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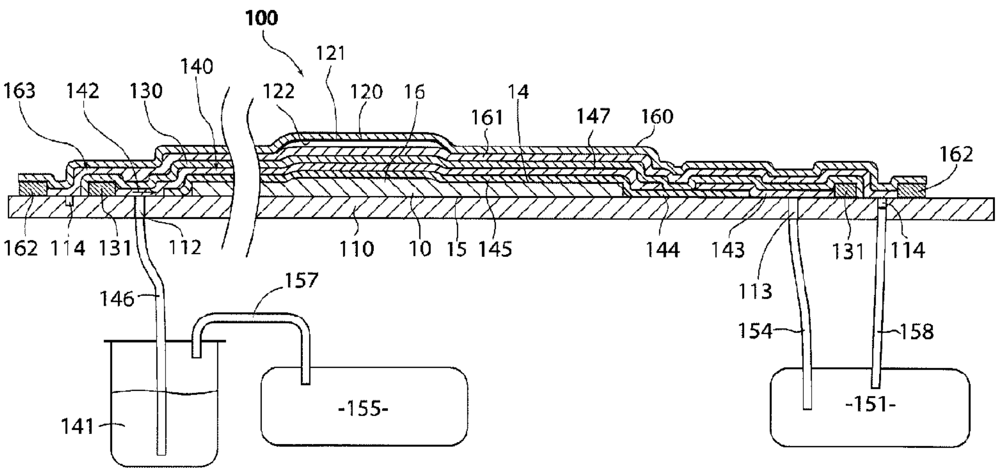

(57) Abrégé/Abstract:

A method and system for resin infusing a composite preform is disclosed. A composite preform is located on an upper tool surface of a tool. A first vacuum bagging film is placed over the tool surface to cover the composite preform and define a sealed first chamber. A bridge structure is located over the first vacuum bagging film over a region of the composite preform. The bridge structure has an underside defining a recess forming a cavity above the first vacuum bagging film. A second vacuum bagging film is placed over the first vacuum bagging film and the bridge structure to define a sealed second chamber. A resin supply is communicated with the first chamber on an upstream side of the composite preform. At least partial vacuum pressure is applied to the first chamber on a downstream side of the composite preform to establish a pressure differential to drive resin from the resin supply through the first chamber, infusing the composite preform with resin. At least partial vacuum pressure is applied to the second chamber, including to the cavity, whilst infusing the composite preform. The exterior of the second vacuum bagging film is exposed to an exterior pressure whilst infusing the composite preform. The exterior pressure exceeds the pressure applied to the first and second chambers, thereby acting on the composite preform outside of the region to compact the composite preform outside of the region. The second vacuum bagging film is supported against the exterior pressure with the bridge structure whilst infusing the composite preform.

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ABSTRACT

A method and system for resin infusing a composite preform is disclosed. A composite preform is located on an upper tool surface of a tool. A first vacuum bagging film is placed over the tool surface to cover the composite preform and define a sealed first chamber. A bridge structure is located over the first vacuum bagging film over a region of the composite preform. The bridge structure has an underside defining a recess forming a cavity above the first vacuum bagging film. A second vacuum bagging film is placed over the first vacuum bagging film and the bridge structure to define a sealed second chamber. A resin supply is communicated with the first chamber on an upstream side of the composite preform. At least partial vacuum pressure is applied to the first chamber on a downstream side of the composite preform to establish a pressure differential to drive resin from the resin supply through the first chamber, infusing the composite preform with resin. At least partial vacuum pressure is applied to the second chamber, including to the cavity, whilst infusing the composite preform. The exterior of the second vacuum bagging film is exposed to an exterior pressure whilst infusing the composite preform. The exterior pressure exceeds the pressure applied to the first and second chambers, thereby acting on the composite preform outside of the region to compact the composite preform outside of the region. The second vacuum bagging film is supported against the exterior pressure with the bridge structure whilst infusing the composite preform.

METHOD AND SYSTEM FOR RESIN INFUSING A COMPOSITE PREFORM

Field

The present disclosure generally relates to the fabrication of composite structures and in particular relates to a method and system for resin infusing a composite preform.

Background

A current method for fabricating composite structures utilises a resin infusion process to infuse a composite preform, formed of multiple plies each formed of composite fibres, with resin prior to curing of the resin to form a composite structure. According to a current method, the composite preform is located on a tool surface and a vacuum bagging film is placed over the tool surface to cover the composite preform and sealed to form a sealed chamber between the tool surface and vacuum bagging film. Resin is infused through the composite preform by application of vacuum pressure to a downstream end of the sealed chamber, creating a pressure differential between the upstream resin supply and the downstream end of the sealed chamber, driving resin from the resin supply through the composite preform. Once the resin has been infused throughout the preform, the entire assembly is heated, typically in an oven, to cure the resin and thus form the composite structure.

Resin infuses through the composite preform with a wavefront that may or may not progress evenly across the lateral extent of the preform. The speed of resin infusion across the wavefront may become limited by the size of the composite preform, as well as other factors like the viscosity of the resin or the permeability of the composite preform. Variations in the geometry of the composite preform, particularly variations in thickness, also effect the local speed of resin infusion. Thicker regions of a composite preform require an increased volume of resin to fully infuse the thicker region. Where the speed of the infusion through the thicker region is insufficient, local dry spots or resin starvation may result. A form of locally thickened region where dry spots may be experienced is a “padup”, where additional plies are utilised to build up the thickened region. Padups are typically utilized in areas of a composite structure subject to increased local stresses, such as at metal fitting attachment points. Local dry spots or resin starvation may also result from other factors, including the specific resin infusion strategy or other local geometry factors.

The present disclosure is made bearing the above problem in mind.

Summary

The present disclosure is generally directed to a method and system for resin infusing a composite preform. According to embodiments of the present disclosure, a bridge structure is utilized in a double vacuum bagging film arrangement. The bridge structure is located over a first (lower) vacuum bagging film over a region of a composite preform and supporting an upper (second) vacuum bagging film against exterior atmospheric pressure applied whilst infusing the composite preform. The first vacuum bagging film is thus not subject to atmospheric pressure located in a cavity under the bridge structure, such that the composite preform is not compacted under atmospheric pressure in the pre-defined region. The permeability of the pre-defined region of the composite preform is thus not reduced by compaction, promoting increased resin flow during resin infusion, thereby assisting in ensuring the pre-defined region of the composite preform is fully resin infused.

According to one aspect, the present disclosure provides a method of resin infusing a composite preform having a pre-defined region susceptible to resin starvation, beside an adjacent region less susceptible to resin starvation. The composite preform is located on an upper tool surface of a tool. A layer of permeable flow media is placed over the composite preform. A first vacuum bagging film is placed over the tool surface to cover the layer of permeable flow media and define a sealed first chamber between the tool surface and the first vacuum bagging film. A bridge structure is located over the first

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vacuum bagging film such that a roof of the bridge structure spans the pre-defined region of the composite preform and such that at least one wall depending from a periphery of the roof and defining an edge of the bridge structure is disposed on the first vacuum bagging film such that no portion of the edge is in the pre-defined region and the entire edge is supported by a portion of the composite preform entirely outside of the pre-defined region, and such that an underside of the bridge structure defines a recess forming a cavity in the form of an enclosed space or a tunnel above the first vacuum bagging film and above the entire pre-defined region; the. A second vacuum bagging film is placed over the first vacuum bagging film and the bridge structure to define a sealed second chamber between the first and second vacuum bagging films. A resin supply is communicated with the first chamber on an upstream side of the composite preform. At least partial vacuum pressure is applied to the first chamber on a downstream side of the composite preform to establish a pressure differential to drive resin from the resin supply through the first chamber, infusing the composite preform with the resin. At least partial vacuum pressure is applied to the second chamber, including to the cavity, whilst infusing the composite preform. An exterior of the second vacuum bagging film is exposed to an exterior pressure whilst infusing the composite preform. The exterior pressure exceeds the pressure applied to the first and second chambers, thereby acting on the composite preform outside of the pre-defined region to compact the composite preform outside of the pre-defined region. The second vacuum bagging film is supported against the exterior pressure with the bridge structure whilst infusing the composite preform.

Typically, the exterior pressure is substantially equal to, or greater than, atmospheric pressure.

The composite preform may have a non-uniform thickness on the tool surface. The pre-defined region of the composite preform may have a thickness greater than an average thickness of the composite preform.

According to a second aspect, the present disclosure provides a method of fabricating a composite structure. A composite preform is resin infused according to the

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method of the first aspect defined above to form a resin infused composite preform. The resin infused composite preform is then cured.

In certain embodiments, following infusing the composite preform with resin, pressure may be applied to the second chamber, including to the cavity, with the pressure applied exceeding the at least partial vacuum pressure applied whilst infusing the composite preform.

In other embodiments, curing the resin infused composite preform comprises heating the resin infused composite preform to a cure temperature, with the bridge structure structurally failing during heating, collapsing the cavity, such that the bridge structure does not support the second vacuum bagging film during curing of the resin infused composite preform. Exterior pressure is thus allowed to act on the pre-defined region of the composite preform following resin infusion.

In one or more specific embodiments, the bridge structure may be formed of a thermoplastic material with a melting temperature at or below the cure temperature, with the bridge structure structurally failing by melting.

The thermoplastic material may have a melting temperature of between **110**^{0}C and **160**^{0}C, and more preferably between **120**^{0}C and **140**^{0}C.

