



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
10.09.2003 Bulletin 2003/37

(51) Int Cl.7: **B21D 26/02**

(21) Application number: **03445005.6**

(22) Date of filing: **17.01.2003**

(84) Designated Contracting States:
**AT BE BG CH CY CZ DE DK EE ES FI FR GB GR
HU IE IT LI LU MC NL PT SE SI SK TR**
Designated Extension States:
AL LT LV MK RO

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(30) Priority: **07.03.2002 SE 0200682**

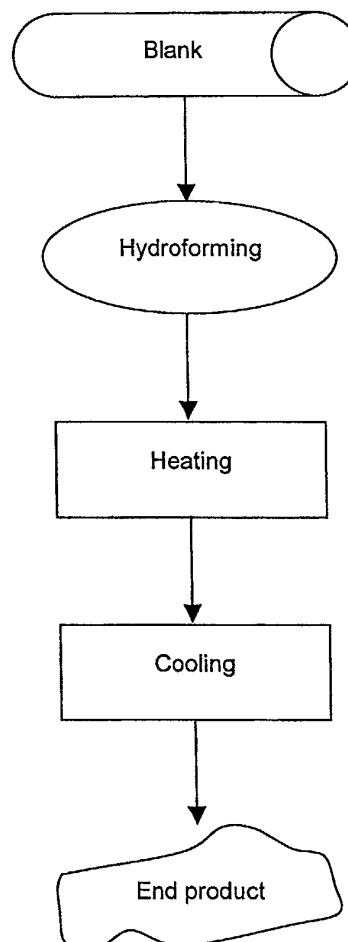
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(54) **Process for the manufacture of closed, hardened sections with no cross-sectional limits**

(57) Method for the manufacture of closed, hardened steel sections by hydroforming, a blank being placed in a substantially enclosing forming tool and openings in the blank being closed and connections for hydraulic fluid being provided to the inside of the blank and fluid being pumped into the blank at high pressure so that the blank is deformed according to the forming tool, the fluid being removed and the blank being hardened by heating and subsequent cooling.

Figure 1



Description

Background to the invention

[0001] In the vehicle industry, in particular, there is an ever increasing demand for constructions which give a reduced weight combined with a high capacity to absorb deformation energy. A lower weight with the same or improved performance is required in order to meet the demand for lower fuel consumption.

[0002] The term closed sections often relates to hollow metal bodies of thin-walled sheet steel.

[0003] The present invention affords the facility for new, cost-effective development of sections having these desired characteristics.

[0004] The prior art primarily involves the press hardening, roll forming and hydroforming. Press hardening may give shaped sections with a very large degree of freedom, but the disadvantage with press hardening is that it cannot produce closed sections.

[0005] Hardened, roll-formed sections can be made closed, but are limited by the actual roll forming, which cannot respond so freely to changes in cross-section. Roll forming only allows limited freedom of geometric design.

[0006] Hydroforming usually involves forming against two or more rigid tool parts by means of high-pressure fluid, which presses the sheet metal against the tool. Hydroforming can provide great freedom of geometric design but cannot go as close to the tensile yield strength of the constituent material.

[0007] A few disadvantages include the fact that weld seams or other methods of joining are restricted or entirely ruled out. The reproducibility is also very high, and also the torsional rigidity. This affords great scope for forming complex parts, since the blank is shaped in a single piece.

[0008] In order to obtain a hardened, shaped product, a procedure is generally used in which the blank is first heated, following which it is introduced into a forming tool for forming. The blank in the heated state is deformed, and by cooling the forming tool and/or direct cooling of the blank remaining in the forming tool, a hardened end product is obtained. When the hardening is then completed, the product is taken out of the forming tool.

[0009] The use of a cooled forming tool with a heated blank, which is placed in the forming tool and subjected to pressure so that it is formed into the desired shape in a short period of time was also previously known. The forming time is usually less than 3 seconds and preferably less than 1 second in order to ensure that the blank does not harden during the forming through contact with the hydraulic medium and the cooled forming tool. The formed product, however, is allowed to come into contact with the forming tool and the hydraulic medium for a sufficient length of time in order to harden before the product is then taken out of the forming tool.

Description

[0010] The present invention relates to a combined hydroforming and post-hardening process.

[0011] In a hydroforming process a hydraulic fluid presses a blank out against a substantially enclosing forming tool whilst a mechanical pressure is applied to the blank in order to transport the blank material into the areas devoid of material. In this way the shape of the blank is modified according to the shape of the tool.

[0012] In the hydroforming process, a hardenable steel blank is used, the shape of which can be modified for subsequent processing stages by bending the blank, for example, or by modifying the blank through other means of deformation.

[0013] The blank is placed in a forming tool of the required shape, which substantially encloses the blank. The blank, in the form of a tube, for example is then sealed at both ends and a hydraulic fluid, preferably water, is pumped in and pressurizes the tube whilst a mechanical pressure is applied at both ends of the blank.

