

Woven structure and panel or vessel including such structure

This invention relates to a woven structure and a part equipped with such a structure. More specifically, it is a flexible vessel comprising such a structure and forming an inflatable reservoir.

We are familiar with inflatable cushions for the lifting of aircraft designed to facilitate the operation of pulling out of mud and recovering commercial and military aircraft that have accidentally left the runway.

These cushions enable airport rescue teams confronted with an aircraft which has gone off the runway to lift and then tow it quickly and safely, avoiding any additional damage.

Figure 1 shows a cross-section of an aircraft lifting cushion of a former design. This cushion typically consists of two woven walls (1, 2), coated for water tightness and heat vulcanized. The edges of these woven walls (1, 2) are linked by an extra layer, 3, made of rubber.

These walls (1, 2) are also linked together by polyamide threads (4), which, once tautened by inflation of the cushion, are parallel and spaced at regular intervals.

These threads (4) are of identical length in order to keep walls (1, 2) parallel. This ensures that equal lifting pressure is applied to the aircraft structure beneath which the cushion is placed.

This is particularly critical for example when lifting fragile parts, such as an aircraft wing (5), in order to avoid structural damage (Fig. 2).

However, air may be lost from these lifting cushions due to a manufacturing defect or may appear over time at rupture points (6) in the structure of the lifting cushion. For example, manufacturing defects may result from poor vulcanization or from slippage of the extra rubber layer (3), prior to vulcanization.

Such defects lead to an uneven lifting force on the aircraft structure and may be responsible for secondary damage.

There is thus an urgent need for an inflatable cushion made in one piece so that it has increased stress resistance.

As a general rule, numerous woven articles of complex form such as pouffes filled with polystyrene balls, armchair covers, etc, are made up of initially separate pieces of fabric which are then joined together, for example, by sewing, to give the article its finished form.

However, these articles have, by definition, a certain structural weakness at these joins.

Premature wear of the article in these zones may result, for example, in the article losing its stuffing.

In short, time required to assemble these articles of complex form can be relatively long and require qualified operators, making the article expensive.

The aim of this invention is therefore to offer a piece of fabric which is simple in its design and mode of operation, in one piece, giving it mechanical properties superior to those of previous known articles made by assembling initially separate parts by sewing or gluing them, or by a combination thereof.

Another aim of the invention is to create a one-piece woven structure with a complex shape such as a conical or cylindrical shape, with increased mechanical resistance for the creation of composite pieces such as radomes, aircraft fuselage sections, ship hulls, or furniture.

To that effect, the invention relates to a woven structure comprising at least two woven walls linked together by at least one unattached linking thread.

According to the invention, the length variation between two consecutive sinkers of the said at least one linking thread, each of said sinkers corresponding to a riser per weft yarn of a different wall, is continuous on at least a portion of the said structure in the direction of the warp and/or in the direction of the weft.

Each of these two sinkers belongs to the basic weave of a different wall or sheet. In other words, as each of these two sinkers corresponds to a linked riser or linking thread, per the weft yarn of a different wall, these walls are linked together by the linking thread. The two woven walls are therefore linked together by supplementary warp yarns.

This woven structure can be closed or at least partially open. The opening can be placed at any point on the woven structure, i.e. at at least one of its extremities, the corresponding edges of these walls therefore not being joined together or indeed the result of the presence of an opening in at least one of the walls.

The advantage is that the division/section of this woven structure can be any shape, circular, square, rectangular, diamond, a T, U, L, H or I shape, once any unnecessary warp yarns have been cut.

‘Continuous variation’, means that the variation is uniform and does present any jumps or stages.

By ‘unattached linking thread’, we mean that this thread is not attached after the weaving of each of these walls to link them, but the opposite in fact – it is inserted into the weft of these woven walls during their manufacture.

The linking thread therefore forms an integral part of the weave of the two walls on portions thereof.

The woven structure thus obtained is of a single piece, which gives it increased mechanical resistance to stress.

This woven structure can be either one piece or, on the contrary, include different materials.

By 'the woven structure is of one piece', we mean that this structure is monoblock and made from a single material. The warp and weft yarn used, however, can be of a different form, ie. monostrand or multistrand yarn, flat yarn, yarn made of twisted fibres, simple or rotor yarn, and be of different thicknesses or diameters.

These yarns can, for example, be cotton, polyester, polyamide, polypropylene, polyethylene yarns, starch-based biodegradable plastic or oxy-degradable plastic yarns, or yarns made from carbon fibres, graphite, glass, silica, aramid, etc.

