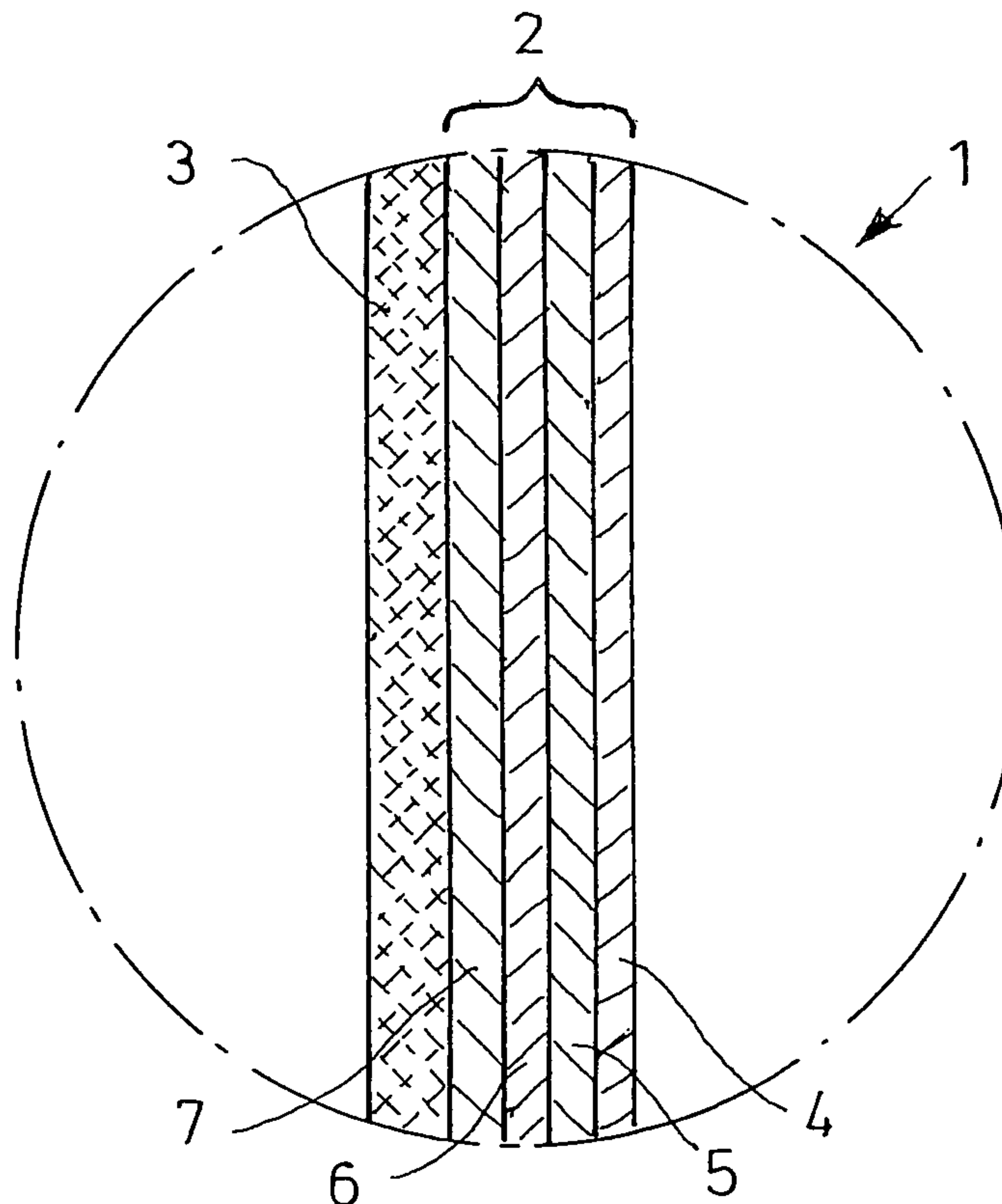




(86) Date de dépôt PCT/PCT Filing Date: 2011/07/05
(87) Date publication PCT/PCT Publication Date: 2012/01/19
(45) Date de délivrance/Issue Date: 2014/11/18
(85) Entrée phase nationale/National Entry: 2012/10/30
(86) N° demande PCT/PCT Application No.: EP 2011/003319
(87) N° publication PCT/PCT Publication No.: 2012/007116
(30) Priorité/Priority: 2010/07/13 (DE10 2010 027 096.2)

