Analysis of the position of robotic cell components and its impact on energy consumption by robot

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Abstract. Location elements in the robot cell is very important must provide reasonable access to technological points. This is a basic condition, but it is possible to shift these elements worth considering over other criteria. One of them can be energy consumption. This is an economic parameter and in most cases its improvement make shorten the working time an industrial robot. In most conventional mechanical systems you do not need to consume power in standby mode only for a move. Robot because of its construction, even if it does not move has enabled engines and is ready to move. In this case, the servo speed is zero. During this stop servo squeak. Low-speed motors cause the engine torque is reduced and increases power consumption. In larger robots are installed brakes that when the robot does not move mechanically hold the position. Off the robot has enabled brakes and remembers the position servo drives. Brakes must be released when the robot wants to move and drives hold the position.

1. Introduction

It is easy to notice the little robot or modular robot [5, 6], which has no brake power is turned off sometimes are close to their position and sometimes fall freely. In the first case: torques from the forces of gravity are smaller than the mechanical resistance and tip the robot stays in place, in the latter torques of the forces of gravity are greater than the mechanical resistance and tip the robot falling down. This means that the servos need a different torque in a different configurations.

During the movement of the robot such differences are related. Additionally included is the movement of individual servo drives. Not all drives operate at the same time and at the same speed. It is possible trajectory, which reduce power consumption.

The same test was done on the robot Fanuc Arc Mate 100iB. This robot has brakes on each drive.

We conduct research in energy consumption while moving the robot and the results obtained helps us minimize energy consumption.

Figure 1 shows a robot connected to a special measuring equipment. The main component of the measurement system is a computer real-time National Instruments PXI Remote Controllers.
Very fast measurement card with integrated FPGA enables measurement of parameters of robot motion.

2. Static measurement.
First, measurements of static energy. The robot has been set in several positions, which measured the power on each engine.

Robot position as shown in figure 2 consumes the least energy of all analysed along the trajectory. Reduced consumption is only when all axes are vertical. The robot in this case is above the workplace. Such mounting requires the construction of special foundation robots. Today, most robots can work produced in this way but it requires additional sealing the first axis.
Robot position as shown in figure 3 consumes the most energy and the work of the drives is very unstable. Maintaining the position in such a situation is very difficult because of the power needed for this, and positioning accuracy. Robot in this situation corrects the position of the tip of a robot changing settings 2, 3, 5 axis. These movements are not visible to the eye but cause a very fast change of power cause vibrations [3, 4, 10].

3. Static measurement.
Most of the time the robot moves [15, 16] figure 4 and consumes more energy than the keeping position. The robot can perform two basic types of movements rapid and linear. For this reason, further analysis were taken of these two types of robot motion.

![Figure 3. The measurement of the power consumed by the robot on each axis. The gripper away from the axis robot.](image)

![Figure 4. Voltage and current consumption during the robot motion on each axis.](image)
In order to achieve the same motion parameters are programmed with the same trajectory but other types of movement. Is set to the maximum value achievable velocity in the movement. It is important to note that the linear movement velocity is much lower because the robot trajectory has to be divided into smaller sections and perform many more calculations.

To be more clear charts waveforms are shown in one axis on a single wire, in fact, is the axis 32. The selected graphs 2 and 3 the axes are the greatest changes because they are horizontal and perpendicular to the robot arm. One of the components of the load torque, these drives are moments derived from the forces of gravity.

The first line includes charts obtained during the move away from the axis of the robot gripper. In the second lines are graphs obtained during the return. Charts on the left side are graphs of voltage changes and on the right are the curves of changes in current.

![Figure 5](image1.png)

**Figure 5.** Voltage and current consumption during the robot motion on one axis.

The joint movement of the robot.

![Figure 6](image2.png)

**Figure 6.** Voltage and current consumption during the robot motion on one axis.

The linear movement of the robot.

Figure 5 shows voltages and currents in the joint motion robot. In this case easily notice the typical voltage regulation in the form of a ramp. At the beginning of the voltage increases linearly to a maximum value, then maintains its value before the end of the movement voltage linearly decreases. The graphs of current change can be seen that the gripper is further from the axis of the robot, the greater the current.
Figure 6 shows changes in the voltage and current in the linear movement of the robot. In this movement voltage value is dependent on the distance of the gripper from the axis of the robot. The current in both directions is a similar plot.

4. Beginning of movement and emergency stop.

![Figure 7. Voltage and current consumption during start the robot motion on one axis.](image1)

Figure 7 shows the start-up of the drive voltage and current. On both these graphs visible moment, shut down the brakes and start the drive. Because starting point was close to the axis of the robot parameters are small.

![Figure 8. Voltage and current consumption during overload robot (emergency stop)](image2)

Figure 8 shows the voltage and current at the time of collision. Easy to see the time off robot.

5. Conclusions

Energy consumption by the robot depends on its configuration. When the trajectory points are far from the axis of robot power consumption is higher. If possible, put these points closer.

This is a continuation of work related to the design of robotic cell [1, 2]. It can also be used when designing the trajectory [13, 14] of robot but also for modelling and simulating robot in CAD [7, 8]. The use of more accurate models will refine models of production management [11, 12].

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