Chapter 8
Analyses on Engineering Mechanics of Robotic Arm for Sorting Multi-Materials

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ABSTRACT

The study involves static analysis on the developed robotic arm. Increasing loads are applied to the robotic arm to determine the maximum load that it can hold. Firstly, the robotic arm model is created using CATIA. Then, it is analyzed using the generative structural analysis tool in the same software. Increasing loads are applied to the end of the robotic arm until significant deformation occurs. The same procedure is done for modified designs in the analysis software. The results considered include displacement and stress. Based on the results, the critical stress areas are near to the rotating joints of the robotic arm, the back of the gripper and the sharp edge of the second arm. Proposed modifications include increasing the servo motor shaft radius and edge filleting the affected area, increasing the thickness and reducing the length of the gripper base plate, and implementing a new design for the second arm.

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INTRODUCTION

A robotic arm is a mechanical arm, usually programmable that resembles with similar functions to a human arm. The arm may be the sum total of the mechanism or may be part of a more complex robot. The links of such a manipulator are connected by joints allowing either rotational motion (such as in an articulated robot) or translational (linear) displacement. The links of the manipulator can be considered to form a kinematic chain. The terminus of the kinematic chain of the manipulator is called the end effector and it is analogous to the human hand.

A serial robot arm can be described as a chain of links that are moved by joints which are actuated by motors. An end-effector, also called a robot hand, can be attached to the end of the chain. As other robotic mechanisms, robot arms are typically classified in terms of the number of degrees of freedom. Usually, the number of degrees of freedom is equal to the number of joints that move the links of the robot arm. At least six degrees of freedom are required to enable the robot hand to reach an arbitrary pose (position and orientation) in three-dimensional space. Additional degrees of freedom allow to change the configuration of some link on the arm (e.g., elbow up/down), while keeping the robot hand in the same pose. Inverse kinematics is the mathematical process to calculate the configuration of an arm, typically in terms of joint angles, given a desired pose of the robot hand in three dimensional spaces.

An industrial robot is a robot system used for manufacturing. Industrial robots are automated, programmable and capable of movement on three or more axis (Mon, Mohd Romlay, & Tamin, 2012). Typical applications of robots include welding, painting, assembly, pick and place for printed circuit boards, packaging and labeling, palletizing, product inspection, and testing; all accomplished with high endurance, speed, and precision. They can assist in material handling.

The end effector, or robotic hand, can be designed to perform any desired task such as gripping, spinning etc., depending on the application. It is the most common manufacturing robot in the industry. In the automotive industry, it is used in assembly lines for welding, parts rotation and placement of parts. It is used in hazardous situations such as bomb disarmament and disposal (Chung & Yi, 2015). Its end effector is used for welding, gripping and spinning of parts. Hydraulic or pneumatic arms are used to lift heavier objects.

It is controlled by a computer program which instructs it to rotate step motors located at each joint. The step motors move in exact increments and is very precise. This is helped by motion sensors which make sure it moves just the right amount. It is useful for operations that require repetition of the same movement. The robotic arm has 7 metal segments which are joined by 6 joints. Typically, it has 6 degrees of freedom. A human hand has 7 degrees of freedom. It usually has a stationary base (Mon, Mohd Romlay, & Tamin, 2012).

Similarly, a mechanical gripper is a robot component that uses movable, finger like levers to grasp objects. It can be used for various types of industrial and household applications. In this case, the mechanical gripper is utilized for industrial pick-and-place purposes. Some mechanical grippers are controlled by servomechanism while others are driven by some linear actuation mechanisms. The most commonly used type of mechanical gripper is the parallel type. This type of mechanical gripper uses two finger-like levers (that move towards each other) to hold objects by applying adequate amount of normal force onto the object. For holding circular objects, a mechanical gripper with three moving levers can be used (Chung & Yi, 2015).