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(54) Method for forming of tubular work-pieces using a segmented tool

Verfahren zum Umformen von rohrförmigen Werkstücken mit einem segmentierten Werkzeug

Procédé de formage de pièces tubulaires utilisant un outil segmenté

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(73) Proprietor: **Sapa Profiler AB
574 81 Vetlanda (SE)**

(72) Inventors:
• **Bjuhr, Jonas
574 93 Vetlanda (SE)**

• **Nilsson, Tomas
574 41 Vetlanda (SE)**

(74) Representative: **Stein, Jan Anders Lennart et al
Groth & Co. KB
P.O. Box 6107
102 32 Stockholm (SE)**

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Description

FIELD OF INVENTION

[0001] The invention relates to the forming of tubular work-pieces by internal pressure created by a fluid, i.e. hydroforming, and in particular to a segmented tool used for said forming operation.

BACKGROUND

[0002] The hydroforming process is described in "Hydroforming - Umformen mit Wirkmedien im Automobilbau, Verlag Moderne Industrie, Landsberg, 2002". In this process tubes formed to final shape by insertion in a tool where the tubes are expanded by applying an internal pressure to the inside of the tube using a fluid. The tubes may be straight or pre-bent depending on the final requirements.

Hydroforming of large work-pieces, such as side-members for car body structures presents significant problems due to the difficulty of handling the very heavy tools that are required as moulds during forming. For this reason segmented tool inserts, i.e. tools that consists of two or more parts, are sometimes used, which considerably facilitates the handling and makes it possible to exchange parts of the inserts if the insert has been damaged or worn, without replacing the whole tool. To keep the segments in place the tool insert is surrounded by a base block, with tight tolerances to the segmented inserts. The base block may be manufactured in one part or may comprise a base and vertical supports fixed to it. The disadvantage of this arrangement is the high cost for the base blocks and the fact that these base blocks are even heavier and more difficult to handle than single piece inserts.

[0003] The problems connected with the use of large toolings become particularly pronounced when small series or prototypes are manufactured, which means that the tool has to be replaced frequently. The problem is discussed in "Innenhochdruck-Umformen für Karosseriekomponenten, 3. Chemnitzer Karosseriekolloquium, CBC 2002, Verlag Wissenschaftliche Scripten, Zwickau", page 62, where it is suggested that tools for prototypes are manufactured by forming a cavity directly in a single piece of metal and simplified in the sense that no inserts are used. This does not make handling of the tool easier and no possibility to exchange a part of the tool is possible.

[0004] In "Hydroforming-Umformen mit Wirkmedien im Automobilbau" segmented inserts are mentioned, but always in combination with base blocks that keep the segments from separating during forming.

SUMMARY OF THE INVENTION

[0005] An object of the present invention is to provide a simplified tool for hydroforming of tubular work-pieces, where the use of very large tooling blocks can be pre-

vented. The invention is particularly useful when small series or prototypes are manufactured.

[0006] According to a first preferred embodiment of the present invention a tool comprising a pair of upper and lower tool inserts having open axial ends and defining an elongated cavity there between when said tool inserts are forced together. The upper and/or lower tool inserts are composed of segments that are attached to the upper and a lower base plates by bolts. Retaining elements, such as pins, are introduced into holes in the base plates from where they extend thorough the base plate and continue into cavities formed in the segmented insert (or extend from the insert into holes in the baseplate). This prevents the insert segments from moving during the forming operation. The retaining elements normally have a round or a conical shape for easier guidance into the cavities and a tight tolerance to the cavities to minimise movement of the segments. In this way the use of base blocks may be omitted.

[0007] To guide the tool inserts to the desired position on the base plate guide columns are used.

The guide columns are attached to the upper base plate and extend through the base plate and the insert. By lowering the upper tool punch vertically towards the lower base plate the guide columns from the upper tool half are introduced into spaces in the lower half of the insert. The guide columns and the retaining elements may also be attached or form part of the inserts and extend through the base plate.

[0008] The retaining elements may act as guide columns, or separate guide columns may be used. The tolerances, however, has to be tight between pin and the hole in the base plate to assure the non-movement of the insert segments.

