

Method and apparatus for cutting a laminate made of a brittle material and a plastic

The invention relates to a method and an
5 apparatus for cutting a laminate made of a brittle material and a plastic with a cutting tool. A preferred application is the cutting of thin glass or glass-ceramic/plastic laminates.

Laminates made of a brittle material and a
10 plastic are composite workpieces, the component parts of which consist of materials which differ greatly on account of their mechanical and thermal properties.

Plastics customarily used for the production of the said laminates are generally mechanically
15 relatively flexible or ductile and have a high thermal expansion of typically 20 to 80 ppm/K and a low softening temperature of typically 120 to 260°C.

In contrast to this, brittle materials, such as glass, glass ceramic or ceramic, used for the
20 production of the abovementioned laminates are mechanically brittle and generally have a low thermal expansion and a high softening temperature. The thermal expansion of glass is typically around 3.5 to 11 ppm/K and the softening temperature T_g is typically 500 to
25 750°C.

On account of the stated very different physical properties of the two materials; until now no method or apparatus has existed for cutting a laminate comprising a brittle workpiece and a plastic with a
30 cutting tool in one operation. The previously known methods and apparatuses relate only to the cutting of the respectively unprocessed material, but not of the composite.

To mechanically cut an unprocessed brittle
35 material, such as glass for example, the glass surface is scored, for example by means of a diamond cutter or a small cutting wheel or a cutting blade made of hard metal. The surface damage produced in this way then represents a rupture joint of the glass, along which

the crack runs in a controlled manner under tensile loading. During scoring of the glass, the normal force exerted on the cutting instrument must not exceed a certain value, dependent on the thickness of the glass.

5 Otherwise, this generally leads to an uncontrolled rupture of the glass (H. Jebesen-Marwedel and R. Brückner (editors), Glastechnische Fabrikationsfehler [glass manufacturing defects], Springer-Verlag, Berlin, Heidelberg, New York, 1980, page 577 et seq.,

10 Chapter 12.7, F. Kerkhof and B. Gänswain, Das "Schneiden" des Glases [the "cutting" of glass]).

In addition to conventional mechanical cutting, methods in which the inducement of stresses along the cutting line is produced by thermal means have been

15 known for some time. For example, DE 197 15 537 A1 discloses a method and an apparatus for severing flat workpieces made of brittle material, a laser beam being used to induce a thermomechanical stress along a separating line.

20 Furthermore, cutting the unprocessed brittle material by means of sand blasting using a mask (JP 06008145 A) or by means of water-jet cutting using an abrasive agent (DE 35 33 340 A1) are known.

In contrast to this, unprocessed plastic films

25 are generally either cut with a shear-action cut, using a shearing action of two sharp-edged hard-metal blades moved against one another, or by using a very sharp cutting knife or cutting wheel.

However, all the methods mentioned above are

30 unsuitable for cutting a laminate of the type mentioned, for example a glass/plastic laminate. It is directly evident that the shear-action cutting of the laminate is possible only when using thin types of glass. However, here too the shear-action cut produced

35 by the shearing action in the thin glass sheet gives rise to uncontrolled brittle cracks transversely to the cutting direction. Although a sharp, scalpel-like cutting knife is capable of severing the plastic film,

it is not able to cut through or score the glass. Rather, it would very quickly be blunted on the glass surface.

5 When cutting with a diamond or a small hard-metal wheel, it is necessary according to the above to keep the loading pressure below a certain limit value to avoid uncontrolled rupture of the glass. The maximum loading pressure of the cutting tool limited in this way is not sufficient, however, to sever the film of
10 the laminate composite reliably. On account of its flexibility, relatively high loading pressures (or normal forces) would be required for severing the plastic film, but for their part would again lead to uncontrolled rupture of the glass.

15 Owing to these facts, it is not possible with the conventional mechanical cutting methods to cut the said laminates in one operation. Alternative methods for cutting the said composite pieces have a series of disadvantages.

20 In the known laser cutting, the apparatus expenditure is significantly greater, on account of the laser and the necessary optical peripherals, resulting in significantly higher costs. Vaporized or even pyrolysed material may be deposited on the laminate or
25 the optical components.

Water-jet cutting leads to soiling of the surface and to surface defects due to the water and the admixed abrasive agent. Cutting by means of sand blasting likewise leads to soiling of the surface and
30 to surface defects of the laminate. These methods usually entail additional cleaning expenditure.

