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Modularity of PRM type cartesian robots and their application in the production of construction materials

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Abstract

The paper deals with the modularity and application of *PRM* robots derived from the *PRKM* set of robots which have been developed by the Technical University of Brno in co-operation with the Research Institute of Construction Materials, Brno. Specification are provided for the robots and their manufacturing operations outlined.

1. PRM ROBOTS

Eight years ago the Department of Production Machines and Industrial Robots was asked to develop a variety of manipulators for applications in the construction industry. Modularity of the robots (both in their dimensions and the load capacity), robustness to prevent failures in harsh conditions, and user friendliness in their programming were the features specified as necessary for their successful application.

Analysis of the problem led to the conclusion to design three types of robots: a Cartesian bridge type, *PRM*, a Cartesian portal type, *PRKMJ*, and an anthropomorphic angular type, ALR, with 6 rotational kinematic pairs.

In 1986, the *PRKM-20* robot was introduced at the international exhibition 'ROBOT 86' in Brno. It was designed for a nominal load capacity of 20 kg and working envelop of 3510 mm x 865 mm x 880 mm. Its intended field of application was manipulation. The next type of robots were derived from this type by multiplying its dimensions by $q = 1.26$ (except its movement modules, where the product typisation was needed). In this series, the *PRKM-20* robot is the 5th one according its dimensions.

Building on the experience gained with the previous type, the bridge-like Cartesian robot, *PRM*, was designed in collaboration with the Research Institute of Construction Materials, Brno. Its 4 dimension variants are listed in Table. 1.

The basic version of the *PRM* robot is the *PRM 55* type with a load capacity of 55 kg. From this one, the next variants are derived by multiplication by $q = 3.6$ in the nominal load

capacity, and by multiplication by q = 1.7 in dimensions. The movement parameters are influenced by the need for unification of the displacement elements, the racks. The bridge conception was used to increase the load capacity of the robot. Two portal robots created the bridge for the transversal displacement. The cross beam, moving along the extremely long portals, can be doubled to reach the higher stiffness. The drive is created by the rack and pinion worm gear unit at each single portal and the basic version of the *PRKM-20* robot is driven by stepper motors. This robot was introduced at the 'ROBOT 90' international exhibition in Brno (see Fig. 2). According to the drive type used, the displacement speeds are between the limits of 0.3 $m.s^{-1}$ and 1.0 $m.s^{-1}$ on the longitudinal and transversal axes and 0.05 $m.s^{-1}$and .3 $m.s^{-1}$ along the vertical axis.

The industrial robot *PRM 200* differs from the previous types in respect to its DC drives, 200 kg nominal load capacity and maximum speeds. In the horizontal plane this is 1.0 $m.s^{-1}$ and in vertical direction 0.5 $m.s^{-1}$. The motion is realised with the aid of pinion and rack worm gearing. In the longitudinal direction the motor is located at the single portal only and both worm gears are mechanically joined by the common shaft to prevent the twisting during travel.

The industrial robot *PRM 2000* is a similar concept to the PRM 200, but having a 4th degree of freedom giving 360° rotation about the vertical axis to improve its capability. For high axial and radial load capacity the X-type roll bearing is used in its construction. Mezomatic type DC servo drives of are used. Its control system, *NS 905,* will be soon replaced by an industrial PC computer.

2. APPLICATIONS

The bridge-like robot *PRM-55* is applied in robotised technology cell producing painting materials of Superlex type in the company Keramicke Zavody Karlovy Vary (Ceramics Karlsbad), Czech Republic. The robot is equipped with the gripper with sucking adapters (see Fig. 3). Robot takes off the paper sheets from the feeding magazine and interleaves the palletised courses of Superlex cans. Robot uses the stepper motor drives and the 8 bit *NS 905* control system which is of Czech origin. This work cell has produced more than 6000 tons of the coating material for Superlex internal plaster. The application was selected to verify the technical features of the robot and its real resistance against the harsh environment conditions.

Today the robot *PRM 200* is being prepared for an application at the Ceramics Teplice Company, where manipulation with the construction semi-products by sucked materials is to be automated. The robot will transport the shaped bricks between the moulding machine and dryer, and will palletise the dry shaped bricks.

3. THE FUTURE

A series of anthropomorphic robots, *ALR,* is under the construction, with 6 degrees of freedom (rotational kinematic twins). These robots are to be applied in both the manufacturing and construction industries for manipulation with the smaller loads, final operations etc. An industrial PC control system is to be used with the analysis, synthesis and motion simulation prepared in the C++ language. The analysis and synthesis is completed by interpolations and an additional swing movement for special applications (like grinding

etc.). A simulation software package allows visualisation of the movement of the robot on the computer screen and shortens the preparation time necessary for implementation of the robot . It can be easily modified for robotic systems of the different types.

