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A Study on Glass Processing System

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Abstract

This study is for the development of Cover Glass Grinding Processing System. This system is developed for manufacturing a mass product system grinding cover glasses with highly precise mechanism, and we improved resulted quality. In the development process, we developed a complete process technology through mechanical design, image processing technology, spindle control, mark identification algorithm etc. With this cover glass grinding development, we could developed process technology, image processing technology, organization mechanisms and control algorithms.

Keywords: *Image Processing, Touch Panel, Manufacturing, Mark Identification*

1. INTRODUCTION

Touch panel cover glass production method is formerly pasting 2 ITO(Indium Tin Oxide, indium tin oxide having a high conductivity of a transparent electrode material) film, known as GFF method, there is a drawback that the thickness becomes large. So reducing method is investigated in many companies. Representative techniques for reducing the thickness of the touch screen has a G2 way to double one meeting with ITO Film ITO Coating on the ITO Coating Glass cover and put in the way of G1F Glass. Common of these techniques were converted to ITO Film that used, or all of ITO Coating method is a point. This thinner by the thickness of the removed ITO Film is effective to increase the transmittance. Collectively, these methods are called Glass method. Touch-screen industry is currently focusing its attention on Glass touch screen development, and ultimately to G2 technology development goals.

The current Cover Glass Processing is done in Chinese companies about 99%, and is supplied to the smartphone and tablet PC manufacturers such as Apple, Samsung Electronics, LG Electronics. But the defect rate in the manufacturing process is 40%, so the method for producing a quality Touch panel is major concern.

The current Mobile and Tablet PC devices use glass to protect the front display (Cover Glass), and coating the ITO on glass is one of the studies to reduce the thickness. Although the overall thickness and the transmittance can be improved when applied to a non-film coating method, a minor company were successful in mass production in the above-described manner G2. So demand for G2 method is still great.

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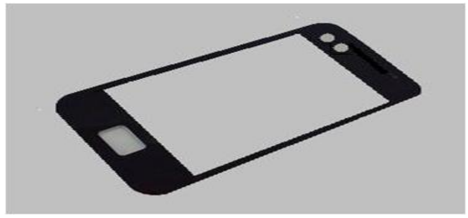


Figure 1. Reinforced cover glass

In Korea G2 method is used as a partial manufacturing in LG Electronics but yield does not appear to be satisfactory. With these production problems, reinforced glass orders are processed mainly through the Chinese companies. Samsung is also reviewing the situation, but there are no special solutions. In addition, it gradually changes to a large-screen LCD display, there is a growing demand for a large area, such as a touch panel so that the touch panel corresponding to a large screen is growing high.

Current touch related market is expected to have annual growth rate to be at 27.6% from 2010 to 201, the mobile phone market in 2015 is expected to be 1.75 billion, Tablet PC that has been estimated at 250 million, laptops and large monitors market is expected to increase six-fold in 2015 compared to 2010.

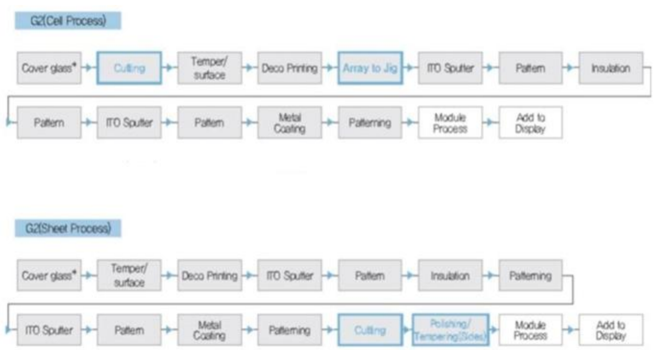


Figure 2. G2 manufacturing process

The importance of the enhanced Cover Glass production process is high, related researches have been continuously performed. Therefore, the need for Edge Grinding which is one of the major glass production processes is increasing and urgent.

Accordingly, this study focused on the development of cover glass grinding process for a large area TSP, because this technique is not commercially available yet. And we developed high tech glass grinding process using vision technology and mechanical control algorithms. With this process we shortened entire processing time to 1 min and manufacturing costs are lowered.

