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Method and device for producing a component from a fiber composite material**Technical field**

The invention concerns a method for producing a component from a fiber composite material comprising the step of introducing a fiber impregnated with a matrix on to a cylindrical inner mold of a mold space formed between the inner mold and a cylindrical outer mold. The invention also concerns a device for producing the component from the fiber composite material with the cylindrical inner mold on which the fiber impregnated with the matrix is applied.

Background of the invention

Organic sheets belonging to fiber composite materials are known from prior art and are used mainly in the construction of airplanes and automobiles to obtain significantly lighter components with comparable or even better stiffness compared with conventional materials. Organic sheets of this type generally have a fiber fabric or fiber mat which is embedded in a thermoplastic plastic matrix and often appear as fiber matrix semi-finished products with glass, aramid or carbon as the fiber material. Since organic sheets can be easily deformed with heat by methods known in metal processing, this results in shorter processing times compared with conventional thermosetting fiber composite materials.

Most recently in the field of airplane manufacture, on average, semicircular fuselage sections have been made separately out of fiber composite materials as lower shells and upper shells and are assembled together in a subsequent final assembly to make a complete airplane fuselage. The fuselage sections are generally reshaped by means of an inner mold and an outer mold in a C-frame press.

US 2016/297 153 A1 describes a method for impregnating a fiber preform with an impregnating composition comprising an application of a liquid on to a structure wherein the structure comprises a chamber in which a fiber preform is placed for impregnation.

BE 886 795 A describes a method and, in particular, a device suitable for performing the method for producing reinforced plastic/resin items by pressing.

However, for some time attempts have failed to produce complete halves of fuselages in such a press since an overall press force of about 15,000 to 20,000 tonnes would be needed to do this and, as a consequence, a press with a total weight of about 10,000 tonnes would be needed which would mean an investment cost of an estimated 100 million EUR would be required due to this

size. In addition, there would be no guarantee in manufacturing a complete half of an airplane fuselage using a press of this nature known from prior art wherein a constant consolidation pressure is applied to all part of the airplane fuselage half. Also, there would be no assurance that the consolidation pressure, for example on the longitudinal edges of the semicircular halves of the airplane fuselage, would have a sufficiently large or actually available component normal to the part.

Description of the invention

With this as the starting point, the task of the present invention is to provide a method and a device by means of which a component can be produced from a fiber composite material, in particular, the fuselage of an airplane, in a particularly simple manner.

The task of the invention is resolved by the features of the independent claims. Advantageous embodiments are explained in the dependent claims.

Accordingly, the invention concerns a method for producing a component from a fiber composite material, comprising the steps of introducing a fiber impregnated with a matrix on to a cylindrical inner mold of a mold cavity formed, in particular pressure tight, between the inner mold and a cylindrical outer mold, introducing a separating membrane on the fiber impregnated with the matrix such that a cavity extending along the lateral surface of the outer mold is formed between the outer mold and the separating membrane; and exposing the cavity to a thermal oil with a temperature greater than the melting point of the matrix and with a pressure greater than ambient pressure such that the thermal oil acts on the separating membrane with the pressure, in particular to obtain the component. According to a preferred further development, the method comprises the further step of exposing the cavity to the thermal oil with the temperature $\geq 250^{\circ}\text{C}$, $\geq 300^{\circ}\text{C}$ or $\geq 400^{\circ}\text{C}$, such that the thermal oil with the pressure ≥ 20 bar, ≥ 30 bar or ≥ 40 bar acts on the separating membrane; and/or cooling the thermal oil to a temperature of $\leq 150^{\circ}\text{C}$, $\leq 200^{\circ}\text{C}$ or $\leq 250^{\circ}\text{C}$ after a predetermined period of time.

Compared with a deformation process using a press known in the prior art, such as a C-frame press with a stationary inner mold and an outer mold travelling exclusively in a vertical direction to generate a pressure with exclusively vertical components, the proposed method is distinguished in that the pressure acts on the separating membrane and therefore on the fibers soaked with, in particular, a thermoplastic plastic matrix due to the pressure acting on the thermal oil at each point of the separating membrane normal to it and therefore also towards the

normal of the component to be obtained or fibers soaked with the thermoplastic plastic matrix. Referring to the aforementioned C-frame press, this means that not only a pressure with exclusively vertical components act on the fibers impregnated with the matrix, but also a pressure is acting with partial or even exclusively horizontal components, for example in lateral longitudinal edges of a mold cavity formed as a semicircle. In contrast to a known press, the press or consolidation pressure needed for deformation is however not exerted by the press, or perhaps only partially, but instead acts completely or substantially by means of the thermal oil.

