



(11) **EP 2 485 864 B1**

(12)

## EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention  
of the grant of the patent:

**30.07.2014 Bulletin 2014/31**

(51) Int Cl.:

**B23K 26/38 (2014.01)**

(21) Application number: **09783865.0**

(86) International application number:

**PCT/EP2009/063122**

(22) Date of filing: **08.10.2009**

(87) International publication number:

**WO 2011/042058 (14.04.2011 Gazette 2011/15)**

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(54) **CONTROLLING RULES AND VARIABLES FOR CUTTING**

STEUERREGELN UND -VARIABLEN FÜR SCHNEIDVERFAHREN

RÈGLES ET VARIABLES DE COMMANDE POUR DÉCOUPAGE

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(84) Designated Contracting States:

**AT BE BG CH CY CZ DE DK EE ES FI FR GB GR  
HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL  
PT RO SE SI SK SM TR**

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(43) Date of publication of application:

**15.08.2012 Bulletin 2012/33**

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**Description****Field of invention**

**[0001]** The present invention relates to a method for machine cutting several parts out of a piece of material using a beam cutting technology, the method providing a set of controlling rules and variables for cutting two dimensional shapes or patterns, where one rule or a combination of several rules are used for the cutting operation depending on the shape or pattern to be cut, the shape or pattern forming the parts out of the piece of material.

**[0002]** The present invention also relates to a system and to a computer program product through which the inventive method can be implemented.

**[0003]** There are various cutting technologies known to cut parts out of a piece of material and the present invention relates to what here is called beam cutting technology. Beam cutting is defined as having some kind of beam as the cutting agent, such as laser cutting, plasma cutting, ion beam cutting, flame or torch cutting, water cutting, pellet cutting or air cutting. This is not to be confused with mechanical cutting where the cutting agent is a mechanical member such as a cutting blade or a rotating cutting head.

**Description of background art**

**[0004]** It is previously known to use a work plan optimization tool based on nesting part placement methods to place out the parts that are to be cut out of a piece of material. Nesting is a geometry optimization tool working in two dimensions that is based on different heuristic search algorithms that rotate and pack polygons in a given work area. In a graphic way nested work plans gives a quite good solution but in production it is required that a safe distance is used between parts. Safe distances have to take into account the machining and material technical conditions that arise in the production process. The size of the safe distance varies depending on used material and used cutting technology, a normal safe distance between parts is 5 - 20 mm.

**[0005]** Examples of used controlling rules for controlling the cutting operation of a machine are how to handle:

- sharp edges,
- turning points,
- beam breaking in critical areas,
- sensing the cutting head,
- take into account of the grid which materials can be located at,
- take into account the pivot risk of pre-cut details,
- length and angle of lead in,
- length and angle of lead out,
- micro joint for parts, and
- different use of gas when cutting and volume of abrasive material in water cutting.

**[0006]** Examples of controlling rules related to used material can be:

- rolling direction for different metal,
- heat,
- that the material settles,
- different patterns in the material,
- material stretch,
- tolerances for parts, and
- part quality.

**[0007]** Due to the above mentioned production and material related conditions there will be waste material between the cut parts.

**[0008]** As the beam makes the cut in the material the thickness of the cut is the same as, or corresponds to, the thickness of the beam, hence the beam thickness has to be taken into consideration when positioning the parts on the material and setting the safe distance between the parts. It is known to use tool radius compensation in the cutting process, where left tool radius compensation is used if the cut is made to the left of the part in the cutting direction, and right tool radius compensation is used if the cut is made to the right of the part in the cutting direction. Whenever the tool radius compensation is changed, the cutting process is stopped, the beam is turned off, and a new piercing is made.

**[0009]** Some known technologies that are used to provide a reliable production process is to use micro joints between a part and the material surrounding the part, normally called the material skeleton. A micro joint is created by stopping the cutting beam in a cut along a cutting path, moving the cutting device a small distance along the cutting path, and then starting the cutting beam again to continue the cut along the cutting path. The small uncut part will then constitute the micro joint.

**[0010]** In order to minimize the number of piercings and positioning distance in the cutting process it is known to manually position bridges between parts and to chain cut.

**[0011]** It is also known to minimize material waste by using common cut for straight lines between two points in order to minimize material waste and cutting length. In a common cut the distance between the two parts is only the thickness of one cut made by the cutting beam and no tool radius compensation is used during the cutting process.

**Summary of the present invention**Problems

**[0012]** With any kind of beam cutting technology there is a huge problem with waste. A normal production reliable cutting plan has 20-50 percent waste. The background to why the wastage incurred in production is the ineffective methods for part placement on the raw material in combination with technology rules for each cutting

method and each material.

**[0013]** When cutting technology is used as production method there are four different costs that bring the detail price. Material costs, which normally is significantly more than 50 percent of the detail price, and three different categories of machine costs; piercings, position distance and cutting distance. It is a problem to bring down the amount of waste material. It is also a problem to limit the number of piercings that are required in a cutting process and it is a problem to optimize the position distances and the cutting distances in the cutting process.

**[0014]** It is a problem to minimize the distance between free shaped parts in order to minimize the waste material.

**[0015]** If parts are positioned very close to each other, it is also a problem to keep the number of piercings to a minimum, to provide turning areas for the beam cutting process and to avoid that parts will pivot if there is no neighboring skeleton that the part can be joined to.

**[0016]** In beam cutting techniques it is a problem that the cutting beam lags behind from the upper surface of the material to the bottom surface of the material in the relative movement between the cutting device and the material. This means that if the machine stops the movement and turns the beam off then the material will not have been cut totally through in the end point of the cut.

**[0017]** Another problem is that if the cutting movement stands still with the beam turned on to catch up this lag, then the properties of the material in the area around the stopping point will be affected, for instance might the material be heated and hardened with some cutting technologies. The same is true at the starting point of a new cut where the piercing of the material will create a crater with a radius of material with affected properties around this starting point. Because of these problems so called lead ins and lead outs are sometimes used at the start point and end point of each cut, where the lead in and lead out is outside the actual cut so that this area of affected material will not be a part of the cut part.

### Solution

**[0018]** With the purpose of solving one or more of the above indicated problems, and from the standpoint of the above indicated field of invention, the present invention provides a method according to claim 1, a system according to claim 19 and a computer program product according to claim 37. The present invention teaches that the set of controlling rules comprises rules for the forming of a cluster of parts with free form shapes, where the parts are positioned so close to each other so that only the thickness of one cut made by the cutting beam is found between adjacent parts whenever the shape of the parts allows it.

**[0019]** This will reduce waste material and it will optimize the position distances and the cutting distances in the cutting process.

**[0020]** The present invention teaches that the set of controlling rules comprises rules for the joining together

of the parts in the cluster by micro joints holding adjacent parts together with each other. It is specifically taught that a micro joint is made by starting the cut of a contour a set distance into the contour to be cut, or by stopping

5 the cut of a contour a set distance before the end of the contour to be cut, thus not closing the complete cut of the contour, where the uncut beginning or end of the contour constitute the micro joint and the size of the hereby made micro joint corresponds to the set distance. This  
10 will allow the making of micro joints without having to start and stop the cutting beam during the cutting process, which will give a cutting process with fewer starts and stops of the cutting beam. By doing this the cluster of parts that are connected to each other by means of  
15 micro joints can be treated as one complex part in the cutting process.

**[0021]** It is also proposed that the set of controlling rules comprises rules for separating the parts within the cluster and joining the parts with the material surrounding

20 the cluster by micro joints holding the parts together with the surrounding material. Also this micro joint is made by starting the cut of a contour a set distance into the contour to be cut, or by stopping the cut of a contour a set distance before the end of the contour to be cut, thus not closing  
25 the complete cut of the contour, where the uncut beginning or end of the contour constitute the micro joint and the size of the hereby made micro joint corresponds to the set distance. This might be more advantageous if the cluster of parts only includes a small number of parts that  
30 are all easily connected to the surrounding material.

**[0022]** It is proposed that the size of the micro joints is controlled through the controlling rules, where those variables for controlling the size are depending on the set distance, used material and used cutting device.

**[0023]** Tool radius compensation is sometimes required to maintain the wanted distance between neighbouring parts and if the wanted quality of cut part requires tool radius compensation. With the purpose of limiting the number of piercings and thereto belonging lead ins  
40 and lead outs, and with the purpose of enabling complex combinations of parts belonging to one cluster, it is proposed that the set of controlling rules comprises rules for switching between right tool radius compensation, left tool radius compensation and no tool radius compensation  
45 during a continuous cut of a line or contour without turn-off and turn-on of the cutting beam.

**[0024]** For the same reason it is also proposed that the set of controlling rules comprises rules for the creation of strategically positioned turning areas by making a split

50 cut for this purpose or by cutting a line or contour longer than necessarily required, and using the hereby created gap as a turning area.

**[0025]** The use of such gap as a turning area is done by allowing the cutting beam to catch up with used cutting

55 device in the turning area, meaning that the lag of the cutting beam can be eliminated in the turning area, allowing a straight cutting beam as the cutting beam has changed direction and continues its cut in the new direc-

tion.

**[0026]** This will make sure that as the machine turns the cutting beam into another direction the cut will be complete all through the material even in the turning point, without leaving unwanted bridging material between adjacent materials in the turning point.

**[0027]** It is also proposed that the set of controlling rules comprises rules for allowing the cutting beam to catch up with used cutting device in an interception point as the cutting beam crosses the interception point.

**[0028]** As several parts positioned close to each other, there will, depending on their form, sometimes be required the cutting of very small angles. These small angles can be formed by two straight cuts, by two tangents or curves, or by a combination of a straight cut and a curve leading into the angle. There is technical problem to cut small angles and the present invention proposes that the set of controlling rules comprises a rule for cutting small angles, said rule stating that a small angle is cut in two cuts, one cut for each line leading into the angle, and each cut leading into the tip of the angle.

**[0029]** The forming of a cluster of parts positioned very close to each other will sometimes require that thin stripes is cut out of the material, and the present invention teaches that when the distance between two cuts is so small that the properties of the material between the two cuts can be affected and start struggle, respective cut is made in two partial cuts, and thereby minimizing the problem with affected material in thin parts. These partial cuts are started from the outer parts of respective cut towards the centre of respective cut.

**[0030]** It is also proposed that the partial cuts are not made all the way along respective cut, but that a micro joint is left between the two partial cuts, thus providing support for the thin part with the neighbouring part.

**[0031]** If the parts of the cluster are joined together by micro joints, it is proposed that the cluster of parts is cut totally free from surrounding material or material between parts not belonging to any part.

**[0032]** In order to further minimize the waste material, it is proposed that, whenever two or more clusters are cut from one piece of material, at least two different variables are used to set the distance between neighbouring parts from two different clusters. A first variable representing a first smallest distance between neighbouring parts with bordering parallel lines, and a second variable representing a second smallest distance between neighbouring parts where at least one of the neighbouring parts has a bordering tangent, where the distance represented by the second variable is shorter than the distance represented by the first variable since two parallel cuts will affect the material of the neighbouring part more than a cut with a tangent.

**[0033]** It is also proposed that the second distance, represented by the second variable, is dependant on the radius of the tangent, where a smaller radius will allow a shorter smallest distance.

