United States Patent Application Publication	20250256809
Kind Code	A1
Publication Date	August 14, 2025
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STRADDLE VEHICLE CHASSIS WITH COMPOSITE SUPERSTRUCTURE

Abstract

A composite superstructure of a straddle-type vehicle, such as a snowmobile, formed from a fiber reinforced polymer and extending from a forward section coupled to a forward portion of a chassis of the vehicle to a rearward section coupled to a rearward portion of the chassis, where the superstructure defines at least one steering post mount configured to couple with a portion of a steering assembly of the vehicle.

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Family ID: **96661601**

Appl. No.: **19/046569**

Filed: **February 06, 2025**

Related U.S. Application Data

us-provisional-application US 63551754 20240209

Publication Classification

Int. Cl.: **B62M27/02** (20060101)

U.S. Cl.:

CPC **B62M27/02** (20130101); B62M2027/028 (20130101)

Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS [0001] This application claims the benefit of U.S. Provisional Patent Application No. 63/551,754, filed Feb. 9, 2024, entitled "STRADDLE VEHICLE CHASSIS WITH COMPOSITE SUPERSTRUCTURE", the entire contents of which are expressly incorporated by reference herein.

BACKGROUND

[0002] Straddle-type recreational vehicles include a straddle seat configured such that an operator is seated stride the seat with feet on respective foot rests, footwells, or floorboards during operation of the vehicle. Such vehicles include a steering system, such as handle bars or a steering wheel, and operator controls at or near one or more of the steering system, foot rests, or a counsel or pod. Commonly, straddle-type vehicles include frame members extending from a position forward of the steering system toward an aft portion of the vehicle. The aft portion of certain straddle-type vehicles may define a tunnel extending from the operator area to the aft end of the vehicle. The frame members may support the straddle seat as well as one or more power plants (e.g., one or more combustion, electric, or hybrid motors and associated fuel tanks or battery packs).

SUMMARY

[0003] The present disclosure describes straddle-type recreational vehicles, including, but not limited to, snowmobiles, all-terrain vehicles, personal watercraft, and two- or three-wheeled motorcycles, having one or more composite frame assemblies extending from a position forward of a steering system of the vehicle and either defining or coupled to frame members supporting at least one of an operator area, straddle seat of the vehicle, fuel tank, or tunnel. The described composite frame members facilitate manufacturing of the vehicle by reducing part count, assembly steps, assembly time, or combinations thereof. Additionally, compared to other frame members configurations, the described composite frame assemblies may reduce the total weight of the vehicle, reduce weight over the center of gravity of the vehicle, and stiffen the complete vehicle structure thereby providing for improved performance, handling, or both.

[0004] In some examples, the disclosure describes a superstructure of a straddle-type vehicle that includes a fiber reinforced polymer extending from a forward section coupled to a forward portion of a chassis of the vehicle to a rearward section coupled to a rearward portion of the chassis. The superstructure defines at least one steering mount aperture configured to receive therethrough and couple with a portion of a steering assembly of the vehicle.

[0005] In some examples, the disclosure describes a straddle-type vehicle that includes a chassis having a plurality of frame members configured to support a power plant, a suspension system, and an operator area. The vehicle also includes at least one front ground engaging member coupled by a respective front suspension of the suspension system to a forward portion of the chassis and at least one rear ground engaging member coupled by a respective rear suspension of the suspension system to a rearward portion of the chassis. The vehicle also includes a superstructure extending from a forward section coupled to the forward portion of the chassis to a rearward section coupled to the rearward portion of the chassis. The superstructure includes a fiber reinforced thermoplastic composite material.

[0006] In some examples, the disclosure describes a method of forming a composite superstructure of a straddle-type vehicle, the superstructure including a fiber reinforced polymer extending from a forward section coupled to a forward portion of a chassis of the vehicle to a rearward section coupled to a rearward portion of the chassis and the superstructure defining at least one steering mount aperture configured to receive therethrough and couple with a portion of a steering assembly of the vehicle. The method includes providing a composite material including the fiber reinforced polymer. The method also includes forming the composite material to define at least a portion of the composite superstructure. The method may include assembling one or more portions of the composite superstructure to define the composite superstructure. The method also includes coupling the composite superstructure to at least a portion of a chassis of a vehicle.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] The disclosure can be understood in consideration of the following detailed description of various embodiments in connection with the accompanying drawings.

[0008] FIGS. **1**A through **1**E are conceptual diagrams illustrating various views of an example straddle-type recreational vehicle **10**.

[0009] FIGS. **2**A through **2**K are conceptual diagrams illustrating various views of an example chassis having a composite superstructure.

[0010] FIGS. **3**A and **3**B are conceptual diagrams illustrating various views of an example composite superstructure including a left frame and a right frame.

[0011] FIGS. **4**A through **4**H are conceptual diagrams illustrating various view of an example composite superstructure including a left frame, a right frame, and a fuel tank shell.