Therefore, in a particularly simple manner, the proposed method enables the fiber impregnated with the matrix to be deformed under pressure and temperature into a tubular or barrel-shaped component in order to obtain, for example, a half of an airplane fuselage as a component. Starting out with the basic idea of using thermal oil as a pressurization and heating medium in the cavity between outer mold and separating membrane, an equally large consolidation pressure is obtainable on all sides on the separating membrane, and a specific uniform heating of the fiber impregnated with the matrix as well as a rapid thermal oil exchange for cooling and obtaining the component is also achievable.

In principle, the inner mold and outer mold can be of any shape, in particular a negative shape of the component desired, as a cylinder and/or, in cross section, as a semicircle or a semicircle-type shape, where it is often assumed in the following that inner mold and outer mold are designed to produce a component of an airplane, in particular the fuselage of an airplane, a half of the fuselage of an airplane or a barrel-shaped fuselage section of an airplane. Preferably, the inner mold is configured to be convex as the inner lower mold and the outer mold is designed to be concave as the outer upper mold. Where a press is involved, the inner mold can represent the lower tool and the outer mold can represent the upper tool. Even more preferably, the inner mold and outer mold resting against each other are pressure tight around their edges and/or provide a seal and/or come into contact with each other at their edges. In this context, preferably the method has the further step of setting the outer mold on the inner mold such that the inner mold and outer mold are sealed at their edges and contact each other to form the mold cavity and/or fix and/or tension together the inner mold and outer mold resting against each other, in particular by means of the press.

During the method, basically any fibers impregnated with the matrix can be processed, preferably whether they are fibers of glass, aramid and/or of carbon or are carboniferous. Still more preferred is the fiber soaked in a thermoplastic plastic matrix as a semifinished fiber matrix

product configured as a fiber composite material and/or as an organic sheet wherein these terms, within the context of the invention, are used partly synonymously. The fiber impregnated with the matrix is preferably implemented as a fiber soaked with a thermoplastic plastic matrix and/or as glass-reinforced aluminum, that is GLARE, as a hybrid material. Glass fiber reinforced aluminum generally has many layers, although each is only a few tenths of a millimetre thick, with alternating layers of aluminum and a glass fiber laminate, such as glass reinforced plastic.

The fibers can comprise a so-called prepreg material and/or can be made in tape form. Preferably the fiber is prepared as an endless material. The matrix can consist of an epoxy resin matrix or a thermoplastic matrix, or mixtures of the same. For example the matrix can comprise polyphenylene sulphide or polyether ether ketone as a thermoplastic so that in this case the melting point would be 285 °C or, respectively, 335 °C. Preferably the temperature is at least 10 °C, 20 °C, 50 °C, 100 °C or 200 °C higher than the melting point. Polyamide or polyetherimide as well as epoxy, polyurethane or polyester can also be used as thermosetting plastics. Preferably the pressure is 10 bar, 20 bar, 30 bar or 40 bar higher than the ambient pressure. Further preferred, before insertion or resting in the inner mold, the fiber is impregnated and/or soaked with the matrix. Within the scope of the invention, for example in the description of the Figures, the terms used for the fiber soaked with the thermoplastic plastic matrix and fiber impregnated with the matrix are used synonymously.

Further preferably the fiber impregnated with the matrix can be made as fiber mats or tissues, wherein reinforcement fibers are embedded in a plastic matrix. Also, a fiber mat can be provided as fibers, particularly as monoaxial or unidirectional fiber mats which can be obtained by fixing a bundle of parallel fibers as biaxial fiber mats wherein two bundles of parallel fibers are fixed in the direction of two axes, or as multiaxial fiber mats wherein several bundles of parallel fibers are fixed along different axes. In contrast to tissues, mats display higher strength due to not having undulations that are unavoidable in tissues. Moreover, tissues can also have a plurality of plain weaves or twill weaves.

