Motions of Neodymium Particles Dispersed in a Permanent Magnet Urethane Elastomer During Mechanical Compression

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Abstract

X-ray CT scans were employed to visualize and track the movement of NdFeB particles dispersing permanent magnet urethane elastomer (PMUE) during the compression process. The particle translation and rotation were quantified by analyzing the data obtained from the CT scans. The findings revealed that particles closer to the compression plane exhibited larger translation distances while the amount of rotation remained unaffected by the initial position. Furthermore, it was observed that most particles did not undergo significant rotations beyond 45 degrees.

1 Introduction

Kinetic energy harvesting using the inverse magnetostrictive effect of magnetic elastomers has been explored [1]. Conventional magnetic elastomers typically require an external magnetic field for magnetization. However, a novel type of magnetic elastomer called permanent magnet elastomer (PME) has recently been developed, eliminating the need for an external magnetic field to magnetize the elastomer [2]. PME incorporates magnetically-hard particles like NeFeB into a viscoelastic material, which in this study is a polyurethane elastomer known for its high elasticity and porosity [3]. Although kinetic energy harvesting using PMUE has been demonstrated, the underlying mechanism remains unclear. Thus, this study aims to investigate the translational and rotational behavior of NdFeB particles during the compression process in order to gain insights into the power generation mechanism.

2 Method

In order to observe the NdFeB particle movement during the compression process of PMUE, an X-ray CT system (inspXio SMX-100CT) is employed for imaging. The experimental setup is depicted in Fig. 1, where PMUE samples were subjected to compression ranging from 0 % to 50 %. The obtained visualization data were analyzed to quantify both translational and rotational motions.

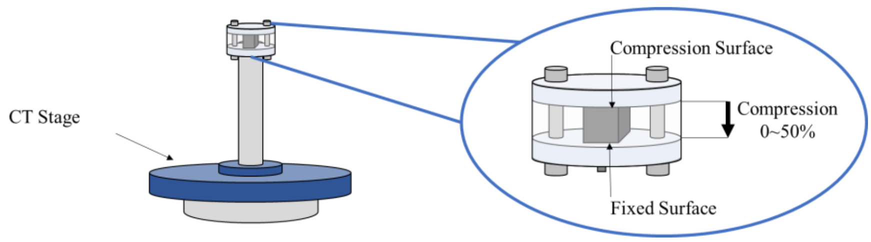
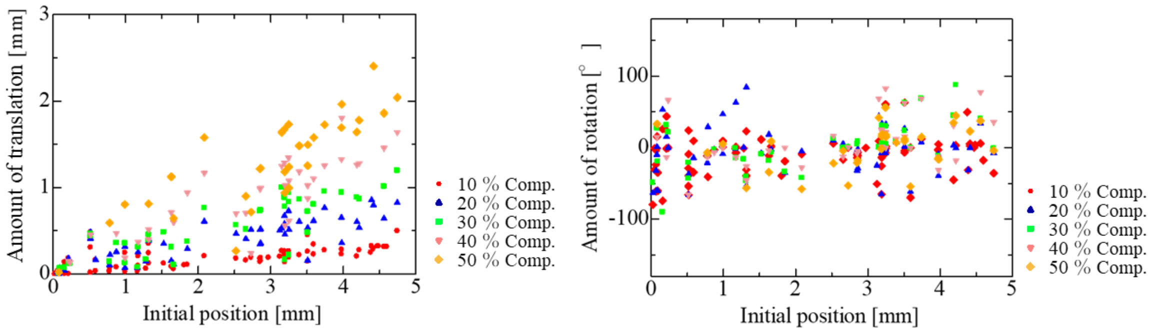


Figure 1: Observation system using an X-ray CT

3 Results and Discussion

Fig. 2 shows the correlation between the initial position of the particles and the amount of (a) translation and (b) rotation, respectively. Fig. 2(a) shows that particles closer to the compression surface (Initial position of 5 mm) exhibit higher translation. This phenomenon is associated with the porous structure of the polyurethane material. The crushing of void within the polyurethane initiates from those closest to the compression surface. From Fig. 2(b), it is found that the rotation does not depend on the initial positions and compression rates. Most particles do not rotate beyond 45 degrees. This behavior is also associated with the porous structure of the material. These findings indicate that the power generation mechanism of kinetic energy harvesting utilizing PMUEs relies on inverse magnetostriction. This mechanism involves the translational motion of magnetized neodymium particles, which subsequently leads to a modification in the magnetization of the PMUEs.



(a) Amount of traslation (b) Amount of rotation

Figure 2: Correlation between the initial position of the particles and the amount of (a) translation and (b) rotation

4 Conclusion

The X-ray CT system was utilized to capture particle images before and after mechanical compression. The obtained image data were analyzed to quantify the translational and rotational motions of NdFeB particles during the PMUE compression. The results revealed that particles closer to the compression surface exhibited a higher degree of translation. And the amount of rotation was found to be independent of the initial position of the particles. These results conclude that the power generation mechanism of kinetic energy harvesting utilizing PMUE relies on the inverse magnetostriction effect.

Acknowledgements

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