UDC 007.52

PRODUCTION OF AN EXOSKELETON BASED ON ARTIFICIAL MUSCLES

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Annotation: The article is devoted to the development of an exoskeleton based on artificial muscles. The effectiveness of exoskeletons is considered. Main advantages of pneumatic muscles are mentioned. The features of a test prototype of a muscle fiber unit are revealed.

Keywords. Exoskeleton, pneumatic, biomechanics, muscle, artificial, fiber, pressure, source, electrolyzer.

Introduction. Development of industrial production increases efficiency of human labor. For increase, endurance and physical strength engineers are developing prototypes of exoskeletons.

Exoskeletons are a type of augmented technology designed to bolster human performance in physically demanding tasks by supporting body parts like the hands, lower back, legs, and upper body. This reduces the energy needs of workers when lifting, transporting, and holding tools, boxes, and other industrial assets safely. With this deployment, the frequency of musculoskeletal disorders is significantly reduced.

Exoskeletons have shown their effectiveness in many areas: industrial production, warehouse work, medicine and military. Exoskeletons are used to increase the range of human movement, physical strength and to reduce the likelihood of injury, recovery from illness and other tasks.

Exoskeletons are divided on two types: passive and active. The passive variation does not have any power source, and they serve mainly to increase strength and provide stability to end-users. On the other hand, active exoskeleton technology utilizes some form of energy to power sensors, actuators, and other tools. Most currently in use are passive, mostly because they are more affordable and they address specific challenges or use cases. Passive exoskeletons use only system of springs and mechanics. Active exoskeletons use also system of drives. This system can be based on servomotors or artificial muscles.

The future of exoskeleton design is to integrate them with the Internet of Things to capture data and provide insights to leadership teams. Eventually, this technology will need to integrate with robotic arms, collaborative robots, and mobile robots through advanced location technologies and gesture control.

This article describes the design and stages of creating an artificial muscle, the principle of operation of the muscle fiber, and the criteria for selecting a pressure source for the muscles.

Main Part. Pneumatic muscles are the best decision for drive of exoskeleton because they have some advantages in compare with servomotors:

- They are lighter than construction with servomotors
- Artificial muscles consist of fewer parts than servomotors, which make them more reliable
- Pneumatic muscles cheaper in production than electrical drives
- Anatomy of artificial and human muscles is almost similar, which allows to make smoother movements.

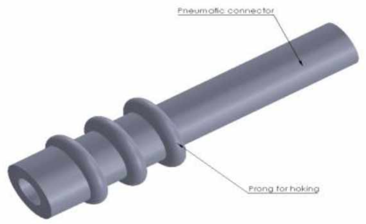
Construction of muscle consists of three main parts: Elastic inner part; Limiting outer casing; Pneumatic union.

Principle of work is simple: when pressure reaches a muscle, an elastic part starts to expand, at the same time casing stops an inner part from self-destruction and shrinks the length of the muscle. Union needs to connect the muscle to main pneumatic system and attachment point for muscle and carcass.

As a source of pressure was chosen electrolyzer. Electrolyzer is a device that can produce mixed gas, consisting of oxygen and hydrogen, from water. Along with the increase in gas mass in a closed pneumatic system, the pressure also increases. The advantages of using an electrolyzer as a pressure source:

- longer system autonomy;
- greater productivity;
- possibility of exhaust gas recovery.

In CAD editor, SolidWorks was created and the pneumatic union was printed on 3D printer. Construction of the union consists of the pong and the pneumatic connector. Rows of pongs are needed to hold an elastic part and casing on union. The function of the pneumatic connector is to connect muscle unit to main pneumatic system.



Picture 1 – Model of a union

A cable braid made of a polyamide with a snakeskin weave type was chosen as a material of outer casing. This type of weave allows along with reducing the length, increase the outer diameter of braid. That secures inner elastic part from self-destruction.

After preparation of all components, first prototype of the muscle unit was designed.

For the test of strength of the muscle a stand consisting of compressor, pneumatic connectors and muscle union was prepared. The union from one side was closed and the other side was connected to the pipe. Then the pressure was applied to the system. The muscle was contracted, outside diameter was increased. After that, a 1-Kilogram load was connected to the muscle. At a pressure of three atmospheres in the compressor, the muscle was able to contract to the same length, as without load and showed no sign that this load was critical. Considering that the muscle fiber's own weight is 5 grams, we can conclude that this prototype is capable of lifting 200 times of its own weight.

Conclusion. During the work, the design of an artificial muscle fiber was developed**.** A test prototype of a muscle fiber unit was created and tests were carried out during which satisfactory results of load-carrying capacity were obtained. Many industries are facing a unique set of challenges, including labor shortages and an aging workforce. While exoskeletons have the potential to help combat these issues, technology providers must make sure that companies and other organizations can see the potential of investing in the technology.

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