Preferably, the cavity with the thermal oil is exposed to a temperature of ≥ 300 °C, ≥ 350 °C, ≥ 400 °C or ≥ 500 °C. The thermal oil acts preferably with a pressure of ≥ 30 bar, ≥ 40 bar or ≥ 50 bar on the separating membrane. The predetermined period of time can comprise 1 minute, 10 minutes, 1 hour or 5 hours. During the cooling of the thermal oil for hardening the component, preferably, the temperature of the thermal oil is ≤ 150 °C or ≤ 100 °C. Still more particularly preferred, to heat or, respectively, melt the organic sheet, that is when exposing the cavity to the

thermal oil with a temperature greater than the melting point of the matrix and during the following cooling of the organic sheet, the same thermal oil is used. In other words, the thermal oil located in the cavity is cooled preferably by means of a pump operation and is fed back into the cavity during which the thermal oil again acts on the separating membrane at a pressure of ≥ 20 bar.

According to a preferred further development, the method comprises the step of preheating the outer mold and/or the inner mold to a basic temperature, in particular prior to introducing the fiber impregnated with the matrix. In addition, the heating and/or cooling channels in the outer mold and/or the inner mold can be provided for tempering the respective mold before and/or during the hardening. The heating and/or cooling channels run preferably in an axial direction at regular intervals in between and/or distributed over the whole lateral surface of the respective mold. Preferably supply channels for the thermal oil are provided to apply thermal oil to the cavity, wherein said channels extend in a radial direction through the outer mold.

According to a still further preferred embodiment, the method comprises the step of applying negative pressure to the lateral surface of the inner mold. Preferably the inner mold has a plurality of vacuum channels provided at regular intervals along the lateral surface which can extend in a radial direction through the lower mold and/or are connected to a vacuum pump by means of which the vacuum is generated. In an analogous fashion a heating and/or cooling device can be provided to preheat or, respectively, to cool the outer mold and/or the inner mold to the base temperature by means of the heating and/or cooling channels.

According to a still further preferred embodiment, the method comprises the step of introducing a stringer, a frame and/or a thickening into a recess in the inner mold, in particular prior to introducing the fiber impregnated with the matrix. Stringers, frames or thickenings can represent local reinforcements, for example for window-, door and/or flap openings in the case of an airplane, and/or structural bracing, which can be included during the proposed method step when producing the molded part. When fusing the organic sheet by applying the thermal oil to the cavity at a temperature greater than the melting point of the matrix, contact surfaces of the stringers, frames or thickenings are fused together and are connected in this manner to the organic sheet. Preferably the recess is formed by a milling process, for example, such that, with stringer, frame or thickening inserted in the recess, it is completed flush with the lateral surface of the inner mold. The stringer, frame or thickening is inserted into the recess preferably as a prefinished and consolidated component.

According to a preferred further development, the method comprises the step of cooling the inner mold to a temperature of $\leq 150^{\circ}\text{C}$, $\leq 200^{\circ}\text{C}$ or $\leq 250^{\circ}\text{C}$ or, according to the preceding claim with the step of cooling the inner mold to a temperature of $\leq 150^{\circ}\text{C}$, $\leq 200^{\circ}\text{C}$ or $\leq 250^{\circ}\text{C}$ in the area of the stringer, the frame and/or the thickening. In addition, preferably in the area of the stringer, the frame and/or the thickening, a plurality of supply channels extending axially through the inner mold is provided wherein the said supply channels are arranged around the recess. This method ensures that the stringer, the frame and/or the thickening provided in the recess while certainly fused by the heated thermal oil to the respective contact surface, the remaining part of the stringer, the frame and/or the thickening remains, however, below a softening temperature.

As a general principle, there are many possibilities of designing the separating membrane. Provision is made, according to a particularly preferred further development, wherein the separating membrane is made of metal and/or is attached to the outer mold. The separating membrane serves to separate the thermal oil from the organic sheet on the one hand and, on the other hand, to form the cavity to accommodate the thermal oil. A separating membrane made out of metal has particularly good thermal conductivity and, on the other hand, good pressure transmission.

According to a preferred further development, the method comprises the step of inserting a separating film between the fiber impregnated with the matrix and the separating membrane. Preferably the separating film is introduced before the insertion of the separating membrane and after the insertion of the fiber impregnated with the matrix. The separating film acts as an anti-adhesion coating, enabling, after the fiber impregnated with the matrix has cooled, the separating membrane to be removed easily from the fiber impregnated with the matrix.

In order to be able to loosen the cured fiber impregnated with the matrix just as simply from the inner mold after cooling, the method comprises, according to a further preferred design, the step, in particular, of applying, in particular, spraying a release agent on to the inner mold and/or the outer mold prior to introducing the fiber impregnated with the matrix.

