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The development of constructive schemes of exoskeletons

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Abstract

The paper deals with the organization of controlled movement of the exoskeleton in the process of lifting the load. Development of an exoskeleton with a hydraulic drive controlled by the operator through a system of levers that control valves is described. Today the exoskeleton has no competitors in the market of means for medical rehabilitation at violation of musculoskeletal function. There are 4 good reasons for this. First, the exoskeleton automatically repeats the natural pattern of human walking, it helps to carry out more effective rehabilitation of patients after injuries, operations and serious diseases leading to partial loss of mobility. Secondly, the exoskeleton increases the mobility of people with reduced mobility: now they can not only take care of themselves, but even travel. Third, the exoskeleton significantly improves the quality of life of older people, whose opportunities have been limited due to diseases of the lower extremities or joint problems. Finally, an important feature of the exoskeleton is the principle of verticalization. The vertical position of the body allows all internal systems of the body to work in the usual, and most importantly, the right conditions, which restores normal blood pressure and circulation. Due to this, rehabilitation of patients with reduced mobility is much more effective than before.

For citation

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Keywords

The exoskeleton, the exoskeleton with hydraulic drive, hydraulic valves, hydraulic cylinder, lifting a load.

Introduction

Science and technology is a constant rivalry between human ingenuity and nature. Since ancient times, man seeks to change the world to improve their livelihoods, without violating the laws of nature. Some invertebrates have an external skeleton, but in humans it is absent. Now there is a need for devices that enhance the physical abilities of a person [Adhikari, 2018, 3212]. One of the ways to solve the given problem is the use of human-machine systems (devices), where the interaction of the operator and the mechanism leads to excellent indicators of human abilities. Exoskeletons are considered to be one of the examples of systems development. Exoskeleton-a device designed to fill the lost functions, increase the strength of the human muscle and expand the amplitude of movements due to the outer frame and drive parts. Similar devices can be used in military Affairs (anti-terror, assault and sapper operations, installation of difficult armor and weapons) and in everyday life. In peaceful life, exoskeletons have three types of tasks: construction and logistics, medical and special. Construction exoskeleton has the ability to carry construction equipment or used as a loader. Medical exoskeletons can be used as wheelchairs for sick and disabled people. Special exoskeletons can be both equipment for rescuers and mechanized diving or protective suits [Alamro, 2018]. Functional development of exoskeletons is currently under way. Developments are necessary to create systems of vertical position of the person and strengthening of his physical capabilities. It is proposed to consider the use of an exoskeleton to lift the load in the event that this requires the movement of all mechanisms (arms, legs and body). Similar actions of the device are equivalent to different work with the load and functional actions of the operator.

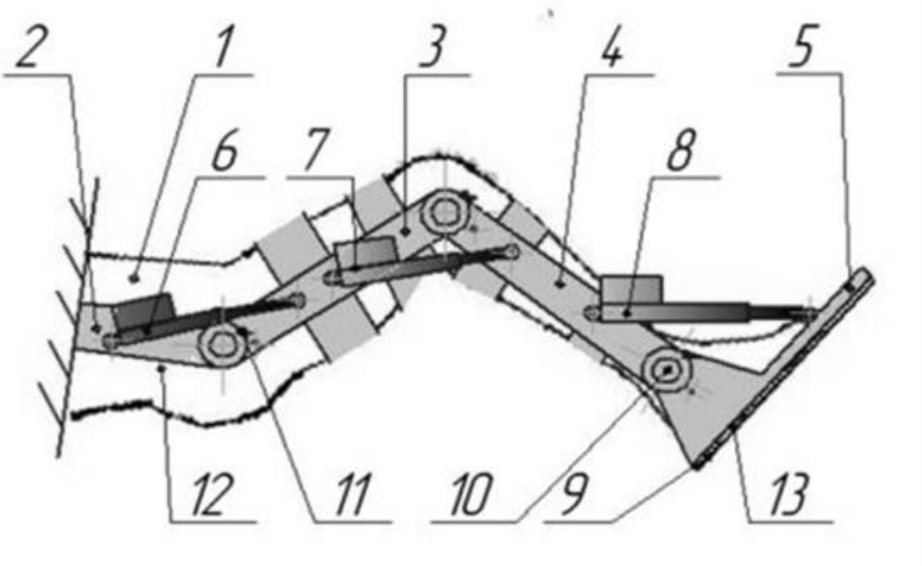
Materials and methods

The organization of the controlled lifting of the load from such an initial position will combine the tasks of verticalization of the mechanism and manipulation of the load with the support of the "hands" of the exoskeleton. For research, we consider models of exoskeletons XOS 2 and HAL (Fig.1.2) XOS 2, weighing 80 kilograms, allows a person to lift 90 additional kilograms, and the Hal exoskeleton by Japanese robot manufacturer Cyberdyne provides the ability to walk for people with disabilities and lift heavy loads [Barnes, 2018].