**[0034]** It is also possible to provide a third variable rep-

resenting a third smallest distance between neighbouring parts where at least one of the neighbouring parts has a bordering corner, where the third distance, represented by the third variable, is shorter than the distances represented by the first and second variables.

**[0035]** It should be understood that the implementation of these rules depend on used beam cutting technology and used material, thus it is proposed that a fourth variable is representing used material, and that a fifth variable is representing used beam cutting technology, such as cutting with plasma, laser, flame, water, ions, torch, pellets or air, so that these variables can be taken into account when applying the rules in a certain cutting operation.

**[0036]** Different cutting technologies will provide cutting beams with different thickness, and different cutting devices using the same cutting technologies will also provide cutting beams with different thickness depending on the conditions of the cutting device. Hence it is proposed that a sixth variable is representing the width or thickness of the cutting beam. This sixth variable is also depending on the fourth and fifth variable.

**[0037]** The present invention teaches that the set of controlling rules may provide rules for a lead in or lead out by means of automatic angle adjustment and length adjustment for the lead in or lead out, depending on used material, the thickness of the used material and used cutting technology, the angle and length adjustment being adapted to position the start and stop point of the cut sufficiently far away from the cut and with a lead in or lead out angle that is as small as possible.

**[0038]** The present invention proposes that the cutting operation is performed in the following sequence:

- 35 - cut all holes, strategically positioned split cuts and common cuts,
- cut all pockets created between clusters or parts, and
- cut the outer contour of the cluster.

**[0039]** It should be understood that the inventive method can be implemented as a tool for computer aided manufacturing (CAM), computer aided design (CAD), or as a part of the controlling rules and variables used by a numerical controller in cutting equipment controlled by means of computer numerical control (CNC).

**[0040]** The present invention also relates to a system for machine cutting several parts out of a piece of material, comprising a beam cutting device and a control unit for controlling the beam cutting device adapted to perform the control according to the inventive method.

**[0041]** The present invention also relates to a computer program product comprising computer program code, which when executed enables a computer to implement the controlling rules and variables according to the inventive method.

### Advantages

**[0042]** The advantages of a method, system, a computer program product according to the present invention are that through the invention it is possible to minimize the material waste and create a production reliable cutting plan with optimized machine cost, meaning an optimization regarding the number of piercings, position distances and cutting distances.

**[0043]** The present invention provides an optimal cutting with a cutting work plan where it is possible to control the cutting variables in the cutting machine to get a reliable process. The invention provides control over turning areas, distance between parts, micro joints between parts, when clustering together more than one free formed part, length and angle of lead in, length and angle of lead out, switching between tool radius compensations, and scanning within the cluster area, that is the possibility to use the sensing cutting head and without lifting the head between holes, splits, common cuts, and pockets within the cluster area, to minimize the positioning distances.

**[0044]** The provided production reliability means a safe process, right tolerance for parts, and an optimal quality for parts with minimum resource waste.

**[0045]** This present invention provides the possibility to create clusters for free form parts. Single parts optimized on the work area in close clusters provide a chance to minimize the material waste. As clusters are created details are positioned against each other which make it possible to use all tangent segments when clustering. The inventive cluster of several parts creates a new part without safe distance only tangents, splits, bridges, turning areas, micro joints, common cut lines and pockets. Different constellations of the inventive rules and variables provides the possibility to give a reliable cutting process for any kind of upcoming situation when free formed two dimensional parts are going to be clustered without safe distance.

**[0046]** The use of micro joints between the parts to be cut instead of between the parts and the skeleton also gives advantages in the manual or automated sorting process.

**[0047]** The use of inventive turning areas will also provide the possibility to avoid using areas of the skeleton for changing the cutting direction and instead use already cut lines where the cutting direction is changed, which again minimize the waste.

### Brief description of the drawings

**[0048]** A method, a system and a computer program product according to the present invention will now be described in detail with reference to the accompanying drawings, in which:

Figure 1 is a schematic and simplified illustration of a method, system and

Figure 2

5 Figure 3

Figure 4

10 Figure 5

Figure 6

15 Figure 7a and 7b

20 Figure 8

Figure 9

25 Figure 10

Figure 11

### 30 Description of embodiments as presently preferred

**[0049]** The present invention will now be described with reference to figure 1 illustrating a method for machine cutting several parts 12a, 12b, 12c out of a piece 35 of material 12 using a beam cutting technology. The schematic illustration of figure 1 shows that a cutting device 13 is movable and the material 12 is fixed, however, it should be understood that the present invention can also be implemented in a system where the cutting device is 40 fixed and the material is movable. The invention relates to controlling the relative movement between the material 12 and the cutting device 13 regardless of what is moving and what is fixed.

**[0050]** In the description of the present invention certain terminology might be used that implies that one specific beam cutting technology is described, but it should be understood that the present invention relates to any beam cutting technology and the skilled person will understand how a feature described with a terminology specific for one beam cutting technology can be adapted and implemented in another beam cutting technology.

**[0051]** The inventive method provides a set of controlling rules and variables for cutting two dimensional shapes or patterns, where one rule or a combination of 55 several rules are used for the cutting operation depending on the shape or pattern to be cut, where the shape or pattern forms the parts out of the piece of material. The controlling rules and parameters are used to control

computer program product according to the present invention,

is a schematic illustration of a cluster of parts with only two parts,

is a schematic illustration of a cluster with several parts,

is a schematic illustration of how to cut over several interception points,

is a schematic and simplified illustration of how a common cut can end in order to achieve different means,

is a schematic and simplified illustration of how to cut small angles,

is a schematic illustration of two different ways of cutting out two parts with neighbouring tangents at a distance of the thickness of one cut made by the cutting beam,

is a schematic illustration of how to cut thin strips,

is a schematic illustration of how distances between different clusters can be set,

is a schematic illustration of how to set lead ins and lead outs, and

is a flow chart illustrating a sequence of cutting operations.

the relative movement between a cutting device 13 and the piece of material 12 so that this movement is performed in a controlled manner to perform the cutting operation.

**[0052]** It is specifically taught that the set of controlling rules comprises rules for the forming of a cluster of parts 15 with free form shapes. By free form shapes is meant that the parts could have any form or shape in the two dimensions that are cut out of the material.

**[0053]** The present invention teaches that the parts 12a, 12b, 12c are positioned so close to each other so that only the thickness 13a' of the cutting beam 13a is found between adjacent parts whenever the shape of the parts allows it.

**[0054]** This means that a common cut will be required between parts where the common line to be cut is not a straight line between two points, rather it could be any curved form, or several connected straight lines.

**[0055]** The different embodiments presented in the following description shows examples of where parts with different forms or shapes can be cut without any required skeleton between the parts, thus saving a lot of material.

**[0056]** One example is illustrated in figure 2 where a first part 21 and a second part 22 are positioned so close so that only the thickness of one cut 23 made by the cutting beam is found between the parts 21, 22.

**[0057]** It is proposed that the set of controlling rules comprises rules for the making of micro joints for the joining together of said parts by micro joints holding adjacent parts together with each other, and that a micro joint is made by starting the cut of a contour a set distance into the contour to be cut, or by stopping the cut of a contour a set distance before the end of the contour to be cut, thus not closing the complete cut of the contour, which will be shown in more detail with reference to figure 5. The size of the hereby made micro joint corresponds to said set distance

**[0058]** It shall be understood that the set of controlling rules may also comprise rules for separating the parts within the cluster and joining the parts with the material surrounding the cluster by micro joints holding the parts together with the surrounding material, which is illustrated in figure 2 showing a first micro joint 24 and a second micro joint 25 is joining the parts 21, 22 with the surrounding material 2.

**[0059]** As can be seen in figure 2 the first micro joint 24 is made by starting the cut of the contour a set distance into the contour to be cut, and the second micro joint 25 is made by stopping the cut of the contour a set distance before the end of the contour to be cut, thus not closing the complete cut of the contour, where the size of the hereby made micro joints 24, 25 corresponds to the set distance.

**[0060]** It should be understood that depending on the thickness of the material, micro joints might not be required at all, since the cut parts will stick to the skeleton and neighbouring parts when the material is thick enough without the risk of tilting for small parts.

**[0061]** The size of the micro joints is controlled through the controlling rules, and variables for controlling the size are depending on the set distance, used material and used cutting device. If for instance the combination of

5 cutting technology and material causes a lag of the beam then the cut can be made almost all the way to another cut part where the beam is turned off, and where the thicker joint on the back of the material due to beam lag is a part of the micro joint. If the combination of cutting technology and material does not cause any lag of the beam, then the micro joints can be cut to precise size.

**[0062]** If the first and second part 21, 22 requires tool radius compensation, the present invention teaches that when starting to cut in point 2a, left tool radius compensation is used for cutting the contour of the first part 21 to the point 2b where the common cut starts. From point 2b to the point 2c, during the common cut part of the contour, no tool radius compensation is used, and from point 2c to point 2d, right tool radius compensation is used for cutting the contour of the second part 22. It is thus proposed that the set of controlling rules comprises rules for switching between right tool radius compensation, left tool radius compensation and no tool radius compensation during a continuous cut of a line or contour 15 without turn-off and turn-on of the cutting beam. This means that cutting the two parts 21, 22 in figure 2 can be done in one continuous cut from point 2a to point 2d. The figure also shows how micro joints 24, 25 are formed by not completing the cut all the way.

**[0063]** Figure 2 is an illustration of a very simple and also specific embodiment of the present invention since the cluster of parts only includes two parts.

**[0064]** Figure 3 is another example of a cluster 3A with four parts, a first 31, second 32, third 33, and fourth 34 part. Here it can be seen that the cut parts creates a pocket 3B in the middle between the four parts since the four parts have round corners.

**[0065]** The present invention teaches that the set of controlling rules comprises rules for the creation of strategically positioned turning areas by making a split cut for this purpose or by cutting a line or contour longer than necessarily required, and using the hereby created gap as a turning area.

**[0066]** In figure 3 it is proposed that the common cuts between three of the parts are cut first, for instance first the first common cut 35 between the first and second part 31, 32, and then the second common cut 36 between the second and third part 32, 33, and then third common cut 37 between the third and fourth part 33, 34. These three common cuts 35, 36, 37 are cut into the pocket 3B in the middle, thereby creating three turning areas, a first burning area 35', a second turning area 36', and a third turning area 37' at the end of respective common cut.

**[0067]** As the fourth common cut 38 is cut, the pocket in the middle is made by the same cut, where the three turning areas 35', 36', 37' allows the beam to enter into the turning area, turn around and then continue out of the turning area, cutting the next corner, and continue

into the next turning area, and so on around the whole pocket 3B.

**[0068]** The embodiment according to figure 3 is also an example where change of tool radius compensation might be required during the cut. To exemplify this it is shown that as the fourth common cut 38 is made no tool radius compensation is used during the cut between the first part 31 and the fourth part 34, this is then changed into left tool radius compensation while cutting the round corner of the fourth part 34, while turning in the third turning area 37', while cutting the round corner of the third part 33, while turning in the second turning area 36', while cutting the round corner of the second part 32, while turning in the first turning area 35', and while cutting the round corner of the first part 31.

**[0069]** The use of the gap as a turning area is done by allowing the cutting beam to catch up with used cutting device in the turning area.

