

GAS SHIELDING DEVICE FOR USE WITH A LASER PROCESSING HEAD

RELATED APPLICATIONS

[0001] The present application claims the benefit of U.S. Provisional Application Serial No. 62/725,028 filed August 30, 2018, entitled GAS SHIELDING DEVICE FOR USE WITH A LASER PROCESSING HEAD, which is fully incorporated herein by reference.

TECHNICAL FIELD

[0002] The present disclosure relates to laser processing and more particularly, to a gas shielding device for use with a laser processing head.

BACKGROUND INFORMATION

[0003] Lasers such as fiber lasers are often used for materials processing applications such as welding. A conventional laser welding head includes a collimator for collimating laser light and a focus lens for focusing the laser light to a target area to be welded. The beam may be moved in various patterns to facilitate welding two structures, for example, using a near field scanning or “wobbler” technique. Various techniques may be used to move the beam including, rotating the beam using rotating prism optics to form a rotating or spiral pattern and pivoting or moving the entire weld head on an X-Y stage to form a zig zag pattern. Another technique for moving the beam more quickly and precisely includes using movable mirrors to provide wobble patterns with the beam, for example, as disclosed in greater detail in U.S. Patent Application Publication No. 2016/0368089 and International Publication No. WO 2017/139769, which are commonly owned and fully incorporated herein by reference.

[0004] Shielding gases, such as inert or semi-inert gases, are often used during laser welding to protect the weld area from atmospheric gases such as oxygen and water vapor and/or to suppress weld plume. Conventional gas shielding uses a single nozzle to apply a flow of gas to the laser weld area, for example, as shown in FIG. 15. A coaxial nozzle, as shown in FIG. 16, may be attached as an accessory to a welding head to provide shield gas to a weld site. Such shielding may be inadequate because the nozzle in FIG. 15 is

separate from the laser welding head and because the nozzles in FIGS. 15 and 16 may not provide a large enough shielding effect.

[0005] A larger shielding effect may be needed, for example, when scanning a laser beam to provide wobble patterns or for certain welding applications. When welding alloys like aluminum, copper and titanium, for example, better shielding is needed because these alloys are very reactive with oxygen, nitrogen and carbon dioxide. If these hot metals are not adequately protected from air, the welding may cause a brittle structure that reduces the mechanical properties of the welding joint and may cause discolorations in the seam. Titanium, in particular, is extremely reactive with gases in the air and should be protected while the temperature is above 350° C.

SUMMARY

[0006] Consistent with one aspect of the present disclosure, a gas shielding device is provided for use with a laser processing head. The gas shielding device includes a neck defining a central aperture extending from a first end to a second end of the neck. The central aperture is configured to receive a laser beam passing from the first end through the second end to a workpiece. A shielding plate is coupled to the neck proximate the second end such that the neck extends from a first side of the shielding plate and the shielding plate extends circumferentially around the central aperture. The shielding plate includes a plurality of gas outlets on a second side of the shielding plate opposite the first side, which are fluidly coupled to at least one gas inlet and are configured to direct a flow of gas in a direction toward a surface of the workpiece at a plurality of locations. Wherein the at least one gas inlet is located on the first side of the shielding plate, and wherein the shielding plate defines a gas diffusion region that fluidly couples the at least one gas inlet to the plurality of gas outlets.

[0007] Consistent with another aspect of the present disclosure, a shielded laser welding head includes a scanning laser welding head device configured to be coupled to an output fiber of a fiber laser and configured to move a laser beam within only a limited field of view and a gas shielding device is coupled to the laser welding head device. The gas shielding device includes a neck defining a central aperture extending from a first end to a second end of the neck. The central aperture is configured to receive the moving laser beam passing from the first end through the second end to the workpiece. A shielding plate is coupled to the neck such that the neck extends

from a first side of the shielding plate and the shielding plate extends circumferentially around the central aperture. The shielding plate includes a plurality of gas outlets on a second side of the shielding plate opposite the first side, which are fluidly

coupled to at least one gas inlet and are configured to direct a flow of gas in a direction toward a surface of the workpiece at a plurality of locations. The at least one gas inlet is located on the first side of the shielding plate, and wherein the shielding plate defines a gas diffusion region that fluidly couples the at least one gas inlet to the plurality of gas outlets.