[0012] FIG. **5** is an example technique **500** of forming a composite superstructure.

DETAILED DESCRIPTION

[0013] For purposes of promoting an understanding of the principles of the disclosure, reference will now be made to the embodiments illustrated in the drawings, and specific language will be used to describe the same. It will nonetheless be understood that no limitation of the scope of the disclosure is intended by the illustration and description of certain embodiments of the disclosure. In addition, any alterations and/or modifications of the illustrated and/or described embodiment(s) are contemplated as being within the scope of the present disclosure. Further, any other applications of the principles of the disclosure, as illustrated and/or described herein, as would normally occur to one skilled in the art to which the disclosure pertains, are contemplated as being within the scope of the present disclosure.

[0014] The described composite frame assemblies may include fiber reinforced polymers defining structural components. Various configurations of the structural components may be derived from full chassis topology optimization. The structural components may include optional hollow portions. In some examples, the composite frame assemblies may include two or three components which may include A-side surfaces, portions of a fuel tank shell, or both.

[0015] Compared to other designs, use of the described composite frame assemblies may reduce part-count which may include, for example, a part-count reduction from 20 or more components to two or three components, thereby reducing assembly steps, assembly time, or both. Also, the described composite frame assemblies may reduce the total weight of the vehicle, reduce weight over the center of gravity of a vehicle, or both, which may improve vehicle performance, handling, or both. Further, the described composite frame assemblies may provide a stiffer frame structure, provide a more efficient load path coupling the front suspension of the vehicle to a rear section of the chassis and/or fuel tank shell, or both compared to other frame configurations, which may further enhance vehicle performance, handling, or both. Additionally, the described composite frame assemblies optionally may provide two different steering system mounting locations, thereby enabling commonality of frame components for multiple vehicle configurations.

[0016] FIGS. **1**A through **1**E are conceptual diagrams illustrating various views of an example straddle-type recreational vehicle **10**. Although illustrated as including a snowmobile, in other examples, vehicle **10** may include other straddle-type vehicles, including, but not limited to, snowmobiles, all-terrain vehicles, personal watercraft, and two- or three-wheeled motorcycles, or other vehicles having an operator area with a straddle seat. Vehicle **10** generally includes a front portion **12** and a rear portion **14**. At the front portion **12** is a front suspension **16**. At the rear portion **14** is a rear suspension **18**. The front suspension **16** and the rear suspension **18** support a chassis **20**.

[0017] Front suspension **16** includes shock absorbers **22**, each of which is connected to a respective ski **24** and a forward portion of chassis **20**. Although illustrated as including skis **24**, in other examples, vehicle **10** may include other ground engaging members, such as, for example, wheels or endless-tracks. The shock absorbers **22** may be any damping devices suitable for absorbing shock resulting from the skis **24** passing over uneven terrain. The skis **24** are steered, at least in part, by a suitable steering assembly, such as handlebars **26** operatively coupled to skis **24**.

[0018] Rear suspension **18** comprises a torque arm **29** coupling a rearward portion of chassis **20** to endless-track **30**. Although illustrated as including endless track **30**, in other examples, vehicle **10** may include other ground engaging members such as wheels or belts. Rotation of track **30** propels vehicle **10**. Track **30** is circulated through a tunnel **32** defined at least in part by the rearward portion of chassis **20** and is positioned by the torque arm **29**. Tunnel **32** may be tapered from a first height and/or a first width toward a smaller second height and/or a smaller second width the rear portion **14** of vehicle **10**. In some examples, a flap **34** is mounted at the rear portion **14** and blocks debris, such as snow, dirt, or mud, from being kicked-up by the track **30**.

[0019] Mounted to the chassis **20** and atop the tunnel **32** is a seat **40** for the operator of the vehicle **10**. On both sides of the chassis **20** or tunnel **32** are running boards **42**, upon which the operator may rest his or her feet when seated on the seat **40**. The seat **40** is positioned to allow the driver to grasp the handlebars **26** for steering the vehicle **10**. The handlebars **26** are mounted to a steering rod **28**, which protrudes out from within the center console **44**. At the center console **44** is a fuel cap **46** of a fuel tank **48**.

[0020] At the front portion **12** of the vehicle **10** is a hood assembly **50**, which is mounted on top of a nose pan or otherwise coupled to chassis **20**. Hood assembly **50** may include a front bumper **52** protruding from a forward most end thereof. The hood assembly **50** houses headlights **54**. An optional windshield is connected to an uppermost portion of the hood assembly **50**. Associated with the hood assembly **50** is a display **58** viewable by the operator when seated on the seat **40**. Mounted to opposite sides of the hood assembly are body panels **60**, which are advantageously interchangeable.

[0021] Vehicle **10** includes a power plant, e.g., an engine assembly, configured to drive the track **30**. The power plant may include any suitable engine, such as an electric motor, 2-stroke internal combustion engine, and 4-stroke internal combustion engine. The power plant may include a suitable exhaust assembly and oil tank assembly.

