University-Industry Partnerships to Enhance Engineering Education

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Abstract

Engineering education is facing a lot of challenges nowadays due to the COVID-19 pandemic and low enrollment issues that caused lowered funding opportunities and administrative budget reductions. Engineering educators are required to play vital leadership roles to face these challenges. Combining efforts and collaborating with other programs and external partners, including community colleges, industry personnel, companies, and businesses, becomes a necessity to enhance engineering education. Technology education, on the other hand, is very dynamic and changes daily. At the technology education level, establishing a partnership and collaboration with industry can help to address some of these challenges. The advantages of university-industry partnerships (UIP) are both incredible and numerous. The strength of any university's program depends on staying relevant to innovative technologies used and current market trends, not only regionally but globally as well. The collaboration between Purdue University Northwest (PNW) and LinMot USA is a great example of a successful university-industry partnership. Through a donation of hardware and software to the university, the goal of this partnership was to build a portable trainer system including a linear electromagnetic actuator integrated with an industrial controller to enhance the capabilities of engineering technology labs. The objective of this project was to provide a demonstration presenting the ability of electromagnetic linear motors to be used in several industries, compared to many cases of the common pneumatic actuator. Electromagnetic linear drives can be integrated with many industrial controllers, such as the Programmable Logic Controllers (PLC). They can be embedded as inputs such as switches, sensor I/O, or directly through a PLCs logic programming. Regarding the scope of this project, the authors created a state-of-the-art trainer system to be used in engineering technology laboratories and to enhance students' hands-on skills using innovative technology. The steps of the design are discussed and explained. As mentioned, the hardware and software were donated by the LinMot USA, and the project marks a collaboration between PNW and the Packaging Machinery Manufacturers Institute (PMMI).

Introduction

Manufacturing processes use different types of linear actuators such as hydraulic, pneumatic, and electromechanical. Electromagnetic actuators are another type of linear actuator/motor (LinMot) that uses the electromagnetic-mechanical principle to convert electrical and mechanical energy into one another [1]. Without the need of mechanical gearboxes, spindles, or belts as intermediaries, the linear motion is generated without wearing issues. The slider and the stator are the only two components that make up the LinMot [2]. Neodymium magnets, placed on a high-precision stainless steel tube, are used to create the slider. The motor windings, slider bearings, position sensors, temperature monitoring, and microprocessor circuitry with an integrated electronic nameplate are all contained within the stator, according to [2].The LinMot actuator is depicted in figure 1. LinMot motors are electromagnetic direct drives with a very long life cycle [3] and are designed as tubular direct drives. The numerous sensors possessed by LinMot motors have enabled them to track the motor's condition and work with other devices.

The goal of this project was to develop a portable trainer using LinMot actuators, drive, and controller system. The PLC and Human machine interface (HMI) used in this trainer are Micrologix 1100 and panel view 600. The newly developed portable trainers must be stored in a compact and hard-shell case that houses all the equipment. The process started by taking measurements of all the needed equipment, and CAD (computer-aided design) drawings for each component to estimate the size constraints of the housing.

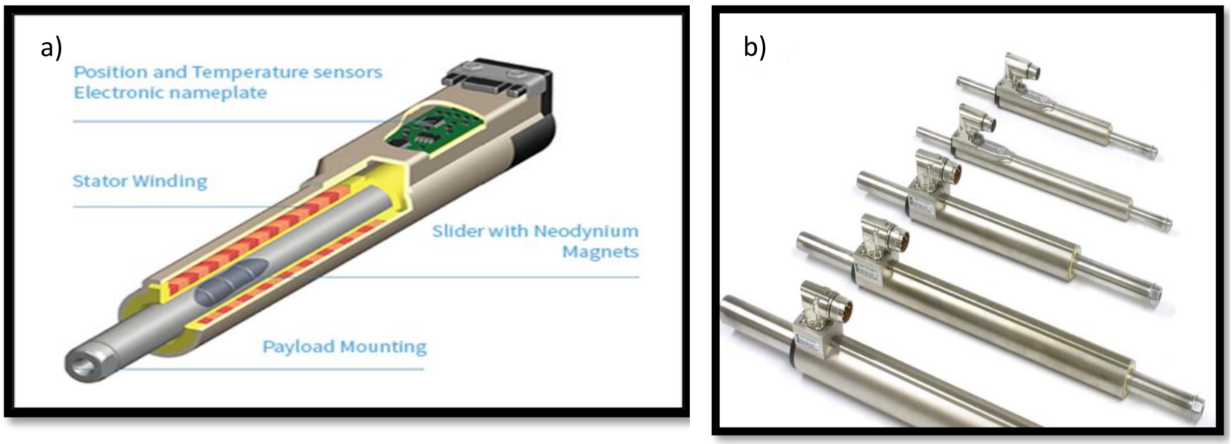

Fig. 1. LinMot actuators: a) LinMot components [4]; b) LinMot product [5]

