is achieved. This material exhibits conductivity comparable to that of highly conductive metals such as silver, copper or aluminum, while maintaining the superior structural characteristics found in many plastics and rubbers or other structural resin based materials.

[0044] The use of conductive loaded resin-based materials in the fabrication of electrostatic discharge-proof pumps significantly lowers the cost of materials and the design and manufacturing processes used to hold ease of close tolerances, by forming these materials into desired shapes and sizes. The pumps can be manufactured into infinite shapes and sizes using conventional forming methods such as injection molding, over-molding, or extrusion, calendering, or the like. The conductive loaded, resin-based materials, when molded, typically but not exclusively produce a desirable usable range of resistivity from between about 5 and 25 ohms per square, but other resistivities can be achieved by varying the doping parameters and/or resin selection(s).

[0045] The conductive loaded resin-based materials comprise micron conductive powders, micron conductive fibers, or any combination thereof, which are substantially homogenized together within the base resin, during the molding process, yielding an easy to produce low cost, electrically conductive, close tolerance manufactured part or circuit. The resulting molded article comprises a three dimensional, continuous network of conductive loading and polymer matrix. Exemplary micron conductive powders include carbons, graphites, amines or the like, and/or of metal powders such as nickel, copper, silver, aluminum, or plated of the like. The use of carbons or other forms of powders such as graphite(s) etc. can create additional low level electron exchange and, when used in combination with micron conductive fibers, creates a micron filler element within the micron conductive network of fiber(s) producing further electrical conductivity as well as acting as a lubricant for the molding equipment. Carbon nano-tubes may be added to the conductive loaded resin-based material. The addition of conductive powder to the micron conductive fiber loading may increase the surface conductivity of the molded part, particularly in areas where a skinning effect occurs during molding.

[0046] The micron conductive fibers may be metal fiber or metal plated fiber. Further, the metal plated fiber may be formed by platting metal onto a metal fiber or by platting metal onto a non-metal fiber. Exemplary metal fibers include, but are not limited to, stainless steel fiber, copper fiber, nickel fiber, silver fiber, aluminum fiber, or the like, or combinations thereof. Exemplary metal platting materials include, but are not limited to, copper, nickel, cobalt, silver, gold, palladium, platinum, ruthenium, and rhodium, and alloys of thereof. Any platting fiber may be used as the core for a non-metal fiber. Exemplary non-metal fibers include, but are not limited to, carbon, graphite, polyester, basalt, mat-made and naturally-occurring materials, and the like. In addition, superconductor metals, such as titanium, nickel, niobium, and zirconium, and alloys of titanium, nickel, niobium, and zirconium may also be used as micron conductive fibers and/or as metal platting onto fibers in the present invention.

[0047] The structural material may be any polymer resin or combination of polymer resins. Non-conductive resins or
inherently conductive resins may be used as the structural material. Conjugated polymer resins, complex polymer resins, and/or inherently conductive resins may be used as the structural material. The dielectric properties of the resin-based material will have a direct effect upon the final electrical performance of the conductive loaded resin-based material. Many different dielectric properties are possible depending on the chemical makeup and/or arrangement, such as linking, cross-linking or the like, of the polymer, co-polymer, monomer, ter-polymer, or homo-polymer material. Structural material can be, here given as examples and not as an exhaustive list, polymer resins produced by GE PLASTICS, Pittsfield, Mass., a range of other plastics produced by GE PLASTICS, Pittsfield, Mass., a range of other plastics produced by other manufacturers, silicones produced by GE SILICONES, Waterford, N.Y., or other flexible resin-based rubber compounds produced by other manufacturers.

[0048] The resin-based structural material loaded with conductive powders, micron conductive fibers, or in combination thereof can be molded, using conventional molding methods such as injection molding or over-molding, or extrusion, or compression molding, or calendaring, to create desired shapes and sizes. The molded conductive loaded resin-based materials can also be stamped, cut or milled as desired to form the desired shape form factor(s) of the electrostatic discharge-proof pumps. The doping composition and directionality associated with the micron conductors within the loaded base resins can affect the electrical and structural characteristics of the pumps and can be precisely controlled by mold designs, gating and or protrusion design(s) and or during the molding process itself. In addition, the resin base can be selected to obtain the desired thermal characteristics such as very high melting point or specific thermal conductivity.