[0022] The vehicle **10** further includes a suitable control module. The control module may be arranged at any suitable location, such as within the hood assembly **50**, beneath the center console **44**, or within any suitable control mounted to the handlebars **26**. The control module include processing circuitry, such as processor hardware (shared, dedicated, or group), that is configured to execute code and memory hardware (shared, dedicated, or group) that is configured to store code executed by the processor circuitry. The code is configured to provide the features of the control module described herein. The term memory hardware is a subset of the term computer-readable medium. The term computer-readable medium, as used herein, does not encompass transitory electrical or electromagnetic signals propagating through a medium (such as on a carrier wave). The term computer-readable medium is therefore considered tangible and non-transitory. Non-limiting examples of a non-transitory computer-readable medium are nonvolatile memory devices (such as a flash memory device, an erasable programmable read-only memory device, or a mask read-only memory device), volatile memory devices (such as a static random access memory device or a dynamic random access memory device), magnetic storage media (such as an analog or digital magnetic tape or a hard disk drive), and optical storage media (such as a CD, a DVD, or a Blu-ray Disc).

[0023] FIGS. **2**A through **2**K are conceptual diagrams illustrating various views of an example chassis **200** having a composite steering support structure **202**, also referred to herein as a composite frame assembly. Composite superstructure **202** provides several benefits compared to other frame assemblies, such as metal frame assemblies or metal rear-steering-hoop-frame assemblies, defining the same or similar structures of chassis **200**. For example, composite superstructure **202** may include fewer parts, which may reduce assembly steps and/or assembly time. Also, composite superstructure **202** may reduce the total weight of the vehicle, reduce weight over the center of gravity of a vehicle, or both, which may improve vehicle performance, handling, or both. Further, composite superstructure **202** may provide a stiffer frame structure, provide a more efficient load paths coupling the front suspension of the vehicle to a rear section of the chassis and/or fuel tank shell, or both, which may further enhance vehicle performance, handling, or both. Additionally, composite superstructure **202** optionally may provide two different steering system mounting locations, thereby enabling commonality of frame components for multiple vehicle steering system configurations. In these ways, and as further described below, composite superstructure **202** is configured to improve the manufacturability and overall performance of chassis **200**, compared to other frame assembly designs.

[0024] Composite superstructure **202** extends from a forward section **204** coupled to a forward portion **206** of chassis **200** to a rearward section **208** coupled to a rearward portion **210** of chassis **200**. Composite superstructure **202** may include a multi-piece assembly or unitary component. For example, composite superstructure **202** may include a left frame **212**, a right frame **214**, and a fuel tank shell **216**. Each of left fame assembly **212**, right frame assembly **214**, and fuel tank shell **216** may include any suitable configuration that is configured to couple with select portions of chassis **200** and, optionally, support other components of a vehicle, such as suspension components, steering components, a power plant, operator interface components, a tunnel, or the like. Although described as including three components, in other examples, composite superstructure may include a unitary component, two components such as a left portion and a right portion or a front portion and a rear portion, or more than three components. As used herein, left, right, top, bottom, front, and back are used generally to describe portions of a vehicle or components thereof from the perspective of the operator when seated on the vehicle.

[0025] In some examples, the configuration of composite superstructure **202**, including the number and shape of components, interfaces between components, or the like may be, at least in part, determined by or otherwise derived from topological optimization, such as full chassis topological optimization. Topology optimization, as understood by a person of ordinary skill, may use mathematical methods to optimize material layout within a given design space, for a given set of loads, boundary conditions, and constraints with the goal of improving the performance of a system. In some examples, topology optimization may use a finite element method (FEM) to evaluate the design performance. For example, a design may be optimized using either gradient-based mathematical programming techniques such as the optimality criteria algorithm and the method of moving asymptotes or non gradient-based algorithms such as genetic algorithms. By using topologic optimization, the above described design objective may be, at least partially, achieved. In some examples, designs produced via topological optimization may be further refined to facilitate manufacturability or provide other desired design qualities such as aesthetics. In some examples, symmetry of select feature was used for full chassis optimization.

[0026] Forward section **204** of composite superstructure **202** may include a first arm **218** and a second arm **220** defining a U-shape when viewed from the top of composite superstructure **202** (FIG. 2B). In some examples, first arm **218** may be a component of left frame **212** and second arm **220** may be a component of right frame **214**. The base (e.g., vertex) of the U-shape may define the at least one steering post mount or aperture, discussed in further detail below. The U-shape of forward section **204** may improve load transfer, such as forces applied to chassis **200** and/or composite superstructure **202** from a suspension, from first arm **218** to second arm **220** compared to other shapes. The improved load transfer may result in a stiffer chassis, thereby improving handling compared to less stiff frame configurations. Although described as a U-shape, in other examples, forward section **204** may define other shapes, such as a V-shape or a substantially squared U-shape, may include crossbars or other supports extending between portions of the arms, or combinations thereof.

