Chapter 5
Kinematic Modelling and Simulation of 8 Degrees of Freedom SCARA Robot

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ABSTRACT

Robots are electromechanical systems that need mechatronic approach before manufacturing to reduce the development cost. In this chapter, the modelling of the 8 degrees of freedom (DOF) SCARA robot with a multiple gripper using SolidWorks CAD software and the dynamic study with the aid of MATLAB/SimMechanics is presented. The SCARA with multiple gripper is used for pick and place operation in manufacturing industries. The SolidWorks CAD model of SCARA with multiple grippers is converted into SimMechanics block diagram by exporting the 3D CAD model to the MATLAB/SimMechanics second generation technology environment. The motion sensing capability of the SimMechanics is used for determining the dynamic parameters of the manipulators. The SimMechanics block diagrams and the results of the dynamic study presented in this chapter infer that the structure of the robot can be changed to get the required dynamic parameters.

INTRODUCTION

The SCARA (Selective Compliance Articulated Robot Arm) is a extensively applicable robot manipulator in this industrial developed age. It is a popular configuration with RRP (Revolute Revolute Prismatic) structure with four degrees of freedom. It has two revolute and one prismatic joint. The gripper is attached to end of the prismatic arm.The prototype of SCARA robot is introduced in the year 1978 in Japan (Siciliano & Khatib, 2008). SCARA is compact and the working envelopes are relatively limited. Today SCARA robots are very widely used in manufacturing industries for its high speed, short cycle time, advanced control for path precision and controlled compliance to perform the necessary light duty

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tasks to achieve high flexibility, dexterity and productivity. Few light duty applications of SCARA are: product inspection, touch panel evaluation, conveying masks for wafers, Screw tightening, stacking electronics components, and inserting components in printed circuit boards, tapping, and chamfering, deburring, drilling, welding, soldering, gluing, packing, loading and unloading parts of an automated line.

BACKGROUND

Nowadays automotive industries are utilizing SCARA robots for handling the body works, engines, chassis, and other components (Jazar, 2009). The flexibility in workspace and the usage of multiple tool is very essential for the above task. This can be achieved by the redundancy in the design of the manipulator. The SCARA with redundant characteristics can be achieved by kinematic modelling of the configuration followed by dynamic study with the help of simulation environment in aid with CAD modelling tools. Rehiara (2011) worked and authored an article explaining the forward kinematics and inverse kinematic approach to find the position of the SCARA robot end effector position using D-H convention and corresponding transformation matrices. Spong, Hutchinson and Vidyasagar (2005) explained the forward and inverse kinematics of various robot configurations, including SCARA comprehensively in his publication. Hernandez, Bravo, de Jesus Rubio and Pacheco (2011) studied forward and inverse kinematics for SCARA, Cylindrical robot with four degrees of freedom to find the end-effector position and orientation which is applicable for TIG or MIG welding. The researchers like Wijesekara Arachchige and Salem Abderrahmane (2013) worked on reconfigurable end effectors. The SCARA robot was reconfigured from 4 DOF to 6 DOF. The state of the joint was selected by the motion of the end effector, and the constraints. This methodology is applied to the SCARA robot manipulator to improve its last joint capability. The researchers replaced the last joint with new reconfigurable joint and robot kinematic theory is applied for model evaluation. Patel and Sobh (2014) made a comprehensive study of manipulator performance measures that are very essential to design and study the applications of robotic manipulators. The kinematic indices, manipulability indices and important performance parameters are referred in his chapter to develop a robot with improvised configuration. These researches facilitates the development of new kinematic model for the SCARA robot with multiple tool which is mentioned in this chapter.

Fang and Li (2013) observed and verified the correctness of the SCARA robot model problem in terms of motion of each joint. The researchers used the kinematic modelling and simulation techniques. Alshamasin, Ionesco and Taha Al-Kasasbeh (2009) developed a complete mathematical model of the SCARA robot which includes servo actuator dynamics and presented together the dynamic simulation in the research. The forward and inverse kinematics equations are derived by using D-H convention. The researchers Ionescu, Chojnowski and Constantin (2002, 2007) proposed that simulation is important for robot programmers in allowing them to evaluate and predict the behaviour of a robot, and in addition to verify and optimize the path planning of the process. Michel (2004) emphasized in his chapter the need and the application of modelling and simulation software's to predict the accuracy and computational efficiency of the manipulator dynamics. Zlajpah (2008) found that the simulation facilitates designing visualization, testing robots and solve many problems before making it a reality. Al Mashagbeh and Khamesee (2015) developed a multi-body model of four degrees of freedom SCARA for pick and place application using MapleSim software and evaluated the robot performance. Wood and Kennedy (2015, April 24) presented the mathematical and software developments needed for efficient simulation