STUDY OF MOTOR-DRIVEN INDUSTRIAL ROBOT WRIST

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Abstract

This report is devoted to study of conception of motor-driven wrist of industrial robots and manipulators. Research is focused on design of motor-driven wrist module aimed at increasing number of degrees of freedom of effector. Study includes varieties with serial, parallel and combined kinematical structure. All three concepts have at least three degrees of freedom; it handles always about three rotary motions. Increased number of degrees of freedom brings new possibilities of effector positioning, which also increases manipulability of whole positioning appliance and its use value.

Key words

motor – driven industrial wrist, robot, manipulator, effector, spherical joint

Introduction

This report is devoted to study of conception of motor-driven wrist of industrial robots and manipulators. Research is focused on design of motor-driven wrist module aimed at increasing number of degrees of freedom of effector. Study includes varieties with serial, parallel and combined kinematical structure. All three concepts have at least three degrees of freedom; it handles always about three rotary motions. Elaborated versions differ in solution of orientation end part. All designed versions have engines with positional feed-back, which is completely necessary for precious driving. Increased number of degrees of freedom brings new possibilities of effector positioning, which also increases manipulability of whole positioning appliance and its use value.

Analyze of possibilities of positioning in space and their realization

General position of an object in space described with Cartesian coordinate system is defined with position (x, y, z) and orientation (φ_x, φ_y, φ_z). The study focuses on conception of

motor-driven industrial wrist that is why the accent is put on the change of position by the change of an object orientation. Designed solutions must have surely a feed-back.
Any required orientation of an object in space can be achieved by the change of independent parameters (φ_x, φ_y, φ_z), i.e. by the rotation around the coordinate axes x, y, z. The change of position we can realize with the change of tree independent parameters φ_x, φ_y, φ_x. During the design this solution of movements was considered as the best one - both by reason of design simplicity, small external size and complex solidity of the design.

Description of particular solutions and classification its possibilities

This chapter describes various design approaches in the analysis of motor-driven wrist. Variants of virtual prototypes were designed in a simply form, i.e. without implementation of fasteners and cable management. Although some basic parts were not designed, they were considered and the design was adjusted to the recess of fastener and the place for power supply and data cable management was considered as well.

The description of each version includes a kinematic chart, a dimensional parameters and a shape of working surface. The general projection and the description of each part and the setting out of external proportions are accompanied with the ISO projection of the whole motor-driven industrial wrist. Each study includes a table of technical specification. The value of torque Mk_i corresponds to an appropriate displacement φ_i.

Version A
This conception of a wrist uses a parallel kinematics structure – tripod, which is supplemented with a central spherical joint and an integrated servo drive enabling a rotation of the whole wrist to a border. The figure No.1 shows a simplified chart of kinematic structure. The rotation φ_1 is ensured with an installed digital servo drive of a range of movement 180°. The rotation φ_2 and φ_3 is realized with three linear drives. The range of movements of φ_2 and φ_3 is restricted to maximal displacement 30°, which is caused by restricted mobility of spherical joint.

