An inner fender panel for a structural fender of an automotive vehicle is disclosed. The panel includes an outer surface configured for attachment to the inner surface of an outer panel of the fender and an inner surface; the inner panel comprising a plurality of abutting inner fender panel sections that are joined to one another, each inner fender panel section having a thickness, at least two abutting inner fender panel sections having thicknesses that are different. A structural fender for an automotive vehicle is also disclosed. The fender includes a formed outer panel having a viewable outer surface and an inner surface. The fender also includes a formed inner fender panel as described comprising a plurality of abutting inner fender panel sections that are joined to one another, each inner fender panel section having a thickness, at least two abutting inner fender panel sections having thicknesses that are different.
FIG. 11B

FIG. 11C

FIG. 11D
LASER WELDED STRUCTURAL FENDER INNER BLANK FOR MASS OPTIMIZATION

CROSS-REFERENCES TO RELATED APPLICATIONS

[0001] This patent application is a continuation application of U.S. patent application Ser. No. 13/873,408 filed on Apr. 30, 2013, which claims priority to U.S. Provisional Patent Application Ser. No. 61/697,755, filed Sep. 6, 2012, the contents of both of which are incorporated herein by reference in their entirety.

FIELD OF THE INVENTION

[0002] The subject invention relates to vehicles, more particularly to a positioning and reinforcement structure for a vehicle, and even more particularly to a structural fender having a multi-gage inner fender panel.

BACKGROUND

[0003] Vehicles, such as automobiles, are assembled by aligning and fastening numerous components and subassemblies to one another. One region of the automobile requiring assembly of such components and subassemblies is a front end region. This portion of the vehicle is frequently assembled as an assembly or subassembly referred to as a “front clip.” The front clip is commonly defined as the assembly comprising the portion of the vehicle extending from the A-pillar (the roof support pillar associated with the front windscreen) to the most forwardly disposed component, typically a front bumper. The front clip includes a structural frame, as well as a variety of vehicle components that collectively form the vehicle body.

[0004] Several efforts to directly or indirectly mount and/or fix the vehicle body components to each other, as well as to the vehicle frame, have relied on welded support structures or frames and machined body mounting locations for the body components. Front end clips that use welded frames to attach front clip components are effective, but they generally require very large capital investments to support automated, high volume mass production. Frameless approaches for assembly of the front end clip are very desirable because they have greatly reduced capital requirements, but have sometimes been subject to undesirably large variations in alignment and fastening of components to one other. These large variations may influence the aesthetic appearance of the automobile to a user by providing non-uniform or undesirably large or small gaps and spacings between components and may be the cause of functional deficiencies, such as undesirable large opening/closing efforts, alignment and mutilation of components due to misalignment and interference, and non-uniform gaps and spacings, which each may affect consumer satisfaction.

[0005] A frameless front clip assembly requires the use of structural fenders as compared to frame-based front end clip construction where the fender sheet metal may be attached directly to the frame and the frame provides much of the needed structural strength. One area of concern in frameless front clip assemblies that use structural fenders, such as the front end sheet metal of the floating structure of a full size truck, has been the development of structural fenders and methods of making and using them so as to set the structural fender in an optimal position to ensure predetermined requirements. These requirements include aesthetic requirements, such as gap, spacing, class A finish and other aesthetic requirements, as well as structural function requirements, such as strength and modal frequency response, and overall vehicle requirements, such as, for example, reduced mass. Mass reduction of structural fenders, particularly the inner fender panel has been difficult to achieve due to the structural requirements of the panel. High load locations, such as the fender attachment points, require load carrying capacity that determines the thickness and hence the weight of a monolithic metal sheet blank. The use of blanks having a reduced thickness with the addition of doubler plates welded at stress concentration locations or beta patches, (e.g. adhesive patches adhered to specific locations to increase the stiffness and frequency response of a panel at specific locations) require secondary manufacturing operations to add them. While providing the benefits described, their use has generally been very limited due to the added labor and material costs, as well as the weight that they add to the vehicle, thereby reducing fuel efficiency.

[0006] Accordingly, it is desirable to provide structural fenders, particularly inner fender panels, which meet the structural requirements while reducing the overall manufacturing cost and weight, thereby reducing vehicle cost and increasing vehicle fuel efficiency.