Design Steps

Prior to putting the parts that form the trainer's housing together, holes have been drilled in the sheets of metal where necessary for L-brackets to be installed. The same was done to plywood that would be as foundational support, as shown in figure 2.

Fig. 2. The metal sheets and plywood base for the trainer’s case.

Then, the wood was placed under the metal floor to support the housing and attached by inserting screws through the prepared holes. The L-shaped brackets are placed at the four outer corner holes which will eventually be the side walls of the housing. A washer and screw are used to secure the assembly as shown in figure 3.

Fig. 3. The four outer corner and L-shaped brackets.

The other sides were attached to the bottom first, and then to the top. The top of the housing is secured using four more L-shaped brackets as shown in figure 4.

Fig. 4. The two side of the case.

The required "Deutsche Institut fur Normung" DIN rail is bolted down and ready to receive the two power supplies and PLC, as shown in figure 5.

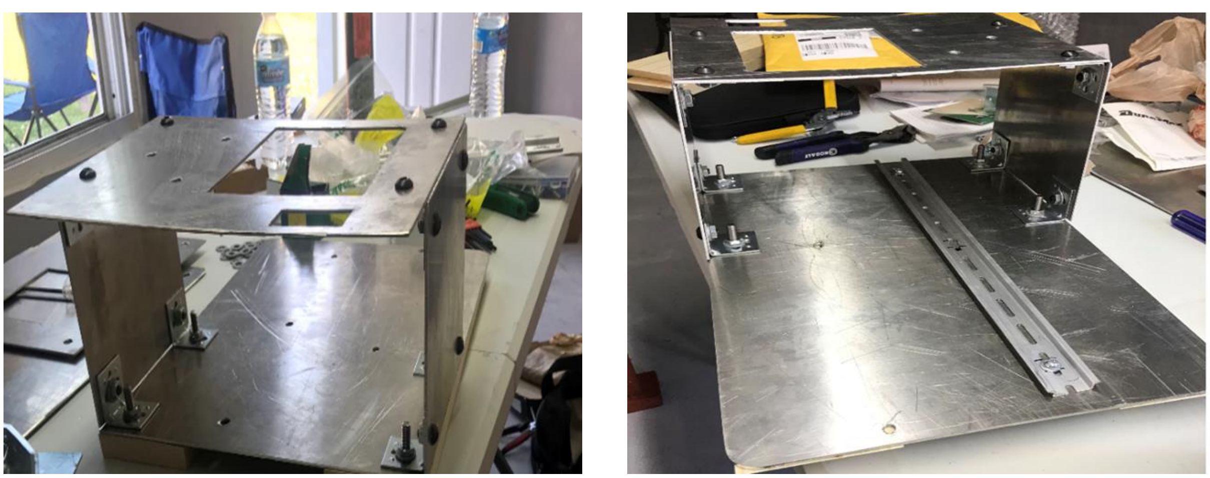

Fig. 5. The top housing and mounting the DIN rail.

A 72-volt power supply, manufactured by the LinMot USA, is DIN rail-compatible attachment placed at one side. A PanelView Plus 600 HMI, manufactured by Allen-Bradley was also installed in the prepared location as shown in figure 6. The HMI was chosen to be slightly small for this case.

