An apparatus for polishing an edge of an automotive glass sheet comprising a retaining device, which is capable of supporting the automotive glass sheet, and a polishing wheel assembly. A motor assembly is coupled to and drives the polishing wheel assembly to polish the edge of the automotive glass sheet to maximize the strength of the glass sheet and improve the aesthetic properties thereof. A pressure system, such as a compliant member, a robotic system, or a floating spindle assembly, is coupled to either the retaining device or the polishing wheel in order to actively maintain a predetermined generally constant contact pressure between the polishing wheel and the edge of the automotive glass sheet to insure proper polishing thereof.
AUTOMOTIVE SAFETY GLASS EDGE POLISHING

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Application No. 60/366,201, filed on Mar. 21, 2002. The disclosure of the above application is incorporated herein by reference.

FIELD OF THE INVENTION

[0002] The present invention generally relates to automotive safety glass and, more particularly, relates to an apparatus for reliable and convenient edge polishing of automotive safety glass.

BACKGROUND OF THE INVENTION

[0003] As is well known, automotive glass is typically constructed using generally flat sheets of glass, which are preferably sized to minimize waste thereof. During processing of this glass, the sheets are cut to size and subsequently treated in a tempering, bending, and/or otherwise shaping process. However, it should be understood that following this cutting step and preferably before further processing, the edges of the sheet should be polished to minimize burrs, reduce small peripheral fractures that could otherwise lead to shattering, and produce an aesthetically pleasing product.

[0004] Frequently the polishing of the edge of the glass sheet is accomplished through a machining process, which consists of passing a fine grain polisher or a diamond wheel along the length of the sheet edge. Typically, the environment is kept humid in order to minimize the presence of air-borne glass dust during the polishing process, while a cooling fluid flows over the polishing wheel.

[0005] However, conventional polishing wheel assemblies lack the ability to accommodate slight variations in the glass sheets and dimensional changes of the polishing wheel caused by wear. That is, as the polishing wheel is polishing the edge of the glass sheet, the grinding properties, such as the contact pressure on the glass sheet, invariably change due to variations in the dimensions of the glass sheet and/or polishing wheel. These dimensional variations between the glass sheet and polishing wheel result in changes in contact pressure, thereby resulting in polishing variations or even stress fractures.

[0006] Accordingly, there exists a need in the relevant art to provide an apparatus for polishing the edge of automotive safety glass that is capable of maximizing the strength of the glass sheet and improving the aesthetic properties thereof. Furthermore, there exists a need in the relevant art to provide an apparatus for polishing the edge of automotive safety glass that is capable of maintaining a constant and consistent contact pressure between the glass sheet and the polishing wheel. Additionally, there exists a need in the relevant art to provide an apparatus for polishing the edge of automotive safety glass that overcomes the disadvantages of the prior art.

SUMMARY OF THE INVENTION

[0007] According to the principles of the present invention, an apparatus is provided for polishing an edge of an automotive glass sheet. The apparatus comprises a retaining device, which is capable of supporting the automotive glass sheet, and a polishing wheel assembly. A motor assembly is coupled to and drives the polishing wheel assembly to polish the edge of the automotive glass sheet to maximize the strength of the glass sheet and improve the aesthetic properties thereof. A pressure system, such as a compliant member, a robotic system, or a floating spindle assembly, is coupled to either the retaining device or the polishing wheel in order to actively maintain a predetermined generally constant contact pressure between the polishing wheel and the edge of the automotive glass sheet to insure proper polishing thereof.

