

## SIMULATION TESTS OF IRB6 ROBOT

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**Abstract:** Robots operated in industrial plants are characterised by out-of-date control systems. In the purpose of designing suitable control system, there must be carried out the simulation tests that provide to determine its kinematic features. The simulation tests presented in the paper were carried out in MATLAB environment. Part of this environment includes SimMechanics tool which is an environment for design and simulation of kinematic rigid members of machines and devices. Data concerning location of centre of gravity, masses and moments of inertia for blocks of SimMechanics tool were obtained in CATIA system.

**Keywords:** Simulation tests, MATLAB, SimMechanics, Industrial robot.

### 1. Introduction

The large part of industrial plants is faced with a problem of operated equipment modernisation. This issue also applies to robots. Operated robots have in principle sufficiently good power transmission systems, however, the control systems are out-of-date. Control Group of Faculty Mechanical Engineering is specialised in modernisation of analysing robots.

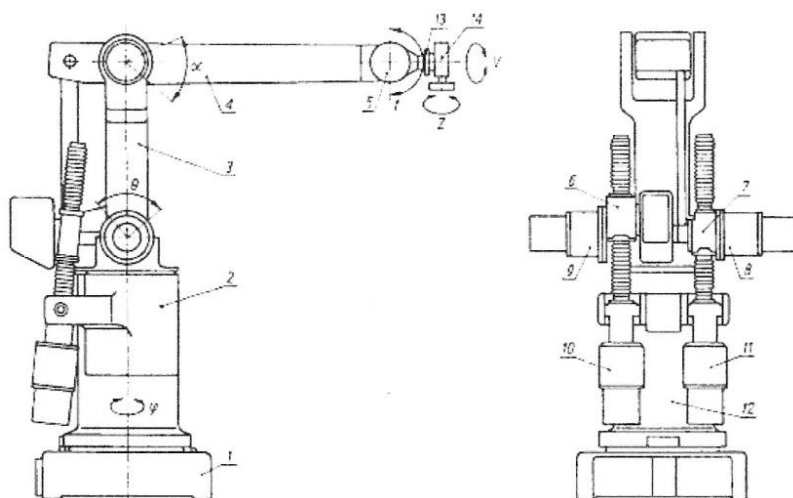


Fig. 1: Components of IRB6 robot: 1- base, 2 - body, 3 - arm, 4 - forearm, 5 – wrist, 6, 7 – working helical gear, 8, 9, 10, 11 – actuators, 12 – actuator for body rotation, 13 – flange, 14 end-of-arm.

The task of the research is IRB6 robot. Manipulation working parts of robot are presented in Fig. 1. They consist of base, body, arm, forearm and wrist ended by flange end-of-arm which is used for adjusting welding devices. Such design of segments provides to five degrees of freedom: rotation around the base, arm rotation, forearm rotation, wrist inclination, and flange end-of-arm rotation. Each motion of

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manipulation working parts are performed by actuators which include direct-current motors as well as driven gears and tie bars. Each motor also includes a transformer of angular position and rate generator.

The paper demonstrates the way of determining kinematic parameters of IRB6 robot by computer simulation method in SimMechanics tool.

## 2. Modelling the Geometry Components of Manipulator

Modelling the three-dimensional geometry robot (Jezierski, 2006; Morecki et al., 2002), showed in Fig. 2, was carried out by using V5R16 Catia system. It allowed obtaining data about centre of gravity locations, masses and moments of inertia for blocks of SimMechanics tool.

