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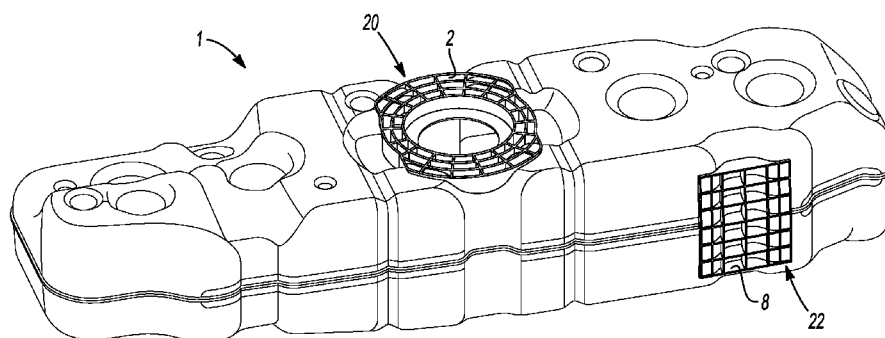


Fig-1

(57) Abstract: A reinforcement for a fuel tank comprising one or more reinforcing structures including a carrier and a structural adhesive. The one or more reinforcing structures are attached to the fuel tank at at least one location by the structural adhesive upon activation of the structural adhesive. The one or more reinforcing structures prevent the fuel tank from deforming when exposed to a force.



STRUCTURAL REINFORCEMENT FOR A FUEL TANK

FIELD

[0001] The present teachings generally relate to a reinforcing structure, more particularly reinforcing structures for fuel tanks to prevent deformation under pressure and a method of assembly and reinforcement.

BACKGROUND

[0002] Fuel tanks have been produced in a wide variety of designs. For example, early designs were fabricated from high tensile strength alloy steels, which resulted in a substantial weight per unit of volume of vessel, and were subject to hydrogen embrittlement. Of course, these types of vessels tended to be unwieldy and, therefore, had a limited application for portable use.

[0003] With the advent of aluminum and plastic fuel tanks, substantial weight savings over steel fuel tanks were gained. However, aluminum and plastic tanks do not have the same strength and rigidity as steel alloy fuel tanks, requiring reinforcement at critical points to reduce deformation.

[0004] What is needed is a reinforcement structure for vehicle fuel tanks that may be located on the tank during its manufacturing at specific locations. Such reinforcement structures may be provided in order to limit critical deformation of the tank preventing a failure of the tank leading to a fuel leak.

SUMMARY

[0005] The present teachings meet one or more of the present needs by providing a reinforcement for fuel tank comprising one or more reinforcing structures including a carrier and a structural adhesive adapted for location on a fuel tank so that at least a portion of the one or more reinforcing structures is shaped to lie in direct planar contact with a surface of the fuel tank; wherein the one or more reinforcing structures are adapted to be adhered to the fuel tank by the structural adhesive upon activation of the structural adhesive; and wherein the one or more reinforcing structures are shaped to prevent the

fuel tank from deforming when exposed to a force. The reinforcement may include at least one location requiring reinforcement located at an opening in the fuel tank. The reinforcement may include at least one location requiring reinforcement located at an exterior recess of the fuel tank. The one or more reinforcing structures may be a first reinforcing structure located at a first location and a second reinforcing structure located at a second location. The first location may be an opening in the fuel tank, and the second location may be an exterior recess of the fuel tank. The structural adhesive may have a lap shear strength of about 4.0 to about 7.0 Mpa. The one or more reinforcing structures may reduce deformation at 6 kPa inner pressure load by at least 100% or more at one or more locations on the fuel tank requiring reinforcement.

[0006] The teachings herein are further directed to a reinforcing system for a fuel tank comprising: a first reinforcing structure; and a second reinforcing structure; wherein the first reinforcing structure and the second reinforcing structure each include a carrier and a structural adhesive; and wherein the first reinforcing structure and second reinforcing structure are adapted to be attached to the fuel tank by the structural adhesive at a first location and a second location, respectively, preventing substantial deformation of the fuel tank under pressure.

[0007] The first location may be an opening in the fuel tank, and the second location may be an exterior recess of the fuel tank. The structural adhesive may cure at room temperature. The first reinforcing structure and second reinforcing structure may reduce deformation of the fuel tank at the first location and the second location under 6 kPa inner pressure load by at least 100% or more. The structural adhesive may adhere to the carrier without surface preparation. The structural adhesive may adhere to the fuel tank upon exposure to heat. The second reinforcing structure may reduce deformation of the fuel tank at the second location at 6 kPa inner pressure load by at least 400% or more.

[0008] A further possible embodiment of the present teachings includes: a method for reinforcing a fuel tank comprising: a) locating a structural adhesive onto a first carrier and a second carrier forming a first reinforcing structure and a second reinforcing structure; b) attaching the first reinforcing structure and the second reinforcing structure to the fuel tank upon activation of the structural adhesive; wherein the fuel tank is reinforced to

provide at least 100% or more rigidity at the first location and the second location to prevent deformation of the fuel tank under 6 kPa pressure.

[0009] The teachings herein provide for one or more structural reinforcements for preventing deformation under load, particularly regarding fuel tanks. The teachings further provide a method of reinforcing a fuel tank with the one or more structural reinforcements.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIG. 1 is a perspective view of a fuel tank with reinforcing structures as taught by the present teachings.

[0011] FIG. 2A and 2B are a perspective view of the body and the structural adhesive of an embodiment of the reinforcing structure.

[0012] FIG. 3A and 3B are a perspective view of the body and the structural adhesive of an embodiment of the reinforcing structure.