[0008] Further areas of applicability of the present invention will become apparent from the detailed description provided hereinafter. It should be understood that the detailed description and specific examples, while indicating the preferred embodiment of the invention, are intended for purposes of illustration only and are not intended to limit the scope of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The present invention will become more fully understood from the detailed description and the accompanying drawings, wherein:

[0010] FIG. 1 is a perspective view illustrating a first embodiment of the present invention employing a floating spindle apparatus having a pressure control device; and

[0011] FIG. 2 is a perspective view illustrating a first embodiment of the present invention employing a servo feedback robotic arm assembly.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0012] The following description of the preferred embodiments is merely exemplary in nature and is in no way intended to limit the invention, its application, or uses. For example, the principles of the present invention may have utility in a wide variety of glass processing applications, such as the polishing of laminated sheets, tempered glass, or other application where glass sheets having improved strength characteristics and aesthetic properties is preferred.

[0013] Referring now to FIG. 1, an edge polishing apparatus, generally indicated at 10, is provided for maintaining a constant and consistent polishing pressure upon the edge of an automotive glass sheet 12 according to a first embodiment of the present invention. Edge polishing apparatus 10 generally includes a moveable support structure 14, a glass sheet retaining device 16, a conveyor assembly 18, a polishing wheel assembly 20, and a chip removal system 22.

[0014] Preferably, glass sheet retaining device 16 is coupled to conveyor assembly 18 such that automotive glass sheet 12 is carried quickly and conveniently between processing stations (not shown) during a complete manufacturing process. Although, the principles of the present invention are intended to be employed in conjunction with traditional processing steps, such as cutting, tempering, laminating, bending, and the like, the present invention should not be regarded as requiring such steps.

[0015] Still referring to FIG. 1, glass sheet retaining device 16 includes a plurality of retaining members 24, such
as suction pads or overlapping retaining arms. The plurality of retaining members 24 releasably secures automotive glass sheet 12 to glass sheet retaining device 16 such that automotive glass sheet 12 may be conveniently carried and transported by conveyor assembly 18.

[0016] Polishing wheel assembly 20 generally includes a motor 26 fixedly coupled to moveable support structure 14 to prevent relative movement therebetween. Polishing wheel assembly 20 further includes a polishing wheel 28 coupled to support structure 14 through a floating pressure assembly 30, which enables polishing wheel 28 to move relative to support structure 14, yet maintain a generally constant contact pressure with automotive glass sheet 12. This relative movement between polishing wheel 28 and support structure 14 accommodates dimensional and positional variations of automotive glass sheet 12 and wear of polishing wheel 28.

[0017] Floating pressure assembly 30 includes a motor linkage or shaft 32 extending from motor 26 and a wheel linkage or shaft 34 pivotally coupled to and driving polishing wheel 28. An intermediate linkage or member 36 is pivotally coupled at one end 38 to an end 40 of motor linkage 32 to permit the pivoting movement of intermediate linkage 36 about motor linkage 32. Intermediate linkage 36 is further coupled at an opposing end 42 to an end 44 of wheel linkage 34. Motor linkage 32, intermediate linkage 36, and wheel linkage 34 thus cooperate to provide a flexing motion between polishing wheel 28 and automotive glass sheet 12. A spring member 47 is coupled to either intermediate linkage 36 or wheel linkage 34 to bias polishing wheel 28 in a retracted position and into contact with automotive glass sheet 12. The biasing force of spring member 47 is adjustable via an adjustment knob 49. Adjustment knob 49 is a screw-type device that when “tightened” will increase the biasing force of spring member 47, thereby increasing the contact pressure of polishing wheel 28. Conversely, when adjustment knob 49 is “loosened”, the biasing force of spring member 47 is decreased, thereby decreasing the contact pressure of polishing wheel 28.

[0018] Preferably, in order to ensure proper contact pressure between polishing wheel 28 and automotive glass sheet 12, an optional pressure sensor 48 is coupled between support structure 14 and intermediate linkage 36. Pressure sensor 48 is preferably a pressure transducer capable of measuring the contact force between polishing wheel 28 and automotive glass sheet 12. Pressure sensor 48 is more preferably adjustable to be set to a specific polishing pressure setting. In operation, pressure sensor 48 could be controlled by a linear variable displacement transformer that is converted to torque or a differential amp draw on the motor created by a position. This torque or differential amp draw may be used to identify a unique position or applied force.