(51) Cl.Int./Int.Cl. *B60K 15/03* (2006.01),
B29C 49/00 (2006.01), *B29C 49/04* (2006.01),
B29C 49/20 (2006.01), *B29C 49/22* (2006.01)
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(54) Titre : RESERVOIR DE CARBURANT EN PLASTIQUE ET SON PROCEDE DE PRODUCTION
(54) Title: FUEL TANK OF PLASTIC AND METHOD FOR THE PRODUCTION THEREOF



(57) **Abrégé/Abstract:**

The invention concerns a fuel tank of plastic with a multilayered tank wall comprising at least one inner layer of thermoplastic material and at least one outer layer of a fibre composite material. The inner layer and the outer layer are connected to each other by a material bond.



(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property
Organization
International Bureau



WIPO | PCT



(10) International Publication Number

WO 2012/007116 A3

(43) International Publication Date
19 January 2012 (19.01.2012)

(51) International Patent Classification:

B60K 15/03 (2006.01) *B29C 49/22* (2006.01)
B29C 49/04 (2006.01) *B29C 49/00* (2006.01)
B29C 49/20 (2006.01)

(21) International Application Number:

PCT/EP2011/003319

(22) International Filing Date:

5 July 2011 (05.07.2011)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

10 2010 027 096.2 13 July 2010 (13.07.2010) DE

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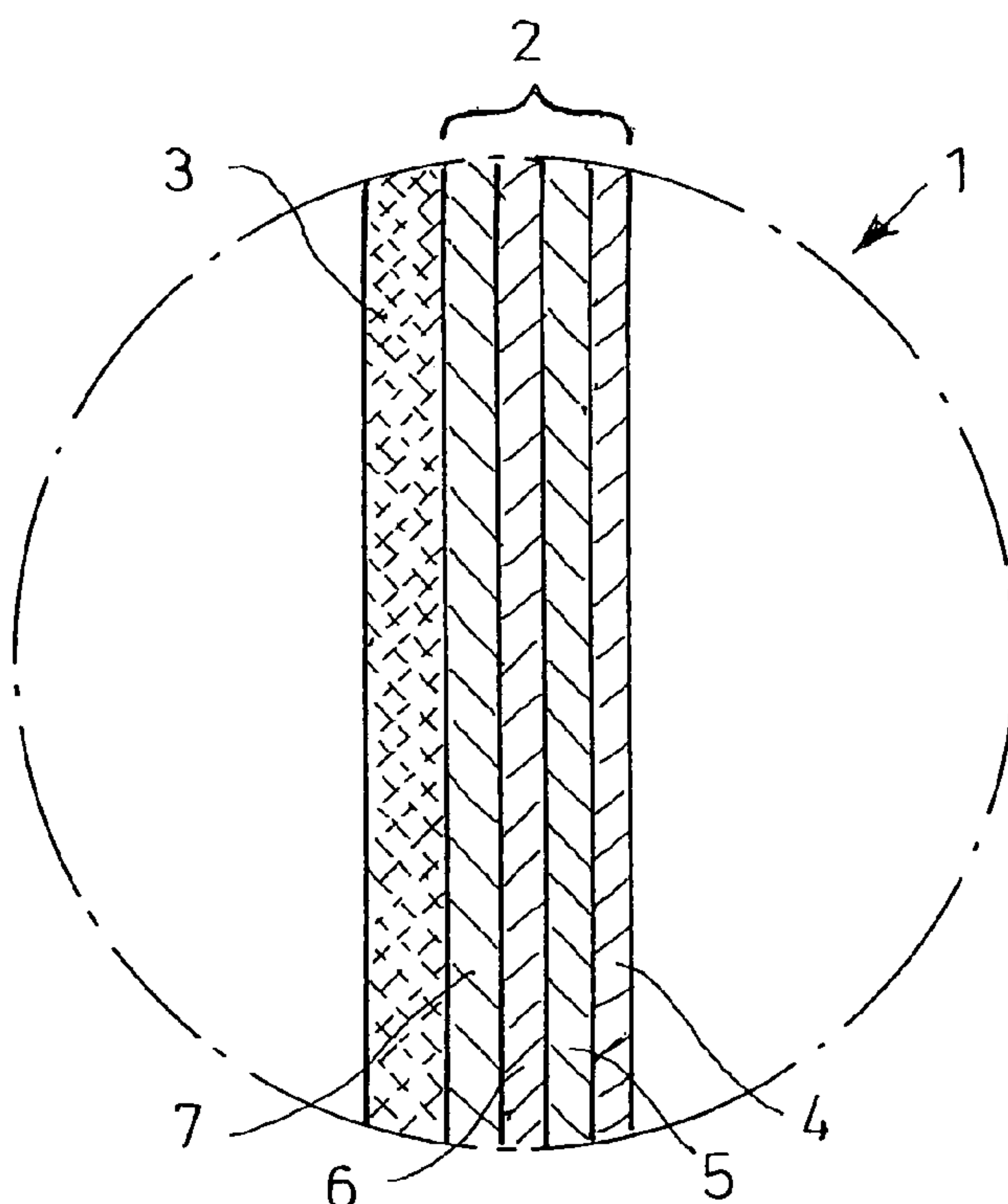
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(81) Designated States (unless otherwise indicated, for every
kind of national protection available): AE, AG, AL, AM,
AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ,
CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO,
DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN,
HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR,
KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME,
MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ,
OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG,
SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ,
UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every
kind of regional protection available): ARIPO (BW, GH,
GM, KE, LR, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG,
ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ,
TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK,
EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV,
MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM,
TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW,
ML, MR, NE, SN, TD, TG).