[0013] FIG. 4A depicts a fuel tank without reinforcement.

[0014] FIG. 4B depicts a fuel tank with example reinforcement structures consistent with the teachings herein.

[0015] FIG. 4C depicts a fuel tank with another example of reinforcement structures consistent with the teachings herein.

DETAILED DESCRIPTION

[0016] The explanations and illustrations presented herein are intended to acquaint others skilled in the art with the teachings, its principles, and its practical application. Those skilled in the art may adapt and apply the teachings in its numerous forms, as may be best suited to the requirements of a particular use. Accordingly, the specific embodiments of the present teachings as set forth are not intended as being exhaustive or limiting of the teachings. The scope of the teachings should, therefore, be determined not with reference to the above description, but should instead be determined with reference to the appended claims, along with the full scope of equivalents to which such claims are entitled. The disclosures of all articles and references, including patent

applications and publications, are incorporated by reference for all purposes. Other combinations are also possible as will be gleaned from the following claims, which are also hereby incorporated by reference into this written description.

[0017] This application is related to and claims the benefit of the filing date of China Patent Application No. 201810782874.5, filed July 17, 2018, the contents of that application being incorporated by reference herein for all purposes.

[0018] The present teachings relate to reinforcing structures. The reinforcing structures may function to provide reinforcement to all or part of a structure. The reinforcing structures may be located within a cavity of, or upon a surface of a structure, or to one or more structural members (e.g., a body panel or structural member) of an article of manufacture (e.g., an automotive vehicle). The reinforcing structures may provide reinforcement to a fuel tank. The reinforcing structures may be one or more, two or more, three or more, four or more, or even a plurality of reinforcing structures. The reinforcing structures may be target reinforcements, reinforcing one or more specific locations that may require structural support.

[0019] The reinforcing structures may be composite reinforcing structures. The composite reinforcing structures may function to provide reinforcement to a structure. The composite reinforcing structure may include one or more, two or more, three or more, four or more, or even a plurality of reinforcing structures. The composite reinforcing structure may include a first layer and a second layer. The first layer of the composite reinforcing structure may be a carrier and the second layer of the composite reinforcing structure may be a structural adhesive.

[0020] The reinforcing structure may include one or more carriers. The one or more carriers may function to provide strength and rigidity to the reinforcing structure, the substrate which the reinforcing structure attaches, the structural adhesive, or a combination thereof. The one or more carriers may be one layer of a composite reinforcing structure. The one or more carriers may have any shape. The one or more carriers may be thermoplastic, metal, or both. The one or more carriers may be in communication with a structural adhesive.

[0021] The one or more carriers may comprise a polyamide material. The one or more carriers may comprise a polyurethane material. The one or more carriers may comprise

a glass-filled polymer. The one or more carriers may include a fiber mat. The one or more carriers may be molded, extruded, or pultruded. The one or more carriers may include a metal insert to reinforce the carrier. The one or more carriers may be substantially planar. The one or more carriers may be curved over at least a portion of the carrier. The one or more carriers may be rounded in shape. The one or more carriers may be elongated in shape, having a longitudinal axis. The one or more carriers may be shaped to correspond with the contours of a fuel tank.

[0022] The reinforcing structure may include a structural adhesive. The structural adhesive may function to bond the reinforcing structure to an article being reinforced. The structural adhesive may function to provide sealing, baffling, reinforcing, structural bonding, or a combination thereof. The structural adhesive may function to provide strength and rigidity to the reinforcing structure, the article being reinforced, or both. The structural adhesive may be an activatable material. As used herein, the phrase activatable material includes any material that may be activated to melt, flow, cure (e.g., thermoset), expand, foam or a combination thereof by an ambient condition or another condition. For example, the material may activate and expand, foam, flow, melt, cure, or a combination thereof upon exposure to a condition such a heat, pressure, chemical exposure, combinations thereof or the like. The structural adhesive may be a blend of two or more activatable materials. The structural adhesive may be expandable (e.g. 0%-3000% volumetric expansion after cure). The structural adhesive may provide direct adhesion without a primer, plasma treatment, corona treatment, flame treatment, or a combination thereof. The structural adhesive may bind to low energy substrates (e.g. polypropylene; polyethylene). The structural adhesive may activate at room temperature. The structural adhesive may bond to polyolefin plastics, metal, composite substrates, or a combination thereof. The structural adhesive may be a sealer. The structural adhesive may have a lap shear strength of about 4.0 Mpa or less to about 7.0 Mpa or more. The structural adhesive may include a polymeric material, an epoxy resin, an impact modifier, a curing agent, or a combination thereof.

[0023] The structural adhesive may include a polymeric material. The polymeric material may comprise a polymeric admixture, which may include a variety of different polymers, such as thermoplastics, elastomers, plastomers, combinations thereof or the

like. For example, and without limitation, polymers that might be appropriately incorporated into the polymeric material include halogenated polymers, polycarbonates, polyketones, urethanes, polyesters, silanes, sulfones, allyls, olefins, styrenes, acrylates, methacrylates, epoxies, silicones, phenolics, rubbers, polyphenylene oxides, terphthalates, acetates (e.g., EVA), acrylates, methacrylates (e.g., ethylene methyl acrylate polymer) or mixtures thereof. Other potential polymeric materials may be or may include, without limitation, polyolefin (e.g., polyethylene, polypropylene) polystyrene, polyacrylate, poly(ethylene oxide), poly(ethyleneimine), polyester, polyurethane, polysiloxane, polyether, polyphosphazine, polyamide, polyimide, polyisobutylene, polyacrylonitrile, poly(vinyl chloride), poly(methyl methacrylate), poly(vinyl acetate), poly(vinylidene chloride), polytetrafluoroethylene, polyisoprene, polyacrylamide, polyacrylic acid, polymethacrylate. The polymeric material typically comprises a substantial portion of the activatable materials (e.g., up to 85% by weight or greater). The polymeric admixture may comprise about 15% to about 85%, about 20% to about 70%, or even 30% to about 65% by weight of the structural adhesive.