[0019] Polishing wheel 28 is generally circular in shape and includes a polishing or grinding groove 50 extending therearound. Preferably, polishing wheel 28 is made of a fine grain or diamond material, however, it should be understood that polishing wheel 28 may be made of any material and have any cross-sectional profile that maximizes the polishing effect of the glass sheet.

[0020] Polishing wheel 28 is driven through a drive system 51 that is coupled to or disposed within floating pressure assembly 30. By way of non-limiting example, the drive system may include a gearing system disposed within the linkage members (i.e. a first drive shaft 51a, a second drive shaft 51b, and an intermediate drive member 51c), which are interconnected through known gearing components. That is, the drive system may include a series of drive shafts interconnected through a belt assembly and/or worm gear systems. Ideally, first drive shaft 51a is directly coupled to motor 26 so as to permit first drive shaft 51a to be driven in response thereto. Intermediate drive member 51c is preferably a belt extending between first drive shaft 51a/motor linkage 32 and second drive shaft 51b/wheel linkage 34, which maintains a driving connection even as polishing wheel 28 floats.

[0021] Still referring to FIG. 1, edge polishing apparatus 10 includes chip removal system 22 and a cooling system 52. Chip removal system 22 is preferably a vacuum system that is capable of removing, containing, and/or treating glass dust and other debris produced during polishing. Cooling system 52 preferably includes pump assembly 54 for pumping a cooling fluid from a sump 56 to an outlet 58. Outlet 58 is preferably oriented such that the cooling fluid is directed generally toward polishing wheel 28 to provide cooling of polishing wheel 28. The cooling fluid further serves to lubricate the contact point between polishing wheel 28 and automotive glass sheet 12. Preferably, pump assembly 54 includes a filtering device (not shown) for removing debris from the cooling fluid.

[0022] During operation, automotive glass sheet 12 is retained by retaining device 16 via the plurality of retaining members 24. According to the present embodiment, automotive glass sheet 12 remains stationary as polishing wheel 28 passes therearound. During this time, motor 26 rotatably drives polishing wheel 28 via drive system 51. Simultaneously, moveable support structure 14 carries polishing wheel assembly 20, chip removal system 22, and cooling system 52 about automotive glass sheet 12 along a predetermined path. As can be appreciated, due to the ability of edge polishing apparatus 10 to accommodate dimensional variations of automotive glass sheet 12 and/or dimensional variations of polishing wheel 28, it is not necessary that moveable support structure 14 trace an exact path relative to automotive glass sheet 12. Alternatively, it should be understood that polishing wheel assembly 20, chip removal system 22, and cooling system 52 may remain stationary while automotive glass sheet 12 is rotated during polishing.

[0023] During the polishing process, polishing wheel 28 remains in contact with automotive glass sheet 12. However, dimensional variations in automotive glass sheet 12 and/or polishing wheel 28 produce a resultant force between polishing wheel assembly 20 and automotive glass sheet 12. This resultant force, in the case where the portion of automotive glass sheet 12 extends outwardly, forces polishing wheel 28 and wheel linkage 34 in a direction, generally indicated by Arrow A. Consequently, intermediate linkage 36 pivots about motor linkage 32, thereby moving intermediate linkage 36 against the biasing force of spring member 47. However, spring member 47 is set to a predetermined setting to maintain the appropriate biasing force within intermediate linkage 36 and, thus, the appropriate contact pressure between polishing wheel 28 and automotive glass sheet 12. A similar, but opposite, operation occurs when a portion of automotive glass sheet 12 extends inwardly.
It should be understood, however, that although pressure sensor 48 may be used to ensure the proper contact pressure between polishing wheel 28 and automotive glass sheet 12, it is not required. That is, once polishing wheel assembly 20, namely spring member 47, is set to maintain the desired contact pressure, further adjustment is not generally required. Therefore, pressure sensor 48 may be subsequently removed. Moreover, it should be understood that motor 26, polishing wheel 28, and a direct drive shaft (not shown) may be used in fixed relationship with each other. In this case, the entire unit consisting of motor 26, polishing wheel 28, and a direct drive shaft would be biased in an engaged position against automotive glass sheet 12. During operation, this unit would be capable of articulating relative to the edge of automotive glass sheet 12.