SUMMARY OF THE INVENTION

[0007] In one exemplary embodiment, an inner fender panel for a structural fender of an automotive vehicle comprising an outer surface configured for attachment to the inner surface of an outer panel of the fender and an inner surface; the inner fender panel comprising a plurality of abutting inner fender panel sections that are joined to one another, each inner fender panel section having a thickness, at least two abutting inner fender panel sections having thicknesses that are different is disclosed.

[0008] In another exemplary embodiment, a structural fender for an automotive vehicle is disclosed. The structural fender includes a formed outer panel having a viewable outer surface and an inner surface. The fender also includes a formed inner fender panel having an outer surface configured for attachment to the inner surface of the outer panel and an inner surface; the inner fender panel comprising a plurality of abutting inner fender panel sections that are joined to one another, each inner fender panel section having a thickness, at least two abutting inner fender panel sections having thicknesses that are different.

[0009] In yet another exemplary embodiment, a method of making an inner fender panel for a structural fender is disclosed. The inner fender panel includes an outer surface configured for attachment to the inner surface of an outer panel of the fender and an inner surface, the inner fender panel comprising a plurality of abutting inner fender panel sections that are joined to one another, each inner fender panel section having a thickness, at least two abutting inner fender panel sections having thicknesses that are different. The method includes forming a plurality of flat planar inner section blanks that are configured to abut one another and define an inner fender panel precursor, each inner section blank having a blank thickness, at least two abutting inner section blanks having thicknesses that are different. The method also includes joining abutting inner section blanks to form the inner fender panel precursor. The method further includes stamping the inner fender panel precursor to plastically deform the inner fender panel blanks and form the inner fender panel.
The above features and advantages and other features and advantages of the invention are readily apparent from the following detailed description of the invention when taken in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Other features, advantages and details appear, by way of example only, in the following detailed description of embodiments, the detailed description referring to the drawings in which:

FIG. 1 is a simplified, partially disassembled perspective view of a front end assembly of a vehicle;

FIG. 2 is a perspective view of a positioning and reinforcement structure of the front end assembly;

FIG. 3 is a perspective view of a hood disposed proximate the positioning and reinforcement structure and fenders;

FIG. 4 is a perspective view of the hood prior to locating the hood relative to the positioning and reinforcement structure and fenders;

FIG. 5 is a perspective view of a hood disposed proximate the positioning and reinforcement structure and fenders;

FIG. 6 is a plan view of the outer surface of an embodiment of a multi-gate inner fender panel as disclosed herein;

FIG. 7 is a front perspective view of the inner fender panel of FIG. 6;

FIG. 8 is a disassembled rear perspective view of an embodiment of a structural fender assembly;

FIG. 9 is an assembled front perspective view of the structural fender assembly of FIG. 8;

FIG. 10A and FIG. 10B are illustrations of a monolithic inner fender panel;

FIGS. 11A-11D are illustrations of fender sections formed on sheet stock;

FIG. 12A and FIG. 12B are illustrations of an inner fender panel formed from the fender sections of FIGS. 11A-11D;

FIG. 13 is a flowchart of an embodiment of a method of making an inner fender panel as disclosed herein.

DESCRIPTION OF THE EMBODIMENTS

The following description is merely exemplary in nature and is not intended to limit the present disclosure, its application or uses. It should be understood that throughout the drawings, corresponding reference numerals indicate like or corresponding parts and features.

In accordance with an exemplary embodiment the gage optimization of a structure supporting inner fender panel of an automotive vehicle by forming a gage optimized, multiple thickness, laser-welded, sheet metal blanks is disclosed. Using laser-welded blanks to form the fender inner panel provides mass and cost reduction for the automotive vehicle while maintaining efficiency of material utilization and structural performance. The fender inner panel may also be attached to a fender outer panel to form a structural fender, or as it may also be termed a structural fender assembly, for the vehicle as described herein.