According to a preferred further development, a press which includes the inner mold and the outer mold, in particular a C-frame press, and/or the step after introducing the separating membrane of tensioning the inner mold and the outer mold against each other until the cavity is formed. Outer mold and inner mold are preferably designed so that the cavity is pressure-tight

after the bracing. Preferably the press has a press frame, in particular a C-frame, which has an upper horizontal C-leg, a lower horizontal C-leg and a vertical C-base connecting the upper C-leg and the lower C-leg.

Preferably the inner mold is fixed in place to the lower horizontal C-leg as the lower tool and the outer mold is supported above a press cylinder on the upper C-leg as an upper tool such that, by activating the press cylinder, the inner mold and the outer mold can be braced against each other until the mold cavity is formed. Preferably, the C-leg is designed as a frame structure, wherein a plurality of press frames are provided, designed in a C-frame manner and connected to each other, one behind the other in the longitudinal direction. Preferably the individual press frames are connected to each other with clamping elements. Alongside a downstroke press described above, wherein the press cylinder is supported on the upper C-leg, the press can also be designed in an upstroke manner so that the inner mold is braced by the press cylinder against the outer mold provided on the upper C-leg.

The task of the invention is resolved, furthermore, by a device for producing a component out of a fiber composite material, including a cylindrical inner mold on which a fiber impregnated with a matrix is applied; a separating membrane, which is applied on the fiber impregnated with the matrix; a cylindrical outer mold, which rests on the inner mold comprising the fiber impregnated with the matrix applied thereto and the separating membrane in such a sealing manner, that a cavity is formed along the lateral surface of the outer mold; and a thermal oil tempering and pressurization device, which is configured to expose the cavity to a thermal oil with a temperature greater than the melting point of the matrix and with a pressure greater than ambient pressure such that the thermal oil acts with the pressure on the separating membrane. Preferably the thermal oil tempering and pressurization device is configured to expose the cavity to the thermal oil with the temperature $\geq 250^{\circ}\text{C}$ $\geq 300^{\circ}\text{C}$ or $\geq 400^{\circ}\text{C}$ such that the thermal oil acts on the separating membrane at a pressure of ≥ 20 bar, ≥ 30 bar or ≥ 40 bar, and/or after a predetermined period of time to cool the thermal oil to a temperature of $\leq 150^{\circ}\text{C}$, $\leq 200^{\circ}\text{C}$ or $\leq 250^{\circ}\text{C}$.

Half shells of an airplane fuselage can be produced in a so-called "baguette" construction manner by the proposed device wherein, firstly, an upper shell and, secondly, a lower shell of this type of airplane fuselage are produced one after the other in the device. The fiber is soaked in particular with a thermoplastic plastic matrix, embedded between the inner mold and the outer mold, heated by the thermal oil on the one hand and exposed, on the other hand, to pressure so that the

component, for example an airplane fuselage, is obtained after the subsequent cooling. The device can be designed as a press in order to achieve a precise movement, that is opening and closing, of the inner mold and outer mold. The inner mold and the outer mold are preferably configured such that, with the press closed, the molds rest together with their edges touching and in such a way that the mold cavity formed by the molds is sealed when closed. Also, the inner mold and the outer mold can be held in place, wound with tension cables or in some other manner to create the mold cavity.

According to a preferred further development of the device or method described above, the cavity is exposed to the thermal oil such that the thermal oil acts on the entire separating membrane at a pressure of ≥ 20 bar, ≥ 30 bar or ≥ 40 bar, and/or wherein in cooling the thermal oil the pressure acting on the separating membrane continues to be ambient pressure of ≥ 20 bar, ≥ 30 bar or ≥ 40 bar. In this context, it is further preferred that the cavity has a thickness of ≥ 1 mm and ≤ 10 mm, in particular ≥ 2 mm and ≤ 5 mm between the outer mold and the separating membrane along the lateral surface, and/or the cavity has the same thickness at any point of the separating membrane. This system ensures that, at every point on the fiber impregnated with the matrix, an equally great or approximately equally great pressure is exerted which acts essentially towards the respective normal of the separating membrane, which acts with the matrix impregnated fiber and/or the lateral surface of the inner mold.