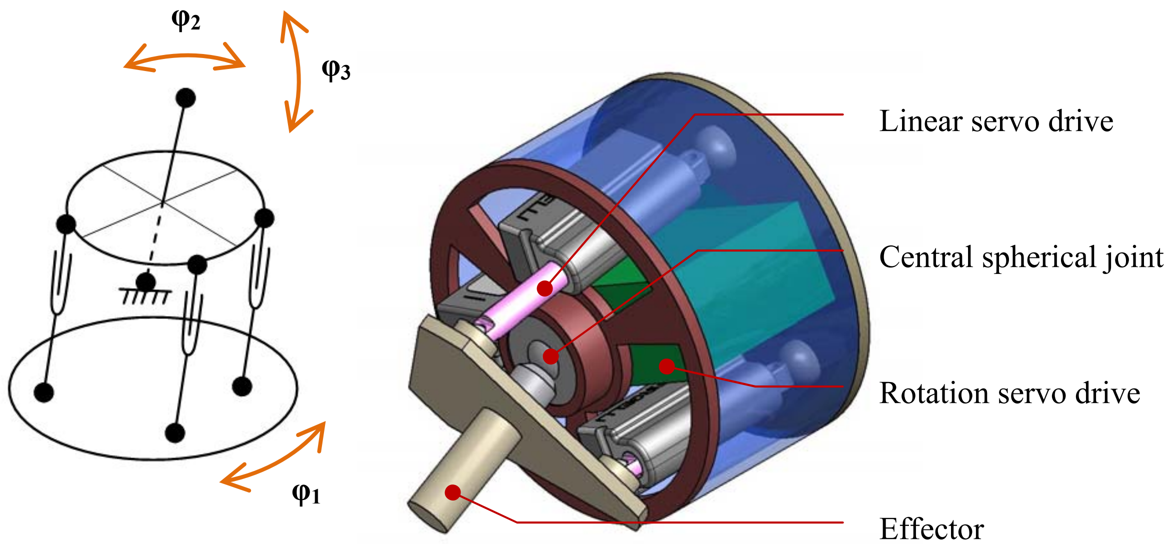


Fig. 1. *Kinematic structure, ISO projection of a motor-driven wrist A*

The duralumin border ensures security of drives and presents a sufficient consistency. The figure No.2 shows the proportion of this version, the shape and the size of working surface of the end part.

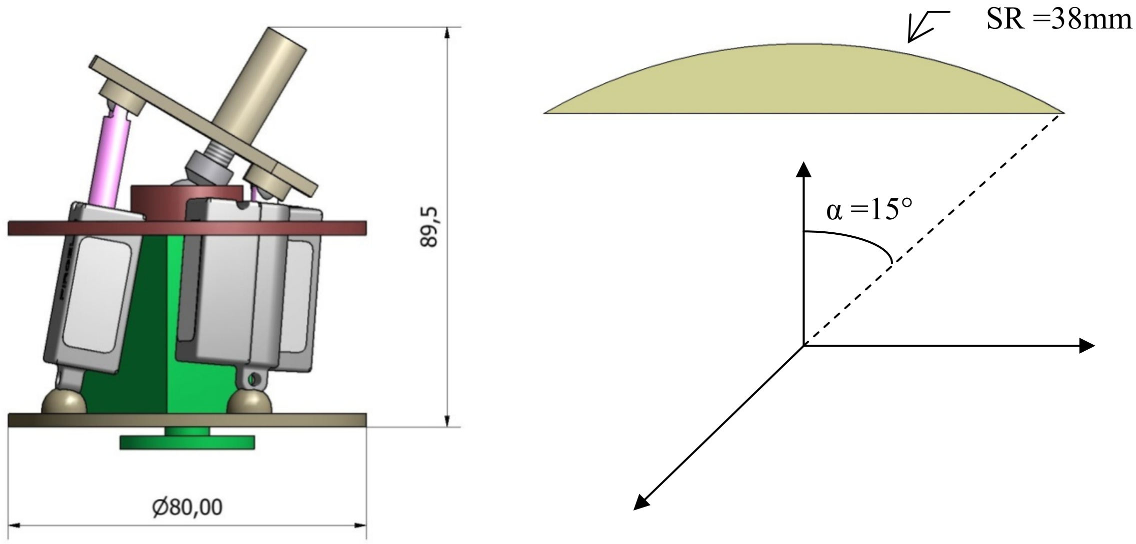


Fig. 2. *Proportional chart of vision A, working surface of end part of version A*

Table 1 shows technical parameters of a motor-driven wrist of version A. The data have only informative character about the size of this wrist and its force parameters.

TECHNICAL PARAMETERS OF VERSION A Table 1

Parametr	**Signification**	**Value**	**Unit**
Hight	V	**95**	mm
Width	Š	**80**	mm
Depth	H	**80**	mm
Torque	Mk1	**1,2**	Nm
Torque	Mk2	**1,2**	Nm
Torque	Mk3	**1,2**	Nm
Range of movement	φ_1	**180**	°
Range of movement	φ_2	**30**	°
Range of movement	φ_3	**30**	°
Weight	m	**0,5**	kg

The design uses advantages of a parallel kinematics, i.e. high consistency and loading limit at low own weight.