During the polishing operation, chip removal system 22 removes, contains, or treats glass dust and other debris produced during polishing. Additionally, chip removal system 22 is preferably capable of removing, cleaning, and recirculating the cooling fluid output by cooling system 52. Such filtering may be accomplished within a filtering device of cooling system 52.

Referring now to FIG. 2, an edge polishing apparatus, generally indicated at 100, is provided for maintaining a constant and consistent polishing pressure upon the edge of an automotive glass sheet 12 according to a second embodiment of the present invention. Although it should be readily understood that such components may be used in conjunction with the present embodiment.

Edge polishing apparatus 100 generally includes a moveable support structure 115, a glass sheet retaining device 116, a polishing wheel assembly 120, chip removal system 22, and a cooling system 52.

Moveable support structure 115 is provided for handling automotive glass sheet 12 during the polishing procedure. Moveable support structure 115 is preferably a joint servo robot 122 having a base structure 124, a first arm linkage 126, and a second arm linkage 128. An end 130 of first arm linkage 126 is pivotally coupled to base structure 124 at joint 132. First arm linkage 126 is articulateable about base structure 124 to provide the necessary degrees of freedom.

Similarly, an opposing end 134 of first arm linkage 126 is pivotally coupled to second arm linkage 128 at an end 136 at joint 138. Unlike joint 132, joint 138 may be limited to freedom along a single plane. However, if additional degrees of freedom are required, joint 138 may be a ball joint or the like. Glass retaining device 116 is further coupled to an opposing end 140 of second arm linkage 128. Glass retaining device 116 may be of similar construction to glass retaining device 16 or may include a single main suction member, as shown.

Joint servo robot 122 includes a plurality of servo motors (not shown) that actuate first arm linkage 126 and second arm linkage 128 to position the edge of automotive glass sheet 12 in contact with polishing wheel assembly 120 according to the principles of the present invention. To this end, joint servo robot 122 rotates automotive glass sheet 12 such that the entire edge of automotive glass sheet 12 is polished.

Polishing wheel assembly 120 generally includes a motor 126 fixedly coupled to a support structure 114 to prevent relative movement therebetween. Polishing wheel assembly 120 further includes a polishing wheel 28 coupled to motor 126 through a direct drive assembly 130.

Direct drive assembly 130 may be a motor linkage 132 extending from motor 126 pivotally coupled to polishing wheel 28. In order to ensure proper contact pressure between polishing wheel 28 and the edge of automotive glass sheet 12, motor linkage 132 is preferably a compliant member that is capable of flexing to accommodate the dimensional variation of automotive glass sheet 12 and/or dimensional variation of polishing wheel 28 caused by wear. However, it should be understood that direct drive assembly 130 may include spring member 47 and adjustment knob 49, as described above and illustrated in phantom in FIG. 2.

Polishing wheel 28 is driven through direct drive system 130, which may include a gearing system disposed within the motor linkage 132. Alternatively, direct drive system 130 may include a drive shaft that is capable of driving polishing wheel 28.

During operation, automotive glass sheet 12 is retaining by retaining device 116. According to the present embodiment, polishing wheel assembly 120 remains generally stationary as joint servo robot 122 rotates automotive glass sheet 12 such that the entire edge of automotive glass sheet 12 is polished by polishing wheel 28. During this time, motor 126 rotatably drives polishing wheel 28 via direct drive system 130. As can be appreciated, due to the ability of edge polishing apparatus 100 to accommodate dimensional variations of automotive glass sheet 12 or dimensional variations of polishing wheel 28, it is not necessary that joint servo robot 122 rotate automotive glass sheet 12 exactly, since variations in contact pressure are accommodated by compliant motor linkage 132.

