Vibro-impact capsule under different conditions of friction

Van-Du Nguyen[*], Ngoc-Tuan La[**], Ky-Thanh Ho and Quoc-Huy Ngo[*]
[*]*Department of Mechanical Engineering, Thai Nguyen University of Technology, Vietnam*
[**] *Faculty of Manufacturing, Vinh University of Technology Education, Vietnam*

Abstract. This report presents an experimental study on the vibro-impact driven capsule, working under different friction conditions, including isotropic and anisotropic resistant forces. The experimental apparatus provided a capacity of varying friction force when keeping the weight of the whole system unchanged. Under isotropic friction (i.e. the friction forces are the same in both forward and backward direction); the results revealed that the level of resistant force may have a significant effect on not only how fast the system move, but also on its direction. For anisotropic friction, a resistant ratio between the resistant force in forward direction and that in backward motion was used as a key parameter. The system behavior was investigated under three levels of such resistant ratio.

Introduction

In vibration-driven locomotion systems, initially proposed by Chernous'ko [**1**], the rectilinear motion can be achieved by using an additional internal mass interacting with the body frame. On the one hand, the simplicity in structure of the system makes it well suitable to form capsule robots. On the other hand, the relative motion of the internal mass must follow a specially designed multi-phase acceleration-controlled. Another choice of self-propelled design is vibration-impact driven locomotion, in other names – vibro-impact driven, or impact-driven system. In this system, the internal mass oscillates and periodically collides with an on-board obstacle [**2**]. The friction force was usually assumed to be isotropic [**3**] or anisotropic **[4]**. Several experimental studies have been investigated in locomotion system. However, the effect of friction level on the system behavior was not fully examined. This report presents an experimental study on the vibro-impact driven capsule, working under different friction conditions, including isotropic and anisotropic resistant forces. The experimental apparatus provided a capacity of varying friction force when keeping the weight of the whole system unchanged (See Figure 1a).

(a) (b)

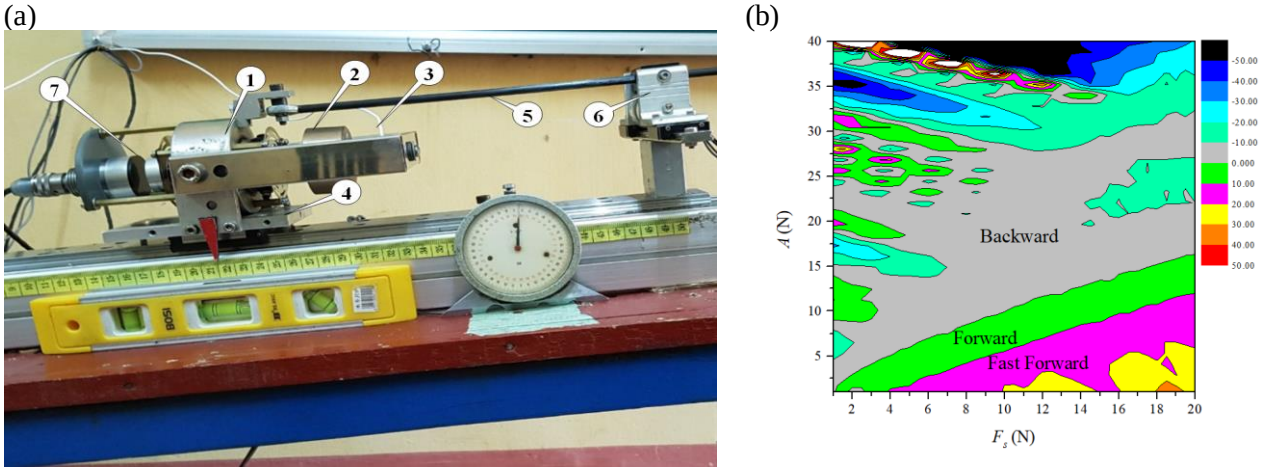

Figure 1: (a) The experimental setup (1: actuator; 2: internal mass; 3: impact obstacle; 4: rolling sliding guide; 5,6: friction variation device; 7: displacement sensor); and (b) Contour plots of the progression rate, with respects to friction force, F_s and the excitation force amplitude, A.

Result and Discussion

The results of our study revealed that with the same force ratio between the excitation amplitude and the friction threshold, the progression can move either backward or forward, depending how large the friction threshold is. With the same force ratio, different values of friction threshold also provided different average velocities of the progression, as illustrated in Figure 1b. For anisotropic friction, the results showed that the vibro-impact locomotion system is able to move forward when the resistant force in forward direction is larger than that in backward direction.

References

[1] F. L. Chernous'ko, "The optimum rectilinear motion of a two-mass system," *Journal of Applied Mathematics and Mechanics*, vol. 66, pp. 1-7, 2002/01/01/ 2002.

[2] Y. Yan, Y. Liu, and M. Liao, "A comparative study of the vibro-impact capsule systems with one-sided and two-sided constraints," *Nonlinear Dynamics*, vol. 89, pp. 1063-1087, 2017/07/01 2017.

[3] Y. Liu, E. Pavlovskaia, D. Hendry, and M. Wiercigroch, "Vibro-impact responses of capsule system with various friction models," *International Journal of Mechanical Sciences*, vol. 72, pp. 39-54, 2013.

[4] J. Xu and H. Fang, "Improving performance: recent progress on vibration-driven locomotion systems," *Nonlinear Dynamics*, 2019/05/03 2019.