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TESTING SYSTEM AND METHOD OF CURVED DISPLAYING APPARATUS

Abstract

An inspection system for a display device includes a plurality of support members supporting a bottom of an inspection panel of the display device. A plurality of imaging devices captures images of four corners of the inspection panel. A position misalignment confirmation unit verifies a misaligned direction of the inspection panel based on gray values of the four corner images of the inspection panel. A control unit corrects a misalignment of the inspection panel determined by the position misalignment confirmation unit. The control unit controls support member driving means that drives the plurality of support members to correct the misalignment.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims priority under 35 U.S.C. § 119 to Korean Patent Application No. 10-2024-0024568, filed on Feb. 20, 2024 in the Korean Intellectual Property Office, the disclosure of which is incorporated by reference in its entirety herein.

1. TECHNICAL FIELD

[0002] The present disclosure relates to an inspection system and method for a curved display device, and more specifically, to an inspection system and method for a curved display panel.

2. DISCUSSION OF RELATED ART

[0003] There are various types of display devices in the electronic products industry, including liquid crystal displays (LCD) and organic light emitting diodes (OLED). The liquid crystal display (LCD) includes a liquid crystal display panel that utilizes the light transmittance of liquid crystals to display images. A backlight assembly is positioned below the liquid crystal display panel to provide light.

[0004] The organic light emitting diode (OLED) is a self-emissive display device which displays images using organic light emitting diodes (OLEDs) that emit light through the recombination of electrons and holes, without requiring a backlight assembly. Organic light emitting diodes have been widely used in the electronic products industry because they provide relatively fast response speeds and operate with relatively low power consumption.

[0005] Curved display devices in which the edges of the screen are curved towards the user are being developed to provide users with a wider field of view for the user. The curved display device increases image viewing with wider angles and increased depth perceptions.

[0006] Curved display devices are being developed in various sizes, curvatures, and resolutions suitable for various fields, including TVs, monitors, smart phones, and wearable electronic devices.

[0007] The curved display device uses a flexible display panel that requires inspection for a bending defect. However automation of the inspection is difficult due to the characteristics of flexible display panels.

[0008] For example, to automate the inspection of the bending defect in flexible display panels, the flexible display panel must move seamlessly, but due to the curved features, stop loss may occur.

[0009] Furthermore, expanding the vision imaging area to identify alignment marks for bending defect inspection in flexible display panels results in a larger inspection system for curved display devices.

SUMMARY

[0010] The present disclosure is designed to solve these problems, and the objective of the present disclosure is to provide an inspection system and method for a curved display device that can automate the inspection of bending defects in flexible display panels used in curved display devices.

[0011] According to an embodiment of the present disclosure, an inspection system for a display device includes a plurality of support members supporting a bottom of an inspection panel of the display device. A plurality of imaging devices captures images of four corners of the inspection panel. A position misalignment confirmation unit verifies a misaligned direction of the inspection panel based on gray values of the four corner images of the inspection panel. A control unit corrects a misalignment of the inspection panel determined by the position misalignment confirmation unit.

The control unit controls support member driving means that drives the plurality of support members to correct the misalignment.

[0012] According to an embodiment of the present disclosure, an inspection system for a display device includes a bending inspection device that inspects a bending defect of an inspection panel of the display device. A transfer device loads, moves, and unloads the inspection panel to the bending inspection device. A control device controls the bending inspection device and the transfer device. The bending inspection device includes a pair of upper rollers fixing an upper portion of the inspection panel. A pair of lower rollers supports a lower portion of the inspection panel. A bending press member presses the upper roller vertically downward to bend the inspection panel. A plane return member returns a curved surface of the inspection panel to a plane surface after a process for inspecting defective bending of the inspection panel.

[0013] According to an embodiment of the present disclosure, a control method of a display device inspection system includes automatically loading an inspection panel into a correct position on the display device inspection system. A bending inspection process is performed on the loaded inspection panel. The loaded inspection panel is bent to have a curved surface during the bending inspection process. A process to return the curved surface of the inspection panel to a plane surface is performed after performing the bending inspection process. A position misalignment of the inspection panel that occurred during the process of returning the inspection panel to the plane surface is checked. A position alignment movement is performed to correct the position misalignment of the inspection panel and place the inspection panel into a correct position. The inspection panel is unloaded in the correct position.

[0014] In the control method of the display device inspection system according to an embodiment of one aspect of the present disclosure, the step of automatically loading the inspection panel in the correct position includes arranging the inspection panel with respect to a pair of support members supporting the inspection panel from the bottom, and the step of inspecting the bending defect may include the steps of pressing the inspection panel from above, and pressing a pair of fixing members positioned in the central area having a gap less than the gap between the pair of support members from above with a bending press member.

[0015] The control method of the display device inspection system according to an embodiment of one aspect of the present disclosure may include a process of returning to the plane surface, which includes a step of moving the bending press member upward and a step of pressing the curved surface of the inspection panel to the plane surface by the plane return member.

[0016] The step of checking the misalignment of the inspection panel may include imaging the four corners of the inspection panel before and after the bending defect inspection using a vision positioned below the four corners of the inspection panel, and comparing the four corners imaging before and after the bending process on a gray value basis.

[0017] According to the inspection system and method for the curved display device of the present disclosure, it is possible to automate the bending defect inspection in flexible display panels used in the curved display device.

