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Building a model of automatic worksheet vibration system using zen programmable controller

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ABSTRACT:
In the process of assembling products and machinery, the inspection of electronic components always aims for full automation. To ensure stable production processes, there needs to be a stage of accurately supplying blanks to the correct positions in space according to the production rhythm, ensuring continuous operation of the system smoothly. Researching and resolving the blank supply process is one of the crucial requirements in automated production systems, aiding in the most effective operation of machinery and equipment, ensuring safety, enhancing labor productivity, and product quality. [1,2,3].
In this paper, the author presents the process of constructing a model of an automatic feeding vibration system for teaching and scientific research purposes at Hai Phong University.

Keyword: Automatic bar vibrating system, Zen programmable controller

I. INTRODUCTION

The application of automation in manufacturing helps manufacturers increase labor productivity, save time, production costs, and liberate labor. To ensure stable production processes, it is necessary to have a stage of accurately supplying blanks to the correct positions in space according to the production rhythm, ensuring continuous operation of the system reliably.

In enterprises, production lines using automatic feeding vibratory hoppers bring about high economic efficiency as they can replace manual labor, reduce error-prone operations leading to decreased product quality, save energy, production time, and labor costs when needing to arrange many small discrete components running in the same direction and then sequentially into another machining or assembly machine. [4,5].

II. THEORETICAL BASIS FOR SYSTEM DEVELOPMENT

1. ANALYSIS OF FORCES APPLIED TO THE VIBRATING HOPPER

Considering an object A with weight G placed on bar BC in the horizontal plane.

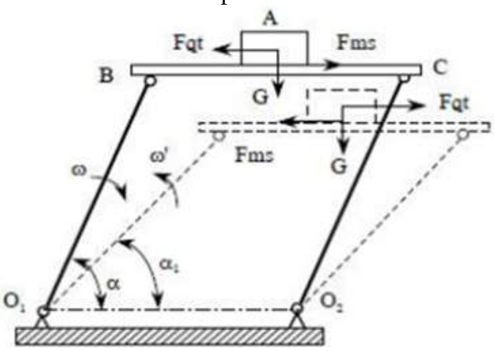

Figure1. The diagram illustrates the movement of the blank on the horizontal plane.

When the bar O1B rotates to the right by an angleα - $\alpha_1$with an angular velocity of$\omega$the object A along with the bar BC moves horizontally downwards. Denoting the maximum acceleration during this journey as a, we have:

$F_{ms} = m\,(g - a_{td}).f$ (1)

$F_{qt} = -\,m.a_n$ (2)

- In there:

a_{td} : as the vertical acceleration

a_n : as the horizontal acceleration

When the lever arm O1B rotates to the left by an angleα -$\alpha_1$with an angular velocity of$\omega$the object A along with the bar B moves vertically upwards. In this case, we have:

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$F'_{ms} = m(g + a'_{td}).f$ (3)
$F'_{qt} = -m.a'_n$ (4)
In there a'_{td} and a'_n as the vertical and horizontal accelerations when object A moves upward. If we consider ω = ω ', then the values of $a_{td} = a'_{td}$ và $a_n = a'_n$.

In that case, the following phenomenon may occur: When the object moves downward and to the right along with the bar, if Fms < Fqt, then the object A will slide on the bar BC, or in other words, the position of object A relative to bar BC will now be behind, meaning object A has a relative leftward motion compared to bar BC. When the bar moves upward and to the left, as Fms increases, in the case where Fms > Fqt, the object firmly clings to the bar BC, or in other words, there is no relative motion between object A and bar BC. Summarizing a cycle of motion of the bar O1B, we have the following observation:

The position of object A relative to bar BC has shifted leftward by an amount s. If this cycle continues, after each such cycle, A keeps shifting leftward relative to bar BC by an amount s. If the mechanism operates continuously, after a while, object A will move relative to bar BC and tend to move away from bar BC. In the case where $g < a_{td}$, then Fms < 0, at this point, object A will no longer be in contact with bar BC, but it will have a relative leap compared to bar BC to the left.

In the case where the bar BC is placed in a plane inclined at an angle β relative to the horizontal plane (Figure 2).