Figure 1 – Hal exoskeleton

Figure 2 – Exoskeleton with hydraulic drive

A system with a hydraulic drive controlled by the operator through a system of levers controlled by control valves is proposed. In contrast to the existing analogues, in the development of some joints will move the muscular forces of the operator. To reduce the load on the spine, muscles and joints of the human body uses a full frame of the human body, additional hydraulic cylinders in the knee, elbow joints and joints of the foot, in the lumbar region. Stopahmadi of the exoskeleton are made of dense shock-absorbing material [Bitikofer, 2018, 4915].



1 — the human Foot; 2 — Strut; 3 — A Femoral link; 4 — Tibia; 5 — Stop; 6, 7, 8 — Drives linear motion; 9 — Rubber sole; 10 — steering angle Sensor (encoder); 11 — Safety limit switch; 12 — Straps to strengthen the human foot; 13 — Gauge load on the abutment heel.

Figure 3 – Diagram of the structure of the legs of the exoskeleton man (side view)

Results and discussions

The key difference in the control system is that it is based on mechanisms, excluding electronics. This increases the possibility of repair and reduces the cost of the product. In the power plant it is possible to use small-sized gasoline generators, which are combined with an electric motor that drives the hydraulic pump shaft [Bulea, 2018, 2802]. This mechanism can be controlled by a 12-valve control valve. The control valve rods can be set in motion with the help of rods controlled by the operator, which simplifies the repair in the field. In addition, it is possible to introduce a load sensor and monitor the supply voltage to protect the battery from full discharge and inform the user about the remaining battery life.

