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Development of High-Precision 3D Printers Using Optics

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Abstract - FDM 3D printers are currently used in many fields, and it is known that a high degree of precision is needed for their quality. In this regard, we developed a device using optics that can measure and correct shaft deflection and also level FDM 3D printers bed, for the purpose of improving their accuracy. The results of our recent study showed that the deflection of the axis is 10 nm, and the horizontal value of the bed is 0.001°. We expect to increase the precision of FDM 3D printers through further research.

Keywords**:** 3D Printer, Bed Levelling, 4-Sigement Photo Detector, CCD Camera,

1. Introduction

Currently, FDM-based 3D printers are most widely used in various fields. In this type of large scale 3D printers, the accuracy of products depends on the horizontal level of axis and bed, and it also affects their quality and price. In this sense, we are now developing a device capable of compensating axis deflection and a bed leveling device which contribute to leveling axis and bed.

2. Principle of Measurement

2.1. Device Capable of Compensating Axis Deflection

A conventional straightness measuring device measures laser interferometers using laser, interferometer, and vertical reflector. However, this equipment is an expensive equipment of 100 million won and hence it is inefficient to use as an industrial equipment. Thus, we have developed a new straightness measuring device which has a conventional resolution and a low cost. The device capable of correcting axis deflection is a method of measuring real-time critical displacement using a CCD camera equipped with a parallel light laser and an image sensor. Since a general semiconductor laser is not a parallel light, a collimating lens and an optical fiber are used to produce a parallel light. As a driving principle, a parallel light was photographed using a CCD camera, and the amount of movement of the pixel at the center position of a parallel light was calculated.

2.2. The Horizontal Adjustment Device

The existing FDM 3D printer has three working methods. The first is a manual leveling device using a limit switch. The second is a manual leveling device using a proximity sensor. Finally, there is an automatic leveling device that recognizes 9 points. These devices have a resolution of 1 to 0.1 and are difficult to work with.

Thus, we have studied an optical leveling method which is precise, simple and quick. The principle of the horizontal measuring device using 4-split device is as follows.

1. The laser installed in the top device was reflected to mercury. 2.The light reflected by the mercury is split into two parts through a beam splitter. 3. One part of the light was directed to the top 4-segment photodetector and the other part was directed to the bottom device. 4. The light coming from the top device was reflected again to the mercury using a mirror. 5. The light reflected to the mercury was directed to the bottom 4-segment photodetector. 6. The numerical values of light recognized by two 4-segment photodetectors was monitored via a computer and the horizontal levels of the bed and the nozzle were checked.

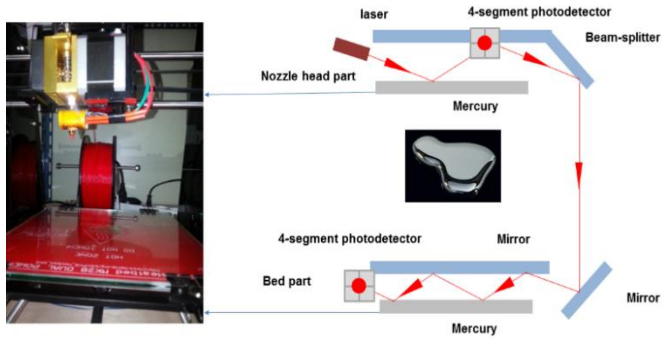

Fig. 1: Horizontal adjustment device principle.

Like horizontal measuring devices, horizontal correction devices are also attached. The horizontal correction device is a motor control device which levels the bed by controlling the height of the motor at the four corners of the bed.

1. The leveling device was first used to identify whether the bed is horizontal. 2. Typically, 3D printing carries on when the bed is horizontal. However, when the bed is not horizontal, it operates 4 motors to level the bed. 3. The 3D printing operation starts when the motors are operated and the numerical values of the leveling device match.

3. Measurement

The objects were placed on a measuring device equipped with a laser interferometer and an image sensor and the critical displacement value was measured. Measurements were repeated 10 times. Results showed that the average value of the laser interferometer was 5.75 μm, and the moving length of the camera was 3.45 μm per pixel and 6.9 μm per 2 pixel. We also measured the level of the bed using a horizontal measuring device. As a result, the horizontal measuring device has a resolution of 0.001°.

4. Conclusion

In this study, it was confirmed that axial deflection correction is possible in real time and precise bed leveling can be done. Our findings will help improve the performance of existing 3D printers at an affordable price, and they will be used in other industries as well.

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