The range of movement is considerably restricted, because of the design of a central spherical joint. To produce this prototype according to this version, it is necessary to solve the design of miniature spherical joints with the necessary range of movement.

Version B
The conception of this motor-driven wrist is based on a kinematic structure of an universal joint, the chart is shown on the figure No.3. The rotation of φ_1 and φ_3 is ensured with step drives, the rotation φ_2 is realized with digital servo drive. The range of movement φ_1 is restricted to the dislocation of 360°. The turning of the end part φ_3 is not restricted. The maximal dislocation φ_2 gather the value 90°, which enable to set any general orientation of the object in a selected semispace, see figure No.3.

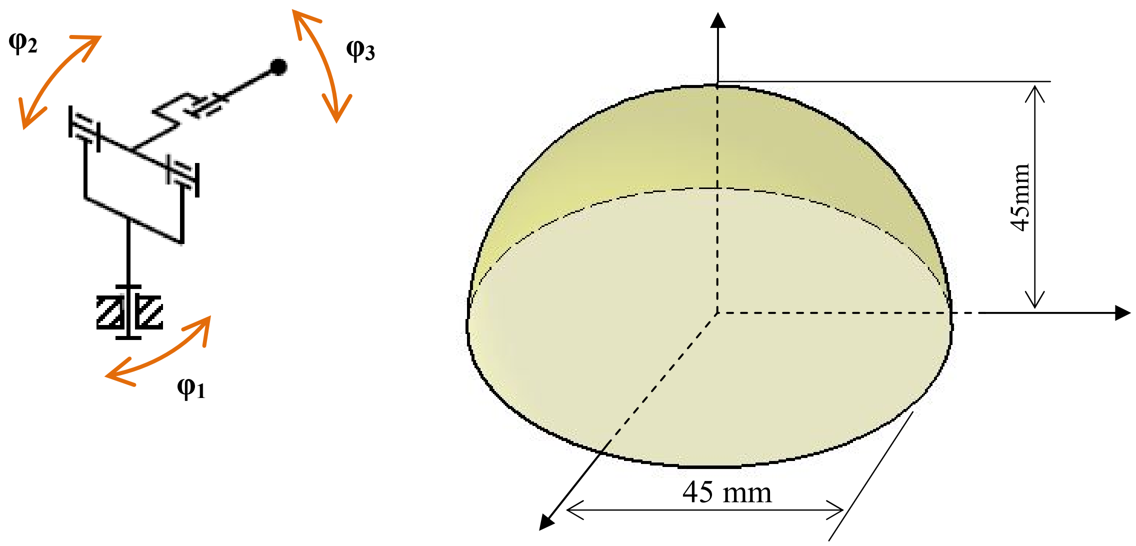


Fig. 3. *Kinematic structure; working surface of end part of version B*

The virtual prototype of version B with a description of main parts is shown on figure No.4. Compact proportions of the whole motor-driven wrist are affected from one side by a servo drive ensuring the rotation φ_2. The duralumin border ensures a sufficient protection of drives and shows sufficient consistency.

