Abstract

The subject of this PhD dissertation are the biomechanical issues related to supporting the movement of the hand with an exoskeleton. The exoskeleton is a particular form of robot, also known as a power suit or wearable robot. It is a structural solution, worn on the wearer like a suit and attached to specific parts of the wearer's body to assist the movement of effectors (muscles). Its purpose is to assist the motorisation of individual body parts, e.g. the upper limbs, both in healthy people and in people with and those with various types of motor deficits. The main focus of the ongoing research in the dissertation is the study and evaluation of the properties of personalised hand exoskeleton prototypes for different types of dysfunction in users. To carry out the research, a methodology for creating the exoskeleton was developed and the exoskeletons were constructed according to the developed methodology. A key issue was the selection of criteria for assessing the functionality of the exoskeletons and how to measure them. The selection of the materials of the exoskeleton components (type of material and shape of the individual components) was made, and then the research experiment started with the scanning of a healthy hand and hands with different dysfunctions. The research group consisted of 10 users with hand dysfunctions. Subsequently, 10 personalised exoskeletons were made by adapting the exoskeletons to these dysfunctions. The fabrication of the exoskeletons allowed for a further stage of the experiment, i.e. performing a three-stage test with each user: fitting the exoskeleton to the dysfunctional hand (putting on and taking off), opening and closing the dysfunctional hand with the exoskeleton on, and grasping the ball with the hand in the exoskeleton. For fitting, the time for putting on and taking off the exoskeleton was measured. For opening and closing, flexion angle, velocity and acceleration were measured. On the other hand, during ball grasping, whether the ball was caught or not was recorded. Proprietary software was also developed to carry out the study, working with an with an electronic goniometer and a test cube: software to size the hand, software to calculate hand parameters, and an exoskeleton control programme to use the knowledge gained to prepare a personalised exoskeleton for the hand. Chapter 1 provides an introduction and discussion of the layout of the work. Chapter 2 contains the state of research in the field of exoskeletons and their design methodologies, as well as a review of the literature and the rationale for taking up the topic of the thesis. Chapter 3 contains the main aim of the thesis and specific objectives, the scope of the thesis and the research

methodology used in the thesis. Chapter 4 describes the author's methodology for creating a personalised prototype of the hand movement support exoskeleton. Chapter 5 presents empirical research on the tests of kinematic parameters and functional tests of the created personalized prototypes of the exoskeleton to support the movement of the hand and summarises the level of improvement in the functioning of the dysfunctional hand in the exoskeleton for 10 users. Chapter 6 provides a discussion and directions for further research, and Chapter 7 provides conclusions, a summary of achievements and limitations.