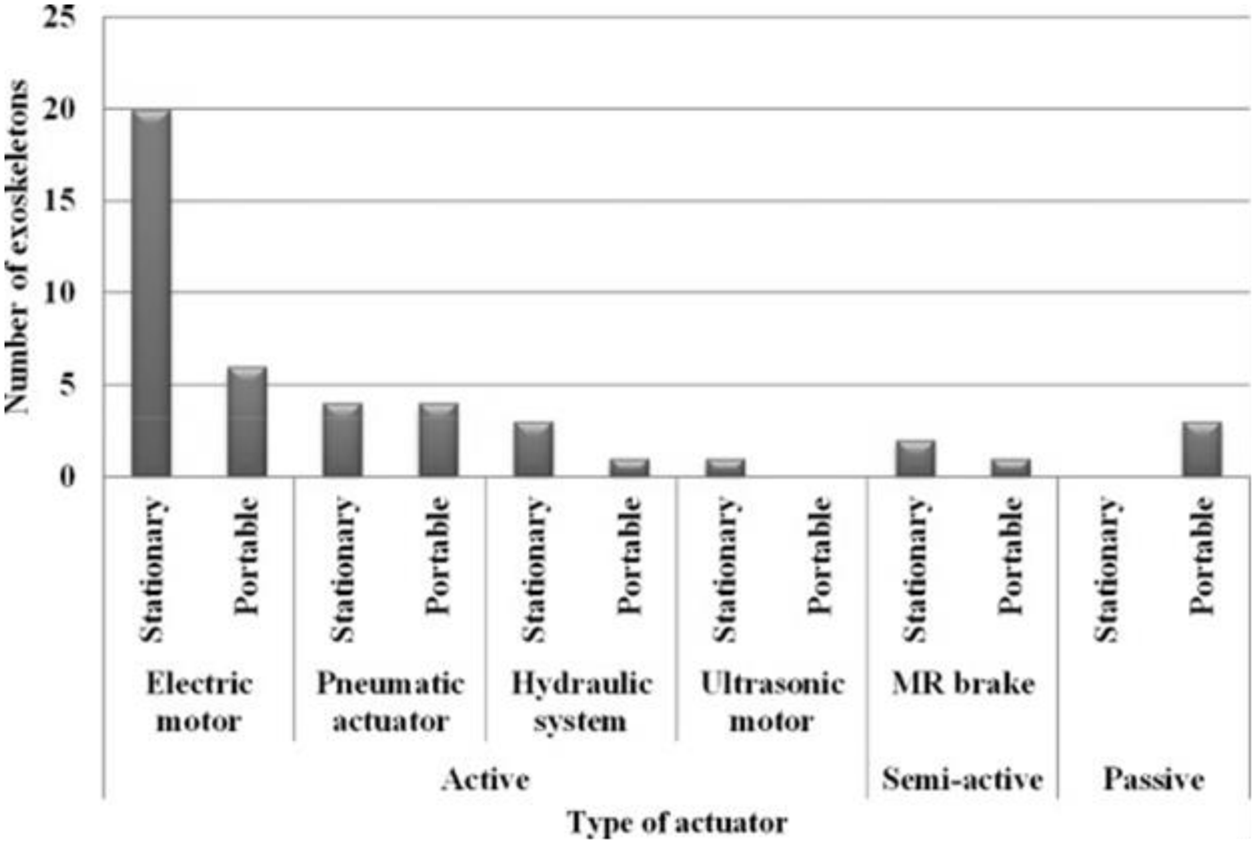


Figure 4 – Sensor Circuit: The main advantages of this exoskeleton are energy freedom, low cost in Assembly and repair in different conditions

Mechanical systems are very widespread in modern technology [Husain, 2018, 2794]. The most popular direction in the development and implementation of robotic systems are exoskeletons. Consequently, with the development of new technologies in different fields of science, new opportunities will open up in the manufacture of new materials, exoskeletons will be improved, reduced in size and become more accurate.

The exoskeleton follows the biomechanics of human rights to a proportional increase in effort during the movements. According to the open press, the actual models are currently created in Japan, the United States and Russia. The exoskeleton can be integrated into a spacesuit

The progenitor of a passive exoskeleton can be considered elastomed. Elastified (left), a device designed to facilitate walking, running and jumping were intended for military applications [Juszczak, 2018, 340]. The author of this invention is the Russian inventor Nikolai Alexandrovich young (1849-1905). In the late nineteenth century, he developed and patented several modifications of the passive exoskeleton Elastomed. This trend in the design of exoskeletons later found development in the invention of Alexander Bock-powerbock or powerskip-jumper simulator. (on the right.)

The first drawings of the prototype active power exoskeleton were registered in the United States in 1868.

The development of active types of exoskeletons began more than half a century ago [Triolo, 2018].

The first exoskeleton was created jointly by General Electric and the United States military in the 60s of the twentieth century and was called Hardiman. The mechanism could lift 110 kg with the force applied when lifting 4.5 kg. However, it was impractical due to the large mass of 680 kg and looked more like a huge robot loader. However, until the appearance of the exoskeleton in its modern sense, there were very few [Liang, 2018, 3927].

The first active walking exoskeleton was created in 1969 under the leadership of the Yugoslav and Serbian scientist, specialist in biomechanics and robotics, Miomir Vukobratovich at the Institute. Mikhail Pupin in Belgrade. This exoskeleton was developed for medical purposes and was intended for the rehabilitation of people with disorders of the musculoskeletal system. In 1972-1974 the exoskeleton developed in Belgrade was transferred to the Russian scientists from the research Institute of Mechanics of Moscow state University for research and further development. At the same time, his clinical trials were held at the Central State Institute of Orthopedics and Traumatology [Liu, 2018].

Since the 80s of the 20th century in the United States Sarcos company began work on the creation of a working prototype of the exoskeleton. Later, this company was bought by the American company Raytheon, one of the largest suppliers of the us military Department.

Since the beginning of 2000-ies the Agency of scientific research USA (Darpa) has funded programs to create exoskeleton that increases the carrying capacity and movement speed of soldiers with full combat gear, which are conducted in the interests of the giants of the military-industrial industry of the United States, such as Raytheon and Lockheed Martin.

To date, the projects of exoskeletons for military use of HULC (DARPA, University of California at Berkeley, Lockheed Martin) and XOS Exoskeleton (DARPA, Sarcos, Raytheon) according to the statements of the American press have been brought to the stage of preparation for production, and in open sources videos are available with a demonstration of existing samples [Martinez, 2018].

Also developed medical exoskeletons for the rehabilitation of patients with disorders of the musculoskeletal system and locomotor functions. At the moment, there are existing exoskeleton samples, some of them already have mass production, although most medical exoskeletons are still at the stage of clinical trials.

In the framework of the project called Actually developed for exoskeletons an application. The developers have been working on the medical version of the exoskeleton since 2013. In June 2014, a working prototype of the exoskeleton was already presented [Mohammadi, 2018]. It is planned to use several options of control systems: walking in automatic mode, control by tilting the body and control by means of sensors.

The only correct exoskeleton scheme is the Android exoskeleton scheme: the exoskeleton is in front of the person, not on the side or behind. If the side (as in the exoskeletons Sarcos Robotics) will not enter the door (important for movers, military and special forces), if the back-crush (lawsuits) in a wet spot exoskeleton in a collision or fall. Bang in real life show-real wild boar is possible only with the Android scheme of the exoskeleton. Then the end of all concrete fences (running at full speed) until the exoskeleton is not sober, after said (a pint) with the boys early testing of the exoskeleton at full speed.