[0018] According to the inspection system and method for the curved display device of the present disclosure, automating the bending defect inspection in the flexible display panel relies on seamless movement of the flexible display panel, resolving stop loss caused by the curved features of the flexible display panel.

[0019] Additionally, to identify alignment marks for bending defect inspection in a flexible display panel, the edges of the display panel are aligned with the alignment marks. Therefore, there is no need to enlarge the vision imaging area.

[0020] The display panel is aligned using the driving device of the lower roller, and since the position alignment motion is performed, there is no need to increase the size of the inspection system for the curved display device.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] FIG. **1** is a conceptual diagram of an inspection system for a curved display device according to an embodiment of the present disclosure.

[0022] FIG. **2** to FIG. **5** are a perspective view, a front view, a perspective view from the bottom, and a side view of an inspection system, respectively, for the curved display device according to embodiments of the present disclosure.

[0023] FIG. **6** is a conceptual diagram of an inspection system for the curved display device according to an embodiment of the present disclosure.

[0024] FIG. **7** to FIG. **10** are a perspective view, a front view, a perspective view from the bottom, and a side view of an inspection system for the curved display device, respectively, according to embodiments of the present disclosure.

[0025] FIG. **11** is an abridged flow chart of a control method of the curved display device inspection system according to an embodiment of the present disclosure.

[0026] FIG. **12** is a detailed flow chart of the control method of the curved display device inspection system of an embodiment of the present disclosure.

[0027] FIG. **13** is a diagram explaining the concept of the position alignment motion method of FIG. **12** according to an embodiment of the present disclosure.

DETAILED DESCRIPTION OF EMBODIMENTS

[0028] Hereinafter, non-limiting embodiments of the present disclosure will be described in detail with reference to the attached drawings.

[0029] However, the present disclosure may be implemented in various forms and is not limited to the embodiments described herein.

[0030] When it is said that a part “includes” a certain component throughout the specification, this means it may further include other components unless specifically stated to the contrary.

[0031] Additionally, throughout the specification, when a part such as a layer, membrane, region, or plate is said to be “above” or “on” another part, this does not only mean “right on top” or “directly on top” of the other part, but that there may be intervening elements therebetween. When a part such as a layer, membrane, region, or plate is said to be “directly above” or “directly on” another part, no intervening elements may be therebetween.

[0032] Furthermore, “above” or “on” means located above or below the target part, and does not necessarily mean located above based on the direction of gravity.

[0033] FIG. **1** is a conceptual diagram of the inspection system for the curved display device according to an embodiment of the present disclosure, while FIGS. **2** to **5** depict the perspective, front, bottom, and side views, respectively, of the inspection system for the curved display device according to an embodiment of the present disclosure.

[0034] Referring to FIG. **1**, in the inspection system for the curved display device according to an embodiment of the present disclosure, a bending inspection device **100** for the flexible display panel performs a bending test set to simulate the application of the display panel in the curved display device. The bending inspection device **100** checks for bending defects while the display panel is bent under inspection.

[0035] For instance, in an embodiment the aforementioned display panel may have flexible characteristics, and depending on the bending strength, the substrate may fracture at the pressurized bending part, the bonded substrate may detach, cracks may develop, or bending defects such as stains may arise.

[0036] In an embodiment, the bending inspection device **100** performs bending inspection under bending inspection conditions by supporting the lower area of the display panel with two lower rollers and pressing the upper area with two upper rollers to achieve an inspection curvature that

can be set to be larger or smaller than the target curvature of the curved display device.
[0037] A display panel that exhibits no defects under the bending test conditions may be classified as a normal, whereas a panel that exhibits a defect under the bending test conditions may be classified as abnormal.
[0038] The bending inspection device **100** may detect the maximum curvature condition under which no bending defect occurs, depending on the type of display panel, through the bending inspection process.
[0039] The maximum curvature condition can serve as basic data in the manufacturing process before and after the bending inspection process, thereby increasing process efficiency by providing optimal overall manufacturing process conditions.
[0040] As shown in FIGS. **2** to **4**, the inspection system **1** for the curved display device according to an embodiment of the present disclosure includes the bending inspection device **100**, a control device **200**, and a transfer device **300**.
[0041] In an embodiment, the bending inspection device **100** includes an inspection panel **110** composed of a driving IC **110**A and a PCB **110**B, a plurality of support members **131**, **133** positioned below the inspection panel **110**.
[0042] In an embodiment, the bending inspection device **100***d* may also include a plurality of detachable fixing members **151**, **153** positioned on the inspection panel **110**, bending press members **171**, **173**, and a bending defect measurement unit **190**.
[0043] In an embodiment, the inspection panel **110** may be a display cell detached from the mother substrate.
[0044] The inspection panel may be a liquid crystal display cell or an organic light emitting display cell.
[0045] The inspection panel may be a display panel before an optical film such as a polarizer or protective film and circuit member such as a driving chip, are attached or it may be a display panel to which the optical film and the circuit member are already attached.
[0046] The plurality of support members **131**, **133** are positioned below the inspection panel **110** (e.g., in the −Z direction) and support the inspection panel **110**.
[0047] In an embodiment,, the plurality of support members **130** are positioned below the inspection panel **110** corresponding to edge areas on both sides (e.g., edge areas in the Y direction and −Y direction) rather than opposite sides of the inspection panel **110**.
[0048] For instance, in an embodiment in which the inspection panel **110** is a rectangular shape and includes a relatively short side and a relatively long side, the first support members **131** among the plurality of support members **130** may be arranged to support the first edge area of the first relatively short side of the inspection panel **110** from below.
[0049] Similarly, the second support members **133** among the plurality of support members **130** may be arranged to support the second edge area of the second relatively short side of the inspection panel **110** that faces the first short side, from below.
[0050] The plurality of support members **131**, **133** may support the inspection panel **110** during the bending defect inspection, and may include first and second roller parts, **131***a*, **133***a* that transfers the inspection panel **110** once the bending defect inspection is completed.
[0051] In an embodiment, the first and second roller parts, **131***a*, **133***a*, may be made from materials resistant to static electricity to reduce the occurrence of scratches caused by the inspection panel **110** moving diagonally rather than horizontally under the bending inspection conditions.
[0052] The plurality of detachable fixing members **151**, **153**, along with the plurality of support members **131**, **133** may fix the loaded inspection panel **110** in a stationary position.
[0053] In an embodiment, the plurality of detachable fixing members **151**, **153** may be positioned on the inspection panel **110** in pairs along with the plurality of support members **131**, **133**.
[0054] The plurality of fixing members **151**, **153**, like the plurality of support members **131**, **132**,