[0027] Additionally, or alternatively, each respective arm of first arm **218** and second arm **220** may define a wishbone shape when viewed, respectively, from left-side (FIG. **2**F) or the right-side (FIG. **2**G). For example, first arm **218** defines a wishbone-shape having a first leg **222** and a second leg **224**, each leg extending from a vertex **226**. Vertex **226** may be configured to couple to at least a portion of chassis **200** or a frame member coupled thereto. In some examples, at least a portion of vertex **226** may be coupled to at least a portion of a suspension system, such as a front suspension. First leg **222** of the wishbone-shaped first arm **218** extends from a first end at vertex **226** upward toward an apex **228** of composite superstructure **202**. A second end of first leg **222**, terminating at or near apex **228**, may include a fork **230** defining a triangular aperture beneath apex **228**. Fork **230** may be configured to more evenly distribute a load applied through first leg **222** across a greater area of composite superstructure **202**, including but not limited to fuel tank shell **216**, at or near apex **228** compared to a configuration without fork **230**. Second leg **224** of the wishbone-shaped first arm **218** extends from a first end at vertex **226** rearward toward rearward portion **210** of chassis **200**. Although not illustrated as including a fork, in other examples, second leg **224** may include a fork. Additionally, or alternatively, first leg **222** and second leg **224** may include more than one fork or other crossbar members configured to distribute load from first arm **218** to selected portions of chassis **200** or other components of the vehicle.

[0028] Similarly, as illustrated in FIG. **2**G, second arm **220** defines a wishbone-shape having a first leg **232** having a fork **238** and a second leg **234**, each leg extending from a vertex **236**. First leg **232**, second leg **234**, vertex **236**, and fork **238** may be the same as or substantially similar to first leg **222**, second leg **224**, vertex **226**, and fork **230** described above in reference to first arm **218** as illustrated in FIG. **2**F.

[0029] Composite superstructure **202** also may include fuel tank shell **216**. Fuel tank shell **216** includes a separate component configured to couple to left frame **212**, right frame **214**, or both. In other examples, fuel tank shell **216** may include a left portion and a right portion, each portion coupled to or defining a unitary structure with left frame **212** and right frame **214**, respectively. Although illustrated as including fuel tank shell **216**, on other examples, composite superstructure **202** may include only left frame **212** and right frame **214**, which may optionally extend toward and be configured to couple to at least a portion of rearward portion **210** of chassis **200**.

[0030] A forward portion **242** of fuel tank shell **216** is coupled to, or defines at least a portion of, at least one steering post mount, such as steering post mounts **240**A and **240**B. By defining steering post mounts **240**A and **240**B composite superstructure **202** may provide greater vehicle handlebar position configurability during manufacturing, by owners, or both. For example, providing for multiple steering post mounts **240**A and **240**B allows for different steering post angles to be paired with a single part.

[0031] A rearward portion **244** of fuel tank shell **216** is configured to couple to rearward portion **210** of chassis **200**. The coupling may include, for example, mechanical fasteners, adhesives, or combinations thereof. Additionally, forward portion **242** of fuel tank shell **216** may be coupled directly or indirectly to one or more portions of a front suspension. In this way, forward portion **242** of fuel tank shell **216** may be configured to simultaneously transmit front suspension loads to both rearward portions **210** of chassis **200**, such as a tunnel assembly, and fuel tank shell **216**.

[0032] Fuel tank shell **216** may be configured to support a separate fuel tank or define a fuel tank having cavity configured to retain a fuel. Fuel tank shell **216** may be configured to retain a fuel for an internal combustion engine. Example fuels may include, but are not limited to, petroleum-based fuels, gasoline, and alcohols. For example, fuel tank shell **216** may include a polymer, such as a fluorinated polymer, configured to direct contact with a liquid fuel or be configured to retain a rigid