[0008] Consistent with a further aspect of the present disclosure, a laser welding system includes a fiber laser including an output fiber, a scanning laser welding head coupled to an output fiber of the fiber laser and comprising movable mirrors configured to move a laser beam within only a limited field of view, and a gas shielding device coupled to the laser welding head. The gas shielding device includes a neck defining a central aperture extending from a first end to a second end of the neck. The central aperture is configured to receive the moving laser beam passing from the first end through the second end to the workpiece. A shielding plate is coupled to the neck such that the neck extends from a first side of the shielding plate and the shielding plate extends circumferentially around the central aperture. The shielding plate includes a plurality of gas outlets on a second side of the shielding plate opposite the first side, which are fluidly coupled to at least one gas inlet and are configured to direct a flow of gas in a direction toward a surface of the workpiece at a plurality of locations. The at least one gas inlet is located on the first side of the shielding plate, and wherein the shielding plate defines a gas diffusion region that fluidly couples the at least one gas inlet to the plurality of gas outlets. The laser welding system further comprising a control system for controlling at least the fiber laser and positions of the movable mirrors.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] These and other features and advantages will be better understood by reading the following detailed description, taken together with the drawings wherein:

[0010] FIG. 1 is a schematic block diagram of a system including a laser welding head with a gas shielding device, consistent with an embodiment of the present disclosure.

[0011] FIG. 2 is a schematic diagram of a focused laser beam with a relatively small range of movement provided by dual mirrors for purposes of wobbling, consistent with an embodiment of the present disclosure.

[0012] FIGS. 3A-3D are schematic diagrams illustrating different wobble patterns capable of being produced by a welding head including dual mirrors for beam movement, consistent with an embodiment of the present disclosure.

[0013] FIGS. 4 and 5 are perspective views of an example embodiment of a laser welding head with a collimator module, wobbler module, and core block module assembled together and emitting a focused beam.

[0014] FIG. 6 is a bottom perspective view of a gas shielding device, consistent with an embodiment of the present disclosure.

[0015] FIG. 7 is a side view of the gas shielding device shown in FIG. 6.

[0016] FIG. 8 is a bottom view of the gas shielding device shown in FIG. 6.

[0017] FIG. 9 is a top perspective view of the gas shielding device shown in FIG. 6.

[0018] FIG. 10 is a cross-sectional perspective view of the gas shielding device shown in FIG. 6.

[0019] FIG. 11 is a cross-sectional side view of the gas shielding device shown in FIG. 6.

[0020] FIGS. 12A and 12B are photographs showing top and bottom perspective views of a gas shielding device coupled to gas distribution tubes, consistent with an embodiment of the present disclosure.

[0021] FIGS. 13A and 13B are photographs showing top and bottom perspective views of a gas shielding device coupled to gas distribution tubes, consistent with another embodiment of the present disclosure.

[0022] FIG. 14 is a side perspective view of the gas shielding device shown in FIGS. 13A and 13B.

[0023] FIG. 15 is a schematic illustration of conventional gas shielding using a single nozzle.

[0024] FIG. 16 is a perspective view of a conventional coaxial nozzle for delivering shield gas coaxially to a weld site.

DETAILED DESCRIPTION

[0025] A gas shielding device, consistent with embodiments of the present disclosure, may be used with a laser processing head, such as a welding head, to diffuse and distribute a shield gas over a larger gas shielding area for shielding a larger area of metal. The gas shielding device may be coupled to the laser processing head to move with the laser beam and may be arranged coaxially to provide the larger shielding effect in all directions of welding. The gas shielding device is particularly useful for welding titanium or other metals that are highly reactive with gases in the air and/or for larger welding areas (e.g., where the laser beam is wobbled).

[0026] In some embodiments, the gas shielding device may be used with a laser welding head with movable mirrors, which performs welding operations, for example, with wobble patterns. The movable mirrors provide a wobbling movement of one or more beams within a relatively small field of view, for example, defined by a scan angle of 1-2°. The movable mirrors may be galvanometer mirrors that are controllable by a control system including a galvo controller. The control system may also be used to

control a fiber laser, for example, in response to the position of the beams relative to the workpiece and/or a sensed condition in the welding head such as a thermal condition proximate one of the mirrors.