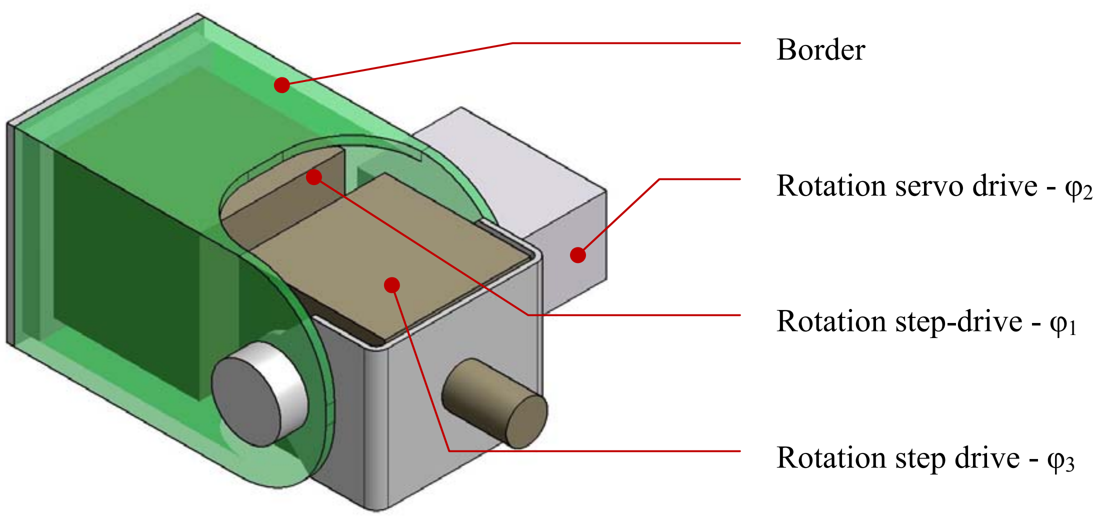
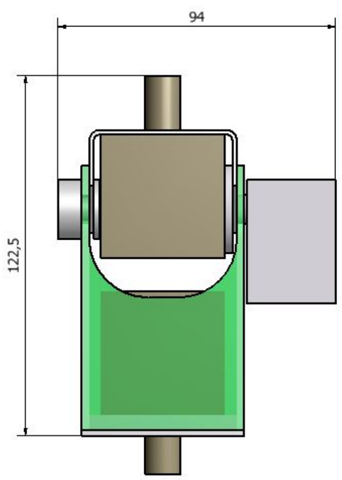


Fig. 4. *Virtual prototype of version B – ISO projection*



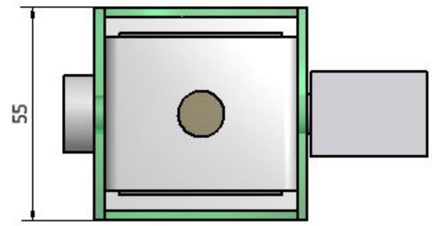


Fig. 5. *Proportional study of version B*

Table 2 shows technical parameters of a motor-driven wrist of version B. The data have only informative character about the size of this wrist and its force parameters.

TECHNICAL PARAMETERS OF VERSION B Table 2

Parametr	Signification	Value	Unit
Hight	V	**122,5**	mm
Width	Š	**94**	mm
Depth	H	**55**	mm
Torque	Mk1	**1,2**	Nm
Torque	Mk2	**1,2**	Nm
Torque	Mk3	**1,2**	Nm
Range of movement	φ_1	**180**	°
Range of movement	φ_2	**30**	°
Range of movement	φ_3	**30**	°
Weight	m	**0,9**	kg

Version C

The conception of this motor-driven wrist is based on a kinematic structure of an universal joint, the chart is shown on the figure No.6. The rotation of φ_1 and φ_3 is ensured with step drives, the rotation φ_2 is realized with two linear drives. The range of movement φ_1 is restricted to the dislocation of 360°, because of power supply. The turning of the end part φ_3 is not restricted. The maximal dislocation φ_2 gather the value 90°, which enable to set any general orientation of the object in a selected semispace, s. figure No.6.

