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Innovative Design of Conveyor Control System using Variable Frequency Drive (VFD)

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***Abstract* – The study focuses on the innovative design of the conveyor control system using variable frequency drive to introduce technology innovation and to produce competent and trained human resources competent with the necessary skills and knowledge that the industries need. A main control panel board is included in the design so as to replicate the real conveyor with its control system. The transfer control system is composed of different electrical control components like the push buttons, indicating lamps, circuit breakers, magnetic contactors, control relays and variable frequency drive (VFD). The transfer system is designed as an instructional device wherein it has the capability to demonstrate the principle and control of a conveyor system using a VFD. The conveyor is designed with a bag sewer machine constructed according to three classifications namely the conveyor, sewer and the controlling devices. The machine's over-all mean shows a numerical value of 4.26 which is highly acceptable. This implies that the machine is acceptable in terms of its Aesthetic, Reliability, Safety and Functions.**

***Keywords* – Conveyor, Control System, Innovation, Variable Frequency Drive, Instructional.**

I. INTRODUCTION

A conveyor system is the commonly used advanced material handling system that moves jobs from one station to another stations. The conveyor systems used may be of converging or diverging or combination of converging and diverging depending on the type of applications. Most of the assembly operations require converging and diverging types of conveyors. The performance of the conveyor system depends on the elements of the conveyor system and its operational parameters [1]. Conveyor equipment selection is a complex, and sometimes, tedious task since there are literally hundreds of equipment types and manufacturers to choose from. The expert system approach to conveyor selection provides advantages of unbiased decision making, greater availability, faster response, and reduced cost as compared to human experts [2].

In a modern electrical system, due to an increase in controlling technology, power quality has become a great concern. Non-linear loads, which were only 15 % of total loads in 1987, have increased to 75 % in 2012. These non-linear loads introduce harmonics into the electrical supply system and draw non-sinusoidal currents from ac mains and cause reactive power load, extreme neutral current, Low power factor, Low energy efficiency, interference by EMI and distortion of the line voltage, etc. The variable frequency drives come under non-linear loads and they are one of the main sources of harmonics generation and power quality problems [3]. A variable frequency drive (VFD) is a power electronic device that drives the common "squirrel cage" induction motor over a range of speeds by converting standard frequency and voltage ac power from the electric utility to variable frequency, variable voltage power to energize the motor. Over the years, improvements have been made to VFDs' efficiency and reliability. They are now viable alternatives to other motor technologies [4].

The need for an infusion of mechatronics-based courses and support systems into the industrial technology programs as a bridging intervention to mitigate the industry-academe imbalance are readily identified [5].This posed as one of the challenges in the Department of Electrical Technology and Management in University of Science and Technology of Southern Philippines (USTSP) to introduce technology innovation and to produce competent and trained human resources who is competent and who acquired the necessary skills and knowledge that the industries need. Presently, in the department of Electrical Technology and Management wherein one of the main emphasis is on machine control, it has the capability to develop graduates with the skills and knowledge needed by the industries but somehow this capability is being hindered due to inadequacy of instructional devices specifically on the conveyor system. With this, the researchers are encouraged to conduct a study on the development of an instructional transfer

system using VFD that would enhance the knowledge and skills of the students about the conveyor systems.
Similarly, the instructional conveyor system using VFD is also one of the innovation on the design of an instructional device that can be locally constructed to enhance laboratory instruction and hands-on activities. The design and construction of this conveyor system can help the needs of the students to acquire the skills, and knowledge of the principle and control of a conveyor control system using VFD. Through this physical demonstrative device, students is guided in analyzing the basic principle of operation and control of a conveyor system. The students is also able to understand the concepts of Variable Frequency Drive (VFD) and enhance their skills in soft starters for drive motors. Significantly, the output of the study can improve teaching and learning thus producing technically competent students.

The design of the innovative conveyor system using VFD is one of the innovations introduced for the conveyor system and as a laboratory device that may help solve the inadequacy of equipment and tools needed in the department of Electrical Technology and Management. In order to accomplish a complete set of research, the researchers established some basic objectives and studies to make the research efficient.
The general objectives of the research study are to design and develop a conveyor system as an instructional trainer. This study is definitely helpful for the Electrical Technology and Management, Electro-Mechanical Technology and Engineering students of USTSP, mainly for those who are concerned in understanding the basic principle behind this project. This project can enhance the student's skill in designing the conveyor system in different applications.