[0024] The polymeric material may include one or more acrylates. The acrylates may include, for example, simple acrylate, methyl acrylate, ethyl acrylate, butyl acrylate, vinyl acrylate, copolymers or combinations thereof or the like. Moreover, any of these acrylates may include other chemical groups such as epoxy, ethylene, butylene, pentene or the like for forming compounds such as ethylene acrylate, ethylene methyl acrylate and so on, and additionally for forming copolymers or combinations thereof or the like. When included, the one or more acrylates may comprise about 10% or less to about 95% or greater, about 20% to about 85%, and even about 35% to about 75% by weight of the polymeric admixture. An example acrylate is a copolymer of butyl acrylate and methyl acrylate and more particularly a copolymer of an ethylene butyl acrylate and ethylene methyl acrylate.

[0025] The polymeric material may include one or more acetates. The acetates may include, for example, acetate, methyl acetate, ethyl acetate, butyl acetate, vinyl acetate, copolymers or combinations thereof or the like. Moreover, any of these acetates may include other chemical groups such as epoxy, ethylene, butylene, pentene or the like for forming compounds such as ethylene acrylate, ethylene methyl acrylate and so on and

additionally for forming copolymers or combinations thereof or the like. When included, the one or more acetates may comprise about 5% or less to about 50% or greater, about 7% to about 35%, and even about 15% to about 25% by weight of the polymeric admixture of the polymeric material.

[0026] The structural adhesive may include an epoxy resin. The epoxy resin is used herein to mean any of the conventional dimeric, oligomeric or polymeric epoxy materials containing at least one epoxy functional group. The polymer-based materials may be epoxy containing materials having one or more oxirane rings polymerizable by a ring opening reaction. For example, the structural adhesive may include up to about 20% of an epoxy resin. In further example, the structural adhesive may include between about 0.1% and 50% by weight epoxy resin. The epoxy may be aliphatic, cycloaliphatic, aromatic or the like. The epoxy may be supplied as a solid (e.g., as pellets, chunks, pieces or the like) or a liquid (e.g., an epoxy resin). The epoxy may include an ethylene copolymer or terpolymer that may possess an alpha-olefin. As a copolymer or terpolymer, the polymer may be composed of two or three different monomers, i.e., small molecules with high chemical reactivity that are capable of linking up with similar molecules. In one example, an epoxy resin is added to the polymeric material to increase properties such as adhesion, cohesion or the like of the material. Additionally, the epoxy resin may strengthen cell structure when the activatable material is a foamable material. The epoxy resin may be a phenolic resin, which may be a novalac type or other type resin. The epoxy containing materials may include a bisphenol-A epichlorohydrin ether polymer, or a bisphenol-A epoxy resin which may be modified with butadiene or another polymeric additive.

[0027] The structural adhesive may include a variety of tackifiers, tackifying agents, or both. The tackifiers may include, without limitation, resins, phenolic resins (e.g., thermoplastic phenolic resins), aromatic resins, synthetic rubbers, alcohols or the like. According to one embodiment, a hydrocarbon resin 9 (e.g., a C5 resin, a C9 resin, a combination thereof or the like) may be employed as a tackifier. The hydrocarbon resin may be saturated, unsaturated or partially unsaturated (i.e., have 1, 2, 3 or more degrees of unsaturation). One example of a hydrocarbon resin is a coumarone-indene resin. When used, the tackifier may comprise about 0.1% or less to about 30% or greater, about 2% to

about 25%, or even about 6% to about 20% by weight of the structural adhesive. Advantageously, the tackifier may be able to assist in controlling cure rates for producing a more consistent or predictable expansion for the structural adhesive.

[0028] The structural adhesive may include one or more blowing agents for producing inert gasses that form an open and/or closed cellular structure within the structural adhesive, after activation. In this manner, it may be possible to lower the density of articles fabricated from the material. In addition, the material expansion helps to improve sealing capability, substrate wetting ability, adhesion to a substrate, acoustic damping, combinations thereof or the like. The blowing agent may include one or more nitrogen containing groups such as amides, amines and the like. Examples of suitable blowing agents include azodicarbonamide, dinitrosopentamethylenetetramine, 4,4i-oxy-bis-(benzenesulphonylhydrazide), trihydrazinotriazine and N, Ni-dimethyl-N,Ni-dinitrosoterephthalamide.

[0029] The structural adhesive may include an accelerator for the blowing agents. Various accelerators may be used to increase the rate at which the blowing agents form inert gasses. One blowing agent accelerator may be a metal salt, or an oxide, e.g. a metal oxide, such as zinc oxide. Other accelerators may include modified and unmodified thiazoles or imidazoles, ureas or the like. Amounts of blowing agents and blowing agent accelerators can vary widely within the structural adhesive depending upon the type of cellular structure desired, the desired amount of expansion of the structural adhesive, the desired rate of expansion, and the like. For example, ranges for the amounts of blowing agents, blowing agent accelerators or both together in the structural adhesive may range from about 0% to about 25% by weight, about 2% to about 20% by weight, or even about 7% to about 15% by weight of the structural adhesive, depending on the desired rate of volumetric expansion. The structural adhesive may be free of a blowing agent.

