Belt-Drive Mechanics: Energy Losses in the Presence of Detachment Waves

CATEGORY
Machine Elements and Systems

AUTHORS AND INSTITUTIONS
Michael Varenberg, Yingdan Wu, Michael J. Leamy – Georgia Institute of Technology

INTRODUCTION
Belt drives represent a simple and inexpensive way to transmit power between rotational machine elements; they need no lubrication and require minimal maintenance. Hence, they are used practically everywhere, appearing in devices employed in manufacturing, mining, farming, household activities, etc. Although properly installed and maintained belt drives can transmit up to 95% of the input energy, their efficiency and performance are still worth investigation so that energy loss can be further reduced with optimal designs.

Power transmission between belt and pulley is realized by tractive force acting at the interface. In this process, energy dissipates as heat due to the relative motion between belt and pulley. This relative motion has been known as slip at the belt-pulley interface for a long time. However, it is recently found that in certain cases the relative motion between belt and pulley is accommodated by detachment waves (or so-called Schallamach waves) instead of sliding [1,2], which can be impeded due to high adhesive friction. This observation requires an updated understanding of the belt drive mechanics, since the mechanisms of sliding- and detachment-based motion differ much. To this end, here we study the energy dissipated in the simple belt drive system characterized by high adhesive friction that prevents sliding.

RESULTS
The dissipative force of rolling friction has been estimated experimentally in the belt drive system. Also, a model has been developed for analyzing the contributions of different components to this dissipative force by considering both the volumetric and surface hysteresis losses. The model is found capable of quantifying the energy dissipation due to bending, stretching, radial compression, shear and adhesion (Fig. 1). The computational results fall close to the experimental results and reveal that the shear- and stretching-induced energy losses dominate in rolling friction for both the driver and the driven cases. The contribution of the Schallamach waves of detachment to energy dissipation is significant in the driver case. This result also supports the observation that a driver pulley usually generates more noise and vibration than a driven pulley.

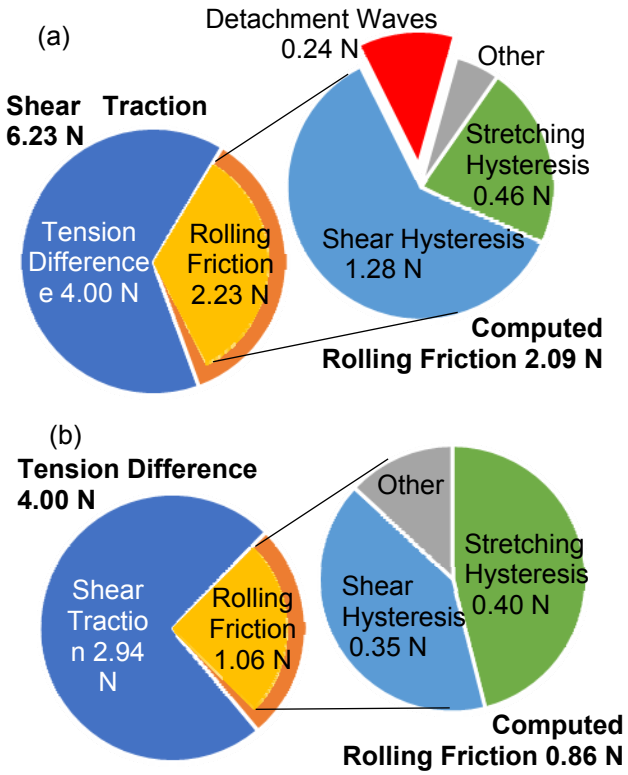

Fig. 1. Maps of forces applied to the belt wrapped over (a) the driver and (b) the driven pulleys.

ACKNOWLEDGMENTS
The authors would like to acknowledge support from the National Science Foundation under Grant No 1562129.

REFERENCES
1. Wu, Y., Leamy, M.J., Varenberg, M.: Schallamach waves in rolling: Belt drives. Tribology International **119**, 354-358 (2018).
2. Wu, Y., Varenberg, M., Leamy, M.J.: Schallamach wave-induced instabilities in a belt-drive system. Journal of Applied Mechanics **86**, 031002 (2019).