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MANUFACTURING METHOD FOR METAL SECTIONS

Technical field

This invention concerns a manufacturing method for metal sections, and more precisely, a method that permits the manufacture of metal sections of complex form, that present for example, three dimensional
5 geometry, evolucional radius of curvature, a variable thickness and/or wings that form evolucional angles with each other in cross section.

The term "sections with a complex form" refers to sections whose various component elements have a non-
10 plane form.

State of the art

An initial recognised manufacturing method for metal sections comprises the extrusion of a metal bar.
15 This provides rectilinear sections. These sections are then formed, if necessary, by bending for example. For certain materials such as titanium, bending must be performed at high temperature. Since it is difficult to obtain a piece with the required measurements using
20 this method directly, generally the piece is produced

slightly larger than requirements, then completed to specification by machining.

This method presents several problems. First of all it is long and difficult to set up. Moreover, it is
5 expensive because of the numerous operations that need to be performed (extrusion, forming, machining). In addition, forming operations applied to a previously extruded section results in provoking mechanical stress in the section structure, and this can lead to reduced
10 resistance capacity in certain zones of the said structure.

Another recognised manufacturing technique for metal sections comprises the direct production through moulding. The sections are therefore obtained in a
15 single operation, by performing a high precision mould casting directly to specified measurements.

This method presents the problem of requiring the same number of moulds as the existing number of different shapes and measurements. Mould costs are very
20 expensive.

Moreover, this method is difficult to set up for sections that are very long compared to their width, such as sections several metres long (in particular, those over 5 metres long) with shapes such as T, I, H,
25 or N, or any other sections where the wings measure only a few tens of millimetres in width, while the thickness ranges between 1.5 to 2 mm. In this case there is a risk that the metal will not cool in a uniform manner throughout the volume, and this can
30 provoke weak points in the section structure.

Moreover, the manufacturing method using moulding applied to very long sections requires large-scale production installations, involving very important investment.

5 A third recognised method is composed of producing the sections directly through machining in the mass of a metal block.

 This method presents the problem of being very long to set up, because of the complicated machining
10 cycle. In addition, it requires specific machine tools, and this too involves large investments. In fact, the production of sections over 5 metres long requires large-scale 5 axis numerical control machine tools. Last of all, this method has a major problem in that a
15 large quantity of metal is lost (approximately 95% of the metal block is transformed into shavings). This is very expensive, especially when the metal involved is costly, such as titanium, for example.

20 Disclosure of the invention

 The precise object of this invention is a new manufacturing method for metal sections of complex form, that does not present the problems involved with existing manufacturing methods and that permits, in
25 particular, the manufacturing of very long sections in a manner that is relatively simple, rapid and inexpensive, without considerable metal loss.

 According to this invention, this result is obtained thanks to a manufacturing method of a metal
30 section when viewed as a cross section, composed of at least two separate non-aligned parts, said method being

characterised in that it is applied to the manufacturing of a section of complex form, exclusively composed of non-plane parts that combine to form an angle of any degree and evolitional according to the
5 length of the section, and that it consists of cutting out elements from at least one metal plate, with the measurements that correspond with each of the said parts, followed by the assembly of the elements to obtain the said metal section.

10 When two elements need to be assembled together but not at right angles, the advantage lies in cutting a bevelled edge on at least one of the elements, before assembling it with the other.

Preferably the different elements that make up the
15 section are cut from the flat metal plates, and then formed after assembly.

As a variation, the elements can be formed before being cut from the metal plate.

Before starting the cutting out operation in the
20 metal plate, precise calculations are made for all possible future deformation (elongation or necking) that will be induced during forming in each element to be formed. Then the element is cut out to the measurements that have been corrected after calculating
25 the said deformation.

According to one of the preferred set ups as described in this invention, the different elements are welded together. This assembly can be performed using at least a laser beam, preferably without the addition
30 of other matter.

According to the structure in question, welding can be performed either in various points along the contact line between the elements, or in continuous mode along the said contact line.

5 Preferably, a three dimensional drawing is made of the metal section according to its final measurements, followed by a drawing of the outline of each of the elements, before beginning the cutting out operation. The most advantageous method for this operation is to
10 use CAD tools.

Then it is possible to draw the outline of each of the elements by marking prior to cutting, using a laser beam. As a variation, the outline of the different elements can also be drawn using a light beam during
15 cutting out operations.