structure or bladder configured to retain a liquid fuel.
[0033] When supporting a separate fuel tank, fuel tank shell **216** may completely encapsulate the separate fuel tank or support at least a portion of the separate fuel tank. For example, a blow and/or rotomolded fuel tank meeting U.S. Environmental Protection Agency (EPA) fuel tank compliance standards, such as a fuel tank with a permeation resistant ethylene vinyl alcohol copolymer (EVOH) layer, may be co-molded with a pre-formed thermoplastic based structural reinforcements defining fuel tank shell **216**. Example EPA standards may include but are not limited to 40 CFR Part **1051** and related EPA guidance letters CCD-05-14 & CISD-07-02. In some examples, the structural reinforcements defining fuel tank shell **216** may include solid surfaces completely or at least partially encapsulating the EPA compliant fuel tank, or at least one support member or a web of support members. In this way, an existing fuel tank design may be integrated with fuel tank shell **216** to define a structural frame member as a component of composite superstructure **202**.
[0034] When defining a fuel tank having cavity configured to retain a fuel, fuel tank shell **216** may include a high specific modulus (GPa/(kg/m.sup.3)) and a high specific strength (MPa/(kg/m.sup.3)) material (e.g., a specific modulus within a range from about 0.9 to about 1.25 and a specific strength greater than about 1) having a shape selected to provide a high stiffness or inertia geometry and define the cavity configured to retain the fuel. In some examples, the high specific strength material, or at least a portion thereof defining a layer directly adjacent the cavity, may include a fluorinated polymer meeting EPA fuel tank compliance standards. Additionally, or alternatively, an EPA compliant bladder may be disposed within the cavity defined by fuel tank shell **216**. In these ways, fuel tank shell **216** defines both an EPA compliant a fuel tank design and a structural frame member as a component of composite superstructure **202**.
[0035] Although described as retaining a fuel, in other examples, such as examples in which chassis **200** is configured to support an electric motor or fuel tank in a different location, fuel tank shell **216** may define a storage area or other structure. By defining at least a portion of fuel tank shell **216**, composition superstructure **202** may replace components of other designs, such as replace rear-steering-hoop-frame assemblies connecting an upper steering post mount to a tunnel or a rear chassis section.
[0036] Additionally, a footprint defined by fuel tank shell **216** may enable a geometry of composite superstructure **202** that projects rearward over a significant portion of a tunnel or other section of rearward portion **210** of chassis **200** with a more efficient load path compared to other designs such as rear-steering-hoop-frame assemblies. For example, an angle (relative to a plane parallel to ground) at which the portion of composite superstructure **202** defining fuel tank shell **216** intersects a tunnel or sections of rearward portion **210** of chassis **200** may be less than the angle at which a rear-steering-hoop-frame assembly intersects a tunnel or other sections of a rearward portion of a chassis.
[0037] In some examples, composite superstructure **202**, such as at least one of left frame **212**, right frame **214**, and fuel tank shell **216** may include or otherwise define A-side surfaces including but not limited to console body work, side panel body work, and operator seat body work. The portion of composite superstructure **202** defining A-side body work may define exoskeleton body work construction configured to aesthetically highlight A-side structure and, optionally, reduce A-side body panel footprint (e.g., total area or size) and further enhance lightweighting of the vehicle. In this way, composite superstructure **202** may replace all or at least a portion of body panels used in other vehicle designs, thereby reducing tooling and manufacturing costs associated with fabrication of console body panels.
[0038] Composite superstructure **202** is formed, at least in part, from one or more composite materials such as fiber reinforced polymers (e.g., fiber reinforced polymeric materials). The fiber reinforced polymers include at least one of a thermoplastic or thermoset polymer and at least one of a plurality of reinforcing fibers. Example thermoplastics may include, but are not limited to, at least one of high-density polyethylene (HDPE), polypropylene (PP), acrylic, polycarbonate (PC),

polyphenylene sulfide (PPS), acrylonitrile butadiene styrene (ABS), nylon (PA), and polyether ether ketone (PEEK). Example thermoset plastics may include, but are not limited to, epoxies, cyanate esters, vinyl esters, polyester polyimide, phenols, and bismaleimide. The plurality of reinforcing fibers may include, but is not limited to, at least one of aramid fibers, carbon fibers, and glass fibers. In some examples, the fiber reinforced polymer may include one or more additives, such as, for example, flame, smoke, and toxicity (FST) and chemical resistance (e.g., moisture or solvent) additives.

[0039] In some examples, additional materials may be integrated with the one or more composite materials of composite superstructure **202**. For example, metal-based or non-metal reinforcement features may be integrated with select portion of composite superstructure **202**. Reinforcement features may include, for example, additional material layers, brackets, washers, plates, or other structures configured to enhance a material performance (e.g., stiffness, tensile strength, or the like) at a selected region, such as regions that may experience high force loadings or other stresses or at interfaces of composite superstructure with chassis **200** or other vehicles components. Example metals of a metal-based reinforcement features may include, but are not limited to, steel, iron alloys, titanium, titanium alloys, aluminum, aluminum alloys, magnesium, magnesium alloys, molybdenum, molybdenum alloys, or combinations thereof. Example non-metals of a non-metal reinforcement features may include, but are not limited to, thermoplastics, thermoset plastics, ceramics, synthetic fibers, or combinations thereof. In some examples, reinforcement features may be integrated into the polymeric matrix and/or fibers of the composited material such as by mechanical interlocking or other mechanical fixation methods such as fasteners, adhesives, or the like.

[0040] As discussed above, forward section **204** is coupled to forward portion **206** of chassis **200** and rearward section **208** is coupled to rearward portion **210** of chassis **200**. FIG. **2**H is a conceptual diagram illustrating a partially exploded view of a joint **246** of forward section **204** of composite superstructure **202** and forward portion **206** of chassis **200**. As illustrated in FIG. **2**H, forward section **204** is coupled to forward portion **206** with fasteners **248**A, **248**B, **248**C, and **248**D (collectively, fasteners **248**). Fasteners **248** may include bolts, rivets, self-tapping screws, or other devices configured to secure, and optionally draw towards one another, two components. In some examples, fasteners **248** may include bolts receivable by nuts or threaded metal-based or non-metal reinforcement features embedded in forward section **204**. Additionally, or alternatively, forward section **204** may be adhesively bonded to forward portion **206** at joint **246**.

