Enhancing Machine Design Course with an Integrated Vending Machine System

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Abstract

Vending machines play an important role in our daily life. Because it is very convenient and not only can save the time of customers, but also the vendors. Thus it brings great convenience to the masses. Vending machine is a good example of mechatronics systems that combing different aspects including, not limited to, electrical, mechanical and control. In Engineering Technology department having a project for building a vending machine integrated with PLC will enhance and craft the student's hands-on skills. In this paper, the authors are proposing a group project to design and control a vending machine in a machine design course. Another purpose of this project is to insure that students enrolled in the course offered as part of the program sponsored by the university is to have a hands on approach toward technology. Students also can learn of the importance of cost by comparing design criteria for different projects. This paper is presented at a time when traditional techniques for learning are being challenged. It is therefore considered necessary to incorporate different design criteria into the course. Different design criteria can be incorporated into the course by incorporating different project applications into the course such as vending machine. The emphasis is to place on designing a vending machine and developing programs to control the motion that can be seen in certain vending machines, which can be considered a marketing ploy. The motion occurring in the vending machine and sequent program development provided the opportunity of using standard equipment offered by manufactures. The development of software for motion control is considered to be an important feature of the class.

Background

At the university level, the facility is divided into several different departments that each have a specific role in the university. These departments are divided up based on what their particular area of study is however; it is a fairly common practice for these various departments to work together in the development of university programs. For example many different degrees that are offered by the university combine several courses from different departments, many of which even have prerequisite classes that are found within a completely different department. One of the best examples of this concept would be the recently established mechatronics program which is, by definition, a combination of both the electrical and mechanical programs, both of which are completely separate departments found at the university. This allows for the degree programs that are offered by the university to contain a wide array of information, which in the end allows for the students to graduate with classroom experience that is much closer to what recruiters are really looking for.

Introduction

Machine design courses are important courses that exist within the mechanical and mechatronics programs offered by the department of engineering technology. More specifically, Machine Design course is concerned with the linear motion that is exhibited by a gimbal set, which emulates the motion characteristics found in many different types of machines seen in the world today. In this course students are typically divided into groups so that each group would have the opportunity

to design the test set. To gain some actual project experience, all while learning the course fundamentals in a manner that enhances their retention of the material necessary to implement the project. In the end, this course is used to provide students with real world experience which will serve them well over the course of their future career.

In order to enhance the machine design course in a manner consistent with the objectives set forth by the engineering technology department for the mechatronics and mechanical engineering programs. A new vending machine system will be implemented into the course [1, 2]. The machine design course would be greatly improved by the implementation of a vending machine project in several ways [3]. First of all, this would allow students to gain real world experience with the concepts seen in machine design course while performing real hands on work with a system that they see every day, and are already somewhat familiar with. In addition, a vending machine system is the perfect platform for a course project as shown in Figure 1, not only does it provide the opportunity for real hands on work but it also encompasses all the aspects that this course focuses on, while building onto the concepts that were seen in the prerequisite courses. By designing the test set students build upon their knowledge of CAD programs such as SolidWorks. The test set itself will involve the integration of actual components that are to be used in the vending machine, which will cause the students to gain industrial experience while enhancing the ability to communicate with a PLC as shown in Figure 2 [4, 5]. The use of a PLC in the project will also force the students to work with, and to gain additional experience in ladder programming. Lastly, the integration of actual components used in a real world vending machine has the added benefit of increasing the fidelity of the emulation of the gimbal set by insuring that a standardized process will be used in the test set.

Figure 1. Vending Machine[5]

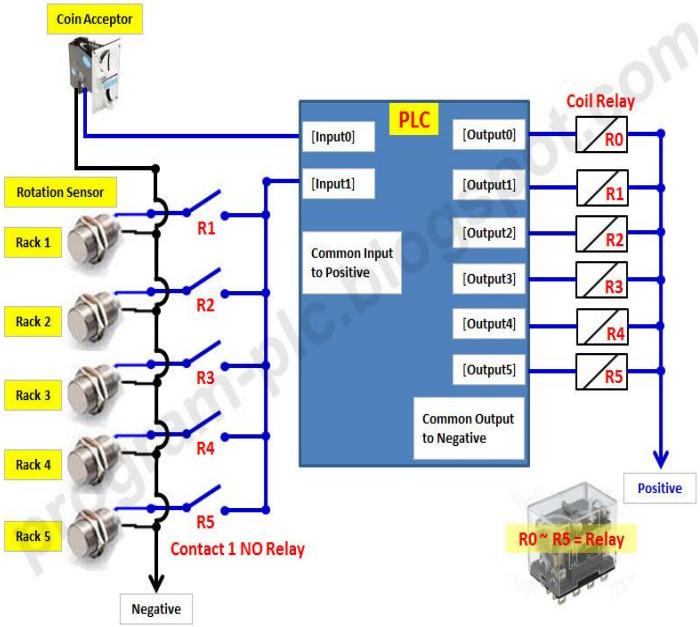

Figure 2. PLC layout for controlling Vending Machine [6]

Motivation

It has been decided that the students enrolled in the machine design course need to reinforce and/or extend a variety of issues in addition to being exposed to relatively new ideals. Issues that are to be emphasized by a course concerned with machine design include programming skills, alignment skills, and an exposure to heat transfer concepts via experiential learning techniques involving an actual project using techniques that complement prior courses taken to obtain a certified degree by ABET from university concerning mechatronics.

