Session 3648

An Automated Inspection System
---A Project Designed and Built by Engineering Technology Students

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Abstract

A project to design and build an automated inspection system was completed by senior engineering technology students. This system consists of: programmable logic controller (PLC), electric motor, linear actuators, photo sensors, and other control components used in industry. It can sort the parts by their dimensions automatically. Students drew from the knowledge learned in many courses in completing this project.

Introduction

In the Department of Engineering Technology and Industrial Studies at Middle Tennessee State University, the students are required to take a senior project course, which is a capstone course required by ABET. The purpose of this course is to give students an opportunity to use the knowledge learned in different courses in the chosen project. In the project, engineering problems are studied and solved by experimental means.

One of the projects completed was the design of an automated inspection system, which inspected and sorted the parts by their physical dimensions. The system makes use of a PLC for control. Loading, inspecting, and sorting of the parts are done automatically. No operator is needed for monitoring the system operation. When the part supply tower is empty or parts jam in the loading path, the PLC detects the error and turns on a strobe and a siren to notify the operator.

System Operation

Figure 1 is a photograph of the automated inspection system. A top view of the system, which sits on a 72” x 28’’ platform, is shown in figure 2. Major components of the system and the PLC, which is not shown in figure 2, are listed in Table 1. The system operation is as follows:

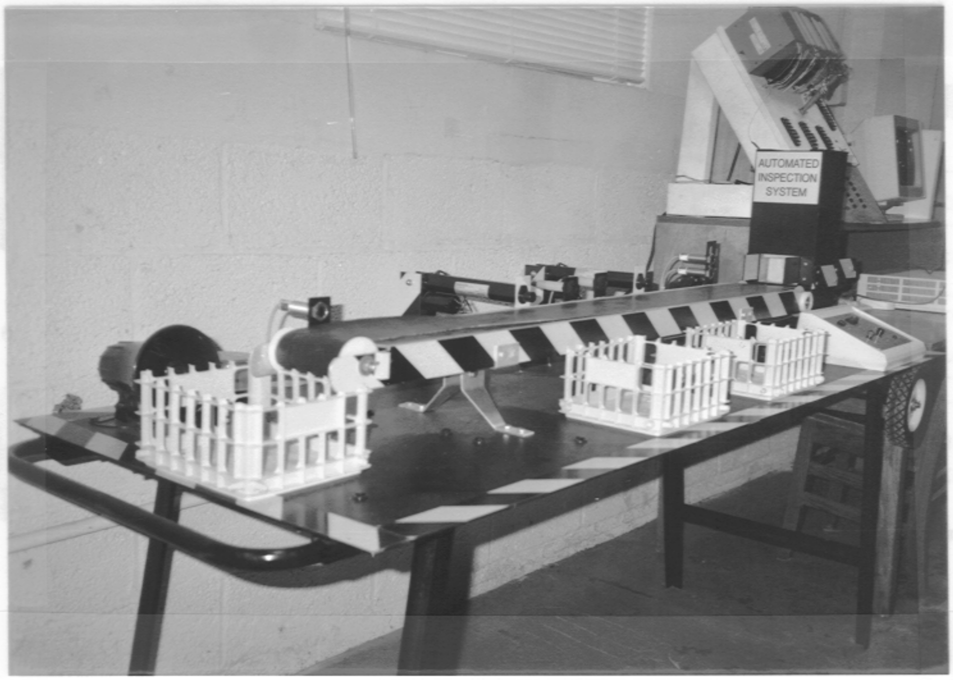

Figure 1. Automated Inspection System

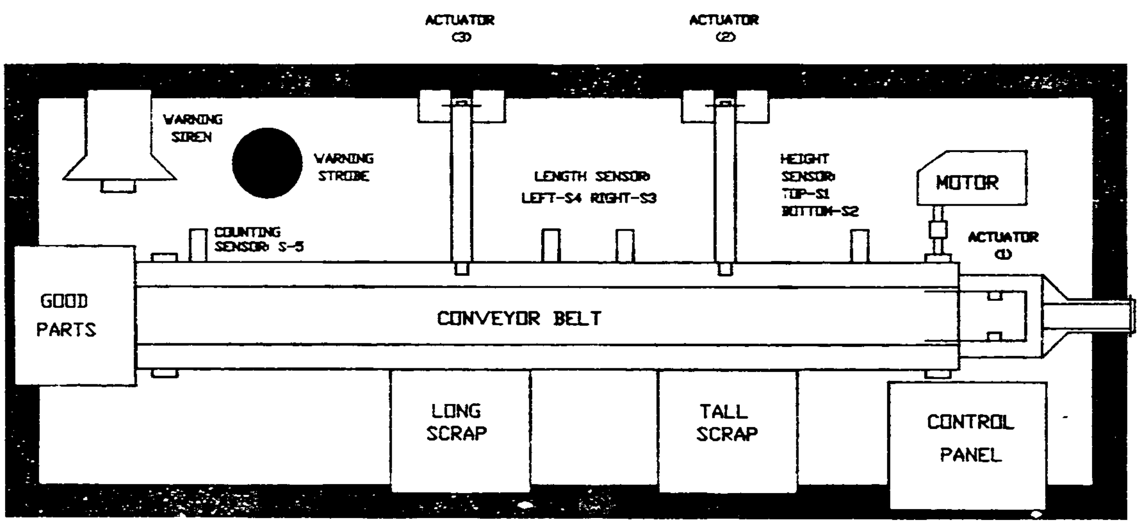

Figure 2. Top view of the automated inspection system

Table 1: Major component specification

Sensor S1-S5	20-250Vac, Balluff Photo Sensor
Actuator 1,2, and 3	24Vdc, Linear Actuator
Motor	115 Vac, 1/25Hp
PLC	Allen-Bradley SLC-500
Conveyer	54" x 6"

I. Loading Parts

The parts are stacked in the part supply tower located on the right side of the platform shown in Figure 2. The part supply tower has an opening on the lower left side wall and a hole on the lower right side wall. When Actuator 1 is activated, it extends its cylinder rod to the left through the hole on the lower right side wall of the part supply tower. The cylinder rod pushes the part at the bottom of the part supply tower, through the opening on the lower left side wall of the tower, to the conveyer belt. Then, Actuator 1 retracts its cylinder rod. Due to the gravity, the remaining parts in the tower fall into position for the next loading.

II. Inspection

The conveyer belt is driven by an electric motor. As long as the system is on, the conveyer belt runs at a constant speed. After being loaded on the conveyer belt, a part moves to the left with the conveyer belt. As the part moves, dimensional inspections are made. Depending on the results of the inspection, the part is dropped into one of the three part bins, which are labeled with GOOD PARTS, LONG SCRAP, and TALL SCRAP in Figure 2.

First, the part moves past the height sensing station consisting of Height Sensors S1 and S2, where S1 sits above S2. The vertical position of S1 is set slightly above the height dimension of the parts. If only S2 senses a part, the part is not too tall. If both S1 and S2 sense a part, the part is too tall. S2 is also used for detecting the absence of parts. As soon as the system is turned on or a part is dropped into a part bin, Actuator 1 loads a new part on the conveyer. If S2 cannot sense a part in a fixed time after Actuator 1 is activated, the part supply tower is empty or the parts are jammed in the tower. This information is sent to the PLC, which shuts down the system and turns on the strobe and siren.

If a part is not too tall, it passes the height inspection and proceeds to the length inspection station consisting of S3 and S4. If both S3 and S4 sense the part at the same moment, the part is too long. Otherwise the length of the part is right.

The positions of the sensors can be changed to fit the dimensional requirements of different parts. The PLC ladder logic program can also be changed from inspecting a part that is too tall or too long to inspecting a part that is too short in height or length.

III. Sorting Parts

If a part is too tall, the PLC senses the feedback from S1 and S2. Then, the PLC turns on a timer in its program. The preset time of this timer is the time taken for a part passing from S1 and S2 to Actuator 2. When this timer times out, the part has moved in front of Actuator 2. Actuator 2 is activated to push the part into the Too Tall Scrap bin.

If a part is too long, the PLC senses the feedback from S3 and S4. Then, the PLC turns on another timer in its program. The preset time of this timer is the time taken for a part passing from S3 and S4 to Actuator 3. When this timer times out, the part has moved in front of Actuator 3. Actuator 3 is activated to push the part into the Too Long Scrap bin.

If a part is dimensionally correct, it moves to the left end of the conveyer and drops into the Good Part bin. Sensor S5 counts the parts passing the inspections and sends a signal to the PLC to inform the controller that the part is cleared from the conveyer.

Control of the System

The PLC does all of the control work. It takes signals from the sensors and the control panel. It also activates or deactivates the actuators, motor, relays, strobe and siren. All the timers and counters used in this system are built into the PLC ladder logic program [1]. A personal computer is connected to the PLC for modifying the PLC ladder logic program or monitoring the operation of the system. There are 35 rungs in the PLC ladder logic program. The first 4 rungs of the program are listed in figure 3.