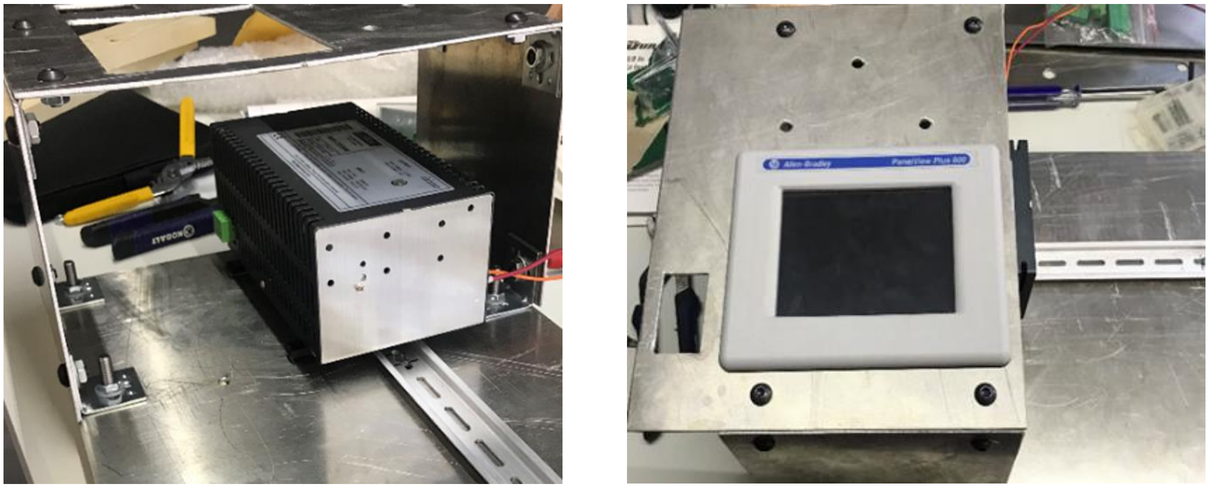

Fig. 6. Mounting the power supply and the HMI.

The second position, to the right of the 72-Volt power supply, is where the second power supply that runs at 24 volts was installed. Next to the second power supply, the PLC was inserted. Below them, the general-purpose drive that supplies the inputs and outputs is bolted down. The top view of the completed system is shown in figure 7.

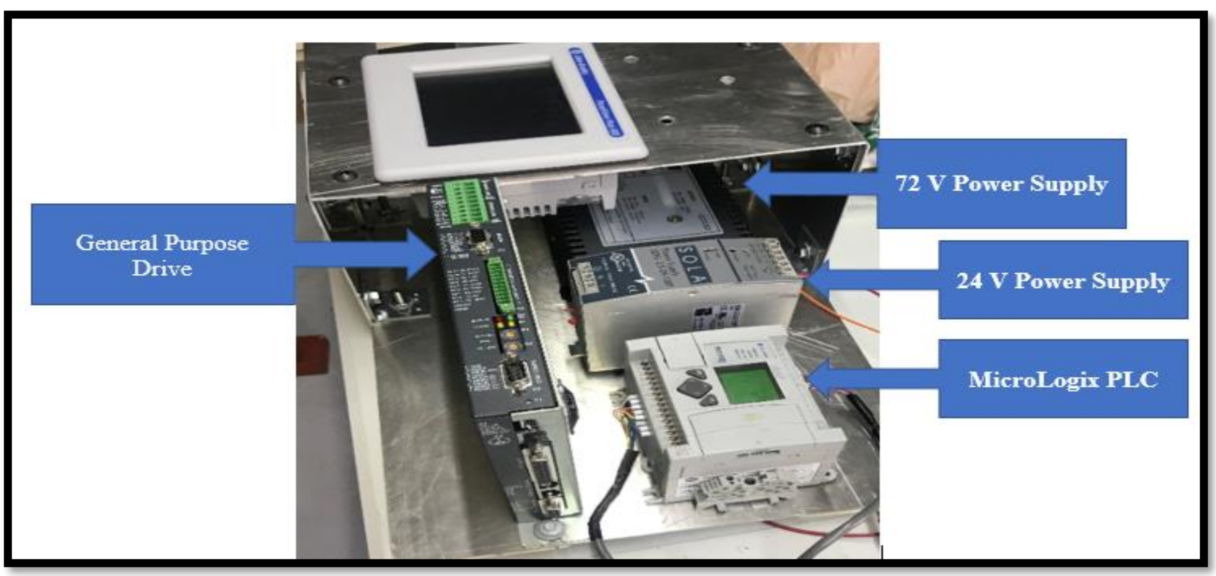

Fig. 7. Top view of the completed system.

Wiring Steps

Connecting the two power supplies is the first step in wiring the system. The first power supply (72-Volt) is used to power the LinMot drive (E1100-GP), while the second power supply (24-Volt) provides power to the input/output signals. The 24-Volt power supply is connected to both X4 (the main power for the PLC input and outputs) and the HMI. The 72-volt power supply is connected to X1 or the motor supply. The most important and essential step is to ensure the system's electrical safety, by applying the proper grounding. Otherwise, the system components/drives can be fried.