[0009] According to a second preferred embodiment of the invention the friction force between the base plate and the insert may be high enough to prevent axial movement of the segments, and in this case the retaining elements may be omitted.

[0010] A pair of mandrels adjacent the axial open ends of the elongated cavity retain the tubular work-piece in the cavity and forms a sealed closure of the ends of the tubular work-piece.

Work-piece material is forced axially inwardly during forming of the work-piece and hydroforming liquid is entered through the mandrel into the work-piece for hydroforming the work-piece into the final shape. The pressurising of the work-piece may be done either before or after the closure of the tool.

[0011] The method of the present invention allows the elimination of the very large and heavy base blocks that has been a prerequisite in previously used methods. In this way production times may be shortened and the costs reduced.

DESCRIPTION OF THE DRAWINGS

[0012]

Figure 1 is a plan view of a hydroforming tool according to the prior art.

Figure 2 is a plan view of a hydroforming tool according to the invention.

DETAILED DESCRIPTION

[0013] In figure 1 a segmented tool according to the state of the art is shown. Vertical supports (V) fixed to the base block, prevents movement of the segments.

[0014] Referring to figure 2, a hydroforming tool comprising a base plate (A) and a segmented insert (B), having through holes for guide columns (C) and smaller diameter holes (D) for the retaining elements (pins not shown in figure). The retaining elements are snugly fitted into the base plate, which makes attachment of the elements superfluous. As can be seen the tool is free from vertical supports acting on the outer surface of the insert.

[0015] When the upper tool half is lowered, the guide columns assure the guiding of the tool parts to their exact position. When pressure is applied to the hydroforming liquid, high forces act on the tool parts, some of these in directions that would cause separation of the segments of the inserts if no opposed forces counteract them. The retaining elements or sometimes, depending on the dimension and shape of the workpiece, only the friction force acting between the base plate and segmented inserts caused by the high pressure applied to the tool surfaces, will prevent the separation of the segments. There is thereby no need for vertical supports acting on the outer surfaces of the insert.

[0016] The number of segments may be varied freely, it is however common for the number of segments to exceed two.

[0017] The number of segments may be varied freely, it is however common for the number of segments to exceed two.

[0018] In particular, the invention provides a method of hydroforming hollow work-pieces in accordance with claim 1.

Example 1

[0019] A hydroforming tool comprising an upper punch, base plates with a pair of upper and lower tool inserts attached to them is used for forming of a tubular work-piece made from extruded aluminium. The inserts have open axial ends and define an elongated cavity between them when the tool is dosed. The inserts are each composed of at least two segments that are screwed onto the base plates. Retaining elements are introduced into holes in the base plate and partially through the segments of the inserts. Guide columns extending through and from the base plates are introduced into cavities formed in the segmented inserts when the upper punch is lowered.

[0020] A tubular work-piece was put in said cavity and the upper and lower tool inserts moved together to deform

portions of the work-piece. The ends of the tubular work-piece were sealed and the work-piece filled with liquid through an inlet in the mandrels while supplying work-piece material axially inwardly.

[0021] Pressure was then applied to the inside of the work-piece by increasing the pressure on said liquid. The cavities in the base plates have a tight tolerance to the retaining elements, so that the movement of the segment during forming is as low as possible. The tool was opened and the formed pieces removed. No marks could be found on the work-piece to indicate that a movement of the segments had taken place. When a number of tubes have been formed the tool insert was replaced by removing each segment separately.

Example 2

[0022] A hydroforming tool as in example 1, but without retaining elements, is used for forming a tubular work-piece made from extruded aluminium. The tubular work-piece is put in said cavity and the upper and lower tool inserts are moved together to deform portions of the work-piece while supplying work-piece material axially inwardly. Pressure of 1500 tonnes is applied to the tool parts by the tool punch. Pressure is then applied to the inside of the work-piece by increasing the pressure on said liquid to 1000 bar. The tool is opened and the formed pieces are removed. No movement of the segments could be observed.