Prior courses include a course concerning hydraulic and pneumatic actuators, a course concerned with initial programming of PLCs using latter logic, an introduction to machine elements, and a course concerned with the torque existing on different rotors that is provided by various types of motors. The content of the course concerned with machine design influences the content of the courses that are considered prerequisites for the course concerned with machine design. Alignment techniques using mechanical trainers purchased from a grant due to participation of the labor department and awarded to the technology department at the university which are used to train qualified individuals can be upgraded by purchases that are consistent with alignment techniques used by the course concerned with machine design. The machine design course is concerned with using electromagnetic techniques to produce the force and/or torque existing with an actuator. Actuators need to complement prior courses and are to be considered a rack and pinion for the vertical axis and a belt drive for producing horizontal motion. Use of a rack and pinion emulates spur gears which are the subject matter of a class subject matter that involves introduction to machine elements. A belt drive module emulates a conveyor system which is discussed in the class dedicated to introduction of machine elements. The use of encoders and the production of torque implemented by a rotor can be considered the subject matter of a course dedicated to motors. Efficient programming skills, which is assumed to including the use of the machine code executed by a microcomputer contained in a PLC, are considered knowledge based upon the courses that are considered prerequisites for a course dedicated to machine design.

The beverage container existing at each slot are the masses to be moved by the actuators used to form the gimbal set of an actual vending machine. The motion occurring in an actual vending machine that is labeled by Aquafina is to be emulated by the test set.

Initial exposure to electromagnetic actuators include a rack and pinion system emulating spur gears that are the subject matter of the prerequisites and a belt drive module for producing horizontal motion which can be considered to emulate conveyor systems that are the subject matter of the prerequisites. The rack and pinion system not only emulates systems that are used in plasma cutting machines existing in conventional machine shops while exposing the student to actuators that are employed when relatively heavy loads must be moved. The belt drive module exposes students to different techniques used to implement actuators including speed of response of electromagnetic actuators. Using different actuators for the two linear motion systems on the two linear motion axes of the gimbal set utilized in the test set exposes students to different techniques used to produce linear motion. Enabling the gimbal set of the test set to produce rotations at the drop off site has the advantage of exposing students to techniques used to generate rotations but also emulates the actual vending machine [1].

Vending Machine System Cost

Costs are an important issue and can be controlled using different techniques. Costs can be considered fixed if the actuators to be used are purchased from a company dedicated to manufacturing actuators used in a machine. The volume of the actuators are expected to influence the cost of the actuators delivered when the actuators are purchased from a third party. Cost considerations are considered important when developing course content which emulates the situation that exists for a majority of graduates from a program sponsored by a department.

Costs can be controlled by purchasing a used machine that is advertised on the net and using components, including the plates and the slots existing on a plate, from the machine that has been purchased. Components used for a test set can be integrated into the test set to control the costs of the test set. The test set is deemed necessary to properly emulate an actual vending machine labeled by Aquafina and to use components that graduates from a mechatronics program are expected or anticipated to be familiar with. Components can be integrated into the test set using a variety of techniques that include adopting the test set with parts that are specified to integrate components were obtained from purchasing a vending machine.

Conceptual Design and Assembly

Figure 3 shows the conceptual block diagram/schematic of the vending machine in simulation and its components.

Remarks of Detail Number:
1-5. Position Rack 1,2,3,4, 5
6. Coin Acceptor 7. Coin Box
8. PLC Box or Panel Control Box
9. Electric Motor for Rack 1
10-13. Electric Motor for Rack 2,3,4,5
14. Rotation Sensor / Proximity Sensor for Rack 1
15. Rotation Sensor / Proximity Sensor for Rack 2
16. Rotation Sensor / Proximity Sensor for Rack 3
17. Rotation Sensor / Proximity Sensor for Rack 4
18. Rotation Sensor / Proximity Sensor for Rack 5

Figure 3. Vending Machin Simulation in PLC Software [7]

The major components that exist, in the test set, are assumed to include the following*:*