[Continued on next page]

(54) Title: FUEL TANK OF PLASTIC AND METHOD FOR THE PRODUCTION THEREOF

**Fig. 6**

(57) Abstract: The invention concerns a fuel tank of plastic with a multilayered tank wall comprising at least one inner layer of thermoplastic material and at least one outer layer of a fibre composite material. The inner layer and the outer layer are connected to each other by a material bond.

WO 2012/007116 A3



Published:

(88) Date of publication of the international search report:

— *with international search report (Art. 21(3))*

31 May 2012

Fuel tank of plastic and method for the production
thereof

The invention concerns a fuel tank of plastic and a
5 method for the production thereof.

Known plastic fuel tanks for motor vehicles are formed
as fuel tanks based on polyethylene (HDPE). These
usually have either a multilayered wall structure with
10 barrier layers for hydrocarbons or have been made
resistant to hydrocarbons by chemical treatment
(fluorination/sulfonation). Plastic fuel tanks based on
HDPE have the advantage that they can be produced with
a spatially relatively complex design and have
15 sufficient shape retention and stability. Such fuel
tanks are also sufficiently impact resistant, so that,
in the event of a crash, they can withstand
corresponding collision forces. Short-term deformations
of a fuel tank in the event of a crash do not generally
20 lead to any permanent changes in contour. Finally, the
known plastic fuel tanks also retain their shape to the
greatest extent when the internal pressure is increased
for a short time, at least such that they resume their
original shape when the pressure subsides.

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In order to prevent changes in shape of the envelope of
fuel tanks in regions covering large areas of the
container wall, it is known to provide supporting
elements of various kinds inside the fuel tank. In the
30 case of relatively small plastic fuel tanks, even the
internals provided in the tank, for example in the form
of internal baffles, feeding units or the like, have a
stabilizing effect on the tank.

35 Stabilizing measures for plastic fuel tanks are
becoming increasingly important with the introduction
of hybrid vehicles. In the case of diesel or petrol
vehicles, fuel tanks usually communicate essentially
pressurelessly by way of a fuel vapour filter of

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varying size. While the internal combustion engine of the motor vehicle is in operation, the fuel vapour filter is backflushed, in that the air required for the engine is taken in via the fuel vapour filter during the operating phases of the engine. The absorption capacity of the fuel vapour filter is designed correspondingly.