The introduction of said laminates, such as thin glass/plastic laminates for example, into existing product applications, for example in the display
35 industry as a substitute for thin glass substrates, is facilitated considerably if there is an available cutting method which is as compatible as possible with the conventional cutting techniques, causes low

additional costs and, if appropriate, can be implemented in existing glass cutting installations.

The object of the present invention is to provide a method and an apparatus for cutting a
5 laminate made of a brittle material, in particular made of glass, glass ceramic or ceramic, and a plastic with a cutting tool, in which case the laminate is to be cut as far as possible in one operation, and at the same time a high cutting accuracy and faithfulness to
10 contours as well as rapid cutting are to be made possible.

It is also the object of the invention to design the method and the apparatus in such a way that they are compatible with existing cutting methods, that
15 low additional costs are caused and that they can, if appropriate, be implemented in existing cutting installations.

For the method, this object is achieved according to the invention by the steps of:
20 - heating-up the plastic at least in the region of a predetermined cutting line, thereby lowering the viscosity of the plastic,
- placing a cutting tool onto the plastic side of the laminate, the loading pressure of the cutting tool on
25 the surface of the laminate being adjustable,
- producing a relative movement between cutting tool and laminate along the cutting line, with severing of the plastic and simultaneous scoring of the brittle material, thereby inducing a mechanical stress, and
30 if appropriate
- additionally increasing the mechanical stress along the cutting line to beyond the rupture strength of the scored brittle material.

With regard to the apparatus, the object is
35 achieved according to the invention by an apparatus having:

- means of heating-up the plastic at least in the region of a predetermined cutting line, thereby lowering the viscosity of the plastic,
- a cutting tool which can be placed onto the plastic side of the laminate, the loading pressure of the cutting tool on the surface of the laminate being adjustable,
- means for producing a relative movement between cutting tool and laminate along the cutting line, for the purpose of severing the plastic and simultaneously scoring the brittle material, thereby inducing a mechanical stress, and if appropriate
- means for additionally increasing the mechanical stress along the cutting line to beyond the rupture strength of the scored brittle material.

The measures according to the invention make it advantageously possible to cut a laminate made of a brittle material and a plastic, in particular a laminate made of a brittle material laminated on one side with plastic, with a single cutting tool in one operation.

This is advantageous since the use of two cutting tools guided towards each other or one after the other always necessitates complicated and process-sensitive adjustment work, which is not needed in the case of the present solution.

The cutting tool must be guided on the plastic side of the laminate in order to sever the plastic reliably, and at the same time be able to score the brittle material for a brittle fracture at the cutting point.

To solve the fundamental problems mentioned at the beginning in the mechanical cutting of said laminates, it is necessary to lower the high loading pressure of the cutting tool for severing the plastic. By heating-up the plastic at least in the region of a predetermined cutting line, its viscosity is considerably lowered, and a small loading pressure of

the cutting tool is already sufficient to sever the plastic.

5 The possibly required additional increase in the mechanical stress along the cutting line up to the rupture strength of the scored brittle material can be carried out, for example, by bending in the region of the score, a stress-induced crack propagation taking place along the cutting line.

10 To cut a laminate made of a brittle material laminated on both sides with plastic, the plastic on each side of the laminate is severed and the brittle material is scored either on one side or on two sides.

15 The severing of the plastic and the scoring of the brittle material may in this case be performed in a single method step with two oppositely arranged cutting tools or in two successive method steps with at least one cutting tool. For this purpose, the plastic is heated up at least in the region of the predetermined cutting line, thereby lowering the viscosity of the plastic, the heating-up taking place at least on the
20 plastic side of the laminate on which the cutting tool is being placed at the time. The cutting tool is placed on one plastic side of the laminate, the loading pressure of the cutting tool on the surface of the laminate being adjustable. A relative movement between
25 cutting tool and laminate is produced along the cutting line, with severing of the plastic on this side.

On the opposite plastic side of the laminate, the cutting tool or a further, additional cutting tool
30 is placed, the loading pressure of the cutting tool on the surface of the laminate being adjustable. A relative movement between cutting tool and laminate is produced along the cutting line, with severing of the plastic and simultaneous scoring of the brittle
35 material, thereby inducing a mechanical stress. If appropriate, the mechanical stress along the cutting line is additionally increased to beyond the rupture strength of the scored brittle material.