According to a third aspect, the present disclosure provides a resin infusion system for resin infusing a composite preform having a pre-defined region susceptible to resin starvation beside an adjacent region less susceptible to resin starvation. The system includes a tool having an upper tool surface supporting the composite preform. A layer of permeable flow media covers the composite preform. A first vacuum bagging film covers the layer of permeable flow media to define a sealed first chamber between the first vacuum bagging film and the tool surface. A second vacuum bagging film covers the first vacuum bagging film to define a sealed second chamber between the first and second vacuum bagging films. An exterior of the second vacuum bagging film is exposed to exterior pressure. A bridge structure is located in the second chamber. The bridge structure includes a roof spanning the pre-defined region of the composite preform and

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at least one wall depending from a periphery of the roof. The at least one wall defines an edge of the bridge structure and is disposed on the first vacuum bagging film such that no portion of the edge is in the pre-defined region and the entire edge is supported by a portion of the composite preform entirely outside of the pre-defined region. An underside of the bridge structure defines a recess forming a cavity in the form of an enclosed space or a tunnel above the first vacuum bagging film and above the entire pre-defined region.. A resin supply communicates with the first chamber on an upstream side of the composite preform. A first vacuum source communicates with the first chamber on a downstream side of the composite preform. A second vacuum source communicates with the second chamber, including with the cavity.

The composite preform may have a non-uniform thickness. The pre-defined region of the composite preform may have a thickness greater than an average thickness of the composite preform.

In certain embodiments, the bridge structure is configured to structurally fail at a temperature at or below a cure temperature of the resin.

In particular embodiments, the bridge structure is formed of a thermoplastic material having a melting temperature at or below the cure temperature. In such embodiments, the bridge structure is configured to structurally fail by melting.

The thermoplastic material may have a melting temperature of between **110**^{0}C and **160**^{0}C and more preferably between **120**^{0}C and **140**^{0}C.

The at least one wall of the bridge structure may be a pair of walls depending from opposing sides of the periphery of the roof.

Alternatively, the at least one wall of the bridge structure may be one wall extending about a periphery of the roof.

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In one or more preferred embodiments, each wall may flare outwardly toward the edge to define a foot supported by the first vacuum bagging film. A thickness of the foot may taper to the edge.

The first vacuum source communicating with the first chamber may be configured to generate a first vacuum pressure and the second vacuum source communicating with the second chamber may be configured to generate a second vacuum pressure. The first vacuum pressure may be equal to the second vacuum pressure.

In another embodiment there is provided a method of resin infusing a composite preform having a pre-defined region susceptible to resin starvation, beside an adjacent region less susceptible to resin starvation. The composite preform is located on an upper tool surface of a tool. A first vacuum bagging film is placed over the tool surface to cover the composite preform and define a sealed first chamber between the tool surface and the first vacuum bagging film. A bridge structure is located over the first vacuum bagging film such that a roof of the bridge structure spans the pre-defined region of the composite preform and such that at least one wall depending from a periphery of the roof and defining an edge of the bridge structure is disposed on the first vacuum bagging film such that no portion of the edge is in the pre-defined region and the entire edge is supported by a portion of the composite preform entirely outside of the pre-defined region, and such that an underside of the bridge structure defines a recess forming a cavity in the form of an enclosed space or a tunnel above the first vacuum bagging film and above the entire pre-defined region . A second vacuum bagging film is placed over the first vacuum bagging film and the bridge structure to define a sealed second chamber between the first and second vacuum bagging films. A resin supply is communicated with the first chamber on an upstream side of the composite preform. At least partial vacuum pressure is applied to the first chamber on a downstream side of the composite preform to establish a pressure differential to drive resin from the resin supply through the first chamber, infusing the composite preform with resin. At least partial vacuum pressure is applied to the second chamber, including to the cavity, whilst infusing the composite preform. The exterior of the second vacuum bagging film is exposed to an exterior

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pressure whilst infusing the composite preform. The exterior pressure exceeds the pressure applied to the first and second chambers, thereby acting on the composite preform outside of the pre-defined region to compact the composite preform outside of the pre-defined region. The second vacuum bagging film is supported against the exterior pressure with the bridge structure whilst infusing the composite preform. Curing the resin infused composite preform comprises heating the resin infused composite preform to a cure temperature, the bridge structure structurally failing during the heating, collapsing the cavity such that the bridge structure does not support the second vacuum bagging film during curing of the resin infused composite preform, allowing the exterior pressure to act on the pre-defined region of the composite preform during curing.

In another embodiment there is provided a resin infusion system for resin infusing a composite preform having a pre-defined region susceptible to resin starvation beside an adjacent region less susceptible to resin starvation. The system includes a tool having an upper tool surface that receives the composite preform to be resin infused. A first vacuum bagging film covers the composite preform to define a sealed first chamber between the first vacuum bagging film and the tool surface. A second vacuum bagging film covers the first vacuum bagging film to define a sealed second chamber between the first and second vacuum bagging films. A bridge structure is located in the second chamber. The bridge structure includes a roof spanning the pre-defined region of the composite preform and at least one wall depending from a periphery of the roof. The at least one wall defines an edge of the bridge structure. The edge is disposed on the first vacuum bagging film such that no portion of the edge is in the pre-defined region and the entire edge is supported by a portion of the composite preform entirely outside of the pre-defined region. An underside of the bridge structure defines a recess forming a cavity in the form of an enclosed space or a tunnel above the first vacuum bagging film and above the entire pre-defined region. . A resin supply communicates with the first chamber on an upstream side of the composite preform. A first vacuum source communicates with the first chamber on a downstream side of the composite preform. A second vacuum source communicates with the second chamber, including with the cavity. The bridge

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structure is formed of a thermoplastic material having a melting temperature at or below the cure temperature. The bridge structure is configured to structurally fail by melting.

The features described above may be implemented independently in various embodiments of the present disclosure or may be combined in the other embodiments as will be appreciated by a person skilled in the art.

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Drawings

Preferred embodiments of the present disclosure will now be described, by way of examples only, with reference to the accompanying drawings wherein:

Figure **1** is a schematic plan view of a system for resin infusing a composite preform according to a first embodiment;

Figure **2** is a schematic cross-sectional view of the system of Figure **1** taken at cross-section **2**-**2**;

Figure **3** is a schematic plan view of the bridge structure of the system of Figure **1**;

Figure **4** is a schematic cross-sectional view of the bridge structure of Figure **3**, taken at cross-section **4**-**4** of Figure **3**;

Figure **5** is an enlarged view of detail A of Figure **4**;

Figure **6** is a schematic plan view of an alternate form of bridge structure; and

Figure **7** is a flow chart of an exemplary method for resin infusing a composite preform.

Detailed Description

Methods and systems according to exemplary embodiments of the present disclosure will now be described in detail. In general, methods of resin infusing a composite preform according to the present disclosure include locating a composite preform on an upper tool surface of a tool. A first vacuum bagging film is placed over the tool surface to cover the composite preform and define a sealed first chamber between the tool surface and the first vacuum bagging film. A bridge structure is located on the first vacuum bagging film over a region of the composite preform. The bridge structure has an underside defining a recess forming a cavity above the first vacuum bagging film. A second vacuum bagging film is placed over the first vacuum bagging film and the bridge structure to define a sealed second chamber between the first and second vacuum bagging film. A resin supply communicates with the first chamber on an upstream side of the composite preform. At least partial vacuum pressure is applied to the first chamber on a downstream side of the composite preform to establish a pressure differential to drive resin from the resin supply through the first chamber, thereby infusing the composite preform with resin. Whilst infusing the composite preform, at least partial vacuum pressure is applied to the second chamber, including to the cavity. Whilst infusing the composite preform, the exterior of the second vacuum bagging film is exposed to an exterior pressure, typically to atmospheric pressure. The exterior pressure thus exceeds the at least partial vacuum pressure applied to the first and second chambers. Accordingly, the exterior pressure acts on the composite preform outside of the region covered by the bridge structure so as to compact the composite preform outside of the region. The bridge structure acts to support the second vacuum bagging film against the exterior pressure whilst infusing the composite preform. As a result, the exterior pressure does not act on the region of the composite preform and the region of the composite preform is not compacted. Without compaction of the region of the composite preform, its permeability is not reduced through compaction, which may promote increased resin flow through the region, helping to avoid any resin starvation or dry spots within the region.

Now referring to Figures **1** to **3** of the accompanying drawings, a system **100** for resin infusing a composite preform according to a preferred embodiment will now be described. The system **100** has a tool **110** having an upper tool surface **111** on which the composite preform **10** to be resin infused is located. A first vacuum bagging film **130** covers the composite preform **10** to define a sealed first chamber **140** between the tool surface **111** and the first vacuum bagging film **130**. A bridge structure **120** is located on the first vacuum film **130** over a region **16** of the composite preform. The bridge structure **120** has an underside **121** defining a recess forming a cavity **122** above the first vacuum bagging film **130**. A second vacuum bagging film **160** is placed over the first vacuum bagging film **130** and the bridge structure **120** to define a sealed second chamber **163** between the first and second bagging films **130**, **160**. A resin supply **141** communicates with the first chamber **140** on an upstream side of the composite preform **10**. In the context of the present specification, upstream and downstream sides of the composite preform **10** are identified with reference to the direction of flow of resin, as will be further described. A first vacuum source **151** communicates with the first chamber **140** on a downstream side of the composite preform **10**, and with the second chamber **163**, including with the cavity **122**. It is also envisaged that separate vacuum sources may communicate with the first and second chambers **140**, **163**.

The tool **110** may be formed of any of various structural materials, including mild steel, stainless steel, invar or a carbon composite material that will maintain its form at elevated temperatures associated with curing, so as to provide a geometrically stable tool surface **111** though the resin curing process. The tool surface **111** may be substantially flat for the production of composite structures having a substantially flat lower surface, such as wing or fuselage skin panels, or otherwise shaped as desired so as to provide a shaped surface of a non-planar composite structure.