**[0070]** The beam can be allowed to catch up with the cutting device in different ways and which way to choose depends on the specific cutting situation.

**[0071]** One way allow the beam to catch up with the cutting device is to allow the cutting speed to slow down within the turning area and accelerate to normal cutting speed as the cutting operation proceeds out of the turning area. The tight turning area will in practical applications of the invention cause the cutting speed to slow down as turns within the turning area is made, thereby allowing the beam to catch up with the cutting device as the turn is made in the turning area. In some applications, depending on reliability and/or quality requirements, it might be required to actively slow down, or even stop, the movement in the cutting process in order to make sure that the beam really is allowed to catch up.

**[0072]** Another way to allow the beam to catch up with the cutting device is by allowing the cutting device to do a radius within the turning area.

**[0073]** Another way to allow the beam to catch up with the cutting device is by allowing the cutting device to do an angle or phase within the turning area.

**[0074]** Figure 4 shows an embodiment of the present invention where the cutting beam 41 crosses several already cut lines 4a, 4b, 4c, 4d, or interception points. This could cause a problem if the beam is lagging behind the cutting device, since the upper part of the beam might start to cut on the other side of the interception point before the lower part of the beam has cut through the first side of the interception point, which might be a risk of cutting interruption.

**[0075]** In order to prevent this the present invention teaches that the set of controlling rules comprises rules for allowing the cutting beam to catch up with used cutting device in an interception point as the cutting beam crosses the interception point.

**[0076]** This catching up can be done in different ways, three different proposed ways are to let the cutting device do a little radius A within the cut gap, to let the cutting device do a little phase B in the cut gap, or to slow down

the cutting speed when entering the gap and then start to cut with normal speed when exiting the gap C.

**[0077]** Figure 5 shows an example of how cuts can be ended in different way in order to achieve different features of the present invention. The figure shows schematically a first part 51, a second part 52, a third part 53 and a fourth part 54 belonging to a cluster of parts 5A, the whole cluster not shown in the figure.

**[0078]** The parts are positioned so that a first cut 512 between the first part 51 and the second part 52 is a common cut, a second cut 523 between the second part 52 and the third part 53 is a common cut, and a third cut 534 between the third part 53 and the fourth part 54 is a common cut, and all four parts border to an outer cut 55.

**[0079]** Here it can be seen that the first cut 512 has been stopped before reaching the outer cut 55, thus forming a micro joint 56 between the first part 51 and the second part 52.

**[0080]** It can also be seen that the second cut 523 has been cut all the way to the outer cut 55, thus separating the second and third parts 52, 53 from each other.

**[0081]** It can also be seen that the third cut 534 has been cut over the outer cut, thus providing a strategically positioned cut that can be used as a turning area 57.

**[0082]** Figure 6 illustrates how the present invention proposes a solution regarding cutting small angles 6A. The present invention teaches that the set of controlling rules comprises a rule stating that a small angle 6A is cut in two cuts, a first cut 61 and a second cut 62, one cut for each line leading into the angle 6A, and each cut leading into the tip 6A' of the angle 6A. In the figure, the angle is exemplified by two curves leading into each other, however, it should be understood that it might also be two straight lines, or one straight line and one curve, leading into each other.

**[0083]** Figure 7a shows an example where a first part 7a1 and a second part 7a2 is positioned so that the distance between the neighbouring tangents is only the thickness of one cut made by the cutting beam. In figure 7a the cutting operation is started by cutting a strategically positioned split cut 7a3 through the common tangent of the first and second part 7a1, 7a2. After that the two parts 7a1, 7a2 are cut in one cut where the cutting beam will use the strategically positioned split cut 7a3 as a turning area 7a3'. In this cut no change of radius compensation is required since the cut direction 7a4, 7a4' is such that the radius compensation remains the same during the whole cut.

**[0084]** Figure 7b also shows an example where a first part 7b1 and a second part 7b2 is positioned so that the distance between the neighbouring tangents is only the thickness of one cut made by the cutting beam. In figure 7b the two parts 7b1, 7b2 are cut in one cut where the cutting beam will cross the already cut tangent point 7b3 as the cutting beam cuts through this point the second time, the already cut tangent point 7b3 thus being an interception point according to figure 4. If there are requirements of tool radius compensation, this can be pro-

vided by a change of radius compensation as the cutting beam moves from cutting the first part 7b1 into cutting the second part 7b2 and vice versa since the cut direction 7b4, 7b4' is such that the radius compensation changes as the cutting beam goes through the tangent point 7b3.

**[0085]** Figure 8 illustrates that when the distance between three cuts, a first cut 81, a second cut 82 and a third cut 83, is so small that the properties of the material between two neighbouring cuts is affected and start struggle, the present invention proposes that the first, second and third cuts 81, 82, 83 are made in two partial cuts 81 a, 81b, 82a, 82b, 83a, 83b starting from the outer parts of respective cut 81, 82, 83 towards the centre of respective cut 81, 82, 83.

**[0086]** Figure 8 also shows that the first and second partial cuts 81 a, 81b, 82a, 82b are not made all the way along respective cut 81, 82, but that a micro joint 81c, 82c is left between the two partial cuts 81 a, 81b, 82a, 82b, while the third partial cuts 83a, 83b, are made all the way to close the contour of the third cut 83.

**[0087]** It is proposed that it is possible to see the cluster of parts as one single complex part, where the cluster of parts is cut totally free from surrounding material or material between parts not belonging to any part, in which case the parts in the cluster might, if required, be joined together by micro joints and the cluster is totally free from the surrounding skeleton material.

**[0088]** The present invention teaches that different variables are available for the control of the cutting device.

**[0089]** Figure 9 illustrates that two or more clusters 9A, 9B, 9C are cut from one piece of material. The clusters can comprise several different parts but for the sake of simplicity the clusters 9A, 9B, 9C are only schematically illustrated as solid parts. At least two different variables are used to set the distance between neighbouring parts from two different clusters. A first variable represents a first smallest distance a9 between neighbouring parts 9A, 9B with bordering parallel lines 9A', 9B'. A second variable represents a second smallest distance b9 between neighbouring parts 9A, 9C where at least one of the neighbouring parts 9C has a bordering tangent 9C'. The present invention teaches that the distance b9 represented by the second variable is shorter than the distance a9 represented by the first variable.

**[0090]** The present invention also teaches that the second distance b9, represented by the second variable, is dependant on the radius of the tangent 9C'.

**[0091]** Figure 9 also shows that a third variable can represent a third smallest distance c9 between neighbouring parts 9B, 9C, where at least one of the neighbouring parts 9B has a bordering corner 9B'', where the third distance c9, represented by the third variable, is shorter than the distances a9, b9 represented by the first and second variables.

**[0092]** It is proposed that a fourth variable is representing used material, and that a fifth variable is representing used beam cutting technology, such as cutting with plasma, laser, flame, water, ions, torch, pellets or air.

**[0093]** It is also proposed that a sixth variable is representing the width of the cutting beam, which is depending on the fourth and fifth variable.

**[0094]** Figure 10 shows that a lead in 101 or lead out 102 can be provided by means of automatic angle adjustment and length adjustment for the lead 101 in or lead out 102, depending on used material, the thickness of the used material and used cutting technology.

**[0095]** It is proposed that the angle 101 a, 102a is chosen as small as possible in relation to the cut 103 so that the crater 101 b created by the piercing as the cutting beam is started in the lead in 101, or affected zone 102b that is created as the beam is stopped in the lead out 102, will be positioned outside of the cut 103, while still minimizing the length of the lead 101 in and lead out 102 respectively.

**[0096]** Figure 11 is a simplified flow chart showing a proposed sequence of performing the cutting operation:

- 20 - cut all holes, strategically positioned split cuts and common cuts 111,
- cut all pockets created between clusters or parts 112, and
- cut the outer contour of the cluster 113.

**[0097]** The first operation 111 is to cut all holes, strategically positioned split cuts and common cuts, and this is done first to create required turning areas and it can easily be done since the piece of material is still a stable piece since all parts are still connected to each other and to the skeleton while performing these operations. Cuts, splits and common cuts are all adapted to any micro joints that are positioned to connect the different parts in the cluster.

**[0098]** The second operation 112 is to cut all pockets created between clusters or parts, and this can easily be done since the piece of material is still a stable piece since all parts are still connected to each other and to the skeleton while performing these operations.

**[0099]** The third and last operation 113 is to cut the outer contour of the cluster, and as this is done, all parts will be released from the skeleton and only be connected to each other by means of any micro joints created during the process. It should be understood that if an embodiment is used where micro joints are connecting the parts of the cluster with the skeleton instead of with each other, the micro joints are created while cutting the outer contour.

**[0100]** It should be understood that a method according to the present invention can be implemented as a tool for computer aided manufacturing (CAM), computer aided design (CAD), or as a part of the controlling rules and variables used by a numerical controller in cutting equipment controlled by means of computer numerical control (CNC).

**[0101]** The present invention also relates to a system which will be described with renewed reference to figure 1, being a system 11 for machine cutting several parts

12a, 12b, 12c out of a piece of material 12, the inventive system 11 comprising a beam cutting device 13 and a control unit 14 for controlling the beam cutting device 13.

**[0102]** The control unit 14 is adapted to follow a set of controlling rules for cutting two dimensional shapes or patterns, where one rule or a combination of several rules can be used for the cutting operation depending on the shape or pattern to be cut, which shape or pattern is forming the parts 12a, 12b, 12c out of the piece of material 12.

**[0103]** The present invention specifically teaches that the control unit 14 is adapted to follow a set of controlling rules comprising rules for the forming of a cluster 15 of parts 12a, 12b, 12c with free form shapes, where the parts 12a, 12b, 12c are positioned so close to each other so that only the thickness 13a' of the cutting beam 13a is found between adjacent parts whenever the shape of the parts allows it.

**[0104]** It is proposed that the control unit is adapted to control the cutting device into leaving micro joints between adjacent parts, thus allowing the micro joints to hold adjacent parts together with each other, where the control unit is adapted to control the cutting device into starting the cut of a contour a set distance into the contour to be cut, or, as shown in figure 5, into stopping the cut of a contour 512 a set distance before the end of the contour to be cut, whereby the cutting device is controlled into not closing the complete cut of the contour, thus providing a micro joint 56 joining the first part 51 and the second part 52, where the size of the micro joint corresponds to the set distance.

**[0105]** As illustrated in figure 2, it is proposed that the control unit is adapted to control the cutting device into leaving micro joints 24, 25 between the parts 21, 22, and the material 2 surrounding the cluster thus allowing the micro joints 24, 25 to hold the parts 21, 22 together with the surrounding material.

**[0106]** The control unit is adapted to follow controlling rules setting the size of the micro joints, and variables for controlling the size are depending on used material and used cutting device.

**[0107]** It is proposed that the control unit is adapted to control the cutting device into switching between right tool radius compensation, left tool radius compensation and no tool radius compensation during a continuous cut of a line or contour without having to cut a new hole. Figure 2 illustrates this by showing that when starting to cut in point 2a, left tool radius compensation is used for cutting the contour of the first part 21 to the point 2b. Where the common cut starts, from point 2b to the point 2c, during the common cut part of the contour, no tool radius compensation is used, and from point 2c to point 2d, right tool radius compensation is used for cutting the contour of the second part 22.