The cutting of the laminate made of a brittle material laminated on both sides with plastic, in which the severing of the plastic and the scoring of the brittle material is performed with two oppositely
5 arranged cutting tools, preferably has the following method steps:

- heating-up the plastic at least in the region of the predetermined cutting line, thereby lowering the viscosity of the plastic,
- 10 - placing a respective cutting tool onto each plastic side of the laminate, the loading pressure of the respective cutting tool on the surface of the laminate being adjustable,
- producing a relative movement between the cutting
15 tools and the laminate along the cutting line, with severing of the plastic and simultaneous scoring of the brittle material, thereby inducing a mechanical stress, the brittle material being scored on one side or on both sides, and if appropriate
- 20 - additionally increasing the mechanical stress along the cutting line to beyond the rupture strength of the scored brittle material.

In this case, the two cutting tools are preferably arranged directly oppositely and execute a
25 synchronized movement in relation to the laminate along the cutting line.

If the two cutting tools are arranged with a lead with respect to one another, the cutting tool which severs only the plastic on one side of the
30 laminate is preferably arranged leading the opposite cutting tool, which severs the plastic and at the same time scores the brittle material.

The plastic is preferably heated up by radiation, in particular infrared and/or laser
35 radiation and/or by a hot-gas jet. In this case, it is also possible for the entire laminate to be heated up.

The heating-up of the plastic may also be performed, however, by the heated cutting tool, in

particular by its heated lower end. In this case, the heating-up of the plastic can be performed both by means of heat energy transfer alone, through the hot cutting tool, at least in the region of the cutting line, and also in addition to the heating-up mentioned.

The heating-up of the plastic may be performed both beyond its softening temperature and below its softening temperature, preferably just below its softening temperature.

By producing a relative movement between cutting tool and laminate, thereby moving the cutting tool and/or moving the laminate along the predetermined cutting line, the heated-up plastic is severed.

Furthermore, the surface of the brittle material can be scored by the cutting tool, and a rupture joint produced, in the same operation. Since the plastic side of the composite has then already been severed, the separating of the laminate - by a tensile-stress-induced crack propagation along the rupture joint of the brittle material - is ensured. The cutting speeds which can be achieved in this case for the cutting-through of the plastic and the simultaneous scoring of the brittle material are comparable with those of conventional glass cutting.

The melted plastic film at the cutting point additionally makes it possible to dispense with the wet film, of water, glycol or propanol for example, often used in conventional glass cutting for improving the cutting quality and for increasing the edge life of the cutting tool.

A fine cut, suitable for severing the plastic and at the same time scoring the brittle material, is preferably obtained by cutting the laminate with a cutting tool having a mounted diamond tip, with a cutting wheel or with a cutting blade.

Diamond, as the hardest mineral, is ideally suited for cutting the laminate, on account of this outstanding property, mounted in the cutting tool,

irrespective of whether the natural or artificially cut edges take effect.

5 Cutting wheels and/or cutting blades which consist of a particularly hard and tough alloy or of a ceramic, in particular of a tungsten-carbide and/or diamond-containing sintered metal, are preferably used. The cutting wheels are preferably tapered in a wedge-shaped manner and provided on the outer edge with highly polished facets.

10 By inducing vibration, the cutting tool, and particularly its lower end, can be made to undergo axial and possibly also transversal vibrations of low amplitude and adjustable frequency. The cutting is improved as a result. An improvement in the cutting
15 action is not dependent on a particular frequency. However, it has been found that higher frequencies have a better effect as a result of the higher number of vibrations per unit of time. The application of ultrasound is preferred, the high frequency of which
20 can be generated by relatively inexpensive means. Frequencies in the range above 100 kHz can be generated with the required amplitudes only with relatively great expenditure. For producing the ultrasound, a modulator is preferably used, for example an oscillator crystal,
25 or a magnetostrictive modulator, for example a nickel rod introduced into a strong magnetic alternating field. The ultrasound produced by ultrasonic stimulation is understood to mean sound waves at frequencies higher than 16 kHz. According to the
30 invention, sound waves at a frequency of from 20 kHz to 100 kHz and an amplitude of from 5 μm to 40 μm are preferably used. In this case, vibrations of the cutting tool executed transversally, longitudinally and/or transversely with respect to the cutting
35 direction bring about a better material displacement of the plastic away from the rupture joint. In this way, renewed flowing together of the just severed, still soft plastic is prevented. The axial vibrations of the

cutting tool lower the thrust and bearing forces required for cutting through the plastic and at the same time scoring the brittle material.