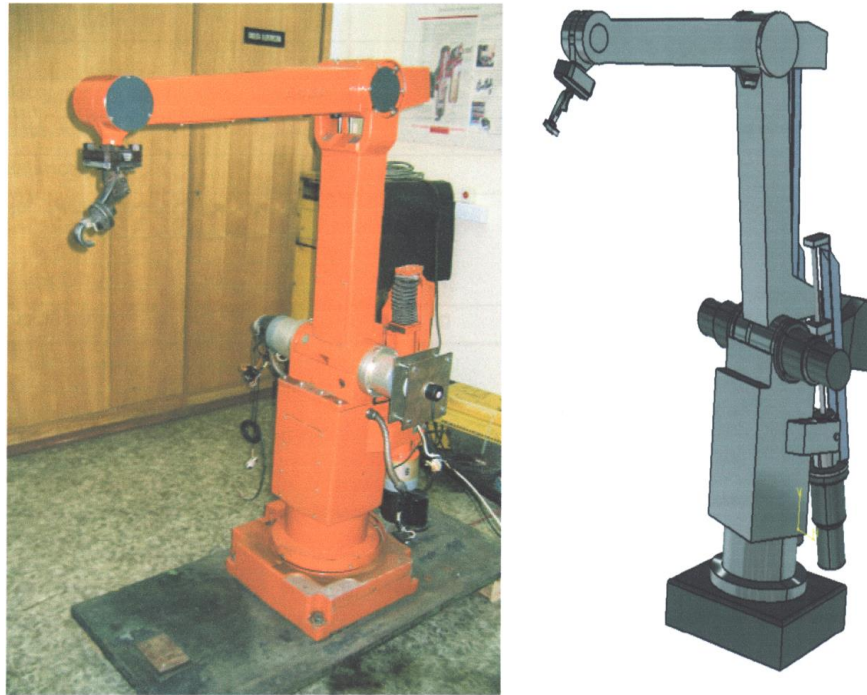


Fig. 2: Industrial robot and its three-dimensional model.

## 3. Simulation Tests

Simulation tests were carried out in MATLAB environment (Kozłowski et al., 2003). It combines calculations, visualisation and programming in an friendly environment to use.

SimMechanics tool is an addition to MATLAB environment. It is an environment for design and simulation of kinematic rigid elements of machines and devices using Newtonian analysis of force and moments, both directly and inversely. Simulations of mechanical systems can be modelled and carried out in SimMechanics. Blocks of this tool represent physical objects and their relations.

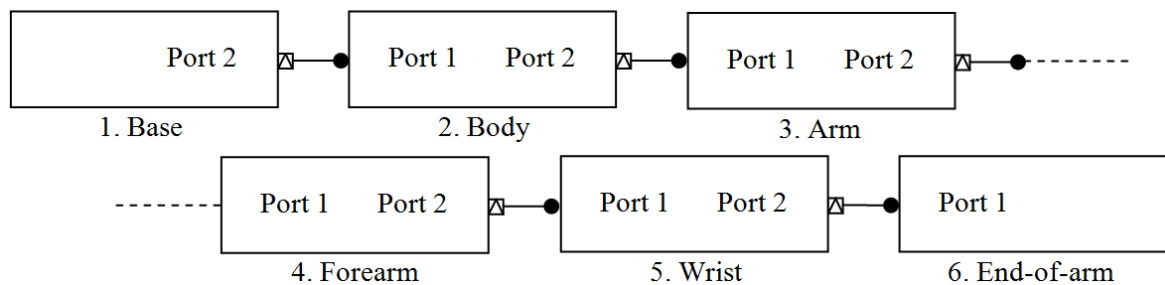


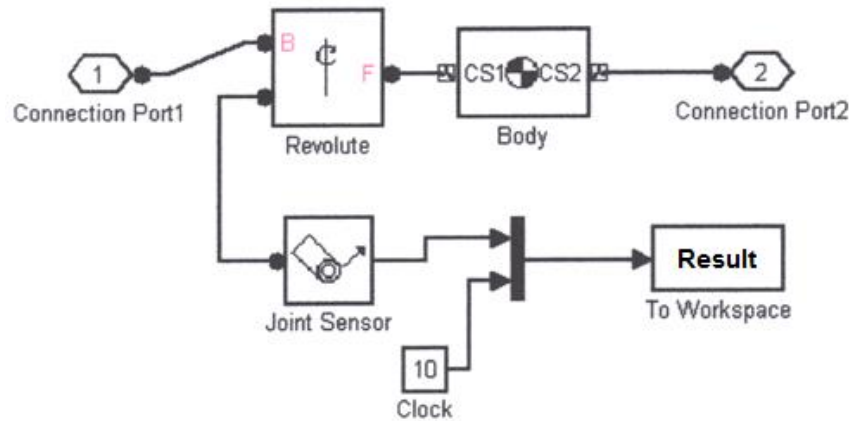
Fig. 3: Simulation model of IRB6 robot.