The composite preform **10** may take any form suitable for resin infusion and as dictated by the geometric and structural requirements of the laminated composite structure to be fabricated. The composite preform **10** comprises a layup of multiple plies of reinforcing material, each formed of woven or braided fibers and/or chopped strand mat. The preform plies may be formed of any of various reinforcing fibers, such as carbon, graphite, glass, aromatic polyamide or any other suitable material for forming a resin reinforced laminated composite structure. The plies may form a dry preform, without any resin, or alternatively the preform may have some pre-existing resin content prior to the resin infusion process. The composite preform **10** is located on the tool surface **111** with the lower surface **15** of the preform **10** oriented on the tool surface **111** such that the lower surface of the resulting cured composite structure will match the form of the tool surface **111**. The composite preform **10** located on the tool surface **111** has a laterally extending downstream edge **11**, an opposing laterally extending upstream edge **12** and opposing longitudinally extending side edges **13**. In the context of the present specification, upstream and downstream sides of the composite preform **10** are identified with reference to the direction of flow of resin, as will be further described. The preform **10** may take any desired shape corresponding to the shape of the laminated composite structure to be formed.

The composite preform may have a uniform thickness or, alternatively as depicted in the embodiment of Figures **2** and **3**, the composite preform **10** may have a non-uniform thickness as measured between the upper and lower surfaces **14**, **15**. Particularly, in the arrangement depicted, the region **16** of the composite preform **10** has a thickness greater than an average thickness of the composite preform **10**. In the first embodiment, the thicker region **16** of the composite preform **10** is in the form of a padup, having an increased thickness as a result of being provided with additional plies of reinforcing material to provide local structural reinforcement. Padups, and other portions of composite preforms having a locally increased thickness, generally require a higher volume of resin per unit of preform surface area and may be more susceptible to resin starvation and local dry spots. Other regions of the composite preform **10** that do not have an increased thickness may also be subject to resin starvation and dry spots, such as resulting from particular infusion strategies and geometries.

The resin supply **141** communicates with the first cavity **140** through one or more resin infusion inlets **112** extending through the tool **110** on the upstream side of the composite preform **10**, via one or more resin supply pipes **146**. The resin supply pipes **146** are typically formed of copper. The first vacuum source **151** communicates with the first chamber **140** through one or more vacuum outlets **113** extending through the tool **110** on a downstream side of the composite preform **10**, via one or more vacuum outlet pipes **154**, which are also typically formed of copper. In the embodiment depicted, the resin supply **141** also communicates with a second vacuum source **155** via a second vacuum pipe **157**.

A flow path **142** extends from the resin supply **141**, through the first chamber **140**, the composite preform **10** and to the first vacuum source **151**. An upstream portion of the flow path **142** comprises the resin supply pipe(s) **146** and resin infusion inlet **112** extending through the tool **110**. A mid portion of the flow path **142**, defined by the first chamber **140**, is formed by the composite preform **10** and various layers of layup materials located beneath the first vacuum bagging film **130**. The layup materials include a permeable peel ply **145** located directly on, and extending over, the entirety of the composite preform **10**, beyond each of the edges **11**, **12**, **13** of the composite preform **10**, with a downstream portion **144** of the peel ply **145** extending downstream of the downstream edge **11** of the composite preform **10**. A layer **147** of permeable flow media is placed over the peel ply **145** and extends beyond the upstream edge of the peel ply **145** to beyond the resin infusion inlet(s) **112**. The layer **147** of permeable flow media extends to beyond the downstream edge **11** of the composite preform **10** but does not cover the entirety of the downstream portion **144** of the peel ply **145**. The peel ply **145** serves to prevent the layer **147** of permeable flow media from sticking to the composite preform **10** and also provides a path for infusion of resin into the composite preform **10**, both along the upstream edge **12** of the composite preform **10** and through the upper surface **14** of the composite preform **10**. The peel ply **145** also allows volatiles given off during curing of the resin to be drawn away from the composite preform **10**. The peel ply **145** also constitutes a permeable flow media, and may suitably be in the form of a PTFE coated fiberglass fabric, such as Release Ease® **234**, available from AirTech International Inc, or any other permeable peel ply material. The layer **147** of permeable flow media provides a passage for the resin through the first chamber **140** along the top of the composite preform **10**, along with a path for the escape of volatiles from the first cavity **140**. The layer **147** of permeable flow media may suitably be in the form of a nylon mesh material, such as Plastinet®**15231** also available from AirTech International Inc, or any other highly permeable media enabling passage of resin therethrough.

A downstream portion of the flow path **142** comprises a further strip **143** of permeable flow media, the vacuum outlet(s) **113** and vacuum pipe(s) **154**. The strip **143** of permeable flow media extends across the downstream edge of the downstream portion **144** of the peel ply **145** and extends further downstream across the vacuum outlet(s) **113**. The strip **143** of permeable flow media is typically formed of the same material as the layer **147** of permeable flow media. A gap is located between the layer **147** and strip **143** of permeable flow media.

The first vacuum bagging film **130** extends over the entire layup formed by the composite preform **10**, peel ply **145** and layer **147** and strip **143** of permeable flow media. Any of various vacuum bagging film materials may be utilized, including but not limited to Airtech WL**7400** or SL**800** vacuum bagging films available from Airtech International Inc. The first vacuum bagging film **130** is sealed relative to the tool surface **111** about the periphery of the first vacuum bagging film **130** by way of strips **131** of sealing tape, which may conveniently be in the form of a mastic sealant tape, such as GS-**213**-**3** sealant tape available from AirTech International Inc.

As may be best appreciated from Figure **2**, the first vacuum bagging film **130** defines the upper boundary of the resin flow path **142**. In the gap located between the layer **147** and strip **143** of permeable flow media, the vacuum bagging film **142** restricts the thickness of the flow path **142** between the tool upper surface **111** and first vacuum bagging film **130** to the downstream portion **144** of the peel ply **145**, which is typically of a reduced permeability as compared to the layer **147** of permeable flow media. All downstream flow of resin is thus restricted through the downstream portion **144** of the peel ply **145**, which defines a permeable resin flow control choke.

A breather layer **161**, typically being a highly permeable fabric formed of fiberglass or the like is then located over, and fully covering, the first vacuum bagging film **130**. A suitable breather layer is a breather cloth formed of a high film non-woven polyester material, such as Airweave® N**10**, available from Airtech International Inc. The breather layer **161** extends over a vacuum groove **114** that extends around the perimeter of the tool surface **111** and is connected to the first vacuum source **151** (or a separate third vacuum source) by way of a third vacuum pipe **158**.

The bridge structure **120** is then located over the first vacuum bagging film **130**, on the breather layer **161**, located over the region **16** of the composite preform **10**. The bridge structure **120** according to a preferred embodiment is depicted in greater detail in Figures **3** to **5**. In Figures **4** and **5**, the various materials forming the layup beneath the bridge structure **120** (that is, the composite preform **10**, breather layer **145**, layer **147**, first vacuum bagging film **130** and breather layer **161**) are depicted schematically as one mass **180**. The bridge structure **120** comprises a roof **123** that spans across the region **16** and at least one wall **124** that depends from a periphery of the roof **123** to an edge **125** of the bridge structure **120** that is located on the breather layer **161** directly over the first vacuum bagging film **130**. In the embodiment depicted, the bridge structure **120** is of a general dome type form, with one wall **124** that extends about the periphery of the roof **123**. In plan view, the bridge structure **120** may take any suitable shape, typically to roughly match the shape of the region **16**. Appropriate shapes may include circular, square, rectangular, elliptical or any other regular or irregular shape. Having a single wall **124** extending about the entire periphery of the roof **123** of the bridge structure **120** may reduce the pressure applied to the upper surface **14** of the composite preform **10**, and thereby reduce the possibility of any mark formed on the upper surface **14** due to the local pressure applied by the bridge structure **120**.

The wall **124** may flare outwardly toward the edge **125** so as to define a foot **126** that is located on the breather layer **161** directly over, and supported by, the first vacuum bagging film **130**. This form of the wall **124** may further reduce the local pressure acting on the upper surface **14** of the composite preform **10** through the wall **124**, as opposed, for example, to having a vertically inclined edge of a side wall located on the first vacuum bagging film **130**. In the embodiment depicted, the thickness of the foot **126** tapers to the edge **125**, so as to generally blend the upper surface of the bridge structure **120** toward the breather layer **161** and the first vacuum bagging film **130** at the edge **125**, so as to reduce any step between the upper surface of the bridge structure **120** at the edge **125** and the breather layer **161**, which the second vacuum bagging film **160** would otherwise need to bridge and result in an unwanted low pressure region around the periphery of the bridge structure **120** and create a region of higher permeability commonly referred to as "race tracks" by persons skilled in the art of resin infusion.

Rather than have the wall **124** extend about the entire periphery of the roof **123** of the bridge structure **120**, it is envisaged that the bridge structure **120** may be in the general form of a tunnel. Such a modified form of bridge structure **120**' is depicted in plan form in Figure **6**. The bridge structure **120**' has a pair of opposing side walls **124**' depending from opposing sides of the periphery of an elongate roof **123**'. The bridge structure **120**' has a transverse cross-section generally the same as that of Figure **4**, with each wall **124**' flaring outwardly to form a foot **126**' at the edge **125**' of the bridge structure **120**'. This form of bridge structure **120**' may be particularly suitable where the bridge structure **120**' is to be applied to narrow elongate regions **16**.

For configurations where it is desired to locally increase the speed of resin infusion in two adjacent regions, a single bridge structure may be provided defining a pair of adjacent cavities, with a central wall formed therebetween dividing the cavities, with the central wall resting on the breather layer **161**.