In the case of modern hybrid vehicles, on the other hand, the number of operating cycles and the operating time of the internal combustion engine are greatly reduced. Consequently, the number and duration of the possible backflushing cycles of the fuel vapour filter are likewise restricted. This requires corresponding dimensioning of the fuel vapour filter, which is often subject to limits owing to installation space. For this reason, fuel tanks for hybrid vehicles are often sealed off from the atmosphere in such a way that pressure fluctuations with respect to the atmosphere of approximately + 400 mbar to - 150 mbar can occur in the fuel tank. It is intended that this pressure difference with respect to the atmosphere can be maintained as far as possible over relatively long periods of time.

Stabilization is important particularly in connection with fuel tanks based on polyethylene. This is so because polyethylene has the characteristic that, if subjected to sustained pressure and/or tension, it flows even at room temperatures, and so the known stabilizing measures in the form of supporting elements inside the tank do not produce satisfactory results under all circumstances.

An embodiment of the invention is therefore based on the object of providing a plastic fuel tank that makes allowance for the problem described above.

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In some embodiments the object may be achieved firstly by a fuel tank of plastic with a multilayered tank wall comprising at least an inner layer of thermoplastic material and an outer layer of a fibre composite material. This "sandwich construction" means that the fuel tank has an outer, relatively rigid and lightweight layer, whereas the inner layer has a certain compliance and, in particular, ensures the impermeability of the entire fuel tank system. The fuel tank according to the invention combines the advantages of a high-strength rigid construction, which at the same time also has a certain brittleness, with the advantages of a shell which is compliant within certain limits and impermeable to hydrocarbons and, in the event of a crash, can absorb corresponding impact loads. For this purpose, it may be advantageous if the inner and outer layers are not materially bonded to each other. In the case of an expedient variant of the fuel tank, these layers are materially bonded to each other.

In some embodiments, there is provided method for producing a fuel tank, comprising the forming of two shell-like semifinished products from thermoplastic material in a multipart tool, forming a mould cavity, and the connecting of the shells to form an essentially closed hollow body, with elements of a fibre composite material being placed in the tool or adapted before the forming of the shells, said elements being placed on the contour prescribed by the mould cavity, so that the fibre composite material preferably enters into a material bond with the shell-like semifinished products during their forming, wherein the shell-like semifinished products from thermoplastic material are obtained by the extrusion of

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3a

- tubular preforms which are cut open to form sheet-like webs and spread out and formed into shells by using the heat of extrusion or by the extrusion of sheet-like preforms in web form which are formed into shells by using the heat of
- 5 extrusion and wherein the preforms are extruded in a multilayered state with at least one barrier layer for hydrocarbons and with at least one bonding agent layer, the bonding agent layer being brought into contact with the sheet-like elements of fibre composite material.
- 10 In the case of a particularly preferred embodiment of the fuel tank according to the invention, it is provided that a multilayered extrudate based on HDPE is provided as the inner layer. The inner layer may have been produced in a conventional manner by a co-extrusion process.
- 15 The inner layer and the outer layer of the fuel tank are expediently connected to each other by means of a bonding agent.

The outer layer may, for example, consist of a fibre material in a thermosetting polymer matrix. In principle,

20 thermoplastics also come into consideration as matrix materials.

Glass fibres/aramid fibres or carbon fibres, preferably as continuous fibres, come into consideration as fibre materials.

- 5 It is particularly expedient if a temperature-curable plastic is provided as the thermosetting plastic; in this way, the inner layer and the outer layer can be bonded to each other particularly advantageously in a single production process.

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The inner layer may, for example, comprise a co-extrudate with a barrier layer for hydrocarbons.

- 15 Particularly preferably, the inner layer is formed as a 4-layered co-extrudate, it being possible, for example, for an outer bonding agent layer of the co-extrudate at the same time to produce the material bond with the outer layer.