[0041] FIG. **2**I is a conceptual diagram illustrating a joint **250** defined by a portion of second leg **234** coupled to respective portions of rearward portion **210** of chassis **200**. FIG. **2**J is a conceptual diagram illustrating a partially exploded view of joint **250**. As illustrated in FIGS. **2**I and **2**J, second leg **234** is coupled to rearward portion **210** with fasteners **252**A and **252**B (collectively, fasteners **252**). Fasteners **252** may be the same as or substantially similar to fasteners **248** describe above in reference to FIG. **2**H. In some examples, fasteners **252** may include bolts receivable by nuts, threaded features defined by rearward portion **210**, or a retainer **254**. In some examples, washers **256**A and **256**B (collectively, washers **256**) may more evenly distribute loads or other stresses applied to second leg **234** through fasteners **252**. Although illustrated as a separate components, in some examples, washers **256** may include a reinforcement feature embedded in or otherwise defined by at least a portion of second leg **234**. Additionally, or alternatively, second leg **234** may be adhesively bonded to rearward portion **210** at joint **250**.

[0042] As illustrated in the cross-sectional view of left frame **212** in FIG. **2**K, in some examples, at least a portion of the fiber reinforced polymer of composite superstructure **202** may include a tubular member defining a hollow core **257**. The advantage to hollow construction is the ability to increase cross-sectional inertia/stiffness with highly efficient use/consumption of material. The result is stiff and lightweight parts in comparison to their solid/filled counterparts. Additionally, or alternatively, hollow core portions may be configured to damp the transmission of vibrations from select portions of a vehicle.

[0043] Hollow core **257** may be formed by any suitable method. For example, at least portions of composite superstructure **202** including hollow core portions may be formed at two separate clamshell components that are subsequently coupled to define hollow core **257**. Coupling the clamshell components may be accomplished via adhesive bonding or polymer welding techniques to define a unitary tubular member. Other methods of forming hollow core portion may include lost core molding, semi-permanent core molding, gas-assisted molding, overmolding, bladder molding, or the like.

[0044] A material that is less dense than a material of composite superstructure **202** may be disposed within at least a portion of hollow core **257**. For example, the less dense material may include at least one of a gas, a foam, an elastomeric material, or a polymeric material. The less dense material may be configured to provide at least some structural continuity or noise, vibration, and harshness (NVH) damping compared to a hollow core composite superstructure **202** without the less dense material or a solid core material. In these ways, portion of composite super structure **202** including one or more hollow core **257** may be lighter than comparable solid components and reduce NVH compared to comparable solid components.

[0045] FIGS. **3**A and **3**B are conceptual diagrams illustrating various views of an example composite superstructure **302** including a left frame **312** and a right frame **314**. Composite superstructure **302** may be the same as or substantially similar to composite super structure **202** described above in reference to FIGS. **2**A through **2**J, except for the differences described herein. For example, left frame **312** and right frame **314**, each may define a wish-bone shape having first legs **322** and **332** and second legs **324** and **334**.

[0046] Each of first legs **322** and **332** may define a portion of a console region **358** and terminate at an interface region **360**. Console region **358** defines steering post mounts **340**A and **340**B. Optionally, console region **358** may define a fuel fill aperture **362**. Fuel fill aperture **362** may be configured to fluidly couple to a fuel tank, receive therein a fuel cap, or both.

[0047] Interface region **360** includes portions of left frame **312** and right frame **314** that are configured to couple to one another. For example, as illustrated in FIG. **3**A, right frame **314** may include a stepped-down portion **364** that is configured to receive a corresponding portion of left frame **312**. Stepped-down portion **364** may enable an A-side surface (i.e., top surface) of left frame **312** and right frame **314** to be substantially planar (i.e., flush) when the corresponding portion of left frame **312** overlaps stepped-down portion **364** of right frame **314**. During assembly, left frame **312** may be adhesively bonded to right frame **314** along interface region **360**. Additionally, or alternatively, left frame **312** may be coupled to right frame **314** using suitable fasteners or other technique such a polymer welding or the like. In examples in which left frame **312** is welded to right frame **314**, interface region **360** may define a substantially unitary composite superstructure **302**. That is, at least a portion of a thermoplastic matrix of left frame **312** may be integrated with at least a portion of a thermoplastic matrix of right frame **314**, thereby forming a single unitary component.

