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(54) **REINFORCEMENT FOR COMPOSITE MATERIALS AND METHOD FOR MAKING THE REFORCEMENT**

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(57) **ABSTRACT**

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A reinforced composite structure is disclosed comprising at least a reactive resin, thermosetting system or other suitable resin composition sandwiched between two metal, thermo-plastic or ceramic substrate materials. The structure can also be modified through the addition of one or more fabrics, metallic meshes, fibers, polymer spacers or other suitable materials positioned within the resin composition and sandwiched between the substrate materials. The resulting structure comprises a composite with reduced thickness and weight as compared to solid metal panels of corresponding flexural strength. The composition of the structure also allows for the tailoring of the properties to affect sound abatement, insulation, strength, and toughness among other characteristics. The structure can be formed and cut to shape to fit any of a number of suitable applications such as ceiling tiles and bulkhead panels in marine vessels.

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REINFORCEMENT FOR COMPOSITE MATERIALS AND METHOD FOR MAKING THE REINFORCEMENT

CROSS REFERENCE TO RELATED PATENT AND PATENT APPLICATIONS

[0001] The subject matter of the instant invention is related to U.S. patent application Ser. No. 10/729,339, filed on Dec. 4, 2003; application Ser. No. 10/978,081, filed on Oct. 27, 2004; and application Ser. No. 11/003,758, filed on _____; all hereby incorporated by reference.

[0002] This application claims the benefit of Provisional Application No. 60/579,051, filed on Jun. 10, 2004 and Provisional Application No. 60/625,051, filed on Nov. 3, 2004. The disclosure of these Provisional Applications is hereby incorporated by reference.

FIELD OF THE INVENTION

[0003] The subject matter of this invention relates to composite structures, and reinforcement compositions and methods for making the reinforcement compositions. The subject matter of this invention also relates to fibrous materials that can be used as reinforcement materials, among other uses.

BACKGROUND OF THE INVENTION

[0004] Solid aluminum ceiling tiles have traditionally been used in marine vessels. Replacing these aluminum ceiling tiles and possibly other similar products or materials within a ship with composite materials may reduce the overall weight of the ship. Other composite reinforcement applications comprise bulkheads (marine & aircraft), tractor trailers, industrial sheet metal, air conditioning duct, repair patch aircraft or industrial, automotive, appliances, pipes and pipe-lines, storage tanks, recreational vehicles, among applications. Composite materials may also bring other added benefits such as, inter alia, sound abatement, added toughness, increased insulation, among other properties.

SUMMARY OF THE INVENTION

[0005] In one aspect, the instant invention enhances properties (e.g., mechanical properties) of panels traditionally composed of sheets or plates (with or without a cosmetic or paint coating), by replacing them with a reinforced composite structure. The reinforced composite structure comprises at least one reinforcing material comprising at least one member selected from the group consisting of an epoxy (or epoxy functional compounds), a polyester or other suitable resin composition (which optionally can embed or contact in at least one of fabrics, metallic meshes, polymer spacers, among other suitable materials), that is positioned (e.g., "sandwiched") between sheets or plates. The sheets or plates can comprise any suitable material such as metals ceramics, among other materials. The sheets or plates can be subsequently processed into a wide range of configurations (e.g., the structure may allow for increased formability and/or easier cutting and shaping, allowing the composite structure to be cut or shaped into a virtually unlimited array of configurations).

[0006] The resultant composite comprises a layered structure which can have a reduced thickness compared to the traditional solid metal sheet (e.g., the reinforcing material

between the metal sheets permits using relatively thin metal). The composite structure's properties can be tailored to meet the requirements for a wide range of end uses. Properties that may be modified comprise at least one of weight, sound abatement, insulation, tear strength, toughness, stiffness, formability, flame retardance, among other properties.

[0007] Another aspect of the invention relates to a fibrous material. The inventive fibrous material can be reactive and incorporate a curing resin system (e.g., the fiber is comprised of a reactive resin and a curing agent), embedded within the aforementioned reinforcing material, among other uses.

DETAILED DESCRIPTION

[0008] The invention comprises a reinforced composite structure comprising at least one substrate, at least one reactive resin system, at least one reinforcing material, among other components that can aid in tailoring the properties of the resultant structure. The reinforcing material is positioned between at least two substrates or "sandwiched" by substrates. If desired, the reinforcing material can comprise a fibrous structure that is embedded by a thermosetting composition (e.g., a blend comprising an epoxy functional compound). The fibrous structure can optionally be embedded within the reinforcing material or reactive resin system.