**[0108]** As illustrated in figure 3, it is proposed that the control unit is adapted to control the cutting device into creating strategically positioned turning areas 35', 36', 37' by making a split cut for this purpose or by cutting a

line or contour longer than necessarily required, and controlling the cutting device into using the hereby created gap as a turning area.

**[0109]** The control unit is adapted to control the cutting device into using the gap as a turning area by controlling the cutting device so that the cutting beam is allowed to catch up with the cutting device in the turning area.

**[0110]** The catching up of the beam can be provided in different ways. It is possible to adapt the control unit to control the cutting operation into slowing down the cutting speed within the cut gap and accelerate to normal cutting speed as the cutting operation is started on the other side of the gap. A natural cause of the tight turning point in the turning area is that the cutting speed is slowed down as the turn is made, however, in some applications, depending on reliability and/or quality requirements, it might be required to actively slow down, or even stop, the movement in the cutting process in order to make sure that the beam really is allowed to catch up.

**[0111]** The control unit can also be adapted to control the cutting device into doing a radius within the cut gap, or into doing an angle or phase within the cut gap.

**[0112]** In the same way, the control unit can be adapted to control the cutting device into allowing the cutting beam to catch up with used cutting device in an interception point as the cutting beam crosses the interception point.

**[0113]** As shown in figure 6 it is proposed that the control unit is adapted to control the cutting device into cutting small angles 6A in two cuts, a first cut 61 and a second cut 62, one cut for each line leading into the angle 6A, and each cut 61, 62 leading into the tip 6A' of the angle 6A.

**[0114]** As shown in figure 8 it is proposed that when the distance between two cuts, a first cut 81 and second cut 82, is so small that the properties of the material between the two cuts 81, 82 is affected and start struggle, the control unit is adapted to control the cutting device into making respective cut 81, 82 in two partial cuts 81a, 81b, 82a, 82b starting from the outer parts of respective cut towards the centre of respective cut.

**[0115]** It is also proposed that the control unit is adapted to control the cutting device into not making the partial cuts 81a, 81b, 82a, 82b all the way along respective cut, but that a micro joint is left between said two partial cuts. Also a third cut 83 is shown where the two partial cuts 83a, 83b are made all the way to close the contour of the third cut 83 without leaving a micro joint.

**[0116]** It is also proposed that the control unit is adapted to control the cutting device into cutting the cluster of parts totally free from surrounding material or material between parts not belonging to any part.

**[0117]** Figure 9 shows that whenever two or more clusters 9A, 9B, 9C are to be cut from one piece of material, it is proposed that the control unit is adapted to control the cutting device into using a first smallest distance a9 between neighbouring parts 9A, 9B with bordering parallel lines 9A', 9B', where this smallest distance a9 is represented by a first variable. A second smallest distance b9 between neighbouring parts 9A, 9C where at

least one of the neighbouring parts has a bordering tangent 9C', this smallest distance b9 being represented by a second variable, where the second distance b9, being represented by the second variable, is shorter than the first distance a9, represented by the first variable.

[0118] The second distance b9, represented by the second variable, is dependant on the radius of the tangent 9C'.

[0119] It is also proposed that a third variable is adapted to represent a third smallest distance c9 between neighbouring parts 9B, 9C where at least one of the neighbouring parts 9B has a bordering corner 9B", where the third distance c9, represented by the third variable, is shorter than the distances a9, b9 represented by the first and second variables.

[0120] It is also proposed that the control unit is adapted to take into account a fourth variable representing used material, and a fifth variable representing used beam cutting technology, such as cutting with plasma, laser, flame, water, ions, torch, pellets or air.

[0121] It is also proposed that the control unit is adapted to take into account a sixth variable representing the width of the cutting beam, which is depending on the fourth and fifth variable.

[0122] Figure 10 shows that the control unit is adapted to provide lead in 101 or lead out 102 by means of automatic angle adjustment and length adjustment for said lead in 101 or lead out 102, depending on used material, the thickness of the used material and used cutting technology.

[0123] A control unit according to the present invention can be adapted to control the cutting device into performing the cutting operation in the following sequence as indicated by the flow chart of figure 11:

- cut all holes, strategically positioned split cuts and common cuts 111,
- cut all pockets created between clusters or parts 112, and
- cut the outer contour of the cluster 113.

[0124] An inventive system can be adapted to function as a tool for computer aided manufacturing (CAM) or computer aided design (CAD), and an inventive control unit can be a numerical controller in a computer numerical control (CNC) machine.

[0125] The present invention also relates to a computer program product P as schematically illustrated in figure 1, comprising computer program code P1, which when executed enables a computer C to implement the controlling rules and variables according to the inventive method.

[0126] It will be understood that the invention is not restricted to the aforescribed and illustrated exemplifying embodiments thereof and that modifications can be made within the scope of the invention, which is defined by the accompanying Claims.

## Claims

1. Method for machine cutting several parts out of a piece of material using a beam cutting technology, said method providing a set of controlling rules and variables for cutting two dimensional shapes or patterns, where one rule or a combination of several rules are used for the cutting operation depending on the shape or pattern to be cut, said shape or pattern forming said parts out of said piece of material, **characterised in, that** said set of controlling rules comprises rules for the forming of a cluster of parts with free form shapes, said parts being positioned so close to each other so that only the thickness of one cut made by the cutting beam is found between adjacent parts whenever the shape of said parts allows it.
2. Method according to claim 1, **characterised in, that** said set of controlling rules comprises rules for the joining together of said parts by micro joints holding adjacent parts together with each other, and that a micro joint is made by starting the cut of a contour a set distance into the contour to be cut, or by stopping the cut of a contour a set distance before the end of the contour to be cut, thus not closing the complete cut of the contour, where the size of the hereby made micro joint corresponds to said set distance.
3. Method according to claim 1, **characterised in, that** said set of controlling rules comprises rules for separating the parts within said cluster and joining the parts with the material surrounding said cluster by micro joints holding the parts together with the surrounding material, and that a micro joint is made by starting the cut of a contour a set distance into the contour to be cut, or by stopping the cut of a contour a set distance before the end of the contour to be cut, thus not closing the complete cut of the contour, where the size of the hereby made micro joint corresponds to said set distance.
4. Method according to claim 2 or 3, **characterised in, that** the size of said micro joints is controlled through said controlling rules, and that variables for controlling said size are depending on said set distance, used material and used cutting device.
5. Method according to any preceding claim, **characterised in, that** said set of controlling rules comprises rules for switching between right tool radius compensation, left tool radius compensation and no tool radius compensation during a continuous cut of a line or contour without turn-off and turn-on of the cutting beam.
6. Method according to any preceding claim, **characterised in, that** said set of controlling rules compris-

- es rules for the creation of strategically positioned turning areas by making a split cut for this purpose or by cutting a line or contour longer then necessarily required, and using the hereby created gap as a turning area.
7. Method according to claim 6, **characterised in, that** the use of said gap as a turning area is done by allowing the cutting beam to catch up with used cutting device in said turning area.
8. Method according to any preceding claim, **characterised in, that** said set of controlling rules comprises rules for allowing the cutting beam to catch up with used cutting device in an interception point as the cutting beam crosses said interception point.
9. Method according to any preceding claim, **characterised in, that** said set of controlling rules comprises a rule for cutting small angles, said rule stating that a small angle is cut in two cuts, one cut for each line leading into the angle, and each cut leading into the tip of the angle.
10. Method according to any preceding claim, **characterised in, that** when the distance between two cuts is so small that the properties of the material between the two cuts is affected and start struggle, respective cut is made in two partial cuts starting from the outer parts of said cut towards the centre of said cut.
11. Method according to any one of claims 1, 2, 4, 5, 6, 7, 8, 9 or 10, **characterised in** cutting said cluster of parts totally free from surrounding material or material between parts not belonging to any part.
12. Method according to any preceding claim, **characterised in, that**, whenever two or more clusters are cut from one piece of material, at least two different variables are used to set the distance between neighbouring parts from two different clusters, a first variable representing a first smallest distance between neighbouring parts with bordering parallel lines, and a second variable representing a second smallest distance between neighbouring parts where at least one of said neighbouring parts has a bordering tangent, where the distance represented by said second variable is shorter than the distance represented by said first variable.
13. Method according to any preceding claim, **characterised in, that** a fourth variable is representing used material, and that a fifth variable is representing used beam cutting technology, such as cutting with plasma, laser, flame, water, ions, torch, pellets or air.
14. Method according to claim 13, **characterised in, that** a sixth variable is representing the width of said cutting beam, which is depending on said fourth and fifth variable.
- 5 15. Method according to any preceding claim **characterised in** providing a lead in or lead out by means of automatic angle adjustment and length adjustment for said lead in or lead out, depending on used material, the thickness of said used material and used cutting technology.
- 10 16. Method according to any preceding claim **characterised in** performing said cutting operation in the following sequence:
- 15 - cut all holes, strategically positioned split cuts and common cuts,
  - cut all pockets created between clusters or parts, and
  - cut the outer contour of the cluster.
- 20 17. Method according to any preceding claim, **characterised in** that said method is implemented as a tool for computer aided manufacturing (CAM) or computer aided design (CAD).
- 25 18. Method according to any one of claims 1 to 16, **characterised in** that said method is implemented as a part of the controlling rules and variables used by a numerical controller in cutting equipment controlled by means of computer numerical control (CNC).
- 30 19. System for machine cutting several parts out of a piece of material, comprising a beam cutting device and a control unit for controlling said beam cutting device, said control unit being adapted to follow a set of controlling rules for cutting two dimensional shapes or patterns, where one rule or a combination of several rules can be used for the cutting operation depending on the shape or pattern to be cut, said shape or pattern forming said parts out of said piece of material, **characterised in, that** said control unit is adapted to follow a set of controlling rules comprising rules for the forming of a cluster of parts with free form shapes, said parts being positioned so close to each other so that only the thickness of one cut made by the cutting beam is found between adjacent parts whenever the shape of said parts allows it.
- 35 40 45 50 55 20. System according to claim 19, **characterised in, that** said control unit is adapted to control said cutting device into leaving micro joints between adjacent parts, thus allowing said micro joints to hold adjacent parts together with each other, where said control unit is adapted to control said cutting device into starting the cut of a contour a set distance into the contour to be cut, or into stopping the cut of a contour a set distance before the end of the contour to be

- cut, whereby the cutting device is controlled into not closing the complete cut of the contour, thus providing a micro joint with a size that corresponds to said set distance.

21. System according to claim 19, **characterised in, that** said control unit is adapted to control said cutting device into separating the parts within said cluster and leaving micro joints between the parts and the material surrounding said cluster, thus allowing said micro joints to hold the parts together with the surrounding material, where said control unit is adapted to control said cutting device into starting the cut of a contour a set distance into the contour to be cut, or into stopping the cut of a contour a set distance before the end of the contour to be cut, whereby the cutting device is controlled into not closing the complete cut of the contour, thus providing a micro joint with a size that corresponds to said set distance.

22. System according to claim 20 or 21, **characterised in, that** said control unit is adapted to follow controlling rules setting the size of said micro joints, and that variables for controlling said size are depending on said set distance, used material and used cutting device.

23. System according to any one of claims 19 to 22, **characterised in, that** said control unit is adapted to control said cutting device into switching between right tool radius compensation, left tool radius compensation and no tool radius compensation during a continuous cut of a line or contour without having to cut a new hole.