[0048] FIGS. **4**A through **4**H are conceptual diagrams illustrating various view of an example composite superstructure **402** including a left frame **412**, a right frame **414**, and a fuel tank shell **416**. Composite superstructure **402** may be the same as or substantially similar to composite super structure **202**, composite super structure **302**, or both, as described above in reference to FIGS. **2**A through **3**B, except for the differences described herein.

[0049] Each of left frame **412** and right frame **414** are configured to couple to fuel tank shell **416**. For example, left frame **412** may be coupled to fuel tank shell **416** with fasteners **466**A, **466**B, and **466**C (collectively, fasteners **466**). Similarly, right frame **414** may be coupled to fuel tank shell **416** with fasteners **468**A, **468**B, and **468**C (collectively, fasteners **468**). Fasteners **466** and **468** may be the same as or substantially similar to fasteners **248** and/or **252** described above in reference to FIGS. **2**H through **2**J. For example, fasteners **466** and **468** may include bolts receivable by nut, threaded reinforcement features embedded in fuel tank shell **416**, or a retainer (e.g., retainer **254**). Additionally, or alternatively, left frame **412** and/or right frame **414** may be adhesively bonded to fuel tank shell **416**. Additionally, or alternatively, left frame **412** and/or right frame **414** may be coupled to fuel tank shell **416** by polymer welding, thereby forming a single unitary component.

[0050] Composite superstructures **202**, **302**, and **402** may be formed using any suitable method. FIG. **5** is an example technique **500** of forming a composite superstructure. While technique **500** is described in reference to composite superstructure **202**, the technique may be used to form other composite superstructures, including, but not limited to, composite superstructures **302** and **402**. Also, composite superstructure **202** may be formed using different techniques.

[0051] Technique **500** includes providing a composite material (**502**). The composite material may include any composite materials described herein. In examples in which reinforcement features are used, the technique also may include providing reinforcement features. In some examples, providing the composite material may include layup of a component material, such as one or more layers or sheets of composite material in a form.

[0052] Technique **500** also includes forming the composite material to define at least a portion of composite superstructure **202** (**504**). For example, the technique may include independently forming each of left frame **212**, right frame **214**, and fuel tank shell **216**. Additionally, or alternatively, the technique may include forming a first half and a second half of a clamshell defining at least a portion of composite superstructure **202**. In some examples, forming the composite material may include trimming excess material from a formed component. Additionally, the technique may include determining, for example, by topology optimization, at least a portion of a configuration of the composite superstructure.

[0053] In some examples, forming the composite material may include forming at least a portion of a component to define a hollow core **257**. Optionally, the technique may include forming the hollow core **257** around a material disposed in hollow core **257** or injecting a material into hollow core **257**. Forming the hollow core portion **257** may include any suitable method of forming a hollow core, such as using one or more of the above-described techniques.

[0054] Technique **500** optionally includes assembling and coupling portions of composite superstructure **202** (**506**). For example, when composite superstructure **202** includes two or more component parts, the component parts may be coupled using fasteners, adhesives, plastic welding, compression molding, thermoforming, over-laying of additional composite material, or other methods of joining plastic components. In some examples, coupling portion of composite superstructure may include consolidating at least a portion of the thermoplastic matrix of two or more components. In examples in which components include clamshell components, assembling and coupling the components may include plastic welding a first half of the clamshell to a second half of the clamshell. The technique optionally may include finishing at least a portion of composite superstructure to provide a selected surface finish.

[0055] Technique **500** also includes coupling composite superstructure **202** to at least a portion of chassis **200** or other components of a vehicle (**508**). In some examples, coupling composite superstructure **202** may include coupling via one or more reinforcement features as described above.

[0056] While the disclosure has been described in connection with what is presently considered to be the most practical and preferred embodiments, it is to be understood that the disclosure is not to be limited to the disclosed embodiments, but on the contrary, is intended to cover various modifications and equivalent arrangements included within the spirit and scope of the appended claims, which scope is to be accorded the broadest interpretation so as to encompass all such modifications and equivalent structures as permitted under the law. Furthermore, it should be understood that while the use of the word preferable, preferably, or preferred in the description above indicates that feature so described may be more desirable, it nonetheless may not be necessary and any embodiment lacking the same may be contemplated as within the scope of the disclosure, that scope being defined by the claims that follow. In reading the claims it is intended that when words such as “a,” “an,” “at least one” and “at least a portion” are used, there is no intention to limit the claim to only one item unless specifically stated to the contrary in the claim. Further, when the language “at least a portion” and/or “a portion” is used the item may include a portion and/or the entire item unless specifically stated to the contrary.