[0009] The substrate may comprise ferrous or nonferrous metals or alloys comprising at least one member selected from the group consisting of aluminum beryllium, brass, bronze, copper, lead, magnesium, molybdenum, nickel, steel, stainless steel, tin, titanium or thermoplastic materials such as ABS polymers, AES polymers, ASA polymers, cyclo olefin polymers, acetal, acrylic, cellulose, fluoro polymers, ethylene vinyl acetate, ethylene butyl acrylate, ethylene methyl acrylate, polyamide-imide, polyarylamide, polyaryl sulfone, polycarbonate, polyesters, polystyrene, polyurethane, polyolefins, and blends thereof, or ceramic materials such as aluminum nitride, boride, carbide, halide, nitride, oxide-aluminum, oxide-magnesium, oxide-silicon, oxide-titanium, oxide-zirconium, among others. The substrate material may be foil (e.g., about 0.08 mm thick), or relatively thick (e.g., up to about 10 mm thick), but typically should be of adequate thickness to provide sufficient strength to prevent tearing in processing or application (e.g., typically about 0.4 mm to about 1.5 mm thick).

[0010] A reinforcing material comprising at least one resin composition can be formulated to enhance toughness, strength, stiffness, insulation, sound dampening, conductivity, impact resistance, corrosion protection or other properties required by the intended application. The resin can also be formulated to enable the composite structure to be more formable. The reactive resin system can have a relatively high expansion, a low to high modulus of elasticity, low to high energy absorbent, have flame retardance, among other selected properties. The resin composition can be employed as a single or multiple layers. The reactive resin or thermosetting system can be 1-part, 2-part, room temperature or force dried, heat, ultraviolet, EB, sonic wave or microwave activated and may be composed of single or multiple parts that may be extruded, powder coat, pumpable, gel, spray-on, wipe-on, paste, filament or any other formation and application methods. Resin compositions such as the resin described in U.S. Pat. Nos. 6,638,590; 6,110,999; 6,461,691

and U.S. patent application Ser. Nos. 10/375,555; 10/729,339; 10/268,309; the disclosure of by which is hereby incorporated by reference, acrylics including monomers and their methacrylate counterparts (with or without functional groups), acrylic acrylates, acrylic functional materials, alkyds, diallyl phthalates, epoxies, epoxy esters, epoxy functional materials, fluoropolymers, furans, melamines, oligomers such as amine modified polyether acrylates, epoxy acrylates and methacrylates, functional acrylics, polyester acrylates, urethane acrylates, methacrylates, among other oligomers, phenolics, phenoxy, polybutadiene (with and without functional groups), polyesters, polyimides, polyurethanes, silicones (with or without functional groups), silicone acrylates, SMC, vinyl esters and blends thereof may be used depending on the desired properties of the resulting composite.

[0011] In one aspect of the invention, the substrate comprises aluminum or aluminum alloy panels or sheets and the reinforcing resin comprises an epoxy cured with at least one metallic acrylate (e.g., zinc diacrylate). The instant invention permits making a composite with aluminum substrates with minimal or no preparation of the aluminum surface. If desired, the epoxy can be modified with at least one polymer to provide a more flexible composite.

[0012] The amount and thickness of the resin will vary with the desired properties. While any suitable thickness can be employed, when the composite comprises a structural component the thickness normally ranges from about 0.05 mm to about 0.5 mm. Sound dampening applications may employ a resin thickness of about 0.5 mm to about 10 mm. The use of internal fabric or mesh layers or other spacers (as described below) can reduce the amount of resin composition needed, produce an even bond line, reduce cost associated with the resin composition, among other advantages.