2. DEVELOPED PROCESS

Equipment must prepare and poor, failure of the product due to the necessary lubricating fluid in machining. In particular, the change in the assembled state by the vibration is analyzed as the most important element and requires the preparation of such shock-absorbing devices and to prepare for it, and the cushion, waterproof property is also an important factor.

Properties of the grinding mechanism of the safety system, precise control, and elements such as the image processing algorithm is the result that is dependent on how well combined.

The entire production process is composed of the same elements in Figure 3. CNC program is required to grinding in an arc shape and the spindle motor is required to precision machining with a high speed. The durability of the equipment is required to prevent vibrations due to high speed operation.

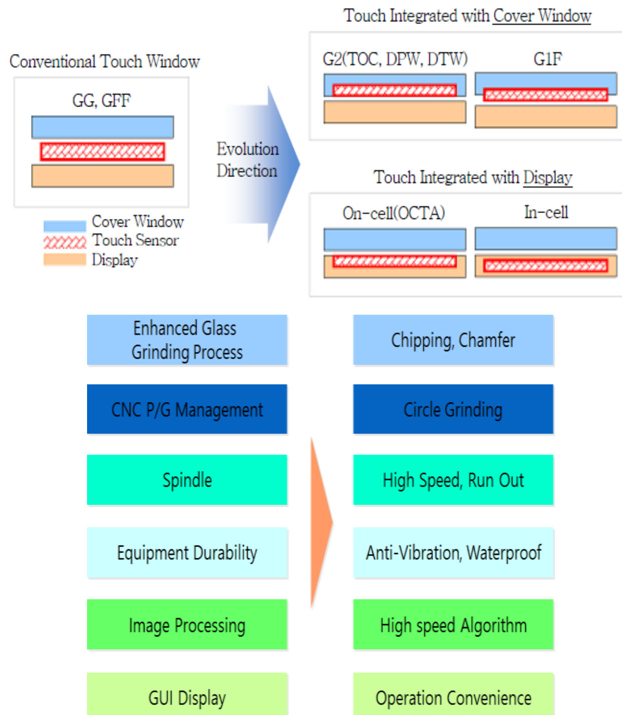


Figure 3. The grinding process and entire production process

By default, in order to implement the accuracy of a micron the mechanical stability is the first to be considered. And it is base of the system, many efforts are made in the design and manufacture of the basis system. The whole system is composed of an optical system, the spindle, Chiller, dust collector, the imaging system, X, Y, Z axis drive system, transfer system, such as the stage frame. We have pre-designed and produced the entire system by 3D program. So we could reduce the error in the actual production.

2.1 Optical Systems

The optical system is a component required for image processing. For the design of the optical system we used a program such as CODEV, ZEMAX and examined system design factors. The final system was configured with a design factor results. We designed in consideration of the radius of the lens, thickness, angle of incidence, the basic form is shown in Figure 4.

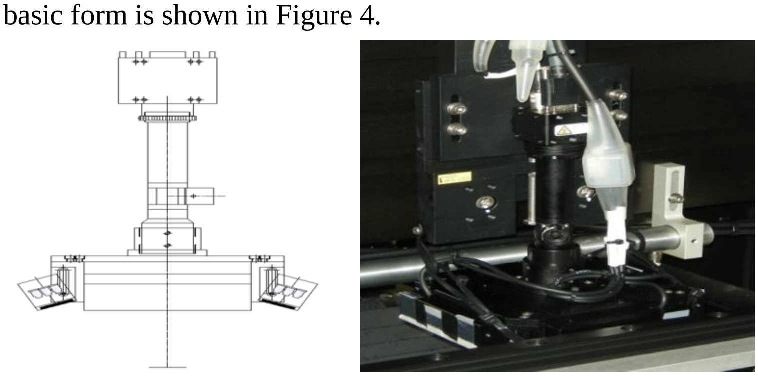


Figure 4. Optical Systems

2.2 Spindle

The spindle works with high-speed rotation and is the most important factor in the precision machining. If the performance of the spindle is lowered, results poor uniformity of the processing surface and a crack occurs in the glass. A characteristic of the spindle system is a main unit of a grinding system and has a major effect on the processing quality.