5 The measures according to the invention enhance the cutting quality and reduce the risk of an uncontrolled brittle fracture of the brittle material. As a result, they assist the performance of the process and improve the achievable yield in the cutting operation or make the operation possible in the first
10 place.

The method and the apparatus are suitable with preference for cutting laminates, in particular thin laminates, made of a brittle material, for example of a glass, glass-ceramic or ceramic sheet, and of a
15 plastic, in particular of a plastic film, it being possible for the plastic film to be a scratch-protective film, preferably a scratch-protective film of polyethylene, or of a sprayed-on polymer film.

In principle, the method and the apparatus are
20 suitable for cutting laminates made of a brittle material and a plastic, the viscosity of which can be lowered by means of heating-up by the cutting tool. Suitable plastics are, for example, thermoplastics, and those particularly suited are, for example, polyamides,
25 polycarbonates, polyether sulphones, olefin copolymers, polyethylene-naphthalenes, polyarylates, polypentadienes or polyethylene terephthalate (PET).

The laminates preferably have in this case a thickness of the plastic of from 1 μm to 300 μm and of
30 the brittle material of from 10 μm to 300 μm .

The brittle material and the plastic are preferably bonded to one another by means of a layer of adhesive, the layer of adhesive preferably having a thickness of from 2 μm to 50 μm .

35 Alternatively, the plastic may be applied to the brittle material by extrusion, by a casting, spraying or roller-coating method or by laminating-on a plastic film.

The method and the apparatus are also suitable, however, for cutting laminates made of a relatively thick brittle material, for example of glass, in particular flat glass, glass ceramic or ceramic, and of
5 a plastic, the thickness of the brittle material preferably being up to 30 mm.

Furthermore, laminates of the type mentioned in which the brittle material consists for example of silicon, germanium or carbon can also be cut.

10 The production of a satisfactory cut line and, in particular, of a satisfactory score path requires a particular arrangement of the cutting tool. The angle between the longitudinal axis of the cutting tool and the cutting plane in the cutting direction is
15 preferably adjustable in the range from 55° to 75° . It is particularly preferred for the angle to be 65° .

The following example is intended to illustrate the invention further on the basis of the single drawing.

20 The drawing shows a preferred apparatus for cutting a laminate 1 made of a brittle material 2 and a plastic 4 with a cutting tool 5 in one operation. The laminate 1 represented is, for example, a thin glass/plastic laminate, the glass sheet 2, which is
25 preferably 10 μm to 300 μm thick, and the plastic film 4, which is 1 μm to 300 μm thick, preferably being bonded to one another by means of a layer of adhesive 3 which is 2 μm to 50 μm thick.

The heatable cutting tool 5 can be placed onto
30 the plastic side 4 of the glass/plastic laminate 1, the loading pressure of the cutting tool 5 on the surface of the glass/plastic laminate 1 being adjustable by suitable means, such as spring elements 13 for example. The respective loading pressure can be easily
35 established experimentally, and generally corresponds to the loading pressure which is required for scoring the unprocessed brittle material of corresponding thickness. The lower end 6 of the heatable cutting tool

5 comprises a mounted wedge-shaped diamond, which is suitable for producing particularly fine cut lines. By means of an electrical heating element 7, the cutting tool 5, and particularly preferably its lower end 6, 5 can be brought to the temperature necessary for cutting the respective plastic 4.

The electrical heating element 7 is preferably controlled by means of a heating-voltage device 8, automatic temperature monitoring and control taking 10 place in a particularly preferred embodiment by means of a thermocouple 9 which is attached as close as possible to the lower end 6 of the cutting tool 5 and is connected to the heating-voltage device 8. In this way, a temperature of the cutting tool 5 necessary for 15 cutting a particular plastic 4 can be set and controlled.

It is advantageous to keep the temperature of the cutting tool 5, or at least the temperature of its lower end 6, necessary for cutting the respective 20 plastic 4 constant during cutting.