When several identical sections need to be made, the identical elements are cut out to best advantage by cutting several plates stacked on top of each other.

Any hollowing out operations, that may be holes
20 that cross through the plate or not, can be machined in at least some of the elements before or during cutting out operations.

According to one of the advantageous characteristics of this invention, in order to reduce
25 metal waste, it is also possible to cut out several elements from the same metal plate arranging them in the most advantageous layout to eliminate waste.

The cutting out operation of the section elements is preferably performed by high-speed laser beam, or by
30 abrasive water jet, or by using traditional mechanical machining techniques.

Brief description of the technical drawings

As an illustrative example, and in no way limitative, is a list of descriptions of the different methods for the embodiment of this invention with reference to the enclosed drawings in which:

- Figure 1 is a diagram showing the various production stages of a rectilinear T-shaped section;
- figure 2 is a view comparable to that shown in figure 1, illustrating the various production stages of a T-shaped section arched in a single direction;
- figure 3 is a view comparable to those shown in figures 1 and 2, that show the various production stages of a T-shaped section arched in two different directions, as described in the invention;
- figure 4 is a diagram showing a cross section of the first techniques for welding the two elements that form the T as shown in figures 1 to 3;
- figure 5 is a view comparable to figure 4 that shows a second technique for welding the elements together;
- figure 6 is a view comparable to those in figures 4 and 5 that show a third technique for welding the elements together; and
- figure 7 is a cross section comparable to those shown in figures 4 to 6 that show the assembly of two elements of a T section, that are not at right angles to each other.

Detailed description of several preferable embodiment methods according to this invention

To make the principle of this invention easier to understand, the embodiment methods illustrated in the figures refer to the construction of sections with a T-shaped profile. However, it is obvious that this invention must not in any way be considered limited to this type of section. On the contrary, any section that can be constructed using the method as described in the invention such as the following shaped profiles : I, H, L, etc, are included within the concept of this invention.

Metal sections envisaged for production are first of all drawn according to their final shape, according to the various appropriate viewpoints to establish the three dimensional geometry. This initial operation is preferably performed using CAD tools.

Using this overall drawing as a base, further drawings are made of all the elements that will be assembled to form the section. Each of these drawings shows one of the component elements in three-dimensional form. The division of the overall drawing into individual drawings for each of the elements is also preferably performed using CAD tools.

Each of the elements defined in this manner is then developed to obtain a flat outline of a piece that will constitute the element in question after forming. The outline is established taking into consideration all elongation and/or necking that may occur during the forming process. For this purpose, calculations are made concerning the deformation that will be induced in the element in question during forming, and the corrected measurements are established for the flat

outline that will be cut out for the element, keeping in mind the deformation changes. For this operation, any appropriate methods may be used, preferably computer aided techniques.

5 In cases where several identical sections are to be produced, the stages described above are set up as a single operation before production start-up. However, on the contrary, the stages described below are repeated during the production of each of the
10 individual sections in an identical series.

 The different metal elements that make up the section are cut out of thin metal plate according to the flat outline established previously. As an example, but in no way limiting, metal plate appropriate for
15 this operation may have a thickness between 0.5mm and 2.5mm.

 When several identical elements are to be produced, these elements can also be cut out simultaneously from a stack of plates.

20 For best results, the different elements to be cut out are placed on the plate laying out the most economical arrangement to avoid wasting metal plate. Careful layout is particularly advantageous when using expensive metals such as titanium.

25 The cutting out operation can be performed using any well known method, in particular high speed laser beam, abrasive water jet machines, or traditional machine tools. In this case the various metal elements can be cut out directly to the measurement of the finished
30 pieces to a precision level of 2/10 mm.

When a laser is used to cut out the pieces, certain parameters of the laser beam can be set to greater advantage (intensity and displacement speed) according to the characteristics of the plate to be cut. In this case, it should be remembered that the same laser beam can be used to perform the prior outline marking for each of the elements to be cut out. The laser beam parameters are then modified to adjust to ensure this join.

As a variation, and in particular when a laser is not used for cutting operations, the outlines of the elements can be located on the plate using a light beam.

Generally, the cutting out operation of the various elements is performed on flat plate. This produces flat metal elements. These elements are then formed, through forming, bending, etc. in a direction that is perpendicular to their thickness.