Since both with raising the temperature of the thermal oil to a level higher than the melting point ≥ 250 °C, ≥ 300 °C or ≥ 400 °C and then by cooling the thermal oil to ≤ 150 °C, ≤ 200 °C or ≤ 250 °C and the pressure greater than the ambient pressure ≥ 20 bar, ≥ 30 bar or ≥ 40 bar, during the deformation preferably no phase without pressure exists. The fiber soaked in particular with the thermoplastic plastic matrix preferably has a thickness comparable to the cavity so that the thermal oil, due to its significantly higher thermal capacity, is sufficient to bring about the melting process for deforming the fiber soaked in particular with the thermoplastic plastic matrix. The thermal oil tempering and pressurization device preferably has a heating device, a cooling device and/or a pump to heat or, respectively, cool the thermal oil to the aforementioned temperature, to pump out, cool down the heated thermal oil introduced into the cavity and to introduce it, cooled again, into the cavity, and/or in order to increase the aforementioned pressure.

According to a preferred further development of the aforementioned method or device, the fiber impregnated with the matrix comprises a pre-consolidated semi-finished shell and/or pre-

consolidated individual layers. The fiber in particular soaked with the thermoplastic plastic matrix can also comprise a fiber fabric and/or fiber mat which is/are embedded in the thermoplastic plastic matrix. With fabrics and mats, fibers can run at right angles to each other to better define mechanical properties such as stiffness, strength and/or thermal expansion compared with materials, such as metal sheets known in prior art.

In principle, there are many possible ways of designing the inner mold and/or the outer mold. The inner mold and/or the outer mold is/are made out of invar. According to a particularly preferred further development of the aforementioned method and the device, the inner mold and/or the outer mold has a cylinder height, or, respectively, a longitudinal extension of ≥ 10 m and ≤ 50 m, in particular ≥ 10 m and ≤ 15 m, and/or a cylinder diameter of ≥ 3 m and ≤ 10 m, in particular 6 m. Invar is a nickel-iron alloy with a very low thermal expansion coefficient so that an inner mold and/or outer mold made of this material is/ are characterized by an extremely low expansion due to the temperature change caused by the thermal oil. With the aforementioned dimensioning of the inner mold and/or the outer mold, airplane fuselage halves and/or barrel-shaped sections of an aircraft can be made by means of the aforementioned method or aforementioned device, having a material thickness of 2 mm, a diameter of, for example, 6 m and a length, as a cylinder height, of 15 m.

In this context, it is preferred, according to a preferred further development, that the inner mold and/or the outer mold is configured to form an aircraft fuselage, an aircraft wing or an aircraft propeller. The inner mold and/or the outer mold is/are preferably designed as negative molds wherein a complete airplane fuselage can be designed as an upper shell and a lower shell or in fuselage sections which can be assembled in a subsequent finishing step.

Short description of the drawings

Below, the invention is explained in more detail using a preferred embodiment example with reference to the attached drawings.

The drawings show, in

Fig. 1 A diagrammatic perspective view of a device for carrying out a method for producing a component from a fiber composite material according to a preferred embodiment example of the invention, and

Fig. 2 A diagrammatic sectional view of a section of the device shown in Fig. 1 with inner mold and outer mold.

Detailed description of the embodiment examples

Fig. 1 shows a device in the form of a C-frame press for performing a method for producing a component of an airplane from organic sheet as a fiber composite sheet. The C-frame press has a press frame designed as a C-frame 2 with an upper horizontal C-leg 3, a lower horizontal C-leg 4 and a vertical C-base 5 which connects the upper C-leg 3 and the lower C-leg 4 together. The press is formed in the shape of a frame and, in the longitudinal direction of the press, has a plurality of press frames 6 connected together, arranged one behind the other, each in the shape of a C.

A cylindrical inner mold 7 is provided supported on the lower C-leg 4. The inner mold 7 is concave-shaped and its cross section is semicylindrical with a cylinder diameter of 6 m. In the longitudinal direction the inner mold 7 extends between its ends with a cylinder height of 15 m. Above the inner mold 7, an outer mold 8 is provided congruent to the inner mold 7, that is, cylindrical and correspondingly concave. A plurality of press cylinders, indicated by arrow 9, is supported on the upper C-legs 3 and acts on the outer mold 8. This system allows the outer mold 8 to be moved by the press cylinders like a moving beam in a vertical direction, indicated by arrow 9, to remove the component 1 out of the device thus designed, indicated by arrow 10.