The walls can also be of different sizes and/or different shapes depending on the application envisaged for the woven structure.

Thus, and purely as an example, when manufacturing an aircraft wing with a biconvex symmetrical profile, we could use a woven structure made up of a convex upper wall, a flat middle wall and a convex lower wall symmetrical to the upper wall in relation to the middle wall. To obtain a wing with an even, convex profile, these walls will have convex portions to form a convex extrados, with a simple curve, flat to form a flat intrados. Of course, these walls are joined at their extremities to form the leading edge and the trailing edge of the wing. The density and composition of the linking threads, once the structure has hardened, provide support for the upper and lower walls and the mechanical rigidity the wing needs in order to bear stress.

Advantageously, this structure has an upper, a middle and a lower wall. These walls are superimposed, with at least one linking thread linking the said upper and middle walls and at least a second linking thread linking the said lower and middle walls. At least one of these first and second linking threads will present a length variation between two consecutive sinkers, each of the said sinkers corresponding to a riser per weft yarn of a different wall, which is continuous on at least a portion of the structure in the direction of the warp, and/or in the direction of the weft.

The invention also relates to a woven structure comprising at least one woven upper wall and one woven lower wall which are linked together by at least one unattached linking thread.

According to the invention, the said at least one linking thread presents several floating portions in the direction of the weft, each of these portions corresponding to the said at least one linking thread linked on the one hand by at least two warp threads from the upper wall and on the other by at least two warp threads from the lower wall. The length variation of these floating portions is continuous on at least a portion of the said woven structure in the direction of the warp and/or weft.

The link between the two woven walls is obtained through supplementary picks. and not through extra warp threads as previously described.

In different individual ways of creating this woven structure, each with its own individual advantages and with numerous possible technical combinations:

- As the linking threads are under pressure, at least the majority of the lengths between two consecutive sinkers of these linking threads are straight and spaced regularly or irregularly,
- the walls and/or linking threads are made of different materials,

An advantage is that the linking threads can be made from different materials so that the woven structure has zones of different mechanical resistance.

For illustrative purposes, we can thus generate a breaking zone in the woven structure with linking threads of a weaker level of resistance than the structure's other linking threads and therefore a rupture point which is lower than that of the other linking threads.

Application of a pressure greater than the maximum pressure threshold recommended, when inflating a flexible lifting reservoir made from this woven structure, could lead to breakage of these linking threads of lower resistance, allowing the operator to

visualize, directly, the fact that this pressure threshold has been exceeded and that he must intervene in order to halt inflation of the reservoir.

This breaking zone thus offers a simple and efficient means of control and safety, in order to ensure that no secondary damage can be caused to a structural part of a plane (which has left the runway) while it is being lifted.

- these walls are either continuous or not.

For purely illustrative purposes, at least one of these walls can include an orifice. The woven structure can also include an orifice and form a ring.

- the length of these warp threads and/or weft threads of at least one of these walls is different from the length of the warp threads and/or weft threads, respectively, of the other walls.

This could be achieved, for example, when the walls have different weaves. These walls can have as a base a plain weave or a twill weave.

The wall that will be in contact with the ground can also have a surface relief composed of projections and hollows to allow it to grip the ground.

Alternatively, a first wall can have a surface relief made up of hollows, whilst a second wall of the woven structure has projections designed to work in conjunction with the hollows in the first wall so as to prevent possible slippage of one structure in relation to the other structure when they are linked together.

These projections and hollows can be, respectively, male or female indentations. For illustrative purposes these indentations can result from a honeycomb weave.

More generally, as the walls have an identical weave, the lengths of the warp threads and/or weft threads can be different – one of these walls being longer.

- as the woven structure comprises at least one lateral wall linking these walls, at the least some of these warp and or weft threads are placed at the same time in at least one of these walls and in the said lateral wall, the said threads being continuous. In this particular manufacturing method, the woven structure is at least partially closed. The continuity of the warp and/or weft threads on all or part of the upper, lower and lateral walls ensures the mechanical resistance of the upper woven structure.

- The density of the linking threads is greater than 1 thread/10cm²,

However this linking thread density depends on the applications envisaged for the woven structure. This linking thread density can therefore vary from one thread/10cm² to several hundred threads/cm².

