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Measurement of the Motion of Micro-Parts on a Vibratory Surface

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1. Introduction

In industrial automation, it is often necessary to sort or to arrange a large number of objects such as ceramic chip capacitors and resistors used large numbers for cellular phones, and palm-top PCs to a desired target at a time.

In this paper, we examine experimentally the instantaneous motion of micro-parts on the feeder system as proposed by Mitani [1] on different surface materials by particle tracking velocimetry method (PTV). In addition, we consider a simulation model for the micro-part dynamics. In the present simulation, instead of using ideal saw-tooth profile as in Mitani's work [1], we approach the real saw surface by superposing a white noise to the ideal saw-surface. This allows us simulate the uncertainties of the micro-part motion.

2. Experiment system

The experimental feeding system includes a saw-tooth surface attached to a vibratory table is driven by an accumulated piezoelectric actuator [1]. In this study, we conducted numerous experiments of 2012- and 0603-type capacitors whose weights are 7.5 mg and 0.3 mg, respectively, on the brass, carbide and zirconia surfaces at different frequencies.

3. Results

The effect of surface material on feeding manipulation is considered by investigating the motion of 2012-type capacitor at the driven frequency of 15 Hz. Fig. 1(a) shows that the present system can transport one direction which coincides with the vibration direction (i.e. *x*–direction). Furthermore, the carbide surface appears the best for micro-part feeding among the considered surfaces. Therefore, hereafter, we consider experiment on the carbide surface. As shown in Fig. 1(b), the lighter capacitors (i.e. 0603 capacitors) move with a small jump as compared to 2012 capacitors.

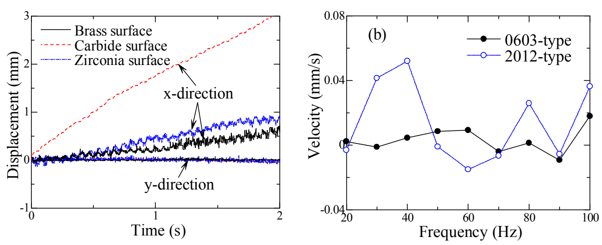

Fig. 1 Variation of micro-part displacement with time (a) and time averaged vertical velocity with frequency (b).

Fig. 2 shows that the micro-parts travel stably with almost invariant velocity when the frequency is less than 80 Hz. Beyond this value, the capacitors move quickly in an uncontrollable manner.

The spectrum of *x*-velocity of micro-part is plotted in Fig. 3. It shows that the motion of micro-part includes several significant modes and the simulated modes by the present model are well agreed with experiment.

4. Summary

In this study, the instantaneous motion of a micro-part on a saw-tooth surface was investigated with the use of PTV technique. The experiments were carried out for different surface materials, driven frequencies, and sizes of micro-part. The present feeder system can transport unidirectionally the micro-parts. However, the velocity of the micro-parts depends on the surface material. The carbide surface shows the best in comparison with brass and zirconia surfaces. Within the range of frequencies within 80Hz, the feeder transports the micro-parts smoothly. In contrast with intuition, smaller micro-pats move with smaller jump than the larger micro-parts.

In addition to experiment, this paper also focused on a simple analysis model. With the modification of the saw-tooth profile, the model can cover the motion modes of the micro-parts as we observed in experiment. Furthermore, the model provides the average velocity in good agreement with the experiment data.

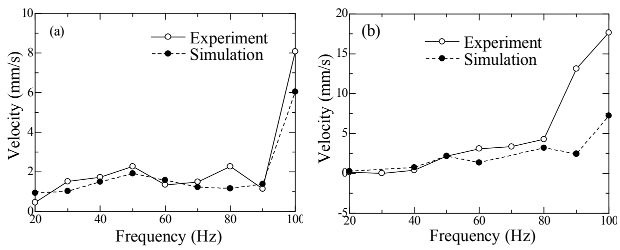

Fig. 2 Variation of time averaged *x*-velocity of micro-parts with frequency: (a): 2012 and (b) 0603.

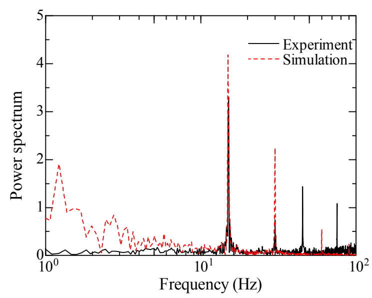

Fig. 3 Spectrum of *x*-velocity.

5. References

[1] Mitani, A., Sugano N., and Hirai S., "Micro-parts feeding by a sawtooth surface," IEEE/ASME Trans. Mechatronics, 11, 6, 2006, 671–681.