The appropriate location and size of region **16** for application of one or more bridge structures **120** may be determined through an assessment of the geometry of the composite preform **10**, locating a bridge structure **120** on regions of increased thickness which are thus expected to be susceptible to resin starvation. Alternatively or additionally, appropriate regions that are susceptible to resin starvation may be identified by one or more trial resin infusion and subsequent curing processes on a sample composite preform without use of bridge structures **120**. Local dry spots that have been subject to resin starvation may then be identified in the cured composite structure.

The bridge structure **120** may be formed of any suitable material capable of supporting the second vacuum bagging film **160** against exterior pressure (typically atmospheric pressure) applied to the system during resin infusion. Where resin infusion is conducted at elevated temperatures, typically in the range of **90**^{0}C to **110**^{0}C, the bridge structure **120** should be capable of supporting the second vacuum bagging film **160** at the resin infusion temperature. Suitable materials may include metallic materials such as aluminum, composite materials or plastics with melting temperatures above the resin infusion temperature. In particularly preferred embodiments, the bridge structure may be formed of a thermoplastic material having a melting temperature higher than the resin infusion temperature and lower than or equal to the resin curing temperature, such as between **120**^{0}C and **140**^{0}C for epoxy resins that are resin infused at infusion temperatures of **90**^{0}C to **110**^{0}C and cured at cure temperatures of **180**^{0}C to **200**^{0}C. Depending on the infusion and cure temperatures, melting temperatures falling within a broader range of **110**^{0}C to **160**^{0}C may be suitable. This melting will ensure that the bridge structure **120** structurally fails after completion of resin infusion and during heating to the resin curing temperature, collapsing the cavity such that the bridge structure **120** does not support the second vacuum bagging film **160** during curing, as will be further discussed below. Suitable thermoplastic materials may include polyoxyethylene (PE) and polypropylene (PP). Rather than structurally failing by melting, it is also envisaged that the bridge structure **120** may otherwise be configured such that it structurally fails by other means during heating.

The second vacuum bagging film **160** is then located to cover the entire breather layer **161** and bridge structure **120** and is sealed relative to the tool surface **111** by way of further strips **162** of sealing tape, forming the sealed second chamber **163** between the first and second vacuum bagging films **130**, **160**. The second vacuum bagging film **160** and associated vacuum applied to the second chamber **163** protects against any minor leaks associated with the first vacuum bag **130**, with the vacuum applied evacuating any air permeating through the second vacuum bagging film **160** toward the composite preform **10** through the breather layer **161**, rather than allowing it to permeate through to the composite preform **10**.

In use, once the system **100** has been assembled as discussed above, the resin supply **141** is catalyzed and heated to bring the resin to a suitable resin infusion temperature. Typically the entire system is heated within the oven (or autoclave) that is also used for subsequent curing. The temperature for resin infusion will be dependent upon the resin system utilized, and will typically be selected to provide a suitable viscosity enabling the resin to be drawn through the resin flow path **142**. For epoxy resins, suitable infusion temperatures may be in the range of **90**^{0}C to **110**^{0}**C.** Apart from epoxy resins, any other resin suitable for use in resin infusion processes, and as dictated by desired characteristics of the composite structure to be formed, may be utilized. Suitable resins may include epoxy, bismaleimide, benzoxazine, polyimide cyanate esters and polyamide-imide resins.

At least partial vacuum pressure is applied to the downstream end of the first chamber **140**, via the first vacuum source **151** and vacuum outlet(s) **113**. A smaller partial vacuum (i.e., a higher absolute pressure) may also be applied to the resin supply **141**, by way of a second vacuum source **155** connected to a second vacuum pipe **157**, as shown in Figure **3**. Where partial vacuum is applied to the resin supply **141** by the second vacuum source **155**, a pressure differential may be maintained between the first vacuum source **151** and second vacuum source **155** such that the absolute pressure at the vacuum outlet(s) **113** applied by the first vacuum source **151** is lower than the absolute pressure at the resin supply **141**. In one example, a full vacuum (**0** mbar / **0** kPa) may be applied by the first vacuum source **151** and a higher pressure / lower vacuum of **500** to **800** mbar (**50** to **80** kPa) may be applied to the second vacuum source **155**, thereby providing a pressure differential of the same amount driving resin from the resin supply **141** through the resin flow path **142**. Maintaining at least partial vacuum on the resin supply ensures at least a partial vacuum is maintained throughout the first chamber **140**. Full vacuum pressure may also be applied to the resin supply **141** by the second vacuum source **155** prior to resin infusion to degas the resin.

During resin infusion, at least partial vacuum pressure is also applied to the second chamber **163**, including to the cavity **122**, via the first vacuum source **151** and vacuum groove **114**. Where vacuum applied to the second chamber **163** is from the first vacuum source **151**, the same vacuum pressure will be applied to both the first and second chambers **140**, **163**. It is, however, envisaged that the vacuum applied to the second chamber **163** may be via a separate vacuum source, and may be a different partial vacuum pressure to that applied to the first chamber **140**.

Resin moves through the first chamber **140** along a wave front, through the layer **147** of permeable flow media, which will generally have a greater permeability than both the peel ply **145** and the composite preform **10**, thus forming the path of least resistance. Resin passing through the layer **147** of permeable flow media will infuse down through the less permeable peel ply **145** and into the preform **10**. Some resin will also flow laterally through the upstream edge **12** of the composite preform **10** and, to a lesser degree, through the opposing side edges **13** of the composite preform **10**. Having the downstream edge **11** of the layer **147** of permeable flow media finish short of both the strip **143** of permeable flow media and the downstream portion **144** of the peel ply **145** prevents resin bypassing the preform **10** and simply being drawn through the layer **147** of permeable flow media directly into the vacuum outlet(s) **113**. The rate of advance of the resin wave front is inhibited by forcing the resin to pass downstream longitudinally through a permeable resin flow control choke defined by the downstream portion **144** of the peel ply **145** once it passes the downstream edge **11** of the composite preform **10** and the downstream edge of the layer **147** of permeable flow media.

The exterior of the second vacuum bagging film **160** is exposed to exterior pressure, being the pressure with the oven (or autoclave). This exterior pressure exceeds the pressure applied to the first and second chambers **140**, **163** and is typically at least substantially equal to atmospheric pressure (**1013**mbar/**101.3**kPa), or greater where an autoclave is utilized. This atmospheric pressure acts on the composite preform **10** through the second vacuum bagging film **160**, breather layer **161**, first vacuum bagging film **130**, layer **147** of permeable flow media and peel ply **145**, apart from in the region **16** where the bridge structure **120** supports against the atmospheric pressure. The atmospheric pressure acting on the composite preform **10** outside of the region **16** acts to compact the composite preform **10** outside of the region **16**, which reduces the permeability of the composite preform **10** outside of the region **16**. The bridge structure **10** supports the second vacuum bagging film **160** against the exterior atmospheric pressure. As a result, it is only the at least partial vacuum pressure applied to the cavity **122** that acts against the first vacuum bagging film **130** directly above the region **16**. Where the at least partial vacuum pressure applied to the cavity **122** is equal to the at least partial vacuum pressure applied to the first chamber **140**, being full vacuum pressure in the preferred embodiment, no net pressure is applied to the composite preform **10** within the region **16** tending to compact the same. Even if the pressure applied to the cavity **122** and first chamber **140** are not equal, the pressure differential acting on the first vacuum bagging film **130** at the region **16** will be less than that applied outside of the region **16**. Accordingly, the permeability of the composite preform **10** within the region **16** is not reduced (or is at least not reduced to the same degree as the remainder of the composite preform **10**) and is greater than the reduced permeability of the remainder of the composite preform **10**. As a result, when the resin wavefront reaches the region **16**, the required increased volume of resin is able to preferentially fill the region **16** at a faster rate, enabling full resin infusion of the region **16** rather than having the resin pass beyond the region **16** without full infusion.

The resin infused composite preform **10** is cured by elevating the temperature of the oven to a temperature suitable for curing of the resin. For epoxy resins, curing temperatures of the order of **180**^{0}C to **200**^{0}C will be typical. Full vacuum is typically maintained on the first vacuum source **151** during the curing process, ensuring vacuum pressure remains applied to the first and second chambers **140**, **163**. Maintaining the vacuum pressure ensures the external pressure applied to the second vacuum bagging film **160** continues to act on the resin infused composite preform (outside of the region **16**) throughout curing, ensuring the composite preform remains compacted/consolidated and to assist in curing of the resin.

Whilst the bridge structure **120** remains in place and intact during resin curing, the quality of the composite structure within the region **16** may be compromised through lack of compaction during the resin curing process. This may affect the structural properties of the region **16** and may also result in surface irregularities due to lack of consistent compaction across the extent of the composite preform **10**. Accordingly, in a preferred embodiment, the bridge structure **120** structurally fails during heating of the resin infused composite preform **10** to resin curing temperature. Structural failure of the bridge structure **120** collapses the cavity **122** such that the bridge structure **120** does not support the second vacuum bagging film **160** against exterior pressure during curing of the resin infused composite preform **10**. The exterior pressure is thus allowed to act on the region **16** of the composite preform **10** during curing, thus compacting the region **16** during the resin curing process, consistent with the remainder of the resin infused composite preform **10**. As discussed above, the structural failing of the bridge structure **10** may be by way of melting of the bridge structure **120** at a temperature at or below the resin curing temperature, or by other means, such as by failure of a joint between the roof **123** and wall **124** of the bridge structure **120**.