-The linking threads are flexible

For illustrative purposes, these linking threads are chosen from the group comprising monofilament yarns, multi-filament yarns, simple or rotor yarns; yarns including agglomerated fibres, flat yarns, flexible metallic yarns, plaited yarns – i.e. each including a core yarn and a sheath made from thermoplastic material and combinations of these elements.

By “flat yarn” we mean a product extruded through a spinneret, stretched or unstretched, the full transversal section of which is full and noticeably constant along its entire length, is oval, square, rectangle, flat circle and modified square or rectangular in shape – i.e. having two opposite sides in the form of a convex arc, the two others being straight, equal and parallel.

These flat yarns could also be hollow and present, for illustrative purposes, a flattened tubular section.

The invention also relates to a flexible vessel. According to the invention, this vessel comprises a structure as previously described.

Preferably, this structure is waterproof. To achieve this, the walls may have been coated with a waterproof material such as a polyvinyl chloride (PVC)-based or polyurethane-based material, or, even better, a plasticized, fireproof PVC-based material.

Being an inflatable cushion used, for example, to lift a plane which has left the runway, the vessel will include a selvedge, a zone designed to form a circular shape when the vessel is under pressure, and a flat central area. It may also include handles to allow for the removal of this cushion.

The invention also relates to a panel comprising at least two walls spaced apart from one another.

According to the invention, these two walls are formed by a structure such as that described previously.

The whole of the structure can be dipped in a hardened resin. Alternatively, if the linking threads and the threads making up the walls having been pre-impregnated, the woven structure is polymerized.

For example, these threads can be pre-impregnated with a thermosetting or thermoplastic resin and, in particular, a thermostable thermoplastic resin such as those of the polyetherimide (PEI), polyetheretherketones (PEEK) or polyamides (PA) families.

Polymerization operations are processes well known within the industry, so they will not be described again here. We will mention, purely for illustrative purposes, the resin transfer moulding process (RTM) or indeed the Liquid Resin infusion (LRI) moulding process.

Of course, we shall try to keep the floating portions of the linking threads straight during the polymerization process. Thus we will avoid compressing the woven structure during the process of impregnating this with a resin.

The panel of this invention presents, advantageously, good mechanical properties in the plane of each wall but also in a direction perpendicular to these walls due to the linking threads that link these walls.

The invention relates to a ship equipped with at least one panel as previously described.

The invention relates to an aircraft equipped with at least one panel as previously described. The said at least one panel can form part of the fuselage of the plane or indeed the radome.

The invention also relates to an interior or exterior fixture such as a seat filled with polystyrene beads, furniture, a foam or down-filled blanket, etc.

According to the invention, this fixture comprises a structure as previously described. The invention relates, more generally, to any manufactured article equipped with a structure as previously described.

The invention will be described in more detail with reference to the appended drawings, in which:

- figure 1 is a cross-section view of a lifting cushion of a former design;
- figure 2 shows a stack of lifting cushions from Figure 1 placed under the wing of an aircraft which has left the runway for the purpose of lifting it;

Figure 3 shows, in perspective, a panel according to the preferred manufacturing method for the invention.

Figure 4 is a cross-section view along the A-A axis of the woven structure used to manufacture the panel of Figure 3;

Figure 5 is a schematic representation of the length variation between consecutive sinkers of a linking thread of the woven structure of Figure 4 in the direction of the warp;

Figure 6 is a schematic representation of the weave of the woven structure of Figure 4;

Figure 7 is a schematic representation of a temple used in the manufacture of the woven structure of Figure 4;

Figure 3 shows a perspective view of the panel according to the preferred manufacturing mode for the invention. This panel is made up of a woven structure 10 dipped in a hardened coating of thermosetting resin such as an epoxide resin.

Figure 4 is a cross-section of the woven structure 10 used for the manufacture of the panel of Figure 3. The woven structure 10 is a single piece and is made up from threads made from carbon fibre.

This woven structure 10 comprises two woven walls 11 and 12 that are connected by linking threads, 12. The upper wall, 11, is slanted and forms an angle in relation to the lower wall, 12, which is horizontal.

These two walls, 11 and 12, are continuous and flat. They are connected at each end by a woven portion, 14 and 15, designed to present a rounded shape or a noticeably rounded shape form after polymerization so that the panel forms a closed object.

These two walls, 11 and 12, present a plain weave 1 to 1 with a number of warp threads greater than 10 threads/cm and a number of weft threads greater than 6 threads/cm so as to provide suitable waterproofing of the woven structure.