- 20 Previously known multilayered fuel tanks generally consist of a 6-layered co-extrudate, the layer structure comprising, from the inside to the outside, a non-coloured pure HDPE, a bonding agent layer, a barrier layer of EVOH, a further bonding agent layer,
25 for example based on LDPE, a layer of recycled or reground material and an HDPE layer of carbon-black-coloured HDPE.

- 30 In the case of the fuel tank according to the invention, the two outer layers of the tank wall are then advantageously substituted by a fibre composite material, it being possible for the thickness of the outer layer to be chosen such that the mass of the outer layer is less than or equal to the mass of the
35 otherwise required outer layers of the co-extrudate. The bonding agent layer located on the EVOH layer

serves in this case for producing the material bond with the outer layer.

The object on which the invention is based is also achieved by a method for producing a fuel tank, in particular for producing a fuel tank of the type described above, comprising the forming of two shell-like semifinished products from thermoplastic material in a multipart tool, forming a mould cavity, and the connecting of the shells to form an essentially closed hollow body, with sheet-like elements of a fibre composite material being placed in the tool before the forming of the shells, said elements being placed on the contour prescribed by the mould cavity, so that the fibre composite material enters into a material bond with the shell-like semifinished products during their forming.

In the case of an expedient variant of the method according to the invention, it is provided that sheet-like elements of a non-cured thermosetting material are placed in the tool. These elements may be, for example, so-called "pre-pregs" (pre-impregnated fibres), that is to say semifinished products consisting of continuous fibres in an uncured thermosetting polymer matrix. The continuous fibres may take the form of a pure unidirectional layer, a woven fabric or a laid structure. For example, they may be placed in the tool as webs of woven fabric and fixed there.

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In the case of a particularly advantageous variant of the method according to the invention, it is provided that the sheet-like elements are cured by contact heat transmission through the molten-hot shell-like semifinished products which are placed against the sheet-like elements fixed in the tool during the forming in the tool and thereby transmit the heat to

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the sheet-like elements. Appropriate setting of the curing characteristics of the matrix material (of the thermoset) achieve the effect that the sheet-like elements adapt themselves to the shrinkage of the polyethylene-based inner layer during the cooling process.

The method according to the invention preferably comprises the extrusion of tubular preforms, which are cut open to form sheet-like webs and spread out and formed into shells by using the heat of extrusion.

Alternatively, sheet-like preforms in web form may be extruded directly and formed into shells by using the heat of extrusion.

Using the heat of extrusion means essentially from the first heat of the polymer plasticated in an extruder.

Extrusion heads or coextrusion heads that are known per se, as also used in extrusion blow moulding, may be used in the extrusion of the preforms.

The method according to the invention is preferably carried out as an extrusion blow-moulding process, in which the preforms are formed into shells essentially in the first heat in a blow moulding tool and are joined together or welded to each other. The sheet-like elements in the form of elements of a fibre composite material are placed into the blow-moulding tool in such a way that they enclose the finished hollow body in the form of shells of fibre composite material.

More expediently, the preforms are extruded in a multilayered state with at least one barrier layer for hydrocarbons and/or oxygen and with at least one bonding agent layer, a bonding agent layer being

brought into contact with the sheet-like elements of fibre composite material in such a way that a material bond is produced between the inner layer and the outer layer.

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In the case of an advantageous variant of the method according to the invention, the preforms of thermoplastic material in web form are first brought between the open parts of a 3-part blow moulding tool, two outer moulds forming a mould cavity which defines the contour of the finished article. In a first method step, the non-cured or only partially cured elements of a fibre composite material are placed in the cavities of the blow mould halves and fixed there. In a further step, sheet-like preforms of a polyethylene-based thermoplastic material in web form are brought between the open outer moulds of the blow moulding tool and a central mould/central tool arranged between them. In a further method step, the blow mould halves are closed against the central tool and the shells of thermoplastic material are formed against the sheet-like elements of a fibre composite material that are provided in the cavities. Directly after forming of the shells, the central tool is used to connect internals of the tank to the shells on the side thereof that is facing the mould cavity. In a further method step, the central tool is removed and the blow mould halves are closed against each other in such a way that the shells are welded to each other while forming a pinch-off weld. The pinch-off weld is produced essentially in the region of the inner layer of the fuel tank. It is not absolutely necessary for the elements of fibre composite material that form the outer layer of the fuel tank to be connected in the region of the pinch-off weld, since they enter into an intimate bond by bonding with the material of the inner layer.

