Method in connection with the production of a packaging container, including a) choosing or manufacturing a web shaped packaging laminate according to claim 1, b) converting said packaging laminate to a continuous tube by overlapping two longitudinal edges of the web shaped packaging laminate and heat sealing the overlapped edges to provide a longitudinal seal, c) filling the tube with contents, d) intermittently performing transversal seals by mechanically pressing together two transversal anvil jaws while the filled tube is arranged there between, e) while at the same time providing energy to the packaging laminate at an area of said transversal seal.
PACKAGING LAMINATE, METHOD OF PRODUCING A PACKAGING CONTAINER AND THE PACKAGING CONTAINER

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a divisional of U.S. application Ser. No. 10/471,565, filed Mar. 22, 2004, the contents of which are incorporated herein by reference, which was the National Stage filing under §371 of International Application No. PCT/SE2004/00436 filed Mar. 11, 2002, which in turn claims priority to Swedish Application No. 0100858-0, filed Mar. 12, 2001.

TECHNICAL FIELD

[0002] This invention relates to a packaging laminate for a packaging container, preferably for liquid food contents, which packaging laminate comprises a structural base layer, and an inside layer. The invention also relates to a method of producing a packaging container from the packaging laminate, and to the packaging container built up from the packaging laminate.

PRIOR ART AND PROBLEMS

[0003] Food packaging processes of today (with the term “food” is meant all sorts of solid and liquid food, such as juices, milk and other beverages as well as pastes, soups, jellies and cheese) often are of the “form-fill-seal” type and may be carried out by shaping a continuously moving web-shaped packaging laminate made of a flexible laminate into a continuously running tube, continuously filling the tube with the desired food product to be packaged and by sealing and finally cutting off sealed packages from the tube.

[0004] The packaging processes are often high speed continuous processes, wherein the packaging laminate in the form of a web is continuously fed through a machine, sterilized, for example by passing through a liquid or gas-phase quick-acting sterilizing medium, formed and sealed into the required tube shape for being filled with the food to be packaged and finally transversally sealed.

[0005] The continuous web-shaped packaging laminate is manufactured with a packaging laminate manufacturing machine and placed on a reel. The packaging laminate often has a laminated structure comprising a base layer of paper or paperboard, an outer heat sealing layer of a thermoplastic polymer (such as for example polyethylene) on each side of the core layer and, if necessary, an aluminum foil gas-barrier layer interposed between the paper core layer and the film. Alternatively, a gas-barrier layer of a plastic or inorganic material, such as for example polyamide, polyethylene vinylalcohol (EVOH) or siliconoxide, may be employed instead of aluminum foil.

[0006] The reel with packaging laminate is installed in the packaging machine where it is reeled out and routed within the packaging machine using drive mechanisms disposed in several positions in the machine. The packaging laminate web is shaped into a tube and sealed in the longitudinal direction within the packaging machine. While the tube is being transferred downward within the packaging machine, the liquid or flowing food product is supplied from above to fill the inside of the tubular packaging laminate. Next, the packaging laminate tube is pressed laterally from both sides and sealed in the lateral direction at specified intervals to form interconnected, filled and sealed packaging containers. Next, the sealed packaging containers are separated off from the tube by cutting between the laterally extending sealed portions, and the thus separated packaging containers are brought into a specified, desired shape, for example by folding and bending along previously formed crease lines in the packaging laminate, and, if required, finally sealed in order to remain in that shape.

[0007] The sealing of the tubular packaging laminate in the longitudinal or lateral direction is carried out by heat sealing of the outer surfaces of the packaging laminate, which are made of heat sealing thermoplastic, to each other. This may be performed by known heat sealing techniques, such as for example induction heat sealing, radio frequency (RF) or microwave heat sealing, heat convection sealing or ultrasonic vibration heat sealing.

[0008] Conventional packaging machines thus employ a heat sealing apparatus to seal the packaging laminate. The sealing apparatus is normally provided with so-called counter jaws and heat seal jaws disposed and working in opposing relation to each other.