Referring to FIGS. 1-11, and particularly to FIGS. 1-4, in accordance with an exemplary embodiment of the invention, a partially disassembled view of a front end assembly 10 of a vehicle 12 is shown in the form of an automobile. Although the vehicle 12 is illustrated as an automobile, it is to be appreciated that the embodiments disclosed herein may be employed in combination with various alternative types of vehicles. With respect to an automobile, it is to be further appreciated that the specific type of automobile is irrelevant to carrying out the embodiments described below. For example, the automobile may include a car, truck, sport utility vehicle (SUV) or van. The preceding list is merely illustrative and is not intended to be limiting of the numerous automobile types that may benefit from the embodiments of the invention.

The vehicle 12 includes a frame 14 formed of several integrally formed or operably coupled components to provide a structural support configured to directly or indirectly support components and subassemblies for the vehicle 12. Supported components and subassemblies include a plurality of body components and the vehicle 12 is typically referred to as having a body-on-frame construction, based on the direct or indirect mounting and fixing of the various components to the frame 14. The front end assembly 10 is the region of the vehicle 12 that is defined by a portion of the vehicle 12 extending forward from what is known conventionally as an “A-pillar” to a forward-most component, such as a front bumper 20. The front end assembly 10 may be interchangeably referred to as a “front clip” of the vehicle 12.

To facilitate assembly of the front end assembly 10, both with respect to components in relation to each other as well as to the frame 14, a positioning and reinforcement structure 30 is included. The positioning and reinforcement structure 30 generally refers to a structure configured to provide a foundation for inter-part dimensional relationships during the assembly process for all components of the front end assembly 10, thereby alleviating reliance on individual machined mounting locations. In one embodiment, the positioning and reinforcement structure 30 comprises a grill opening reinforcement (GOR) structure that acts to define and reinforce a grill opening. Since the positioning and reinforcement structure 30 may be formed as an assembly, it may also be referred to herein as a positioning and reinforcement structure 30 or a GOR assembly. As will be described in detail below, the positioning and reinforcement structure 30 includes locators, fastening features, and other critical dimensional relationship interfaces of several components and subassemblies. Such components and subassemblies typically include structural fenders or fender assemblies 76, 98, headlamps 122, grills 142, fascias 22, bumpers 20 and bumper attachment features, hoods 118, hood latches (not shown), hood bumpers 18 and under-hood closeout panels (not shown), air baffles (not shown) and radiator supports 60, for example. It is to be understood that the preceding list is merely illustrative of the numerous components and subassemblies which may be included in the front end assembly 10 and may benefit from the positioning and reinforcement structure 30. Exemplary components and subassemblies will be described in detail below. As used herein, an axial direction 26 refers to a direction that extends forward and rearward along a central axis 25 of the vehicle, a cross-car direction 27 refers to a direction that extends laterally or across the vehicle and a vertical direction 28 refers to a direction that extends upwardly and downwardly. In one embodiment, these directions are mutually orthogonal with regard to one another.

Referring now to FIGS. 1 and 2, and particularly FIG. 2, the positioning and reinforcement structure 30 is illustrated in greater detail. The positioning and reinforce-
ment structure 30 includes a rectilinearly situated geometry defined by a top support member 32, a bottom support member 34, a first side member 36 and a second side member 38. The top support member 32 and the bottom support member 34 each extend relatively horizontally in a cross-car direction 27 and relatively parallel to each other. The first side member 36 and the second side member 38 extend relatively parallel to each other, but in a relatively vertical 28 direction. As may be understood, the positioning and reinforcement structure 30 is therefore a substantially cross-car extending and vertically extending structure or frame. The first side member 36 is coupled proximate a first side member top region 40 to the top support member 32 and to the bottom support member 34 proximate a first side member bottom region 42. Likewise, the second side member 38 is coupled proximate a second side member top region 44 to the top support member 32 and to the bottom support member 34 proximate a second side member bottom region 46. The coupling between the top support member 32, the bottom support member 34, the first side member 36 and the second side member 38 may be in the form of an integral formation process so as to form an integral positioning and reinforcement structure 30, such as by casting, laser welding or spot welding, for example. Alternatively, an operable coupling may facilitate the formation of the positioning and reinforcement structure 30 as an assembly, such as by mechanical fasteners, for example. Alternatively, an operable coupling may facilitate the formation of the positioning and reinforcement structure 30 as an assembly, such as by mechanical fasteners, for example. The preceding examples of the precise connections between the top support member 32, the bottom support member 34, the first side member 36 and the second side member 38 are merely illustrative and numerous alternative coupling configurations are contemplated. Irrespective of the precise attachment, the top support member 32, the bottom support member 34, the first side member 36 and the second side member 38 form a central portion 39 of the positioning and reinforcement structure 30. Furthermore, the above-described components associated with the positioning and reinforcement structure 30, as well as those described below, may comprise various materials, such as plastic or metal. Additionally, the components may be formed as an over-mold having more than one material forming one or more of the components. Such materials may include magnesium, aluminum, and composites, for example, however, many alternative materials are contemplated. The positioning and reinforcement structure 30 or GOR structure may have any suitable size and shape, and may be used, for example, to define and reinforce a grill opening having any suitable size and shape.

