Dynamic Transverse Force Regulation of Axially-Moving Flexible Media with Advanced Guiding and Actuation

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Abstract

The rapid growth of computing and information technology has enabled pervasive access to the World Wide Web. Over 280EB of digital data has been generated from around the world and flowing in the digital universe; as a result, the need for data storage has grown rapidly. A variety of information storage solutions such as hard disk drive (HDD) products that are common information storages for personal computing are available in the market. Modern magnetic tape data storage in terms of its capacity and reliability has been employed as an ideal solution for enterprise-level storage of archival data with applications that include financial records, satellite images, and consumer databases.

In magnetic tape technology, the thin, flexible media is transported between the supply and take up packs at a prescribed speed and tension, and over guides and the read/write head. As the tape is transported, in-plane vibration of axially moving tape, known as lateral tape motion (LTM), arises from excitation sources such as the run out of tape pack and impacts between the tape and the flanges on guides or packs. LTM has been identified as a major factor that degrades recording accuracy. Limiting the LTM is the one of the keys that enables the multi-terabytes data storage, and flanged roller guides are commonly implemented in modern tape drives. However, for higher recording density, thinner media is desirable. Reducing the thickness of media can significantly decrease its stiffness and increase the likelihood of damage to media edges by adjacent mechanical components on the guiding path. To avoid this, alternative tape guiding and actuation are required, and many advanced guiding mechanisms without the use of flanged guides have been developed to reduce lateral tape motion in industry and academia. The transverse force (tension) applied to the travelling tape is another key element of LTM dynamics and is controlled using the dynamics of tape pack driving sources in the modern tape drive products in using an open loop control logic. However, the developing advanced guiding and actuation technologies influence the tension irregularly and the current tension control algorithm is not able to handle the irregular changes of tension. An active tension control is required to feasibly advance LTM actuations.

This thesis is motivated by the need for future engineering advances in guiding and actuation technologies for magnetic tape. Advanced guiding and actuation technologies have been developed to enable the active tension (transverse force) actuation of axially moving tape. An advanced tension actuation technology of axially moving media with dynamic tape path alternation using a novel rotary guider is considered in this thesis, and its effectiveness and technical feasibility is analysed in the context of actuating travelling tape tension. The specific issues addressed in this thesis are listed below.

Development of linear magnetic tape transport system with an advanced active tension actuation.

- A homemade linear magnetic tape transport system is developed.
- The footsteps of development including technical design details of hardware and software are described.
- A tape transport system that enables an actuation of travelling tape tension with dynamic tape path alternation using a novel rotary guider was purposely developed.
- The tension is regulated actuating the amount of surface friction force between the tape and the rotary guider by altering the tape path dynamically rotating the rotary guider based on the feedback from strain gauge based tension sensor.

Experimental studies of travelling tape tension shift phenomena with fixed tape path.

- Parameter studies are carried to investigate the transitions of travelling tape tension during the tape transport process with the fixed angle of rotary guider (fixed tape path) in the travelling speed of tape and the angle of rotary guider.
- Through experimental studies, it is found that the tension gradually increases as the tape is transported and the state of change in tension is heavily relay on the dynamics of tape pack driving source.
- The angle of rotary guider shifts the level of tension. Generally, higher rotation angle of the rotary guider and the travelling speed of tape apply greater tension to the tape.

Transverse force regulation with dynamic tape path alternation.

- The effectiveness of tension regulation with dynamic tape path alternation using the rotary guider is investigated through experimental studies.
- A closed loop control algorism of rotary guider controller is developed in order to control the operations of the rotary guider and implemented to the tape transport system.
- The developed controller has a significant influence to the transition of tension.
- The travelling tape tension is successfully regulated as targeted with the designed controller. It can be concluded that the rotary guider with a closed loop control algorism has an ability to actuate the travelling tape tension without relying on the dynamics of tape pack driving sources to control the tension.

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