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The invention is explained below on the basis of an exemplary embodiment that is represented in the drawings, in which:

5 Figure 1 shows a schematic perspective representation of the inner layer of a plastic fuel tank in the form of two elements of a fibre composite material,

10 Figure 2 shows a schematic representation of a blow moulding tool for producing the fuel tank according to the invention when the sheet-like elements are being introduced into the cavities of the blow mould halves,

15

Figure 3 shows a view corresponding to Figure 2 which illustrates the method step of extruding preforms of thermoplastic material,

20 Figure 4 shows a corresponding view which illustrates the forming of the shells in the tool against the elements of fibre composite material,

25 Figure 5 shows a view of the closed blow moulding tool during the welding of the shells of the fuel tank and

Figure 6 shows an enlarged view of the wall structure of the fuel tank according to the invention.

30

The fuel tank 1 of thermoplastic material that is represented in the drawings (Figure 5) is shown in a highly schematic simplified form. It comprises an inner layer 2 of a thermoplastic material and an outer layer 3 of a fibre composite material. The outer layer 3 comprises continuous fibres, for example glass fibres or carbon fibres, in a matrix of thermosetting,

temperature-curable material. This may be, for example, an epoxy resin with a hardener which is temperature-activatable. The outer layer 3 completely encloses the fuel tank and enters into a material bond with the inner layer over the full surface area. The inner layer 2 is a 4-layered co-extrudate based on HDPE, comprising an inner HDPE layer 4, a first bonding agent layer 5 based on LDPE, a barrier layer 6 of EVOH and a second outer bonding agent layer 7, which produces a material bond with the outer layer 3 fibre composite material.

The production of the fuel tank 1 according to the invention takes place in the altogether 3-part blow moulding tool 8 represented in Figure 2, which comprises two outer moulds 9a, 9b and a central tool 10. The central tool 10 primarily serves the purpose of sealing off the cavity formed by the outer moulds 9a, 9b for the purpose of forming shells, and the central tool 10 secondarily serves the purpose of introducing inserts and elements of a fibre composite material into the cavities 11 of the outer moulds 9a, 9b.

Figure 1 shows two elements 12a, 12b, which already have the form of half-shells and in this form are brought into the cavities 11 of the outer moulds 9a, 9b in a completely cured state, as is intimated in Figure 2. The invention should be understood in principle as meaning that the elements 12a, 12b may also initially be brought between the opened parts of the outer moulds 9a, 9b as elements in web or strip form in a basically contourless state and placed against the cavities 11 of the outer moulds 9a, 9b by means of differential pressure, for example by means of a vacuum. They may, however, also be placed against the cavities by corresponding manipulators/handling devices and fixed there. Shown in the drawings is a variant in which the elements 12a, 12b already have the form of half-shells,

which however are not completely able to retain their shape.

In a method step represented in Figure 2, arranged
5 between the outer moulds 9a, 9b, which can be displaced
away from each other and towards each other in the
plane of the drawing, is a central tool 10, which can
be displaced transversely in relation to the
displacement movement of the outer moulds 9a, 9b, i.e.
10 into and out of the plane of the drawing. The central
tool 10 comprises component carriers 14, which can be
made to move in and out in the direction of the outer
moulds from the frame formed by the central tool 10 by
means of pneumatic cylinders 15. In the case of the
15 method step represented in Figure 2, the component
carriers 14 are loaded with the elements 12a, 12b,
which are first brought into the outer moulds 9a, 9b
and placed there in the cavities 11. These elements may
be fixed there, for example, by means of a vacuum. In a
20 further method step (Figure 3), sheet-like preforms 17
in web or strip form are continuously extruded from the
extrusion head in a hanging manner, i.e. in the
direction of gravitational force. As mentioned above,
the preforms 17 are formed as 4-layered co-extrudates
25 based on HDPE with barrier layers of EVOH. In a further
method step, the outer moulds 9a, 9b are closed against
the central tool 10, the outer moulds 9a, 9b in each
case clamping the preforms 17 against the central tool
10.

