Impact Analysis on Auto Focusing Actuator for Mobile Electronic Devices

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Abstract

In the portable electronics market, the miniaturization and integration of the components of devices became a trend due to the portability and versatility. Recently, small sized portable electronic devices with multiple functions are popular. One of the most important functions that almost all portable electronic devices are being equipped with is the camera module. The robustness against daily impact has become the important factor in mobile electronics, especially in mobile phones. Most parts of the mobile phone should pass the drop test, in which they fall from a height of 1.5 m. The purpose of this test is to ensure the phone is protected from critical damage when it slips out of the hand. This paper studies the drop test for an automatic focusing (AF) actuator of the camera module in a portable electronic device. The module is composed of a voice coil motor (VCM) as an actuator and a leaf spring as a guide and suspension. While the conventional drop test has been carried out after fabricating a real AF actuator, we propose a simulation model of the drop test by using finite element analysis (FEA). With this model, the deformation on the clamping and the curved parts of leaf spring is investigated. The simulation shows that the stress over Von Misses criterion deformed the leaf spring permanently and, as a result, the AF actuator malfunctioned. This method is useful not only to design and modify the AF actuator without manufacturing the real product, but also to save time and cost of new products.

1 Introduction

With the recent developments in technology, the demand for multipurpose smart phones is increasing rapidly. Among the many functions, the camera module for mobile devices is classified as an essential component because of its ease of performance. During the development phase, these mobile handset camera modules are tested for durability, which requires an experimental prototype.

The production of a prototype is time consuming and costly and the test results may be inconclusive and not indicative of weak points. This also creates a longer than necessary product turn-around time, making it hard to keep up with the new product exploitation cycle. In this paper, we eliminated the need for prototype experiments through a commercial finite element program which can determine the weak points of the spring to develop a process that can be studied.

2 Theoretical Background

2.1 Voice Coil Motor

The VCM is comprised of permanent magnets, coils, and a speaker. It is operated by interaction between the magnetic flux of the magnet and the current flowing in the coil. The direction of the actuating force is determined simply by the Fleming's left-hand law. The AF actuator used in the experiments is shown schematically in Fig. 1. The coil and magnet of VCM can be identified in Yokes, which concentrate the magnetic flux more onto the coil. The coil moves in the direction determined by the Fleming's left-hand law.

2.2 Leaf Spring

As shown Fig. 1, the leaf spring connects the moveable part, composed of the lens and the lens holder assembly, and the stationary part, composed of the magnet, yoke, and the cover. The leaf spring guides the moveable part along the central axis in an up-and-down direction, desirably without any tilting motion. And it supports the moveable part so that the lens is moved to a position where the force induced by the coil and the restoring force of the leaf spring are balanced out.

To achieve this objective, the leaf spring is made in a S-shape, as depicted in Fig. 1.

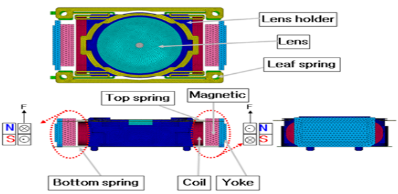

Figure 1: Auto focusing actuator with VCM

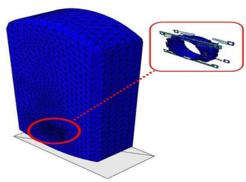

Figure 2: FEA model

3 Finite Element Analysis

In order to find out the dynamic characteristics of a mechanical system, an actual test would be the most accurate method, but it takes substantial cost to produce real products for the test. Also, it is difficult to visualize the dynamic change of the product. Hence, the finite element analysis (FEA) method using a computer program is widely implemented because it makes it possible to spot structural problems on various parts while the product is being developed. In the present work, as the initial step of the impact analysis, Solidworks™ for detailed 3-D modeling, and HyperMesh™ for generating finite elements are used. The parts were modelled with the hexagonal meshes (C3D6R) to enhance the precision of the analysis. The elements were divided coarsely for the parts that do not mainly influence the dynamic characteristics much, and finely for the part that influence greatly.

4 Finite Element Analysis Result

The leaf spring, which is the key component in the auto focusing actuator, can experience plastic deformation or buckling upon impact, which would impair the focusing performance and greatly deteriorate the quality of the image of the photograph.

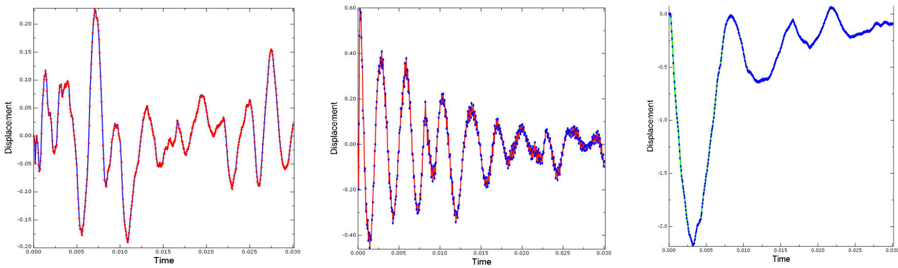

Figure 3: AF module centre point in the X, Y, Z displacement

In the actual cases of dropping cellular phones, the phones would fall vertically in two orientations, upright position or upside-down position. Intuitively, the impact would be more to the last case than the first. That is, the upside-down position suffers more because the AF actuator is close to the impact area. This study is conducted accordingly to the upside-down case as shown in Fig. 2. The S-shaped portion of the leaf spring is not attached to any solid bodies, and if that part suffers plastic strain, the lens cannot make on-axis movement along the optical axis. Accordingly, the investigation focused on the plastic strain of the S-shape part. The movement of the axis of the module is graphed shown in Figure 3.

5 Conclusion

The conventional method relies on actual impact tests with real products in a trial and error process, incurring in high expenses. Moreover, an actual test reveals only the end-result, without shedding any light on the dynamic change during the transient period. In contrast, finite element analysis as conducted in the present study identifies the spot where the stress is the highest, and reveals the process during the impact in details with respect to time. The analysis data can be applied during the product development phase, helping to devise measures for preventing potential problems. Also the newly developed method saves money and shortens the design cycle.

Acknowledgement

This work has been financially supported by the Ministry of Knowledge Economy in Korea through Strategic Technology Development Project (Manufacturing & modularization technology of precision miniaturized components for micro actuator) and the Ministry of Knowledge Economy (MKE) and Korea Institute for Advancement of Technology (KIAT) through the Human Resource Training Project for Strategic Technology. The authors are also grateful to the colleagues for their essential contribution to this work.

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