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NON - TRADITIONAL DRIVE UNITS FOR EFFICIENT ROBOT MODULS

Driving unit in robots serves, through the change of input energy, programmed precise movement of mechanical movement system. At the same time, the requirements on its optimization lead to the concept of its design with transformer block (transmission), or without this block. One of the solutions without the transformer block is the usage of the principle of bio-drives (artificial muscle). The paper gives the driving unit set on the principle of modified artificial muscle (tire). The driving unit is constructively simple, with the possibility of minimizing it into real space of the movement unit. The results confirm (linear module) that its efficiency parameters and working qualities are suitable for the construction of robots, mainly for the effectors, or the movement units with small lifts.

INTRODUCTION

The function of the driving unit in robots, generally consisted of the control block (CB), own motor (M) and the transformer block (TB), is based on the change of the input energy to the programmed precise movement of the mechanical system (action system), Fig. 1.

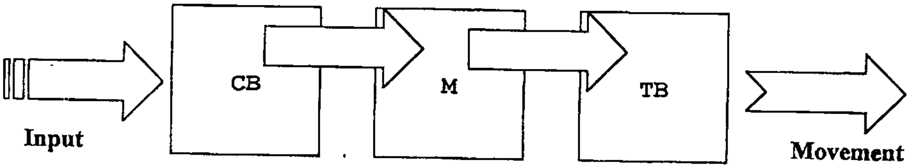


Fig. 1

There are high technical and functional demands put on the driving unit, mainly: fluent smooth start and braking; needed (high) accuracy of positioning; satisfactory position rigidity; specific requirements on the movement speed (manipulative, technological robot); specific efficiency and mechanical characteristics in output (dynamical parameters in transitions states, minimal start); minimal outline (construction) parameters; minimal weight; suitable space setting; characteristic work of discontinuous reversible movements; user's comfort; low working costs; etc.

The driving unit, as a constructive monoblock, see Fig. 1, comprises various elements, which can be ranked to several variants of functional sets. There are optimization processes based on the evaluation of the criteria of chosen technical and functional parameters, criteria evaluating utility features, total concept of the construction of the robot driving unit, robot working in its supposed working environment, that are used for its design.

Given requirements on the driving unit lead to two concepts of its design, to the concept of the driving unit with TB (concept A) or to the concept without TB (concept B). The development of the driving units for the given purposes leads to the design of compact driving modules with minimal inner structure and integration of its functional parts with the aim to reach minimal dimension, minimal own weight and efficient integrated space configuration.
The technical realization of the given approaches to the driving units leads, besides the innovative new approaches based on the classical principles, also to the way of searching new, non-traditional principles of the own motor M and consequently all structure of the driving unit.
One of the recent ways of development of complicated intelligent mechanisms is the shift and application of the information of bioscience into technical science. In the area of robotics, this trend has been formed into the discipline called "biorobotics", the main task of which is to solve theoretically and practically the construction of robots on the base of the information about the construction and behavior of living (biological) organisms, Fig. 2.

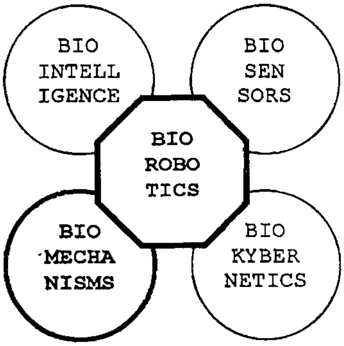


Fig.2 .

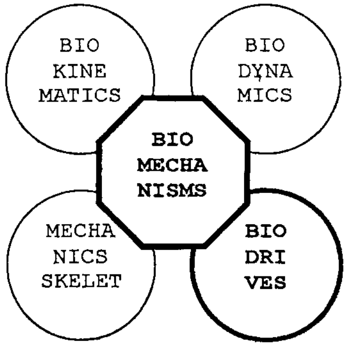


Fig. 3

Biorobotics also deals with the problem of driving systems constructed on non-traditional principles derived from motorical systems of living organisms.

ROBOTIC MACHINERY ON THE BASE OF BIOMECHANISMS

For the construction of the movement systems of robots nature shows a number of models (biological organisms). The transfer of these models into technical systems is based on the knowledge connected with the structure of movement organs, character of the influence of motorical (muscular) groups evoking movement in the kinematics of the skeleton of the biological organism, with the laws of the skeleton movement and its different parts as well as the relationship of interactive influence of motorical groups on the skeleton of the organism. Biorobotics generalized these information and formed them into the structure and features of the subsystems of biomechanisms, Fig. 3.

