

CLAIMS

1. A method of laser processing of a metallic material, in particular for laser cutting, drilling or welding of said material, by means of a focused laser beam having a predetermined trans-verse power distribution at at least one working plane of the metallic material, comprising the steps of:

- providing a laser beam emitting source;
- leading the laser beam emitted by said emitting source along a beam transport optical path to a working head arranged in proximity of said metallic material;
- collimating the laser beam along an optical axis of propagation incident on the metallic material;
- focusing said collimated laser beam in an area of a working plane of said metallic material; and
- conducting said focused laser beam along a working path on the metallic material comprising a succession of working areas,

characterized in that the method comprises shaping the laser beam, wherein shaping the laser beam comprises:

- reflecting said collimated beam by means of a deformable controlled surface reflecting element having a reflecting surface with a continuous curvature including a plurality of independently movable reflection areas, and
- controlling the arrangement of said reflection areas to establish a predetermined transverse power distribution of the beam at at least one working plane of the metallic material as a function of the area of the current working plane and/or the current direction of the working path on the metallic material.

2. The method according to claim 1, comprising the steps of:

- delivering a flow of assist gas towards said area of the working plane of the metallic material along an axis of the assist gas flow, and
- controlling the arrangement of said reflection areas to establish said predetermined transverse power distribution of the beam in an area of the working plane on the metallic material comprised in a predetermined neighborhood around the axis of the assist gas flow and within a delivering area of said flow.

3. The method according to claim 2, comprising the relative translation of the axis of the assist gas flow along a predetermined working path on the metallic material, the detection of the current position and/or of the direction of the current translation of the axis of the assist gas flow, and the automatic control of the transverse power distribution of the laser beam as a function of the detected current position and/or the detected current translation direction of the axis of the assist gas flow.

4. The method according to claim 3, wherein the automatic control of the transverse power distribution of the laser beam as a function of the current position and/or of the detected current translation direction of the axis of the assist gas flow is performed by reference to a predetermined control pattern or program.

5. The method according to any one of the preceding claims, comprising the step of controlling the arrangement of said reflection areas to establish a transverse power distribution of the beam in an area of at least one working plane on the metallic material having a Gaussian form with a predetermined diameter.

6. The method according to any one of claims 1 to 4, comprising the step of controlling the arrangement of said reflection areas to establish a transverse power distribution of the beam in an area of at least one working plane on the metallic material having an annular shape.

7. The method according to any one of claims 1 to 4, comprising the step of controlling the arrangement of said reflection areas to establish a transverse power distribution of the beam in an area of at least one working plane on the metallic material having a flat profile shape with a predetermined diameter.

8. The method according to any one of claims 1 to 4, comprising the step of controlling the arrangement of said reflection areas to establish a transverse power distribution of the beam in an area of at least one working plane on the metallic material including a Gaussian distribution with a predetermined diameter and an annular

distribution externally concentric to the Gaussian distribution.

9. The method according to any one of claims 1 to 4, comprising the step of controlling the arrangement of said reflection areas to establish a transverse power distribution of the beam in an area of at least one working plane on the metallic material including a Gaussian distribution with a predetermined diameter and a semi-annular distribution externally concentric to the Gaussian distribution.

10. The method according to claim 9, comprising the orientation of the axis of symmetry of said transverse power distribution of the beam including a Gaussian distribution with a predetermined diameter and a semi-annular distribution externally concentric to the Gaussian distribution in the area of the working plane, depending on the local direction of the working path.

11. The method according to any one of claims 1 to 4, comprising the step of controlling the arrangement of said reflection areas in order to establish a transverse power distribution of the beam in an area of at least one working plane on the metallic material having a Gaussian form with an elliptical section.

12. The method according to claim 11, comprising the orientation of the axis of symmetry of said transverse power distribution of the beam having a Gaussian form with an elliptical section in the area of the working plane, depending on the local direction of the working path.

13. The method according to claim 2, comprising the relative translation of the axis of the assist gas flow along a predetermined working path on the metallic material, the detection of the current position and/or the detection of the current direction of translation of the axis of the assist gas flow, and the automatic adjustment of the position optical axis of propagation of the laser beam as a function of the detected current position and/or the detected current direction of translation of the axis of the assist gas flow.

14. The method according to claim 13, wherein the automatic adjustment of the

position of the optical axis of propagation of the laser beam as a function of the detected current position and/or the detected current direction of translation of the axis of the assist gas flow is performed by reference to a predetermined adjustment pattern or program.

