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Dissertation outline

Stabilization and modeling of tensile properties for synthetic fiber rope

This thesis presents suitable unit to discuss longitudinal elastic modulus, stabilization of the longitudinal elastic modulus for both static and dynamic applications, and modeling of tensile properties of the braided high modulus polyethylene (HMPE) rope that applied in tendon-driven robot. This thesis consists of six chapters.

Chapter 1 Introduction: A brief introduction of synthetic fiber rope with its application was carried out. The previous researches of synthetic fiber rope and research objective of this study were given.

Chapter 2 Longitudinal elastic modulus of synthetic fiber rope: Suitable unit for longitudinal elastic modulus was discussed in detail because of irregular shape of the rope and presence of voids (space between the strands in the rope). The main cause of change in longitudinal elastic modulus of the rope is investigated based on experimental data and modulus determined from classical laminate theory (CLT). Input parameters for CLT are orientation angle (strand angle) and modulus of strand and packing factor (PF), i.e., the cross sectional area of strand to rope. However, PF and voids in the rope are greatly change during service and difficult to measure accurately during experiment, CLT by using conventional unit which based on cross sectional area of rope could not be used properly. Therefore, it is proposed to replace the conventional unit of MPa in CLT by N/tex which is not taken voids into account. Results from both experimental data and CLT showed that the change in longitudinal elastic modulus was caused by change in strand angle constituting the rope. Rope modulus had almost constant value as strand angle remained nearly constant value.

Chapter 3 Stabilization of longitudinal elastic modulus for static application: The longitudinal elastic modulus of virgin rope greatly changes at the first loading due to large change in construction geometry and modulus changes with strand angle. These cause an unstable in controlling the tendon-driven robot. To solve this problem, a method to stabilize the modulus by mean of preload treatment was applied to the rope for the used in static application. Preload treatment at different load levels and methods were applied to ropes and strands in order to stabilize rope modulus, and clarify the effect of preload treatment on construction geometry of rope and polymeric material. Preloaded ropes and strands were tested in five cyclic loadings further in order to investigate their stabilities. Results show that at the first cyclic loading both modulus of rope and strand had smallest values for all cases of preload levels, although they were virtually stable comparing to virgin rope and strand. The lowest of moduli at the first cycle in both preloaded strand and rope were caused by polymeric material used to produce them in which elastic recovery would probably occur. Therefore, in practical application preload treatment should be implemented just prior to utilizing the rope otherwise instability of the rope could occur at early stage in service. If rope is used in static loading, the minimum preload treatment should be conducted at the same level of the utilized load level.

Chapter 4 Stabilization of longitudinal elastic modulus for dynamic application: In real application of tendon-driven robot, dynamic loading could be applied, thus, it is necessary to study the rope behavior under dynamic loading. Dynamic loading in this study was assumed as impact loading presented in term of number of drops applied on the rope. Preload treatment of the rope utilized in dynamic application was carried out at difference preload levels. Since dynamic loading is more severe than that of static loading, then the stabilization of the rope modulus in dynamic loading is needed. The stability of the rope modulus was studied based on experimental data of impact loading of preloaded ropes and the proposed empirical equation which considered preload levels and number of drops into account. Results show that preload treatment is an effective method to stabilize rope modulus for dynamic application. If the rope is used in dynamic loading or unknown condition (either static or dynamic loadings), preload treatment should be conducted at higher than that of the utilized load level in order to obtain safety in stability of rope modulus because of severe condition in dynamic loading.

Chapter 5 Modeling of tensile properties for synthetic fiber rope: Spring-dashpot model was applied to estimate the tensile properties of the rope in both cyclic static and impact loadings. The strain (change-in-length) of the preloaded rope was also examined in model. The estimated results using the proposed model agreed well with experimental results. By using this model, the delayed time between the input (stress) and output (strain) in impact loading could be estimated which is very important parameter in controlling the tendon-driven robot.

Chapter 6 General conclusion and future work: The results from all chapters were summarized in this chapter and the future works were suggested in order to apply the results into real application of tendon-driven robot as well as to expand the present research