The respective temperature of the cutting tool 5, and in particular its lower end 6, can likewise be easily established experimentally. The softening temperature of the plastic 4 respectively to be cut, or 25 a temperature which lies somewhat above the softening temperature, can be used as a point of reference. In this case, the temperature of the cutting tool 5, and in particular the temperature of its lower end 6, may be all the higher the higher the cutting speed, in 30 order to permit a required heat energy transfer to the plastic 4 respectively to be cut. The viscosity of the plastic 4 should be lowered by the heating-up of the plastic 4 by the cutting tool 5 to the extent that the loading pressure necessary for the simultaneous scoring 35 of the glass 2 is not, or scarcely, exceeded.

By means (not shown) which may preferably include a radiation source, in particular a heat source, for example an infrared and/or laser heater, or

a hot-gas jet source, the plastic can, however, be additionally heated up also on its own, at least in the region of the predetermined cutting line.

In a further development of the invention, the means for heating-up are guided in such a way that a local heating-up of the plastic takes place at least along the cutting line. The means for heating-up are preferably guided together with the cutting tool and leading the latter. In this case, the said means may be used both alone for the heating-up of the plastic - heating-up by the cutting tool then not being required - and for the additional heating-up by the heated cutting tool.

The cutting tool 5 is connected via a suspension 14 to guide elements 15, which permit moving of the cutting tool 5 along any desired, predetermined cutting line along the glass/plastic laminate 1, it being possible for the movement to be performed both manually and by machine.

By moving the heated cutting tool 5 along the predetermined cutting line, the plastic 4, together with layer of adhesive 3, is severed and at the same time the glass 2, which lies thereunder and is bonded with the plastic 4, is scored, thereby inducing mechanical stress along the cutting line, and in the case of thin laminates is severed.

If appropriate, further increasing of the mechanical stress along the cutting line is performed by additional means (not shown) to beyond the rupture strength of the glass 2. In this way, crack propagation along the cutting line, the so-called rupturing of the glass, is achieved. In this case, the rupture is carried out, essentially by flexural tensile loading, along the scoring line with its chain of fine incipient cracks lying thereunder.

For example, at least the lower end of the cutting tool is heated up to approximately 200°C to cut a flat glass/plastic laminate comprising a 50 µm to

400 μm thick glass sheet which is bonded with a 50 μm thick plastic film 4 made of polyethylene terephthalate (PET). In this case, a loading pressure of approximately 1 N is set for a cutting speed of approximately 10 m/min.

The invention is not restricted to the making of straight cuts; rather, curved cuts can also be accomplished.

In a preferred embodiment of the invention, the cutting tool 5, and particularly preferably its lower end 6, can be induced to undergo ultrasonic vibrations which are axial and/or transversal to the cutting tool 5 (longitudinally and/or transversely to the cutting direction), are of low amplitude, preferably an amplitude of from 5 μm to 40 μm , and of adjustable frequency, by means of a piezo- or magnetostrictive modulator 10 and a coupling element 12. The frequency of the ultrasonic vibration can be set by means of a function generator 11, good cuts having been achieved at frequencies in the range from 20 kHz to 100 kHz.

The cutting tool can preferably be set such that it can be pivoted by at least one axial element 16 perpendicularly and parallel to the cutting plane, in the cutting direction, the angle between the longitudinal axis of the cutting tool 5 and the cutting plane in the cutting direction being adjustable in the range from 55° to 75° and preferably being 65° .

The invention is also not restricted to the cutting of flat laminates; for instance, laminates deviating from the flat form, for example convex composite workpieces, e.g. plastic-coated car windscreens or mirrors, but also composite workpieces made of plastic-coated hollow glass, can also be advantageously cut.

The method according to the invention and the apparatus according to the invention are compatible with the existing mechanical glass cutting methods, and can be integrated into existing methods and apparatuses

without great expenditure. The method and apparatus allow for the first time laminates made of a brittle material and a plastic to be cut with a cutting tool at high speed in one operation. Cutting accuracy and
5 faithfulness to contours match the known methods for cutting brittle materials or unprocessed plastics.

A preferred application is the cutting of thin glass or glass-ceramic/plastic laminates, the glass or glass ceramic preferably being 10 μm to 300 μm thick
10 and the plastic 1 μm to 300 μm thick.