[0009] One preferred method of performing the transversal seal, when no metallic layer is present in the laminate, is to use ultrasonic energy while simultaneously applying a pressure, in order to melt the sealing layer while overlapping and pressing together two edges of the laminate to a seal. During such ultrasonic vibration heat sealing, the amount of ultrasonic energy converted into heat is proportional to the pressure applied to the laminate in the area of the seal. However, for such a seal to become truly strong and liquid-tight in a container made from a conventional packaging laminate, it is a prerequisite that the settings of the sealing machine are performed with extremely sharp tolerances, which tolerances also must be extremely stable during the continuous operation of the machine. These settings are settings such as the tube guiding, the movement of the anvil jaws that provide the pressure for the seal and the parallelism between the ultrasonic horns and the cutting rails for cutting off the tube between the transversal seals. With poor tolerances in the mechanical settings, the pressure applied will be poor at some locations and hence the energy converted into heat will be low and the produced seal will be weak and not liquid-tight. Also, there may be problems with the formation of plastic lumps in the sealing layer. Moreover, the ultrasonic vibration heat sealing process can be very unforgiving in other respects too, such as the presence of foreign matter at the area of the seals, when used on a conventional packaging laminate. Another very important aspect to consider is requirements on the laminate material when the packaging is to be filled with liquid food, such as milk, juice, water etc.

[0010] In the case of transversal seals, the problem of weak seals due to poor tolerances in the mechanical settings will be especially pronounced due to the overlap with the longitudinal seal. In order to compensate for the extra thickness at the overlap between the transversal seal and the longitudinal seal, the one of the anvil jaws is provided with a compensation profile, which however means that it is even more important to have small tolerances. If the extra thick overlap between the transversal seal and the longitudinal
seal is displaced in relation to the compensation profile, e.g. due to problems in the continuous tube guiding such as twist of the tube, the pressure will drop in certain areas of the seal and hence the strength of the seal will negatively affected. A weak seal can lead to channels being formed and thus to leaking packages.

[0011] Despite these drawbacks in connection with the use of an ultrasonic transversal sealing process, it is most often desired to use the ultrasonic transversal sealing process, since it is a fast process.

BRIEF ACCOUNT OF THE INVENTION

[0012] The object of the present invention is to provide a packaging laminate which is more forgiving to the prevailing circumstances during sealing by ultrasonic energy, and which preferably also exhibits improved mechanical properties. Especially, the object is to provide a packaging laminate which is more forgiving to prevailing circumstances such as poor tolerances in the mechanical settings of the sealing machine, poor tube guiding, disturbed movements of the anvil jaws, poor parallelism between the ultrasonic horns and the cutting rails, presence of foreign matter in the area of the seals, etc.

[0013] Of course, the prime object of the invention is to provide strong and liquid-tight transversal seals in packaging containers produced from the packaging laminate according to the invention, also at the overlaps between the transversal seals and the longitudinal seal in the packaging container.

[0014] Moreover, the packaging laminate according to the invention should be well adapted to be used in packaging containers for food.

[0015] These and other objectives are accomplished by the packaging laminate of the invention, as defined in claim 1, by the method according to the invention, as defined in claim 11 and by the packaging container produced from the packaging laminate, as defined in claim 16.

[0016] The general concept of the invention is to provide a packaging laminate which is very forgiving to the sealing circumstances due to the fact that it is provided with an inside layer comprising a sealing ply of a heat sealable thermoplastic material (polyolefin), which sealing ply is arranged to be the outermost ply on one side of the laminate and intended to be arranged on the inside of the container. According to the invention, this sealing ply is a heat sealable thermoplastic material, which material exhibits a melt enthalpy lower than 115 J/g, preferably lower than 105 J/g and even more preferably lower than 95 J/g, but normally at least 40 J/g and preferably at least 50 J/g. Examples of such materials are metalloocene polyethylene materials, preferably a metalloocene low density polyethylene material and even more preferably a metalloocene linear low density polyethylene material. One preferred example of such a material is Affinity PL 1880 by Dow. Other conceivable materials in the same group are other Affinity grades by Dow as well as Exceed ML 1023 by ExxonMobil, Exact by ExxonMobil, Elite by Dow, Umerit by JPO and Kernel by JPC.