Claims

1. A method of hydroforming hollow work-pieces by providing a pair of upper and lower tool inserts (B) having open axial ends and defining an elongated cavity (E) there between when said tool inserts are forced together in a Z-direction by means of a tool punch, said upper and lower tool inserts being composed of at least two longitudinal segments that are in a locked position relative to a base plate (A) during the forming of the work-piece and

- a) providing a hollow work-piece in said cavity
- b) sealing the ends of the hollow work-piece
- c) filling said work-piece with liquid
- d) applying an internal pressure to the inside of the work-piece by increasing the pressure on said liquid
- e) moving said upper and lower tool inserts together to deform portions of the work-piece at any time after step a

characterized in that said longitudinal segments are in contact with said base plate (A) on the side opposite to the elongated cavity and movement of said segments in the x and y directions is prevented by other means than by using vertical supports acting

on the outer surfaces of the inserts.

2. Method according to claim 1, **characterized in that** movement of the segments is prevented by providing retaining elements which extend from at least one base plate(A) into cavities for retaining elements (D) formed in the segments on the opposite side of the elongated cavity or vice versa, said cavities for retaining elements being adapted to receive said retaining elements. 5
3. Method according to claim 1, **characterized in that** segment movement of the segments is prevented by providing retaining elements which extend from said segments into cavities for retaining elements formed in the base plate on the opposite side of the elongated cavity, said cavities for retaining elements being adapted to receive said retaining elements. 10
4. Method according to any of claims 1-2, **characterized in that** the segments are guided into the upper and the lower base plates by guide columns (C). 15
5. Method according to claim 3, **characterized in that** the retaining elements are guide columns. 20
6. Method according to claim 1, **characterized in that** the segments are kept in said locked position mainly by friction forces acting between the base plate and the insert. 25
7. A tool for hydroforming a hollow work-piece comprising a pair of upper and lower base plates (A) and a pair of upper and lower tool inserts (B) having open axial ends and defining an elongated cavity (E) there between when said tool inserts are forced together by means of a tool punch in a Z-direction, said upper and lower tool inserts each being composed of longitudinal segments that are in a locked position in relation to said base plate (A) **characterized in that** said segments are in contact with said upper and lower base plate (A) on the side opposite to the elongate cavity said tool being free from vertical supports acting on the outer surfaces of the insert to prevent movement thereof in the X- and Y- direction. 30
8. A tool for hydroforming a hollow work-piece according to claim 7, **characterized in that** retaining elements are provided which extend from at least one of the base plates into cavities for retaining elements (D) formed in the segments on the opposite side of the elongated cavity, said cavities for retaining elements being adapted to receive said retaining elements. 35
9. A tool for hydroforming a hollow work-piece according to claim 7, **characterized in that** retaining elements are provided which extend from at least one 40

of the segments into cavities for retaining elements (D) formed in the base plate on the opposite side of the elongated cavity, said cavities for retaining elements being adapted to receive said retaining elements. 45

10. A tool for hydroforming a hollow work-piece according to any of claims 7-9, **characterized in that** the segments are guided onto the base plate on the opposite side of the elongated cavity by guide columns (C) which extend from said base plates. 50
11. A tool for hydroforming a hollow work-piece according to any of claims 7-10, **characterized in that** the upper and the lower base plates are guided onto the segments on the opposite side of the elongated cavity by guide columns (C) which extend from said segments. 55
12. A tool for hydroforming a hollow work-piece according to any of claims 8-9, **characterized in that** the retaining elements are guide columns.
13. A tool for hydroforming a hollow work-piece according to any of claims 8-12, **characterized in that** the retaining elements are in the shape of pins.