[0031] The positioning and reinforcement structure 30 also includes a first brace 50 extending in a relatively diagonal manner from proximate the first side member bottom region 42 to a relatively central location along the top support member 32, to which the first brace 50 is operably coupled. The first brace 50 may be coupled to the first side member 36 or the bottom support member 34, or both. Similarly, a second brace 52 is included and extends in a relatively diagonal manner from proximate the second side member bottom region 46 to the top support member 32, to which the second brace 52 is attached. The second brace 52 may be coupled to the second side member 38 or the bottom support member 34, or both. The first brace 50 and the second brace 52 may be operably coupled to the top support member 32 in a relatively coaxial manner, such that the first brace 50 and the second brace 52 mount to a single location of the top support member 32. The first brace 50 and the second brace 52, both singularly and in combination, provide structural support for the overall positioning and reinforcement structure 30. Additionally, the first brace 50 and/or the second brace 52 include mounting and locating features corresponding to components integrated with, or associated with, the positioning and reinforcement structure 30.

[0032] Referring again to FIG. 2, the positioning and reinforcement structure 30 includes a first wing structure 70 and a second wing structure 72, with the first wing structure 70 being detachably coupled to the first side member 36, while the second wing structure 72 is detachably coupled to the second side member 38. The first wing structure 70 includes a first side flange 74 proximate an outermost location of the first wing structure 70 for fixing the positioning and reinforcement structure 30 to a first fender assembly. The second wing structure 72 includes a second side flange 96 proximate an outermost location of the second wing structure 72 for fixing the positioning and reinforcement structure 30 to a second fender assembly.

[0033] Referring to FIGS. 3-5, the positioning and reinforcement structure 30 is used to establish predetermined visual modalities by the positioning and attachment of one or more components of the front end assembly 10, and preferably a plurality of the components of the front end assembly 10, particularly those components that are directly visible or viewable, or those components that are not directly visible, but whose position directly or indirectly effects the position of components that are directly visible. The predetermined visual modalities may include positioning various components with various predetermined gaps and spacings, including three-dimensional gaps and spacings, and particularly uniform gaps and spacings, such as by positioning the structural fender assemblies 76, 98 with regard to the front hood 118.