DRIVING UNITS ON THE BASE OF BIODRIVES

The movement apparatus of the biological organism generally consists of the system of skeleton muscles, the system of the skeleton segments, the system of connecting elements. The kinematic chain made of the skeleton segments and connecting elements secures the

system of skeleton muscles for moving. So that the contraction of the muscular system could show as the movement of the skeleton of the biological organism, the muscular system must be functionally and dispositionally arranged for the skeleton in certain (defined, conditioned) relations.
The principle of the drive of the moving apparatus of the biological organism was taken into biorobotics as the model for the technical design of the subsystem of biodrives, the representative of which is so-called "artificial muscle". The aim was to create a highly efficient drive, in which the relation of the output and weight would be comparable to the efficiency of the biological muscle. The artificial muscle presents a new sort of drive that is principally based on the change of the input pressure energy into output mechanical energy, constructionally it is designed as a combination of a flexible action element (element M, Fig. 1) and electronic elements (regulative, control elements of CB, Fig. 1), working medium (input) can be hydraulics or a tire. The artificial muscle works on the principle of change (deformation) of the outline dimension activated by the change of pressure of the working medium (overpressure, underpressure) and its transformation into length (movement, efficiency) change of the final element of the action part (drive output), Fig. 4.

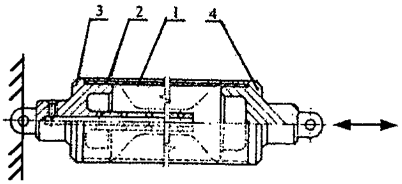


Fig. 4.

The history of this drive can be briefly showed by the overlook of the development of its technical solutions: overpressure pneumatic drive according to S. Garasiev (1930); artificial overpressure pneumatic muscle according to McKibbon (1947, 1950); overpressure pneumatic drive according to K. Nazarszuk (1964); overpressure pneumatic artificial muscle according to A. Morocky (1968); overpressure pneumatic artificial muscle according to H. A. Baldwin (1969); artificial overpressure pneumatic element according to G. B. Immeg (1986); artificial overpressure pneumatic muscle of the company Bridgestone Corporation Tokyo (1988), commercially available; artificial overpressure pneumatic muscle according to Liang and Winters (1989); hydraulic artificial overpressure muscle of the company Komatsu Ltd. (1990); underpressure pneumatic artificial muscle according to J. N. Marcinčin and A. Palko (1992).

NEW APPROACH TO THE DRIVING UNIT ON THE BASE OF FLEXIBLE ACTION ELEMENTS

The experience of the development of the driving unit on the base of artificial muscle confirm that the development in this area can be generally formed on the following principles:

- driving units based on the principle of shortening action elements (motor M)
- driving units based on the principle of lengthening action elements (motor M)

Hydraulics or pneumatics can be the working medium. The output element can have three degrees of flexibility: lengthening, bending, turning around transverse axe.

Newly designed driving unit with lengthening action element is principally designed on the change of input pressure (tire) energy, shape and volume change of action element into output mechanical (power, movement) energy, Fig. 5. The action element is a pipe of flexible material (rubber, kevlar), in the side of the pipe there are non-pullable fibers placed (designed into the form of skeleton), that participate considerably on the transfer of the output power (efficiency) of the drive. The action element is closed tightly on both ends by terminals 2 and 3, the terminal 2 connects the action element with the base body 4 of he driving unit and the terminal 3 connects the action element to the transfer of the pressure energy as well as fixes it. The action element is placed and fixed (range R of fixing must be smaller than geometrical length of the action element) in the conductive box 5, the box has a movable upper side 6. The upper side is finished by the output mechanical interface of the driving unit.