[0030] The structural adhesive may include one or more curing agents, one or more curing agent accelerators, or both. Amounts of curing agents and curing agent accelerators can, like the blowing agents, vary widely within the structural adhesive material depending upon the type of cellular structure desired, the desired amount of expansion of the structural adhesive, the desired rate of expansion, the desired structural properties of the structural adhesive and the like. For example, amounts of the curing

agents, curing agent accelerators, or both together present in the structural adhesive may range from about 0% by weight to about 7% by weight. The one or more curing agents may assist the structural adhesive in curing by crosslinking the polymers, epoxy resins (e.g., by reacting in stoichiometrically excess amounts of curing agent with the epoxide groups on the resins), or both. Useful classes of the one or more curing agents may be materials selected from aliphatic or aromatic amines or their respective adducts, amidoamines, polyamides, cycloaliphatic amines, (e.g., anhydrides, polycarboxylic polyesters, isocyanates, phenol-based resins (such as phenol or cresol novolak resins, copolymers such as those of phenol terpene, polyvinyl phenol, or bisphenol-A formaldehyde copolymers, bishydroxyphenyl alkanes or the like), peroxides or mixtures thereof. The one or more curing agents may include modified and unmodified polyamines or polyamides such as triethylenetetramine, diethylenetriamine tetraethylenepentamine, cyanoguanidine, dicyandiamides and the like. The one or more curing agent accelerators (e.g., a modified or unmodified urea such as methylene diphenyl bis urea, an imidazole or a combination thereof) may also be provided for preparing the structural adhesive.

[0031] Though longer curing times are also possible, curing times of less than 5 minutes, and even less than 30 seconds are possible for the formulation of the present teachings. Moreover, such curing times may depend upon whether additional energy (e.g., heat, light, radiation) is applied to the structural adhesive or whether the material is cured at room temperature.

[0032] The structural adhesive may include one or more fillers, including but not limited to particulated materials (e.g., powder), beads, microspheres, nanoparticles or the like. The filler may include a relatively low-density material that is generally non-reactive with the other components present in the structural adhesive. Examples of fillers include silica, diatomaceous earth, glass, clay, talc, pigments, colorants, glass beads or bubbles, glass, carbon ceramic fibers, antioxidants, and the like. Such fillers, particularly clays, may assist the activatable material in leveling itself during flow of the material. The clays that may be used as fillers may include nanoparticles of clay and/or clays from the kaolinite, illite, chloritem, smectite or sepiolite groups, which may be calcined. Examples of suitable fillers include, without limitation, talc, vermiculite, pyrophyllite, sauconite, saponite, nontronite, montmorillonite or mixtures thereof. The clays may also include

minor amounts of other ingredients such as carbonates, feldspars, micas and quartz. The fillers may also include ammonium chlorides such as dimethyl ammonium chloride and dimethyl benzyl ammonium chloride. Titanium dioxide might also be employed. One or more mineral or stone type fillers such as calcium carbonate, sodium carbonate or the like may be used as fillers. Silicate minerals such as mica may be used as fillers. It has been found that, in addition to performing the normal functions of a filler, silicate minerals and mica in particular may improve the impact resistance of the blended thermoplastic material. When employed, the fillers in the structural adhesive may range from 1% to 90% by weight. For example, the activatable material may include from about 3% to about 30% by weight, and in further example about 10% to about 20% by weight clays or similar fillers.

[0033] It is contemplated that one of the fillers or other components of the structural adhesive may be thixotropic for assisting in controlling the viscosity and thus the flow of the materials as well as properties such as tensile, compressive or lap shear strength in its green state, during activation and post-cure.

[0034] The structural adhesive may include other additives, agents or performance modifiers as desired, including but not limited to a UV resistant agent, a flame retardant, an impact modifier, a heat stabilizer, a UV photoinitiator, a colorant, a processing aid, an anti-oxidant, a lubricant, a coagent, a reinforcement (e.g., chopped or continuous glass, glass fiber, ceramics and ceramic fibers, aramid fibers, aramid pulp, carbon fiber, acrylate fiber, polyamide fiber, polypropylene fibers, or combinations thereof). In one example, an acrylate coagent may be employed for enhancing cure density. The structural adhesive may include 0 to about 5.00 weight percent of an anti-oxidant such as a propionate (e.g., pentaerythritol tetrakis (3-(3,5-di-tert-butyl-4-hydroxyphenyl) propionate)) for assisting in controlling oxidation, cure rate or both.

[0035] For mixing the additives, fillers or both, it may be preferable for the additives or fillers to be mixed with a dispersant prior to mixing them with the other ingredients of the structural adhesive. Such a dispersant may typically have a relatively low molecular weight of less than about 100,000 amu, less than about 50,000 amu or even less than about 10,000 amu, although not required. Examples of such dispersants include, without

limitation, liquid waxes, liquid elastomers or the like such as ethylene-propylene rubber (EPDM), paraffins (e.g., paraffin wax). The structural material may be free of a dispersant.

[0036] Figure 1 illustrates a perspective view of one example of a fuel tank 1 with reinforcing structures 2, 8. The reinforcing structures 2, 8 are located at locations 20 (top of tank) and 22 (side of tank) as target reinforcements, resulting in a lighter and more efficient fuel tank.

[0037] Figure 2A and 2B show the first reinforcing structure 2 as the carrier 4 and structural adhesive 6. Together, the carrier 4 and the structural adhesive 6 form the first reinforcing structure 2.

[0038] Figure 3A and 3B show the second reinforcing structure 8 as the carrier 10 and structural adhesive 12. Together, the carrier 10 and the structural adhesive 12 form the second reinforcing structure 8.