2.3 Chiller

Chiller works cooling the heat generated during high-speed rotation is the main factor affecting the performance of spindle's stable operation.

2.4 X, Z axis drive system

The drive system is a device for processing the sheet Glass moving the X, Z axis. Y-axis was constructed as a separate system. We have reviewed a variety of designs in order to improve the mechanical durability, minimize the interference between the cables during movement to and to hold a reference to the image were considered the mechanism to set the initial position. The final shape is shown in Figure 5.

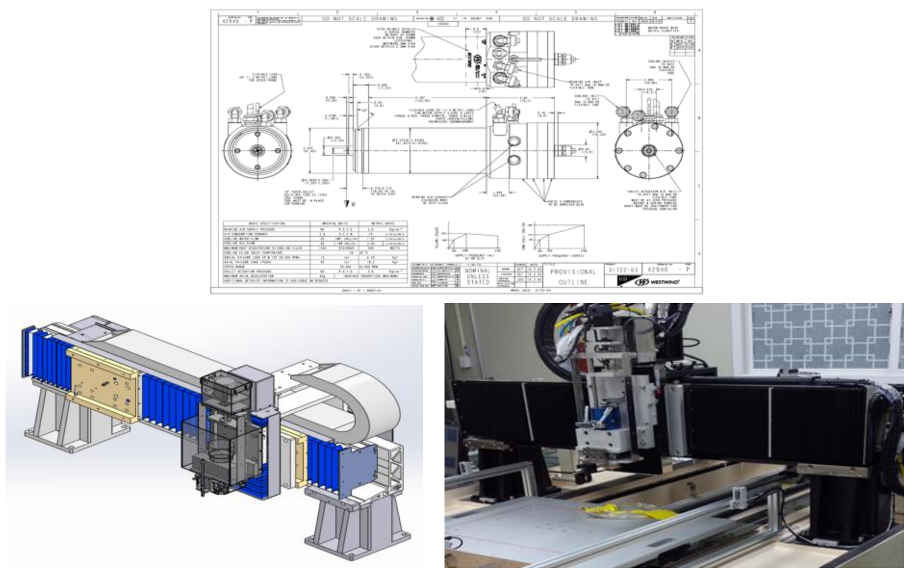


Figure 5. Spindle drive system photos

2.5 Y-Axis Stages

Y-axis stage moves in the Y-axis securing the device to a vacuum Glass, and used to process the glass. Y-axis stage are driven independently with X, and Z-axis module. And this is designed to minimize interferences between axes and was produced in consideration of various structures in order to reduce the error due to vibration. And the implementation of showed in Figure 6.

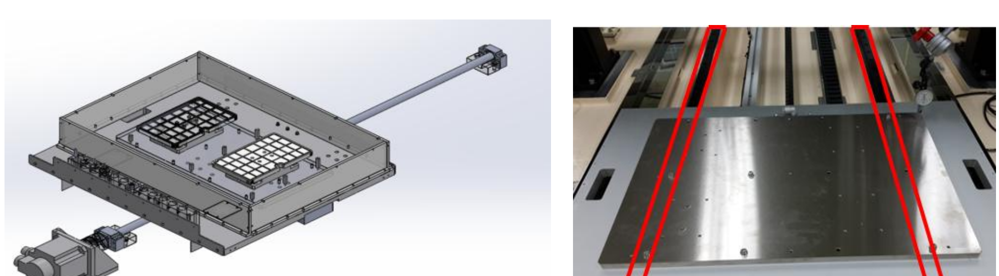


Figure 6. Y-axis Lm guide

2.6 System Diagram

Figure 7 showed a complete system.