are positioned on the inspection panel **110** corresponding to edge areas on both sides of the inspection panel **110** that face each other (e.g., edge areas in the Y direction and −Y direction).
[0055] For instance, in an embodiment in which the inspection panel **110** is a rectangular shape and includes a relatively short side and a relatively long side, the first fixing members **151** among the plurality of fixing members **150** of the inspection panel **110** may be arranged to support the first edge area on the relatively short side (e.g., the edge area in the −Y direction).
[0056] Similarly, the second fixing members **153** among the plurality of fixing members **150**, are located on the second relatively short side of the inspection panel **110**, facing the first short side, and may be arranged to support the second edge area of the relatively short side (e.g., the edge area in the Y direction).
[0057] In an embodiment, the plurality of detachable fixing members **151**, **153** can fix the inspection panel **110** during the bending defect inspection, and the plurality of detachable fixing members **151**, **153** may further include the third and fourth roller parts **151***a*, **153***a* for transporting the inspection panel **110** after the bending defect inspection is completed.
[0058] Like the first and second roller parts **131***a*, **133***a*, the third and fourth roller parts **151***a*, **151***b* can be made of a material that is resistant to static electricity so that the inspection panel **110** does not move diagonally under the bending inspection condition, to reduce the occurrence of scratches.
[0059] In an embodiment, the plurality of detachable fixing members **151**, **153** are mounted on the inspection panel **110** in pairs with the plurality of support members **131**, **133** to fix the inspection panel **110** before imaging the pressurized surface using the plurality of imaging devices **191**, **193**.
[0060] In an embodiment, the plurality of fixing members **151**, **153** may be detached from the inspection panel **110** during the bending inspection process, where the inspection panel **110** is bent and moved to be mounted near a central area to facilitate the bending inspection process. In an embodiment, the bending press members **171**, **173** may be coupled to the plurality of fixing members **151**, **153** during the bending fixation process.
[0061] The plurality of fixing members **151**, **153** are used after the bending inspection process of the inspection panel **110** is completed and before imaging the pressed surface using the plurality of imaging devices **191**, **193**. In an embodiment, the plurality of fixing members **151**, **153** may be mounted on the inspection panel **110** to fix it to a stationary position.
[0062] The bending press member **170** is configured to press in the Z-axis direction perpendicular to the opposing pairs of the plurality of detachable fixing members **151**, **153**, which move towards the central area along the Y-axis direction, the longitudinal direction of the plurality of detachable fixing members **151**, **153**.
[0063] In an embodiment, the bending press member **170** is detachably coupled to the plurality of detachable fixing members **151**, **153**, and is installed at both ends of the rotation axes **151***a*, **151***b* when the plurality of detachable fixing members **151**, **153** are connected to the third and fourth roller parts, to press the inspection panel **110** in the X-axis direction, which is the relatively short side direction of the inspection panel **110**.
[0064] In an embodiment, the bending press member **170** presses both ends of the rotation axes **151***b*, **153***b* of the third and fourth roller parts **151***a*, **153***a* in the Y-axis direction, which is the longitudinal side, centered on the central area of the inspection panel **110**, and bends the inspection panel **110** to achieve a set curved surface.
[0065] In an embodiment, the movement of the bending press member **170** may be controlled in micrometer units.
[0066] Therefore, the bending curvature of the inspection panel **110** can be precisely controlled.
[0067] In an embodiment, the plurality of imaging devices **190** includes at least four imaging devices **191**, **193** arranged at the bottom of each of four vertices where sides of the inspection panel **110** meet, with respect to the inspection panel **110** supported by the plurality of support members **131**, **133**. However, embodiments of the present disclosure are not necessarily limited thereto and the number of the plurality of imaging devices **190** may vary. For example, in an embodiment the

bending inspection device **100** may include two imaging devices **191**, **193** arranged at two different corners of the of the inspection panel **110**.