[0017] According to one aspect of the invention, the low melt enthalpy heat sealable thermoplastic sealing ply exhibits a melt enthalpy which is lower than the melt enthalpy of an adjacent thermoplastic ply in the inside layer, and preferably lower than the melt enthalpy of any of the plies in the inside layer. In this context, "lower" will preferably mean at least 10 J/g, even more preferably at least 15 J/g lower and most preferably at least 20 J/g lower. Most preferably, the melt enthalpy is decreased in each step when going through the different plies in the direction from the base layer to the outermost ply, although some adjacent plies may have the same melt enthalpy.

[0018] Thanks to the properties of the heat sealable thermoplastic, the packaging laminate is brought to exhibit a sealing window having a lowest limit which is lower than the corresponding limit of conventional packaging laminates. Moreover, it is preferred that the laminate according to the invention, comprising the heat sealable thermoplastic sealing ply, exhibits a broad sealing window, preferably a broader sealing window than conventional packaging materials.

[0019] The sealing window concept is well known by the skilled man and is defined as the energy range within which sealing is possible. A low lowest limit means that an acceptable seal takes place at low energy levels, which in turn decreases the sensitivity of the ultrasonic vibration heat sealing system to the mechanical settings and to other prevailing circumstances. Even if a low pressure is applied in some spots along the sealing area, the energy converted into heat will be enough to melt the heat sealable thermoplastic sealing ply having a low melt enthalpy, thus allowing a strong and liquid-tight seal to be formed. A high uppermost limit of the sealing window means that a considerable energy supply can be allowed.

[0020] Moreover, it is preferred that the inside layer also comprises a ply consisting of so called C4, C6 or C8 linear low density polyethylene (C4 LLDPE, C6 LLDPE, C8 LLDPE). C4, C6 and C8 LLDPE are polyethylenes which are obtained by small quantities of C4, C6 or C8 alpha olefins being used as comonomers during the polymerisation of ethylene. Preferably, this C4, C6 or C8 LLDPE ply, and even more preferred a C6 or LLDPE ply, is the second ply as counted from the outer surface of the laminate, i.e. the ply which is in direct contact with the heat sealable thermoplastic material ply having a low melt enthalpy. The combination of these two plies will beneficially and surprisingly result in extremely strong and liquid-tight transversal seals being achieved despite deviations in the mechanical settings of the sealing machine.

[0021] It has moreover surprisingly been found that the openability of an opening device consisting of a perforation partly passing through the transversal seal is very good, despite the fact that the transversal seal is so strong.

[0022] A laminate according to the invention is especially well adapted to be used in connection with ultrasonic vibration heat sealing. A feature of the ultrasonic vibration heat sealing technique is that the entire material under pressure between the ultrasonic horn and the anvil jaw is heated up by the vibrations at the same time. For a strong seal to take place, it is enough that the outermost layer (i.e. the outermost layer on the side of the laminate that is facing the inside of the container) reaches the melting point. As a consequence it is enough to provide only a thin sealing ply of the heat sealable thermoplastic material with low melt enthalpy in the inside layer, in order to decrease the sensitivity of the ultrasonic vibration heat sealing process and to
achieve strong and liquid-tight transversal seals. In other words, even a thin layer of the heat sealable thermoplastic according to the invention is enough to beneficially lower the lowest limit of the sealing window.

**DETAILED DESCRIPTION OF THE INVENTION**

**[0023]** In the following, the invention will be described in greater detail, with reference to the drawings, of which:

**[0024]** FIG. 1 is showing a preferred embodiment of a packaging laminate according to the invention, as seen in cross section,

**[0025]** FIG. 2 illustrates a conventional process of forming a tube from a continuous web of packaging laminate and the further formation of packaging containers, involving a step of transversal sealing,

**[0026]** FIG. 3 is showing an overlap between a longitudinal seal and a transversal seal, as seen in cross section,

**[0027]** FIG. 4 is showing a conventional anvil jaw for the sealing process, as seen in perspective,

**[0028]** FIG. 5 is showing a force-elongation curves for transversal seals in a packaging container according to the invention as compared to a reference container,

**[0029]** FIG. 6 is showing the resulting transversal seal width for different packaging containers as a function of tube position in relation to anvil jaw,