24. System according to any one of claims 19 to 23, **characterised in, that** said control unit is adapted to control said cutting device into creating strategically positioned turning areas by making a split cut for this purpose or by cutting a line or contour longer than necessarily required, and controlling said cutting device into using the hereby created gap as a turning area.

25. System according to claim 24, **characterised in, that** said control unit is adapted to control said cutting device into using said gap as a turning area by controlling said cutting device so that the cutting beam is allowed to catch up with the cutting device in said turning area.

26. System according to any one of claims 19 to 25, **characterised in, that** said control unit is adapted to control said cutting device into allowing the cutting beam to catch up with used cutting device in an interception point as the cutting beam crosses said interception point.

27. System according to any one of claims 19 to 26, **characterised in, that** said control unit is adapted to control said cutting device into cutting small angles in two cuts, one cut for each line leading into the angle, and each cut leading into the tip of the angle.

28. System according to any one of claims 19 to 27, **characterised in, that** when the distance between two cuts is so small that the properties of the material between the two cuts is affected and start struggle, said control unit is adapted to control said cutting device into making respective cut in two partial cuts starting from the outer parts of said cut towards the centre of said cut.

29. System according to any one of claims 19, 20, 22, 23, 24, 25, 26, 27 or 28, **characterised in, that** said control unit is adapted to control said cutting device into cutting said cluster of parts totally free from surrounding material or material between parts not belonging to any part.

30. System according to any one of claims 19 to 29, **characterised in, that** whenever two or more clusters are to be cut from one piece of material, said control unit is adapted to control said cutting device into using a first smallest distance between neighbouring parts with bordering parallel lines, said smallest distance being represented by a first variable, and using a second smallest distance between neighbouring parts where at least one of said neighbouring part has a bordering tangent, this smallest distance being represented by a second variable, where the second distance, represented by said second variable, is shorter than the first distance, represented by said first variable.

31. System according to any one of claims 19 to 30, **characterised in that**, said control unit is adapted to take into account a fourth variable representing used material, and a fifth variable representing used beam cutting technology, such as cutting with plasma, laser, flame, water, ions, torch, pellets or air.

32. System according to any one of claims 19 to 31, **characterised in, that** said control unit is adapted to take into account a sixth variable representing the width of said cutting beam, which is depending on said fourth and fifth variable.

33. System according to any one of claims 19 to 32, **characterised in, that** said control unit is adapted to provide lead in or lead out by means of automatic angle adjustment and length adjustment for said lead in or lead out, depending on used material, the thickness of said used material and used cutting technology.

34. System according to any one of claims 19 to 33, **characterised in that**, said control unit is adapted to control said cutting device into performing said cutting operation in the following sequence:
- cut all holes, strategically positioned split cuts and common cuts,
  - cut all pockets created between clusters or parts, and
  - cut the outer contour of the cluster.
35. System according to any one of claims 19 to 34, **characterised in, that** said system is adapted to function as a tool for computer aided manufacturing (CAM) or computer aided design (CAD).
36. System according to any one of claims 19 to 34, **characterised in, that** said control unit is a numerical controller in a computer numerical control (CNC) machine.
37. Computer program product **characterised in** comprising computer program code, which when executed enables a computer to implement the controlling rules and variables according to any one of claims 1 to 18.

#### Patentansprüche

1. Verfahren zum maschinellen Schneiden mehrerer Teile aus einem Materialstück unter Einsatz einer Strahlen-Schneidtechnologie, wobei das Verfahren einen Satz von Steuerregeln und Variablen zum Schneiden zweidimensionaler Formen oder Muster bereitstellt, wobei eine Regel oder eine Kombination mehrerer Regeln für den Schneidvorgang in Abhängigkeit von der zu schneidenden Form oder dem zu schneidenden Muster verwendet wird, wobei die Form oder das Muster die Teile aus dem Materialstück bilden, **dadurch gekennzeichnet, dass** der Satz von Steuerregeln Regeln zum Bilden einer Gruppe von Teilen mit freien Formen aufweist, wobei die Teile so nahe aneinander positioniert sind, dass nur die Stärke eines von dem Schneidstrahl herzustellenden Schnitts zwischen benachbarten Teilen gefunden wird, wenn die Form der Teile es erlaubt.
2. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, dass** der Satz von Steuerregeln Regeln zum Zusammenfügen der Teile durch Mikroverbindungen aufweist, die benachbarte Teile miteinander zusammenhalten, und dass eine Mikroverbindung durch Beginnen des Schnitts einer Kontur in einer eingestellten Entfernung in die zu schneidende Kontur oder durch Stoppen des Schnitts einer Kontur in einem eingestellten Abstand vor dem Ende der zu schneidenden Kontur hergestellt wird, so dass der komplette Schnitt der Kontur nicht geschlossen wird, wobei die Größe der dadurch hergestellten Mikroverbindung dem eingestellten Abstand entspricht.
3. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, dass** der Satz von Steuerregeln Regeln zum Trennen der Teile innerhalb der Gruppe aufweist und das Verbinden der Teile mit dem Material, das die Gruppe umgibt, durch Mikroverbindungen, die die Teile mit dem umgebenden Material zusammenhalten, und dass eine Mikroverbindung durch Beginnen des Schnitts einer Kontur in einer eingestellten Entfernung in die zu schneidende Kontur oder durch Stoppen des Schnitts einer Kontur in einem eingestellten Abstand vor dem Ende der zu schneidenden Kontur hergestellt wird, so dass der komplette Schnitt der Kontur nicht geschlossen wird, wobei die Größe der dadurch hergestellten Mikroverbindung dem eingestellten Abstand entspricht.
4. Verfahren nach Anspruch 2 oder 3, **dadurch gekennzeichnet, dass** die Größe der Mikroverbindungen durch die Steuerregeln gesteuert wird, und dass die Variablen zum Steuern der Größe von dem eingestellten Abstand, dem verwendeten Material und dem verwendeten Schneidgerät abhängen.
5. Verfahren nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** der eingestellte Satz von Steuerregeln Regeln zum Umschalten zwischen rechter Werkzeugradiuskompensation, linker Werkzeugradiuskompensation und keiner Werkzeugradiuskompensation während eines ununterbrochenen Schnitts einer Linie oder Kontur ohne Abschalten und Einschalten des Schneidstrahls aufweist.
6. Verfahren nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** der eingestellte Satz von Steuerregeln Regeln zum Anlegen strategisch positionierter Wendebereiche aufweist, indem zu diesem Zweck ein Trennschnitt ausgeführt wird, oder indem eine Linie oder Kontur länger als notwendigerweise erforderlich geschnitten wird, wobei die dadurch angelegte Spalte als ein Wendebereich verwendet wird.
7. Verfahren nach Anspruch 6, **dadurch gekennzeichnet, dass** der Gebrauch der Spalte als Wendebereich erfolgt, indem es dem Schneidstrahl erlaubt wird, das verwendete Schneidgerät in dem Wendebereich einzuholen.
8. Verfahren nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** der eingestellte Satz von Steuerregeln Regeln aufweist, um es dem Schneidstrahl zu erlauben, das verwendete Schneidgerät in einer Abfangstelle einzuholen,

- wenn der Schneidstrahl die Abfangstelle durchquert.
9. Verfahren nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** der Satz von Steuerregeln eine Regel zum Schneiden kleiner Winkel aufweist, wobei die Regel festlegt, dass ein kleiner Winkel in zwei Schnitten geschnitten wird, ein Schnitt für jede Linie, die in den Winkel führt, und ein Schnitt, der in die Spitze des Winkels führt.
10. Verfahren nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass**, wenn der Abstand zwischen zwei Schnitten so klein ist, dass die Eigenschaften des Materials zwischen den zwei Schnitten beeinflusst und schwierig wird, der jeweilige Schnitt in zwei teilweisen Schnitten ausgehend von den äußeren Teilen des Schnitts zu der Mitte des Schnitts ausgeführt wird.
11. Verfahren nach einem der Ansprüche 1, 2, 4, 5, 6, 7, 8, 9 oder 10, **dadurch gekennzeichnet, dass** das Schneiden der Gruppe von Teilen völlig frei von umgebendem Material oder Material zwischen Teilen, das nicht zu irgendeinem Teil gehört, ist.
12. Verfahren nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet dass**, wenn zwei oder mehr Gruppen aus einem Materialstück geschnitten werden, mindestens zwei unterschiedliche Variablen verwendet werden, um den Abstand zwischen benachbarten Teilen von zwei unterschiedlichen Gruppen einzustellen, wobei eine erste Variable einen ersten kleinsten Abstand zwischen benachbarten Teilen mit angrenzenden parallelen Linien darstellt, und eine zweite Variable einen zweiten kleinsten Abstand zwischen benachbarten Teilen darstellt, wo mindestens einer der benachbarten Teile eine angrenzende Tangente hat, wo der Abstand, der von der zweiten Variablen dargestellt wird, kürzer ist als der Abstand, der von der ersten Variablen dargestellt wird.
13. Verfahren nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** eine vierte Variable das verwendete Material darstellt, und dass eine fünfte Variable die verwendete Strahlen-Schneide-technologie darstellt, wie zum Beispiel Schneiden mit Plasma, Laser, Flamme, Wasser, Ionen, Brennschneider, Pellets oder Luft.
14. Verfahren nach Anspruch 13, **dadurch gekennzeichnet, dass** eine sechste Variable die Breite des Schneidstrahls, die von der vierten und fünften Variablen abhängt, darstellt.
15. Verfahren nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** ein Hineinführen oder Hinausführen mittels automatischer Win-
- 5 kelanpassung und Längenanpassung für das Hineinführen oder Hinausführen in Abhängigkeit von dem verwendeten Material, der Stärke des verwendeten Materials und der verwendeten Schneidtechnologie bereitgestellt wird.
16. Verfahren nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** der Schneidvorgang in der folgenden Abfolge ausgeführt wird:
- Schneiden aller Löcher, strategisch positionierter Trennschnitte und gemeinsamer Schnitte,
  - Schneiden aller Taschen, die zwischen Gruppen oder Teilen angelegt werden und
  - Schneiden der äußeren Kontur der Gruppe.
17. Verfahren nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** das Verfahren als ein Tool für die computergestützte Fertigung (CAM) oder die computergestützte Konstruktion (CAD) umgesetzt wird.
18. Verfahren nach einem der Ansprüche 1 bis 16, **dadurch gekennzeichnet, dass** das Verfahren als ein Teil der Steuerregeln und Variablen umgesetzt wird, die von einer numerischen Steuerung in Schneid-ausrüstung, die mittels computergestützter numerischer Steuerung (CNC) gesteuert wird, verwendet wird.
19. System zum maschinellen Schneiden mehrerer Teile aus einem Materialstück, das eine Strahlen-Schneidvorrichtung und eine Steuereinheit zum Steuern der Strahlen-Schneidvorrichtung aufweist, wobei die Steuereinheit angepasst ist, um einem Satz von Steuerregeln zum Schneiden zweidimen-sionaler Formen oder Muster zu folgen, wobei eine Regel oder eine Kombination mehrerer Regeln für den Schneidvorgang in Abhängigkeit von der zu schneidenden Form oder dem zu schneidenden Muster verwendet werden kann, wobei die Form oder das Muster die Teile aus dem Materialstück formt, **dadurch gekennzeichnet, dass** die Steuereinheit angepasst ist, um einem Satz von Steuerregeln zu folgen, der Regeln zum Formen einer Gruppe von Teilen mit freier Form aufweist, wobei die Teile so nahe aneinander positioniert sind, dass nur die Stärke eines Schnitts, den der Schneidstrahl aus-führt, zwischen benachbarten Teilen gefunden wird, wenn die Form der Teile es erlaubt.
20. System nach Anspruch 19, **dadurch gekennzeichnet, dass** die Steuereinheit angepasst ist, um die Schneidvorrichtung zum Belassen von Mikroverbin-dungen zwischen benachbarten Teilen zu steuern, wobei es den Mikroverbindungen erlaubt wird, be-nachbarte Teile miteinander zusammenzuhalten,

wobei die Steuereinheit angepasst ist, um die Schneidvorrichtung zum Beginnen des Schnitts einer Kontur in einem eingestellten Abstand in die zu schneidende Kontur oder zum Stoppen des Schneidens einer Kontur in einem eingestellten Abstand vor dem Ende der zu schneidenden Kontur zu steuern, wobei die Schneidvorrichtung dazu gesteuert wird, den vollständigen Schnitt der Kontur nicht zu schließen, so dass eine Mikroverbindung mit einer Größe bereitgestellt wird, die dem eingestellten Abstand entspricht.