Figure 5 shows the length variation (axis Y, 16) of a linking thread between two consecutive sinkers in the direction of the warp, which is here in the length of the panel (axis X 17).

As each of these two sinkers corresponds to a riser, or a linking thread linked by a weft yarn from a different wall, these walls are linked to each other. Between these

two consecutive sinkers, the corresponding linking thread, 13, is floating, i.e. it presents a portion of floating yarn.

This length variation (ΔL) in the direction of the warp, is therefore calculated by finding the difference between the lengths of two floating portions of the same linking thread immediately following one another in the warp direction.

From Figure 5 it can be seen that the length variation of a linking thread, 13 between two consecutive sinkers in the direction of the warp of the woven structure follows a straight line, 18. This variation is therefore progressive – i.e. continuous and regular. More generally, what has just been demonstrated in the case of a supplementary warp thread which is a linking thread could be applied to a supplementary weft yarn.

Likewise, as the woven structure comprises several linking threads in the direction of the warp or the weft; we could show the continuous and successive variation in the lengths of the floating portions in a given direction, each of these portions belonging to a different linking thread. These directions could be those of the weft, the warp or indeed a diagonal. In the latter case, the floating portions could be offset in relation to the others, arranged in a quincunx for example.

This woven structure was obtained according to the manufacturing process described below.

We start simultaneously weaving the walls by weaving an upper layer, 11, and a lower layer, 12, following the basic weave of each of these walls, the linking yarn, 13, being linked only to the basic weave of the upper layer, 11. When linking these two walls by the said at least one linking thread, 13, i.e. before linking the linking thread to the lower layer, we cease the weaving and introduce into the weaving zone a rod, 19, known as a temple, in order to pull only the said at least one linking thread, 13. The length of the linking thread, thus pulled, is placed above the upper layer, 11.

Of course it would be possible to proceed systematically and pull the linking thread under the lower layer after having inserted it into this layer and prior to linking it to the basic weave of the upper layer.

In figure 4, we can see that the fabric course 21 of the weaving corresponds schematically to the replacement of a pick, i.e. a weaving phase, by the introduction into the weaving zone of the temple to pull the linking threads numbered 5 and 6, each opposite a vertical column. The warp yarns numbered 1 and 3 correspond to the

warp yarns of the lower layer and the warp yarns numbered 2 and 4 correspond to the warp yarns of the upper layer.

This length, thus pulled from the linking thread and the distance separating the upper and lower layers corresponds to the distance separating the walls of the final woven structure at the point where these walls are linked by the said at least one linking thread.

Once the linking thread yarn is pulled to the right length, the temple is removed from the weaving zone and normal manufacture of the woven walls is resumed until the next linking of the walls by this linking thread.

These linking threads 13 are therefore pulled to the top of (or symmetrically, beneath) the two layers forming the upper (11) and lower (12) walls of the woven structure and they are therefore placed in the external portion of the woven structure.

These linking threads are then returned into the woven structure, by spacing the layers apart from each other.

The rod (19) presents the advantage of having, on one of its sides, a rugged surface or network of vertical grooves (20) each designed to receive a linking thread so that the linking threads cannot slip on the surface of the rod (19) during the pulling phase of the said at least one linking thread.

It also has the advantage of being mobile when in translation on a horizontal plane (21, 22).

The walls 11, 12 being flat here, the rod has a uniform diameter and does not present a surface relief (Fig.7). When we wish to give one of the walls of the woven structure a particular shape, the rod will include a surface relief on the side including the rough surface

or the network of grooves, this relief constituting an imprint of the relief to be conferred on the wall at the level of the linking threads thus pulled. Of course, it may be necessary to change the temple between the pulling phases of the linking threads in order gradually construct, during the weaving of the woven structure, the final form of this wall.

More generally, the invention relates to a process for the weaving of at least two layers linked together by a linking thread. According to the invention,

- a) the weaving of these layers is started by inserting into the basic weave of a first layer at least one warp yarn or supplementary pick, with either of these latter constituting the said linking thread,
- b) before inserting the said at least one linking thread into the basic weave of the second layer, the weaving of these layers is paused,
- c) we then pull the at least one linking thread from the side of the second layer by placing at least a portion of the pulled length outside of the whole formed by these layers thus linked,
- d) then weaving of the layers is resumed by inserting the said at least one linking thread into the basic weave of the second layer,
 - before each new insertion of the said at least one linking thread into the basic weave of one of these layers, the following cycle is repeated:
- e) the weaving of the layers is paused,
- f) the said at least one linking thread is pulled by placing at least a portion of the pulled length outside of the whole formed by these two layers thus linked, this (thus pulled) length being capable of being placed above or below,
- g) then, weaving of the layers is resumed by inserting the said at least one linking thread into the basic weave of the said layer.