The description of the invention is merely exemplary in nature and, thus, variations that do not depart from the gist of the invention are intended to be within the scope of the invention. Such variations are not to be regarded as a departure from the spirit and scope of the invention.

What is claimed is:

1. An apparatus for polishing an edge of automotive glass, the apparatus comprising:
   a base;
   a retaining device operable to support the automotive glass;
   a polishing wheel operable to polish the edge of the automotive glass;
   a motor assembly driving the polishing wheel; and
   a pressure assembly coupled to one of the retaining device and the polishing wheel to actively maintain a predetermined generally constant contact pressure between the polishing wheel and the edge of the automotive glass.

2. The apparatus according to claim 1, further comprising:
   a cooling system disposed generally adjacent to the polishing wheel, the cooling system operable to deliver a cooling fluid to the polishing wheel during a polishing operation.
3. The apparatus according to claim 1, further comprising:
a chip removal system disposed generally adjacent to the
polishing wheel, the chip removal system operable to
remove debris during a polishing operation.
4. The apparatus according to claim 1 wherein the retaining
device comprises:
a suction pad connectable to the automotive glass, the
suction pad being selectively disengageable with the
automotive glass.
5. The apparatus according to claim 1 wherein the retaining
device comprises:
a retaining arm clampingly connectable to the automotive
glass, the retaining arm being selectively disengageable
with the automotive glass.
6. The apparatus according to claim 1 wherein the pressure
assembly comprises:
a first member pivotally coupled to the base;
a second member pivotally coupled to the polishing
wheel;
a third member pivotally coupled between the first member
and the second member; and
a biasing member biasing at least one of the second
member and the third member such that the polishing
wheel is engageable with the edge of the automotive
glass, the biasing member actively maintaining the
predetermined generally constant contact pressure
between the polishing wheel and the edge of the
automotive glass.
7. The apparatus according to claim 6, further comprising:
an adjustment device for adjusting the biasing force of the
biasing member.
8. The apparatus according to claim 6 wherein the motor
assembly comprises:
a motor, and
a drive system drivingly interconnecting the motor to the
polishing wheel to rotatably drive the polishing wheel.
9. The apparatus according to claim 8 wherein the drive
system comprises:
a first drive shaft drivingly enmeshing with the motor, the
first drive shaft being driven in response to the motor;
a second drive shaft drivingly enmeshing with the pol-
ishing wheel; and
an intermediate drive member operably coupling the first
drive shaft to the second drive shaft, the intermediate
drive member being operable to transmit a driving
force from the first drive shaft to the second drive shaft.
10. The apparatus according to claim 9 wherein the
intermediate drive member is a drive belt.
11. The apparatus according to claim 9 wherein the
intermediate drive member is a third drive shaft.
12. The apparatus according to claim 1, further comprising:
a pressure sensor operably coupled to the pressure assem-
bly, the pressure sensor being operable to provide an
output signal in response to the generally constant
contact pressure between the polishing wheel and the
edge of the automotive glass.
13. The apparatus according to claim 1 wherein the
pressure assembly comprises:
a robotic arm assembly having a base and at least one arm
linkage, the retaining device being disposed at an end of
the at least one arm linkage, the robotic arm assem-
bly being actuateable into a plurality of positions.
14. An apparatus for polishing an edge of automotive
glass, the apparatus comprising:
a base;
a retaining device operable to support the automotive
glass;
a polishing wheel operable to polish the edge of the
automotive glass;
a motor assembly driving the polishing wheel;
a first member pivotally coupled to the base;
a second member pivotally coupled to the polishing
wheel;
a third member pivotally coupled between the first member
and the second member; and
a biasing member biasing at least one of the second
member and the third member such that the polishing
wheel is engageable with the edge of the automotive
glass, the biasing member actively maintaining the
predetermined generally constant contact pressure
between the polishing wheel and the edge of the
automotive glass.
15. The apparatus according to claim 14, further compris-
ing:
a cooling system disposed generally adjacent to the pol-
ishing wheel, the cooling system operable to deliver a
cooling fluid to the polishing wheel during a polishing
operation.
16. The apparatus according to claim 14, further compris-
ing:
a chip removal system disposed generally adjacent to the
polishing wheel, the chip removal system operable to
remove debris during a polishing operation.
17. The apparatus according to claim 14 wherein the
retaining device comprises:
a suction pad connectable to the automotive glass, the
suction pad being selectively disengageable with the
automotive glass.
18. The apparatus according to claim 14 wherein the
retaining device comprises:
a retaining arm clampingly connectable to the automotive
glass, the retaining arm being selectively disengageable
with the automotive glass.
19. The apparatus according to claim 14, further compris-
ing:
an adjustment device for adjusting the biasing force of the
biasing member.
20. The apparatus according to claim 14 wherein the
motor assembly comprises:
a motor; and
a drive system drivingly interconnecting the motor to the
polishing wheel to rotatably drive the polishing wheel.
21. The apparatus according to claim 20 wherein the drive system comprises:

a first drive shaft drivingly enmeshing with the motor, the first drive shaft being driven in response to the motor, the first drive shaft being disposed within the first member;

a second drive shaft drivingly enmeshing with the polishing wheel, the second drive shaft being disposed within the second member; and

an intermediate drive member operably coupling the first drive shaft to the second drive shaft, the intermediate drive member being operable to transmit a driving force from the first drive shaft to the second drive shaft.

22. The apparatus according to claim 21 wherein the intermediate drive member is a drive belt.

23. The apparatus according to claim 21 wherein the intermediate drive member is a third drive shaft.

24. The apparatus according to claim 14, further comprising:

a pressure sensor operably coupled to one of the second member and third member, the pressure sensor being operable to provide an output signal in response to the generally constant contact pressure between the polishing wheel and the edge of the automotive glass.

25. An apparatus for polishing an edge of automotive glass, the apparatus comprising:

a retaining device operable to support the automotive glass;

a polishing wheel operable to polish the edge of the automotive glass;

a motor assembly driving the polishing wheel;

a robotic arm assembly having a base and at least one arm linkage, the retaining device being disposed at an end of the at least one arm linkage, the robotic arm assembly being actuable into a plurality of positions; and

a biasing member biasing the polishing wheel into a position engagable with the edge of the automotive glass, the biasing member actively maintaining a pre-determined generally constant contact pressure between the polishing wheel and the edge of the automotive glass.

26. The apparatus according to claim 25, further comprising:

a cooling system disposed generally adjacent to the polishing wheel, the cooling system operable to deliver a cooling fluid to the polishing wheel during a polishing operation.

27. The apparatus according to claim 25, further comprising:

a chip removal system disposed generally adjacent to the polishing wheel, the chip removal system operable to remove debris during a polishing operation.

28. The apparatus according to claim 25 wherein the retaining device comprises:

a suction pad connectable to the automotive glass, the suction pad being selectively disengagable with the automotive glass.

29. The apparatus according to claim 25 wherein the retaining device comprises:

a retaining arm clampingly connectable to the automotive glass, the retaining arm being selectively disengagable with the automotive glass.

30. The apparatus according to claim 25 wherein the motor assembly comprises:

a motor; and

a drive system drivingly interconnecting the motor to the polishing wheel to rotatably drive the polishing wheel.

31. The apparatus according to claim 30, further comprising:

a pressure sensor operably coupled to the drive system, the pressure sensor being operable to provide an output signal in response to the generally constant contact pressure between the polishing wheel and the edge of the automotive glass.

32. The apparatus according to claim 30 wherein the drive system is a compliant drive system.

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