21. System nach Anspruch 19, **dadurch gekennzeichnet, dass** die Steuereinheit angepasst ist, um die Schneidvorrichtung beim Trennen der Teile innerhalb der Gruppe und beim Belassen von Mikroverbindungen zwischen den Teilen und dem Material, das das umgebende Material umgibt, zu steuern, wobei die Steuereinheit angepasst ist, um die Schneidvorrichtung zum Beginnen des Schnitts einer Kontur in einem eingestellten Abstand in die zu schneidende Kontur oder zum Stoppen des Schnitts einer Kontur in einem eingestellten Abstand vor dem Ende der zu schneidenden Kontur zu steuern, wobei die Schneidvorrichtung dazu gesteuert wird, den vollständigen Schnitt der Kontur nicht zu schließen, so dass eine Mikroverbindung mit einer Größe bereitgestellt wird, die dem eingestellten Abstand entspricht.
  22. System nach Anspruch 20 oder 21, **dadurch gekennzeichnet, dass** die Steuereinheit angepasst ist, um Steuerregeln zu folgen, die die Größe der Mikroverbindungen einstellen, und dass Variablen zum Steuern der Größe von dem eingestellten Abstand, dem verwendeten Material und der verwendeten Schneidvorrichtung abhängen.
  23. System nach einem der Ansprüche 19 bis 22, **dadurch gekennzeichnet, dass** die Steuereinheit angepasst ist, um die Schneidvorrichtung zum Umschalten zwischen rechter Werkzeugradiuskompensation, linker Werkzeugradiuskompensation und keiner Werkzeugradiuskompensation während eines kontinuierlichen Schnitts einer Linie oder Kontur umzuschalten, ohne ein neues Loch schneiden zu müssen.
  24. System nach einem der Ansprüche 19 bis 23, **dadurch gekennzeichnet, dass** die Steuereinheit angepasst ist, um die Schneidvorrichtung zum Anlegen strategisch positionierter Wendebereiche zu steuern, indem zu diesem Zweck ein Trennschnitt angelegt wird, oder indem eine Linie oder Kontur länger geschnitten wird als notwendigerweise erforderlich, und die Schneidvorrichtung zum Verwenden der dadurch angelegten Spalte als einen Wendebereich zu steuern.

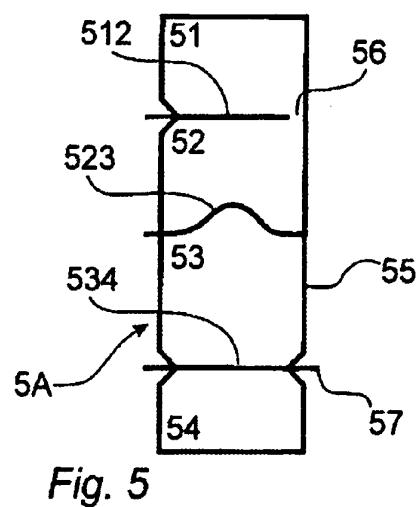
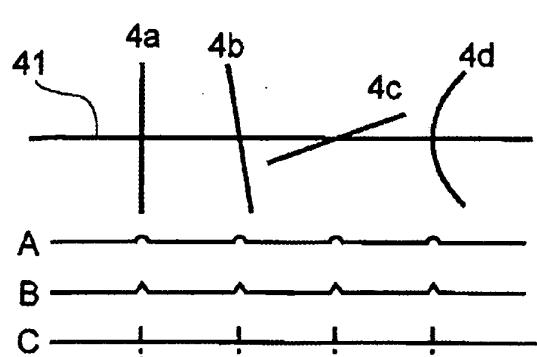
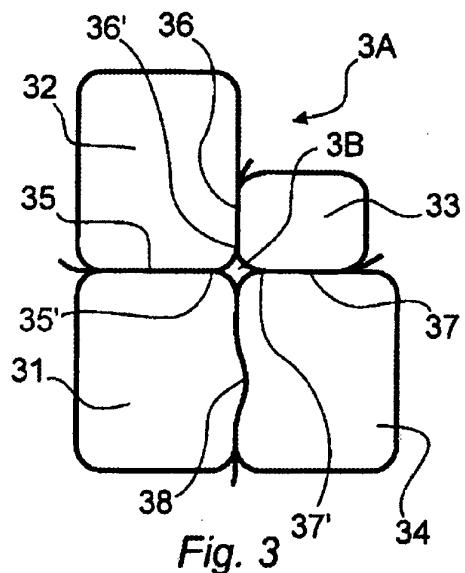
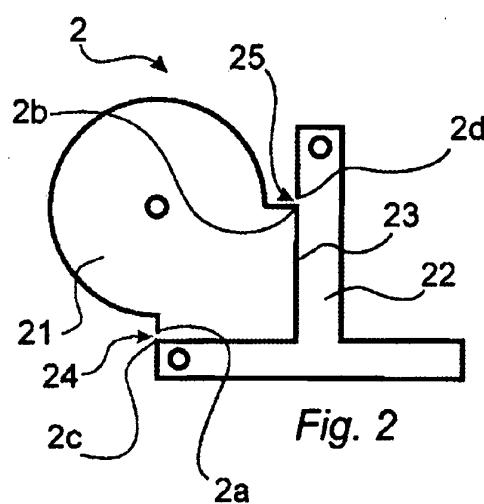
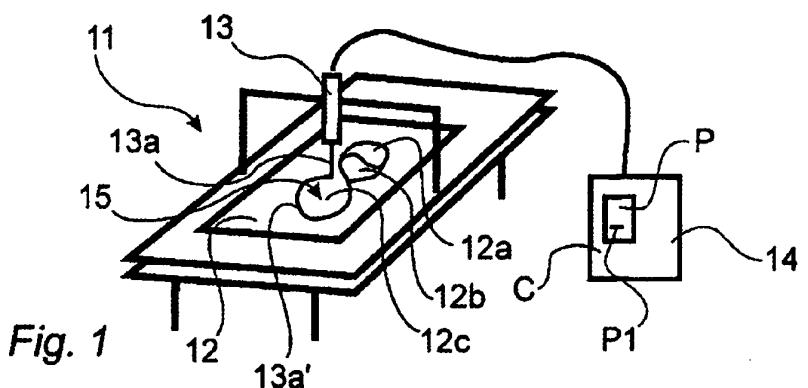
25. System nach Anspruch 24, **dadurch gekennzeichnet, dass** die Steuereinheit angepasst ist, um die Steuervorrichtung zum Benutzen der Spalte als einen Wendebereich zu steuern, indem die Steuervorrichtung derart gesteuert wird, dass es dem Schneidstrahl erlaubt wird, die Schneidvorrichtung in dem Wendebereich einzuholen.
  26. System nach einem der Ansprüche 19 bis 25, **dadurch gekennzeichnet, dass** die Steuereinheit angepasst ist, um die Schneidvorrichtung zu steuern, um es dem Schneidstrahl zu erlauben, die Schneidvorrichtung in einer Abfangstelle einzuholen, wenn der Schneidstrahl die Abfangstelle durchquert.
  27. System nach einem der Ansprüche 19 bis 26, **dadurch gekennzeichnet, dass** die Steuereinheit angepasst ist, um die Schneidvorrichtung zum Schneiden kleiner Winkel in zwei Schnitten zu steuern, ein Schnitt für jede Linie, die in den Winkel führt, und ein Schnitt, der in die Spitze des Winkels führt.
  28. System nach einem der Ansprüche 19 bis 27, **dadurch gekennzeichnet, dass**, wenn der Abstand zwischen zwei Schnitten so klein ist, dass die Eigenschaften des Materials zwischen den zwei Schnitten beeinflusst und schwierig wird, die Steuereinheit angepasst ist, um die Schneidvorrichtung zum Ausführen des jeweiligen Schnitts in zwei teilweisen Schnitten ausgehend von den äußereren Teilen des Schnitts zu der Mitte des Schnitts zu steuern.
  29. System nach einem der Ansprüche 19, 20, 22, 23, 24, 25, 26, 27 oder 28, **dadurch gekennzeichnet, dass** die Steuereinheit angepasst ist, um die Schneidvorrichtung zum Schneiden der Gruppe von Teilen völlig frei von umgebendem Material oder Material zwischen Teilen, das nicht zu irgendeinem Teil gehört, zu steuern.
  30. System nach einem der Ansprüche 19 bis 29, **dadurch gekennzeichnet, dass** jedes Mal, wenn zwei oder mehr Gruppen aus einem Materialstück zu schneiden sind, die Steuereinheit angepasst ist, um die Steuervorrichtung zum Verwenden eines ersten kleinsten Abstands zwischen benachbarten Teilen zu benachbarten parallelen Linien zu steuern, wobei der kleinste Abstand durch eine erste Variable dargestellt wird, und zum Verwenden eines zweiten kleinsten Abstands zwischen benachbarten Teilen zu steuern, wo mindestens einer der benachbarten Teile eine angrenzende Tangente hat, wobei dieser kleinste Abstand durch eine zweite Variable dargestellt wird, wobei der zweite Abstand, der von der zweiten Variable dargestellt wird, kürzer ist als der erste Abstand, der von der ersten Variablen dargestellt wird.