[0034] Referring again to FIGS. 3-5, in one embodiment, this includes providing a modality for establishing a predetermined position for the structural fender assemblies 76, 98, including an optimal position as described herein, wherein the fender assemblies 76, 98 are each spaced from the front hood 118 with uniform gaps and spacings, and preferably the same uniform gaps and spacings. The positioning and reinforcement structure 30 may be used to set the position of the fender assemblies 76, 98 relative to the hood 118 upon closure of the hood. In one embodiment, for example, the positioning and reinforcement structure 30 may include a centering bracket 110 disposed proximate a top side of the top support member 32. The centering bracket 110 is configured to locate a front region of the hood 118 to the positioning and reinforcement structure 30 by a locating pin 114, disposed in a predetermined location on the front portion of the hood 110 that is configured to engage a centering feature, such as a bore or slot 112 in the centering bracket 110. The pin 114 and the slot 112 thereby position, such as by centering, the hood 118 and the fender assemblies 76, 98, which are attached, to the structure 30 through a first side flange 74 and a second side flange 96 by the closure of the hood 118. Further explanation of the positioning of fender assemblies 76, 98 using the positioning and reinforcement structure 30 is provided in U.S. Provisional Patent Applications 61/695,667, filed on Aug. 31, 2012, and 61/695,695, filed on Aug. 31, 2012, which are assigned to the same assignee as this application, and which are hereby incorporated by reference herein in their entirety.
Referring to FIGS. 6-10, an inner fender panel 200 for a structural fender assembly 76, 98 of an automotive vehicle 12 includes an outer surface 210 configured for attachment to the inner surface 320 of an outer fender panel 300 of the fender assembly and an inner surface 220. The inner fender panel 200 is a multi-gage inner fender panel comprising a plurality of abutting inner fender panel sections 230 that are distinguished herein using a tensile digit 230.1, 230.2, 230.3, etc. that are permanently joined to one another. Any number of inner fender panel sections may be used, including 2, 3, 4, 5, etc. sections. Each of the inner panel sections may include formed ribs 232, pockets 233, corners, flanges 235 or tabs 236 and other formed features or structures that may be used to increase the stiffness of the panel, or provide a clearance or accommodate another front end component that is nested within, or positioned by, or attached to the inner fender panel section 230, or a combination thereof. The inner fender panel 200 may also include various cutouts 237, holes or bores 238, slots 239 or other openings used to lower the mass of the panel, or provide an opening needed for another component (e.g., an air box or air conduit), or to receive a fastener or a locating member.

Each inner fender panel section 230 has a thickness, and the multi-gage inner fender panels disclosed herein are characterized by having at least two abutting inner fender panel sections 230 having thicknesses that are different. In one embodiment, only two abutting inner fender panel sections have different thicknesses. In other embodiments, more than two panels have thicknesses that are different. In one embodiment, all of the inner fender panel sections 230 have different thicknesses.

In one embodiment, the outer surface 210 of the inner fender panel 200 that engages the inner surface 320 of the outer fender panel 300 is substantially planar. That is, even though the inner fender panel 200 includes a plurality of inner fender panel sections 230, and the outer surface 210 is a surface of complex curvature, the surface forms a continuous plane, and particularly does not have stepwise discontinuities at the interfaces between abutting inner fender panel sections, including those having different thicknesses. Stated differently, the outer surfaces 210 of abutting inner fender panel sections 230 having thicknesses that are different are substantially co-planar. In one embodiment, the thickness of the inner fender panel sections may range from about 0.75 mm to about 2.5 mm, and more particularly may range from about 0.8 mm to about 1.5 mm. These ranges may include the thicknesses of the formed inner panel sections that may include up to about 16% plastic strain (deformation), including a reduction in thickness from the flat planar inner fender panel blanks from which the formed inner panel sections are made up to about 16%.

The inner fender panel 200 may be made from any suitable material. In one embodiment, each of the plurality of abutting inner fender panel sections 230 includes a metal sheet material having a material composition. Any formable metal sheet material and material composition that meets the structural and performance requirements of the vehicle, particularly the vehicle fender, may be used. Suitable material compositions of the metal sheet material include various steel alloys or aluminum alloys. Other lightweight, high strength sheet materials may also be used as the metal sheet, including various magnesium alloys and titanium alloys. In one embodiment, the metal sheet material of each of the plurality of abutting inner fender panel sections 230 may have the same material composition. In another embodiment, the metal sheet material of the plurality of abutting inner fender panel sections 230 may have different material compositions. The abutting inner fender panel sections 230 may be joined to one another by any suitable joint or joining method. In one embodiment, the abutting panel sections are joined to one another by laser welding to form laser weld joints 240 between them. The laser weld joints 240 may be configured to extend in a substantially vertical direction 28 or a substantially axial direction 26, or a combination thereof, when the inner fender panel 200 is installed on an automotive vehicle 12. In one embodiment, the laser weld joints 240 may be selected so that they all in extend in the same direction (e.g., vertically or axially). This may be advantageous to increase the efficiency or accuracy, or both, by allowing the laser welding apparatus to index quickly from the end of one weld pass to the beginning of the pass on the adjacent blank as shown schematically, for example, in the laser welded blank of FIG. 12A.

