21st International Conference **ENGINEERING MECHANICS 2015**
Svratka, Czech Republic, May 11 –14, 2015
Paper **#043, pp. 70–71**

Numerical and Experimental Study of Control Algorithm for Unloading System in Mechatronic Device for Gait Reeducation

Grzegorz Gembalczyk

Silesian University of Technology, Department of Theoretical and Applied Mechanics, Konarskiego 18A, 44-100 Gliwice, Poland

Grzegorz.Gembalczyk@gmail.com

Keywords: control system simulation, gantry control system, parameter optimization

Abstract: This paper presents the results of simulations and experimental research on unloading system used in mechatronic device for gait reeducation. This device works like a special purpose crane, which is equipped with a system for control over keeping up the movement of a crane. Thus, winch can follow the patient and relieve him with a constant value of the force in the vertical direction [3].

First part of the publication regards the simulation study and includes for example: identification of the kinematics, development of the physical model of the winch system and the assembly of the computational model in the MATLAB / Simulink software. The numerical model of device was developed using the multibody systems methodology.

One of the important parts of the numerical model of the crane is description of a BLDC motor model and identification of its parameters. In this case, motor behavior was modeled using a transfer function based on Strejc model [7].

$$K_{eng}(s) = \frac{k}{(1+sT_1)^n} \tag{1}$$

The values of the model parameters were determined in the estimation process, using a genetic algorithm [1,5].

The next part of the paper deals with the concept of the control algorithm for relief system.

This algorithm requires continuous measurement of the relieving force. A new strain gauge load cell has been designed [4] to facilitate this measurement. The concept of the control system concept is shown in a diagram in Fig. 1.

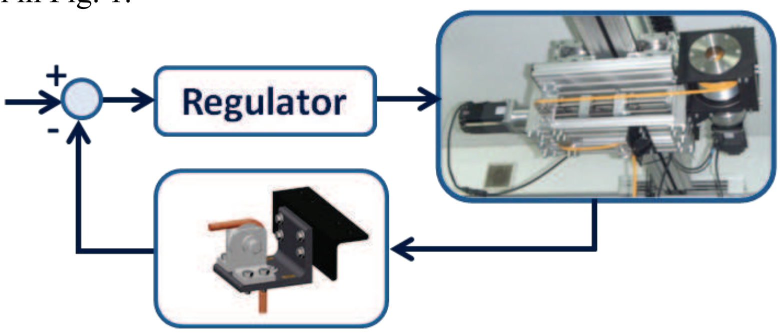

Fig. 1: Scheme of control system

The initially estimated parameters of the proportional-integral-derivative controller are continuously adjusted by a feedback loop. The transmittance of the whole controller was expressed by the equation [3]:

$$K_{reg}(s) = k_p\left(1 + \frac{1}{sT_c} + \frac{sT_D}{1+sT}\right) \tag{2}$$

The complete drive system of the winch is equipped with two engines. One of them provides a quick response to changes in relief force. The other one controls height of the handle.

In this paper we resent results of the tests with the first engine only. This motor is connected via a planetary gear with a drum winding.

Values of the controller settings were estimated using the numerical simulation. In optimization process, the error signal was minimized. Forcing signal was replicated in the center of gravity of person- with gait impairment [2,6]. Obtained results have been verified during the bench tests.

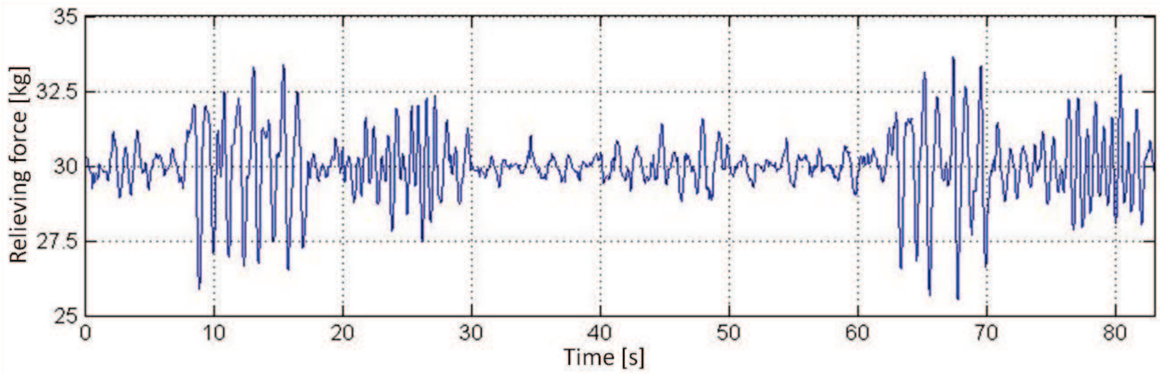

Fig. 2: Values of the relieving force as a function of time

References

[1] M. B. Anandaraju, P. S. Puttaswamy, J. S. Rajpurohit, Genetic Algorithm: An approach to Velocity Control of an Electric DC Motor. International Journal of Computer Applications, 26 (2011) 37-43.

[2] K. Bellad, S.S. Hiremath, M. Singaperumal, S. Karunanidhi, Optimization of PID Parameters in Electro-Hydraulic Actuator System Using Genetic Algorithm. Applied Mechanics and Materials, 592-594 (2014) 2229-2233.

[3] S. Duda, K. Kawlewski, G. Gembalczyk, Concept of the System for Control over Keeping Up the Movement of a Crane. Mechatronic systems and materials VI: Trans Tech Publications, 220/221 (2015) 339-344.

[4] G. Gembalczyk, S. Duda, Projekt i walidacja urządzeń pomiarowych – siły w linie i kąta wychylenia liny zawiesia suwnicy, Modelowanie Inżynierskie, 47 (2013) 75-81.

[5] A. Kapun, M. Curkovic, A. Hace, K. Jezernik, Identifying dynamic model parameters of a BLDC motor, Simulation Modelling Practice and Theory, 16 (2008) 1254–1265.

[6] J. Wei, A Novel PID Controller Parameter Optimization Method, Applied Mechanics and Materials, 738-739 (2015) 1077-1081.

[7] A. Żuchowski, Nietypowe metody eksperymentalnego wyznaczania parametrów zastępczego modelu Strejca, Pomiary Automatyka Kontrola, 59 (2013) 55-58.