[0027] Referring to FIG. 1, a laser welding system 100 includes a laser welding head 110 coupled to an output fiber 111 of a fiber laser 112 (e.g., with a connector 111a) for delivering a laser beam 118 to a workpiece 102 and a gas shielding device 150 coupled to a gas source 151 via at least one gas distribution tube 152. The gas shielding device 150 may be generally coaxial with the laser beam 118 to allow the laser beam 118 to pass to the workpiece 102 while also diffusing and distributing shield gas 153 around the laser beam 118 and throughout the weld area, as will be described in greater detail below. The shield gas 153 may include any shield gas used in welding or laser processing, such as inert and semi-inert gases.

[0028] The laser welding head 110 may be used to perform welding on a workpiece 102, for example, by welding a seam 104 to form a weld bead 106. The laser welding head 110 and/or the workpiece 102 may be moved relative to each other along the direction of the seam 104. The laser welding head 110 may be located on a motion stage 114 for moving the welding head 110 relative to the workpiece 102 along at least one axis, for example, along the length of the seam 104. Additionally or alternatively, the workpiece 102 may be located on a motion stage 108 for moving the workpiece 102 relative to the laser welding head 110.

[0029] The fiber laser 112 may include an Ytterbium fiber laser capable of generating a laser in the near infrared spectral range (e.g., 1060-1080 nm). The Ytterbium fiber laser may be a single mode or multi-mode continuous wave Ytterbium fiber laser capable of generating a laser beam with power up to 1 kW in some embodiments and higher powers up to 50 kW in other embodiments. Examples of the fiber laser 112 include the YLR SM Series or YLR HP Series lasers available from IPG Photonics Corporation. The fiber laser 112 may also include a multi-beam fiber laser, such as the type disclosed in International Application No. PCT/US2015/45037 filed 13 August 2015 and entitled Multibeam Fiber Laser System, which is capable of selectively delivering one or more laser beams through multiple fibers.

[0030] The laser welding head 110 generally includes a collimator 122 for collimating the laser beam from the output fiber 111, at least first and second movable mirrors 132, 134 for reflecting and moving the collimated beam 116, and a focus lens

142 for focusing and delivering a focused beam 118 to the workpiece 102. In the illustrated embodiment, a fixed mirror 144 is also used to direct the collimated laser beam 116 from the second movable mirror 134 to the focus lens 142. The collimator 122, the movable mirrors 132, 134, and the focus lens 142 and fixed mirror 144 may be provided in separate modules 120, 130, 140 that may be coupled together, as will be described in greater detail below. The laser welding head 110 may also be constructed without the fixed mirror 144, for example, if the mirrors 132, 134 are arranged such that the light is reflected from the second mirror 134 toward the focus lens 142.

[0031] The movable mirrors 132, 134 are pivotable about different axes 131, 133 to cause the collimated beam 116 to move and thus to cause the focused beam 118 to move relative to the workpiece 102 in at least two different perpendicular axes 2, 4. The movable mirrors 132, 134 may be galvanometer mirrors that are movable by galvo motors, which are capable of reversing direction quickly. In other embodiments, other mechanisms may be used to move the mirrors such as stepper motors. Using the movable mirrors 132, 134 in the laser welding head 110 allows the laser beam 118 to be moved precisely, controllably and quickly for purposes of beam wobbling without having to move the entire welding head 110 and without using rotating prisms.

[0032] In an embodiment of the welding head 110, movable mirrors 132, 134 move the beam 118 within only a relatively small field of view (e.g., less than 30 x 30 mm) by pivoting the beam 118 within a scan angle α of less than 10° and more particularly about 1-2°, as shown in FIG. 2, thereby allowing the beam to wobble. In contrast, conventional laser scan heads generally provide movement of the laser beam within a much larger field of view (e.g., larger than 50 x 50 mm and as large as 250 x 250 mm) and are designed to accommodate the larger field of view and scan angle. Thus, the use of the movable mirrors 132, 134 to provide only a relatively small field of view in the laser welding head 110 is counter-intuitive and contrary to the conventional wisdom of providing a wider field of view when using galvo scanners. Limiting the field of view and the scan angle provides advantages when using galvo mirrors in the welding head 110, for example, by enabling faster speeds, allowing use with less expensive components such as lenses, and by allowing use with accessories such as air knife and/or gas assist accessories.