[0068] The plurality of imaging devices **191**, **193** can be used to determine whether the inspection panel **110** has been loaded or unloaded by the loading/unloading device for the bending inspection process, and to input and/or discharge the inspection panel **110** from the correct position before and after the bending inspection process.

[0069] The plurality of imaging devices **191**, **193** image four corners of the inspection panel **110**, respectively, which is supported by the plurality of support members **131**, **133** and the plurality of detachable fixing members **151**, **153** before and after the bending inspection process. However, embodiments of the present disclosure are not necessarily limited thereto and the plurality of imaging devices **191**, **193** may image three or less corners of the inspection panel **110** in some embodiments. Additionally, in some embodiments in which the shape of the inspection panel **110** differs from a rectangular shape, the number of corners or other surfaces of the inspection panel **110** that are imaged by the imaging devices **191**, **193** may vary.

[0070] By comparing images of the four corners of the inspection panel **110** taken by the plurality of imaging devices **191**, **193** before and after the bending inspection process, it can be determined whether to perform a bending defect inspection on the inspection panel **110**.

[0071] In an embodiment, the bending defect measurement unit **195** senses sound waves generated from the inspection panel **110** during the bending inspection process on the inspection panel **110** loaded on the plurality of support members **131**, **133**. In an embodiment, the bending defect measurement unit **195** may be a sonic sensor that is built into the plurality of fixing members **151**, **153**.

[0072] The bending defect measurement unit **195** senses the amplitude of the sound wave generated from the inspection panel **110** during the bending inspection process, and detects defects based on the amplitude of the sound wave generated during the bending inspection process.

[0073] The bending defect measurement unit **195** may use the plurality of imaging devices **191**, **193**, and may be positioned in various positions with respect to the inspection panel **110**. For instance, in an embodiment the bending defect measurement unit **195** may be located at a horizontal distance or a vertical distance from the central area of the inspection panel **110**.

[0074] The control device **200** controls the overall automated inspection operation of the bending inspection device **100**.

[0075] In an embodiment, the control device **200** includes a transfer device control unit **210** that controls a transfer device, which transfers the inspection panel **110** before and after the bending inspection process, and a support member control unit **220**, which controls loading on the plurality of the support members **131**, **133**, as well as fixing and detaching of the inspection panel **110** loaded on the plurality of support members **131**, **133**. In an embodiment, the control device **200** includes a fixing member control unit **230** that controls the attachment and detachment of the plurality of detachable fixing members **151**, **153** to the inspection panel **110**, an imaging control unit **240** that captures and stores an image of predetermined positions on the inspection panel **110** using a plurality of imaging devices **191**, **193**, a pair of the fixing members **151**, **153** that perform a bending inspection process by bending the inspection panel **110** to a set inspection curvature, a bending press member control unit **250** that selects the fixing members **151**, **153** and aligns the bending press member **170** with respect to the selected pair of fixing members **151**, **153** to press them in the Z-axis direction, and a bending defect measurement unit control unit **260** that controls the operation of the bending defect measurement unit **195** when the bending inspection process is started.

[0076] In an embodiment, the transfer device **300** includes a support member driving means **310** that rotationally drives the plurality of support members **131**, **133** to position the inspection panel **110** correctly during loading or unloading, and may include a fixing member driving means **330** that rotates the plurality of fixing members **151**, **153**.

[0077] The support member driving means **310** and the fixing member driving means **330** may be motors capable of rotating in both a forward direction and a reverse direction.
[0078] In an embodiment, the transfer device **300** may include vertical reciprocating means **350** for reciprocating the bending press member **170** in the Z-direction before and after the bending inspection process.
[0079] The vertical reciprocating means **350** may include first vertical reciprocating means **351** that drives the bending press member **170** vertically up on the inspection panel **110**.
[0080] In an embodiment, the vertical reciprocating means **350** may be a conventional pneumatic or hydraulic cylinder.
[0081] FIG. **6** is a conceptual diagram of an inspection system for the curved display device according to an embodiment of the present disclosure.
[0082] As shown in FIG. **6**, in the bending inspection process, the bending press member **170** is applied to both sides of the central area in the Y-axis direction of the inspection panel **110** loaded on the plurality of support members **131**, **133**, to bend the inspection panel **110** to form a curved surface having an inspection curvature.
[0083] In an embodiment, when the bending inspection process is completed, the bending press member **170** is moved in the −Z direction, which is opposite to the +Z direction, by the second vertical reciprocating means **353** to release the pressure on the inspection panel **110**, after which the bending pressure member **170** returns to the +Z direction, which is opposite to the −Z direction.
[0084] Accordingly, the inspection panel **110** is restored from the curved surface to its original surface by movement of the bending pressure member **170** to release the pressure on the inspection panel **110**.
[0085] However, even though the bending inspection process of the inspection panel **110** is completed, since the inspection panel **110** is not completely restored from the curved surface to its original surface, a panel plane return member **180** may be further included to restore the original surface of the inspection panel **110** from the curved surface of the inspection panel **110**.
[0086] In an embodiment, the panel plane return member **180** is positioned below the central area of the curved surface of the inspection panel **110** and is configured to press the inspection panel **110** vertically upward.
[0087] In an embodiment, the panel plane return member **180** is a bar-shaped pressing member and can be vertically reciprocated by the second vertical reciprocating means **353**, which is positioned below the display panel among the vertical reciprocating means **350**.
[0088] When the panel plane return member **180** returns the curved surface of the inspection panel **110** to its original surface by pressing vertically upward, a force is generated in an oblique direction due to the resultant force between the elastic restoring force of the inspection panel **110** and the vertical upward pressing force of the panel plane return member **180**. Consequently, a position deviation may occur when the inspection panel **110** returns to the plane, making it difficult to confirm the pickup position of the panel **110** after the bending inspection process.
[0089] However, the inspection system **1′** of the curved display device according to an embodiment of the present disclosure as shown in FIGS. **6**-**10**, is designed to solve the problems of the inspection system **1** for the curved display device in an embodiment of the present disclosure as shown in FIG. **1**. As shown in FIGS. **7** to FIG. **10**, the inspection system **1′** includes a plurality of imaging devices **191**, **193** capturing images of the four corners of the inspection panel **110**, identifying the distorted orientation of the inspection panel **110**, and aligning the position of the inspection panel **110** by micro-positioning the position alignment means **390** on the plurality of support members **131**, **133**.
[0090] Hereinafter, the inspection system **1′** for the curved display device according to an embodiment of the present disclosure will be described in detail with reference to FIGS. **7** to FIG. **10**.
[0091] FIG. **7** to FIG. **10** are a perspective view, a front view, a perspective view from the bottom,