[0049] A resin-based sandwich laminate could also be fabricated with random or continuous webbed micron stainless steel fibers or other conductive fibers, forming a cloth-like material. The webbed conductive fiber can be laminated or the like to materials such as Teflon, Polyespers, or any resin-based flexible or solid material(s), which when discretely designed in fiber content(s), orientation(s) and shape(s), will produce a very highly flexible cloth-like material. Such a cloth-like material could also be used in forming pumps that incorporate other resin materials such as rubber(s) or plastic(s). When using conductive fibers as a webbed conductor as part of a laminate or cloth-like material, the fibers may have diameters of between about 3 and 12 microns, typically between about 8 and 12 microns or in the range of about 10 microns, with length(s) that can be seamless or overlapping.

[0050] The conductive loaded resin-based material may also be formed into a prepreg laminate. A laminate, cloth, or webbing of the conductive loaded resin-based material is first impregnated with a resin-based material. In various embodiments, the conductive loaded resin-based material is dipped, coated, sprayed, and/or extruded with resin-based material to cause the laminate, cloth, or webbing to adhere together in a prepreg grouping that is easy to handle. This prepreg is then placed, or laid up, onto a form and heated to form a permanent bond. In another embodiment, the prepreg laid up onto the impregnating resin while the resin is still wet and then cured by heating or other means. In yet another embodiment, a wet prepreg is formed by spraying, dipping, or coating the conductive loaded resin-based material laminate, cloth, or webbing in high temperature capable paint.

[0051] The conductive loaded resin-based material of the present invention can be made resistant to corrosion and/or metal electrolysis by selecting micron conductive fiber and/or conductive powder and base resin that are resistant to corrosion and/or metal electrolysis. For example, if a corrosion/electrolysis resistant base resin is combined with stainless steel fiber and carbon fiber/powder, then a corrosion and/or metal electrolysis resistant conductive loaded resin-based material is achieved. Another additional and important feature of the present invention is that the conductive loaded resin-based material of the present invention may be made flame retardant. Selection of a flame-retardant (FR) base resin material allows the resulting product to exhibit flame retardant capability. This is especially important in electrostatic discharge-proof pumps as described herein.

[0052] The substantially homogeneous mixing of micron conductive fiber and/or micron conductive powder and base resin described in the present invention may also be described as doping. That is, the substantially homogeneous mixing converts the typically non-conductive base resin material into a conductive material. This process is analogous to the doping process whereby a semiconductor material, such as silicon, can be converted into a conductive material through the introduction of donor/acceptor ions as is well known in the art of semiconductor devices. Therefore, the present invention uses the term doping to mean converting a typically non-conductive base resin material into a conductive material through the substantially homogeneous mixing of micron conductive fiber and/or micron conductive powder into a base resin.

[0053] As an additional and important feature of the present invention, the molded conductor loaded resin-based material exhibits excellent thermal dissipation characteristics. Therefore, electrostatic discharge-proof pumps manufactured from the molded conductor loaded resin-based material can provide added thermal dissipation capabilities to the application. For example, heat can be dissipated from electrical devices physically and/or electrically connected to pumps of the present invention.

[0054] As a significant advantage of the present invention, electrostatic discharge-proof pumps constructed of the conductive loaded resin-based material can be easily interfaced to an electrical circuit or grounded. In one embodiment, a wire can be attached to a conductive loaded resin-based electrostatic discharge-proof pumps via a screw that is fastened to the pump casing. For example, a simple sheet-metal type, self tapping screw, when fastened to the material, can achieve excellent electrical connectivity via the conductive matrix of the conductive loaded resin-based material. To facilitate this approach a boss may be molded into the conductive loaded resin-based material to accommodate such a screw. Alternatively, if a solderable screw material, such as copper, is used, then a wire can be soldered to the screw that is embedded into the conductive loaded resin-based material. In another embodiment, the conductive loaded resin-based material is partly or completely plated with a metal layer. The metal layer forms excellent electrical conductivity with the conductive matrix. A connection of
this metal layer to another circuit or to ground is then made. For example, if the metal layer is solderable, then a soldered connection may be made between the pump and a grounding wire.

[0055] Where a metal layer is formed over the surface of the conductive loaded resin-based material, any of several techniques may be used to form this metal layer. This metal layer may be used for visual enhancement of the molded conductive loaded resin-based material article or to otherwise alter performance properties. Well-known techniques, such as electroless metal plating, electro metal plating, sputtering, metal vapor deposition, metallic painting, or the like, may be applied to the formation of this metal layer. If metal plating is used, then the resin-based structural material of the conductive loaded, resin-based material is one that can be metal plated. There are many of the polymer resins that can be plated with metal layers. For example, GE Plastics, SUPEC, VALEX, ULTEM, CYCOLAC, UGKLAL, SYRON, CYCOLY are a few resin-based materials that can be metal plated. Electroless plating is typically a multistage chemical process where, for example, a thin copper layer is first deposited to form a conductive layer. This conductive layer is then used as an electrode for the subsequent plating of a thicker metal layer.