The following applications of the computer control are prepared: data transformation from the AUTOCAD module for projects of robotised work cells to the control program (motion module) in the C++ language for PC system with AC servo drive modules. Another prepared package uses logistics for the robotic control in the FMS with robots, with application of mathematical methods of analysis, modelling, optimisation and assessment of production and similar processes. The artificial intelligence elements in the knowledge and decision processes have been also studied.

CONCLUSIONS

A modular series of robots have been presented which have considerable potential in the manufacture of construction materials. They are established on a rational basis of dimension and capacity multiples. Their usefulness has been demonstrated in the commercial production of ceramic products.

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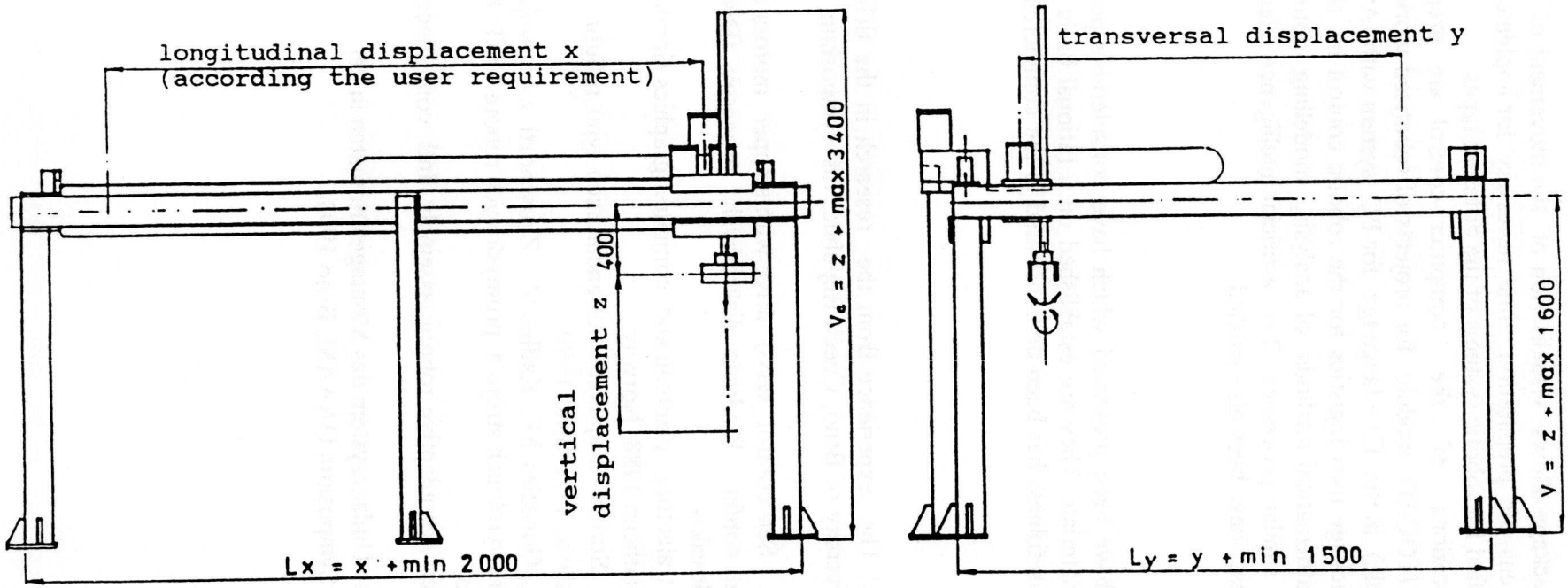
Bridge-like industrial robot PRM



nominal load weight m
operation space of the robot:
- longitudinal displacement x
- transversal displacement y
- vertical displacement z
accuracy of the head positioning: 1 mm

Fig. 1 Bridge-like industrial robot PRM

Table. 1. The PRM series - basic features.