Next, the PLC is wired by integrating its inputs and outputs into the E1100-GP Drive. The PLC is powered by the 24-Volt power supply. Then the flange was bolted down and ready to receive the stator, as shown in figure 8.

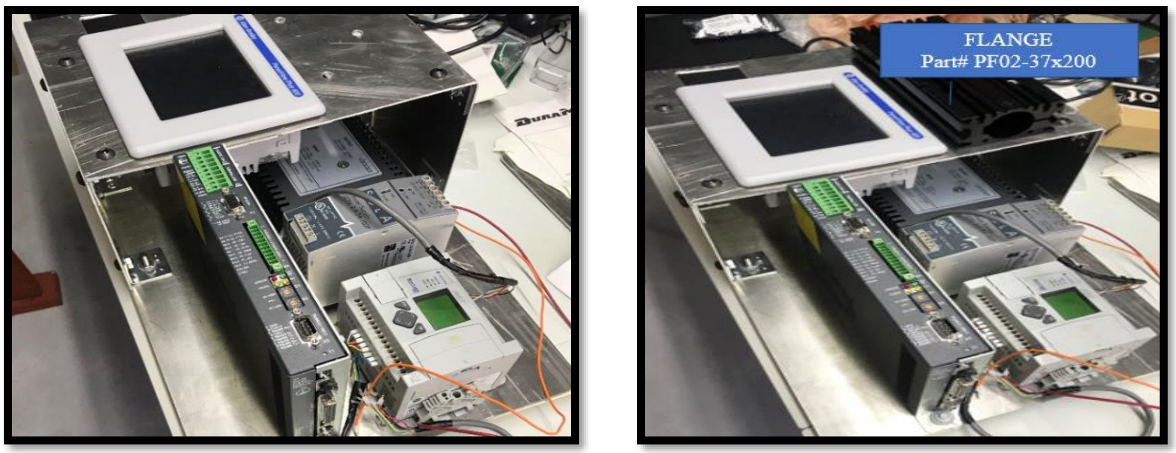

Fig. 8. Wiring the motor and mounting the flange.

Figure 9 shows the wiring that leads to the ON/OFF switch and its corresponding connection, as well as the connection for the stator by a motor cable to X2, or the motor supply of E1100-GP Drive.

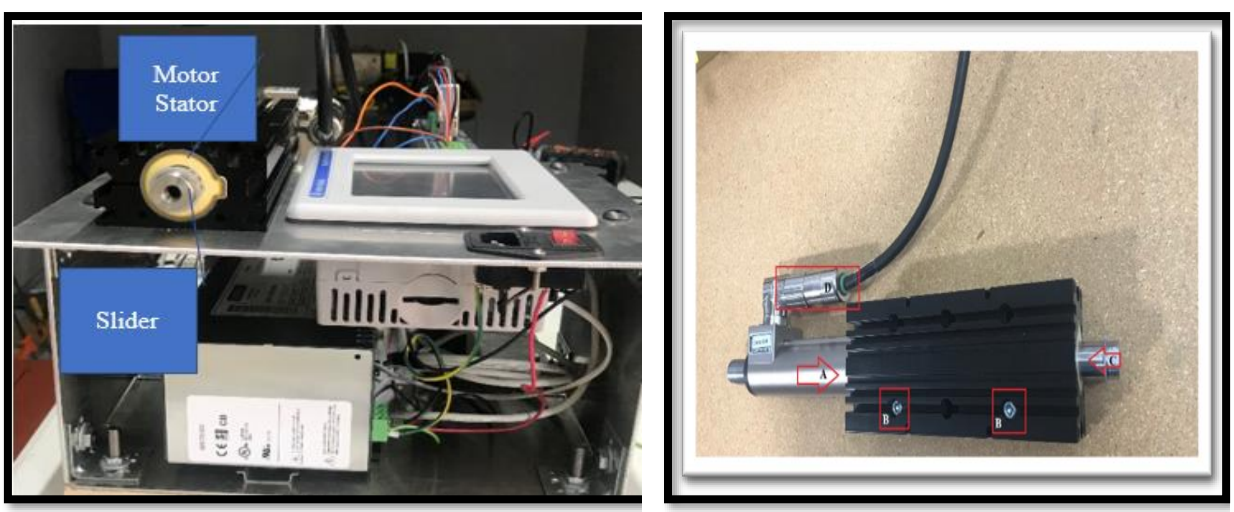

Fig. 9. Mounting the completed motor.