In one of the variants of this invention, the elements can also be cut out directly from plate that has been formed previously, such as bent plate, or similar material.

In certain cases the cutting stage and the forming stage can be followed by a complementary stage for surface treatment such as degreasing, binding, clogging, etc.

Generally each of the elements that make up the section has a uniform thickness and a constant width for the total length. However, this layout should not be considered as limiting, according to this invention. On the contrary, at least some of the said elements may

have a thickness that is not uniform (according to the length and/or the width of the element) and/or a variable width (in continuous and evolutionary mode or in discontinued mode) according to the length. In cases
5 where the element has a variable thickness, this characteristic in particular can be obtained by chemical or mechanical machining, preferably after the cutting out operation.

When the different elements destined for section
10 composition have been cut out and bent, at least two of the adjacent elements are positioned so that they are in contact with each other in the position they will occupy in the finished section. If necessary, these elements can be maintained in contact in the said
15 relative position, using clamping equipment.

The elements positioned in this manner are then assembled together. Assembly can be performed using any appropriate means, preferably by welding.

The positioning and assembly stages are repeated
20 as often as necessary, always keeping in mind the accessibility of the components to be welded until the final completion of the section in question. The stages repeated in this manner can concern either, at least two individual elements, or at least one individual
25 element and at least one sub-unit composed of several elements previously assembled together, or of at least two sub-units composed of several elements previously assembled together.

Figure 1 shows the production of a rectilinear
30 section P1, with a T shaped cross-section.

In this case the section P1 was manufactured by assembling two flat rectangular elements A1 and B1.

Element A1 (diagram (a) in figure 1) forms the lower wing of the T and the element B1 (diagram (b) in figure 1) forms the upper wing of the T. The element B1 is positioned at a right angle to one of the faces of element A1 so that one of the lengthwise edges of the element B1 (f_{B1}) is in contact with the face of element A1 (described previously) along the longitudinal axis (x_{A1}) of this face (diagram (c) in figure 1). Assembly of elements a1 and B1 is preferably performed by welding, as will be described further on in greater detail.

Figure 2 shows the section P2, with a T shaped cross-section, bent in a single spatial direction

In this case, the section P2 is also manufactured by assembling the two elements A2 and B2.

Element A2 is flat and arc shaped (diagram (a) in figure 2) and forms the lower wing of the T. Element B2 that forms the upper wing of the T is obtained by cutting out a rectangular element in flat plate (diagram (b) in figure 2). This element is then formed to a curve that is identical to that of the longitudinal axis (x_{A2}) of element A2 (diagram (c) in figure 2). The elements A2 and B2 are then assembled, preferably through welding, by positioning the element B2 at a right angle to one of the faces of element A2 so that the lengthwise edges (f_{B2}) of element B2 are in contact with the said face of element A2 according to the longitudinal axis (x_{A2}) of this face (diagram (d) in figure 2).

In the embodiment method shown in figure 3, the method as described in this invention is applied to the production of a section P3 with a T shaped cross-section, bent in two different spatial directions, and
5 at right angles to each other.

As described previously, the section is manufactured by assembling the elements A3 and B3, preferably through welding.

Element A3 that forms the lower wing of the T, is
10 obtained by cutting out an element that is flat and arc shaped from flat metal plate (diagram (a) in figure 3. This is then bent in a direction perpendicular to its thickness as shown in diagram (b) in figure 3.

Element B3 that forms the upper wing of the T, is
15 obtained by cutting out an appropriately shaped element in flat plate (diagram © in figure 3). This element is then bent to the same curve as the longitudinal axis (x_{A3}) of element A3 (diagram (d) in figure 3).

As shown on the right hand side of diagram (e) in
20 figure 3, assembly is then performed, preferably through welding, placing element B3 in a perpendicular position against one of the faces of element A3 so that one of the longitudinal edges (f_{B3}) of element B3 is in contact with the said face of A3 according to the
25 longitudinal axis (x_{A3}) of this face.

No matter what their shape, and as has been described previously, once the two metal elements are positioned in contact with each other, best results are obtained if they are maintained in this position with
30 appropriate clamping equipment. This clamping equipment can be composed of wedges, presses, sash clamps, etc.

