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THE DESIGN OF TRAINING HEXAPOD

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ABSTRACT
This paper informs about design and construction of mechanism with parallel kinematic structure with six degree of freedom at Department of Machining and Automation at University of Žilina. Inverse kinematic analyse is used in parallel kinematic structures design. Hexapod simulation software was developed. Designed algorithm was used for calculation of the length values of active legs during moving in real time.
Keywords: *parallel kinematic structures, hexapod, simulation software*

1 INTRODUCTION

Over the last years high development automation and robotization has been coming, mainly in the department of automobile industry in the Slovak Republic and generally in engineering industry. Effort to continue raising productivity of labour and enhancement the production process is laying large request for new, progressive technology. CA technology, flexible production systems and new generation of cutting machines, that are raising quality of products and reducing production time and financial charges, are implementing to practice increasingly.

High speed cutting and automation of manufacturing lines are presenting mainstream in current development of cutting machines, robotics and automated workstations. Raising the speed of working cycle raises the pressure and requirements on construction and configuration of working cells, equally also statically and dynamically stiffness, temperature stability and precision. Reduction mass of moving machine units on minimum is necessary to achieve high dynamic carrying capacity of the machine. This request is complete by machines with parallel kinematic structure. Complicated control of parallel mechanism is the heavy obstruction for putting machines with parallel conception to the machine industry. Request for qualitative software and hardware equipment of the control system is necessary condition for effective control of the process of those structures. Progress of electrical engineering and information technologies brought the possibility to develop it on various universities and apply it to the industrial praxis. This architecture has been applied in more areas of industry and thereby increased the production process successfully.

2 PARALLEL KINEMATIC STRUCTURES

Parallel kinematics structure is mechanism with closed kinematical chain, which consists of the base, platform and at least two reciprocally independent leading legs. Leading chains are also ordered parallel towards base and platform. Arrangement of kinematical chain of parallel kinematic machines is more varied compared to serial kinematics. For that reason parallel kinematics are usually presented in the specialized literature through typical construction with six degree of freedom, which is called hexapod.

Parallel kinematic structure is a closed-loop mechanism in which the end-effector is connected to the base by at least two independent kinematic chains. A fully-parallel manipulator is a closed-loop mechanism with n degrees of freedom, end-effector is connected to the base by n independent chains which have at most two links and are actuated by a unique prismatic or rotary actuator.

Hexapod is mechanism, which is compound by the six parallel arranged legs with variable length, whose are connecting base with platform. All connections between base, legs and platform are realized by universal joints. Considering to this arrangement platform has six degree of freedom, what allows her sliding in axis: x, y, z and rotation around those axes. Final motion of platform is set up by contemporary change of lengths of all legs. It follows that, motion of one leg evocate spatial and angle position of platform in all axes. Those behaviors are modal for all parallel kinematics. Machines with parallel kinematics structures are characterized as nonlinear three-dimensional system not respecting superposition principle of fractional movements [1].

3 TRAINING HEXAPOD DESIGN

The school hexapod is developed at University of Žilina (Slovakia) at Department of Machining and Automation. Kinematic structures: to fully describe the position and orientation of the 6 degree of freedom (DOF) platform of the hexapod manipulator, six co-ordinates are needed. Three of them are positional displacements that define the position of a reference point for the platform with respect to a fixed co-ordinate frame. The other three co-ordinates are angular displacements that define the orientation of the distal platform. We define generalised Cartesian space co-ordinates **p**, whose elements are the six variables chosen to describe the position and orientation of the platform, as **p** = f ($x, y, z, \varphi, \theta, \psi$).