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The blow moulding tool 8 is displaced away from under
the extrusion head 16, in order not to hinder the
emergence of the continuously extruded preforms 17.

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Then, the preforms 17 (Figure 4) are placed against the
elements 12a, 12b by applying differential pressure,
for example by evacuating the cavities 11 or by

applying blowing air to the inner wall of the cavities 11. As mentioned at the beginning, the elements 12a, 12b comprise a temperature-curable matrix of a thermosetting material. Curing of the elements in the contour defined by the cavities together with the thermoplastic material of the inner layer 2 to form half-shells 18 takes place by contact heat transmission from the molten-hot preforms 17. In a further method step, the central tool 10 can be used to introduce internals into the still molten-hot half-shells. The previously mentioned component carriers 14 may likewise be used, for example, for this purpose. Finally, the central tool 10 is removed from between the outer moulds 9a, 9b and they are closed against each other, the half-shells taking place to form the finished fuel tank 1 by the inner layer 2 being welded in the region of a peripheral pinch-off edge 19.

List of designations

1	fuel tank
2	inner layer
3	outer layer
4	inner HDPE layer
5	first bonding agent layer
6	barrier layer
7	outer bonding agent layer
8	blow moulding tool
9a, 9b	outer mould
10	central tool
11	cavities
12a, 12b	elements
14	component carriers
15	pneumatic cylinders
16	extrusion head
17	preform
18	half-shells
19	pinch-off edge

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CLAIMS:

1. Method for producing a fuel tank, comprising the forming of two shell-like semifinished products from thermoplastic material in a multipart tool, forming a mould
5 cavity, and the connecting of the shells to form an essentially closed hollow body, with elements of a fibre composite material being placed in the tool or adapted before the forming of the shells, said elements being placed on the contour prescribed by the mould cavity, so that the fibre composite material
10 preferably enters into a material bond with the shell-like semifinished products during their forming, wherein the shell-like semifinished products from thermoplastic material are obtained by the extrusion of tubular preforms which are cut open to form sheet-like webs and spread out and formed into
15 shells by using the heat of extrusion or by the extrusion of sheet-like preforms in web form which are formed into shells by using the heat of extrusion and wherein the preforms are extruded in a multilayered state with at least one barrier layer for hydrocarbons and with at least one bonding agent
20 layer, the bonding agent layer being brought into contact with the sheet-like elements of fibre composite material.
2. Method according to claim 1, wherein sheet-like elements of a non-cured thermosetting material are placed in the tool.
- 25 3. Method according to either of claims 1 and 2, wherein the sheet-like elements are cured by contact heat transmission via the molten-hot shell-like semifinished products.

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4. Fuel tank of plastic obtained by the method according to any one of claims 1 to 3 with a multilayered tank wall comprising at least one inner layer of thermoplastic material and at least one outer layer of a fibre composite material,
- 5 where the inner layer and the outer layer are materially bonded to each other, and wherein a multilayered extrudate based on polyethylene, preferably based on HDPE, is provided as the inner layer, wherein the inner layer and the outer layer are connected to each other by means of a bonding agent.
- 10 5. Fuel tank according to claim 4, wherein the outer layer consists of a fibre material in a thermosetting polymer matrix.
6. Fuel tank according to one of claims 4 or 5, wherein glass fibres or carbon fibres, preferably as continuous fibres,
- 15 are provided as fibre material.
7. Fuel tank according to claim 5, wherein a temperature-curable plastic, preferably based on epoxy resin, is provided as the thermosetting plastic.
8. Fuel tank according to one of claims 4 to 7, wherein
- 20 the inner layer comprises at least one barrier layer for hydrocarbons.
9. Fuel tank according to any one of claims 4 to 8, wherein the inner layer is formed as a 4-layered co-extrudate.