[0039] Figures 4A-C show three examples of the fuel tank 1 under 6 kPa inner pressure load with different sized top and side reinforcements. Test results are shown below at Table 1.

	Deformation at top (mm) at 6 kPa	Deformation at side (mm) at 6 kPa	Increased Rigidity (Top)	Increased Rigidity (Side)
Example 1 w/o Reinforcement	13.00	18.80		
Example 2	0.60	2.80	2067%	571%
Example 3	6.10	3.60	113%	422%

TABLE 1

[0040] In FIG. 4A, the fuel tank does not have any reinforcing structures attached. The fuel tank is deformed at location 20 by about 13.0mm and at location 22 by about 18.80mm when exposed to 6 kPa inner pressure.

[0041] FIG. 4B shows one embodiment of fuel tank 1 with reinforcing structures 2, 8. The fuel tank under load is deformed at location 20 by about 0.6 mm and at location 22 by about 2.80mm. The reinforcing structures 2,8 are located at the target positions needing reinforcement 20, 22. As can be seen in Table 1, the fuel tank is more rigid than the unreinforced tank by about 2000% at location 20 when reinforcement 2 is present.

Additionally, the fuel tank is more rigid when reinforcement 8 is present, increasing rigidity of the fuel tank by about 570% at location 22.

[0042] FIG. 4C shows another embodiment of fuel tank 1 with reinforcing structures 2, 8 at locations 20, 22, respectively. The reinforcing structures 2, 8 are resized to reduce material while maintaining increased rigidity of the fuel tank, preventing substantial deformation. As seen in Table 1, the fuel tank 1 under 6 kPa of pressure shows a deformation at location 20 of about 6.10 mm and show a deformation at location 22 of about 3.60 mm, both locations are substantially more rigid than compared with the unreinforced fuel tank.

[0043] The explanations and illustrations presented herein are intended to acquaint others skilled in the art with the invention, its principles, and its practical application. The above description is intended to be illustrative and not restrictive. Those skilled in the art may adapt and apply the invention in its numerous forms, as may be best suited to the requirements of a particular use.

[0044] Accordingly, the specific embodiments of the present invention as set forth are not intended as being exhaustive or limiting of the teachings. The scope of the teachings should, therefore, be determined not with reference to this description, but should instead be determined with reference to the appended claims, along with the full scope of equivalents to which such claims are entitled. The omission in the following claims of any aspect of subject matter that is disclosed herein is not a disclaimer of such subject matter, nor should it be regarded that the inventors did not consider such subject matter to be part of the disclosed inventive subject matter.

[0045] Plural elements or steps can be provided by a single integrated element or step. Alternatively, a single element or step might be divided into separate plural elements or steps.

[0046] The disclosure of "a" or "one" to describe an element or step is not intended to foreclose additional elements or steps.

[0047] While the terms first, second, third, etc., may be used herein to describe various elements, components, regions, layers and/or sections, these elements, components, regions, layers and/or sections should not be limited by these terms. These terms may be used to distinguish one element, component, region, layer or section from another

region, layer or section. Terms such as “first,” “second,” and other numerical terms when used herein do not imply a sequence or order unless clearly indicated by the context. Thus, a first element, component, region, layer or section discussed below could be termed a second element, component, region, layer or section without departing from the teachings.

[0048] Spatially relative terms, such as “inner,” “outer,” “beneath,” “below,” “lower,” “above,” “upper,” and the like, may be used herein for ease of description to describe one element or feature's relationship to another element(s) or feature(s) as illustrated in the figures. Spatially relative terms may be intended to encompass different orientations of the device in use or operation in addition to the orientation depicted in the figures. For example, if the device in the figures is turned over, elements described as “below” or “beneath” other elements or features would then be oriented “above” the other elements or features. Thus, the example term “below” can encompass both an orientation of above and below. The device may be otherwise oriented (rotated 90 degrees or at other orientations) and the spatially relative descriptors used herein interpreted accordingly.

[0049] The disclosures of all articles and references, including patent applications and publications, are incorporated by reference for all purposes. Other combinations are also possible as will be gleaned from the following claims, which are also hereby incorporated by reference into this written description.

CLAIMS

We claim:

1. A reinforcement for fuel tank comprising:

one or more reinforcing structures including a carrier and a structural adhesive adapted for location on a fuel tank so that at least a portion of the one or more reinforcing structures is shaped to lie in direct planar contact with a surface of the fuel tank;

wherein the one or more reinforcing structures are adapted to be adhered to the fuel tank by the structural adhesive upon activation of the structural adhesive; and

wherein the one or more reinforcing structures are shaped to prevent the fuel tank from deforming when exposed to a force.

2. The reinforcement of claim 1, including at least one location requiring reinforcement located at an opening in the fuel tank.

3. The reinforcement of claim 1 or claim 2, including at least one location requiring reinforcement located at an exterior recess of the fuel tank.

4. The reinforcement of any of claims 1 through 3, wherein the one or more reinforcing structures are a first reinforcing structure located at a first location and a second reinforcing structure located at a second location;

wherein the first location is an opening in the fuel tank, and the second location is an exterior recess of the fuel tank.

5. The reinforcement of any of claims 1 through 4, wherein the structural adhesive has a lap shear strength of about 4.0 to about 7.0 Mpa.

6. The reinforcement of any of claims 1 through 5, wherein the one or more reinforcing structures reduce deformation at 6 kPa inner pressure load by at least 100% or more at one or more locations on the fuel tank requiring reinforcement.