[0056] A typical metal deposition process for forming a metal layer onto the conductive loaded resin-based material is vacuum metallization. Vacuum metallization is the process where a metal layer, such as aluminum, is deposited on the conductive loaded resin-based material inside a vacuum chamber. In a metallic plating process, metal particles, such as silver, copper, or nickel, or the like, are dispersed in an acrylic, vinyl, epoxy, or urethane binder. Most resin-based materials accept and hold paint well, and automatic spray systems apply coating with consistency. In addition, the excellent conductivity of the conductive loaded resin-based material of the present invention facilitates the use of extremely efficient, electrostatic painting techniques.

[0057] The conductive loaded resin-based material can be contacted in any of several ways. In one embodiment, a pin is embedded into the conductive loaded resin-based material by insert molding, ultrasonic welding, pressing, or other means. A connection with a metal wire can easily be made to this pin and results in excellent contact to the conductive loaded resin-based material. In another embodiment, a hole is formed in to the conductive loaded resin-based material either during the molding process or by a subsequent process step such as drilling, punching, or the like. A pin is then placed into the hole and is then ultrasonically welded to form a permanent mechanical and electrical contact. In yet another embodiment, a pin or a wire is soldered to the conductive loaded resin-based material. In this case, a hole is formed in the conductive loaded resin-based material either during the molding operation or by drilling, stamping, punching, or the like. A solderable layer is then formed in the hole. The solderable layer is preferably formed by metal plating. A conductor is placed into the hole and then mechanically and electrically bonded by point, wave, or reflow soldering.

[0058] Another method to provide connectivity to the conductive loaded resin-based material is through the application of a solderable ink to the surface. One exemplary solderable ink is a combination of copper and solder par-ticles in an epoxy resin binder. The resulting mixture is an active, screen-printable and dispensable material. During curing, the solder flows to coat and to connect the copper particles and to thereby form a cured surface that is directly solderable without the need for additional plating or other processing steps. Any solderable material may then be mechanically and/or electrically attached, via soldering, to the conductive loaded resin-based material at the location of the applied solderable ink. Many other types of solderable inks can be used to provide this solderable surface onto the conductive loaded resin-based material of the present invention. Another exemplary embodiment of a solderable ink is a mixture of one or more metal powder systems with a reactive organic medium. This type of ink material is converted to solderable pure metal during a low temperature cure without any organic binders or alloying elements.

[0059] A ferromagnetic conductive loaded resin-based material may be formed of the present invention to create a magnetic or magnetizable form of the material. Ferromagnetic micron conductive fibers and/or ferromagnetic conductive powders are mixed with the base resin. Ferrite materials and/or rare earth magnetic materials are added as a conductive loading to the base resin. With the substantially homogeneous mixing of the ferromagnetic micron conductive fibers and/or micron conductive powders, the ferromagnetic conductive loaded resin-based material is able to produce an excellent low cost, low weight magnetizable item. The magnets and magnetic devices of the present invention can be magnetized during or after the molding process. The magnetic strength of the magnets and magnetic devices can be varied by adjusting the amount of ferromagnetic micron conductive fibers and/or ferromagnetic micron conductive powders that are incorporated with the base resin. By increasing the amount of the ferromagnetic doping, the strength of the magnet or magnetic devices is increased. The substantially homogeneous mixing of the conductive fiber network allows for a substantial amount of fiber to be added to the base resin without causing the structural integrity of the item to decline. The ferromagnetic conductive loaded resin-based magnets display the excellent physical properties of the base resin, including flexibility, moldability, strength, and resistance to environmental corrosion, along with excellent magnetic ability. In addition, the unique ferromagnetic conductive loaded resin-based material facilitates formation of items that exhibit excellent thermal and electrical conductivity as well as magnetism.