A model has two meaning in SimMechanics tool. One of them refers to physical object that contains at least one rigid component. The second one applies to a different and separate block. Each block represents one physical device. It means that a model can consist of one or many devices. A model

created in SimMechanics tool represents physical structure of a device, its geometric and kinematic relations which later is transformed into structural representation to inside and equivalent mathematic model.

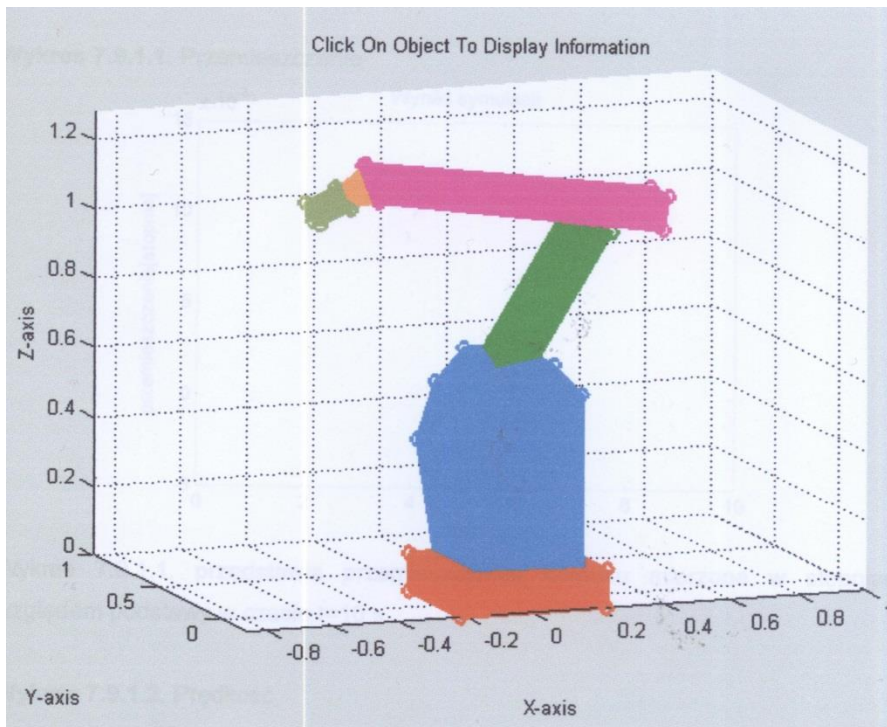
The various stages of modelling (Tarnowski & Bartkiewicz, 2003) in SimMechanics tool:

- selection of basis and connection of blocks,
- distribution of blocks,
- configuration of solids in the individual blocks,
- selection, connection and configuration of sensors and actuators,
- model connection (as a subsystem) into major model.



*Fig. 4: Flow chart of IRB6 robot body created in SimMechanics tool.*

Each block includes data regarding specific component. All of the blocks are connected by ports. The basis is connected only to the body, while the body has two connections, both basis and arm. The next parts are connected in the same way until the end-of-arm which is not connected to any other part. The following figure presents an example of body flow chart.



*Fig. 5: Three-dimensional model of IRB6 robot in SimMechanics.*

After entering all data in SimMechanics tool, the flow chart was obtained. The model, presented in Fig. 5, is in the initial position, i.e. in the way it was entered in the simulation. In the purpose of simplification of the model, motors that were installed on the body of actual object, were entered into the body block. Therefore, apparent lack of motors during the visualisation is not a mistake.