Referring to the section illustrated in Fig. 2 showing a diagrammatic section where the inner mold 7 and outer mold 8 rest one on top of the other, a release agent 10 is then sprayed on to the inner mold 7 in the situation shown in Fig. 1, in which the outer mold 8 is spaced apart from the inner mold 7, as shown in Fig. 2. Next, a fiber, in particular a glass fiber, aramid fiber and/or carbon fiber, soaked with a thermoplastic plastic matrix, is placed on the inner mold 7 as a pre-consolidated half shell or, in pre-consolidated individual sheets as a so-called organic sheet so that the organic sheet 7 covers the entire lateral surface 12 of the cylindrical inner mold 7 right to the edges of the inner mold 7.

In an optional step, a separating film 13 is placed on the fiber soaked with the thermoplastic plastic matrix 1 as an anti-adhesive layer. The separating film 13 is then covered with a separating membrane 14 of metal, which also covers the entire lateral surface 12 of the inner mold 7.

Then the outer mold 8, as shown in Fig. 2, is arranged over the inner mold 7 in such a way that a cavity 15 is formed between the lateral surface 14 of the outer mold 8. The cavity extends over the entire lateral surface 14 of the outer mold 8 and has an almost constant thickness between 2 and 5 mm. Inner mold 7 and outer mold 8 are made from invar, an nickel-iron alloy, and are configured such that, when the outer mold 8 as shown in Fig. 2 rests on the inner mold 7 forming the cavity 15, the inner mold 7 and outer mold 8 are sealed tightly at the edges of their respective lateral surfaces 12, 14 or, respectively, lie on each other so that they are touching.

The device has a thermal oil tempering and pressurization device 16 which is mainly designed to expose the cavity 15 to thermal oil 17 with a temperature $> 400\text{ }^{\circ}\text{C}$ so that, due to the thermal oil 17, a pressure of about 40 bar is applied to the separating membrane. Since the thermal oil 17 can be distributed freely inside the cavity 15 along the entire lateral surface 14 of the outer mold 8, the pressure of 40 bar acts on every point of the separating membrane 14a in a direction normal to the lateral surface 12 of the inner mold 7 or, respectively, in the extension direction of the fiber soaked with the thermoplastic plastic matrix 1.

The thermal oil 17 serves therefore as a pressurization and heating medium, exerting a constant consolidating pressure on all sides over the separating membrane 14a on the fiber soaked with the thermoplastic plastic matrix and in order to obtain a specifically uniform heating of the fiber soaked with the thermoplastic plastic matrix 1. Due to the thermal oil with its significantly higher thermal capacity compared with the fiber soaked with the thermoplastic plastic matrix 1, the melting process of the fiber soaked with the thermoplastic plastic matrix takes place. After a predetermined period of time the thermal oil 17 is cooled down by the thermal oil tempering and pressurization device 16 to a temperature of $< 200\text{ }^{\circ}\text{C}$ at constant pressure to obtain component 1.

In order to introduce the thermal oil 17 into the cavity 15, a plurality of feed channels 18 is provided in the outer mold 8 which extend radially through the outer mold 8. Heating and/or cooling channels 19 are provided, extending axially in the inner mold 7 and in the outer mold 8 for heating and cooling, by means of which pre-heating, cooling and/or temperature control is possible in the respective mold. The lateral surface 12 of the inner mold 7 can have a vacuum applied by a vacuum channel 20 provided in the inner mold 7 and extending radially through the inner mold 7.

Recesses 21 are provided in the inner mold 7 in which, as can be seen in Fig. 2, a stringer 22, on the left, and a cover 23, on the right, are inserted. A plurality of cooling channels 19 are arranged adjacent to the respective slots 21 surrounding the respective slot 19. While the thermal oil 17 is fusing the contact faces of the stringer 22, or, respectively, the cover 23 and is able to connect with the fiber soaked with the thermoplastic plastic matrix 1, the cooling channels 19 arranged around the recess 21 provide the cooling for the stringer 22 or, respectively, the cover 23, so that they remain at a softening temperature.

After the curing of the molded part 1, the outer mold 8 is raised, as shown in Fig. 1, and the mold part 1 is removed from the mold cavity formed by the inner mold 7 and outer mold 8. The inner mold 7 and outer mold 8 can be designed to form a half of an airplane fuselage, as shown in Fig. 1, wherein it is also possible, however, to form any other parts, for example the wing or propeller of an airplane using the proposed method as well as the device in a particularly simple fashion.