	PRM 55	PRM 200	PRM 550	PRM 2000
x [mm]	3 000	3 000	5 000	8 000 and more
y [mm]	1 500	1 500	3 000	5 000
z [mm]	800	1 200	2 000	3 500
m [kg]	55	200	550	2 000

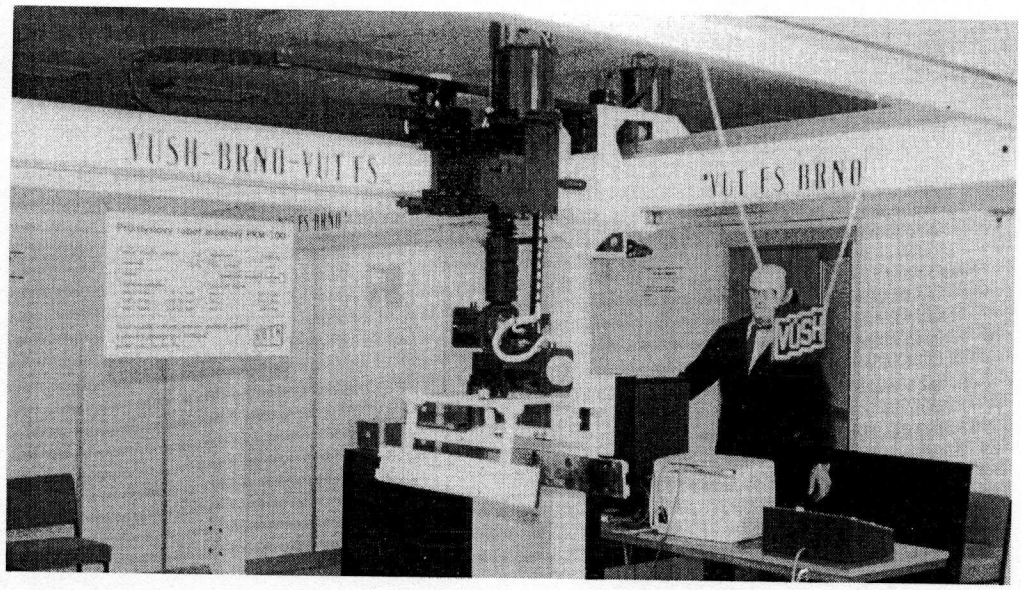


Fig. 2. Prototype robot *PRM-100* with the load capacity 100 kg in TU Brno exposition at the international exhibition 'ROBOT 90'.

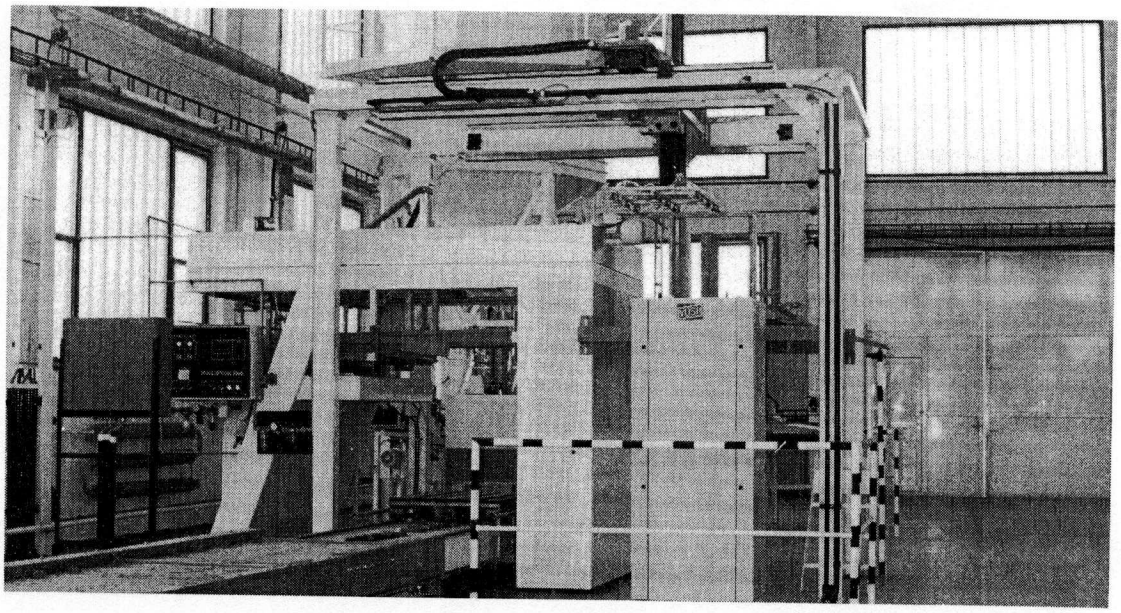


Fig. 3. Robot *PRM-55* application in the coating materials (plaster) production in Ceramics Karlsbad, Czech Republic