7. A reinforcing system for a fuel tank comprising:
a first reinforcing structure; and
a second reinforcing structure;
wherein the first reinforcing structure and the second reinforcing structure each include a carrier and a structural adhesive; and
wherein the first reinforcing structure and second reinforcing structure are adapted to be attached to the fuel tank by the structural adhesive at a first location and a second location, respectively, preventing substantial deformation of the fuel tank under pressure.
8. The reinforcing system of claim 7, wherein the first location is an opening in the fuel tank, and the second location is an exterior recess of the fuel tank.
9. The reinforcing system of claim 7 or claim 8, wherein the structural adhesive cures at room temperature.
10. The reinforcing system of any of claims 7 through 9, wherein the first reinforcing structure and second reinforcing structure reduce deformation of the fuel tank at the first location and the second location under 6 kPa inner pressure load by at least 100% or more.
11. The reinforcing system of any of claims 7 through 10, wherein the structural adhesive adheres to the carrier without surface preparation.
12. The reinforcing system of any of claims 7 through 11, wherein the structural adhesive adheres to the fuel tank upon exposure to heat.
13. The reinforcing system of any of claims 7 through 12, wherein the second reinforcing structure reduces deformation of the fuel tank at the second location at 6 kPa inner pressure load by at least 400% or more.
14. A method for reinforcing a fuel tank comprising:

i) locating a structural adhesive onto a first carrier and a second carrier forming a first reinforcing structure and a second reinforcing structure;

ii) attaching the first reinforcing structure and the second reinforcing structure to the fuel tank upon activation of the structural adhesive;

wherein the fuel tank is reinforced to provide at least 100% or more rigidity at the first location and the second location to preventing deformation of the fuel tank under 6 kPa pressure.

15. The method of claim 14, wherein the structural adhesive cures at room temperature.

16. The method of claim 14 or claim 15, wherein the structural adhesive is expandable.

17. The method of any of claims 14 through 16, wherein the structural adhesive is activatable by heat.

18. The method of any of claims 14 through 17, wherein the second reinforcing structure reduces deformation of the fuel tank at the second location at 6 kPa inner pressure load by at least 400% or more.