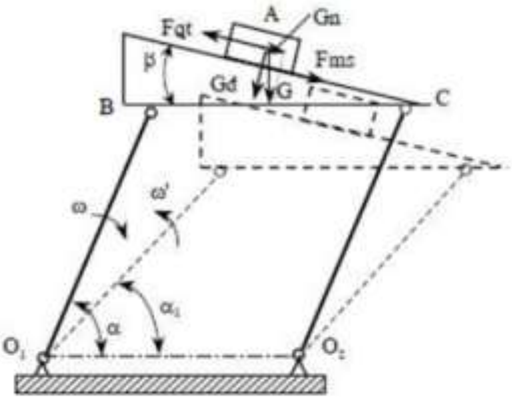

Figure 2. Diagram of Workpiece Movement on Inclined Plane

Similarly analyzing as above, pay attention to the weight G of object A being divided into Gn and Gđ corresponding to the horizontal and vertical directions, respectively, we have:

$\vec{\mathbf{G}} = \overrightarrow{\mathbf{Gn}}.\overrightarrow{\mathbf{G\text{đ}}}$ (5)

Setting up the formulas to calculate Fms, Fqt based on the weight components Gđ and Gn, a_{td} and a_n, we have the following observation: When the bar BC moves downward and to the right, for object A to have the ability to move relative to the bar BC to the left as in the above case, its condition is:

$F_{qt} > F_{ms} + G_n$ (6)

When the bar rotates back to the left and moves upward, the condition for the object not to slide on the bar BC is:

$F_{qt} < F_{ms} - G_n$ (7)

If both conditions above are satisfied, after a cycle of motion of the bar O1B, object A will move relative to bar BC by an amount s. If the mechanism operates continuously, after a period of time, object A will shift to the left and tend to detach from bar BC. Based on such calculated results, vibrating chute designs are constructed following this principle (Figure 2), wherein the bar BC is replaced by a helical wing inclined at an angle β to increase its length and allow object A to move over a larger distance for orientation and position adjustment before transferring to the feeding trough. The structure of the 4-link hinge in the schematic principle is replaced by a vibrating mechanism supported on the elastic bar with vibration generated using electromagnetic magnets. The advantage of this type of vibrating mechanism is the ease of adjusting the vibration frequency and amplitude, meaning it is easily adjustable to change the speed and acceleration for the feeding chute.

2. PROPOSAL FOR DESIGNING THE FEEDING HOPPER

2.1. The design proposal for the rotary disc feeding mechanism

Used for feeding cylindrical or stepped cylindrical components where l ≥ d, or disc-shaped and ring-shaped blanks.

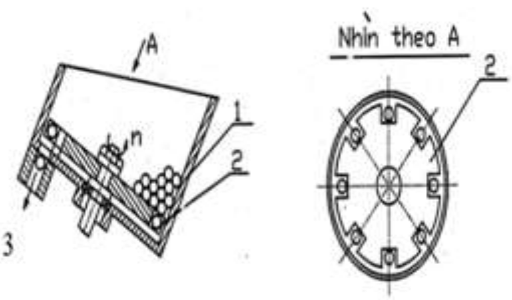

Figure 3. Rotary Disc-Type Feeder Hopper

The working principle of the rotary disc feeding mechanism: Blanks are poured chaotically

into the hopper (1), while the disc (2) rotates round via a screw system. The rotation of the disc causes vibration among the blanks. When the groove on the disc reaches its lowest position, a blank falls into it; as the groove rotates to its highest position, the blank is conveyed to the chute (3). With multiple grooves on the disc, the blank feeding process occurs continuously. To facilitate the shaping of blanks into the grooves, guide vanes can be arranged on the disc. The hopper bottom is inclined at an angle of 30 to 45 degrees relative to the horizontal plane.
Advantages: Smooth operation; Simple and easy-to-machine structure; Accurate orientation; No need for clamping of blanks.
Disadvantages: High cost; Low productivity.

2.2. The design proposal for the vibrating feeding hopper

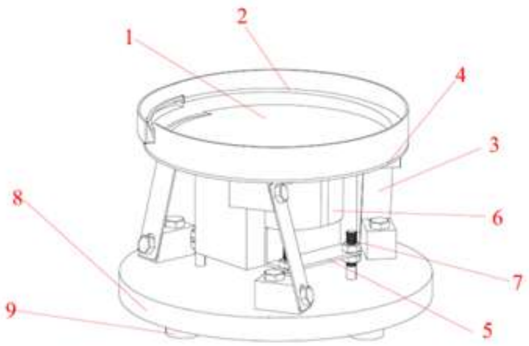

Figure 4. Structure of the Vibratory Feeder for Feeding Stock

1: Vibrating hopper; 2: Spiral chute; 3: Leaf spring; 4: Electromagnet coil; 5: Magnet base; 6: Electromagnet inductive part.

The working principle of the vibrating hopper: When power is supplied to the electromagnet coil 6, it generates oscillations pulling the hopper downward. However, due to the presence of the leaf spring, the hopper oscillation system moves both up and down while rotating around its center at a very small angle. The blanks, which are initially chaotic in the hopper, spread out around it and begin to approach the entry point of the spiral chute. The blanks then move along the spiral chute from the bottom of the hopper upwards along the inclined plane until they exit the hopper. Once the blanks exit the hopper, they follow the chute into the packaging area.
Advantages: High productivity; No blank jamming; Simple structure; Easy blank adjustment.
Disadvantages: Vibration; Noise.