15. The method according to claim 14, comprising the step of controlling the arrangement of said areas of reflection to establish an overall transverse power distribution of the beam in an area of at least one working plane on the metallic material corresponding to a TEM₁₀ transverse electromagnetic mode, including a combination of two Gaussian distributions with a predetermined diameter transversely aligned with respect to the direction of the working path, wherein the relative position of the optical propagation axis and the focusing plan of said two Gaussian distributions varies cyclically over time depending on the local direction of the working path according to a law which includes the combination of the following movements:

- advancement of the barycenter of the overall power distribution along the local direction of the working path;
- when projected onto a horizontal plan, movement of the optical axis of each of said two Gaussian distributions according to an elliptical revolving trajectory around a respective predetermined time revolution geometric barycenter, respectively clockwise at the right of the barycenter of the overall power distribution with respect to the progressing direction of working, and counter-clockwise at the left of the barycenter of the overall power distribution with respect to the progressing direction of working;
- during the time revolution movement around the respective predetermined barycenter, varying the location of the focusing plane of each of said two Gaussian distributions along the respective optical axis of propagation, with retrograde evolution along a parallelogram trajectory in projection on a sagittal plan;
- progressing of the barycenters of revolution of the optical axis of each of said two Gaussian distributions along directions which are parallel to the direction of movement of the barycenter of the overall power distribution, respectively to the right and to the left thereof.

16. The method according to claim 15, wherein the cyclic variation of the relative position of the optical axis of propagation of each of said two Gaussian distributions and of

the location of the focusing plane of each of said two Gaussian distributions along its respective optical axis of propagation occurs with a frequency that is an integer multiple of $v/2D$, where v is the progressing speed of the barycenter of the overall power distribution and D is the diameter of the focusing spot of the laser beam in the waist.

17. The method according to any one of the preceding claims, wherein controlling the arrangement of said reflection areas of the controlled surface reflecting element comprises controlling a combination of moves of said areas with respect to a reflecting reference flat surface.

18. The method according to claim 17, wherein controlling a combination of moves of said reflection areas of the controlled surface reflecting element comprises controlling the translation movement of said areas along the optical axis of the reflecting element and/or the rotation of said areas to obtain an inclination with respect to the optical axis of the reflecting element.

19. The method according to any one of the preceding claims, comprising providing a deformable controlled surface reflecting element having a reflecting surface with a continuous curvature including a plurality of independently movable reflection areas by means of a corresponding plurality of movement modules which include a central area and a plurality of ranks of circular crown sectors concentric to said central area.

20. The method according to claim 19, wherein said ranks of concentric circular crown sectors are in number of 6, the circular crown sectors are in number of 8 for each rank, and the height of circular crown sectors is increasing from the first to the third rank and from the fourth to the sixth rank in the radial direction towards the outside of the reflecting element, the height of circular crown sectors of the fourth rank being intermediate between the height of the circular crown sectors of the first and second rank.

21. A machine for laser processing of a metallic material, in particular for laser cutting, drilling or welding of said material, by means of a focused laser beam having a predetermined transverse power distribution at at least one working plane of the metallic

material, comprising:

- a laser beam emitting source;
- means for leading the laser beam emitted by said emitting source along a beam transport optical path to a working head arranged in proximity of said metallic material;
- optical means for collimating the laser beam along an optical axis of propagation incident on the metallic material;
- optical means for focusing said collimated laser beam in an area of a working plane of said metallic material,

wherein at least said focusing optical means of said collimated laser beam are carried by said working head at a controlled distance from said metallic material; and

- means for adjusting the mutual position between said working head and said metallic material, adapted to conduct said focused laser beam along a working path on the metallic material comprising a succession of working areas,

characterized in that it comprises:

- optical means for shaping the laser beam including a deformable controlled surface reflecting element having a reflecting surface with a continuous curvature including a plurality of independently movable reflection areas, adapted to reflect said collimated laser beam, the arrangement of said reflection areas being adapted to establish a predetermined transverse power distribution of the beam at at least one working plane of the metallic material; and
- electronic processing and control means arranged to implement a shaping of said laser beam in accordance with the method of laser processing according to any one of claims 1 to 20.

22. Computer program comprising one or more code modules for performing a method of shaping a laser beam in a machine for laser processing of a metallic material, in accordance with the method of laser processing according to any one of claims 1 to 20, when the program is executed by electronic processing and control means of said machine.