[0014] In the hydroforming process a desired shape is obtained by modifying the shape of the blank, following which the water is removed from the forming tool, as is the blank, which in the next stage of the process is heated up in an oven to hardening temperature. The blank is further placed in a fixing tool so that the blank will retain its shape during the forthcoming cooling phase, in which the heated blank is cooled by suitable media, such as water or oil. A hardened, formed product has now been obtained by means of the aforementioned process stages. The formed, hardened product now only requires finishing by end machining and the incorporation of holes, which is done by a cutting tool or by laser cutting.

Preferred embodiment

[0015] The invention will be described in more detail below with reference to the examples of embodiments shown in the drawing attached.

[0016] Figure 1 shows a flow chart for a hydroforming process with hardening.

[0017] A process of hydroforming in which a blank is to be formed into a finished end product is described below.

[0018] In the process, the blank used is preferably in the form of a tube of hardenable steel, such as boron steel, for example, the shape of which can be modified for subsequent stages of the process. The tubular blank is placed in an enclosing forming tool of the desired shape. The tubular blank is then closed at both ends and connections for hydraulic fluid are provided to the inside of the blank, following which a hydraulic fluid, preferably water, is pumped in at a pressure of approximately 2000 bar, which pressurizes the tubular blank, whilst a mechanical pressure of approximately 150 tonnes is applied at both ends of the tubular blank.

These pressures act on the tubular blank for at least 30 seconds, preferably for approximately 60 seconds, which deforms the tubular blank according to the tool at a tubular blank and tool temperature of less than 100°C, preferably room temperature. The pressure needed to close the tool during the process is approximately 5000 tonnes.

[0019] The hydroforming process imparts the required shape to the tubular blank. The water is removed from the forming tool, as is the blank, which in the next stage of the process is heated up in an oven to a hardening temperature of approximately 900°C. The heating process lasts less than approximately 50 seconds.

[0020] In order that the tubular blank will retain its shape during the forthcoming cooling phase, the tubular blank is placed in a fixing tool. The tubular blank is fixed in a suitable number of areas and/or at a suitable number of points by a mechanical fixing pressure of approximately 50 tonnes, the heated blank being cooled down by a suitable medium, such as water or oil. The cooling medium is sprayed on to the tubular blank from a number of different directions for approximately 30 seconds at a pressure of approximately 10 bar, the heated tubular blank being cooled to approximately 40°C

[0021] The hardening process generally takes less time than the hydroforming process. That is to say the process of hardening the blank after hydroforming is included in the time taken for the hydroforming process, which results in a cost-effective overall process.

[0022] The present invention is not limited to a simple tubular blank with two openings at each end, it being possible to also use the process with a considerably more complex shape which also permits fewer or more than two openings in the blank.

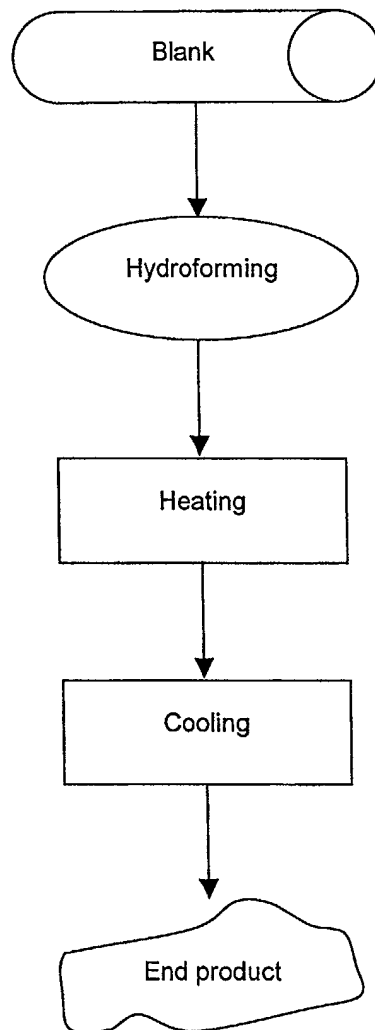
at least 30 seconds, preferably approximately 60 seconds.

5. Method according to Claim 1, **characterised in that** the hardening process preferably takes less time than the time for the hydroforming process.

Claims

1. Method for the manufacture of closed, hardened steel sections by hydroforming, **characterised in that** a blank is placed in a substantially enclosing forming tool, openings in the blank are closed and connections for hydraulic fluid are provided to the inside of the blank, fluid is pumped into the blank at high pressure so that the blank is deformed according to the forming tool, the fluid is removed and the blank is hardened by heating and subsequent cooling.
2. Method according to Claim 1, **characterised in that** the hydraulic fluid is water.
3. Method according to Claim 1, **characterised in that** the temperature during forming is <100°C, preferably room temperature.
4. Method according to Claim 1, **characterised in that** a high pressure is maintained inside the blank for

Figure 1





European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 03 44 5005

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The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (Int.Cl.7)
			B21D C21D
Place of search		Date of completion of the search	Examiner
MUNICH		15 April 2003	Forciniti, M
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

EPO FORM 1503 03.82 (P44C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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