The pulling of the linking thread is achieved using a gripping device, which could be a temple as previously described or a group of needles equipped with a hook at the end, each of these needles being capable of pulling a single linking thread. These needles are activated by electromagnets or a hydraulic or pneumatic piston. They are more suited to translational movements.

The invention process can be applied in the creation of composite pieces of sheet metal and structural parts in the manufacture of aircraft, for example fuselages or portions of fuselage such as aircraft wings or the radome. It is also possible to produce propeller reservoirs or reservoir skirts.

Shipping applications can also be considered, for illustrative purposes, such as the creation of ship hulls, containers, floats etc.

CLAIMS

1. A woven structure comprising at least two woven walls (11, 12) attached to each other by at least one linking thread (13), characterized by the fact that the length variation between two consecutive sinkers of the said at least one linking thread (13), each of the sinkers corresponding attached to a riser per weft yarn of a different wall, is continuous on at least a portion of the said structure in the direction of the warp and/or in the direction of the weft.
2. Structure as per claim 1, characterized by the fact that it comprises an upper wall (11), a middle wall and a lower wall (12), the said walls being superimposed, with at least a first linking thread linking the upper and middle walls and at least a second linking thread linking the said lower and middle walls. at least one of the first and second linking threads presenting a length variation between two consecutive sinkers, each of the said sinkers corresponding to a riser per weft yarn of a different wall, which is continuous on at least a portion of the said structure in the direction of the warp, and/or in the direction of the weft.
3. A woven structure comprising at least one woven upper wall (11) and one woven lower wall (12) connected together by at least one unattached linking thread (13), characterized by the fact that the said at least one linking thread (13) presenting several floating portions in the direction of the weft, each of these portions corresponding to the said at least one linking thread (13) linked on the one hand by at least two warp threads from the upper wall and on the other by at least two from the lower wall, the length variation of the said floating portions is continuous on at least a portion of the said woven structure in the direction of the weft and/or the warp.
4. Structure as per any one of claims 1 to 3, characterized by the fact that when the said linking threads (13) are under pressure, at least the majority of the lengths between two consecutive sinkers of the said linking threads (13) are straight rectilinear and spaced either regularly or irregularly.
5. Structure as per any one of claims 1 to 4, characterized by the fact that the length of the warp threads and/or the weft threads of at least one of the said

- walls (11, 12) is different from the length of the warp threads and/or the weft threads of the other walls (11, 12).
6. Structure as per claim 5, characterized by the fact that the said walls (11, 12) have different weaves.
 7. Structure as per any one of claims 1 to 6, characterized by the fact that the said walls (11, 12) are either continuous or non-continuous.
 8. Structure as per any of claims 1 to 7, characterized by the fact that the said structure is of one piece.
 9. Structure as per any one of claims 1 to 7, characterized by the fact that the said walls (11, 12) and/or the linking thread (13) are made from different materials.
 10. Structure as in per any one of claims 1 to 9, characterized by the fact that the said linking threads (13) are chosen from the group containing monofilament yarns, multi-filament yarns, yarns including agglomerated fibres, flat yarns, flexible metallic yarns and combinations of these elements.
 11. Structure as per any one of claims 1 to 10, characterized by the fact that the said woven structure comprising at least one lateral wall (14, 15) linking the said walls (11, 12), at least some of the said warp and/or the weft threads are placed at the same time in at least one of the said walls (11, 12) and in the said lateral wall (14, 15), the said threads being continuous.
 12. A flexible vessel, characterized by the fact that it comprises a structure as per any one of claims 1 to 11.
 13. Vessel as per claim 12, characterized by the fact that the said structure is more waterproof..
 14. Vessel as per claim 13, characterized by the fact that it comprises a selvedge, a zone designed to form a circular shape when the vessel is put under pressure and a flat central area to form an inflatable cushion.
 15. Panel comprising at least two walls spaced apart from each other, characterized by the fact that the said two walls (11, 12) are formed from a structure as per any one of claims 1 to 11.
 16. A ship equipped with at least one panel as per claim 15.
 17. An aircraft equipped with at least one panel as per claim 15.
 18. An internal or external fixture characterized by the fact that it comprises a structure as per any one of claims 1 to 11.