Ain Shams University

Faculty of Engineering

Electronics and Communications Engineering Department

FIBER TENSION CONTROL APPLYING ADAPTIVE FUZZY-PID CONTROLLER

A Thesis
Submitted in partial fulfillment for the requirements of the degree of Master of Science
in Electrical Engineering

(Electronics and Communications Engineering)

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STATEMENT

This dissertation is submitted to Ain Shams University in partial fulfillment of the degree of Master of Science in Electrical Engineering (Electronics and Communications Engineering).

The work included in thesis was carried out by the author at the laboratories of the department of Engineering and Scientific Instrument, Nuclear Research Center, Atomic Energy Authority.

No part of this thesis has been submitted for a degree or qualification at any other university or institute.

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ABSTRACT

Gyroscope fiber winding is considered the better choice for measuring the angular deviation rates with high accuracy. However, its accuracy depends on the quality of producing the fiber windings which represents the mean component of the optical gyroscope.

In this thesis, newly developed swinging tension sensor and control structure are proposed to achieve high precision of fiber tension during winding process. The advantage of the proposed tension and control structure is to relax the control objective, which allows using high torque motors with slow dynamics and large time constant to drive the supply spool.

The thesis also introduces the mathematical model of optical fiber, DC-motor, and Tension sensor where the mathematical driving system and total mathematical model are developed.

Finally, a simple PID controller is presented as a proposal for the tension control of the fiber during the winding process. And this thesis introduces the MATLAB simulation and experimental results of the newly developed swinging tension sensor and the control structure applied to the driving system with dc motor supply and product spool.

Keywords:

Modeling, Tension control, Optical Gyroscope, Fiber coil winding.

SUMMARY

Tension control is a process that can be found in many industrial process such as paper production, rolling mills, and winding process. This thesis presents fiber tension control for fiber winding process required for Fiber Optic Gyroscope (FOG). The tension control during winding process of fiber optic rings, used for FOG, is vital. Poor tension control could destroy expensive lengthy fiber or produce FOG with poor performance. In this thesis, a proposed mechanism of tension transducer that relaxes the control objective and perform tension control using one control loop is introduced. The mathematical model of winding process with transducer and control mechanism is established. A simulation of the model with different characteristics is introduced. The results are analyzed to verify the control mechanism and the developed model. The results shows that the proposed control mechanism has fast response for rejection of tension disturbance. The thesis is organized in five chapters as follow:

Chapter one contains an introduction and identification to the different types of gyroscopes, list their advantages and disadvantages and their application. Moreover, working principle of FOG and its structure is introduced.

Chapter two provides an overview on gyroscopes. It gives brief information about what are gyroscopes, what they are used for and how they work. A focus will be made on FOG where its structure and operation is introduced. Moreover, the chapter presents the winding process of optical coils used for optical gyroscopes. It introduces the state of art of winding process. Finally, it includes the optical fiber winding tension control system with its structure and literature survey.

Chapter three presents the development of mathematical model of fiber winding process. The winding process is broken down to subsystems according to their function and physical characteristics. The subsystems are connected to each other according to their relations in block diagram. Each subsystem mathematical model is developed. Moreover, the kinematic modeling of the fiber tension systems is verified by applies PID controller in feedback system using the proposed tension transducer.

Chapter Four provides MATLAB simulation results for tension system in both open loop and PID closed loop system. In addition, a comparison between the simulation results of the transducer measurements and the experimental measurements for different characteristics of transducer arm is conducted. The objective of the comparison study is to verify the accuracy of the mathematical model with different setting of the transducer characteristics. In addition, comparison between the active dancer and proposed passive dancer is introduced. Finally, the simulation result of the tension control model applying PID controller is conducted for different winding stages.

Finally, Conclusion and future work are presented in Chapter 5 where the main points summarizing the thesis are shown. References are presented at the end of the thesis.

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