[0060] A high aspect ratio magnet is easily achieved through the use of ferromagnetic conductive micron fiber or through the combination of ferromagnetic micron powder with conductive micron fiber. The use of micron conductive fiber allows for molding articles with a high aspect ratio of conductive fiber to cross sectional area. If a ferramagnetic micron fiber is used, then this high aspect ratio translates into a high quality magnetic article. Alternatively, if a ferromagnetic micron powder is combined with micron conductive fiber, then the magnetic effect of the powder is effectively spread throughout the molded article via the network of conductive fiber such that an effective high aspect ratio molded magnetic article is achieved. The ferromagnetic conductive loaded resin-based material may be magnetized, after molding, by exposing the molded article to a strong magnetic field. Alternatively, a strong magnetic field may be used to magnetize the ferromagnetic conductive loaded resin-based material during the molding process.
The ferromagnetic conductive loading is in the form of fiber, powder, or a combination of fiber and powder. The micron conductive powder may be metal fiber or metal plated fiber. If metal plated fiber is used, then the core fiber is a platable material and may be metal or non-metal. Exemplary ferromagnetic conductive fiber materials include ferrite, or ceramic, materials as nickel zinc, manganese zinc, and combinations of iron, boron, and strontium, and the like. In addition, rare earth elements, such as neodymium and samarium, typified by neodymium-iron-boron, samarium-cobalt, and the like, arc useful ferromagnetic conductive fiber materials. Exemplary ferromagnetic micron powder leached onto the conductive fibers include ferrite, or ceramic, materials as nickel zinc, manganese zinc, and combinations of iron, boron, and strontium, and the like. In addition, rare earth elements, such as neodymium and samarium, typified by neodymium-iron-boron, samarium-cobalt, and the like, arc useful ferromagnetic conductive powder materials. A ferromagnetic conductive loading may be combined with a non-ferromagnetic conductive loading to form a conductive loaded resin-based material that combines excellent conductive qualities with magnetic capabilities.

Electrostatic discharge-proof pumps comprising conductive loaded resin-based material of the present invention are ideally suited for commercial and industrial applications wherein protection from flammability is an issue. These applications include the pumping of flammable liquids and gasses. These applications further include the pumping of non-flammable liquids and gasses in an environment that is potentially flammable. Because the conductive loaded resin-based material of the present invention is electrically conductive, it is able to safely discharge any electric charge which may be present without causing flammability or safety concerns. This trait is of critical importance in commercial and industrial pumping environments.

There are many examples of pumps which transport flammable liquid. These include the pumping of oil. Oil is pumped at several different stages of the oil production process. It is pumped from under the ground; it is pumped during the refinement process; it is pumped onto and off from ships and/or trucks used for transport, and it is pumped through pipelines. Fuel such as automotive gasoline is another example of a flammable liquid which is routinely pumped. Such fuel is pumped at the refinery; it is pumped onto and off from trucks used for transport, and it is pumped into the end-use vehicle at the gas station. Aviation fuel and kerosene are pumped in a manner similar to gasoline. Hydraulic fluid is another flammable liquid which is routinely pumped. Hydraulic fluid is used for earth moving equipment and in many industrial machinery/equipment applications. Flammable gas-phase fluids also require the use of electrostatic discharge-proof pumps. These gas-phase fluids include oxygen and hydrogen. Oxygen may also be pumped as a liquid. In any situation where flammable fluids are pumped, it is vital that the pump itself not be a source of spark and potential combustion. Conductive loaded resin-based material pumps of the present invention provide reliable transport of flammable fluids without the risk of spark. They are inherently able to dissipate any potential electric charge to ground.

There are also many applications for the use of a conductive loaded resin-based material electrostatic discharge-proof pump in the transport of non-flammable fluids or slurries in an environment that is potentially flammable. The term “slurry” is used to describe the suspension of a ground solid in a liquid. In industrial applications such as mining, slurries are used to transport the ground solid. A slurry pump is used to facilitate the transport of the slurry. That is, the slurry pump is used to pump the slurry from one location to another. Often the surrounding environment is potentially flammable. This is the case in mines, for example. The conductive loaded resin-based material pump of the present invention is ideal for this application in that it provides intrinsic spark resistance. In slurry pump design, special care must be taken to select wear-resistant materials. This is true because the solid pieces being transported generally cause more degradation than do typical liquid-only mediums. For the conductive loaded resin-based material slurry pump, the resin is selected from those very resistant to wear. Further, the conductive loaded resin-based material slurry pump is optionally coated with a material such as, for example, Teflon to inhibit wear. The conductive filler material of the conductive loaded resin-based material slurry pump is likewise selected from those able to withstand the abrasion imposed by the slurry. In every pump application, whether for flammable or non-flammable fluids or slurries, the resin host and conductive material are selected from those resins which are resistant to the chemicals present in the particular environment.

Conductive loaded resin-based material of the present invention provides many advantages when forming electrostatic discharge-proof pumps. The first advantage is cost. The cost to fabricate conductive loaded resin-based material pumps is considerably less than the fabrication cost of the metal pumps found in the prior art. This is due to the simplicity of the manufacturing process. Conductive loaded resin-based material pump components are formed using conventional molding techniques. This is a low cost alternative to typical metal fabrication. Reduced weight is another benefit of conductive loaded resin-based material pumps when compared to conventional metal pumps. The reduced weight of conductive loaded resin-based material of the present invention translates to reduced shipping costs both at the component level and at the final pump product level. The reduced weight also makes the conductive loaded resin-based material pump much more manageable during installation at the job site. These benefits of cost and weight reduction apply to all conductive loaded resin-based material electrostatic discharge-proof pumps regardless of the application or the fluid being pumped.