- 31.** System nach einem der Ansprüche 19 bis 30, **dadurch gekennzeichnet, dass** die Steuereinheit angepasst ist, um eine vierte Variable, die verwendetes Material darstellt, und eine fünfte Variable, die die verwendete Strahlen-Schneidtechnologie darstellt, zu berücksichtigen, wie zum Beispiel Schneiden mit Plasma, Laser, Flamme, Wasser, Ionen, Brennschneider, Pellets oder Luft. 5
- 32.** System einem der Ansprüche 19 bis 31, **dadurch gekennzeichnet, dass** die Steuereinheit angepasst ist, um eine sechste Variable zu berücksichtigen, die die Breite des Schneidstrahls, die von der vierten und fünften Variablen abhängt, darstellt. 10
- 33.** System nach einem der Ansprüche 19 bis 32, **dadurch gekennzeichnet, dass** die Steuereinheit angepasst ist, um Hineinführen oder Hinausführen anhand automatischer Winkeleinstellung und Längeneinstellung für das Hineinführen oder Hinausführen in Abhängigkeit von dem verwendeten Material, der Stärke des verwendeten Materials und der verwendeten Schneidtechnologie bereitzustellen. 15
- 34.** System nach einem der Ansprüche 19 bis 33, **dadurch gekennzeichnet, dass** die Steuereinheit angepasst ist, um die Schneidvorrichtung zum Ausführen des Schneidvorgangs in der folgenden Reihenfolge zu steuern: 20
- Schneiden aller Löcher, strategisch positionierter Trennschnitte und gemeinsamer Schnitte,
  - Schneiden aller Taschen, die zwischen Gruppen oder Teilen angelegt werden und
  - Schneiden der äußeren Kontur der Gruppe.
- 35.** System nach einem der Ansprüche 19 bis 34, **dadurch gekennzeichnet, dass** das System angepasst ist, um als ein Tool für computergestützte Fertigung (CAM) oder computergestützte Konstruktion (CAD) zu funktionieren. 25
- 36.** System nach einem der Ansprüche 19 bis 34, **dadurch gekennzeichnet, dass** die Steuereinheit eine numerische Steuerung in einer Maschine mit computergestützter numerischer Steuerung (CNC) ist. 30
- 37.** Computerprogrammprodukt, **dadurch gekennzeichnet, dass** es einen Computerprogrammcode aufweist, der, wenn er ausgeführt wird, es einem Computer erlaubt, die Steuerregeln und Variablen gemäß einem der Ansprüche 1 bis 18 umzusetzen. 35
- Revendications**
1. Procédé de découpe en machine de plusieurs parties dans une pièce de matériau en utilisant une technologie de découpe par faisceau, ledit procédé fourni un ensemble de règles de commande et de variables pour découper des formes ou des motifs en deux dimensions, dans lequel on utilise une règle ou une combinaison de plusieurs règles pour l'opération de découpe en fonction de la forme ou du motif à découper, ladite forme ou ledit motif formant lesdites parties dans ladite pièce de matériau, **caractérisé en ce que** ledit ensemble de règles de commande comprend des règles pour la formation d'un groupe de parties aux formes libres, lesdites parties étant positionnées assez près l'une de l'autre pour que seule l'épaisseur d'une découpe faite par le faisceau de découpe se trouve entre des parties adjacentes chaque fois que la forme desdites parties le permet. 40
  2. Procédé selon la revendication 1, **caractérisé en ce que** ledit ensemble de règles de commande comprend des règles pour la jonction conjointe desdites parties par des micro joints maintenant mutuellement des parties adjacentes et **en ce qu'** un micro joint est élaboré en amorçant la découpe d'un contour à une distance réglée dans le contour à découper ou en arrêtant la découpe d'un contour à une distance réglée avant la fin du contour à découper, en ne terminant pas ainsi la découpe complète du contour, la taille du micro joint ainsi formé correspondant à ladite distance réglée. 45
  3. Procédé selon la revendication 1, **caractérisé en ce que** ledit ensemble de règles de commande comprend des règles pour séparer les parties au sein dudit groupe et joindre les parties avec le matériau entourant ledit groupe par des micro joints maintenant les parties conjointement avec le matériau environnant et **en ce qu'** un micro joint est élaboré en amorçant la découpe d'un contour à une distance réglée dans le contour à découper ou en arrêtant la découpe d'un contour à une distance réglée avant la fin du contour à découper, en ne terminant pas ainsi la découpe complète du contour, la taille du micro joint ainsi formé correspondant à ladite distance réglée. 50
  4. Procédé selon la revendication 2 ou la revendication 3, **caractérisé en ce que** la taille desdits micro joints est commandée par lesdites règles de commande et **en ce que** les variables permettant la commande de ladite taille dépendent de ladite distance réglée, du matériau utilisé et de dispositif de découpe utilisé. 55
  5. Procédé selon l'une quelconque des revendications précédentes, **caractérisé en ce que** ledit ensemble

- de règles de commande comprend des règles pour passer entre une compensation de rayon d'outil droite, une compensation de rayon d'outil gauche et aucune compensation de rayon d'outil au cours d'une découpe continue d'une ligne ou d'un contour sans coupure ni amorçage du faisceau de découpe.
6. Procédé selon l'une quelconque des revendications précédentes, **caractérisé en ce que** ledit ensemble de règles de commande comprend des règles pour la création de zones de rotation positionnées stratégiquement en effectuant une découpe segmentée à cet effet ou en découpant une ligne ou un contour plus long(ue) que cela n'est nécessairement requis et en utilisant l'intervalle ainsi créé comme zone de rotation.
7. Procédé selon la revendication 6, **caractérisé en ce que** l'utilisation dudit intervalle comme zone de rotation se fait en permettant au faisceau de découpe de rattraper le dispositif de découpe utilisé dans ladite zone de rotation.
8. Procédé selon l'une quelconque des revendications précédentes, **caractérisé en ce que** ledit ensemble de règles de commande comprend des règles pour permettre au faisceau de découpe de rattraper le dispositif de découpe utilisé en un point d'intersection lorsque le faisceau de découpe passe par ledit point d'interception.
9. Procédé selon l'une quelconque des revendications précédentes, **caractérisé en ce que** ledit ensemble de règles de commande comprend une règle pour découper de petits angles, ladite règle indiquant qu'un petit angle est coupé en deux découpes, une découpe pour chaque ligne menant à l'angle et chaque découpe menant à la pointe de l'angle.
10. Procédé selon l'une quelconque des revendications précédentes, **caractérisé en ce que**, lorsque la distance entre deux découpes est si faible que les propriétés du matériau entre les deux découpes en sont affectées et commencent à s'opposer, la découpe respective est faite en deux découpes partielles partant des parties externes de ladite découpe vers le centre de ladite découpe.
11. Procédé selon l'une quelconque des revendications 1, 2, 4, 5, 6, 7, 8, 9 ou 10, **caractérisé par** la découpe dudit groupe de parties tout à fait libre du matériau environnant ou du matériau entre les parties qui n'appartient pas à une partie quelconque.
12. Procédé selon l'une quelconque des revendications précédentes, **caractérisé en ce que**, chaque fois que deux groupes ou plus sont découpés dans une pièce de matériau, au moins deux variables différen-
- tes sont utilisées pour régler la distance entre des parties voisines de deux groupes différents, une première variable représentant une première distance très petite entre des parties voisines avec des lignes de bord parallèles et une deuxième variable représentant une seconde distance très petite entre des parties voisines, où au moins l'une desdites parties voisines a une tangente de bord, où la distance représentée par ladite deuxième variable est plus courte que la distance représentée par ladite première variable.
13. Procédé selon l'une quelconque des revendications précédentes, **caractérisé en ce qu'** une quatrième variable représente le matériau utilisé et une cinquième variable représente la technologie de découpe par faisceau utilisée, notamment une découpe au plasma, au laser, à la flamme, à l'eau, par ions, au chalumeau, par granules ou à l'air.
14. Procédé selon la revendication 13, **caractérisé en ce qu'** une sixième variable représente la largeur dudit faisceau de découpe qui dépend desdites quatrième et cinquième variables.
15. Procédé selon l'une quelconque des revendications précédentes, **caractérisé par** la mise en oeuvre d'une entrée ou d'une sortie au moyen d'un ajustement d'angle automatique et d'un ajustement de longueur automatique pour ladite entrée ou ladite sortie en fonction du matériau utilisé, de l'épaisseur dudit matériau utilisé et de la technologie de découpe utilisée.
16. Procédé selon l'une quelconque des revendications précédentes, **caractérisé par** la réalisation de ladite opération de découpe dans la séquence suivante consistant à :
- découper tous les trous, les découpes segmentées positionnées stratégiquement et les découpes communes,
  - découper toutes les poches créées entre les groupes ou les parties, et
  - découper le contour externe du groupe.
17. Procédé selon l'une quelconque des revendications précédentes, **caractérisé en ce que** ledit procédé est mis en oeuvre comme outil de fabrication assistée par ordinateur (FAO) ou de conception assistée par ordinateur (CAO).
18. Procédé selon l'une quelconque des revendications 1 à 16, **caractérisé en ce que** ledit procédé est mis en oeuvre en tant que partie des règles de commande et des variables utilisées par un contrôleur numérique dans un équipement de découpe commandé au moyen d'une commande numérique informatisée

- (CNI).
19. Système de découpe en machine de plusieurs parties dans une pièce de matériau comprenant un dispositif de découpe par faisceau et une unité de commande pour commander ledit dispositif de découpe par faisceau, ladite unité de commande étant à même de suivre un ensemble de règles de commande pour découper des formes ou des motifs en deux dimensions, dans lequel on utilise une règle ou une combinaison de plusieurs règles pour l'opération de découpe en fonction de la forme ou du motif à découper, ladite forme ou ledit motif formant lesdites parties de ladite pièce de matériau, **caractérisé en ce que** ladite unité de commande est à même de suivre un ensemble de règles de commande comprenant des règles pour la formation d'un groupe de parties avec des formes libres, lesdites parties étant positionnées assez près l'une de l'autre pour que seule l'épaisseur d'une découpe faite par le faisceau de découpe se trouve entre des parties adjacentes chaque fois que la forme desdites parties le permet.
20. Système selon la revendication 19, **caractérisé en ce que** ladite unité de commande est à même de commander ledit dispositif de découpe pour laisser des micro joints maintenant mutuellement des parties adjacentes, dans lequel ledit système de commande est à même de commander ledit dispositif de découpe pour amorcer la découpe d'un contour à une distance réglée dans le contour à découper ou arrêter la découpe d'un contour à une distance réglée avant la fin du contour à découper, de manière à commander le dispositif de découpe pour ne pas terminer la découpe complète du contour, formant de la sorte un microjoint d'une taille correspondant à ladite distance réglée.
21. Système selon la revendication 19, **caractérisé en ce que** ladite unité de commande est à même de commander ledit dispositif de découpe pour séparer les parties au sein dudit groupe et laisser des micro joints entre les parties et le matériau environnant ledit groupe, permettant ainsi auxdits micro joints de maintenir les parties conjointement avec le matériau environnant, dans lequel ladite unité de commande est à même de commander ledit dispositif de découpe pour amorcer la découpe d'un contour à une distance réglée dans le contour à découper ou arrêter la découpe d'un contour à une distance réglée avant la fin du contour à découper, de manière que le dispositif de découpe soit commandé pour ne pas terminer la découpe complète du contour, formant ainsi un microjoint d'une taille correspondant à ladite distance réglée.
22. Système selon la revendication 20 ou la revendication 21, **caractérisé en ce que** ladite unité de com-
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- mande est à même de suivre des règles de commande régulant la taille desdits micro joints et **en ce que** les variables pour la commande de ladite taille dépendent de ladite distance réglée, du matériau utilisé et de dispositif de découpe utilisé.
23. Système selon l'une quelconque des revendications 19 à 22, **caractérisé en ce que** ladite unité de commande est à même de commander ledit dispositif de découpe pour passer entre une compensation de rayon d'outil droite, une compensation de rayon d'outil gauche et aucune compensation de rayon d'outil au cours d'une découpe continue d'une ligne ou d'un contour sans devoir découper un nouveau trou.
24. Système selon l'une quelconque des revendications 19 à 23, **caractérisé en ce que** ladite unité de commande est à même de commander ledit dispositif de découpe pour créer des zones de rotation positionnées stratégiquement en effectuant une découpe segmentée à cet effet ou en découpant une ligne ou un contour plus long(ue) que cela n'est nécessairement requis et en commandant ledit dispositif de découpe pour utiliser l'intervalle ainsi créé comme zone de rotation.
25. Système selon la revendication 24, **caractérisé en ce que** ladite unité de commande est à même de commander ledit dispositif de découpe pour utiliser ledit intervalle comme zone de rotation en commandant ledit dispositif de découpe de sorte que le faisceau de découpe puisse rattraper le dispositif de découpe dans ladite zone de rotation.
26. Système selon l'une quelconque des revendications 19 à 25, **caractérisé en ce que** ladite unité de commande est à même de commander ledit dispositif de découpe pour permettre au faisceau de découpe de rattraper le dispositif de découpe utilisé en un point d'intersection lorsque le faisceau de découpe passe par ledit point d'interception.
27. Système selon l'une quelconque des revendications 19 à 26, **caractérisé en ce que** ledit dispositif de commande est à même de commander ledit dispositif de découpe pour découper de petits angles en deux découpes, une découpe pour chaque ligne menant à l'angle et chaque découpe menant à la pointe de l'angle.
28. Système selon l'une quelconque des revendications 19 à 27, **caractérisé en ce que**, lorsque la distance entre deux découpes est si faible que les propriétés du matériau entre les deux découpes sont affectées et commencent à s'opposer, ladite unité de commande est à même de commander ledit dispositif de découpe pour faire une découpe respective en deux