In one embodiment, illustrated in FIG. 6, the plurality of abutting inner fender panel sections 230 of an inner fender panel 200 for a structural fender assembly 76, 98 include a door attachment section 250 that abuts a central section 252 that in turn abuts a front attachment section 254. The door attachment section is located axially rearward of the other sections on the vehicle and is positioned proximate the front door structure and configured for attachment to the front door structure, such as the front door frame. The door attachment section 250 may be formed as a one-piece door attachment section. Alternatively, the door attachment section 250 may be formed as a two-piece door attachment section that includes an upper door attachment member 250.1 and a lower door attachment member 250.2. The door attachment section 250 defines a portion of the wheel cutout 253 as does the front attachment section 254. In one example, the central section 252 has a thickness that is less than the door attachment section and the front attachment section. This is because the stress/load-bearing requirements for the central section are lower than the adjacent sections, as may be understood from FIG. 9. Thus, the size, shape, location and lesser thickness of the central section 252 may be selected to accommodate the lower stresses and loads. Similarly, the size, shape, location and greater thicknesses of the door attachment section 250 and front attachment section 254 may be selected to accommodate the lower stresses and loads.

In one embodiment, a structural fender or structural fender assembly 76, 98 for an automotive vehicle 12 includes a formed outer fender panel 300 having a viewable outer surface 310 and an inner surface 320. The structural fender assembly 76, 98 also includes a formed inner fender panel 200 having an outer surface 210 configured for attachment to the inner surface 320 of the outer panel 300 and an inner surface 220, where the inner fender panel 200 includes a plurality of abutting inner fender panel sections 230 that are joined to one another, with each inner fender panel section 230 having a thickness, and at least two abutting inner fender panel sections 230 having thicknesses that are different. The outer fender panel 300 and inner fender panel 200 may be attached to one another by any suitable attachments or attachment methods, including by a plurality of weld joints, such as a plurality of spot weld joints. The attachment of the outer fender panel 300 and inner fender panel 200 forms a structural fender assembly 76, 98 that provides the necessary vehicle structure to surround and enclose the associated members of
the vehicle frame and front corner, including the various members of the braking assembly and wheel assembly as are known in the art, without the need for an attachment to a separate frame for the front clip. The structural fender assembly 76, 98 may also include additional braces 410 or struts that may be used to reinforce or strengthen portions of the assembly, as well as various brackets or braces, such as door attachment bracket, 412, positioning and reinforcement attachment bracket 414 and radiator support bracket 416 that may be used to attach and/or reinforce the structural fender assembly 76, 98 to other concomitant portions of the vehicle 12 structure.

[0042] As shown, for example, in FIGS. 1-5, in one embodiment, a first front fender assembly 76, 98 is operably attached to a first end 174 of a cross-car extending positioning and reinforcement structure 30 having the first end 174, such as first side flange 74, and an opposed second end 196, such as second side flange 96. A second front fender 98 that comprises a mirror image of the first front fender 76 is attached to the second end 196 of the positioning and reinforcement structure 30, wherein the positioning and reinforcement structure is operable to fix a predetermined position of the first fender and the second fender in relation to a hood 118 of the vehicle 12.

[0043] Referring to FIGS. 11A-13 with continuing reference to FIG. 8, a method 500 of making an inner fender panel 200 (FIG. 12A) for a structural fender assembly 76, 98 comprising an outer surface 210 configured for attachment to the inner surface 320 of an outer fender panel 300 of the fender and an inner surface 220, where the inner fender panel 200 comprises a plurality of abutting inner fender panel sections 230 (FIGS. 11A-11D) that are joined to one another (FIG. 12A), each inner fender panel section 230 having a thickness, and at least two abutting inner fender panel sections having thicknesses that are different, includes the following. The method 500 includes forming 510 a plurality of flat planar inner section blanks 230' that are configured to abut one another and define an inner fender panel precursor 200' (FIG. 12A), wherein each inner section blank 230' has a blank thickness, and at least two abutting inner section blanks 230' have thicknesses that are different. In the example of FIG. 12A, forming includes stamping four flat inner section blanks 230', including blanks 230.1', 230.2', 230.3' and 230.4' having the shapes indicated. These blanks can be cut from different width rolls of sheet stock as shown in FIGS. 11A-11D that are selected based on the blank sizes to improve the utilization of the sheet stock and reduce waste and the associated cost. In one embodiment, forming 510 the inner section blanks 230' comprises forming a door attachment section blank 250' (that may be formed as two separate blanks that are joined together) that abuts a central section blank 252' that abuts a front attachment section blank 254', and wherein the central section blank 252' has a thickness that is less than the door attachment section blank 250' and the front attachment section blank 254', and wherein joining comprises laser welding abutting blanks to form a laser weld joint 240' between them. The method 500 may also include performing a stress concentration analysis to determine the stress carrying requirements, which also may be used to determine the desired thicknesses of the panel sections 230 based upon a predetermined stress profile in a monolithic inner panel 199 (FIG. 10A) having a predetermined thickness.