Referring now to FIG. 1, a first preferred embodiment of the present invention is illustrated. A horizontal drilling-duty, electrostatic discharge-proof pump is shown. This exemplary pump comprises conductive loaded resin-based material in any or all of various components or features. In one embodiment, an external housing comprises a relatively thick wall of conductive loaded resin-based material. In another embodiment, access plates comprise conductive loaded resin-based material. In another embodiment, a shaft extension comprises conductive loaded resin-based material. In yet another embodiment, suction and/or discharge connection ports are formed of conductive loaded resin-based material. This pump exemplifies an ultra heavy duty pump used, for example, for pumping oil in drilling applications. Pump components formed of the conductive loaded resin-based
material provide reduced weight and manufacturing cost, excellent resistance to corrosion, chemical impermeability, and electrostatic dissipation. Pumps or pump components comprising the conductive loaded resin-based material of the present invention demonstrate excellent electrical conductivity such that electrostatic charge does not build. An intrinsically or inherently safe pump for flammable fluids is thus achieved. The conductive loading may be selected to achieve a range of resistivity values such that the material dissipates electrostatic energy via resistive action or merely shunts the charge to ground. In addition, the pump or pump component demonstrates excellent thermal conductivity to dissipate frictional heat build-up. Finally, the pump or pump component exhibits excellent acoustical response to limit the noise produced by the pump.

[0067] Referring now to FIG. 7, a second preferred embodiment of the present invention is illustrated. An exemplary electrostatic discharge-proof pump 130 comprises conductive loaded resin-based material in any or all of various components or features. In particular, a centrifugal pump 130 is shown. A suction inlet 136 provides the fluid entrance into the pump. The balanced impeller 134 serves to propel the fluid within the body of the pump 130. The open area of the pump housing is referred to as the volute 138. Fluid journeys through the volute 138 on its way to being expelled through the discharge outlet 132. All of these components contact the fluid which is being pumped. In various embodiments any or all of these components 132, 134, 136, 138, and the housing which adjoins defines them comprise conductive loaded resin-based material. In another embodiment, a seal 140 comprises conductive loaded resin-based material. This seal 140 is fabricated using a base resin host which remains pliable to provide an excellent seal to keep the pumped fluid from migrating beyond the seal 140. In another embodiment, the seal 140 is a Ni-Resist or similar material as found in prior art. A shaft 146 provides a means of inputting rotational energy into the pump system. In another embodiment, the shaft 146 comprises conductive loaded resin-based material. Alternately, the shaft 146 comprises metal or a metal alloy. Ball bearings 142 and/or other bearings, not shown, provide a means of fixing the shaft 146 vertically and horizontally within the pump housing while enabling the shaft 146 to rotate freely on its axis. In one embodiment, the pedestal or stand 144 comprises conductive loaded resin-based material. Alternately, the stand 144 comprises metal or a metal alloy. In yet another embodiment, the stand 144 comprises metal mounting interfaces or “feet”, not shown, over-molded with conductive loaded resin-based material. The stand 144 is integrally molded into the pump housing. Alternately, the stand 144 is a separate component which may be removed from the pump housing. Pump components formed of the conductive loaded resin-based material provide reduced weight and manufacturing cost, excellent resistance to corrosion, chemical impermeability, and electrostatic dissipation.

[0068] Referring now to FIG. 8, a third preferred embodiment of the present invention is illustrated. Another electrostatic discharge-proof pump 150 is shown. This pump 150 is similar to the pump 130 shown in FIG. 7 in that both are designed to be self-priming, centrifugal pumps. In FIG. 8, the exterior of the volute 154 is labeled. In various embodiments, the suction inlet 152, the volute 154, the balanced impeller 156, the seal 158, and the bearings 160 are constructed of the conductive loaded resin-based material and function in much the same way as those described in FIG. 7.