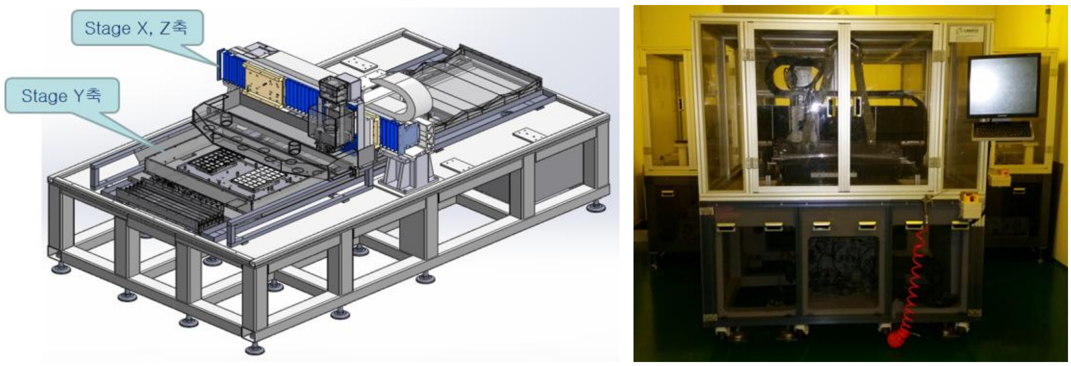


Figure 7. System Diagram

2.7 Image Processing

Image processing is necessary to analyze the precise location, and used the data marked on the BM glass. In the image processing, we binarized the data and extracts the outline of BM. We did double recognition by extracting the specific contours of the top and using this information we again extracted the contour for a more accurate recognition as shown in Figure 8. BM method was used for comparing with the shape of the contour.

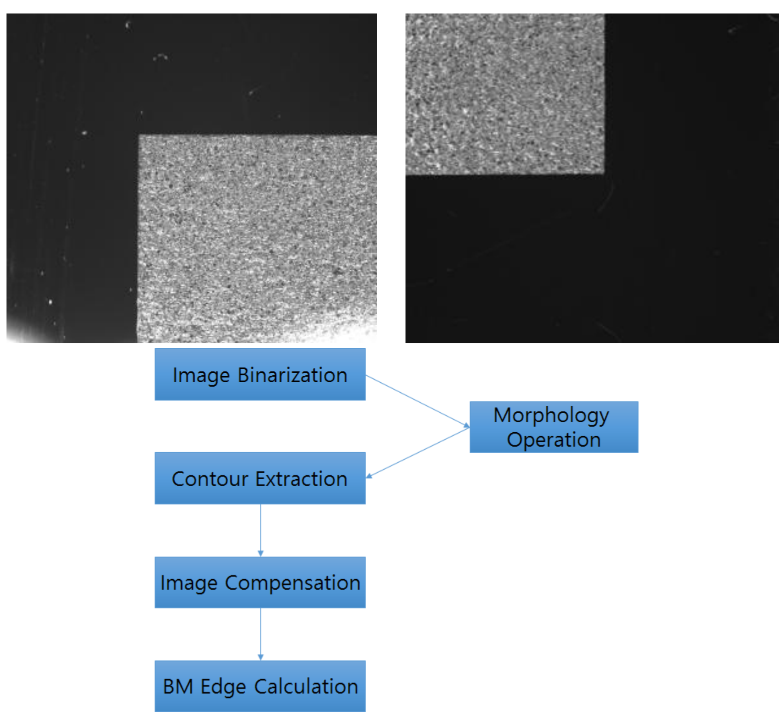


Figure 8. Image processing flow

2.8 BM recognition algorithm

BM coordinate recognition algorithms undergoes the steps of the binary image, edge detection, the distance from the center point to extract contour graph comparison, BM coordinate calculation. Figure 9 shows the flow of an algorithm for recognizing the BM coordinate.