More details on the assembly of the flange, stator, and slider are provided below:

- A – Install the Stator onto the flange using the notch as a guide.
- B – Once the stator is pushed all the way in, tighten the bolts to secure the stator in place (torque to 8 N.m).
- C – Insert the slider from the opposite side of the stator with the notches on the right end.
- D – Screw in the motor cable and make sure it is secure.

Figure 10 shows an aerial view of the motor cable that runs from the stator to X2 and X3 on the E1100-GP drive for different motor phases.

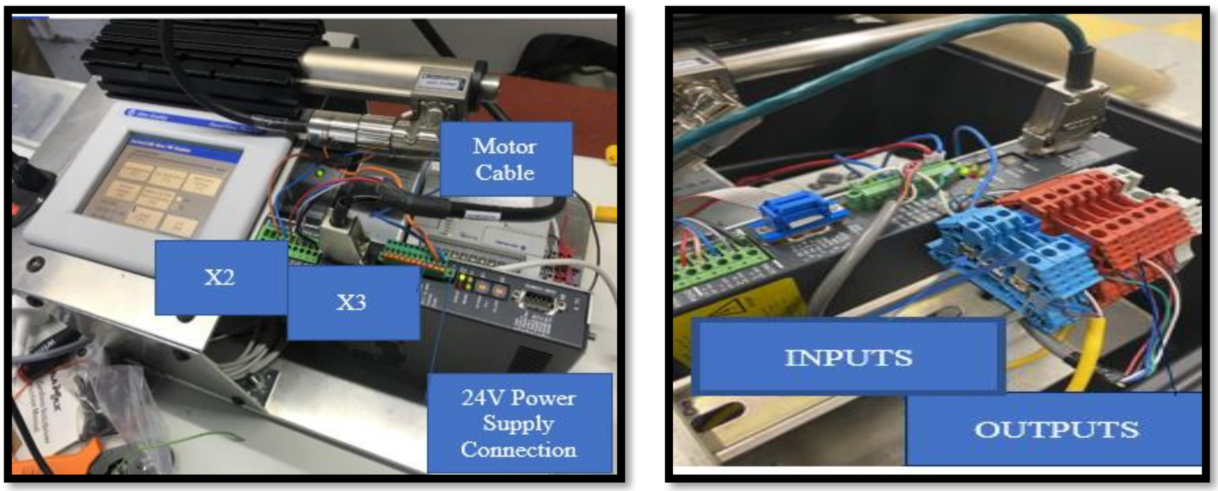

Fig. 10. The completed wired system.

LinMot Talk Software

As far as utilizing the software for compatibility, the LinMot Talk 6.9 software (newer versions are available) was downloaded to communicate with the hardware from the LinMot official website under software downloads [6]. Before launching a new project, a physical connection is required between the computer and the COM/CONFIG port at the E1100-GP drive, and it must be detected by the computer. Once the process is successfully finished and not aborted, the main screen of LinMot software should open with all the following information on the main homepage, as shown in figure 11.