[0044] The method 500 also includes joining 520 abutting inner section blanks 230' to form the inner fender panel precursor 200', such as by welding, including welding according to welding path 242. This may include a welding path 242 (FIG. 12A) that forms the weld joints 240' by translating the laser back and forth during welding in a single welding direction, or more than one welding direction as is shown in FIG. 12A.

[0045] In one exemplary embodiment, the inner fender panel 200 is formed from four sections. The first panel section 230.1' has a thickness of 1.5 millimeters. The second panel section 230.2' has a thickness of 0.8 millimeters. The second panel being laser welded 240' to first panel section 230.1' along a straight path that allows the welding to be performed in a first direction. The third panel 230.3' has a thickness of 1.5 millimeters and is laser welded 240' to the second panel section 230.2' along a second straight path in a second direction. In this embodiment, the second direction is substantially opposite the first direction. Finally, the fourth panel section 230.4' has a thickness of 0.8 millimeters. The fourth panel section 230.4' being laser welded to the third panel section 230.3' along a straight path in a third direction.

[0046] It has been found that the disclosed inner fender panel 200 formed using multiple section panels of different thicknesses has a part weight of 4.83 kilograms. By way of comparison, the monolithic fender panel 199 has a weight of 6.81 kilograms. Further, due to the layout of the panel sections 230 on sheet stock, the material usage for the fender panel 200 is 13.0 kilograms while the monolithic fender panel 199 uses 17.5 kilograms of material. In another embodiment, the panel section 203.1' uses a 2.4 millimeter thick material, this increases the material usage to 14.59 kilograms. Still less than that of the monolithic fender panel 199.

[0047] The method further includes stamping 530 the inner fender panel precursor 200', once the inner section blanks 230' have been welded together to form the inner fender panel precursor 200', to plastically deform it and the inner fender panel blanks 230' and form the inner fender panel 200. Stamping may be performed using conventional methods for stamping metal sheet, such as progressive stamping.

[0048] A method 500 of making a fender inner panel by forming gage optimized, multiple thickness, laser-welded, sheet metal blanks is disclosed. The structural fenders described herein are made by discrete placement and laser welding of thin gage sheet metal pieces of different thicknesses in areas where typical load paths do not require thicker material. The method includes performing a load path analysis of the inner fender panel of a structural fender using multi-gauge sheet metal stampings. Forces and load paths are analyzed for optimum gage reduction of the sheet metal while maintaining strength where stress concentrations occur. The method also includes performing a formability and draw stretch thinning analysis of structural fender using a multi-gage sheet metal blank. Formability, seam-weld line placement and coil steel usage efficiency, are balanced within the stamping process. The method further includes performing a full body modal frequency effect of a multi-gage structural fender assembly that includes the multi-gage fender inner panel and the fender outer panel. Vehicle modal frequency improvements are also evaluated by eliminating non-structural mass. The method further includes blank utilization for optimization of coil fed trim to length sheet metal. Still further, the method includes assessment of blank to blank weld seam placement for stretch form, trim, and piercing operations. This may be used in some embodiments to avoid placing weld seams in heavily deformed areas of the blank, as
well as avoiding placing weld seams that intersect cutouts, holes and other features. Usage of a laser welded blank provides opportunity for mass and cost reduction while maintaining efficiency of material utilization and structural performance. Yet further, the method includes incorporation of blank locating features to ensure weld seam placement during forming.