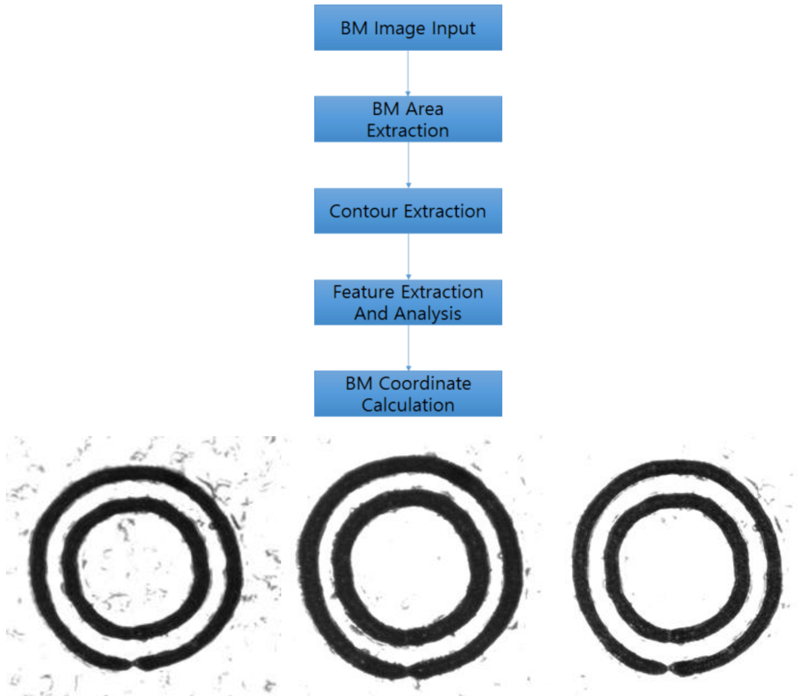


Figure 9. BM coordinate calculation algorithm & results

- BM zone detection

First extracts the RGB values of all pixels in the image. BM colors tend to change as the light changes. So, in this paper we prefer YCbCr than RGB because YCbCr can control brightness, so we didn't consider the changes of the light. Equation 1 shows the formula to convert RGB to YCbCr.

$$\begin{pmatrix} Y \\ C_b \\ C_r \end{pmatrix} = \begin{pmatrix} 0.2570 & 0.504 & 0.098 \\ -0.148 & -0.291 & 0.439 \\ 0.439 & -0.368 & -0.071 \end{pmatrix} \begin{pmatrix} R \\ G \\ B \end{pmatrix} + \begin{pmatrix} 16 \\ 128 \\ 128 \end{pmatrix} \quad (1)$$

Figure 10 illustrates a pseudo code algorithm for binarization to extract the BM area. First we set an appropriate domain in the image by using the experiment data and processed the pixel as white(255) or black(0).

```
ıme ← Original images
mp ← binary image
← One of the images of the x-coordinate
← one of the y-coordinate of the image
← R value of frame(x, y)
← G value of frame(x, y)
← B value of frame(x, y)
← 0.257*R + 0.504*G + 0.098*B + 16
› ← -0.148*R - 0.291*G + 0.439*B + 128
· ← 0.439*R - 0.368*G - 0.071*B + 128
(77 <= Cb < 127, 133 <= Cr <= 173) temp(x, y) =
ıite
se temp(x, y) = black
```

Figure 10. The binary algorithm

- Normalized graph

First after drawing a graph of the distance of the contour from the center point of the angle, we adjusted the size of the graph to be constant, since the number of images with various graph size must have the same size for comparison.

- Edge Detection

We used a morphology gradient algorithm to extract an outlines from binary images. Morphology gradient algorithm is to get image contour using subtracting image from eroded image to expanded image. In this paper, the number of correction on the binarized image generated for further contour of the image, and processed using an outline search method.

- Compare errors

In this paper, the image properties were compared with a difference operation to calculate the error more accurately. We subtracted the value of the y coordinate according to x-coordinate and checked the accuracy by accumulating the absolute value. It can be seen that the smaller the accumulated value, the accuracy is superior. This method, however, there is a possibility that the same data can increase the error if it is slightly rotated.

$$I_d = \sum_{x=0}^{n} \sum_{y=0}^{m} |I_t(x, y) - I_c(x, y)|$$
$$Where\ I_t = template\ Image,\ I_c = Current\ Image \qquad (2)$$

2.9 Results

There are difference between theory and real situation. That is enhanced glasses has cuttings like holes and outline, straight lines, circles, spline etc., so there exist difficulties in calculating glass center.

We can overcome this by inserting a recognition mark for vision in the glass protective tape and with this we can catch the exact center. But it may cause low machine productivity and inefficiency, so we used BM (Black Mask) for high machine productivity. With this, we can get high quality uniform data calculating the corners using image processing.