**[0030]** FIG. 7 is showing the sealing window for the laminates which were tested.

**[0031]** FIG. 1 is showing a preferred embodiment of a packaging laminate 10 according to the present invention. A structural base layer in the laminate consists of a paper or paperboard layer 4. It is however also conceivable that the structural base layer consists of mineral-filled polyolefin, e.g. mineral-filled polypropylene. The structural base layer is the layer which gives the largest bulk and thickness contribution to the laminate 10. On the side of the laminate which is intended to face the inside of the packaging container to be produced from the packaging laminate, there is provided an inside layer 6, built up from at least one ply, preferably at least two plies, and up to six plies, here four plies. Normally, the structural base layer 4 exhibits a thickness which is at least 6 times, preferably at least 8 times and even more preferred at least 10 times as thick as said inside layer 6. Expressed in another way, the structural base layer has a thickness of at least 200 μm, preferably at least 250 μm and even more preferred at least 300 μm.

**[0032]** A first ply 1 in the inside layer 6 consists of a first thermoplastic material (polyolefin). Suitably, said first ply is a polyethylene (PE) ply, preferably a low density polyethylene (LDPE) ply and even more preferred a linear low density polyethylene (LLDPE) ply, exhibiting a grammage of 3-30 g/m², preferably 4-10 g/m² and even more preferred 5-8 g/m². According to the invention, it is especially preferred that said first ply is a so called C4, C6 or C8 LLDPE ply, most preferred a C6 or C8 LLDPE ply.

**[0033]** According to the invention, said inside layer 6 also comprises a second ply 2, also denoted sealing ply 2, of a second heat sealable thermoplastic material (polyolefin), which second ply is arranged to be the outermost layer on the side of the laminate which is intended to face the inside of the packaging container. The second thermoplastic material in the second ply 2 is different from said first thermoplastic material and exhibits a low melt enthalpy according to the above. Due to the fact that it is enough that the outermost layer 2 reaches the melting point in order for a strong seal to be produced, the second ply 2 does not need to exhibit a grammage larger than 10 g/m². Preferably it has a grammage of 2-10 g/m² and even more preferred 3-8 g/m². Even a ply as thin as less than 5 g/m² might be conceived.

**[0034]** According to one aspect of the invention, said inside layer 6 also comprises a third ply 3 of a thermoplastic material (polyolefin). Suitably the third ply too is a polyethylene (PE) ply, preferably a low density polyethylene (LDPE) ply, and exhibits a grammage of 10-30 g/m², preferably 1.5-25 g/m². The third ply 3 is arranged between said first ply 1 and said structural base layer 4 in the packaging laminate 10.

**[0035]** Moreover, the inside layer (6) may also comprise a fourth ply 7 of a thermoplastic material, which fourth ply preferably is a low density polyethylene (LDPE) ply. It might however also be conceivable that it can be a linear low density (LLDPE) ply. Although not shown, this fourth ply 7 may per se consist of 1-5 sub-plies of identical material. The fourth ply 7 exhibits a total grammage of 5-30 g/m², preferably 8-20 g/m² and even more preferred 10-15 g/m². It is arranged in direct contact with said first ply 1 on the opposite side of the second ply 2 in the laminate 10, i.e. in-between the first ply 1 and the third ply 3.

**[0036]** It is an advantage of the invention that the beneficial properties of the second ply 2 will allow decreased grammages of the first 1, third 3 and fourth 7 plies, thus counteracting an increased cost due to the material of the second ply 2 being relatively expensive.

**[0037]** On the side of the laminate 10 which is intended to form the outside of the packaging container, there is arranged a decor layer 5, preferably consisting of a polyethylene (PE) ply, preferably a low density polyethylene (LDPE) ply, which exhibits a grammage of 5-25 g/m², preferably 8-20 g/m².

**[0038]** In the manufacturing of the packaging laminate 10 according to the invention, the base layer 4, including the decor layer 5, is provided as a web on a reel. On another reel, there is provided a film which includes the first ply 1 of thermoplastic material together with the second 2 and fourth 7 ply of thermoplastic material. Lamination between the materials on the two reels preferably takes place by the third 3 ply of thermoplastic material being extruded in-between the web and the film, in a conventional laminator. The three-ply film including the first ply 1, the second ply 2 and the fourth ply 7 of thermoplastic material may have been manufactured in the form of e.g. an extrusion blown film or an extrusion blow film. Another technique of producing the packaging laminate according to the invention is to extrusion coat the base layer with the different plies of the inside layer 6, preferably by coextrusion technique.