3.Proposed design model

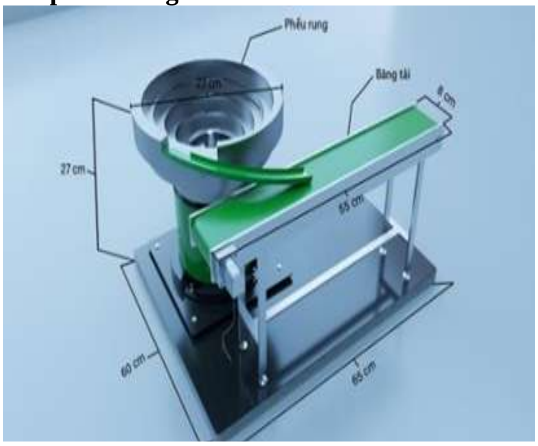

Figure 5. Proposed Model of an Automatic Vibratory Feeder Machine

Mechanical requirements:The mechanical component of the model must be designed to be robust, stable, precise, and minimize errors during operation.

Electrical components: Calculating and selecting electrical equipment such as power sources, sensors, indicator lights, pneumatic valves, motors, etc., should be suitable for the weight, size, and shape of the individual blanks. The electrical design must be rational, safe, and ensure accurate connections. The electrical cabinet of the model should be designed to be compact, enclosed, easy to operate, maintain, and repair.
System control: An optimal control scheme is needed, with simple, compact control devices that are easy to program, reliable, cost-effective, and applicable in both industrial and civilian contexts.
Ensure correct operational procedures: Feed blanks from the hopper at maximum speed: products/minute, with adjustable speed. Allow for setting the number of products to be packaged in a bag. Run both continuous blank feeding modes from the main hopper (vibrating hopper) and single blank feeding from the auxiliary hopper.
Have versatility: adjust some details for use with various blanks of similar shapes and sizes in the simplest way possible.
Control interface: Design should be simple and user-friendly.
Stability: The system should operate reliably, safely, and with high industrial aesthetics.

4.CONSTRUCTION OF AN AUTOMATIC FEEDING SYSTEM MODEL

In section 3, the author presents a proposed model for the automatic feeding system. To validate the effectiveness of the proposed

model, in this section, the author constructs a physical model for the proposed system. The operation of the system model built by the author's team follows a 6-step process:
Step 1. Start the conveyor belt for blank transport.
Step 2. Activate the vibrator motor for blank feeding hopper.
Step 3. Classify the incoming blank products.
Step 4. Products from the vibrating hopper are conveyed out by the conveyor belt.
Step 5. Count the products sent to the packaging stage.
Step 6. Stop the system.
To ensure that the system operates according to these steps and ensures reliability during operation and exploitation, researching and selecting a control system, as well as developingcontrol programs for the system, is essential.

4.1. Mechanical part drawing
Design drawing of the model:

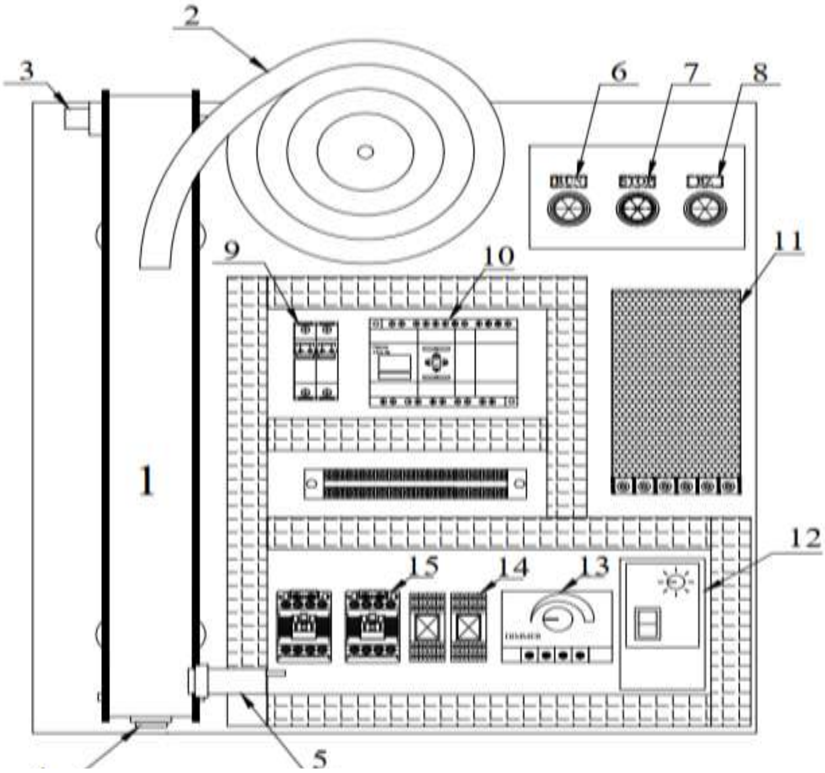

Figure 6. Overview design drawing of the model

Figure caption:
1. Transport conveyor
2. Vibrating hopper
3. Conveyor motor
4. Sensor
5. counter
6. Running indicator light
7. Stop light
8. Sirens
9. Circuit breaker
10. CPU Zen
11. Source
12. Vibration regulator
13. Conveyor controller
14. Contactor
15. Relay