[0013] In one aspect of the invention, at least one woven or fabric layer is located between the substrates. Fabric layers can comprise an open mesh or any suitable mesh pattern that would meet the requirements of the intended application. The fabric should be of proper thickness and composition to provide the desired toughness, tear strength, stiffness, insulation, sound dampening, or other specific properties for a particular application. Fabrics ranging from about 0.08 mm to about 10 mm thick but usually about 0.1 mm to about 1.5 mm may be used. Fabrics or meshes such as those comprising knitted, woven or non-woven yarns, fibers, filaments or mats, films, thick gauge films, Kevlar, fiberglass, carbon fiber, thermoplastics (such as ABS polymers, AES polymers, ASA polymers, cyclo olefin polymers, SMA polymers, acetal, acrylic, cellulose, fluoro polymers, ethylene vinyl acetate, ethylene butyl acrylate, ethylene methyl acrylate, polyamide-imide, polyarylamide, polyaryl sulfone, polycarbonate, polyesters, polystyrene, polyurethane, polyolefins and blends thereof), perforated thermoplastic film (thin and thick gauges), wire mesh or perforated ferrous or non-ferrous metals or alloys may be incorporated depending on the desired properties of the resulting composite structure. Normally the fabric is embedded within a reactive resin. The fabric layers can also comprise the inventive fibrous material and be used alone or with the resin.

[0014] The composite structure can also be constructed using unwoven fibers, particles, cubes, spheres, beads,

bubbles, or other spacers composed of materials such as glass, Kevlar, graphite, ceramic, vectran, thermoplastics (such as polyesters (nylon), ABS polymers, AES polymers, ASA polymers, cyclo olefin polymers, SMA polymers, acetal, acrylic, cellulose, fluoro polymers, ethylene vinyl acetate, ethylene butyl acrylate, ethylene methyl acrylate, polyimide, polyamide-imide, polyarylamide, polyaryl sulfone, polycarbonate, polystyrene, polyurethane, polyolefins and blends thereof instead of or in addition to fabric, metallic mesh or other suitable fabrics. The fibers, particles, cubes or other spacers could also be fabricated from the same or different reactive resin or thermosetting system that is to be used to form the reinforced composite structure. The fibers, particles, cubes or spacers chosen for use may be applied by mixing with the reactive resin or thermosetting system or by being sprayed, laminated, extruded, pumped, sprinkled, or otherwise dispersed on to a component of the composite structure. Quantities of the fibers, particles, cubes or other spacer chosen may range from about 0.1 wt % to about 70 wt % but typically range from about 1 wt % to about 30 wt % of the reactive resin or thermosetting system weight. Polymer or metallic spacers (e.g., nylon, metallic or non metallic cubes mixed into a resin composition) can provide a means of spacing between the substrate materials (e.g., in order to minimize squeeze out or movement of the resin composition between the substrates and add conductivity path when metallic spacers used). The polymer spacers permit forming a uniform layer of reinforcing material within of the composite. The weight percent of the spacers can be adjusted for a given end use, but in general range from about 2% to about 10% weight is appropriate.

[0015] Another aspect of the invention relates to a method for producing the composite without using fabrics, fiber shreds or spacers by employing an epoxy resin or other suitable thermosetting compositions formulated such that the compositions are drawn into a monofilament or string or formed into a non-woven fabric (e.g., refer to Examples 4 and 5). The monofilament could be used to assemble a resin layer by crisscrossing, weaving or arranging the monofilament in any suitable layout. This monofilament could then be sandwiched between the substrates and cured to form the composite. The arrangement of the monofilament and its diameter could be used as parameters to determine the contact area, amount of air trapped between the substrates and the thickness of the resulting composite structure (the particular arrangement can also be modified to reduce costs). If desired, spray bound cloth can also be processed from the thermosetting composition, to provide a non woven reactive fabric.

[0016] In one aspect of the invention, the reinforced composite structure may be produced by interlaying structural resin saturated fabric (described above and for example, an epoxy based system that embeds a fiberglass mesh), between the substrates. The fabric may be saturated with resin by dipping, roll coating or by using a pump-on, spray-on or other suitable process. If no fabric is used, the reactive resin or thermosetting system may be pumped, sprayed, extruded or applied by any other suitable method directly onto the substrate material. Next, the remaining substrate layer can be applied mechanically, by hand or by another suitable method. Once assembled, the structure can be cured by convection, induction, radiant, radio frequency or other suitable method of heating. The time of heating and

the cure temperatures of the reactive resin or thermosetting system are determining factors in selecting the cure properties of the composition.

[0017] In one aspect of the invention, the substrates sandwich at least one epoxy functional composition that is heat cured with at least one metal acrylate (e.g., zinc diacrylate). If desired, the epoxy functional composition can be reinforced with at least one reinforcing material.