Patentansprüche

1. Verfahren zum Umformen hohler Werkstücke durch Hydroformung, bei dem man ein Paar oberer und unterer Werkzeugeinsätze (B) mit offenen axialen Enden bereitstellt, die zwischen, sich einen langgestreckten Hohlraum (E) umschließen, wenn die Werkzeugeinsätze mittels eines Werkzeugstempels in einer Z-Richtung zusammengedrückt werden, wobei die oberen und/oder unteren Werkzeugeinsätze sich jeweils aus mindestens zwei längsgerichteten Segmenten zusammensetzen, die während der Formgebung des Werkstücks eine versperrte Position relativ zu einer Grundplatte (A) einnehmen, und
 - a) ein hohles Werkstück in den Hohlraum einbringt,
 - b) die Enden des hohlen Werkstücks dicht verschließt,
 - c) das Werkstück mit Flüssigkeit füllt,
 - d) das Innere des Werkstücks mit einem Innendruck beaufschlagt, indem man den auf der Flüssigkeit lastenden Druck erhöht,
 - e) die oberen und unteren Einsätze zusammenführt, um zu beliebiger Zeit nach dem Schritt a) Teile des Werkstücks zu verformen,

dadurch gekennzeichnet, dass die längsgerichteten Segmente auf der dem langgestreckten Hohlraum entgegengesetzten Seite in Berührung mit der

Grundplatte (A) stehen und dass eine Bewegung der Segmente in der X- und der Y-Richtung durch andere Mittel als auf die Außenflächen der Einsätze wirkende vertikale Stützen verhindert ist.

2. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, dass** eine Bewegung der Segmente durch Rückhalteelemente verhindert ist, die von der Grundplatte (A) weg in Hohlräume für Rückhalteelemente (D) hinein verlaufen, die in den Segmenten auf der dem langgestreckten Hohlraum abgewandten Seite ausgebildet und in der Lage sind, die Rückhalteelemente aufzunehmen. 5
3. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, dass** eine Bewegung der Segmente durch Rückhalteelemente verhindert ist, die von den Segmenten weg in Hohlräume für Rückhalteelemente hinein verlaufen, die in der Grundplatte auf der dem langgestreckten Hohlraum entgegengesetzten Seite ausgebildet und in der Lage sind, die Rückhalteelemente aufzunehmen. 10
4. Verfahren nach einem der Ansprüche 1-2, **dadurch gekennzeichnet, dass** die Segmente auf der oberen und der unteren Grundplatte durch Führungssäulen (C) geführt werden. 15
5. Verfahren nach Anspruch 3, **dadurch gekennzeichnet, dass** die Rückhalteelemente Führungssäulen sind. 20
6. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, dass** die Segmente hauptsächlich durch zwischen der Grundplatte und dem Einsatz wirkende Reibungskräfte in der versperrten Position gehalten werden. 25
7. Werkzeug zur Hydroformung eines hohlen Werkstücks durch Hydroformung, das eine obere und eine untere Grundplatte (A) sowie ein Paar oberer und unterer Werkzeugeinsätze (B) mit offenen axialen Enden aufweist, die zwischen sich einen langgestreckten Hohlraum (E) umschließen, wenn die Werkzeugeinsätze mittels eines Werkzeugs in einer Z-Richtung zusammengedrückt werden, wobei die oberen und/oder unteren Werkzeugeinsätze sich jeweils aus längsgerichteten Segmenten zusammensetzen, die eine versperrte Position relativ zur Grundplatte (A) einnehmen, **dadurch gekennzeichnet, dass** die Segmente auf dem langgestreckten Hohlraum (E) entgegengesetzten Seiten in Berührung mit der oberen bzw. unteren Grundplatte (A) stehen und dass das Werkzeug frei von vertikalen Stützen ist, die auf die Außenflächen des Einsatzes wirken, um eine Bewegung desselben in der X- und der Y-Richtung zu verhindern. 30