and a side view, respectively, of an inspection system for the curved display device according to an embodiment of the present disclosure.

[0092] Similar to the curved display device inspection system **1** according to an embodiment of the present disclosure as shown in FIG. **1**, the curved display device inspection system **1′** according to an embodiment of the present disclosure in FIGS. **7-10** includes the bending inspection device **100**, the inspection panel **110**, a plurality of support members **131**, **133**, a plurality of detachable fixing members **151**, **153**, bending press members **171**, **173**, and imaging devices **191**, **193**.

[0093] However, in an embodiment as shown in FIGS. **7-10**, the inspection panel **110** is continuously supplied by a loading/unloading device, which may act as a pickup device.

[0094] In an embodiment, the gap between the plurality of support members **131**, **133** may be arranged to be greater than the gap between the plurality of detachable fixing members **151**, **153**.

[0095] Accordingly, in this embodiment, the inspection panels **110** are supported by the plurality of support members **131**, **133**, and the bending press members **171**, **173** are coupled to the plurality of detachable fixing members **151**, **153**.

[0096] Similar to the inspection system **1** for a curved display device according to an embodiment of the present disclosure as shown in FIG. **1**, the curved display device inspection system **1′** according to an embodiment of the present disclosure as shown in FIGS. **6-10** uses the first and second roller parts **131***a*, **133***a* as the plurality of support members **131**, **133**. The inspection panel **110** can be automatically moved before and after the bending defect inspection, and the support member driving means **310**, attached to the first and second roller parts **131***a*, **133***a*, may be stopped to support the inspection panel **110** during the bending defect inspection.

[0097] Similarly, the plurality of detachable fixing members **151**, **153** supported by the plurality of support members **131**, **133** using the third and fourth roller parts **151***a*, **153***a*, respectively, can be fixed to prevent movement, and the inspection panel **110** can be automatically moved before and after the bending defect inspection.

[0098] Similarly, the aforementioned first and second roller parts **131***a*, **133***a* and the third and fourth roller parts **151***a*, **151***b* can be made of a material resistant to static electricity to reduce the occurrence of scratches caused by the movement of the inspection panel **110** in a diagonal direction as opposed to a horizontal direction under the bending inspection conditions.

[0099] The plurality of fixing members **151**, **153** are used to facilitate the bending inspection process while the inspection panel **110** is bent during the bending inspection process. In an embodiment, the plurality of fixing members **151**, **153** can be removed from, moved to, and mounted near the central area where the inspection panel **110** is bent, and the bending press members **171**, **173** are coupled to the plurality of fixing members **151**, **153** during the bending inspection.

[0100] The plurality of fixing members **151**, **153** are used after the bending inspection process of the inspection panel **110** is completed and before imaging the pressed surface of the inspection panel **110** using the plurality of imaging devices **191**, **193**, and they may be mounted on the inspection panel **110** to fix the inspection panel **110** to a stationary position.

[0101] The bending press member **170** is configured to be coupled with an opposing pair of the plurality of detachable fixing members **151**, **153** installed with respect to the inspection panel **110** in a combined perpendicular Z-axis direction.

[0102] In an embodiment, the bending press member **170** is detachably coupled to the plurality of detachable fixing members **151**, **153**, and is installed around both ends of the rotation axis **151***b*, **153***b* when the plurality of detachable fixing members **151**, **153** act as the third and fourth roller parts **151***a*, **153***b*, uniformly pressing the inspection panel **110** in the X-axis direction, which is the relatively short-side direction of the inspection panel **110**.