In the preferable embodiment method described in this invention where the different elements are assembled through welding, the welding seam is best created in continuous manner without the addition of
5 other materials, using a laser beam. As a variant, the welding can be effectuated in various points along the contact line between the two elements to be assembled.

As illustrated by the arrows in (a) and (b) in figure 4, welding can be effectuated in two stages
10 using a laser beam (single flux) one side and then on the other of the junction between the two elements A and, to be assembled.

As shown by the arrows in figure 5, welding can also be performed in a single operation using two laser
15 beams (double flux) simultaneously on each side of the junction between the two elements A and B to be assembled.

As shown by the arrow in figure 6, welding can also be performed in a single operation (transparent)
20 using a single laser beam when element A (or the lower element of the T) has a sufficiently fine thickness (maximum: 2.5mm). Welding is then performed through this element A. in this case; clamping equipment is used, preferably, in order to maintain the parts to be
25 welded in correct position, and to prevent danger of deformation. In this manner it is possible to direct the laser beam on the element B to be welded, so that the laser beam follows the line of the join, even in the case where deviation of the element B may occur for
30 some reason.

In certain cases, and as described in figure 7, elements such as A and B that form the section P must be assembled together in a direction that is not at a right angle. Before beginning assembly, the edge of
5 part is machined to produce a bevelled edge ready for assembly with part A, in order to form a welding edge. In this manner the edge of part B is in contact with the opposite face of part A along the total surface of the welding edge. This layout permits welding action
10 identical to the type between two elements perpendicular to each other.

It should be noted that the angle formed between the elements such as A and B that form section P, can also be evolutionary according to the length of the
15 section. In this case, the welding edge angle machined on the edge of part B to be assembled with part A will also be evolutionary

One or several elements destined for forming a section may also necessitate complementary machining
20 such as hollowing out. The cavities produced with this operation may fulfil various functions without deviation from the context of this invention. On the contrary, they may be holes drilled for further fixing of the section, or for the attaching of other elements
25 on the section, fixing holes, or cable passage holes, or cavities destined to lighten the weight of the finished section while maintaining sufficient resistance against mechanical stress to which it may be subject.

30 These holes or cavities described above may be executed directly according to their finished diameter,

preferably during the cutting out stage of the element in question. When a laser is used to perform the cutting out operations, the same laser should preferably be used to create the cavities. Hollowing
5 and drilling before welding provides the advantage of being easier to perform because of the flat surface, and because the cutting means have already been set up. Naturally it is harder to hollow or drill in a completed section, of a three dimensional nature as is
10 the case with extruded sections or sections machined from blocks, common in prior art. Since the outline cutout and eventual cavities are created with their final measurements, no retouching is necessary, thus saving considerable time.

15 The manufacturing method according to this invention presents the great advantage of providing the production of sections with complex shapes directly to the required measurements and with excellent precision levels (approximately to a few tenths of a millimetre).

20 The method according to the invention also permits a considerable saving in material loss. In fact, material loss is limited to off-cuts produced during outline cutout. As stated previously, these off-cuts can be reduced by positioning the different elements
25 with the most economical layout during cutout preparation.

Given that material loss is minimal and that the method set-up is composed of very few production stages (cutting out, eventual forming, eventual surface
30 treatment, and assembly), the manufacturing method according to this invention permits the production of

sections with complex shapes at a lower cost than other methods used in prior art.

Moreover, mechanical stress in section structure is reduced to a minimum because there is no three dimensional forming, but exclusively fine plates, according to the various thicknesses. Since the thickness of these plates is reduced compared to the other measurements of the elements subject to forming, and also compared to curving radius in general set up during forming, the mechanical stress induced in the various elements that make up the section is very low.

CLAIMS

1. Manufacturing method for metal sections (P; P1; P2; P3) in which the cross section is composed of at least two individual, non-aligned parts, said method is characterised in that it is applied to the
5 manufacturing of complex shaped sections exclusively composed of non-plane parts that forma an angle that can be of any degree and evolutionary according to the length of the section, and in that the method also consists of cutting out the elements (A, B; A1, B1; A2, B2; A3, B3) in at least one metal plate, according to
10 the measurements that correspond to each one of the said parts, and the assembly of these elements together to form said metal section.
- 15 2. Method as described in claim 1, in which one of the edges of at least one of the elements (B) is bevelled before assembly with the other element (A) where the two elements are not perpendicular to each other.
- 20 3. Method as described in either claim 1 or 2, in which said elements (A, B; A1, B1; A2, B2; A3, B3) are cut as flat pieces from flat metal plates, then formed before assembly.
- 25 4. Method as described in claim 1, in which the elements (A, B; A1, B1; A2, B2; A3, B3) are cut from previously formed metal plates.