[0069] Referring now to FIG. 9, a fourth preferred embodiment of the present invention is illustrated. Another electrostatic discharge-proof pump 170 comprising conductive loaded resin-based material is shown. In one embodiment, an impeller 172 comprises the conductive loaded resin-based material. A volute area 176 essentially adjoins the impeller 172. In another embodiment, a seal 176 comprises conductive loaded resin-based material. Alternately, the seal 176 comprises a Ni-resist material or other such material found in the art. In another embodiment, the pump housing 178 comprises conductive loaded resin-based material. In another embodiment, a shaft 180 comprises conductive loaded resin-based material. In an alternate embodiment of the present invention, the shaft 180 comprises metal or a metal alloy. The mounting stand 182 comprises conductive loaded resin-based material. In an additional embodiment of the present invention, the mounting stand 182 comprises a metal mounting portion over-molded with conductive loaded resin-based material. In yet another embodiment of the present invention, the mounting stand 182 comprises metal. Pump components formed of the conductive loaded resin-based material provide reduced weight and manufacturing cost, excellent resistance to corrosion, chemical impermeability, and electrostatic dissipation. Pumps or pump components comprising the conductive loaded resin-based material of the present invention demonstrate excellent electrical conductivity such that electrostatic charge does not build. The conductive loading may be selected to achieve a range of resistivity values such that the material dissipates electrostatic energy via resistive action or merely shunts the charge to ground. In addition, the pump or pump component demonstrates excellent thermal conductivity to dissipate frictional heat build-up. Finally, the pump or pump component exhibits excellent acoustical response to limit the noise produced by the pump.

[0070] Referring now to FIG. 10, a fifth preferred embodiment of the present invention is illustrated. An electrostatic discharge-proof pump 190 for petroleum application is shown. The pump 190 comprises conductive loaded resin-based material. This pump 190 represents petroleum pumps used to pump fuel oil onto and off from delivery trucks. It is also used for stationary applications such as the pumping of refined petroleum products and industrial solvents. This particular pump 190 is a vane type pump in that it utilizes vanes and a vane driver 192 rather than an impeller to propel the fluid. In one embodiment, the vanes and vane driver 192 comprise conductive loaded resin-based material of the present invention. In another embodiment, the mechanical seals 194 comprise conductive loaded resin-based material. In an alternate embodiment, the mechanical seals 194 are formed of conventional materials. In another embodiment, the fluid inlet 196 comprises conductive loaded resin-based material. In another embodiment, the pump housing 198 comprises conductive loaded resin-based material. Pump components formed of the conductive loaded resin-based material provide reduced weight and manufacturing cost, excellent resistance to corrosion, chemical impermeability, and electrostatic dissipation.

[0071] Referring now to FIG. 11, a sixth preferred embodiment of the present invention is illustrated. A
vehicle-fueling pump application 200 is shown. More specifically, a pump 210 is shown pumping gas from the storage tank 250 through the pipe 220 to the fuel hose dispenser 230. Fuel is then pumped into the vehicles 240 on demand. In various embodiments, the pump 210, tank 250, pipe, and/or dispenser 230 comprise conductive loaded resin-based material of the present invention. Pump components formed of the conductive loaded resin-based material provide reduced weight and manufacturing cost, excellent resistance to corrosion, chemical impermeability, and electrostatic dissipation. Pumps or pump components comprising the conductive loaded resin-based material of the present invention demonstrate excellent electrical conductivity such that electrostatic charge does not build. The conductive loading may be selected to achieve a range of resistivity values such that the material dissipates electrostatic energy via resistive action or merely shunts the charge to ground. In addition, the pump or pump component demonstrates excellent thermal conductivity to dissipate frictional heat build-up. Finally, the pump or pump component exhibits excellent acoustical response to limit the noise produced by the pump.

[0072] FIGS. 1 and 7-11 illustrate various electrostatic discharge-proof pumps comprising conductive loaded resin-based material. These exemplary pumps represent only a few of the many forms which electrostatic discharge-proof pumps comprising conductive loaded resin-based material of the present invention may take. In the heretofore described pumps, any or all of the components comprising the pump comprise conductive loaded resin-based material of the present invention. These pump components include, but are not limited to: the pump housing, mounting stand, impeller, vanes, vane driver, seals, O-rings, inlets, outlets, volute, valves, bearings, shaft, and the like. By careful selection of the base resin host and the conductive loading materials, conductive loaded resin-based material provides the necessary structural, chemical, electrical, and thermal properties for various pump components in various pump applications. Conductive loaded resin-based material provides significant advantages over conventional metal components especially in terms of cost and weight.

[0073] The conductive loaded resin-based material of the present invention typically comprises a micron powder(s) of conductor particles and/or in combination of micron fiber(s) substantially homogenized within a base resin host. FIG. 2 shows cross section view of an example of conductor loaded resin-based material 32 having powder of conductor particles 34 in a base resin host 30. In this example the diameter D of the conductor particles 34 in the powder is between about 3 and 12 microns.