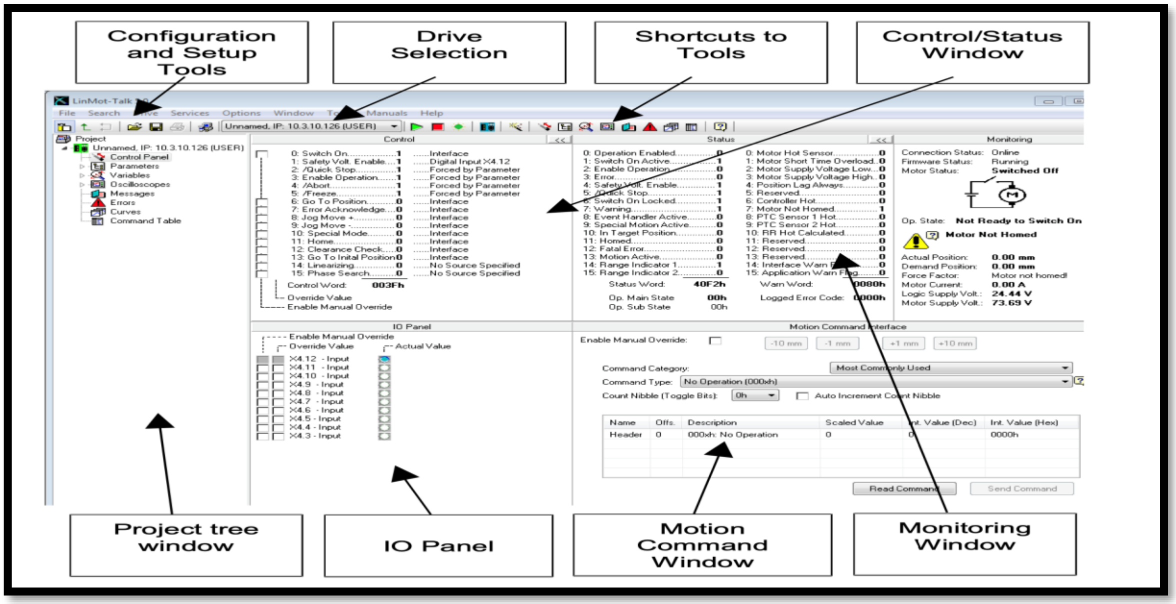

Fig. 11. The LinMot software main page [7].

To trigger the slider for making the continuous movement necessary to record with the built-in oscilloscope reader, one needs to select the following options, subsequently to one other, and in the respective order; Parameters, Motion Control SW, Run Mode Settings, Run Mode Selection, and “VAI 2 Pos Continuous”, as shown in figure 12.

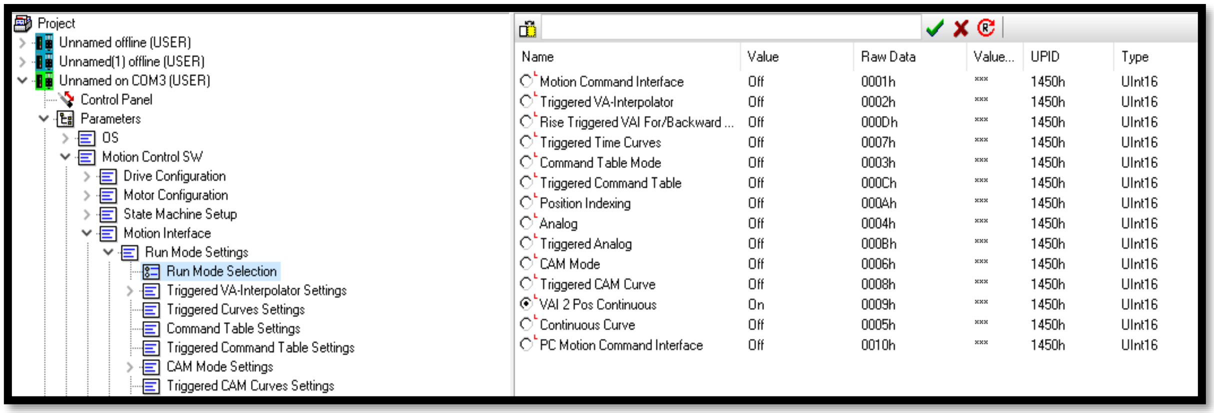

Fig. 12. Continuous mode operation.

Testing with Oscilloscope

Figure 13 below presents a motor's oscilloscope readout, with no obstructions applied, from the start of the recording process.