This device can demonstrate the basic functions and operations of the transfer system using VFD and industrial motor control since most of the subjects that are included in the BSETM course involve industrial technology and practices.
The prototype device can help the students to analyze the basic principle of the conveyor system. This device aims to provide students more knowledge about the transfer system and industrial control, especially during actual and laboratory activities. It can also enhance the skills of students in dealing with different types of controls. The instructional transfer system would be the appropriate tool for the students' hands-on training. The study can be beneficial to the teacher as well as the students. The use of the instructional transfer system can help the instructor enhance his/her teaching methodology and strategy. Moreover, the students can be able to develop their competencies and knowledge in their practice in industrial control, particularly in the conveyor system. For researchers and engineers, it can encourage innovation in the control system using the VFD and other combinations of software and automation technology for a more efficient and reliable control system.

II. PROBLEM STATEMENT

The capability to develop graduates with the skills and knowledge is being hindered due to inadequacy of instructional devices specifically on the conveyor system. The design and development an innovative conveyor system using VFD can enhance students skill on the basic functions and operations of the transfer system using VFD and industrial motor control.

III. METHODOLOGY

1. Prototype Design

Figure 3.1 shows the Perspective View of the Machine. The conveyor has a dimension of 3000 mm x 500 mm by the use of a flat belt; it is connected into the body of the conveyor, and wound around to the roller with a diameter of 82 mm and has a length of 400 mm. It has also a motor that serves as a main part of the conveyor. This has a capacity to run about ½ horsepower and 1350 revolution per minute (rpm). A gearbox is used to convert the rpm of the motor from 1350 rpm into 20 rpm in case the VFD malfunctions.

Fig.3.1. Prototype Design.

The bag sewer is designed using the portable bag closer high-speed type with plastic handle and lubricator. It has a combination of one (1) thread chains titch or two (2) thread chains titch models with the high-speed revolution of 1,500 – 1,600 rpm. It is equipped with a steel cam automatic thread cutting for horizontal and vertical

operation. The machine used to close sewing bags filled with various products. e.g.: foodstuff, fertilizer, feed, & chemicals. It has the capability of handling 200~600 bags/hour with automatic and simple operation. It is suitable to sew the plastic bags, woven bags, and sacks perfectly. It is attached to the conveyor with an adjustable of the shaft in order to adjust whatever the size and how long the bag is. For the sewer control system, the machine is equipped with a capacitive sensor that detects the object or incoming bag and actuates the sewer machine.

Capacitive Sensor Assembly serves as the signaling input of the prototype. When the sensor detects the incoming bag it automatically energizes the motor and runs the conveyor. The motor drives the prototype and after conveying the bag the sewer closes the bag. After that when the sensor detects the tip of the bag the cutter energizes and cuts the treads.

Fig.3.2. Sewer Machine.

2. Development

The instructional transfer system is fabricated using the appropriate materials and following the proposed design. Modification can be conducted after the completion of the proposed instructional conveyor system. A main control panel board is included in the design so as to replicate the real conveyor with its control system. The transfer control system is composed of different electrical control components like the push buttons, indicating lamps, circuit breakers, magnetic contactors, control relays and variable frequency drive (VFD). The transfer system is designed as an instructional device wherein it has the capability to demonstrate the principle and control of a conveyor system using a VFD. The conveyor is designed with bag sewer machine was constructed according to three classifications namely the conveyor, sewer and the controlling devices.

3. Prototype Implementation

The final design of the prototype had been implemented, and the fabrication was done to achieve the desired and efficient function of the device. Where it could sew three to four (3 - 4) bags per minute and it takes 5 to 10 seconds to sew one bag at a time. The running time of the prototype and it generates from 4 to 8 hours. The test conducted was recorded and noted..

4. Evaluation

The project is rated by the respondents in terms of aesthetics, functionally, reliability and portability. A Five-Point Likert Scale is used as a statistical baseline to determine the acceptability of the proposed prototype as shown in Table 1.

Table –I: The Five- Point Likert Scale, Scale Range, and Adjectival Ratings

Rating	Scale Rating	Adjectival Rating
5	4.5 above	Highly Acceptable
4	3.5 – 4.4	Moderately Acceptable
3	2.5 – 3.4	Slightly Acceptable
2	1.5 – 2.4	Acceptable
1	1.4 below	Not Acceptable

IV. RESULTS AND DISCUSSION

1. Design and Development

Figure 4.1 shows the Complete Main Frame Assembly, the mainframe is the skeletal structure of the bag sewer which all other components are mounted. There are two several factors considered in the determination of the material required for the frame, the distance to detect and speed. The size of this assembly is 1032mm x 750mm, in. this work flat bar of 40 mm x 40 mm and 5mm thickness was used to give the required rigidity

Fig.4.1.Completed Main Frame.