19. The method of any of claims 14 through 18, wherein the structural adhesive cures in 5 minutes or less.

20. The method of any of claims 14 through 19, wherein the structural adhesive cures in about 30 seconds.

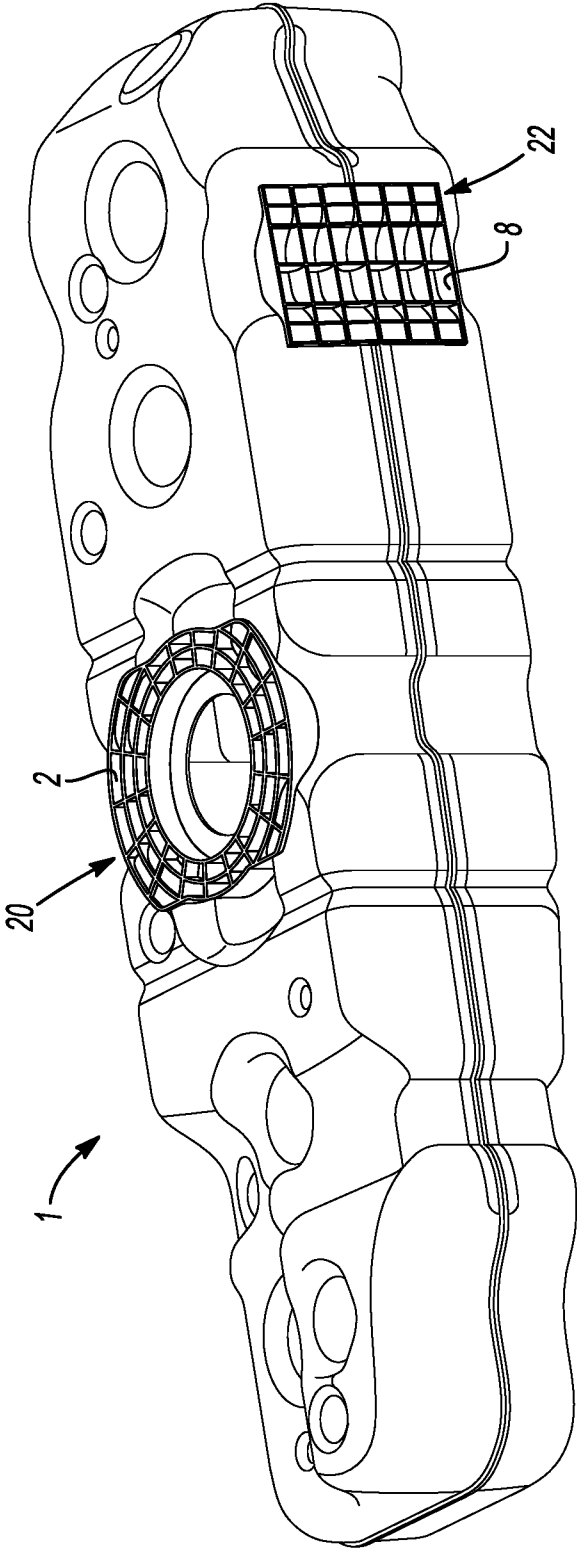


Fig-1

2/4

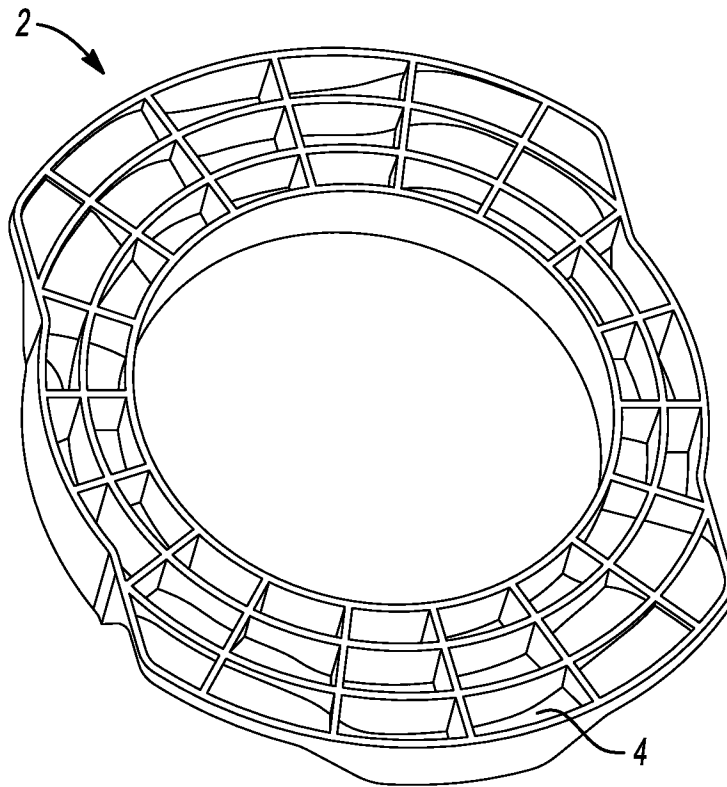


Fig-2A

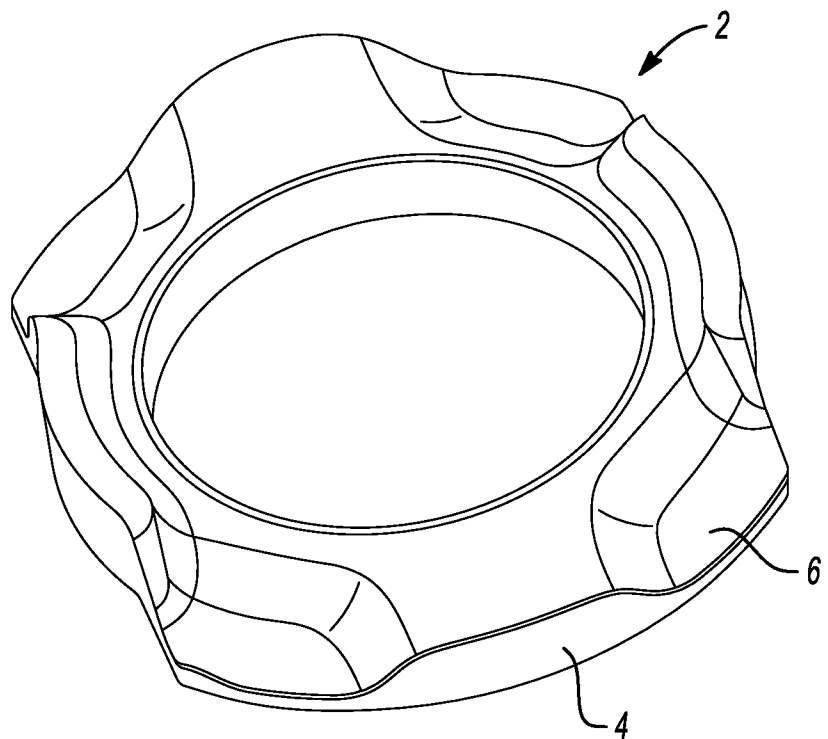
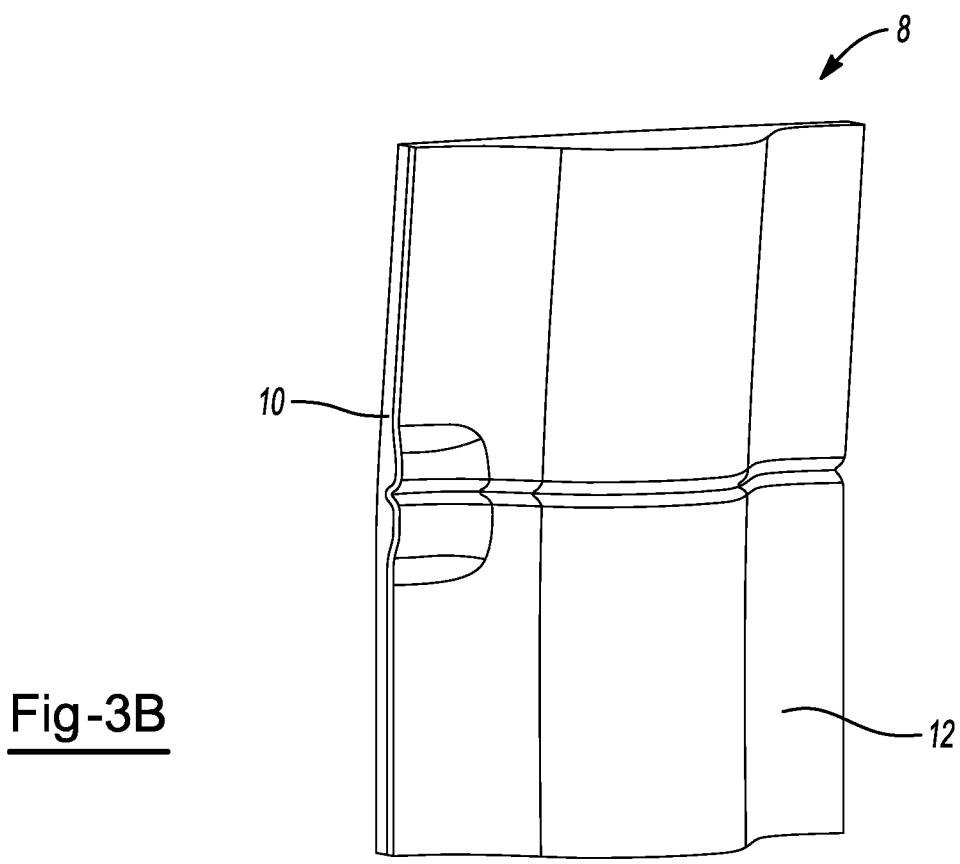
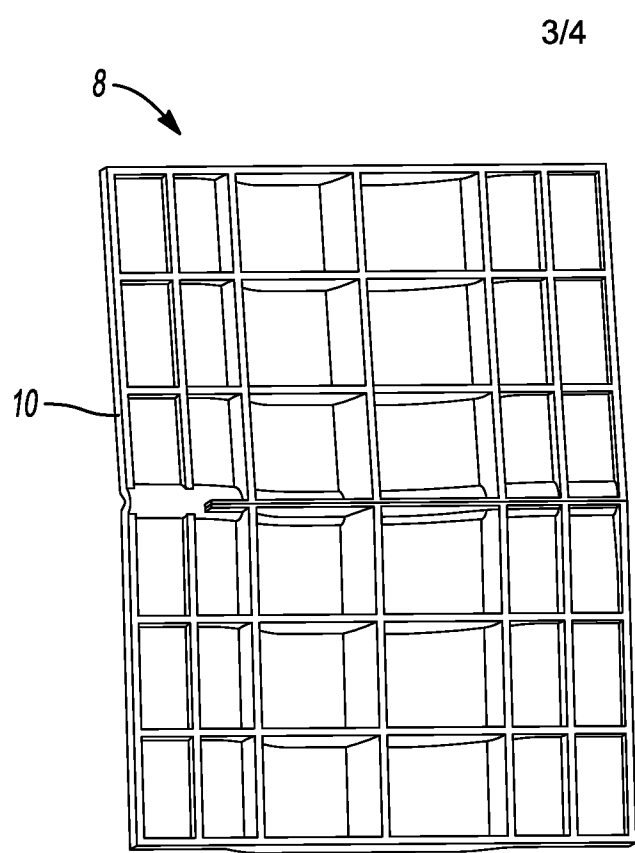