[0018] Another aspect of the invention relates to a fiber composition and to methods for making the composition. The fiber can comprise at least one epoxy functional compound that is heat cured with at least one metal acrylate cured composition such as that described in the Cross-Referenced Patents and Patent Applications. The inventive fiber composition can be employed alone or as a component of the previously described reinforcing material (e.g., a fibrous mass comprising the inventive fiber composition can be applied between substrates and heated to form a composite). The fiber is normally substantially free of conventional curing agents. By "substantially free of conventional curing agents", it is meant that an epoxy functional compound fiber is cured while in the presence of less than about 0.1 to about 1.0 wt. % (e.g., about 0% of conventional epoxy curing agents) of the following compounds polyamides, dicyandiamides, imidizoles, imidizole compounds, amines, ureas, substituted ureas, boron trifluoride and complexes, polysulfides, anhydrides, melamines, amidoamines, phenol/formaldehyde, among other conventional curing agents. While the inventive fiber can be cured in combination with such conventional curing agents, the instant invention obviates the necessity of such compounds, among other benefits.

[0019] The following Examples are provided to illustrate certain aspects of the invention and shall not limit the scope of the invention as recited in any claims appended hereto.

EXAMPLES

Example 1

Composition and Method for Producing Reinforced Composite Structure for 3-Point Flexural Strength Testing

[0020] The composites constructed by this Example comprised a heat reactive material that was "sandwiched" between 2 substrates. The substrates used in these tests were alloy 3003 aluminum panels (McMaster-Carr Supply Co)

with a thickness of 0.016" (0.41 mm). The reactive resin compositions were prepared by mixing in a tin cup by hand (Methods A and B), or by mixing with a double arm Baker-Perkins lab mixer (Method C).

[0021] The composite structures were prepared by one of the following methods:

[0022] Method A. Saturated the fabric with the material and applied between 2 aluminum panels. Hand pressure was applied to achieve good "wet out." "Bull dog" clips were applied at the ends of the panels to hold the "sandwich" together. The composite was then cured for 5 minutes at 400° F.

[0023] Method B. The material was applied with spacer cubes mixed in to an aluminum panel. The other aluminum panel was then applied to form a "sandwich." Hand pressure was applied to achieve good "wet out." A weight of approximately 1 lb was placed on top of the composite while it was cured for 5 minutes at 400° F.

[0024] Method C. The reactive resin material was pressed at 160-180° F. A fabric or spacer cubes were then placed on the material and repressed so that the fabric or cubes became embedded into the reactive resin material. The reactive resin and fabric or spacer cube material was then placed between 2 aluminum panels. Hand pressure was applied to achieve good "wet out." Spring clips ("Bull dog" clips) were applied at the ends to hold the "sandwich" together. The composite structure was then cured for 5 minutes at 400 F.

[0025] Test samples were constructed that were 1" wide by 6" long. The materials used to construct the test samples are listed below in Tables 1 and 2. After constructing the test samples measurements were taken to determine their thickness, weight per area, flexural strength and displacement. Flexural strength was found by completing 3-point flexural strength tests over a span of 4", at a crosshead speed of 1"/minute and support and load bars equaling 0.5"d. The control samples used for the tests were aluminum ceiling panels with a cosmetic coating. Measurements of the control samples showed the control samples to have a weight per area of 2.33 g/in² and a thickness of 0.0570". The control samples were also shown to have flexural strength of 16 lbs. at 0.6" displacement (the values were the same for normal or inverted testing). The compositions of the test samples and the results of the measurements and flexural tests are shown in Tables 3, 4 and 5.

TABLE 1

Fabrics From BGF Industries (* = Fiberglass):									
				Breaking Strength					
Weave		Yarn Description		Count	Weight	Warp	Fill	Thickness	
Style	Finish	Pattern	Warp	Fill	(Ends × Picks)	(oz/yd ²)	(lbs/in)	(lbs/in)	(in)
*1659	Greige	Leno	ECG 150 1/0	ECG 75 1/0	20 × 10	1.6	80	70	0.0042
*3714	558	Plain	ECG 37 1/0	ECK 18 1/0	18 × 28	11.7	78	280	0.0140
*7628	558	Plain	ECG 75 1/0	ECG 75 1/0	44 × 31	6	N/A	N/A	0.0068
*7628	White	Plain	ECG 75 1/0	ECG 75 1/0	44 × 31	≈6	N/A	N/A	≈0.0068
*7628	Black	Plain	ECG 75 1/0	ECG 75 1/0	44 × 31	≈6	N/A	N/A	≈0.0068