[0033] Because of the smaller field of view and scan angle in the example embodiment of the welding head 110, the second mirror 134 may be substantially the

same size as the first mirror 132. In contrast, conventional galvo scanners generally use a larger second mirror to provide for the larger field of view and scan angle and the larger second mirror may limit the speed of movement in at least one axis. A smaller sized second mirror 134 (e.g., about the same size as the first mirror 132) in the welding head 110 thus enables the mirror 134 to move with faster speeds as compared to larger mirrors in conventional galvo scanners providing large scan angles.

[0034] The focus lens 142 may include focus lenses known for use in laser welding heads and having a variety of focal lengths ranging, for example, from 100 mm to 1000 mm. Conventional laser scan heads use multi-element scanning lenses, such as an F theta lens, a field flattening lens, or a telecentric lens, with much larger diameters (e.g., a 300 mm diameter lens for a 33 mm diameter beam) to focus the beam within the larger field of view. Because the movable mirrors 132, 134 are moving the beam within a relatively small field of view, a larger multi-element scanning lens (e.g., an F theta lens) is not required and not used. In one example embodiment of the welding head 110 consistent with the present disclosure, a 50 mm diameter plano convex F300 focus lens may be used to focus a beam having a diameter of about 40 mm for movement within a field of view of about 15 x 5 mm. The use of the smaller focus lens 142 also allows additional accessories, such as air knife and/or gas assist accessories, to be used at the end of the welding head 110. The larger scanning lenses required for conventional laser scan heads limited the use of such accessories.

[0035] Other optical components may also be used in the laser welding head 110 such as a beam splitter for splitting the laser beam to provide at least two beam spots for welding (e.g., on either side of the weld). Additional optical components may also include diffractive optics and may be positioned between the collimator 122 and the mirrors 132, 134.

[0036] A protective window 146 may be provided in front of the lens 142 to protect the lens and other optics from the debris produced by the welding process. The protective window 146 may also be integrated into or replaced by the gas shielding device 150. The laser welding head 110 with movable mirrors is capable of being used with welding head accessories, such as the gas shielding device 150 and other existing laser welding accessories.

[0037] The illustrated embodiment of the laser welding system 100 also includes a detector (now shown), such as a camera, for detecting and locating the seam 104, for

example, at a location in advance of the beam 118. The camera/detector may be located at one side of the welding head 110 or may be directed through the welding head 110 to detect and locate the seam 104. An additional light source (not shown) may be used with the camera, as may be needed due to shading by the gas shielding device 150.

[0038] The illustrated embodiment of the laser welding system 100 further includes a control system 160 for controlling the fiber laser 112, the positioning of the movable mirrors 132, 134, and/or the motion stages 108, 114, for example, in response to sensed conditions in the welding head 110, a detected location of the seam 104, and/or movement and/or a position of the laser beam 118. The laser welding head 110 may include sensors such as first and second thermal sensors 162, 164 proximate the respective first and second movable mirrors 132, 134 to sense thermal conditions. The control system 160 is electrically connected to the sensors 162, 164 for receiving data to monitor the thermal conditions proximate the movable mirrors 132, 134. The control system 160 may also monitor the welding operation by receiving data from a camera/detector (not shown), for example, representing a detected location of the seam 104.

[0039] The control system 160 may control the fiber laser 112, for example, by shutting off the laser, changing the laser parameters (e.g., laser power), or adjusting any other adjustable laser parameter. The control system 160 may cause the fiber laser 112 to shut off in response to a sensed condition in the laser welding head 110. The sensed condition may be a thermal condition sensed by one or both of the sensors 162, 164 and indicative of a mirror malfunction resulting in high temperatures or other conditions caused by the high power laser.