- découpes partielles partant des parties externes de ladite découpe vers le centre de ladite découpe.
29. Système selon l'une quelconque des revendications 19, 20, 22, 23, 24, 25, 26, 27 ou 28, **caractérisé en ce que** ladite unité de commande est à même de commander ledit dispositif de découpe pour découper ledit groupe de parties tout à fait librement du matériau environnant ou du matériau entre les parties qui n'appartient pas à une partie quelconque. 5
30. Système selon l'une quelconque des revendications 19 à 29, **caractérisé en ce que**, chaque fois que deux groupes ou plus doivent être découpés dans une pièce de matériau, ladite unité de commande est à même de commander ledit dispositif de découpe pour utiliser une première distance très petite entre des parties voisines avec des lignes de bord parallèles, ladite distance très petite étant représentée par une première variable, et d'utiliser une seconde distance très petite entre des parties voisines, où au moins l'une desdites parties voisines a une tangente de bord, cette très petite distance étant représentée par une seconde variable, la seconde distance représentée par ladite seconde variable étant plus courte que la première distance représentée par ladite première variable. 10
31. Système selon l'une quelconque des revendications 19 à 30, **caractérisé en ce que** ladite unité de commande est à même de prendre en compte une quatrième variable représentant le matériau utilisé et une cinquième variable représentant la technologie de découpe par faisceau utilisée, notamment une découpe au plasma, au laser, à la flamme, à l'eau, par ions, au chalumeau, par granules ou à l'air. 15
32. Système selon l'une quelconque des revendications 19 à 31, **caractérisé en ce que** ladite unité de commande est à même de prendre en compte une sixième variable représentant la largeur dudit faisceau de découpe qui dépend desdites quatrième et cinquième variables. 20
33. Système selon l'une quelconque des revendications 19 à 32, **caractérisé en ce que** ladite unité de commande est à même de mettre en oeuvre une entrée ou une sortie au moyen d'un ajustement d'angle et d'un ajustement de longueur automatiques pour ladite entrée ou ladite sortie en fonction du matériau utilisé, de l'épaisseur dudit matériau utilisé et de la technologie de découpe utilisée. 25
34. Système selon l'une quelconque des revendications 19 à 33, **caractérisé en ce que** ladite unité de commande est à même de commander ledit dispositif de découpe pour réaliser ladite opération de découpe dans la séquence suivante consistant à : 30
- découper tous les trous, les découpes segmentées positionnées stratégiquement et les découpes communes,
- découper toutes les poches créées entre des groupes ou des parties, et
- découper le contour externe du groupe. 35
35. Système selon l'une quelconque des revendications 19 à 34, **caractérisé en ce que** ledit système est à même de fonctionner comme outil de fabrication assistée par ordinateur (FAO) ou de conception assistée par ordinateur (CAO). 40
36. Système selon l'une quelconque des revendications 19 à 34, **caractérisé en ce que** ladite unité de commande est un contrôleur numérique dans une machine à commande numérique informatisée (CNI). 45
37. Produit de programme d'ordinateur **caractérisé en ce qu'il comprend** un code de programme informatique qui, lorsqu'il est exécuté, permet à un ordinateur de mettre en oeuvre les règles de commande et les variables selon l'une quelconque des revendications 1 à 18. 50



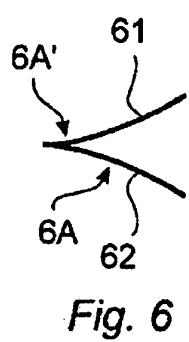


Fig. 6

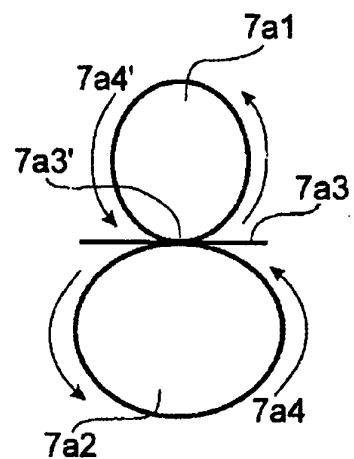


Fig. 7a

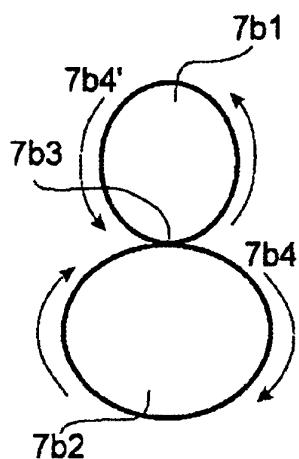


Fig. 7b

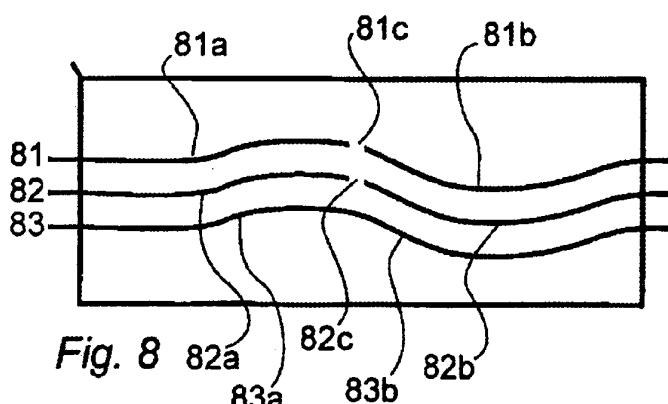


Fig. 8 82a 82c 83a 83b 82b

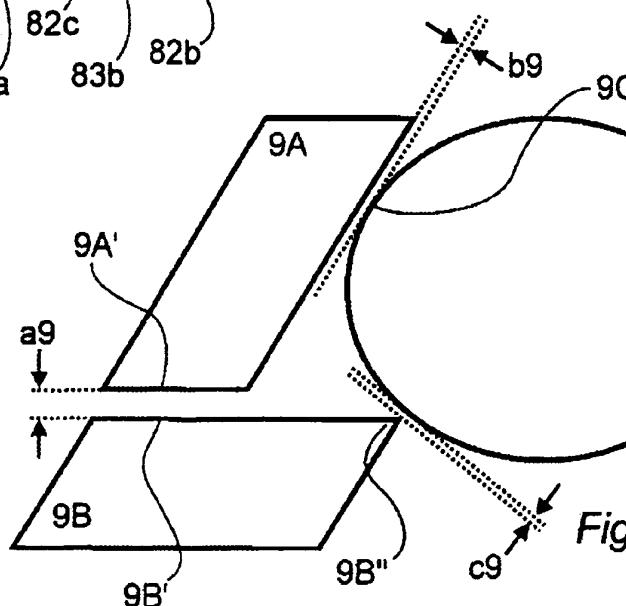


Fig. 9

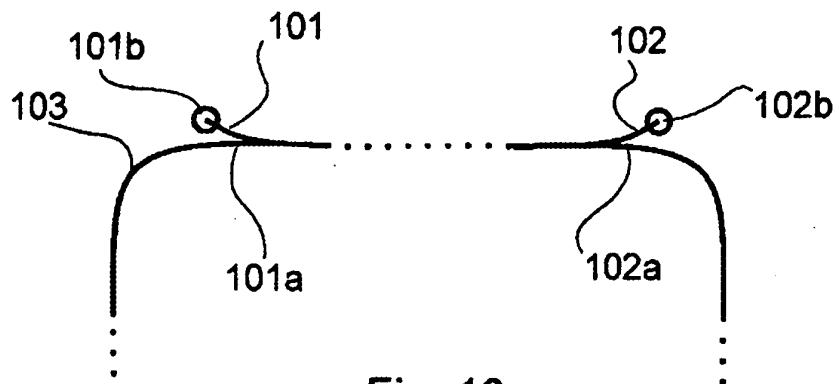


Fig. 10

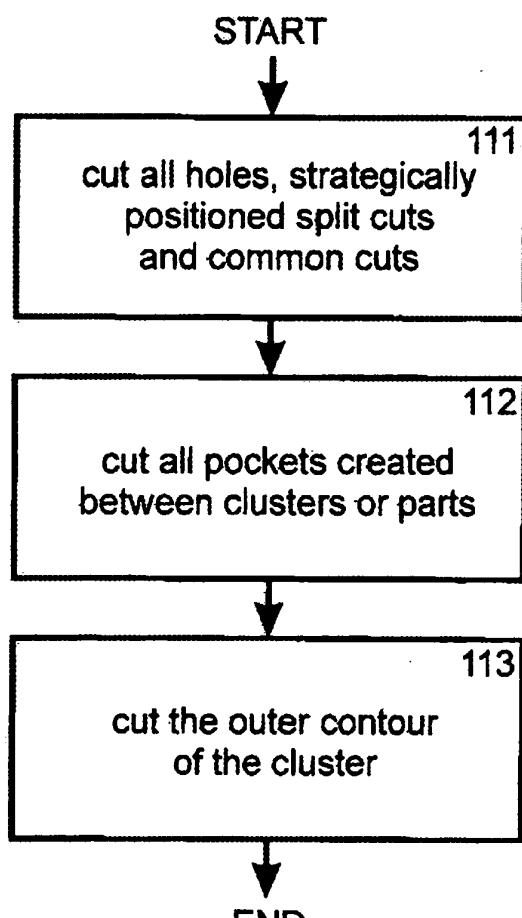


Fig. 11