**[0039]** Suitably, the different plies and layers in the inside layer and the laminate are joined to one another directly or indirectly over essentially the whole of their surfaces facing one another. It might however also be possible to use a second ply of the second thermoplastic material, which is
only arranged at the area of the laminate where the transversal seals are to be formed, i.e. a second ply in the form of a strip or a partial ply.

Although the packaging laminate according to the invention is especially developed not to include any further plies or layers, except the above described ones, it is of course possible, though not preferred, that other types of plies or layers are present too, such as barrier layers.

With reference to FIG. 2, a web-shaped flexible packaging laminate 10 is installed as a reel 21 in the packaging machine where it is reeled out and routed within the packaging machine using drive mechanisms (not specifically shown) disposed in several positions in the machine. The packaging laminate 10 is guided with the aid of a guide 22, sealed in the longitudinal direction with a sealing apparatus (not specifically shown) and formed into a tube 23. While the tube 23 is being transferred downward within the packaging machine, the liquid or flowing product is supplied from above through a filler pipe 24 to fill the inside of the tube. Next, the packaging laminate of the tube is laterally pressed from both sides with a counter jaw and a heat sealing jaw (not specifically shown) so that the tubular packaging laminate is sealed in the lateral direction at specified intervals to form interconnected, filled and sealed pillow-shaped packaging containers. Next, the sealed packaging containers are separated off, as individual pillow-shaped primary containers 25, from the tube by cutting between the laterally extending sealed portions.

In FIG. 3, there is shown, in cross section, an overlap between a longitudinal seal 31, which extends out of the plane in the figure, and a transversal seal 32, which extends in the plane of the figure. Here, the tube which is formed by the longitudinal seal 31 is pressed together so that two outermost second plies 2, now arranged at the inside of the tube, will face each other. A sealing strip 34 is arranged over the inner seam 33 of the longitudinal seal, which sealing strip preferably is constituted by a polypropylene strip. The most critical areas for a correct transversal seal are called zone 1 (z1) and zone 2 (z2). The pressure applied in connection with the ultrasonic vibration heat sealing process at these areas is critical because of the thickness steps between two and three layers of laminate in the area of the overlap with the longitudinal seal 31. To compensate for these steps, the anvil jaws 40 are conventionally, and preferably also in connection with the present invention, provided with a compensation profile 41, such as shown in FIG. 4. Basically the compensation profile 41 consists of a recess, having edges 42 adapted to correspond to the width (w) of the overlap, shown in FIG. 3. The position (or rotation) of the tube in relation to the anvil jaws is defined by the value of d, FIG. 3, which is the distance between a counter mark setting X on the anvil jaw 40, in the middle of compensation profile 41, and the thickness step in zone 1. If the tube position and hence the position of the overlap is poorly registered in relation to the compensation profile 41, as measured by d, the resulting pressure will be low in the z1 and/or z2 areas. In connection with the present invention, however, there will very beneficially be produced a strong and liquid-tight seal 32 anyhow, thanks to the composition of the forgiving packaging laminate 10 according to the invention.

The transversal sealing process is performed by supply of energy, preferably ultrasonic energy, at the same time as the tube is mechanically pressed together between two anvil jaws. Suitably, one of the anvil jaws is provided with ultrasonic horns, arranged to be pressed against the tube with the other anvil jaw as holder-on, for supply of the ultrasonic energy. Usually the pressing and providing of energy is performed during a time interval of 100-250 milliseconds, preferably 140-220 milliseconds and with a pressure of 1-10 MPa.

**EXAMPLES**

In the examples three different laminates according to the invention were tested and also one reference laminate of conventional type. The laminates are specified in table 1. L1 and L2 had been produced by laminating a film together with the paperboard/decor layer. The film of L1 consisted of a first, second and fourth ply according to the above description. The film of L2 consisted of a second and fourth ply. The reference and the L3 laminate had been produced by extrusion coating. In table 1, the numbering of the plies follows the numbering shown in FIG. 1. As is evident from table 1, an inside layer in a laminate according to the invention may comprise different numbers of plies, meaning that the first ply 1, the fourth ply 7 or the third ply 3 may be the ply which is arranged in direct contact with the second sealing ply 2.