5. Method as described in claims 3 and 4, in which the deformation that will be induced in each element (B2, A3, B3) are calculated for forming, and where the element will be cut out to measurements corrected according to the modifications due to said deformation.

6. Method as described in any of the previous claims, in which the elements (A, B; A1, B1; A2, B2; A3, B3) are assembled by welding.

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7. Method as described in claim 6, in which the welding is performed by at least one laser beam.

8. Method as described in Claim 7, in which the welding is performed on the edge of a first element (B) for assembly to the face of a second element (A) using a single laser beam effectuated successively, on one side of the first element (B) followed by welding on the second side.

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9. Method according to claim 7, in which the welding is performed on the edge of a first element (B) for assembly to the face of a second element (A) using a two laser beams simultaneously on both sides of the first element (B)

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10. Method as described in claim 7, in which the welding is performed on the edge of a first element (B) for assembly to the face of a second element (A) using a single laser beam in transparent mode through the second element (B).

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11. Method as described in all claims between 6 and 11, in which the welding operation is effectuated without the addition of other material.
- 5 12. Method as described in all claims between 6 and 11, in which the welding operation is effectuated in various points along the contact line between the two elements.
- 10 13. Method as described in all claims between 6 and 11, in which the welding operation is effectuated in continuous mode along the contact line between the two elements.
- 15 14. Method as described in any of the previous claims, in which the elements (A, B; A1, B1; A2, B2; A3, B3) are maintained in contact with each other using clamping equipment, in a position established at the moment of assembly.
- 20 15. Method as described in any of the previous claims, in which a three dimensional drawing is made of the metal section (P; P1; P2; P3) to its final measurements, followed by a drawing of the flat outline
- 25 of each of the elements (A, B; A1, B1; A2, B2; A3, B3) before these are cut out.
16. Method as described in claim 15, in which a three dimensional drawing is made of the metal section (P;
- 30 P1; P2; P3) to its final measurements, followed by a

drawing of the flat outline of each of the elements (A, B; A1, B1; A2, B2; A3, B3) using CAD tools.

17. Method as described in claims 15 and 16, in which
5 the outline of the elements (A, B; A1, B1; A2, B2; A3, B3) are drawn by marking with a laser beam before they are cut out.

18. Method as described in claims 15 and 16, in which
10 the outline of the elements (A, B; A1, B1; A2, B2; A3, B3) are drawn using a light beam before they are cut out.

19. Method as described in any one of the previous
15 claims, in which several identical elements (A, B; A1, B1; A2, B2; A3, B3) can be cut out simultaneously from a stack of plates.

20. Method as described in any of the previous claims,
20 in which at least some of the elements (A, B; A1, B1; A2, B2; A3, B3) are hollowed out.

21. Method as described in any of the previous claims,
in which several of the elements (A, B; A1, B1; A2, B2;
25 A3, B3) are cut from the same metal plate arranging the layout position to minimise metal waste.

22. Method as described in any of the previous claims,
in which several of the elements (A, B; A1, B1; A2, B2;
30 A3, B3) using a cutting technique chosen from the group, including cutting out using high speed laser

beam, abrasive water jet, and traditional mechanical machining.

23. Method as described in any of the previous claims,
5 in which at least one of the elements (A, B; A1, B1; A2, B2; A3, B3) is subjected to a complementary surface treatment before element assembly.

24. Method as described in any of the previous claims,
10 in which the elements (A, B; A1, B1; A2, B2; A3, B3) are assembled, and where at least one of the elements has a variable thickness.

25. Method as described in claim 24, in which the
15 variable thickness is obtained through chemical or mechanical machining.

26. Method as described in any of the previous claims,
in which (A, B; A1, B1; A2, B2; A3, B3) are assembled,
20 and where at least one of the elements has a variable width.

27. Method as described in any of the claims between 1
and 22, in which (A, B; A1, B1; A2, B2; A3, B3) are
25 assembled, and where the elements have constant width and thickness.