[0040] The control system 160 may cause the fiber laser 112 to shut off by triggering a safety interlock. A safety interlock is configured between the output fiber 111 and the collimator 122 such that the safety interlock condition is triggered and the laser is shut off when the output fiber 111 is disconnected from the collimator 122. In the illustrated embodiment, the laser welding head 110 includes an interlock path 166 that extends the safety interlock feature to the movable mirrors 132, 134. The interlock path 166 extends between the output fiber 111 and the control system 160 to allow the control system 160 to trigger the safety interlock condition in response to potentially hazardous conditions detected in the laser welding head 110. In this embodiment, the control system 160 may

cause the safety interlock condition to be triggered via the interlock path 166 in response to a predefined thermal condition detected by one or both sensors 162, 164.

[0041] The control system 160 may also control the laser parameters (e.g., laser power) in response to movement or a position of the beam 118 without turning off the laser 112. If one of the movable mirrors 132, 134 moves the beam 118 out of range or too slowly, the control system 160 may reduce the laser power to control the energy of the beam spot dynamically to avoid damage by the laser. The control system 160 may further control selection of laser beams in a multi-beam fiber laser.

[0042] The control system 160 may also control the positioning of the movable mirrors 132, 134 in response to the detected location of the seam 104 from a camera/detector, for example, to correct the position of the focused beam 118 to find, track and/or follow the seam 104. The control system 160 may find the seam 104 by identifying a location of the seam 104 using the data from the camera/detector and then moving one or both of the mirrors 132, 134 until the beam 118 coincides with the seam 104. The control system 160 may follow the seam 104 by moving one or both of the mirrors 132, 134 to adjust or correct the position of the beam 118 continuously such that the beam coincides with the seam 104 as the beam 118 moves along the seam to perform the weld. The control system 160 may also control one or both of the movable mirrors 132, 134 to provide the wobble movement during welding, as described in greater detail below.

[0043] The control system 160 thus includes both laser control and mirror control working together to control both the laser and the mirrors together. The control system 160 may include, for example, hardware (e.g., a general purpose computer) and software known for use in controlling fiber lasers and galvo mirrors. Existing galvo control software may be used, for example, and modified to allow the galvo mirrors to be controlled as described herein. The control system 160 may further control the gas source 151, for example, to control the pressure of the shield gas delivered through the gas distribution tube(s) 152 to the gas shielding device 150.

[0044] FIGS. 3A-3D illustrate examples of wobble patterns that may be used to perform stir welding of a seam 304. As used herein, “wobble” refers to reciprocating movement of a laser beam (e.g., in two axes) and within a relatively small field of view defined by a scan angle of less than 10°. FIGS. 3A and 3B show a circular pattern and a figure 8 pattern, respectively, being formed sequentially along the seam 304. FIGS. 3C

and 3D show a zig-zag pattern and an undulating pattern, respectively, being formed along the seam 304. Although certain wobble patterns are illustrated, other wobble patterns are within the scope of the present disclosure. One advantage of using the movable mirrors in the laser welding head 110 is the ability to move the beam according to a variety of different wobble patterns.

[0045] FIGS. 4 and 5 illustrate an example embodiment of a scanning laser welding head 410 in greater detail. Although one specific embodiment is shown, other embodiments of the laser welding head and systems and methods described herein are within the scope of the present disclosure. As shown in FIG. 4, the laser welding head 410 includes a collimator module 420, a wobbler module 430, and a core block module 440. The wobbler module 430 includes the first and second movable mirrors as discussed above and is coupled between the collimator module 420 and the core block module 440.

[0046] The collimator module 420 may include a collimator (not shown) with a fixed pair of collimator lenses such as the type known for use in laser welding heads. In other embodiments, the collimator may include other lens configurations, such as movable lenses, capable of adjusting the beam spot size and/or focal point. The wobbler module 430 may include first and second galvanometers (not shown) for moving galvo mirrors (not shown) about different perpendicular axes. Galvanometers known for use in laser scanning heads may be used. The galvanometers may be connected to a galvo controller (not shown). The galvo controller may include hardware and/or software for controlling the galvanometers to control movement of the mirrors and thus movement and/or positioning of the laser beam. Known galvo control software may be used and may be modified to provide the functionality described herein, for example, the seam finding, the wobbler patterns, and communication with the laser. The core block module 440 may include a fixed mirror (not shown) that redirects the beam received from the wobbler module 430 to a focus lens and then to the workpiece.