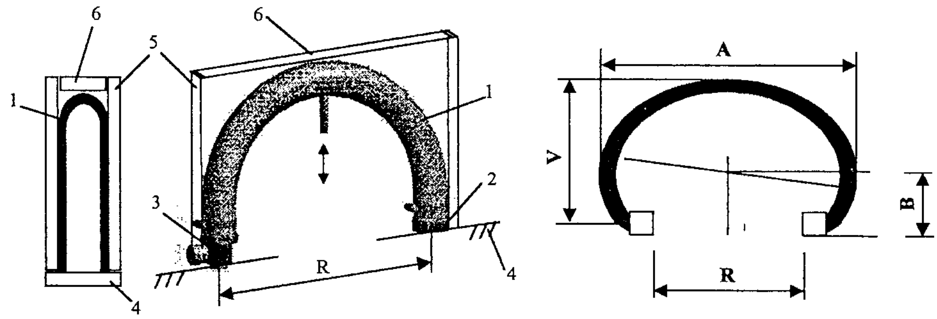
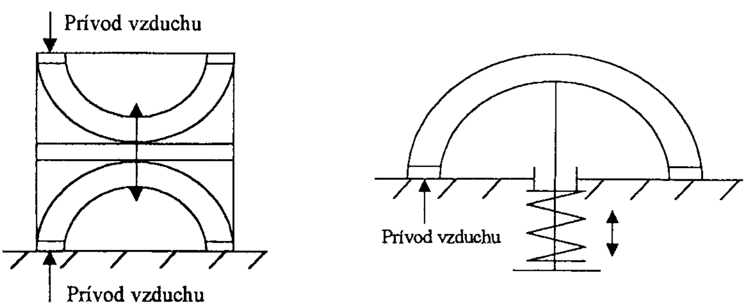


Fig. 5.

The action element, through its construction characteristics and placement in the conductive box, after connecting the pressure energy changes its geometrical disposition and shape, the change is connected with its considerable deformation in longitudinal direction, in transverse direction the action element deforms much less. Longitudinal deformation evokes mechanical straight movement of the upper side of the conductive box, where the range of deformation, i.e. range of movement, depends on the change of pressure energy on the input. Backward movement of the action element can be solved by a spring, combination of two action elements in vice versa functions etc.

The pros of so constructed driving unit is its constructional simplicity, possibility to minimize in real space of the movement unit (variability of placement of flexible action element), economic efficiency, high standard of working reliability, good working utility, positive output characteristics and technical parameters.

Given principle of the driving unit can be realized in the construction of any linear and rotation driving units, Fig. 6.



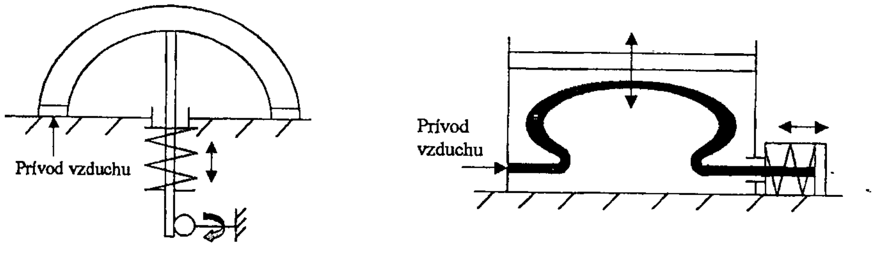


Fig. 6.

EXPERIMENTAL TESTING OF NEW PRINICPLE OF DRIVING UNIT

The functional model of the linear driving unit underwent a large program of experimental tests. The principle and function, the influence of the quality of material of the action element (pipe, skeleton filling) on he function and basic parameters, basic technical parameters of the driving unit were tested (methodology of planned experiment) mainly.
The methodology of experimental testing was based on the principle of the scheme of measuring, Fig. 7, composed of the compressor 1, valve 2, five-way valve 3, action element 4, power reader 5, manometer 6, filter 7, path reader 8.

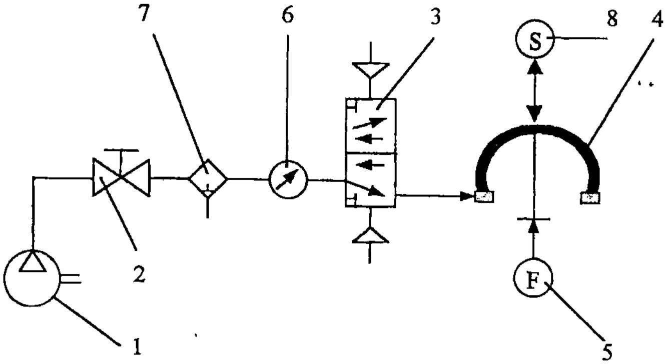


Fig 7.