1. Two plates used to cover the top and bottom of the test set
2. Feet extending from the horizontal extrusions used to mount the bottom plate including rollers that can be considered part of the feet and used to locate the test set
3. Horizontal extrusions used to form the frame to mount the bottom plate
4. Horizontal extrusions used to form the frame to mount the top plate
5. Vertical extrusions located between the horizontal extrusions used to form the bottom and top frame.
6. Vertical extrusions located between the horizontal extrusions used to form the bottom and top frame.
7. Left side panel mounted to specific vertical extrusions
8. Back side panel mounted to specific vertical extrusions
9. Transparent front panel mounted to specific vertical extrusions
10. Extrusions to mount the belt drive module. The extrusions to mount the belt drive module do not allow the belt drive module to deflect.
11. Round rail and the necessary components to allow horizontal motion of the test set while supplying support to the vertical axis and exposing students to the alignment principles to be used in the test set. The round rail and components used by the round rail are to be mounted to the bottom plate.
12. Cabinet affixed to specific vertical extrusions
13. Five (5) plates with each plate containing nine (9) slots
14. Beverage containers located at each slot
15. Flap located at drop off site separating holding volume from the slots located on the plates

The cabinet located on the right side of the test set contains the following:

1. Display (HMI)
2. Encoder which is a keyboard existing in actual machines
3. Holding volume
4. Swipe card reader
5. Money changer
6. The components necessary to move the gimbal set of the test set in the vertical including the controller used in the vertical which contains the necessary power supplies and interface circuits used to communicate with the PLC and the absolute encoder which generates pulses and is affixed to the rotor of the motor used on the vertical.
7. The components necessary to move the gimbal set of the test set in the horizontal including the controller used in the horizontal which contains the necessary power supplies and interface circuits used to communicate with the PLC and the absolute encoder which generates pulses and is affixed to the rotor of the motor used to produce horizontal motion.
8. The components necessary to move the gimbal set of the test set with rotations including the controller used to produce rotations at the drop off site which contains the necessary power supplies and interface circuits used to communicate with the PLC and the absolute encoder which generates pulses and is affixed to the rotor of the motor used to produce rotations.
9. Electrical strips

10. The necessary wiring including cables routed to or from the gimbal set from or to the cabinet
11. The necessary power supplies
12. Cord used to supply power to the test set
13. PLC including the necessary DIN mounting, interface circuits and power supply for operating the PLC and interface circuits.

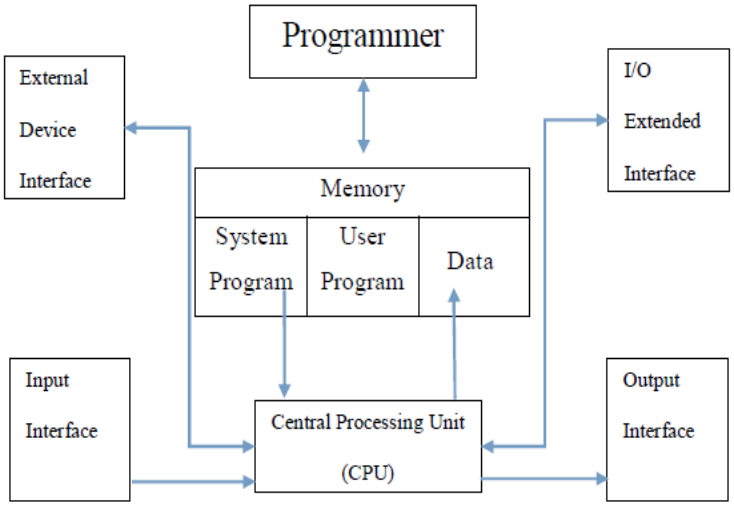

Figure 3 composition of PLC

Course Alignment Techniques

Alignment techniques that can be used to align the test set include*:*

1. The top plate and the bottom plate are to be considered planes and the normal to the major surfaces of these planes is to be orientated parallel to the local vertical and the local vertical can be used to determine the tolerance of the dimension of the plates set parallel to the local vertical. The ability to determine the orientation of the local vertical will be determined after more information concerning the vertical and/or the horizontal motion of the gimbal set used in the test set is obtained.
2. The extrusions located between the frames used to mount the top plate and the bottom plate are affixed to the frames and orientated to the local vertical using levels that contain air bubbles having at least one degree of freedom.
3. The left side panel, the back side panel, the cabinet, and the transparent front side panel will be affixed to the vertical extrusions.
4. The belt drive module will be affixed to the frame that is used to mount the bottom plate by the use of extrusions
5. The gap existing between the plates and the gimbal set used in the test set to emulate motion of the actual vending machine will be set by spacers which can be fabricated in a machine shop such as the machine shop which is available at university.
6. The distance between the front of the frame used to mount the bottom plate and the extrusions used to affix the plates to the test set will be measured and the distance from the

front of the frame to the extrusions will be consistent to within a degree that can be conveniently implemented in a conventional machine shop.

Conclusion

In this paper provided a background about machine design course that offered by the University for Engineering Technology students. The authors presented the rational to integrate a vending machine system into machine design course. The author are proposing the project to the students during spring semester and post evaluation will be given to the students for the evaluations. The steps that are needed of development are discussed and the components of the vending machine were mentioned. The authors believe that this project enhance students learning and improve the machine design course learning. Yet, examining the impact of these trainers on students learning is the subject of a future study. For future, the authors are planning to conduct a survey to learn about students' feedback on what they think about the vending machine project in terms of the design, programming, etc.

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