[0047] FIGS. 4 and 5 show the assembled laser welding head 410 with each of the modules 420, 430, 440 coupled together and emitting a focused beam 418. A laser beam coupled into the collimator module 420 is collimated and the collimated beam is directed to the wobbler module 430. The wobbler module 430 moves the collimated beam using the mirrors and directs the moving collimated beam to the core block module 440. The

core block module 440 then focuses the moving beam and the focused beam 418 is directed to a workpiece (not shown).

[0048] Referring to FIGS. 6-12, an example embodiment of a gas shielding device 600 is shown and described in greater detail. This embodiment of the gas shielding device 600 includes a neck 610 for passing a scanning laser beam (e.g., as described above) to a workpiece and a gas shielding plate 620 coupled to the neck 610 for diffusing and distributing shield gas to the workpiece in a welding region. The neck 610 defines a central aperture 612 extending from a first end 611 to a second end 613 and configured to allow the scanning laser beam to be directed through the shielding plate 620 to the workpiece on the opposite side of the shielding plate 620. The shielding plate 620 is coupled to the neck 610 proximate the second end 613 and extends circumferentially around the central aperture 612 such that the shielding plate 620 is coaxial with the central aperture 612 receiving the scanning laser beam. The central aperture 612 in the neck 610 may have a diameter in a range of about 10-60 mm.

[0049] In this embodiment, the shielding plate 620 includes one or more gas inlets 622 on a first surface 621 and a plurality of gas outlets 624 on a second surface 623, which is opposite the first surface 621 and will face the workpiece during use. The shielding plate 620 defines a gas diffusing region 626 that fluidly couples the gas inlet(s) 622 to the plurality of gas outlets 624. In an embodiment, the gas diffusing region 626 may include a porous material, such as the non-woven pads available from 3M under the name Scotch-Brite™ General Purpose Scour Pads, or any other diffuser material capable of providing a laminar flow distribution from the gas outlets 624.

[0050] As shown by the arrows in FIG. 11, the shield gas passes through the gas inlet(s) 622 into the gas diffusing region 626 and then out the gas outlets 624 toward the workpiece 602, for example, in a direction substantially perpendicular to a surface of the workpiece 602. As such, the shielding plate 620 and gas outlets 624 are designed and configured to diffuse the shield gas and provide a laminar flow of shield gas in the processing or weld area.

[0051] As shown in the illustrated embodiment, the gas outlets 624 may be spaced across a substantial portion of the second side 623 of the shielding plate 620 to distribute the shield gas across a relatively wide area that includes at least the scanning region of the laser beam and the processing or weld area. Examples of the shielding plate 620 may have a diameter in a range of about 100 mm to 150 mm and more specifically about 100

mm, about 125 mm, or about 150 mm. Although the shielding plate 620 is shown as a circular disc, other shapes are also contemplated including, without limitation, polygonal and oblong shapes. Providing a coaxial configuration allows good shielding at the weld area in any direction relative to the laser beam.

[0052] Each of the gas outlets 624 may be relatively small holes or openings, for example, having a diameter in a range of about .2 – 5.0 mm. The gas outlets 624 are distributed in a pattern on the second side 623 of the shielding plate 620 to provide adequate diffusion to create the laminar flow of shield gas. In the illustrated embodiment, the pattern includes the gas outlets 624 arranged in lines extending from a central portion of the shielding plate 620 (e.g., proximate the central aperture 612) to an outer portion of the shielding plate 620. Other patterns of gas outlets 624 are also contemplated including, without limitation, concentric circles and radial lines. The gas outlets 624 may also be substantially evenly distributed across the second surface 623 of the gas shielding plate 620.

[0053] Although the illustrated embodiment shows four (4) gas inlets 622 substantially evenly distributed around the first surface 621 of the shielding plate 620, other numbers and locations of gas inlets 622 are contemplated. In other embodiments, the gas inlets 622 may also be in other locations such as on the neck 610. The gas inlet(s) 622 may be coupled to gas tubes 630, for example, as shown in FIGS. 12A and 12B. The size, number and location of the gas inlets and gas outlets and the gas pressure may be varied to provide a desired laminar flow. As shown in FIG. 12B, a bottom neck portion 616, defining central aperture 612, may extend beyond the shielding plate 620.