[0074] FIG. 3 shows a cross section view of an example of conductor loaded resin-based material 36 having conductor fibers 38 in a base resin host 30. The conductor fibers 38 have a diameter of between about 3 and 12 microns, typically in the range of 10 microns or between about 8 and 12 microns, and a length of between about 2 and 14 millimeters. The micron conductive fibers 38 may be metal fiber or metal plated fiber. Further, the metal plated fiber may be formed by plating metal onto a metal fiber or by plating metal onto a non-metal fiber. Exemplary metal fibers include, but are not limited to, stainless steel fiber, copper fiber, nickel fiber, silver fiber, aluminum fiber, or the like, or combinations thereof. Exemplary metal plating materials include, but are not limited to, copper, nickel, cobalt, silver, gold, palladium, platinum, ruthenium, and rhodium, and alloys thereof. Any platable fiber may be used as the core for a non-metal fiber. Exemplary non-metal fibers include, but are not limited to, carbon, graphite, polystyrene, basalt, man-made and naturally-occurring materials, and the like. In addition, superconductor metals, such as titanium, nickel, niobium, and zirconium, and alloys of titanium, nickel, niobium, and zirconium may also be used as micron conductive fibers and/or as metal plating onto fibers in the present invention.

[0075] These conductor particles and/or fibers are substantially homogenized within a base resin. As previously mentioned, the conductive loaded resin-based materials have a sheet resistance between about 5 and 25 ohms per square, though other values can be achieved by varying the doping parameters and/or resin selection. To realize this sheet resistance the weight of the conductor material comprises between about 20% and about 50% of the total weight of the conductive loaded resin-based material. More preferably, the weight of the conductive material comprises between about 20% and about 40% of the total weight of the conductive loaded resin-based material. More preferably yet, the weight of the conductive material comprises between about 25% and about 35% of the total weight of the conductive loaded resin-based material. Still more preferably yet, the weight of the conductive material comprises about 30% of the total weight of the conductive loaded resin-based material. Stainless Steel Fiber of 6-12 micron in diameter and lengths of 4-6 mm comprising, by weight, about 30% of the total weight of the conductive loaded resin-based material will produce a very highly conductive parameter, efficient within any EMF, thermal, acoustic, or electronic spectrum. Referring now to FIG. 4, another preferred embodiment of the present invention is illustrated where the conductive materials comprise a combination of both conductive powders 34 and micron conductive fibers 38 substantially homogenized together within the resin base 30 during a molding process.

[0076] Referring now to FIGS. 5a and 5b, a preferred composition of the conductive loaded, resin-based material is illustrated. The conductive loaded resin-based material can be formed into fibers or textiles that are then woven or webbed into a conductive fabric. The conductive loaded resin-based material is formed in strands that can be woven as shown. FIG. 5a shows a conductive fabric 42 where the fibers are woven together in a two-dimensional weave 46 and 50 of fibers or textiles. FIG. 5b shows a conductive fabric 42 where the fibers are formed in a webbed arrangement. In the webbed arrangement, one or more continuous strands of the conductive fiber are nested in a random fashion. The resulting conductive fabrics or textiles 42, see FIG. 5a and 42; see FIG. 5b, can be made very thin, thick, rigid, flexible or in solid form(s).

[0077] Similarly, a conductive, but cloth-like, material can be formed using woven or webbed micron stainless steel fibers, or other micron conductive fibers. These woven or webbed conductive cloths could also be sandwich laminated to one or more layers of materials such as Polyester(s), Teflon(s), Kevlar(s) or any other desired resin-based material(s). This conductive fabric may then be cut into desired shapes and sizes.
molded in a number of different ways including injection molding, extrusion, calendaring, or chemically induced molding or forming. FIG. 6a shows a simplified schematic diagram of an injection mold showing a lower portion 54 and upper portion 58 of the mold 50. Conductive loaded blended resin-based material is injected into the mold cavity 64 through an injection opening 60 and then the substantially homogenized conductive material cures by thermal reaction. The upper portion 58 and lower portion 54 of the mold are then separated or parted and the pump component is removed.

[0079] FIG. 6b shows a simplified schematic diagram of an extruder 70 for forming pump components using extrusion. Conductive loaded resin-based material(s) is placed in the hopper 80 of the extrusion unit 74. A piston, screw, press or other means 78 is then used to force the thermally molten or a chemically induced curing conductive loaded resin-based material through an extrusion opening 82 which shapes the thermally molten curing or chemically induced cured conductive loaded resin-based material to the desired shape. The conductive loaded resin-based material is then fully cured by chemical reaction or thermal reaction to a hardened or pliable state and is ready for use. Thermoplastic or thermosetting resin-based materials and associated processes may be used in molding the conductive loaded resin-based articles of the present invention.