<table>
<thead>
<tr>
<th>TABLE 1</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sealing ply</strong></td>
</tr>
<tr>
<td>LDPE, 27 g/m²</td>
</tr>
<tr>
<td>Affinity</td>
</tr>
<tr>
<td>Melt enthalpy, 120.8 J/g</td>
</tr>
<tr>
<td>Ply 1</td>
</tr>
<tr>
<td>Ply 2</td>
</tr>
<tr>
<td>Ply 3</td>
</tr>
<tr>
<td>Grammage, 52 g/m²</td>
</tr>
<tr>
<td>Base layer 4</td>
</tr>
<tr>
<td>Decor layer 5</td>
</tr>
</tbody>
</table>

In FIG. 5 there is illustrated, for the reference laminate, a force-elongation curve (i.e. maximum tensile load) for a transversal seal that overlaps the longitudinal seal. The corresponding curve for L1 is dotted. As can be seen, the strength of the L1 seal is dramatically improved in relation to the reference. This can be attributed to the beneficial combination of the low melt enthalpy sealing ply and the strong C6 LDPE middle ply.

In table 2, there is shown the defect rate of the top and bottom seals of 1050 samples tested, measured as red ink leakage. As can be seen, there were no leakage at all in the bottom seals in containers made from L1, L2 and L3 laminate, whereas 2.6% of the bottom seals were leaking in containers made from the reference laminate. The effect was not equally pronounced in the top seals, but at least L1 and L3 were much better than the reference laminate.
<table>
<thead>
<tr>
<th>Laminate</th>
<th>Leaking seals, Defect rate, Top</th>
<th>Leaking seals, Defect rate, Bottom</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference</td>
<td>26 2.5% 27 2.6%</td>
<td></td>
</tr>
<tr>
<td>L1</td>
<td>7 0.7% 0 0</td>
<td></td>
</tr>
<tr>
<td>L2</td>
<td>31 3.0% 0 0</td>
<td></td>
</tr>
<tr>
<td>L3</td>
<td>11 1.0% 0 0</td>
<td></td>
</tr>
</tbody>
</table>

In FIG. 6 there is shown the resulting transversal seal width in Zone 1 as a function of tube position in relation to the anvil jaw, for different packaging containers produced from the three laminates according to the invention and from the reference laminate. The lower the value of d on the x-axis, the worse the positioning is. For the definition of d, see FIG. 3 and the related description. It can be seen that at least for L1 and L3, a much worse positioning could be allowed as compared to the reference.

In FIG. 7 there is shown the sealing window for the laminates which were tested in the examples. Here, it is confirmed that the laminates L1 and L3 are the best embodiments of the invention, since these laminates exhibit the lowermost lower limit in the sealing window and also relatively broad sealing windows.

The invention is however not limited by the description of preferred embodiments, but may be varied within the scope of the claims.

What is claimed is:

1. Method in connection with the production of a packaging container, comprising
   a) choosing or manufacturing a web shaped packaging laminate according to claim 1,
   b) converting said packaging laminate to a continuous tube by overlapping two longitudinal edges of the web shaped packaging laminate and heat sealing the overlapped edges to provide a longitudinal seal,
   c) filling the tube with contents,
   d) intermittently performing transversal seals by mechanically pressing together two transversal anvil jaws while the filled tube is arranged there between,
   e) while at the same time providing energy to the packaging laminate at an area of said transversal seal.

2. Method according to claim 1, wherein said energy is provided as ultrasonic energy.

3. Method according to claim 1, wherein said mechanical pressing and said providing of energy is performed during a time interval of 100-250 milliseconds, preferably 140-220 milliseconds.

4. Method according to claim 1, wherein said mechanical pressing is performed at 1-10 MPa.

5. Method according to claim 1, wherein a continuous sealing strip is provided to cover an inside seam of the longitudinal seal, which sealing strip preferably is constituted by a polypropylene strip.

* * * * *