The control panel is shown in figure 4. The power button turns the system power on or off. The stop button turns the system off. The reset button turns the system back on, after the system being interrupted either by the stop button or a system fault. When the siren switch is turned on, both the siren and the strobe will be activated when a system fault occurs. To reduce the noise level in the workplace, the siren switch may be turned off to allow only the strobe to be activated in the event of a system fault. The system enable, system fault, and emergency stop pilot lights indicate the system status.

The control box is underneath the control panel. Relays and other circuit components are located in the control box. The relays are used for turning the actuators and motor on or off and changing their moving directions.

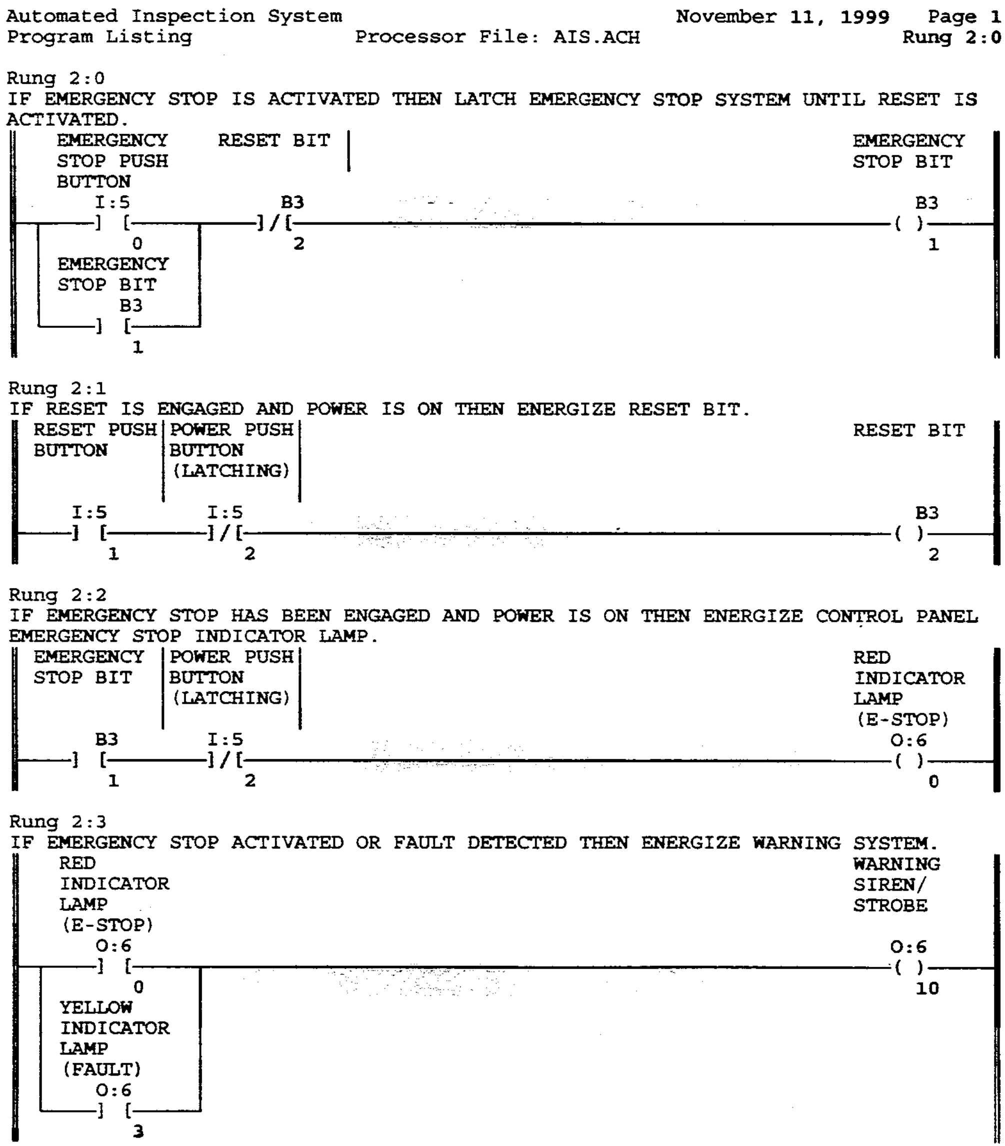

Figure 3. First page of the PLC ladder diagram

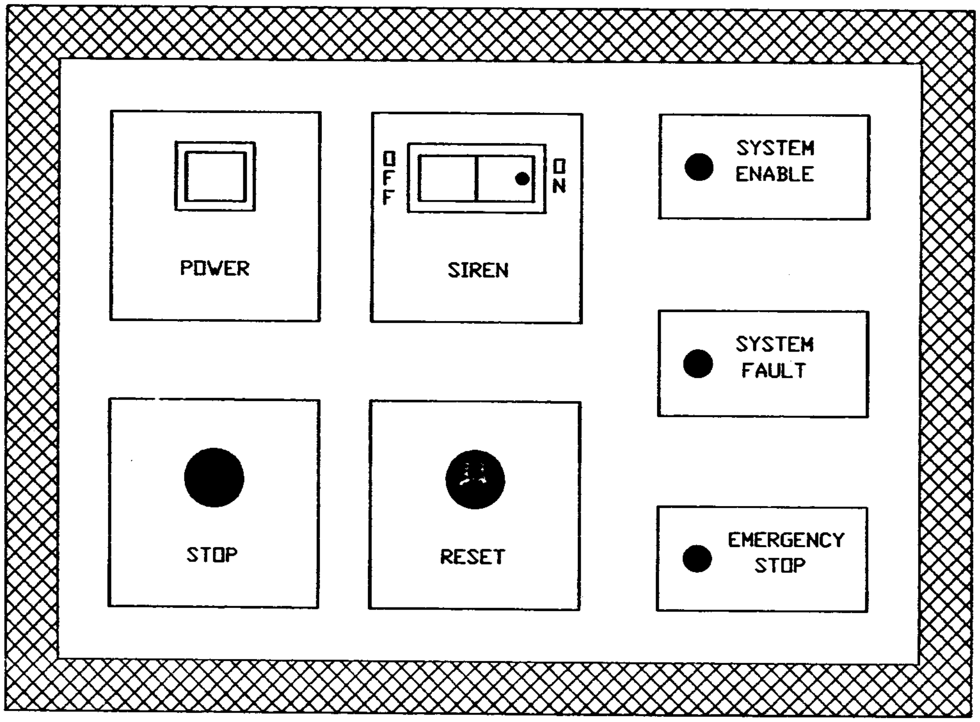

Figure 4. Control panel

Student and Course Involvement in the Project

This project was completed by two Electro-Mechanical Engineering Technology students in their senior project course. This project was advised by a faculty member and received supports from other faculty of the department. At Middle Tennessee State University, the Electro-Mechanical Engineering Technology is a concentration under the major of Engineering Technology. This concentration is structured to prepare the student for positions in industry requiring integration of electronics and mechanical devices. The required technical courses for this concentration include: circuit analysis, analog electronics, digital electronics, microprocessor, industrial electricity, instrumentation and controls, programmable logic controllers, computer programming, computer assisted drafting/design, machine shop, metal and metallurgy, statics, thermodynamics and heat transfer, strength of materials, fluid power, and robotics. A student should take the senior project course in his/her last semester of school. The senior project course is designed to let students practice the knowledge learned in technical courses and basic science courses when they work on the project.