TABLE 1-continued

<u>Fabrics From BGF Industries (* = Fiberglass):</u>									
				<u>Breaking Strength</u>					
		Weave	Yarn Description		Count	Weight	Warp	Fill	Thickness
Style	Finish	Pattern	Warp	Fill	(Ends × Picks)	(oz/yd ²)	(lbs/in)	(lbs/in)	(in)
5285	618	4 HS	1140 T965 Kevlar ® 49	1140 T965 Kevlar ® 49	17 × 17	5	650	650	0.0100

[0026]

TABLE 2

<u>Maxi-Blast Inc Cubes:</u>		
Company	Product Name	Description
Maxi-Blast Inc.	PA-20 Nylon (Polyamide) Cubes	0.02" cube × 0.035" diagonal (0.50 mm cube × 0.88 mm diagonal)

[0027]

TABLE 3

Example				
Epalloy 8240 (CVC Specialty - Epoxy)		90%		90%
Epon 828 (Resolution - Epoxy)	90%			
PC-300 (Sartomer - Metallic Diacrylate)	10%	10%	10%	10%
Maxi-Blast PA-20 (Maxi-Blast Inc. - Nylon Cubes)				
Fabric	1659/Greige	1659/Greige	7628/Black	7628/White
Cure Schedule	5 mins at 400 F.	5 mins at 400 F.	5 mins at 400 F.	5 mins at 400 F.
Composite	Prepared by Method A	Prepared by Method A	Prepared by Method A	Prepared by Method A
Thickness	0.0410" (1.04 mm)	0.0415" (1.05 mm)	0.0485" (1.23 mm)	0.0425" (1.08 mm)
Weight per Area	1.50 g/in ²	1.54 g/in ²	1.68 g/in ²	1.64 g/in ²
Flex Strength	10.8 lbs	11 lbs	13.5 lbs	11.1 lbs
Displacement	0.51"	0.55"	0.49"	0.59"
Comments	This approaches the strength of the Control and has a weight per area reduction of 36%	This approaches the strength of the Control and has a weight per area reduction of 34%	This approaches the strength of the Control and has a weight per area reduction of 36%	This approaches the strength of the Control and has a weight per area reduction of 30%

[0028]

TABLE 4

Example				
Epalloy 8240 (CVC Specialty - Epoxy)	90%	90%	90%	
Epon 828 (Resolution - Epoxy)				85%
PC-300 (Sartomer - Metallic Diacrylate)	10%	10%	10%	10%
Maxi-Blast PA-20 (Maxi-Blast Inc. - Nylon Cubes)				5%
Fabric	7628/558	3714/558	Kevlar 5285/618	
Cure Schedule	5 mins at 400 F.	5 mins at 400 F.	5 mins at 400 F.	5 mins at 400 F.
Composite	Prepared by Method A	Prepared by Method A	Prepared by Method A	Prepared by Method B
Thickness	0.0515" (1.31 mm)	0.0475" (1.21 mm)	0.0515" (1.31 mm)	0.0630" (1.60 mm)
Weight per Area	1.72 g/in ²	1.77 g/in ²	1.64 g/in ²	1.76 g/in ²

TABLE 4-continued

Example	16.2 lbs	13.0 lbs	13.3 lbs	17.6 lbs
Flex Strength	0.25"	0.44"	0.58"	0.39"
Displacement				
Comments	This is similar to the strength of the Control and has a weight per area reduction of 26%	This approaches the strength of the Control and has a weight per area reduction of 24%	This approaches the strength of the Control and has a weight per area reduction of 30%	This is similar to the strength of the Control and has a weight per area reduction of 24%

[0029]

TABLE 5

Example	
Vamac DP (DuPont - Elastomer)	150 g
LER HH (InChem - Epoxy/Phenoxy)	225 g
Epon 1001F (Resolution - Epoxy)	150 g
HM 443 (Hoosier Magnetics - Metal Powder)	400 g
Zinc Oxide (Midwest Zinc - Zinc Oxide)	0.5 g
Perkadox BC-40K-pd (AkroChem - Peroxide)	10 g
SR 9016 (Sartomer - Metallic Diacrylate)	20 g
Lica 38J (Kenrich Petrochemicals - Titanate)	2 g
Fabric	1659/Greige
Cure Schedule	5 mins at 400 F.
Composite	Prepared by Method C
Thickness	0.0665" (1.69 mm)
Weight per Area	1.79 g/in ²
Flex Strength	4.9 lbs
Displacement	0.50"
Comments	This doesn't approach the strength of the Control but has a weight per area reduction of 23%