Fig-2B



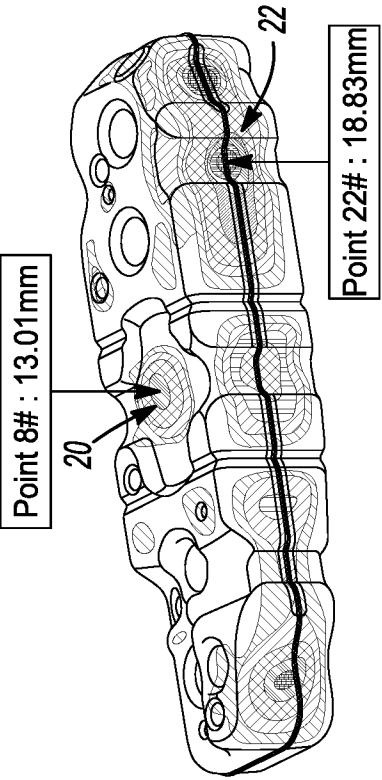


Fig-4A

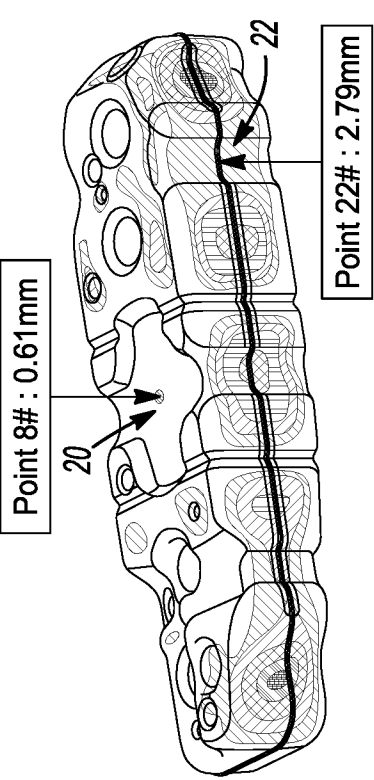


Fig-4B

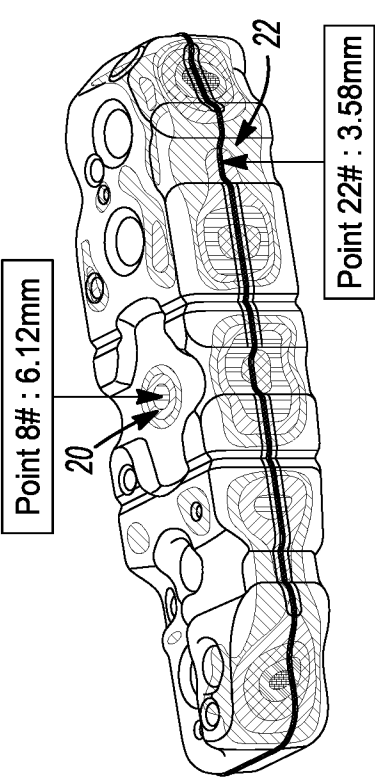


Fig-4C