The embodiment examples described are simply examples which can be modified and/or supplemented in many ways within the scope of the claims. Every feature which has been described for a specific embodiment example can be used on its own or in combination with other features in any other embodiment example. Each feature which has been described for an embodiment example in a specific category can be used in a corresponding manner in an embodiment example in another category.

List of references

Component, with a fiber impregnated with a matrix	1
C-frame	2
Upper C-leg	3
Lower C-leg	4
C-base	5
Press frame	6
Inner mold	7
Outer mold	8
Arrows	9
Arrow	10
Release agent	11
Lateral surface (of the inner mold)	12

Separating film	13
Lateral surface (of the outer mold)	14
Separating membrane	14a
Cavity	15
Thermal oil tempering and pressurization device	16
Thermal oil	17
Supply channel	18
Heating and/or cooling channel	19
Vacuum channel	20
Recess	21
Stringer	22
Thickener	23

Patentkrav:

1. Fremgangsmåde til fremstilling af en komponent (1) af et fiberkompositmateriale, der omfatter trinnene:

5 at indføre et fibermateriale (1), der er imprægneret med en matrice, på en indre støbeform (7) i et støbeformshulrum, der er dannet mellem den indre støbeform (7) og en cylindrisk ydre støbeform (8), hvor den indre støbeform (7) og/eller den ydre støbeform (8) er fremstillet af invar,

10 at indføre en adskillelsesmembran (14a) på fibermaterialet (1), der er imprægneret med matricen, således at et hulrum (15), der strækker sig langs den laterale overflade (14) af den ydre støbeform (8), dannes mellem den ydre støbeform (8) og adskillelsesmembranen (14a), og

15 at udsætte hulrummet (15) for en termiske olie (17) med en temperatur, der er højere end smeltepunktet for matricen, og med et tryk, der er højere end omgivende tryk, således at den termiske olie (17) indvirker med trykket på adskillelsesmembranen (14a).

2. Fremgangsmåde ifølge det foregående krav, der omfatter trinnet:

at udsætte hulrummet (15) for den termiske olie (17) med en temperatur på ≥ 250 °C, ≥ 300 °C eller ≥ 400 °C, således at den termiske olie (17) indvirker på

20 adskillelsesmembranen (14a) med et tryk på ≥ 20 bar, ≥ 30 bar eller ≥ 40 bar, og/eller

at afkøle den termiske olie (17) til en temperatur på ≤ 150 °C, ≤ 200 °C eller ≤ 250 °C efter en forudbestemt tidsperiode.

3. Fremgangsmåde ifølge et hvilket som helst af de foregående krav, der omfatter trinnene:

25 at forvarme den ydre støbeform (8) og/eller den indre støbeform (7) til en basistemperatur, især inden indføring af fibermaterialet (1), der er imprægneret med matricen, og/eller

30 at påføre et undertryk på den laterale overflade (12) af den indre støbeform (7).

4. Fremgangsmåde ifølge et hvilket som helst af de foregående krav, der omfatter trinnet at indføre en stringer (22), en ramme og/eller en fortykning (23) i en fordybning i den cylindriske indre støbeform (7), især inden indføring af fibermaterialet (1), der er imprægneret med matricen.

5. Fremgangsmåde ifølge et hvilket som helst af de foregående krav, der omfatter trinnet at afkøle den indre støbeform (7) til en temperatur på ≤ 150 °C, ≤ 200 °C eller ≤ 250 °C eller ifølge en fremgangsmåde ifølge det foregående krav, der omfatter trinnet at afkøle den indre støbeform (7) til en temperatur på ≤ 150 °C, ≤ 200 °C eller ≤ 250 °C i området omkring stringeren (22), rammen og/eller fortykningen (23).

6. Fremgangsmåde ifølge et hvilket som helst af de foregående krav, hvor adskillelsesmembranen (14a) er fremstillet af metal og/eller er fastgjort til den ydre støbeform (8).

7. Fremgangsmåde ifølge et hvilket som helst af de foregående krav, der omfatter trinnene:

at indføre en adskillelsesfolie (13) mellem fibermaterialet (1), der er imprægneret med matricen, og adskillelsesmembranen (14a), og/eller

5 at påføre, især at sprøjte, et frigørelsesmiddel (11) på den indre støbeform (7) og/eller den ydre støbeform (8) inden indføring af fibermaterialet (1), der er imprægneret med matricen.