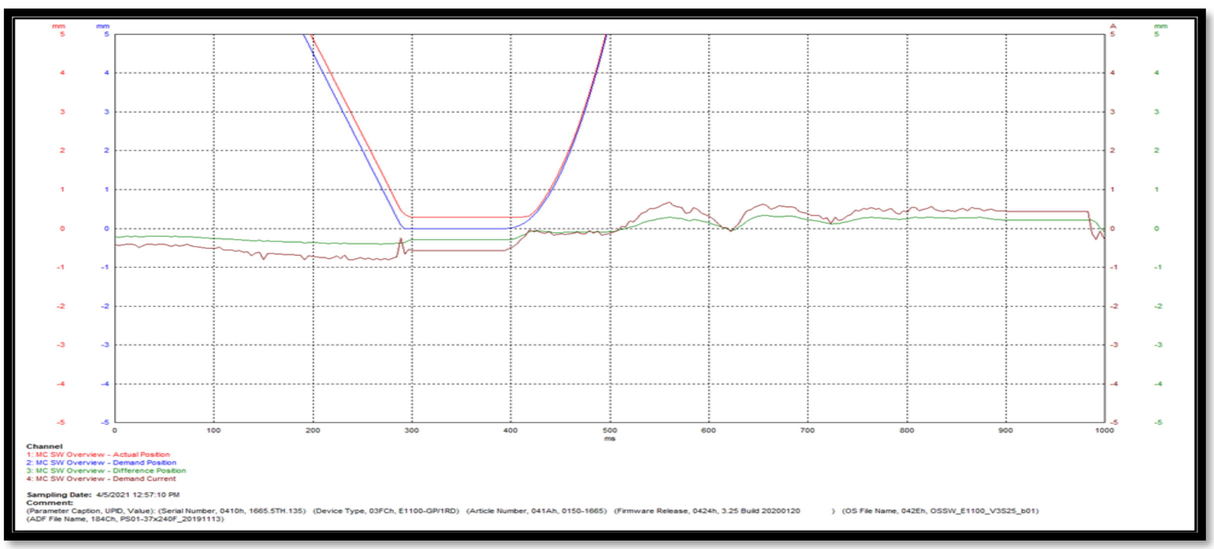

Fig. 13. Oscilloscope plots for motor status.

By observing the peak amplitudes in the sinewaves generated, one can identify the moments where the obstruction and the slider meet, thereby changing the rhythm of what is transpiring[8].

Final Product and Conclusion

The project was built, designed, wired, and tested successfully. The trainer has been used in many classes at PNW. The final case is shown in Figure 14.

Fig. 14. The completed trainer.

LinMot is applicable in many aspects of the industry for meeting specific needs, such as wood processing with multiple drills that can be moved quickly, infinite materials that can be precisely sliced, and many materials that may be fed into and handled by the machine. LinMot can also be utilized in applications in the areas of assembly, material management, and error inspection in the automotive sector [7]. Examples of the LinMot applications are shown in figure 15.

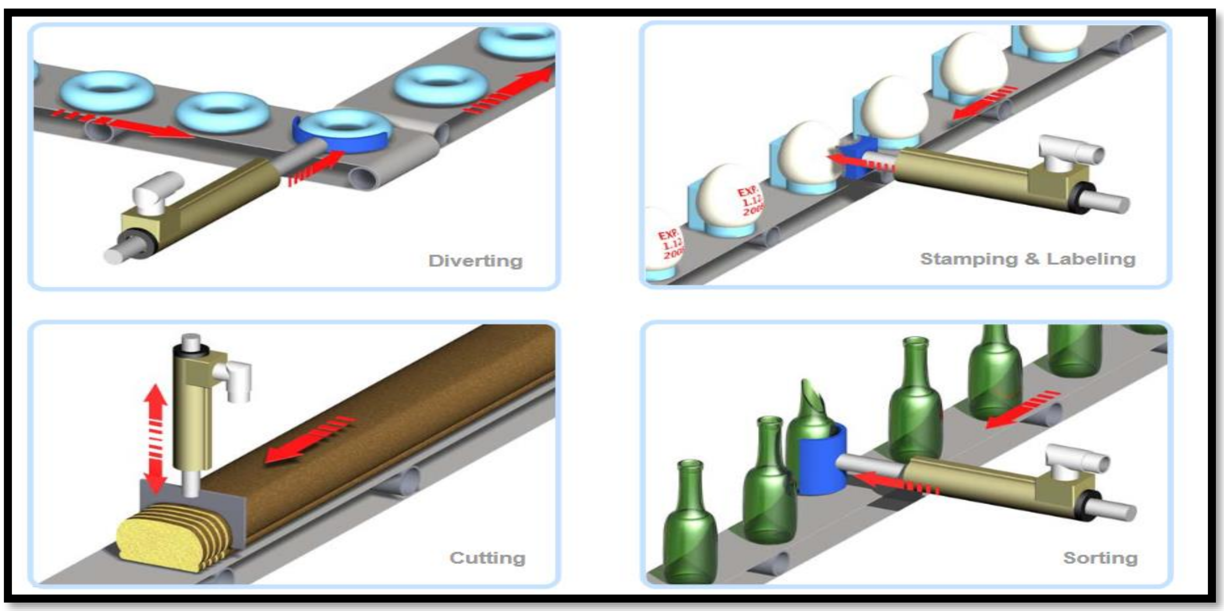

Fig. 15. LinMot applications [7].

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Biographies

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