[0080] The advantages of the present invention may now be summarized. An effective electrostatic discharge-proof pump is achieved. A method to form an electrostatic discharge-proof pump is achieved. The electrostatic discharge-proof pump is molded of conductive loaded resin-based materials. The electrostatic discharge-proof pump is intrinsically or inherently safe with respect to static discharge. The electrostatic discharge-proof pump has reduced weight and manufacturing cost. The electrostatic discharge-proof pump has excellent corrosion resistance and chemical impermeability. The electrostatic discharge-proof pump has excellent thermal conductivity. The electrostatic discharge-proof pump has excellent acoustical response and noise dampening. The electrostatic discharge-proof pump has optimal electrostatic dissipation effect based on the conductive loading. Components for an electrostatic discharge-proof pump are achieved. The chemical, electrical, thermal, or acoustical characteristics can be altered or the visual characteristics can be altered by forming a metal layer over the conductive loaded resin-based material.

[0081] As shown in the preferred embodiments, the novel methods and devices of the present invention provide an effective and manufacturable alternative to the prior art.

[0082] While the invention has been particularly shown and described with reference to the preferred embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be made without departing from the spirit and scope of the invention.

What is claimed is:

1. A method to form an electrostatic discharge-proof pump component device, said method comprising:

   providing a conductive loaded, resin-based material comprising conductive materials in a resin-based host;

2. The method according to claim 1 wherein the percent by weight of said conductive materials is between about 20% and about 50% of the total weight of said conductive loaded resin-based material.

3. The method according to claim 1 wherein said conductive materials comprise micron conductive fiber.

4. The method according to claim 2 wherein said conductive materials further comprise conductive powder.

5. The method according to claim 1 wherein said conductive materials are metal.

6. The method according to claim 1 wherein said conductive materials are non-conductive materials with metal plating.

7. The method according to claim 1 wherein said step of molding comprises:

   injecting said conductive loaded, resin-based material into a mold;

   curing said conductive loaded, resin-based material; and

   removing said electrostatic discharge-proof pump component device from said mold.

8. The method according to claim 1 wherein said step of molding comprises:

   loading said conductive loaded, resin-based material into a chamber;

   extruding said conductive loaded, resin-based material out of said chamber through a shaping outlet; and

   curing said conductive loaded, resin-based material to form said electrostatic discharge-proof pump component device.

9. The method according to claim 1 wherein said electrostatic discharge-proof pump component device comprises a housing.

10. The method according to claim 1 wherein said electrostatic discharge-proof pump component device comprises an impeller.

11. The method according to claim 1 wherein said electrostatic discharge-proof pump component device comprises an inlet or outlet port.

12. The method according to claim 1 wherein said electrostatic discharge-proof pump component device comprises a valve.

13. A method to form an electrostatic discharge-proof pump device, said method comprising:

   providing a conductive loaded, resin-based material comprising conductive materials in a resin-based host; and

   molding said conductive loaded, resin-based material into an electrostatic discharge-proof pump component device.

14. The method according to claim 13 wherein said conductive materials are nickel plated carbon micron fiber,
stainless steel micron fiber, copper micron fiber, silver micron fiber or combinations thereof.

15. The method according to claim 13 wherein said conductive materials comprise micron conductive fiber and conductive powder.

16. The method according to claim 15 wherein said conductive powder is nickel, copper, or silver.

17. The method according to claim 15 wherein said conductive powder is a non-metallic material with a metal plating.

18. The method according to claim 13 wherein said housing comprises said conductive loaded resin-based material.

19. A method to form an electrostatic discharge-proof pump, said method comprising:

providing a conductive loaded, resin-based material comprising micron conductive fiber in a resin-based host wherein the percent by weight of said micron conductive fiber is between 20% and 50% of the total weight of said conductive loaded resin-based material; and

molding said conductive loaded, resin-based material into an electric motor device comprising:

a housing comprising said conductive loaded, resin-based material;

an inlet port through said housing;

an outlet port through said housing; and

an impeller in said housing and between said inlet and outlet ports wherein said impeller comprises said conductive loaded, resin-based material.

20. The method according to claim 19 wherein said micron conductive fiber is stainless steel.

21. The method according to claim 19 wherein said conductive loaded resin-based material further comprises conductive powder.

22. The method according to claim 19 wherein said micron conductive fiber has a diameter of between about 3 \( \mu m \) and about 12 \( \mu m \) and a length of between about 2 mm and about 14 mm.

23. The method according to claim 19 wherein said inlet port or said outlet port comprises said conductive loaded resin-based material.

24. The method according to claim 19 further comprising a seal comprising said conductive loaded resin-based material.

25. The method according to claim 19 further comprising a valve comprising said conductive loaded resin-based material.