The Complete innovative conveyor transfer system with Bag Sewer Assembly shown below, an industrial bag closer usually one of the smallest pieces of equipment in a processing facility, but it is one of the most important. This machine is responsible for creating the right seal or package and it can close 100 to 200 pieces of the bag every hour and they are the most seen in processing plants that handle food or animal feeds. The body of this machine is usually made of metal and it is readily available in the market.

Fig.4.2. Bag Sewer Assembly.

The complete motor assembly is shown in Figure 4.3. For ease and effortless, conveyor with bag sewer is electrically driven itself so that the person who is authorized to operate can just guide and take surveillance of the machine. The materials needed for this assembly is a capacitive sensor that detects objects, the VFD, the electric motor that runs the whole prototype, the indicating lamps, and relays.

Fig.4.3. Motor Assembly.

Figure 4.4 shows the complete Control Panel circuitry and front panel assembly. This assembly controls the sequencing process of the machine as well as indicating lights to visualize components' functions.

Fig.4.4. Control Panel Assembly.

2. Implementation

After the researchers tested 10 kilos of grains to be sailed in 26 – 30 seconds from the Automated Weight Bagging System. The following are the data gathered during testing:

5 kilos of grains = 1 sack
1 sack = 26 – 30 seconds to close
1 minute = 1 – 2 sacks to close
1 hour = 120 sacks to close
10 hours = 1200 sacks to close

3. Evaluation Results

In Figure 4.5, the bar graph shows the mean responses of the Automated Conveyor with Bag Sewer based on the different categories. The mean result on the category Aesthetic is 4.4, thus, it implies that the respondent rated moderately acceptable in terms of the overall appearance of the machine is presentable. Also, machines Reliability has a numerical rating of 4.38 corresponding to highly acceptable adjectival rating which implies that the overall operations of the machine are convenient and easy for the respondents. Moreover the Safety of the machine, 4.4 numerical ratings were rated by the respondents corresponding to a highly acceptable adjectival rating indicates the safety and harm-free operations of the machine. Furthermore, the functionality is 4.43, thus, it implies that the respondents rated highly acceptable in terms of giving the exact functionality of the machine. The machine's over-all mean shows a numerical value of 4.26 which is highly acceptable. This implies that the machine is acceptable in terms of its Aesthetic, Reliability, Safety and Functions.

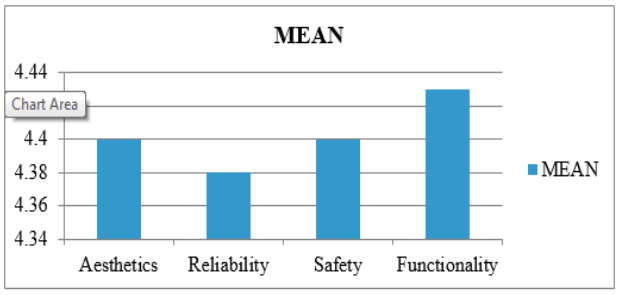

Fig.4.5. Mean Responses in Automated Conveyor with Bag Sewer.

V. CONCLUSION

Anchored on the functionality of the Conveyor transfer system with Bag Sewer was proven with a 4.3 mean rating for functionality necessarily in conveying and bag sewing. The Conveyor system with Bag Sewer functions properly. The sensor is used as a control parameter to activate the motor to run conveyor automatically energizes as well as the sewer. The machine was potentially accepted due to its noticeable aesthetics and influence in the industry. The economic impact of the machine provides reliable marketability.

The recommendations were attached to the least significant advantage of the Conveyor transfer system with Bag Sewer which was capable of its simple mechanism. On the other hand, the Conveyor system with Bag Sewer played a significant role in the community. The benefits of its convenience are practical in the sense that the prototype is the easiest and the most convenient especially on conveying and sewing bags.

1. In terms of the reliability, findings and conclusion in the study researchers have the following recommendations:
2. The sensor must be detached to the machine to avoid malfunctioning because of vibration.
3. In the cutting process, the thread puller must be wider in order to space to the thread's movement to the cutter.
4. Further study is encouraged to improve the design.
5. It is recommended that the study shall lead in innovating power run devices not just in conveyor but also in other useful devices.

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