8. Werkzeug zur Hydroformung eines hohlen Werkstücks nach Anspruch 7, **dadurch gekennzeichnet, dass** Rückhalteelemente vorgesehen sind, die von mindestens einer der Grundplatten weg in Hohlräume für Rückhalteelemente (D) hinein verlaufen, die in den Segmenten auf der dem langgestreckten Hohlraum entgegengesetzten Seite ausgebildet und in der Lage sind, die Rückhalteelemente aufzunehmen. 35
9. Werkzeug zur Hydroformung eines hohlen Werkstücks nach Anspruch 7, **dadurch gekennzeichnet, dass** Rückhalteelemente vorgesehen sind, die von mindestens einem der Segmente weg in Hohlräume für Rückhalteelemente (D) hinein verlaufen, die in der Grundplatte auf der dem langgestreckten Hohlraum entgegengesetzten Seite ausgebildet und in der Lage sind, die Rückhalteelemente aufzunehmen. 40
10. Werkzeug zur Hydroformung eines hohlen Werkstücks nach Anspruch 7-9, **dadurch gekennzeichnet, dass** die Segmente auf der Grundplatte auf der dem langgestreckten Hohlraum entgegengesetzten Seite von Führungssäulen (C) geführt sind, die von den Grundplatten abstehen. 45
11. Werkzeug zur Hydroformung eines hohlen Werkstücks nach Anspruch 7-10, **dadurch gekennzeichnet, dass** die oberen und unteren Grundplatten auf den Segmenten auf der dem langgestreckten Hohlraum entgegengesetzten Seite von Führungssäulen (C) geführt sind, die von den Segmenten abstehen. 50
12. Werkzeug zur Hydroformung eines hohlen Werkstücks nach Anspruch 8-9, **dadurch gekennzeichnet, dass** die Rückhalteelemente Führungssäulen sind. 55
13. Werkzeug zur Hydroformung eines hohlen Werkstücks nach Anspruch 8-12, **dadurch gekennzeichnet, dass** die Rückhalteelemente in der Gestalt von Bolzen vorliegen.

Revendications

1. Un procédé d'hydroformage de pièces de fabrication creuses, par disposition d'une paire de plaquettes d'outil supérieure et inférieure (B) ayant des extrémités axiales ouvertes et définissant une cavité allongée (E) entre elles lorsque cesdites plaquettes d'outil sont poussées ensemble dans une direction Z- au moyen d'un poinçon à outil, lesdites plaquettes d'outil supérieure et/ou inférieure étant composées d'au moins deux segments longitudinaux qui sont en position verrouillée par rapport à une plaque de base