Reached results allow to define the following knowledge, parametric data and relations:

- relation of efficiency (pulling power F) of the driving unit on the size of lift of the action element (path s) and pressure of the input pressure energy, with constant distance of the terminals of the action element R, shows the path as shown in Fig. 8.

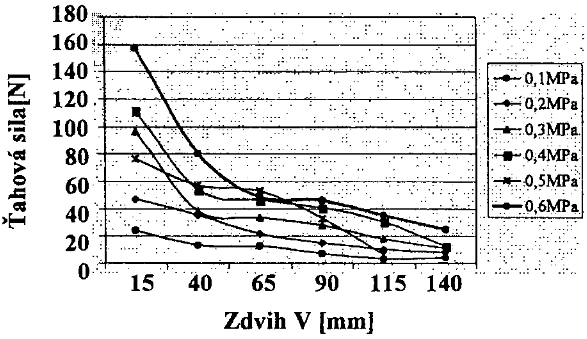


Fig. 8.

- relation of efficiency (pulling power F) on the driving unit on the size of lift of the action element (path s) and the distance of the terminals of the action element R, with constant pressure of the input energy, shows the path as shown in Fig. 9.

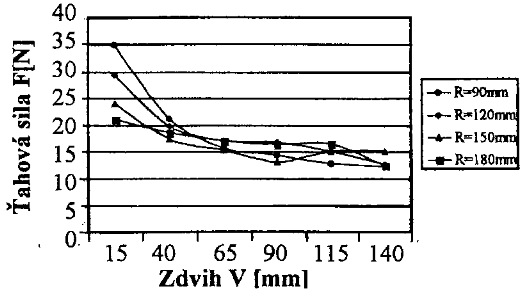


Fig. 9.

- from the measured results it can be said that with the input energy 0,2 MPa there are no considerable changes of the values of followed parameters, next measurements were therefore realized with pressures of the input energy over 0,2 MPa.
- working regime of the driving unit was simulated with the load up to 20 A, with input pressure 0,6 MPa, distance R = 90 mm, repeated regime with hold 25 sec with full pressure, Fig. 10, lift of the element was 72 mm. Limit value of the minimal lift 8 mm was reached in regime with the load 100 A with kept value of the input pressure and distance R = 120 mm, Fig. 11. For the given action element (sample No. 4) the measured values present the level of efficiency possibilities.

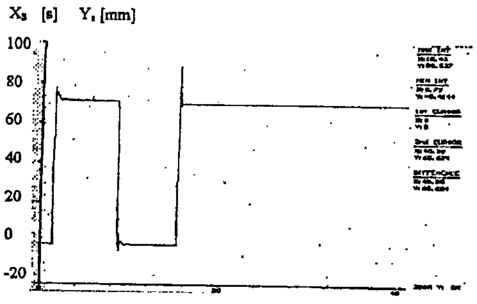


Fig. 10.

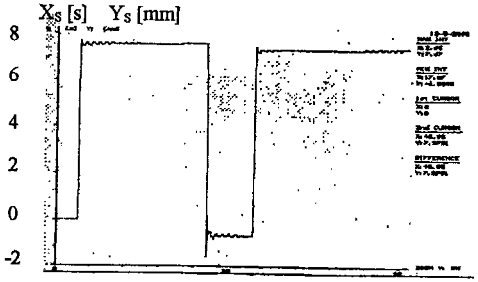


Fig. 11.

- the analysis of the results of measurements (set of measurements, 4 samples of action element) of the given relations allows to say that the pulling power F and the lift grow with the change of geometric composition of the action element in the box of the driving unit (dimensions V, A, B, R).
- efficiency parameters of the driving unit can be regulated by the number of action elements connected in the unit (creating two and more elemental sets).

CONCLUSION

Reached results confirm the recentness and technical reality of using the given principles of unconventional modifications of biodrive on the base of artificial muscles. The results also confirm (for linear movement module) that the efficiency parameters and working features of so constructed drive are usable in robot construction, mainly for the design of effector or movement modules with small lifts.

Next solution will be led by widened program of experimental measurements (variants of action element, variants of working conditions), program of detailed design of construction of linear and rotary module. Considering the variability of possible construction solutions of such a unit it is recommended to verify a concrete application by the test of chosen parameters.

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