[0103] The bending press member **170** presses both ends of the rotation axes **151***b*, **153***b* of the third and fourth roller parts **151***a*, **153***a* in the Y-axis direction, which is the longitudinal side, centered on the central area of the inspection panel **110**, to bend the inspection panel **110** and

achieve a set curved surface.
[0104] In an embodiment, the movement of the bending press member **170** may be controlled in micrometer units.
[0105] Accordingly, the bending curvature of the inspection panel **110** can be precisely controlled.
[0106] In an embodiment, the plurality of imaging devices **191**, **193** include at least four imaging devices positioned, respectively, below each of the four vertices where the sides of the inspection panel **110** meet and supported by the plurality of support members **131**, **133**.
[0107] The plurality of imaging devices **191**, **193** may image the inspection panel **110** to determine whether a bending defect has occurred in the inspection panel **110** during the bending inspection process. After completing the bending inspection process, the inspection panel **110** may transform from a curved surface to a plane surface (e.g., a flat surface). By the plurality of imaging devices **191**, **193** imaging of the inspection panel **110** to determine whether the inspection panel **110** has returned to the plane surface, the inspection panel **110** can be loaded or unloaded at the correct position, thereby automating the bending inspection process.
[0108] The bending defect measurement unit **195** may use the plurality of imaging devices **191**, **193** and may be positioned at various positions with respect to the inspection panel **110**.
[0109] For instance, in an embodiment the bending defect measurement unit **195** may be located at a horizontal distance or a vertical distance from the central area of the inspection panel **110**.
[0110] Similar to the inspection system **1** of the curved display device according to an embodiment of the present disclosure shown in FIGS. **1-5**, the inspection system **1′** of the curved display device according to an embodiment of the present disclosure shown in FIGS. **6-10** includes a control device **200**. In an embodiment, the control device **200** includes a transfer device control unit **210**, a support member control unit **220**, a fixed member control unit **230**, a bending press member control unit **250**, and a bending defect measurement unit control unit **260**. In an embodiment, the control device **200** further includes a transceiver unit **270** for transmitting and receiving from the imaging devices **191**, **193** and/or the bending defect measurement unit **195**, and a position alignment motion control unit **280** for the transportation or unloading of the inspection panel **110** after the bending inspection process based on the gray value of the captured image of the imaging devices **190**. In an embodiment, the imaging control unit **240** is linked with (e.g., electrically connected thereto for communication therewith) the position alignment motion control unit **280** to control the position alignment motion of the inspection panel **110** before and after the bending inspection process.
[0111] In an embodiment, the imaging control unit **240** includes an image processing unit **241** that processes images captured by the imaging devices **190** of four corners of the inspection panel **110** to enable linkage with the position alignment motion control unit **280**, an alignment mark determination unit **243** that determines whether the alignment mark is recognized based on the gray value of the alignment mark captured image, and the position of the inspection panel **110** when the alignment mark determination unit **243** fails to recognize the alignment mark; additionally, it may also include a position misalignment confirmation unit **245** that checks the distortion (e.g., misalignment of the inspection panel **110**) based on the gray value of the captured image.
[0112] In an embodiment, the transfer device **300** can rotate the plurality of support members **131**, **133** to accurately position the inspection panel **110** for loading and unloading.
[0113] In an embodiment, the transfer device **300** includes the support member driving means **310** for rotating the support members **131**, **133**, and the fixing member driving means **330** for rotating the plurality of fixing members **151**, **153**.
[0114] In some embodiments, the support member driving means **310** and the fixing member driving means **330** may be motors capable of rotating in both a forward direction and a reverse direction.
[0115] The transfer device **300** may include a vertical reciprocating means **350** for reciprocating the bending press member **170** in the Z direction before and after the bending inspection process. In some embodiments the vertical reciprocating means may be positioned at both the upper and lower

surfaces of the inspection panel **110**. In some embodiments, a single vertical reciprocating means **350** may be used positioned at an upper or lower surface of the inspection panel **110**.
[0116] In an embodiment, the transfer device **300** may include a fine position alignment means **390** which operates under the control of the position alignment motion control unit **280** in the control device **200**.
[0117] The fine position alignment means **390** is installed on the support members **131**, **133**, and the support member driving means **310** may also be used for positioning the inspection panel **110**.
[0118] By using the support member driving means **310** as the fine position control means **390**, transport, support, and position control motion of the inspection panel **110** can be performed. Thus, the size of the bending inspection defect device **100** can be reduced as well as the costs.
[0119] Hereinafter, the control method of a curved display device inspection system according to an embodiment of the present disclosure will be described with reference to FIGS. **11** to **13**. FIG. **11** is a simple flowchart of the control method of the curved display device inspection system according to an embodiment of the present disclosure.
[0120] FIG. **12** is a detailed flowchart of the control method of the curved display device inspection system according to an embodiment of the present disclosure.
[0121] FIG. **13** is a diagram explaining the concept of the position alignment motion method of FIG. **12**.
[0122] As shown in FIG. **11**, the control method of the curved display device inspection system of an embodiment of the present disclosure may include: step S**10** which is automatically loading an inspection panel **110** to a proper position of a bending defect inspection device **100** to automate a bending defect inspection of a curved display device, step S**20** which is performing a bending defect inspection on the loaded inspection panel **110**, step S**30** which is restoring the curved surface of the bent inspection panel **110** to a plane surface after the bending defect inspection, step S**40** which is confirming the misalignment of the position of the inspection panel **110** that occurred in the process of being restored to a plane surface, step S**50** that is a position alignment motion execution in which the misaligned position of the inspection panel **110** is moved in the X-axis direction using the support member driving means **310** of a plurality of support members **131**, **133** under the inspection panel **110** to align the position of the inspection panel **110** to a proper position suitable for unloading, and step S**60** which is unloading the inspection panel **110** on which the bending defect inspection has been completed using a pickup device.
[0123] As shown in FIG. **12**, the control method of the curved display device inspection system, according to an embodiment of the present disclosure, controls the control device **200** to load the inspection panel **110** onto the plurality of support members **131**, **133** using a pickup device.
[0124] In step S**110**, the control device **200** may load the inspection panel **110** onto the plurality of support members **131**, **133**.
[0125] In step S**120**, the control device **200** uses the plurality of detachable fixing members **151**, **153** to fix the inspection panel **110**, which is loaded on the plurality of support members **131**, **133** to the inspection panel **110**, and each of the support members **131**, **133** is mounted on the upper part to be less than the gap between them.
[0126] In step S**130**, the control device **200** uses a plurality of imaging devices **191**, **193** to image four corners of the inspection panel **110** fixed by the plurality of detachable fixing members **151**, **153**, and the control device **200** stores the captured images of the four corners of the inspection panel **110**.
[0127] In step S**140**, the plurality of detachable fixing members **151**, **153** are detached (e.g., separated) from the inspection panel **110**. In step S**150**, the controller **200** couples the bending press member **170** to both edges of the fixing members **150** to perform a bending test process to bend the inspection panel **110** to a set (e.g., predetermined) inspection curvature. In step S**160**, bending pressure is applied in the Z-axis direction, and the controller **200** operates the bending defect measurement unit **195** to perform a bending defect inspection.