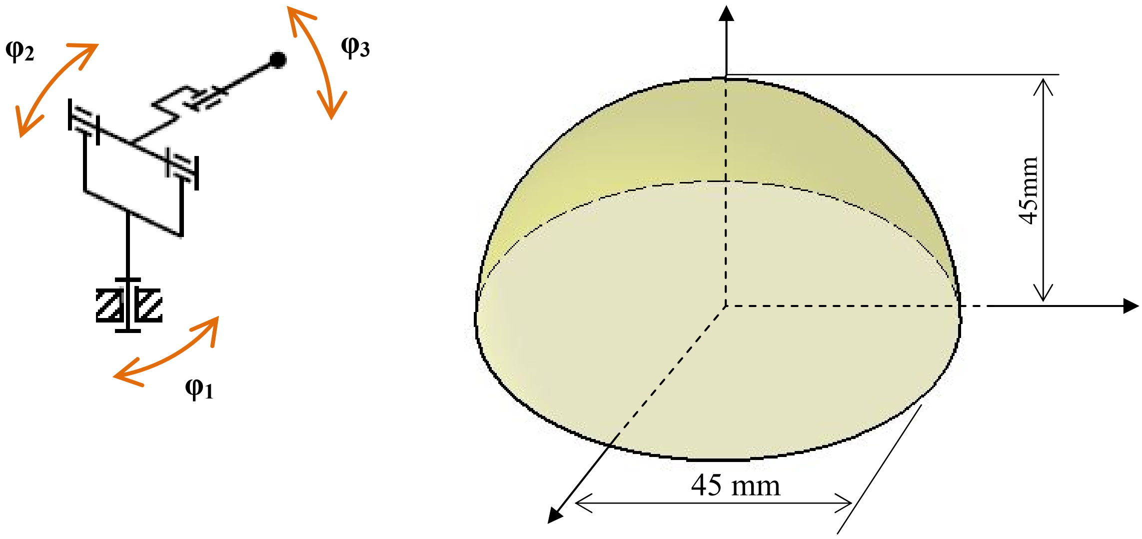


Fig. 6. *Kinematic structure; working surface of end part of version C*

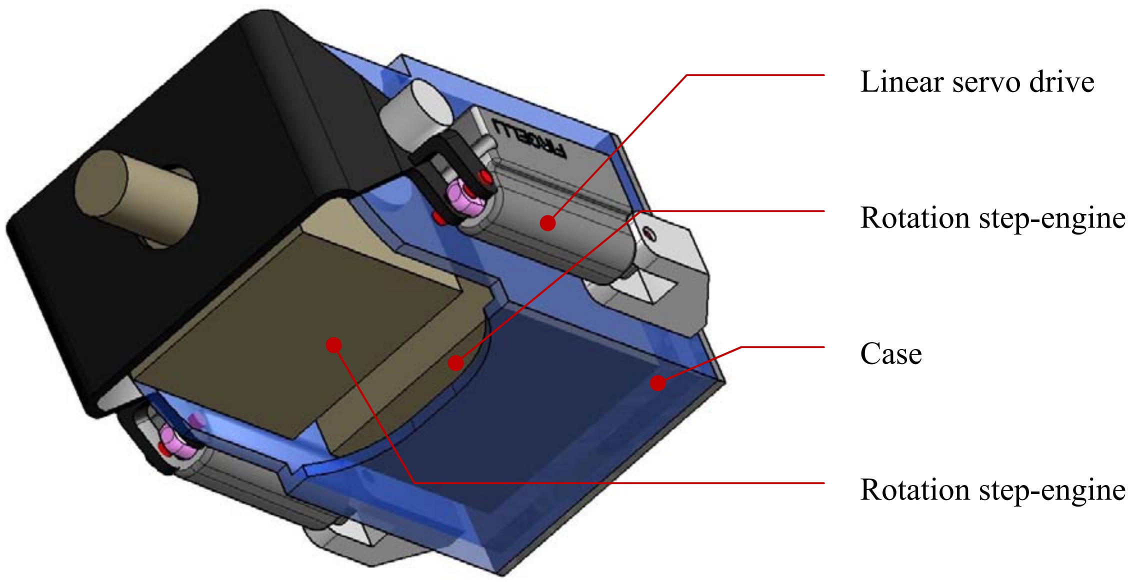


Fig. 7. *Virtual prototype of version C – ISO projection*

The duralumin border ensures a sufficient protection of drives and shows sufficient consistency. The location of linear drives balanced on both sides of the border minimally increases external proportions of the motor-driven wrist and keeps the solidity of the whole design.