Specific tasks of this project included: design of the system, selection and purchase of all materials and components, machining and assembly of mechanical components, wiring of all electrical circuits, and writing the PLC ladder logic program. Also included were: testing, troubleshooting, and modification of the system's hardware and software. All of these were completed within the span of one semester. Over the course of this project, the students made use of their mechanical design, machining, electronics, and PLC control skills. This project involved more than ten technical courses required for the Electro-Mechanical Engineering Technology concentration.

Benefits of the Project

This project did not only give the students involved some good experience, it also benefits following students and the department. This project has been used to demonstrate to other classes what electronics and PLC control can do. The addition of more inspection features, such as for weight and color, into the system is being considered for future student projects. For recruiting purposes, the department demonstrated the automated inspection system many times to high school students to raise their interest in studying engineering technology.

Conclusions

The automated inspection system was a very successful senior student project. The students involved had an opportunity to put into practice their knowledge learned in school and gained valuable experience in this industrial level project. The department and future students will also benefit from this project.

Bibliography

1. Allen-Bradley Company. *Advanced Programming Software User Manual.* 1993.

Biography

Dr. Chong Chen is an associate professor in the Department of Engineering Technology and Industrial Studies, Middle Tennessee State University. He received his B.S. degree from Hebei Institute of Technology in China, M.S. degree from Tianjin University in China, and Ph.D. degree from the University of Kentucky, all in Electrical Engineering. Dr. Chen teaches electric circuits, electronics, controls, and industrial electricity. His research areas include controls, power electronics, electric machines, and electromagnetic fields. Dr. Chen is a Professional Engineer registered in the State of Tennessee.