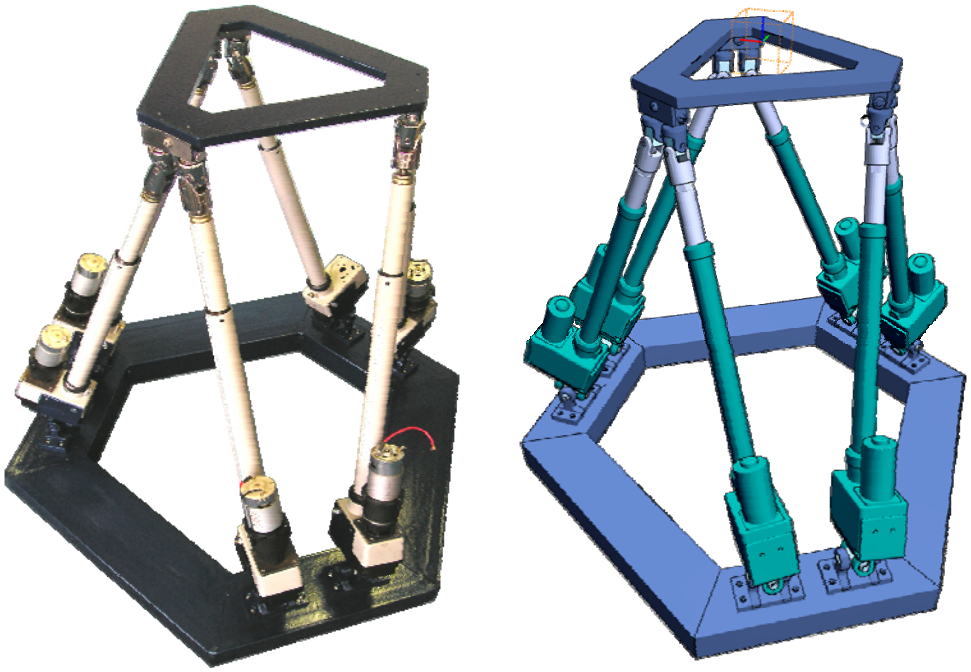
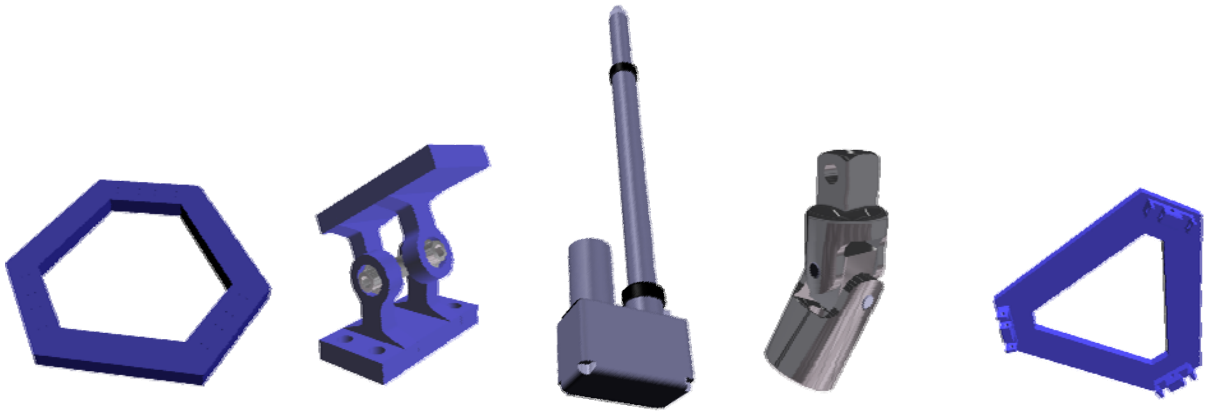


Figure 1. Built construction and computer model of training hexapod

Parameters of school hexapod:

- DOF : 6 °
- Dimensions a x b x c : 700x600x600 [mm]
- Weight : 40 kg
- Max. angle of platform rotation Ux : 30 °
- Max. angle of platform rotation Uy : 30 °
- Max. angle of platform rotation Uz : 30 °
- Max. operating space X-axis : -50 - +50mm
- Max. operating space Y-axis : -50 - +50mm
- Max. operating space Z-axis : 0 - +100mm

Mechanism has following parts: fixed base, moving platform, six legs with six drive unit, six Cardan joints for junction of legs and fixed base, six Cardan joints for junction of legs and moving platform.