Example 2

Testing Weight Reduction Over Solid Materials

[0030] The reinforced composite structure for this Example comprised a one-part epoxy formulation and glass beads which were "sandwiched" between two (2) aluminum substrates. The epoxy formulation comprised 50 grams of InChemRez LER-HH (distributed by Mozel) and 5 grams of

Erisys DDA10 powder cure (supplied by CVC Specialty Chemicals, Inc.). The two ingredients of the epoxy were mixed in a tin cup by hand or with a high speed disperser until a homogenous mixture were obtained. If needed the materials (with or without the curing agent) may be pre-heated prior to mixing. Glass beads 0.00984" (0.25 mm) in diameter (supplied by MO-SCI Corporation) were used. The aluminum substrates were alloy 3003 (supplied by McMaster-Carr Supply Co.) and were 0.016" (0.41 mm) in thickness. To construct the samples for these tests an adequate amount of the epoxy formulation was applied to one side of an aluminum panel. Enough epoxy was added to cover the entire surface with a thin layer. About 0.2 to about 0.6 grams (or as commonly described by one skilled in the art, about 1 or 2 pinches) of glass beads were then sprinkled by hand onto the epoxy layer to provide an even dispersion of beads across the surface. The second aluminum panel was then applied over the glass beads and pressed by hand onto the glass beads and epoxy to form the composite. Next, "bulldog" clips were attached to the composite to press the layers together while the composite was thermally cured at 400° F. for 30 minutes. An optional cosmetic coating or paint may be applied to the outer aluminum surfaces if desired.

[0031] To test the feasibility of the aluminum composite panels, two samples were constructed by the method above. Weight calculations were made on a standard electronic balance and compared to both a standard aluminum ceiling tile used as the control sample (the control sample contained a cosmetic coating on its surface) and a single aluminum substrate. Rigidity tests were also performed by attempting to flex the samples by hand and comparing to the control (standard aluminum ceiling tile). The test results are shown in Table 6 below. The tests demonstrated that the aluminum composite samples reduce the weight of the panels by greater than 33% while also reducing the thickness and maintaining nearly the same rigidity.

TABLE 6

Sample	Control Ceiling Panel	Aluminum Only	Aluminum Composite (Sample #1)	Aluminum Composite (Sample #2)
Dimensions	10" x 4" x 0.0570" (1.45 mm)	12" x 6" x 0.016" (0.41 mm)	10" x 4" x 0.0472" (1.20 mm)	9" x 2" x 0.04803" (1.22 mm)
Area	40 in ²	72 in ²	40 in ²	18 in ²
Weight	0.2056 lbs 93.33 g	0.1111 lbs 50.42 g	0.1367 lbs 62.06 g	0.0605 lbs 27.47 g
Weight/Area	0.00514 lbs/in ² 2.333 g/in ²	0.00154 lbs/in ² 0.7003 g/in ²	0.00342 lbs/in ² 1.552 g/in ²	0.00336 lbs/in ² 1.526 g/in ²
Rigidity			Observed to approach the	Observed to approach the

TABLE 6-continued

Sample	Control Ceiling Panel	Aluminum Only	Aluminum Composite (Sample #1)	Aluminum Composite (Sample #2)
Comments			rigidity of the control ceiling panel. 33.5% weight reduction vs. the Control Ceiling Panel.*	rigidity of the control ceiling panel. 34.6% weight reduction vs. the Control Ceiling Panel.*

*The cosmetic coating or paint is not included in this calculation.

Example 3

Production of Epoxy Resin Monofilament

[0032] The compositions of Example #5 were placed in a stainless steel crucible and mixed with a stirring rod or other suitable mixing method. (Some compositions may require more intensive mixing and thus may require the use of a double arm mixer or other suitable mixing method) After mixing, the composition was heated to activate the composition. At this temperature (about 130° F. for the Vamac® composition of Example #5) the components became sticky or nearly molten and appeared somewhat flakey. Care was taken so as not to exceed the curing temperature of the composition. Next, a stirring rod (or other suitable tool) was dipped by hand into the surface of the mixture and raised above and away from the surface until the mixture that stuck to the stirring rod began to neck and form a small diameter filament (about 1 mm in diameter.) The filament was rotated so as to wind the filament onto the stirring rod. Careful attention was paid to the rate at which the filament was wound in order to insure a generally consistent diameter in the filament and to allow enough distance and time for the filament to cool before being wound onto the stirring rod to avoid sticking. Spools of the filament could then be used to produce the desired mesh or other pattern of the filament.