- (A) pendant le formage de la pièce de fabrication et
- a) disposition d'une pièce de fabrication creuse dans ladite cavité
 - b) scellement des extrémités de la pièce de fabrication creuse
 - c) remplissage de ladite pièce de fabrication avec du liquide
 - d) application d'une pression interne à l'intérieur de la pièce de fabrication en augmentant la pression sur ledit liquide
 - e) poussée desdites plaques d'outil supérieure et inférieure ensemble pour déformer des portions de la pièce de fabrication en tout temps après l'étape a
- caractérisé en ce que** lesdits segments longitudinaux sont en contact avec ladite plaque de base (A) sur le côté opposé de la cavité allongée et le mouvement desdits segments dans des directions X et Y est empêché par d'autres moyens que par l'utilisation de supports verticaux agissant sur les surfaces externes des plaquettes.
2. Un procédé selon la revendication 1, **caractérisé en ce que** le mouvement des segments est empêché par la disposition d'éléments de retenue qui s'étendent à partir de ladite plaque de base (A) jusque dans les cavités prévues pour des éléments de retenue (D) formés dans les segments sur le côté opposé de la cavité allongée, lesdites cavités pour les éléments de retenue étant adaptées pour recevoir lesdits éléments de retenue.
 3. Un procédé selon la revendication 1, **caractérisé en ce que** le mouvement des segments est empêché par la disposition d'éléments de retenue qui s'étendent à partir desdits segments jusque dans les cavités prévues pour les éléments de retenue formés dans la plaque de base sur le côté opposé de la cavité allongée, lesdites cavités pour les éléments de retenue étant adaptées pour recevoir lesdits éléments de retenue.
 4. Un procédé selon l'une quelconque des revendications 1-2 **caractérisé en ce que** les segments sont guidés sur les plaques de base supérieure et inférieure par des colonnes de guidage (C).
 5. Un procédé selon la revendication 3, **caractérisé en ce que** les éléments de retenue sont des colonnes de guidage.
 6. Un procédé selon la revendication 1, **caractérisé en ce que** les segments sont maintenus dans ladite position verrouillée principalement par des forces de frictions agissant entre la plaque de base et la plaquette.
 7. Un outil pour l'hydroformage d'une pièce de fabrication creuse comportant une plaque de base supérieure et inférieure (A) et une paire de plaquettes d'outil supérieure et inférieure (B) ayant des extrémités axiales ouvertes et définissant une cavité allongée (E) entre elles lorsque cesdites plaquettes d'outil sont poussées ensemble au moyen d'un poinçon à outil, dans une direction Z-, lesdites plaquettes d'outil supérieure et/ou inférieure étant chacune composées de segments longitudinaux qui sont en position verrouillée par rapport à ladite plaque de base (A), **caractérisé en ce que** lesdits éléments sont en contact avec ladite plaque de base supérieure et inférieure (A) sur les côtés opposés de la cavité allongée (E), respectivement, ledit outil étant exempt de supports verticaux agissant sur les surfaces extérieures de la plaquette, pour en prévenir le mouvement dans la direction X- et Y-.
 8. Un outil pour l'hydroformage d'une pièce de fabrication creuse selon la revendication 7, **caractérisé en ce que** des éléments de retenue sont pourvus et ceux-ci s'étendent à partir d'au moins une des plaques de base jusque dans les cavités prévues pour les éléments de retenue (D) formés dans les segments sur les côtés de la cavité allongée, lesdites cavités pour les éléments de retenue étant adaptées pour recevoir lesdits éléments de retenue.
 9. Un outil pour l'hydroformage d'une pièce de fabrication creuse selon la revendication 7, **caractérisé en ce que** des éléments de retenue sont pourvus et ceux-ci s'étendent à partir d'au moins un des segments dans les cavités prévues pour les éléments de retenue (D) formés dans la plaque de base sur le côté opposé de la cavité allongée, lesdites cavités pour les éléments de retenue étant adaptées pour recevoir lesdits éléments de retenue.
 10. Un outil pour l'hydroformage d'une pièce de fabrication creuse selon l'une quelconque des revendications 7-9, **caractérisé en ce que** les segments sont guidés sur la plaque de base, sur le côté opposé de la cavité allongée, par des colonnes de guidage (C) qui s'étendent à partir desdites plaques de base.
 11. Un outil pour l'hydroformage d'une pièce de fabrication creuse selon l'une quelconque des revendications 7-10, **caractérisé en ce que** la plaque de base supérieure et la plaque de base inférieure sont guidées sur les segments, sur le côté opposé de la cavité allongée, par des colonnes de guidage (C) qui s'étendent à partir desdits segments.
 12. Un outil pour l'hydroformage d'une pièce de fabrication creuse selon l'une quelconque des revendications 8-9, **caractérisé en ce que** les éléments de retenue sont des colonnes de guidage.

13. Un outil pour l'hydroformage d'une pièce de fabrication creuse selon l'une quelconque des revendications 8-12, **caractérisé en ce que** les éléments de retenue sont en forme de tiges.

