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GRAPHICS MODELLING OF NON-CONTACT THICKNESS MEASURING ROBOTICS WORK CELL

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1 Introduction

The goal of this research task is to develop a system for measuring, in real time, the thickness of a sprayable insulation during its application. Two types of insulation are to be considered: MSA (Marshall Sprayable Ablator) and SOFI (Spray On Foam Insulation). By measuring the thickness of the coating during the spray process (on-line), more precise control of the process can be achieved.

An additional requirement on the system is that it must use non-contact measurement devices. The surface of the coating will be wet during the spray process and must be undisturbed during measurement.

The short term, (10 week summer), goal of this project was to graphically model the system, off-line, using a state-of-the-art graphics workstation and associated software. This model was to contain a three dimensional color model of a workcell containing a Cincinnati Milacron T3-776 robot and an air bearing turntable. The second phase of the 10 week project was to establish a communication link between the graphics workstation and the robot's controller. Sequences of robot motion generated by the computer simulation are transmitted to the robot for execution. The sections that follow describe these items as well as some additional hardware work that was performed.

2 Graphic Simulation

The graphic simulation was performed on a Silicon Graphics Iris 3120 workstation using the Igrip software from Deneb Robotics, Inc. This software allows coordinated motion between various devices in the workcell. In this case it will be the robot carrying the non-contact sensing device and a large cylinder mounted on the air bearing turntable.

The Igrip software gives an operator the ability to design new devices and experiment with the motion of its parts without actually fabricating hardware. This is ideal for the design and testing of robot systems. Deneb Robotics also markets accurate robot models that can be retrieved to become part of the workcell. For this project, the Cincinnati Milacron T3-776 robot was to be used. This robot model is available as part of robot library from Deneb. It is then the duty of the operator to position the base of the robot in the workcell and to verify that the desired motion can be achieved from this location. Also, any end effectors to be used must be attached by the operator.

The second part of the workcell model was the air bearing turntable. This model is not available from the robot library and was developed. The model used consists of a stationary base that will be rigidly mounted to the floor. A right cylinder was used to model this fixed base. Air bearing turntables come in a variety of styles, so a cylinder was used as a generic model in lieu of a specific style. The rotating part of the turntable was placed atop the fixed base cylinder.

Once the parts of the turntable were completed, kinematics were assigned for the device. For a kinematic simulation, the motion of the parts in a device relative to one another must be known. The turntable model is relatively simple: The upper part of the turntable rotates about the axis of symmetry of the fixed base. Once this is assigned, the maximum angular velocity and the angular acceleration profiles of the turntable are assigned.

The thickness measurement system was to be generic, for the most part, so that it could be used with various coating systems. MSA is sprayed on segments of the SRB's, (Solid Rocket Booster). A right circular cylinder was used to depict one of these segments, although measurement will not be restricted to this. This cylinder is then attached to the turntable model and is fixed to the rotational part of the turntable.

The measurement hardware has not been selected for the system yet. A small package containing two cylinders and an air jacket surrounding them was used to depict the non-contact measuring device. This device will be updated when measurement hardware is selected. The graphic model is attached to the robot model at the last link and is assigned the kinematics of that link. The robot's tool point is then moved to the end of the measurement device.

The total system is now completed by placing the various devices at their appropriate location in the workcell. The base of the robot became the origin for the wokcell and the location of the turntable was determined so that most of the sprayed cylinder would be within the reach of the measurement device mounted on the robot. Following this, the motion of the turntable was coordinated with the robot so that the measurement device could be positioned at any desired location on the cylinder. Coordinated motion is achieved by establishing I/O, (input–output), connections between the robot model and the turntable model. Simulation runs were then developed to show a typical sequence of moves of the robot and the turntable.

3 Communication

The goal of this phase of the project was to establish a communication link between the graphic simulation and the robot's controller. Software is available from Cincinnati Milacron, called ROPS (Remote Off-line Programming Software), for communicating between a host VAX computer and the robot's controller. In theory, sequences of robot moves are determined on the graphic workstation, the files that contain these are transferred to the VAX host computer, and finally are translated into the robot's machine code and downloaded from the VAX computer to the robot.

In practice, however, there is a problem. The Deneb software does not properly output coordinate data to the ROPS program. The Igrip software uses Z–Y–X Euler angles to define the rotations of rigid bodies, while the ROPS software uses Z–Y–Z Euler angles. A program was written to convert the data files from the Igrip software into data files compatible with the ROPS software. The procedure is to rebuild the transformation matrix using the data from Igrip and then extract the Z–Y–Z Euler angles from this matrix. Once the conversion software was completed, several sequences of robot moves were downloaded without error.

4 Hardware

The original ten week goals were accomplished ahead of schedule. This allowed time to begin on the hardware aspects of the project. The first step was to determine what types of sensors are available, (off the shelf), for measuring the thickness of coatings. The sensors fall into three major categories: optical, acoustic, and inductive and capacitive. After discussion with several vendors of these devices, it appears as though the ultrasonic (acoustic) and the laser (optical) sensors are best suited for this task. Two sensors have been sent by vendors for evaluation and two others were demonstrated by other vendors.

5 Future Work

There is quite a bit of work left to do on this project in the areas of sensor evaluation, measurement system design, and final hardware designs. To fully evaluate the various sensors that are available, several need to be acquired and tested in a controlled environment as well as in the spray environment in which the sensors will ultimately be used.

Once the appropriate sensors have been selected, a complete measurement system needs to be developed. Questions to be answered include the placement of the sensors and any additional actuators that will be needed to move the sensors to various places within the workspace. Finally, an engineering design and analysis needs to be completed for any hardware to be constructed for use with the measurement system.