Rather than, or additionally to, configuring the bridge structure **120** to structurally fail during heating of the resin infused composite preform **10** so as to allow exterior pressure to act on the region **16** of the composite preform **10** during curing, it is envisaged that, following resin infusion, pressure may be applied to the second chamber **163**, including the cavity **122**, via the first vacuum source **151** and vacuum groove **114** (or a separate vacuum source). The absolute pressure applied at this stage will exceed that of the at least partial vacuum pressure applied to the second chamber **163** during resin infusion. As a result, increased pressure in the cavity **122** will provide a net positive pressure on the upper surface of the first bagging film **130**, acting to compact the region **16** of the composite preform **10** following resin infusion and prior to curing of the resin. This may therefore address the lack of compaction during resin infusion. The pressure applied to the second chamber **163** may suitably be atmospheric pressure, although pressures exceeding atmospheric pressure, or partial vacuum pressures having an absolute pressure higher than that applied during infusion are also envisaged.

Once the resin is cured, and the system **100** cooled to room temperature, the various consumable layers, including the first and second vacuum bagging films **130**, **160**, the layer **147** and strip **143** of permeable flow media, peel ply **145** and breather layer **161** are removed, along with the bridge structure **120**. The fully formed composite structure may then be removed from the tool surface **111**.

A general method of resin infusing the composite preform as discussed above is depicted in general terms in the flow diagram of Figure **7**.

At block **201** a composite preform is located on an upper tool surface of a tool. At block **202** a first vacuum bagging film is placed over the tool surface to cover the composite preform and define a sealed first chamber between the tool surface and the first vacuum bagging film.

At block **203** a bridge structure is located on the first vacuum bagging film over a region of the composite preform. The bridge structure has an underside defining a recess forming a cavity above the first vacuum bagging film.

At block **204** a second vacuum bagging film is placed over the first vacuum bagging film and the bridge structure to define a sealed second chamber between the first and second vacuum bagging films.

At block **205** a resin supply is communicated with the first chamber on an upstream side of the composite preform.

At block **206** at least partial vacuum pressure is applied to the first chamber on a downstream side of the composite preform to establish a pressure differential to drive resin from the resin supply through the first chamber, infusing the composite preform with resin. At block **207** at least partial vacuum pressure is applied to the second chamber, including to the cavity, whilst infusing the composite preform.

At block **208** the exterior of the second vacuum bagging film is exposed to an exterior pressure whilst infusing the composite preform. The exterior pressure exceeds the pressure applied to the first and second chambers, thereby acting on the composite preform outside of the region to compact the composite preform outside of the region.

At block **209** a resin flow path is provided from the resin supply to the resin infusion chamber on an upstream side of the composite preform, through the composite preform and through the reservoir inlet to the resin reservoir.

At block **210** the second vacuum bagging film is supported against the exterior pressure with the bridge structure whilst infusing the composite preform.

Further, the disclosure comprises embodiments according to the following clauses:

Clause **1**. A method of resin infusing a composite preform, said method comprising:

locating a composite preform on an upper tool surface of a tool;

placing a first vacuum bagging film over said tool surface to cover said composite preform and define a sealed first chamber between said tool surface and said first vacuum bagging film;

locating a bridge structure over said first vacuum bagging film over a region of said composite preform, said bridge structure having an underside defining a recess forming a cavity above said first vacuum bagging film;

placing a second vacuum bagging film over said first vacuum bagging film and said bridge structure to define a sealed second chamber between said first and second vacuum bagging films;

communicating a resin supply with said first chamber on an upstream side of said composite preform;

applying at least partial vacuum pressure to said first chamber on a downstream side of said composite preform to establish a pressure differential to drive resin from said resin supply through said first chamber, infusing said composite preform with resin;

applying at least partial vacuum pressure to said second chamber, including to said cavity, whilst infusing said composite preform;

exposing the exterior of said second vacuum bagging film to an exterior pressure whilst infusing said composite preform, said exterior pressure exceeding the pressure applied to said first and second chambers, thereby acting on said composite preform outside of said region to compact said composite preform outside of said region; and

supporting said second vacuum bagging film against said exterior pressure with said bridge structure whilst infusing said composite preform.

Clause **2**. The method of Clause **1**, wherein said exterior pressure substantially equal to, or greater than, atmospheric pressure.

Clause **3**. The method of either one of Clauses **1** and **2**, wherein locating said bridge structure comprises locating said bridge structure over a region of said composite preform susceptible to resin starvation.

Clause **4**. The method of any one of Clauses **1** to **3**, wherein locating said composite preform comprises locating a composite preform having a non-uniform thickness on said tool surface, and locating said bridge structure comprises locating said bridge structure over a region of said composite preform having a thickness greater than an average thickness of said composite preform.

Clause **5**. A method of fabricating a composite structure, said method comprising:

resin infusing a composite preform according to the method of any one of claims **1** to **4** to form a resin infused composite preform; and curing said resin infused composite preform.

Clause **6**. The method of Clause **5**, further comprising, whilst curing said resin infused composite preform, applying a pressure to said second chamber, including to said cavity, exceeding the at least partial vacuum pressure applied whilst infusing said composite preform.

Clause **7**. The method of Clause **5**, wherein curing said resin infused composite preform comprises heating said resin infused composite preform to a cure temperature, said bridge structure structurally failing during said heating, collapsing said cavity, such that said bridge structure does not support said second vacuum bagging film during curing of said resin infused composite preform, allowing said exterior pressure to act on said region of said composite preform during curing.

Clause **8**. The method of Clause **7**, wherein locating said bridge structure comprises locating a bridge structure formed of a thermoplastic material with a melting temperature at or below said cure temperature, said bridge structure structurally failing by melting.

Clause **9**. The method of Clause **8** wherein said thermoplastic material has a melting temperature of between **110**^{0}C and **160**^{0}C.

Clause **10**. A resin infusion system for resin infusing a composite preform, said system comprising:

a tool having an upper tool surface receiving a composite preform to be resin infused;

a first vacuum bagging film covering said composite preform to define a sealed first chamber between said first vacuum bagging film and said tool surface;

a second vacuum bagging film covering said first vacuum bagging film to define a sealed second chamber between said first and second vacuum bagging films;

a bridge structure located in said second chamber over a region of said composite preform, said bridge structure supporting said second vacuum bagging film and having an underside defining a recess forming a cavity above said first vacuum bagging film;

a resin supply communicating with said first chamber on an upstream side of said composite preform;

a vacuum source communicating with said first chamber on a downstream side of said composite preform; and

a vacuum source communicating with said second chamber, including with said cavity.

Clause **11**. The system of Clause **10**, wherein said composite preform has a non-uniform thickness, said region of said composite preform having a thickness greater than an average thickness of said composite preform.

Clause **12**. The system of either one of Clause **10** or **11**, wherein said bridge structure is configured to structurally fail at a temperature at or below a cure temperature of said resin.

Clause **13**. The system of Clause **12**, wherein said bridge structure is formed of a thermoplastic material having a melting temperature at or below said cure temperature, said bridge structure being configured to structurally fail by melting.

Clause **14**. The system of Clause **13**, wherein said thermoplastic material has a melting temperature of between **110**^{0}C and **160**^{0}C.

Clause **15**. The system of Clause **13**, wherein said thermoplastic material has a melting temperature between **120**^{0}C and **140**^{0}C.

Clause **16**. The system of any one of Clauses **10** to **15**, wherein said bridge structure comprises a roof and at least one wall depending from a periphery of said roof to an edge of said bridge structure located on said first vacuum bagging film.

Clause **17**. The system of Clause **16** wherein said bridge structure has a pair of said walls depending from opposing sides of said periphery of said roof.

Clause **18**. The system of Clause **16**, wherein said bridge structure has one wall extending about a periphery of said roof.

Clause **19**. The system of either one of Clauses **17** and **18**, wherein each said wall flares outwardly towards said edge to define a foot supported by said first vacuum bagging film.

Clause **20**. The system of Clause **19**, wherein a thickness of said foot tapers to said edge.

EMBODIMENTS IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. A method of resin-infusing a composite preform having a pre-defined region susceptible to resin starvation, beside an adjacent region less susceptible to resin starvation, the method comprising:

locating the composite preform on an upper tool surface of a tool;

placing a layer of permeable flow media over the composite preform;

placing a first vacuum bagging film over the tool surface to cover the layer of permeable flow media and define a sealed first chamber between the tool surface and the first vacuum bagging film;

locating a bridge structure over the first vacuum bagging film such that a roof of the bridge structure spans the pre-defined region of the composite preform and such that at least one wall depending from a periphery of the roof and defining an edge of the bridge structure is disposed on the first vacuum bagging film such that no portion of the edge is in the pre-defined region and the entire edge is supported by a portion of the composite preform entirely outside of the pre-defined region, and such that an underside of the bridge structure defines a recess forming a cavity in the form of an enclosed space or a tunnel above the first vacuum bagging film and over the entire pre-defined region;

placing a second vacuum bagging film over the first vacuum bagging film and the bridge structure to define a sealed second chamber between the first and second vacuum bagging films;

communicating a resin supply with the first chamber on an upstream side of the composite preform;

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applying at least partial vacuum pressure to the first chamber on a downstream side of the composite preform to establish a pressure differential to drive resin from the resin supply through the first chamber, infusing the composite preform with the resin;

applying at least partial vacuum pressure to the second chamber, including to the cavity, whilst infusing the composite preform;

exposing an exterior of the second vacuum bagging film to an exterior pressure whilst infusing the composite preform, the exterior pressure exceeding the pressure applied to the first and second chambers, thereby acting on the composite preform outside of the pre-defined region to compact the composite preform outside of the pre-defined region; and

supporting the second vacuum bagging film against the exterior pressure with the bridge structure whilst infusing the composite preform.