Claims

1. A superstructure of a straddle-type vehicle comprising a fiber reinforced polymer extending from a forward section coupled to a forward portion of a chassis of the vehicle to a rearward section coupled to a rearward portion of the chassis, wherein the superstructure defines at least one steering mount aperture configured to receive therethrough and couple with a portion of a steering assembly of the vehicle.
2. The superstructure of claim 1, wherein the fiber reinforced polymer comprises: a thermoplastic matrix comprising at least one of high-density polyethylene (HDPE), polypropylene (PP), acrylic, polycarbonate (PC), polyphenylene sulfide (PPS), acrylonitrile butadiene styrene (ABS), and polyether ether ketone (PEEK); and a plurality of reinforcing fibers comprising at least one of aramid fibers, carbon fibers, and glass fibers.
3. The superstructure of claim 1, wherein at least a portion of the fiber reinforced polymer comprises a tubular member defining a hollow core, and wherein at least one of a gas, a foam, an elastomeric material, or a polymeric material is disposed within at least a portion of the hollow core.
4. The superstructure of claim 1, wherein the forward section of the superstructure comprises a first arm and a second arm defining a U-shape, when viewed from the top, the base of the U defining the at least one steering mount aperture.
5. The superstructure of claim 1, wherein the forward section of the superstructure comprises a first arm and a second arm, each respective arm defining a wishbone shape, when viewed from the side, wherein a first leg of the wishbone extends upward toward an apex of the superstructure and a second leg of the wishbone extends rearward, and wherein the first leg defines an aperture beneath the apex.
6. The superstructure of claim 1, wherein the forward section defines at least a first steering post mount and a second steering post mount.
7. The superstructure of claim 1, wherein rearward section of the superstructure defines fuel tank shell, wherein the forward section of the superstructure is configured to transmit forces from a suspension of the vehicle through the fuel tank shell to the rearward portion of the chassis.
8. The superstructure of claim 1, wherein fuel tank shell defines at least a portion of a fuel tank of the vehicle.
9. The superstructure of claim 1, wherein the forward section of the superstructure is configured to couple to a front suspension and wherein the rearward section of the superstructure is configured to support an operator seat.
10. The superstructure of claim 1, wherein the superstructure defines a left portion and a right portion configured to be couped along an interface defining at least a portion of a central console.
11. A straddle-type vehicle comprising: a chassis comprising a plurality of frame members configured to support a power plant, a suspension system, and an operator area; at least one front ground engaging member coupled by a respective front suspension of the suspension system to a forward portion of the chassis; at least one rear ground engaging member coupled by a respective rear suspension of the suspension system to a rearward portion of the chassis; a superstructure extending from a forward section coupled to the forward portion of the chassis to a rearward section coupled to the rearward portion of the chassis, wherein the superstructure comprises a fiber reinforced thermoplastic composite material.

12. The straddle-type vehicle of claim 11, wherein the superstructure defines at least one steering mount aperture configured to receive therethrough and couple with a portion of a steering assembly of the vehicle.
13. The straddle-type vehicle of claim 11, wherein the straddle-type vehicle comprises a snowmobile.
14. The straddle-type vehicle of claim 11, wherein the powerplant comprises an internal combustion engine, wherein the vehicle further comprises a fuel tank configured to deliver a liquid fuel to the internal combustion engine, and wherein at least a portion of the rearward section of the superstructure defines at least a portion of the fuel tank or is coupled to at least a portion of the fuel tank.
15. The straddle-type vehicle of claim 11, wherein the at least one rear ground engaging member comprises an endless track, and wherein the rearward portion of the chassis comprises a tunnel extending over at least a portion of the endless track, and wherein at least a portion of the rearward section of the superstructure is coupled to the tunnel.
16. The straddle-type vehicle of claim 11, wherein the superstructure defines a first aperture configured to receive therethrough a portion of a steering assembly of the vehicle in a first position and a second aperture configured to receive therethrough the portion of the steering assembly of the vehicle in a second, different position, wherein at least a portion of the superstructure adjacent the aperture is configured to secure a mounting structure of the steering assembly.
17. A method of forming a superstructure of a straddle-type vehicle, the method comprising: providing a composite material including a fiber reinforced polymer; forming the composite material to define one or more portions of the superstructure; assembling the one or more portions of the composite superstructure to define the composite superstructure, wherein the superstructure is configured to define at least one steering mount aperture configured to receive therethrough and couple with a portion of a steering assembly of the vehicle; and coupling the composite superstructure to at least a portion of a chassis of a vehicle, wherein the superstructure extends from a forward section coupled to a forward portion of the chassis to a rearward section coupled to a rearward portion of the chassis.
18. The method of claim 17, wherein the fiber reinforced polymer comprises: a thermoplastic matrix comprising at least one of high-density polyethylene (HDPE), polypropylene (PP), acrylic, polycarbonate (PC), polyphenylene sulfide (PPS), acrylonitrile butadiene styrene (ABS), and polyether ether ketone (PEEK); and a plurality of reinforcing fibers comprising at least one of aramid fibers, carbon fibers, and glass fibers.
19. The method of claim 17, wherein the method further comprises: consolidating at least a portion of a thermoplastic matrix of the composite material; and trimming excess material from the formed composite material.
20. The method of claim 17, wherein forming the composite material comprises forming the composite material to define at least one hollow core portion of the superstructure.