List of reference numerals

- 1 laminate
- 2 brittle material
- 3 layer of adhesive
- 4 plastic
- 5 cutting tool
- 6 lower end of the cutting tool
- 7 heating element
- 8 heating-voltage device
- 9 thermocouple
- 10 piezo- or magnetostrictive modulator
- 11 function generator
- 12 coupling element
- 13 spring elements
- 14 suspension
- 15 guide element
- 16 axial element



PATENT CLAIMS

1. Method of cutting a laminate made of a brittle material and a plastic with a cutting tool,
5 characterized by the steps of:
 - heating-up the plastic at least in the region of a predetermined cutting line, thereby lowering the viscosity of the plastic,
 - placing the cutting tool onto the plastic side of the
10 laminate, the loading pressure of the cutting tool on the surface of the laminate being adjustable,
 - producing a relative movement between cutting tool and laminate along the cutting line, with severing of the plastic and simultaneous scoring of the brittle
15 material, thereby inducing a mechanical stress, and if appropriate
 - additionally increasing the mechanical stress along the cutting line to beyond the rupture strength of the scored brittle material.
- 20 2. Method according to Claim 1, characterized in that, for cutting the laminate made of a brittle material laminated on both sides with plastic:
 - the plastic is heated up at least in the region of the predetermined cutting line, thereby lowering the
25 viscosity of the plastic,
 - a cutting tool is respectively placed on each side of the plastic of the laminate, the loading pressure of the respective cutting tool on the surface of the laminate being adjustable,
 - 30 - a relative movement is produced between the cutting tools and the laminate along the cutting line, with severing of the plastic and simultaneous scoring of the brittle material, thereby inducing a mechanical stress, the brittle material being scored on one side
35 or on both sides, and if appropriate
 - the mechanical stress is additionally increased along the cutting line to beyond the rupture strength of the scored brittle material.



3. Method according to one of Claims 1 or 2, characterized in that the heating-up is performed by radiation, in particular a infrared and/or laser radiation or by a hot-gas jet.
- 5 4. Method according to at least one of Claims 1 to 3, characterized in that the heating-up is performed by the heated cutting tool, in particular by its heated lower end.
5. Method according to at least one of Claims 1 to
10 4, characterized in that the entire laminate is heated up.
6. Method according to at least one of Claims 1 to 5, characterized in that the laminate is cut by a mounted diamond tip of the cutting tool.
- 15 7. Method according to at least one of Claims 1 to 6, characterized in that the laminate is cut by a cutting wheel and/or a cutting blade of the cutting tool.
8. Method according to Claim 7, characterized in
20 that a cutting wheel or a cutting blade made of a hard metal or of a ceramic, in particular a tungsten-carbide and/or diamond-containing sintered metal, is used.
9. Method according to at least one of Claims 1 to 8, characterized in that the cutting tool, in
25 particular its lower end, executes axial ultrasonic vibrations.
10. Method according to at least one of Claims 1 to 9, characterized in that the cutting tool, in particular its lower end, executes transverse
30 ultrasonic vibrations longitudinally and/or transversely with respect to the cutting direction.
11. Method according to at least one of Claims 9 or 10, characterized in that the ultrasonic vibrations have low amplitudes, in particular amplitudes of from
35 5 μm to 40 μm .
12. Method according to least one of Claims 9 to 11, characterized in that frequencies of the ultrasonic



vibrations in the range from 20 kHz to 100 kHz are used.

13. Method according to at least one of Claims 1 to 12, characterized in that a plastic film or a sprayed-on polymer film is used as the plastic.

14. Method according to Claim 13, characterized in that a plastic film made of polyethylene or polycarbonate is used.

15. Method according to at least one of Claims 1 to 14, characterized in that the plastic has a thickness of from 1 μm to 300 μm .

16. Method according to at least one of Claims 1 to 15, characterized in that glass, in particular flat glass, glass ceramic or ceramic is used as the brittle material.

17. Method according to Claim 16, characterized in that the brittle material has a thickness of up to 30 mm.

18. Method according to at least one of Claims 1 to 17, characterized in that a glass, glass-ceramic or ceramic sheet is used as the brittle material.

19. Method according to Claim 18, characterized in that the brittle material has a thickness of from 10 μm to 300 μm .

20. Method according to at least one of Claims 1 to 19, characterized in that the brittle material and the plastic are bonded to one another by means of a layer of adhesive.