[0128] In an embodiment, in the bending inspection process, the bending press member **170** presses adjacent to the central area in the Y-axis direction of the inspection panel **110**, which is loaded on the roller portions of the plurality of support members **131**, **133**. Thereby the inspection panel **110** bends to the inspection curvature, forming a curved surface.
[0129] When the bending inspection process is completed, the control device **200** stops the operation of the bending defect measurement unit **195** and releases the bending press member **170** by moving it in the −Z direction, which is opposite to the +Z direction, while the panel plane return member **180** restores the central area of the inspection panel **110** from the curved surface to the original surface in step S**170**.
[0130] Then, the inspection panel **110** may be misaligned in the X-axis direction due to the resultant force in the Z-axis direction and the Y-axis direction due to the panel plane return member **180**.
[0131] In step S**180**, the control device **200** uses the plurality of detachable fixing members **151**, **153** to fix the inspection panel **110** loaded on the plurality of support members **131**, **133** after the bending inspection process is performed. When both edges of the inspection panel **110** are fixed, the four corner lower surfaces of the inspection panel **110** are imaged using a plurality of imaging devices **191**, **193**, and the four corner captured images are stored after bending.
[0132] In step S**190**, the control device **200** determines whether the inspection panel **110** is out of position after the bending inspection process by comparing the four corner images taken before and after the bending inspection process. The control device **200** then determines the correct position of the inspection panel **110** for loading and aligning the inspection panel position.
[0133] In step S**200**, the control device **200** can check the alignment motion and unload the inspection panel **110** in the correct position using the pickup device.
[0134] As shown in FIG. **13**, the position alignment motion method of FIG. **12** involves capturing (e.g., imaging) the four corners of the inspection panel **110**, which is fixedly supported by the plurality of supports **131**, **133** and the plurality of detachable fasteners **151**, **153**, before and after the bending inspection process using the plurality of imaging devices **191**, **193**. The presence of alignment marks in the image processed by the image processing unit **241** is determined by the alignment mark determination unit **243**. In an embodiment, the direction of misalignment of the inspection panel **110** is confirmed through the misalignment confirmation unit **245** based on the gray value of the alignment mark in the image processed by the image processing unit **241**. If no alignment mark is detected in the image, failure to recognize the alignment mark can be displayed on the management terminal **400**.
[0135] The management terminal **400** displays an alignment mark recognition failure alarm for the pickup or placement device, which uses vacuum suction to pick up and place the inspection panel **110**, prompting alignment of the inspection panel **110**.
[0136] According to the above embodiment, inspection of bending defects in an inspection panel can be automated using an inspection device.
[0137] Additionally, by comparing the images of the four corners of the inspection panel captured before and after the bending inspection process, the positional distortion occurred by returning the curved surface of the inspection panel to a plane surface after bending can be corrected using the driving means of the support members positioned at the bottom of the inspection panel.
[0138] Accordingly, the inspection of bending defects in flexible curved display panels used in curved display devices can be automated.

Claims

1. An inspection system for a display device, the inspection system includes: a plurality of support members supporting a bottom of an inspection panel of the display device; a plurality of imaging devices that captures images of four corners of the inspection panel; a position misalignment

confirmation unit verifying a misaligned direction of the inspection panel based on gray values of the four corner images of the inspection panel; and a control unit that corrects a misalignment of the inspection panel determined by the position misalignment confirmation unit, the control unit controlling support member driving means that drives the plurality of support members to correct the misalignment.

2. The inspection system for the display device of claim 1, wherein: the support member driving means moves the inspection panel in an X-axis direction to correct the misalignment of the inspection panel, wherein the misalignment is caused by a resultant force in a Z-axis direction and a Y-axis direction when the inspection panel is restored from a curved surface during the bending inspection process to a plane surface after the bending inspection process.