Figure 5 – Guardian XO by Sarcos Robotics. Gain 20 times: when lifting 90kg in the hands of an exoskeleton-4.5 kg in the hands of a person. For sale: 2020

Android scheme of the exoskeleton is the cheapest, requires a minimum length (less reducers of drives of the hands) the hands of the exoskeleton, ceteris paribus.

Two-second starting power (proportional to the circumferential speed. Power is the moment multiplied by the speed) of the transistor coupling 5-7 times more accelerating from zero (at almost zero speed power is almost zero) of the electric motor [Murray, 2018]. The two-second starting power of the flywheel-stator + transistor clutch + friction clutch system (the clutches operate in parallel) is 20-100 times greater than the electric motor accelerating from scratch. A friction clutch transmits main torque coupling transistor in feedback with a sensor of the output torque of the actuator, adds the time or slows down to the schedule form, the output time of the actuator control signal present at the input to the actuator [Nolan, 2018].

SpaceX will not fly to Mars. This does not provide any commercial or military benefit, let alone the unresolved problem of space radiation. SpaceX is a program of industrial development of material natural resources (uranium, rare earth and other metals, water...) The moon USA. This will allow the US to monopolize all outer space by transferring the production of launch vehicles to the industrial enterprises of the moon. Then, without the use of U.S. nuclear weapons, all countries will be under the gun kinetic weapons of the United States in space. In favor of this version says that according to the 2018 Russian lunar base is developed on the inexplicable logic and common sense of 12 people (with fright: apparently there are access plans USA) on the moon, although in the polar lunar base is most advantageous to have only one person connected with the Ground high-speed Internet. The rest of the budget is more profitable to spend on equipment to solve the problems of lunar industrial production [Ramanujam, 2018].

Figure 6 – A good example of an exoskeleton

Drive type is CONSTANTLY ROTATING motor-flywheel + PROPORTIONALLY controlled clutch + gear" spends energy per unit of useful work in times less than the drive type of electric motor + reduction gear. In a constantly rotating electric motor-flywheel energy in the absence of useful work, practically is not spent if it rotates in high-quality bearings and valve-1 closes the air inlet to its

CENTRIFUGAL (for protection from surging) fan, cooling the winding of the electric motor-flywheel. The valve-1 operates in feedback with the winding temperature sensor. On the output nozzle of the ventilation (cooling) winding valve-2 is not needed. When the valve-1 is closed, the rotor of the electric motor-flywheel rotates in a partial vacuum: small air resistance to the rotating rotor of the electric motor-flywheel.

In a wire exoskeleton is about the same design of the clamping frame of the palm in the control arm exoskeleton, only actuators located in the clamping frame of the trunk where the cables go through pulleys to the clamping frame of the palm. Such a scheme reduces the moment of inertia (control delay) of the clamping frames of the hand, significantly reduces the diameter of the cables in the control exoskeleton of the hand, evenly distributing the load between them.

Conclusion

Exoskeleton is an Android, which is controlled by a person connected by clamps (fingers, hands, feet) with an Android. The best scheme of the exoskeleton is the Android scheme of the exoskeleton: the exoskeleton is in front of the person, not on the side or behind.

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Разработка конструктивных схем экзоскелетов

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Аннотация

Статья посвящена организации контролируемого движения экзоскелета в процессе подъема груза. Описана разработка экзоскелета с гидравлическим приводом, управляемым оператором через систему рычагов управления клапанами. Сегодня экзоскелет не имеет конкурентов на рынке средств для медицинской реабилитации при нарушениях функций опорно-двигательного аппарата. Для этого есть 4 веские причины. Во-первых, экзоскелет автоматически повторяет естественный режим ходьбы человека, это помогает проводить более эффективную реабилитацию пациентов после травм, операций и серьезных заболеваний, приводящих к частичной потере подвижности. Во-вторых, экзоскелет увеличивает мобильность людей с ограниченной подвижностью: теперь они могут не только заботиться о себе, но даже путешествовать. В-третьих, экзоскелет значительно улучшает качество жизни пожилых людей, чьи возможности ограничены из-за заболеваний нижних конечностей или проблем с суставами. Наконец, важной особенностью экзоскелета является принцип вертикализации. Вертикальное положение тела позволяет всем внутренним системам организма работать в обычных, а главное, правильных условиях, которые восстанавливают нормальное кровяное давление и кровообращение. Благодаря этому реабилитация пациентов с ограниченной подвижностью становится гораздо эффективнее, чем раньше.

Для цитирования в научных исследованиях

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Ключевые слова

Экзоскелет, экзоскелет с гидравлическим приводом, гидравлические клапаны, гидроцилиндр, подъем груза.

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