2. The method of claim **1** wherein the exterior pressure substantially equal to, or greater than, atmospheric pressure.

3. The method of claim **1** or **2** wherein the composite preform has a non-uniform thickness on the tool surface, and the pre-defined region of the composite preform has a thickness greater than an average thickness of the composite preform.

4. A method of fabricating a composite structure, the method comprising:

resin infusing a composite preform according to the method of any one of claims **1** to **3** to form a resin infused composite preform; and

curing the resin infused composite preform.

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5. The method of claim **4** further comprising, whilst curing the resin infused composite preform, applying a pressure to the second chamber, including to the cavity, exceeding the at least partial vacuum pressure applied whilst infusing the composite preform.

6. The method of claim **4** wherein curing the resin infused composite preform comprises heating the resin infused composite preform to a cure temperature, the bridge structure structurally failing during the heating, collapsing the cavity, such that the bridge structure does not support the second vacuum bagging film during curing of the resin infused composite preform, allowing the exterior pressure to act on the pre-defined region of the composite preform during curing.

7. The method of claim **6** wherein the bridge structure is formed of a thermoplastic material with a melting temperature at or below the cure temperature, the bridge structure structurally failing by melting.

8. The method of claim **7** wherein the thermoplastic material has a melting temperature of between **110**^{0}C and **160**^{0}C.

9. A resin infusion system for resin infusing a composite preform having a pre-defined region susceptible to resin starvation beside an adjacent region less susceptible to resin starvation, the system comprising:

a tool having an upper tool surface supporting the composite preform;

a layer of permeable flow media covering the composite preform;

a first vacuum bagging film covering the layer of permeable flow media to define a sealed first chamber between the first vacuum bagging film and the tool surface;

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a second vacuum bagging film covering the first vacuum bagging film to define a sealed second chamber between the first and second vacuum bagging films, an exterior of the second vacuum bagging film being exposed to exterior pressure;

a bridge structure located in the second chamber, the bridge structure including a roof spanning the pre-defined region of the composite preform and at least one wall depending from a periphery of the roof, the at least one wall defining an edge of the bridge structure disposed on the first vacuum bagging film such that no portion of the edge is in the pre-defined region and the entire edge is supported by a portion of the composite preform entirely outside of the pre-defined region, and such that an underside of the bridge structure defines a recess forming a cavity in the form of an enclosed space or a tunnel above the first vacuum bagging film and over the entire pre-defined region;

a resin supply communicating with the first chamber on an upstream side of the composite preform;

a first vacuum source communicating with the first chamber on a downstream side of the composite preform; and

a second vacuum source communicating with the second chamber, including with the cavity.

10. The system of claim **9** wherein the composite preform has a non-uniform thickness, the pre-defined region of the composite preform having a thickness greater than an average thickness of the composite preform.

11. The system of claim **9** or **10** wherein the bridge structure is configured to structurally fail at a temperature at or below a cure temperature of the resin.

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12. The system of claim **11**, wherein the bridge structure is formed of a thermoplastic material having a melting temperature at or below the cure temperature, the bridge structure being configured to structurally fail by melting.

13. The system of claim **12** wherein the thermoplastic material has a melting temperature of between **110**^{0}C and **160**^{0}C.

14. The system of claim **12** wherein the thermoplastic material has a melting temperature between **120**^{0}C and **140**^{0}C.

15. The system of claim **9** wherein the at least one wall of the bridge structure is a pair of walls depending from opposing sides of the periphery of the roof.

16. The system of claim **9** wherein the at least one wall of the bridge structure is a single wall extending about the periphery of the roof.

17. The system of claim **15** or **16** wherein each the wall flares outwardly towards the edge to define a foot supported by the first vacuum bagging film.

18. The system of claim **17** wherein a thickness of the foot tapers to the edge.

19. The system of claim **9** in which the first vacuum source communicating with the first chamber is configured to generate a first vacuum pressure and the second vacuum source communicating with the second chamber is configured to generate a second vacuum pressure, wherein the first vacuum pressure is equal to the second vacuum pressure.

20. A method of resin infusing a composite preform having a pre-defined region susceptible to resin starvation, beside an adjacent region less susceptible to resin starvation, the method comprising:

locating the composite preform on an upper tool surface of a tool;

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placing a first vacuum bagging film over the tool surface to cover the composite preform and define a sealed first chamber between the tool surface and the first vacuum bagging film;

locating a bridge structure over the first vacuum bagging film such that a roof of the bridge structure spans the entire pre-defined region of the composite preform and such that at least one wall depending from a periphery of the roof and defining an edge of the bridge structure is disposed on the first vacuum bagging film such that no portion of the edge is in the pre-defined region and the entire edge is supported by a portion of the composite preform entirely outside of the pre-defined region, and such that an underside of the bridge structure defines a recess forming a cavity in the form of an enclosed space or a tunnel above the first vacuum bagging film and over the entire pre-defined region;

placing a second vacuum bagging film over the first vacuum bagging film and the bridge structure to define a sealed second chamber between the first and second vacuum bagging films;

communicating a resin supply with the first chamber on an upstream side of the composite preform;

applying at least partial vacuum pressure to the first chamber on a downstream side of the composite preform to establish a pressure differential to drive resin from the resin supply through the first chamber, infusing the composite preform with resin;

applying at least partial vacuum pressure to the second chamber, including to the cavity, whilst infusing the composite preform;

exposing the exterior of the second vacuum bagging film to an exterior pressure whilst infusing the composite preform, the exterior pressure exceeding the pressure applied to the first and second chambers, thereby

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acting on the composite preform outside of the pre-defined region to compact the composite preform outside of the pre-defined region; and

supporting the second vacuum bagging film against the exterior pressure with the bridge structure whilst infusing the composite preform,

wherein curing the resin infused composite preform comprises heating the resin infused composite preform to a cure temperature, the bridge structure structurally failing during the heating, collapsing the cavity such that the bridge structure does not support the second vacuum bagging film during curing of the resin infused composite preform, allowing the exterior pressure to act on the pre-defined region of the composite preform during curing.

21. The method of claim **20**, wherein the exterior pressure substantially equal to, or greater than, atmospheric pressure.

22. The method of claim **20 or 21**, wherein locating the composite preform comprises locating a composite preform having a non-uniform thickness on the tool surface, and locating the bridge structure comprises locating the bridge structure over the pre-defined region of the composite preform wherein the pre-defined region has a thickness greater than an average thickness of the composite preform.

23. A method of fabricating a composite structure, the method comprising:

resin infusing a composite preform according to the method of any one of claims **20** to **21** to form a resin infused composite preform; and

curing the resin infused composite preform.

24. The method of claim **23**, further comprising, whilst curing the resin infused composite preform, applying a pressure to the second chamber, including to the cavity, exceeding the at least partial vacuum pressure applied whilst infusing the composite preform.

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25. A resin infusion system for resin infusing a composite preform having a pre-defined region susceptible to resin starvation beside an adjacent region less susceptible to resin starvation, the system comprising:

a tool having an upper tool surface receiving the composite preform to be resin infused;

a first vacuum bagging film covering the composite preform to define a sealed first chamber between the first vacuum bagging film and the tool surface;

a second vacuum bagging film covering the first vacuum bagging film to define a sealed second chamber between the first and second vacuum bagging films;

a bridge structure located in the second chamber, the bridge structure including a roof spanning the pre-defined region of the composite preform and at least one wall depending from a periphery of the roof, the at least one wall defining an edge of the bridge structure disposed on the first vacuum bagging film such that no portion of the edge is in the pre-defined region and the entire edge is supported by a portion of the composite preform entirely outside of the pre-defined region, and such that an underside of the bridge structure defines a recess forming a cavity in the form of an enclosed space or a tunnel above the first vacuum bagging film and over the entire pre-defined region;

a resin supply communicating with the first chamber on an upstream side of the composite preform;

a first vacuum source communicating with the first chamber on a downstream side of the composite preform; and

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a second vacuum source communicating with the second chamber, including with the cavity;

wherein the bridge structure is formed of a thermoplastic material having a melting temperature at or below the cure temperature, the bridge structure being configured to structurally fail by melting.

26. The system of claim **25**, wherein the composite preform has a non-uniform thickness, the pre-defined region of the composite preform having a thickness greater than an average thickness of the composite preform.

27. The system of claim **25** or **26**, wherein the bridge structure is configured to structurally fail at a temperature at or below a cure temperature of the resin.

28. The system of any one of claims **25**-**27** wherein the at least one wall of the bridge structure is a pair of walls depending from opposing sides of the periphery of the roof.

29. The system of any one of claims **25**-**28**, wherein each the wall flares outwardly towards the edge to define a foot supported by the first vacuum bagging film.