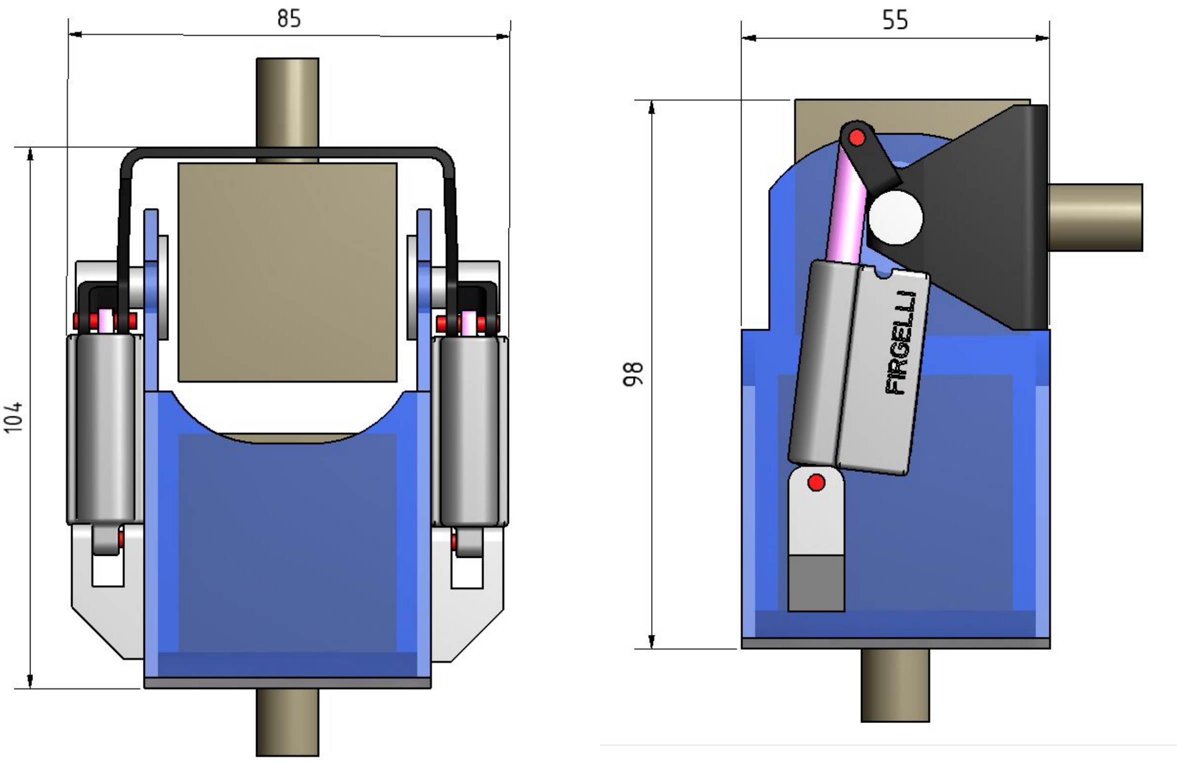


Fig. 8. *Proportional study of version C*

Table 3 shows technical parameters of a motor-driven wrist of version C. The data have only informative character about the size of this wrist and its force parameters.

TECHNICAL PARAMETERS OF VERSION C Table 3

Parametr	**Signification**	**Value**	**Unit**
Hight	V	**124**	mm
Width	Š	**85**	mm
Depth	H	**55**	mm
Torque	Mk1	**1,2**	Nm
Torque	Mk2	**1,2**	Nm
Torque	Mk3	**1,2**	Nm
Range of movement	φ_1	**180**	°
Range of movement	φ_2	**30**	°
Range of movement	φ_3	**30**	°
Weight	m	**0,9**	kg

Conclusion

All described versions of this study shape a real direction of development of motor-driven industrial wrists and manipulators. Particular concepts have their perfections but also restrictions. The consideration of suitability of application of one of designed versions and it is following research depends on in advance stated requirements and working conditions. A very important parameter for the election of a suitable prototype of a wrist is still the weight of a manipulated object and required dynamic features of the whole kinematic chain.

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