[0049] While the invention has been described with reference to exemplary embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from the essential scope thereof. Therefore, it is intended that the invention not be limited to the particular embodiments disclosed, but that the invention will include all embodiments falling within the scope of the application.

What is claimed is:

1. A method of forming an automotive vehicle structural fender, the method comprising:
   forming a plurality of panel sections, the plurality of panel sections having at least a first panel section having a first thickness and a second panel section having a second thickness, the second thickness being smaller than the first thickness;
   welding the first panel section to the second panel section; and
   forming at least one opening in one of the first panel section and the second panel section, wherein the at least one opening is does intersect a welded area; and
   plastically deforming the fender panel precursor to form the structural fender.

2. The method of claim 1, wherein the welding of the first panel section to the second panel section includes forming a first straight weld in a first direction.

3. The method of claim 2, wherein the welding of the fender panel precursor to the remainder of the plurality of panel sections includes forming a second straight weld in a second direction.

4. The method of claim 3, wherein the second direction being opposite the first direction.

5. The method of claim 4, further comprising forming a third straight weld in a third direction, the third straight weld having a starting end proximate an end of the second straight weld, the third direction being different than the first direction and the second direction.

6. The method of claim 5, further comprising performing the first straight weld, the second straight weld and the third straight weld sequentially.

7. The method of claim 3, further comprising translating a laser during welding to form the first straight weld substantially parallel with the second straight weld.

8. The method of claim 1, wherein the plurality of panel sections includes a third panel section having a third thickness, the third thickness being larger than the second thickness.

9. The method of claim 8, further comprising welding the third panel section to the second panel section opposite the first panel section to form the fender panel precursor.

10. The method of claim 9, wherein the first panel section is a front attachment section and the third panel section is a door attachment section.

11. The method of claim 10, further comprising forming the door attachment section from two separate blanks.

12. The method of claim 3, further comprising forming the first straight weld and the second straight weld with a laser.

13. The method of claim 1, further comprising:
   forming a plurality of first panel blanks in a first sheet stock having a first width;
   forming a plurality of second panel blanks in a second sheet stock having a second width, the first width being different from the second width;
   selecting the first panel section from the plurality of first panel blanks; and
   selecting the second panel section from the plurality of second panel blanks.

14. The method of claim 13, wherein the step of forming the plurality of first panel blanks includes arranging the plurality of first panel blanks on the first sheet stock to reduce waste.

15. The method of claim 14, wherein the step of forming the plurality of second panel blanks includes arranging the plurality of second panel blanks on the second sheet stock to reduce waste.

16. The method of claim 8, further comprising:
   forming a plurality of first panel blanks in a first sheet stock having a first width;
   forming a plurality of second panel blanks in a second sheet stock having a second width, the first width being different from the second width;
   forming a plurality of third panel blanks in a third sheet stock having a third width, the third width being different from the first width and the second width;
   selecting the first panel section from the plurality of first panel blanks; and
   selecting the second panel section from the plurality of second panel blanks.

17. A method of forming an automotive vehicle structural fender, the method comprising:
   forming a first panel section having a first thickness and a second panel section having a second thickness, the second thickness being smaller than the first thickness;
   forming a third panel section having a third thickness, the third thickness being larger than the second thickness;
   coupling the first panel section to the second panel section with a first straight weld formed by moving a laser in a first direction;
   forming a fender panel precursor by coupling the second panel section to the third panel section on a side opposite the first panel section, the second panel section being coupled to the third panel section with a second straight weld formed by moving the laser in a second direction; plastically deforming the fender panel precursor to form an inner fender panel having an outer surface;
   forming an outer fender panel having an inner surface; and
   attaching the outer surface to the inner surface to form a structural fender.

18. The method of claim 17 wherein the second direction is opposite the first direction.

19. The method of claim 17 wherein the second direction is parallel to the first direction.
20. The method of claim 17 further comprising coupling a fourth panel section to the third panel section with a third straight weld, the third straight weld being formed by moving the laser in a third direction, the third direction being on an angle relative to the second direction.