30. The system of claim **29**, wherein a thickness of the foot tapers to the edge.

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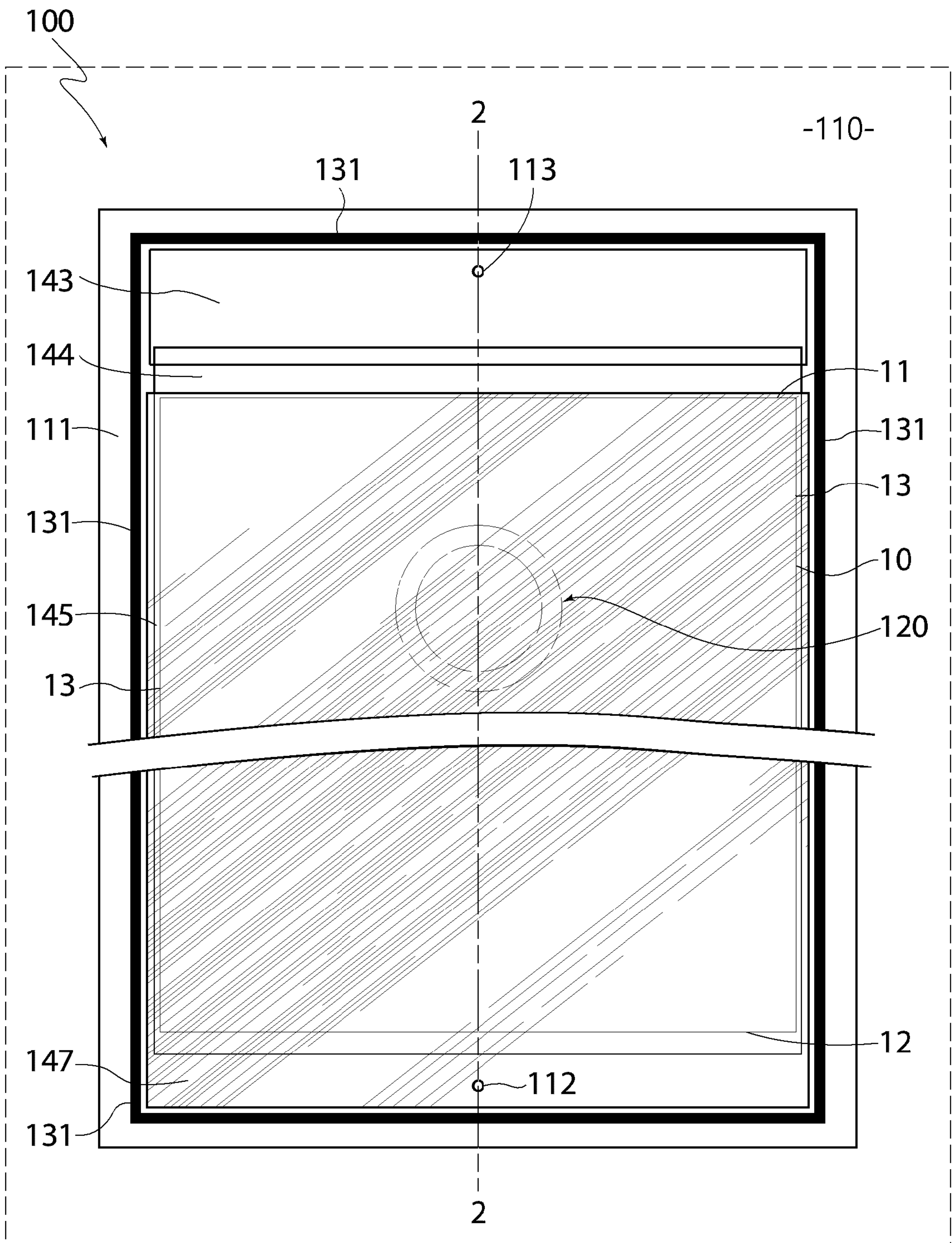

Fig. 1

Date Reçue/Date Received 2020-06-08

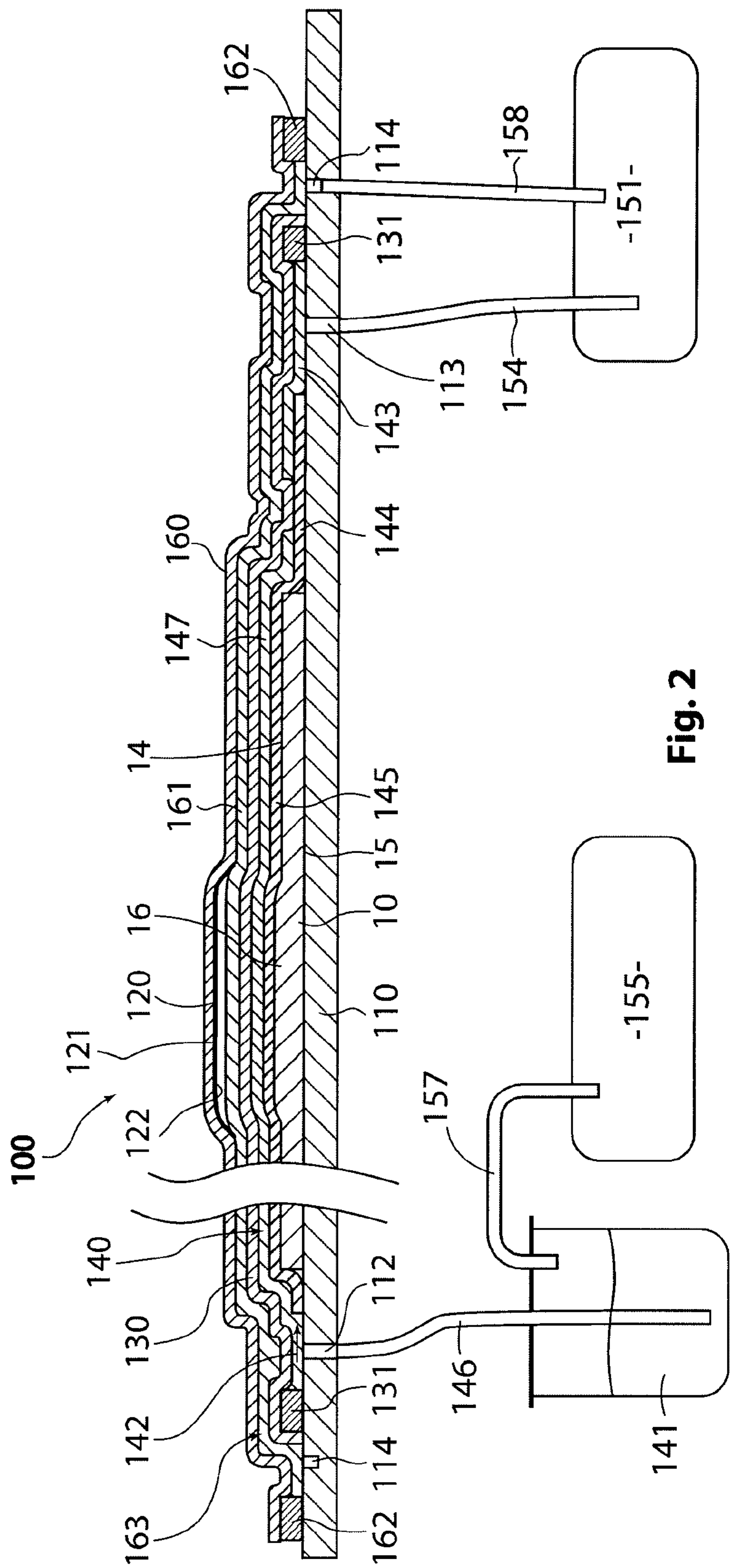
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Fig. 2