#### 4. Selected Results of Simulation Tests

After the simulation, the calculation results were obtained as graphs of displacement and speed of analysed robot parts. Selected results of tests are presented in Figs. 6 and 7.

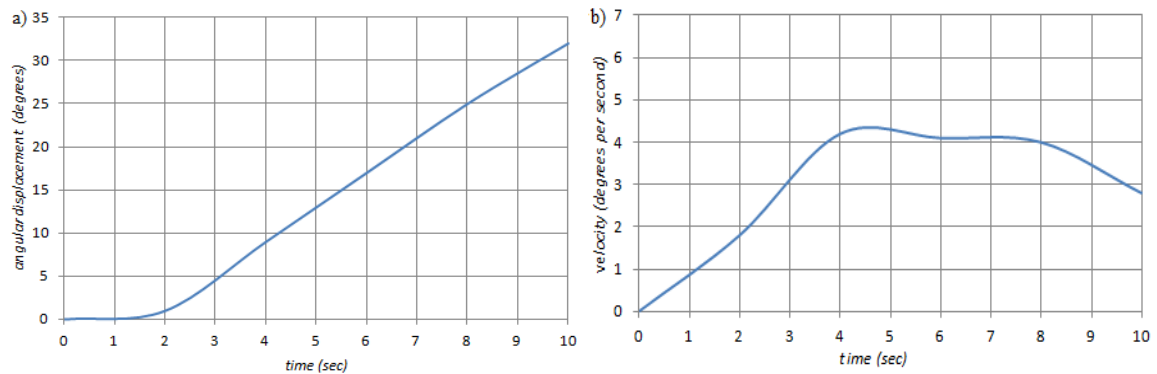


Fig. 6: Simulation of robot arm: a) angular displacement, b) angular velocity.

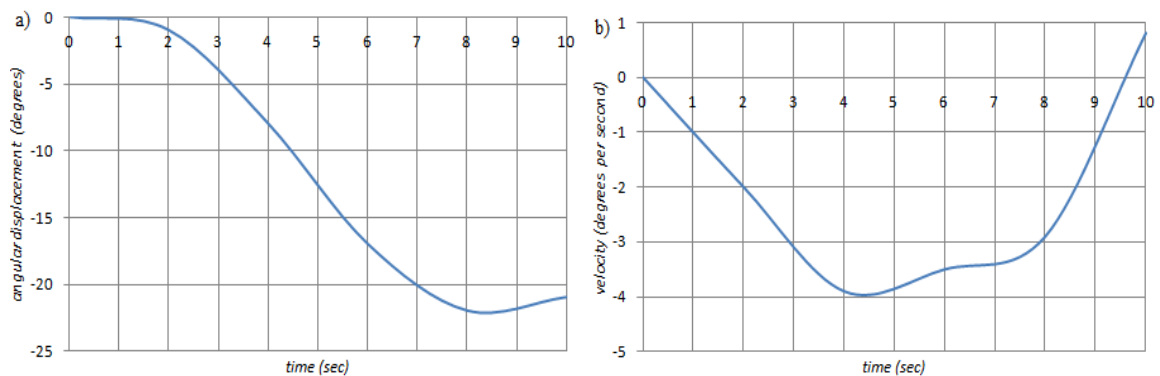


Fig. 7: Simulation of robot forearm: a) angular displacement; b) angular velocity.

#### 5. Conclusions

MATLAB environment as well as its tools, such as SimMechanics, Simulink, and SimDriveline, were used for the simulation calculations of kinematic properties. Those tools allowed building model of robot kinematic chain. On that basis, simulation model of IRB6 robot was obtained and provided to determine its kinematic features.

In the purpose of correct robot modelling, it was necessary to determine the parameters values such as mass, moments of inertia, centre of gravity, and overall dimensions. The aim was achieved by accepting the modelled values in CATIA V5R16.

Simulation calculations, presented in the paper, were used for further studies, which aim was to determine any trajectory of end-of-arm which reflects robot motions in practice (welding, painting) and then they were used for selection appropriate time constants of control system.

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