In Figure 11, 12, 13, we showed various results of the study. X, Y linearity, processing precision, tact time etc. And we showed the result using Vision Camera inspection. Using BM center calculation and we accomplished vision precision about ± 10 ㎛. And using BM we recognizes the coordinates of the cover glass shown in Figure 14 a, 11 b, the figure actually showed a recognition result, it was confirmed that the awareness within ± 10 ㎛ in the picture.

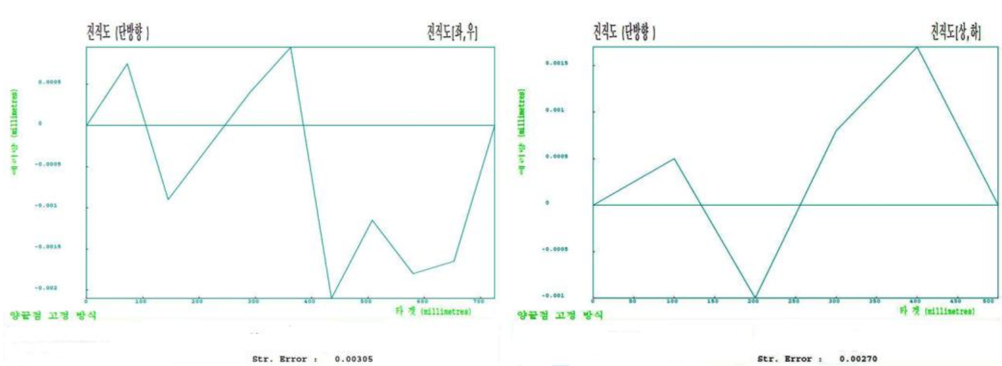


Figure 11. X, Y axis Linearity

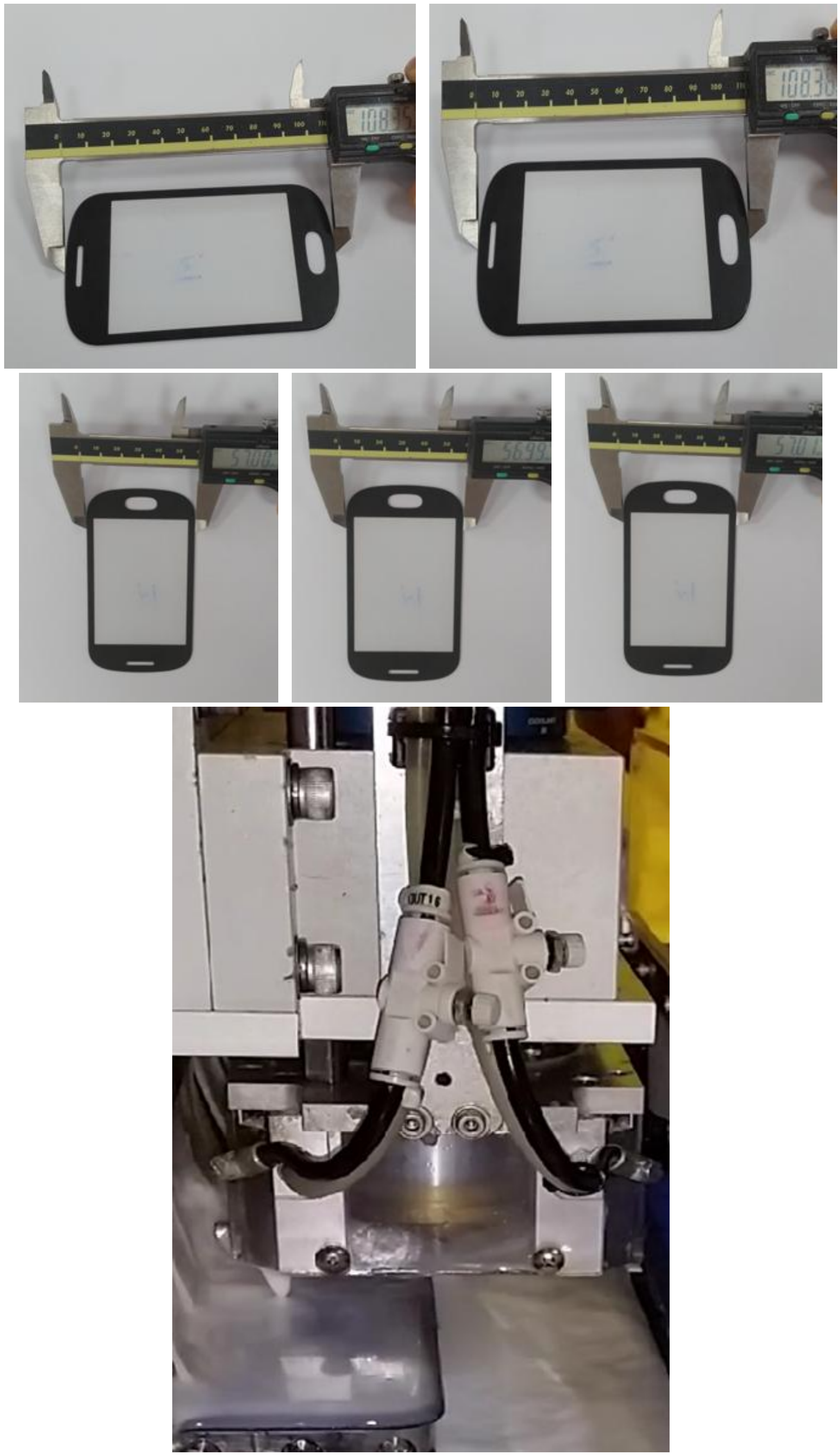
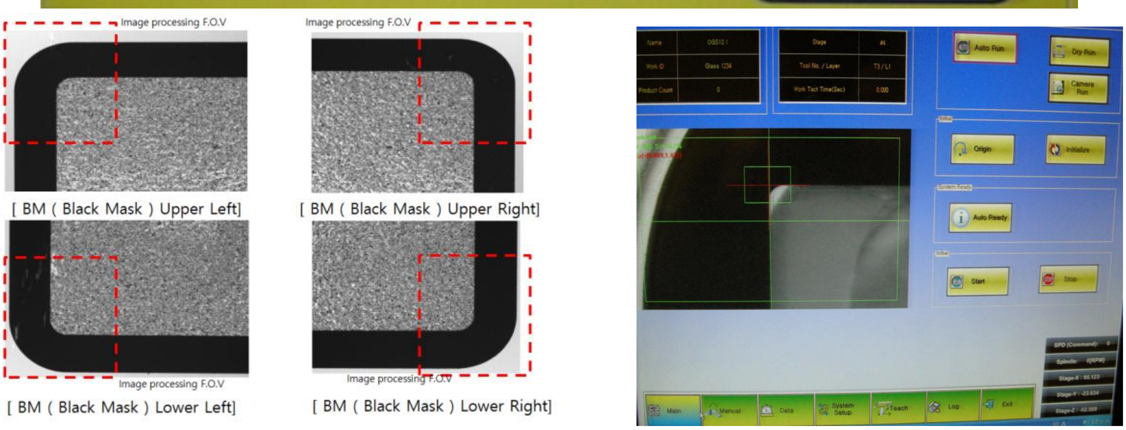


Figure 12. Processing Precision

Figure 13. Measured Actual Tact Time

Jig Height Info.

Jig No.	Avg.	Left/Top	Right/Top	Right/Bottom	Left/Bottom
1	-4.858	-4.851	-4.868	-4.868	-4.847
2	-4.819	-4.831	-4.809	-4.811	-4.827
3	-4.801	-4.795	-4.810	-4.809	-4.791
4	-4.840	-4.849	-4.834	-4.827	-4.850



(a) BM-screen (b) BM recognizes the actual screen

Figure 14. BM recognize the actual screen display

3. CONCLUSION

Results from the above study were as follows:

1) We designed and manufactured high precision glass grinding system.
2) We accomplished high precision image processing resolution about ± 10 ㎛.
3) We expected existing markets and new customers with professional commercialized production.

4) Applicable to other group development and expansion.
In addition, the result of this study is a technique that requested from the TSP manufacturer in China. If the development is completed, this product is expected to be able to export to the associated equipment.
And when such a manufacturing process requiring accuracy of the micron scale for glass manufacture are developed, it can be incorporated into the processing techniques for the various materials, and in addition to the process, accurate positioning technology applications are wide. So its ripple effect will have greater effect.

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