21. Method according to Claim 20, characterized in that the layer of adhesive has a thickness of from 2 μm to 50 μm .

22. Method according to at least one of Claims 1 to 21, characterized in that the plastic is applied to the brittle material by extrusion, by a casting, spraying or roller-coating method or by laminating-on a plastic film.



23. Apparatus for cutting a laminate made of a brittle material and a plastic with a cutting tool, characterized by:

- 5 - means of heating-up the plastic at least in the region of a predetermined cutting line, thereby lowering the viscosity of the plastic,
- a cutting tool which can be placed onto the plastic side of the laminate, the loading pressure of the cutting tool on the surface of the laminate being
10 adjustable,
- means for producing a relative movement between cutting tool and laminate along the cutting line, for the purpose of severing the plastic and simultaneously scoring the brittle material, thereby
15 inducing a mechanical stress, and if appropriate
- means for additionally increasing the mechanical stress along the cutting line to beyond the rupture strength of the scored brittle material.

24. Apparatus according to Claim 23, characterized
20 in that the apparatus for cutting the laminate made of a brittle material laminated on both sides with plastic has:

- means of heating-up the plastic at least in the region of a predetermined cutting line, thereby
25 lowering the viscosity of the plastic,
- a cutting tool which can be placed onto one plastic side of the laminate and a further cutting tool which can be placed onto the opposite plastic side of the laminate, the loading pressure of the cutting tools
30 on the surface of the laminate being adjustable,
- means for producing a relative movement between the cutting tools and the laminate along the cutting line, for the purpose of severing the plastic and simultaneously scoring the brittle material, thereby
35 inducing a mechanical stress, the scoring of the brittle material taking place on one side or on both sides, and if appropriate



- means for additionally increasing the mechanical stress along the cutting line to beyond the rupture strength of the scored brittle material.

25. Apparatus according to Claim 23 or 24,
5 characterized in that the means for heating-up the plastic include a radiation source, in particular a heat source, for example an infrared and/or laser heater, and/or a hot-gas jet source.

26. Apparatus according to at least one of Claims
10 23 to 25, characterized in that the cutting tool, in particular its lower end, is heatable.

27. Apparatus according to at least one of Claims 23 to 26, characterized in that the lower end of the cutting tool comprises a mounted diamond.

15 28. Apparatus according to at least one of Claims 23 to 27, characterized in that the tip of the cutting tool comprises a cutting wheel and/or a cutting blade made of a hard metal or of a ceramic, in particular a tungsten-carbide and/or diamond-containing sintered
20 metal.

29. Apparatus according to at least one of Claims 23 to 28, characterized in that the cutting tool, in particular its lower end, is induced to undergo
25 ultrasonic vibrations in a direction axial to the cutting tool by means of a piezo- or magnetostrictive modulator and a coupling element.

30. Apparatus according to at least one of Claims 23 to 29, characterized in that the cutting tool, in particular its lower end, is induced to undergo
30 ultrasonic vibrations transversely to the cutting direction, in a direction transversal to the cutting tool, by means of a piezo- or magnetostrictive modulator and a coupling element.

31. Apparatus according to at least one of Claims
35 23 to 30, characterized in that the cutting tool, in particular its lower end, is induced to undergo ultrasonic vibrations longitudinally to the cutting direction, in a direction transversal to the cutting



tool, by means of a piezo- or magnetostrictive modulator and a coupling element.

32. Apparatus according to at least one of Claims 29 to 33, characterized in that the amplitudes and the
5 frequencies of the ultrasonic vibrations are controllable in an open-loop and closed-loop manner.

33. Apparatus according to Claim 32, characterized in that the amplitudes of the ultrasonic vibrations lie in the range from 5 μm to 40 μm and the frequencies of
10 the ultrasonic vibrations lie in the range from 20 kHz to 100 kHz.

34. Apparatus according to at least one of Claims 23 to 33, characterized in that the means for heating-up the plastic by the cutting tool comprise at least
15 one heating element, one thermocouple and one heating-voltage device.

35. Apparatus according to at least one of Claims 23 to 34, characterized in that the cutting tool can be pivoted by at least one axial element perpendicularly
20 and parallel to the cutting plane, at least in the cutting direction.