3. An inspection system for a display device, comprising: a bending inspection device that inspects a bending defect of an inspection panel of the display device; a transfer device that loads, moves, and unloads the inspection panel to the bending inspection device; a control device that controls the bending inspection device and the transfer device, wherein the bending inspection device includes a pair of upper rollers fixing an upper portion of the inspection panel, a pair of lower rollers supporting a lower portion of the inspection panel, a bending press member that presses the upper roller vertically downward to bend the inspection panel, and a plane return member that returns a curved surface of the inspection panel to a plane surface after a process for inspecting defective bending of the inspection panel.

4. The inspection system for the display device of claim 3, wherein: the plane return member is positioned below the inspection panel, and an imaging device is mounted at the bottom of each of four corners of the inspection panel.

5. The inspection system for the display device of claim 4, wherein: the imaging device detects a bending defect of the inspection panel and simultaneously detects alignment of the four corners of the inspection panel based on a gray value of images of the inspection panel captured by the imaging device.

6. The inspection system for the display device of claim 4, wherein: the pair of lower rollers is mounted at an edge in the y-axis direction that is a longitudinal direction of the inspection panel, and a pair of fixed rollers is mounted closer to a center in the y-axis direction than the pair of lower rollers.

7. The inspection system for the display device of claim 4, wherein: a lower roller driving means is positioned on a rotation axis of the pair of lower rollers, and the lower roller driving means aligns and moves at least one of the four corners of the inspection panel in conjunction with images captured by the imaging device.

8. The inspection system for the display device of claim 4, wherein: the bending press member is detachable from the pair of upper rollers and is coupled to both ends of the pair of upper rollers at a top of the inspection panel.

9. The inspection system for the display device of claim 8, wherein: the bending press member and the plane return member are positioned at an upper and lower surface of the inspection panel, respectively; and the display device further includes first and second vertical reciprocating drive means for reciprocating the bending press member vertically up and down, respectively.

10. The inspection system for the display device of claim 3, wherein: the control device comprises a transfer device control unit that controls the transfer device, a loading control unit that controls loading of the inspection panel on the pair of lower rollers, a fixing member control unit that controls fixing of the inspection panel by the pair of upper rollers, and an imaging control unit that controls imaging devices to capture images of each of four corners of the inspection panel, a bending press member control unit that controls the pressing of the upper roller by the bending press member in response to bending conditions of the inspection panel, and a bending defect control unit that measures and controls the bending defect of the inspection panel.

11. The inspection system for the display device of claim 10, further comprising: a transceiver unit

that transmits and receives data from the imaging devices and the bending defect measurement unit; and a position alignment control unit that controls transfer or unloading of the inspection panel to a correct position after the bending inspection process based on a gray value of the images captured image by the imaging devices.

12. The inspection system for the display device of claim 11, wherein: the imaging control unit includes an image processing unit that processes the images captured by the imaging devices and is connected to the position alignment control unit, the imaging control unit determines whether or not an alignment mark is recognized in the four corners of the inspection panel based on the gray values, and a position misalignment conformation unit that checks a misalignment of the inspection panel based on the gray values when the alignment mark determination unit fails to recognize the alignment mark.

13. The inspection system for the display device of claim 12, wherein: the transfer device includes support member driving means for rotating a support member supporting a bottom of the inspection panel, a fixing member driving means for rotating the pair of upper rollers, and a vertical reciprocating means for reciprocating the bending press member in the vertical direction, and the support member driving means comprises a fine position alignment means for fine alignment in the x-axis direction under control of the position alignment motion control unit.

14. A control method of a display device inspection system, comprising: automatically loading an inspection panel into a correct position on the display device inspection system; performing a bending inspection process on the loaded inspection panel, the loaded inspection panel is bent to have a curved surface during the bending inspection process; performing a process to return the curved surface of the inspection panel to a plane surface after performing the bending inspection process; checking a position misalignment of the inspection panel that occurred during the process of returning the inspection panel to the plane surface; performing a position alignment movement to correct the position misalignment of the inspection panel and place the inspection panel into a correct position; and unloading the inspection panel in the correct position.

15. The control method of the display device inspection system of claim 14, wherein: the automatic loading of the correct position comprises arranging a pair of support members supporting the inspection panel from a bottom of the inspection panel, and the bending inspection process comprises pressing the inspection panel from above by a bending press member, while pressing a pair of fixing members positioned in a central area of the inspection panel, the pair of fixing members has a gap less than a gap between the pair of support members.

16. The control method of the display device inspection system of claim 15, wherein: the process of returning to the plane surface is performed by returning the bending press member upward and a plane returning member pressing the curved surface of the inspection panel to the plane surface from the bottom to a top of the inspection panel.

17. The control method of the display device inspection system of claim 14, wherein: the checking of the position misalignment of the inspection panel comprises imaging four corners of the inspection panel before and after the bending inspection process by imaging devices positioned below the four corners of the inspection panel, and the position misalignment is determined based on a gray value of the captured images.

18. The control method of the display device inspection system of claim 17, wherein: the checking of the position misalignment of the inspection panel comprises registering a reference mark, photographing and registering the reference mark with the four corners of the inspection panel aligned before the bending inspection process; imaging the alignment mark of the inspection panel after the bending inspection process by photographing the four corners of the inspection panel after the bending inspection process; and comparing gray values of the reference mark aligned before the bending inspection process with the alignment mark and moving the inspection panel in the X-axis direction using a support member driving means to perform a position alignment movement of the inspection panel.