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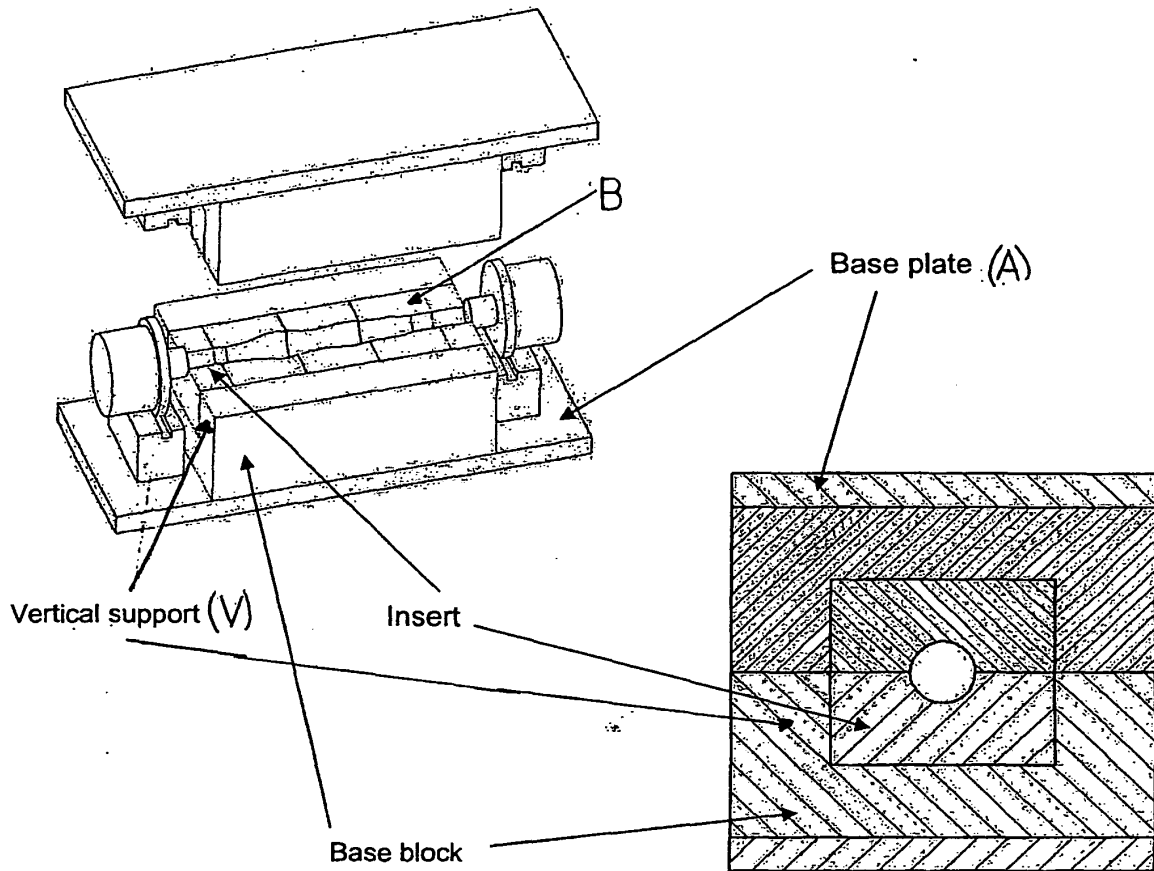


Figure 1

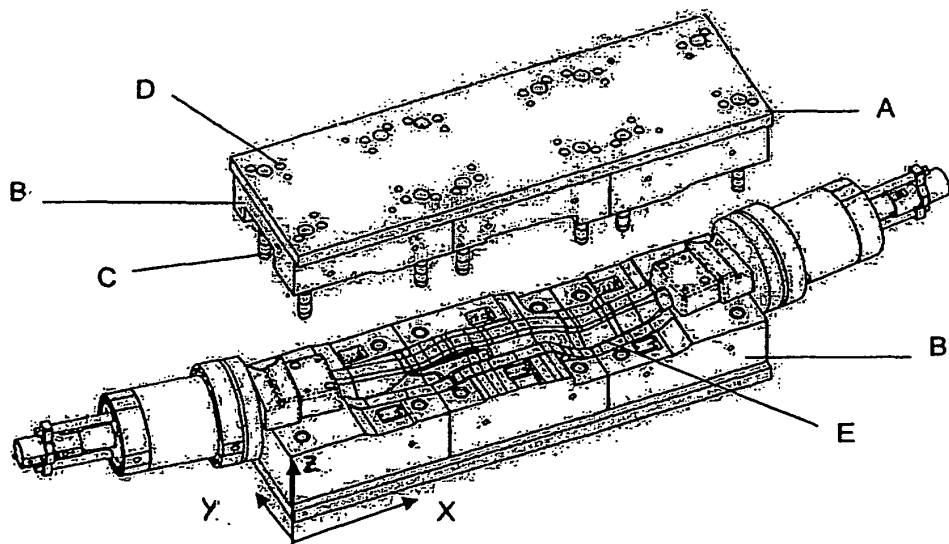


Figure 2