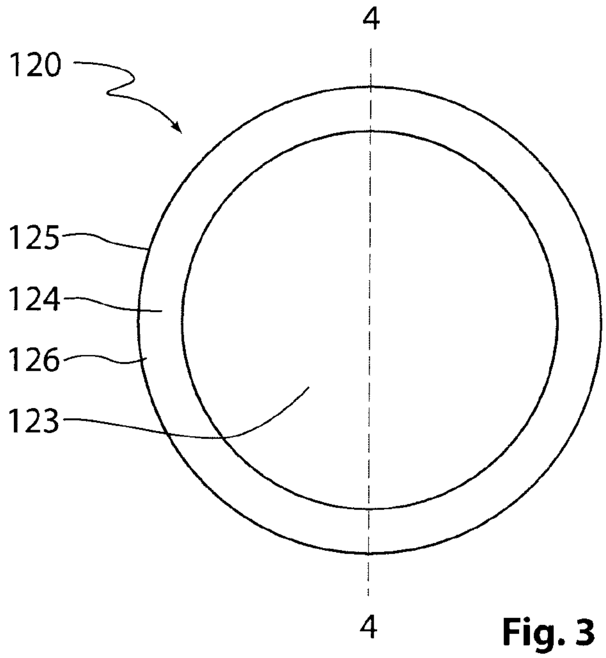


Fig. 3

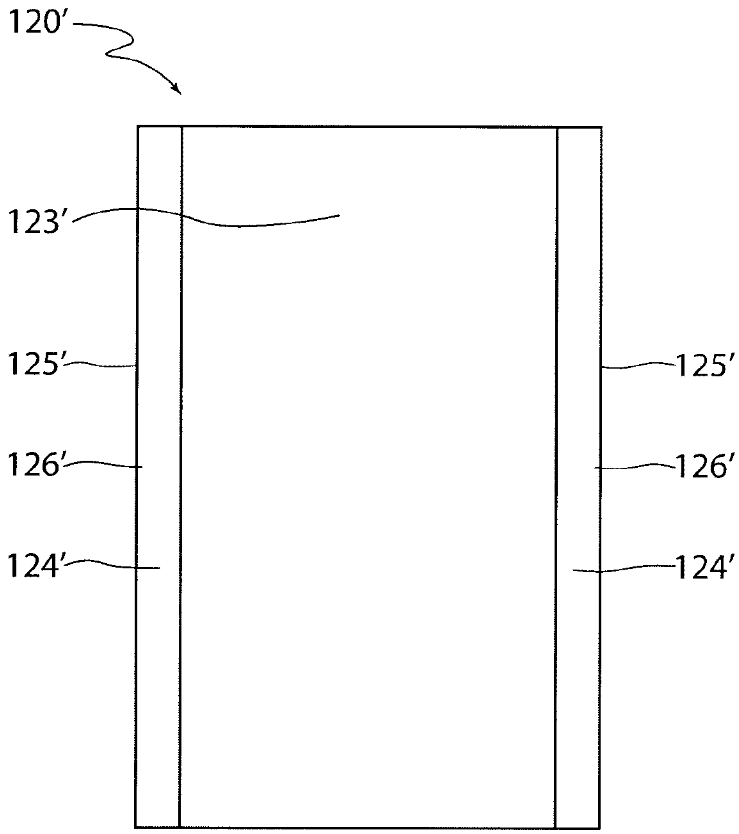


Fig. 6

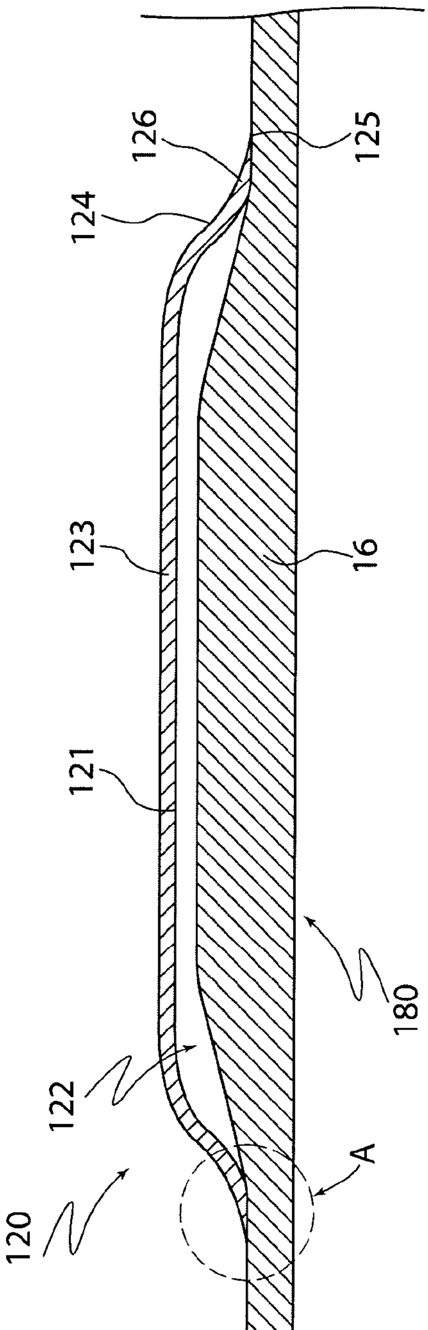


Fig. 4

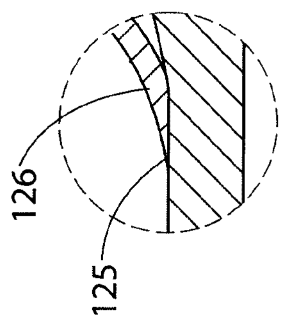
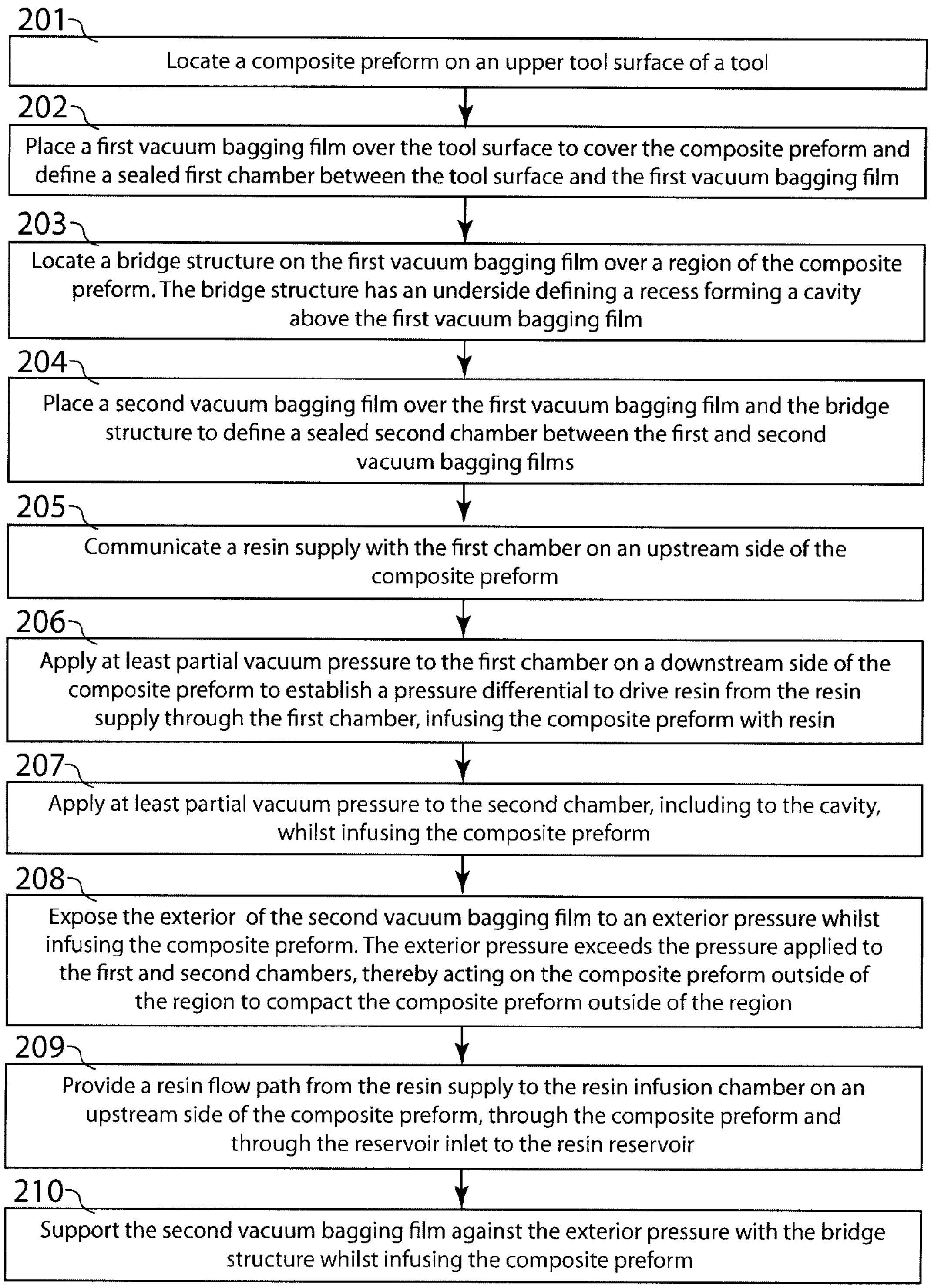


Fig. 5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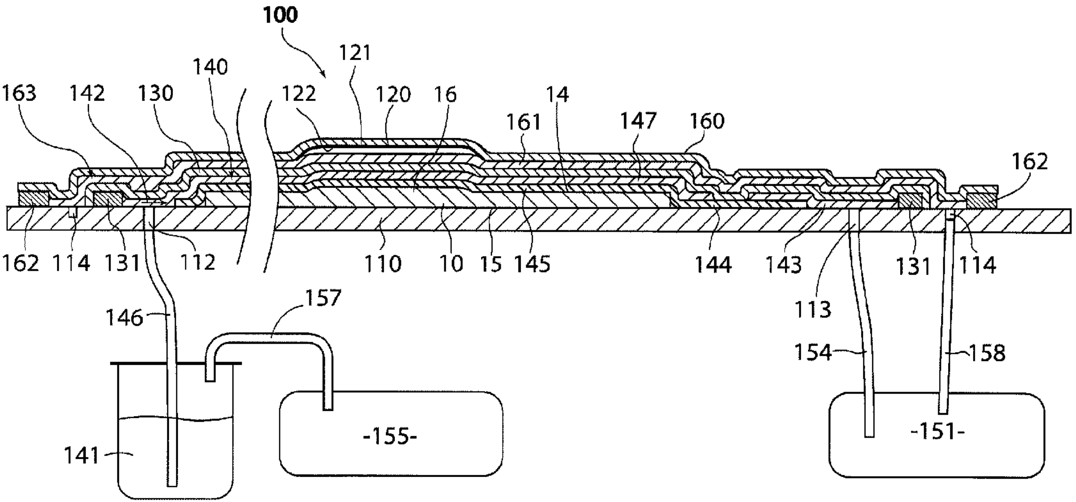
Locate a composite preform on an upper tool surface of a tool
202
Place a first vacuum bagging film over the tool surface to cover the composite preform and define a sealed first chamber between the tool surface and the first vacuum bagging film
203
Locate a bridge structure on the first vacuum bagging film over a region of the composite preform. The bridge structure has an underside defining a recess forming a cavity above the first vacuum bagging film
204
Place a second vacuum bagging film over the first vacuum bagging film and the bridge structure to define a sealed second chamber between the first and second vacuum bagging films
205
Communicate a resin supply with the first chamber on an upstream side of the composite preform
206
Apply at least partial vacuum pressure to the first chamber on a downstream side of the composite preform to establish a pressure differential to drive resin from the resin supply through the first chamber, infusing the composite preform with resin
207
Apply at least partial vacuum pressure to the second chamber, including to the cavity, whilst infusing the composite preform
208
Expose the exterior of the second vacuum bagging film to an exterior pressure whilst infusing the composite preform. The exterior pressure exceeds the pressure applied to the first and second chambers, thereby acting on the composite preform outside of the region to compact the composite preform outside of the region
209
Provide a resin flow path from the resin supply to the resin infusion chamber on an upstream side of the composite preform, through the composite preform and through the reservoir inlet to the resin reservoir
210
Support the second vacuum bagging film against the exterior pressure with the bridge structure whilst infusing the composite preform

Fig. 7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