[0054] The gas shielding device 600 may be coupled to the scanning laser welding head 400 described herein or to any other laser welding head or laser processing head. This embodiment of the gas shielding device 600 may be coupled coaxially with the laser processing head. The gas shielding device 600 may be coupled to the laser processing head coaxially using a coupling mechanism 650 similar to that used with an existing coaxial nozzle, for example, as shown in FIG. 16. By coupling the gas shielding device 600 to the laser processing head, the gas shielding device 600 and the larger shielding effect moves with the scanning laser beam and avoids the need to control two separate devices.

[0055] Another embodiment of a gas shielding device 1300 is shown in FIGS. 13A, 13B and 14. In this embodiment, the gas shielding device 1300 includes a gas shielding

plate 1320 and a neck 1310 including one or more cooling passageways to provide water (or other liquid) cooling functionality that allows continuous operation without overheating. One or more cooling inlets/outlets 1340 are coupled to a top portion 1318 of the neck 1310 to allow water or other cooling liquid to pass in to and out of the cooling passageways. In this embodiment, the neck 1310 defines a central aperture 1312 and the gas shielding plate 1320 defines a plurality of gas outlets 1324, similar to the embodiment described above.

[0056] In this embodiment of the gas shielding device 1300, gas inlets 1322 are also located on the top portion 1318 of the neck 1310 and gas passageways run through the neck to the gas outlets 1324 on the bottom of the shielding plate 1320. As described above, a coupling mechanism 1350 may be used to couple the top portion 1318 of the neck 1310 to the welding head. A bottom neck portion 1316 also defines the central aperture 1312 and extends from the bottom of the shielding plate 1320.

[0057] To accommodate the cooling passageway and the gas passageway, the neck 1310 of the gas shielding device 1300 has a larger diameter than the embodiment described above. In one example, the neck 1310 has a diameter of about 76.2 mm, the shielding plate 1320 has a diameter of about 128 mm, the top portion 1318 of the neck 1310 has a diameter of about 95 mm, the coupling mechanism 1350 has a diameter of about 39.5 mm, and the bottom neck portion 1316 has a diameter of about 42 mm. In this embodiment, the neck 1310 may include an outer tube and an internal tube (not shown) with the cooling and gas passageways located therebetween. The internal tube may be made from stainless steel (i.e., as opposed to Aluminum).

[0058] Accordingly, a gas shielding device, consistent with embodiments disclosed herein, provides effective gas shielding over a wider area around a laser processing region, which is particularly advantageous for wobble welding applications with materials that are sensitive to or react with oxygen or nitrogen.

[0059] While the principles of the invention have been described herein, it is to be understood by those skilled in the art that this description is made only by way of example and not as a limitation as to the scope of the invention. Other embodiments are contemplated within the scope of the present invention in addition to the exemplary embodiments shown and described herein. Modifications and substitutions by one of ordinary skill in the art are considered to be within the scope of the present invention, which is not to be limited except by the following claims.

CLAIMS

What is claimed is:

1. A gas shielding device for use with a laser processing head, the gas shielding device comprising:
 - a neck defining a central aperture extending from a first end to a second end of the neck, wherein the central aperture is configured to receive a laser beam passing from the first end through the second end to a workpiece; and
 - a shielding plate coupled to the neck proximate the second end such that the neck extends from a first side of the shielding plate and the shielding plate extends circumferentially around the central aperture,
 - the shielding plate including a plurality of gas outlets on a second side of the shielding plate opposite the first side,
 - wherein the plurality of gas outlets are fluidly coupled to at least one gas inlet and are configured to direct a flow of gas in a direction toward a surface of the workpiece at a plurality of locations,
 - wherein the at least one gas inlet is located on the first side of the shielding plate, and
 - wherein the shielding plate defines a gas diffusion region that fluidly couples the at least one gas inlet to the plurality of gas outlets.
2. The gas shielding device of claim 1, further including
 - at least one gas distribution tube coupled to the at least one gas inlet for distributing shielding gas to the plurality of gas outlets on the second side.
3. The gas shielding device of claim 1,
 - wherein the neck includes at least one cooling passageway and at least one cooling inlet/outlet coupled to the cooling passageway to allow a cooling liquid to flow through the cooling passageway.
4. The gas shielding device of claim 1,
 - wherein the shielding plate is circular shaped.