8. Fremgangsmåde ifølge et hvilket som helst af de foregående krav, der omfatter en
10 presse, der indbefatter den indre støbeform (7) og den ydre støbeform (8), især en C-formet presse (6), og/eller trinnet efter indføring af adskillelsesmembranen (14a) at spænde den indre støbeform (7) og den ydre støbeform (8) mod hinanden, indtil hulrummet (15) dannes.

15 9. Anordning til fremstilling af en komponent (1) af et fiberkompositmateriale, der omfatter:

en cylindrisk indre støbeform (7), hvorpå fibermaterialet (1), der er imprægneret med matricen, påføres,

20 en adskillelsesmembran (14a), der påføres på fibermaterialet (1), der er imprægneret med matricen,

en cylindrisk ydre støbeform (8), der hviler på den indre støbeform (7), der omfatter fibermaterialet (1), der er imprægneret med matricen, der er påført derpå, og adskillelsesmembranen (14a) på en forseglende måde, således at et hulrum (15) dannes langs den laterale overflade (14) af den ydre støbeform (8), og

25 en tempererings- og presningsanordning (16) til termisk olie, der er konfigureret til at udsætte hulrummet (15) for en termisk olie (17) med en temperatur, der er højere end smeltepunktet for matricen, og med et tryk, der er højere end omgivende tryk, således at den termiske olie (17) indvirker med trykket på adskillelsesmembranen (14a),

30 hvor den indre støbeform (7) og/eller den ydre støbeform (8) er fremstillet af invar.

10. Anordning ifølge det foregående krav, hvor tempererings- og presningsanordningen (16) til termisk olie er konfigureret til at udsætte hulrummet (15) for den termiske olie (17) med en temperatur på $\geq 250\text{ }^{\circ}\text{C}$, $\geq 300\text{ }^{\circ}\text{C}$ eller $\geq 400\text{ }^{\circ}\text{C}$, således at den termiske olie (17) indvirker på adskillelsesmembranen (14a) med et tryk på $\geq 20\text{ bar}$, $\geq 30\text{ bar}$ eller $\geq 40\text{ bar}$,
35 og/eller at afkøle den termiske olie (17) til en temperatur på $\leq 150^{\circ}\text{C}$, $\leq 200\text{ }^{\circ}\text{C}$ eller $\leq 250\text{ }^{\circ}\text{C}$ efter en forudbestemt tidsperiode.

11. Fremgangsmåde eller anordning ifølge et hvilket som helst af de foregående krav, hvor hulrummet (15) udsættes for den termiske olie (17), således at den termiske olie (17)
40 indvirker på hele adskillelsesmembranen (14a) med et tryk på $\geq 20\text{ bar}$, $\geq 30\text{ bar}$ eller $\geq 40\text{ bar}$, og/eller hvor trykket på adskillelsesmembranen (14a) forbliver omgivende tryk, $\geq 20\text{ bar}$, $\geq 30\text{ bar}$ eller $\geq 40\text{ bar}$ ved afkøling af den termiske olie (17).

12. Fremgangsmåde eller anordning ifølge et hvilket som helst af de foregående krav,
45 hvor hulrummet (15) har en tykkelse på $\geq 1\text{ mm}$ og $\leq 10\text{ mm}$, især $\geq 2\text{ mm}$ og $\leq 5\text{ mm}$, mellem den ydre støbeform (8) og adskillelsesmembranen (14a) langs den laterale

overflade (14), og/eller hulrummet (15) har samme tykkelse langs hvert punkt på adskillelsesmembranen (14a).

5 13. Fremgangsmåde eller anordning ifølge et hvilket som helst af de foregående krav, hvor fibermaterialet (1), der er imprægneret med matricen, omfatter en forstærket præfabrikeret skal og/eller forstærkede individuelle lag.

10 14. Fremgangsmåde eller anordning ifølge et hvilket som helst af de foregående krav, hvor den indre støbeform (7) og/eller den ydre støbeform (8) har en cylinderhøjde på ≥ 10 m og ≤ 50 m, især ≥ 10 m og ≤ 15 m, og/eller en cylinderdiameter på ≥ 3 m og ≤ 10 m, især 6 m.

15 15. Fremgangsmåde eller anordning ifølge et hvilket som helst af de foregående krav, hvor den indre støbeform (7) og/eller den ydre støbeform (8) er konfigureret til at danne et flyskrog, en flyvinge eller en flypropel.