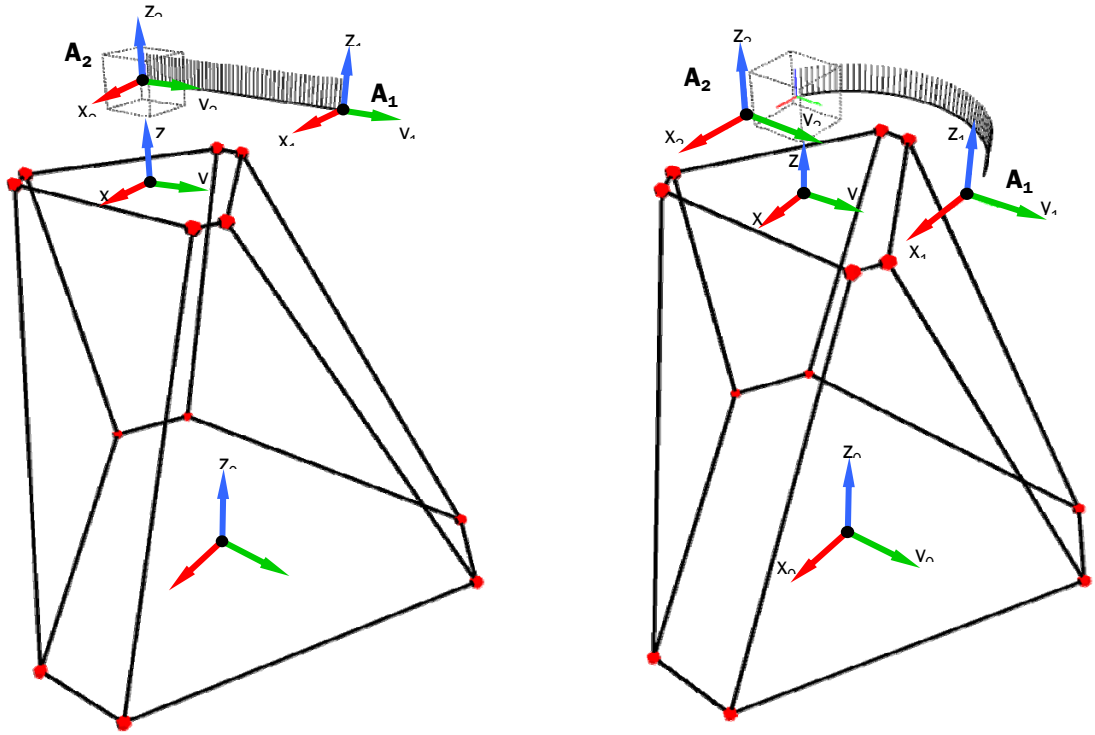


a) *b)* *c)* *d)* *e)*

Figure 2. Parts of training hexapod: a) fixed platform (base), b) lower Cardan joint, c)leg with drive, d) upper Cardan joint, e) moving platform of hexapod

3 HEXAPOD KINEMATIC UNIT MOVEMENT CALCULATION

Movement of tool centre point is realised by changing of length and space orientation of all mechanism legs. Realisation most simply movements needs coordinate cooperation all six legs too. Calculated length values of mechanism legs are operated in control system and are sent to power unit in periodical time interval.



a) *b)*

Figure 3. Linear (a) and circle(b) interpolation in plane XY

4 HEXAPOD SIMULATION SOFTWARE

Computer simulation of school hexapod structures is used for study on its model. Systems action is defined as relation system for transformation of parameters from input and status space to parameters in its output and status space.

Important for mechanism simulation is information about dimensions and forms its kinematic chains and joins, presentations of position its elements.

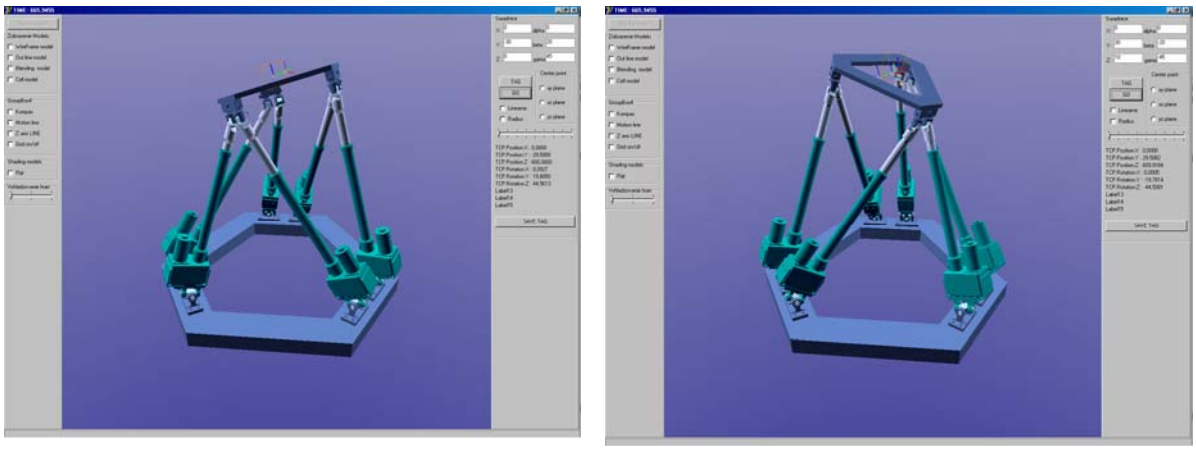


Figure 4. Hexapod computer simulation

5 CONCLUSIONS

PKS development is short – run compared with long – run machinery development with serial kinematic structure. Whereupon it is possible to expect, that in the future will arise more and more projects supporting PKS research.

Due to common interest in obtaining information about development of new technologies in mechanical industry, was realized idea of creation mechanism with parallel kinematics and design simulating program which enables analyze mechanism of hexapod.

Hexapod construction and simulating software can be used as teaching aid for better understanding of parallel structure behavior and also as inspiration for next innovations and improving hardware part of control system.

6. ACKNOWLEDGEMENT

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