5. The gas shielding device of claim 4,
wherein the shielding plate has a diameter in a range of 100 mm to 150 mm.
6. The gas shielding device of claim 1,
wherein the shielding plate is coaxial with the neck and the central aperture.
7. The gas shielding device of claim 1,
wherein the neck includes a processing head coupling mechanism at the first end of the neck for coupling to a laser processing head.
8. The gas shielding device of claim 1,
wherein the plurality of gas outlets are formed in lines extending outward from a central portion of the shielding plate to an outer portion of the shielding plate.
9. The gas shielding device of claim 1,
wherein the plurality of gas outlets are arranged to deliver a laminar flow of gas surrounding the laser beam passing through the shielding plate to the workpiece.
10. The gas shielding device of claim 1,
wherein the central aperture has a diameter in a range of 10-60 mm.
11. The gas shielding device of claim 1,
wherein the shielding plate includes a porous material between the at least one gas inlet and the plurality of gas outlets.
12. A shielded laser welding head comprising:
a scanning laser welding head device configured to be coupled to an output fiber of a fiber laser and configured to move a laser beam within only a limited field of view; and
a gas shielding device coupled to the scanning laser welding head device, the gas shielding device comprising:
a neck defining a central aperture extending from a first end to a second end of the neck, wherein the central aperture is configured to receive the moving laser beam passing from the first end through the second end to a workpiece; and

a shielding plate coupled to the neck such that the neck extends from a first side of the shielding plate and the shielding plate extends circumferentially around the central aperture,

the shielding plate including a plurality of gas outlets on a second side of the shielding plate opposite the first side,

wherein the plurality of gas outlets are fluidly coupled to at least one gas inlet and are configured to direct a flow of gas in a direction toward a surface of the workpiece at a plurality of locations,

wherein the at least one gas inlet is located on the first side of the shielding plate, and

wherein the shielding plate defines a gas diffusion region that fluidly couples the at least one gas inlet to the plurality of gas outlets.

13. The laser welding head of claim 12,

wherein the limited field of view is defined by a scan angle of 1-2°.

14. The laser welding head of claim 12, wherein the scanning laser welding head device comprises:

a collimator;

at least first and second movable mirrors configured to receive a collimated laser beam from the collimator and to move the beam in the first and second axes within the limited field of view; and

a focus lens configured to focus the laser beam relative to the workpiece while the beam is moved.

15. The laser welding head of claim 14,

wherein the movable mirrors are galvanometer mirrors.

16. The laser welding head of claim 14,

wherein the movable mirrors are configured to move the collimated laser beam within only a limited field of view having a dimension less than 30 x 30 mm.

17. A laser welding system comprising:
a fiber laser including an output fiber;
a scanning laser welding head coupled to the output fiber of the fiber laser and comprising movable mirrors configured to move a laser beam within only a limited field of view;
a gas shielding device coupled to the scanning laser welding head, the gas shielding device comprising:
a neck defining a central aperture extending from a first end to a second end of the neck, wherein the central aperture is configured to receive the moving laser beam passing from the first end through the second end to a workpiece; and
a shielding plate coupled to the neck such that the neck extends from a first side of the shielding plate and the shielding plate extends circumferentially around the central aperture,
the shielding plate including a plurality of gas outlets on a second side of the shielding plate opposite the first side,
wherein the plurality of gas outlets are fluidly coupled to at least one gas inlet and are configured to direct a flow of gas in a direction toward a surface of the workpiece at a plurality of locations,
wherein the at least one gas inlet is located on the first side of the shielding plate, and
wherein the shielding plate defines a gas diffusion region that fluidly couples the at least one gas inlet to the plurality of gas outlets; and
a control system for controlling at least the fiber laser and positions of the movable mirrors.
18. The laser welding system of claim 17,
wherein the fiber laser includes an Ytterbium fiber laser.
19. The laser welding system of claim 17,
wherein the fiber laser includes multiple output fibers for delivering multiple laser beams.

20. The laser welding system of claim 17,
wherein the control system is configured to control movement of the moving laser beam within the limited field of view to provide a wobble pattern.