Example 4

Composition of Epoxy Resin Monofilament or Non-Woven Epoxy Resin Fabric

[0033] Epoxy resin compositions compatible with the procedure depicted in Example #4 were produced. The compositions used capable of being heat activated by industrial methods including convection, induction, radiant heating or other method common to one skilled in the art. The epoxy resin compositions had physical properties to allow formation of a non-woven fabric or a filament which would be suitable for producing a woven web, crisscross pattern, or other acceptable layout of the filament. The composition comprised a blend of elastomer such as ethylene methyl acrylate copolymer (Vamac® from DuPont), solid epoxy resin such as Epon™ Resin 1001 (from Resolution Performance Products), phenoxy resin and phenoxy resin blends from (Inchem) and a curing agent. Pre-blended formulations such as HyPox RK 84 (a 40% nitrile rubber blend from CVC Specialty Chemicals, Inc.) were also tested. The epoxy composition normally had a viscosity and thermal properties to allow filament formation below the heat activation temperature, but also to allow rapid skinning for winding of the

filament. Compositions ranging from about 20% to about 40% by weight of elastomer were tested. The compositions showed that generally greater than about 30% by weight of the elastomer component was required to obtain adequate flexibility in the product. These compositions can be formed into a filament, spray bond cloth, used in the aforementioned reinforcing material, among other uses.

Product Name	Compound	Supplier	Amount
<u>Composition 1</u>			
SR 9016	ZDA	Sartomer	10%
Epon 1009	solid epoxy	Resolution	40%
Epon 828	Liquid epoxy	Resolution	40%
TC 140	ethylene methacrylate	Exxon	10%
<u>Composition 2</u>			
SR 9016	ZDA	Sartomer	10%
Epon 1007	solid epoxy resin	Resolution	45%
Paphen 200	phenoxy resin	Inchem	10%
Epon 834	liquid epoxy	Resolution	35%
<u>Composition 3</u>			
SR 9016	ZDA	Sartomer	10%
Epon 1007	epoxy resin	Resolution	40%
Paphen 200	phenoxy resin	Inchem	10%
Epon 834	liquid epoxy	Resolution	30%
TC 140	ethylene methacrylate	Exxon	10%

[0034] While desirable results are obtained by using ZDA as an epoxy curing agent, if desired Compositions 1-3 above can be cured by using Dicyandiamide alone or in combination with ZDA. Dicyandiamide is available commercially as ErysisDDA10 (CVC specialty chemical).

[0035] While the apparatus, compositions and methods of this invention have been described in terms of preferred or illustrative embodiments, it will be apparent to those of skill in the art that variations may be applied to the process described herein without departing from the concept and scope of the invention. All such similar substitutes and modifications apparent to those skilled in the art are deemed to be within the scope and concept of the invention and the appended claims.

The following is claimed:

- 1) A composite comprising at least one heat cured epoxy composition that is reinforced with at least one fibrous composition and located between two substrates.
- 2) The composite of claim 1 wherein the substrates comprise aluminum.

3) The composite of claim 1 wherein the heat cured epoxy composition further comprises a curing agent comprising at least one metal acrylate.

4) The composite of claim 3 wherein the metal acrylate comprises zinc diacrylate.

5) A fiber comprising a heat curable epoxy functional compound and at least one metal acrylate curing agent.

6) The fiber of claim 5 wherein the fiber is substantially free of at least one member selected from the group consisting of polyamides, dicyandiamides, imidizoles, imidazole compounds, amines, ureas, substituted ureas, boron

trifluoride and complexes, polysulfides, anhydrides, melamines, amidoamines, and phenol/formaldehyde.

7) The fiber of claim 5 wherein the metal acrylate curing agent comprises zinc diacrylate.

8) The composite of claim 1 wherein the fibrous composition comprises the fiber of claim 7.

9) The fiber of claim 5 further comprising at least one phenoxy resin.

10) The composite of claim 1 wherein the fibrous composition comprises fiberglass.

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