4.2. Electrical drawing
Power supply diagram for the system:

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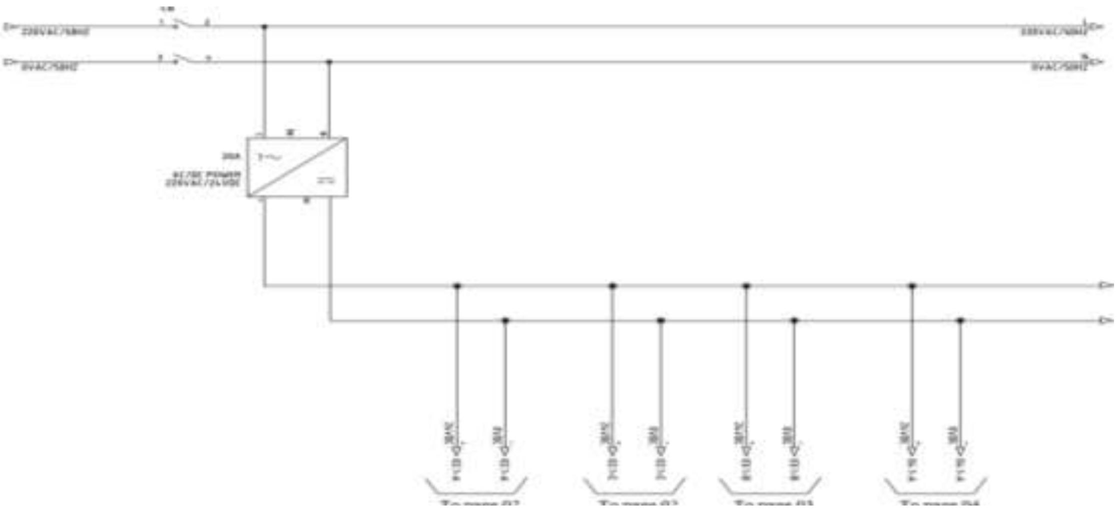

Figure 7. Power supply diagram for the system

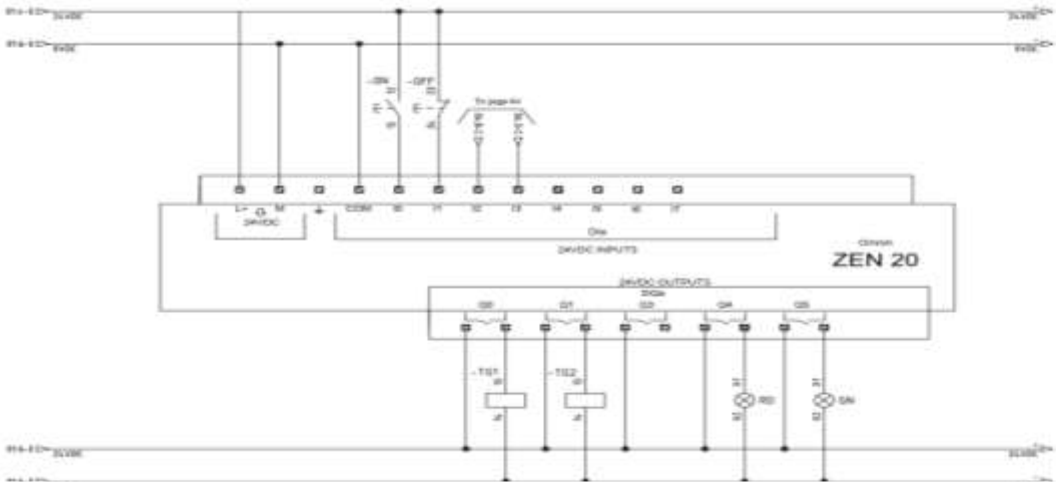

Figure 8. Control system diagram

4.3. Equipment selection for the model

Table of equipment used in the model

Number	Equipment Name	Quantity
1	Conveyor belt 100x600x400mm	01
2	Vibrating hopper – P=250W	01
3	Conveyor motor – P=35W	01
4	Bag sensor - E3F DS30P	01
5	Count sensor - E3F DS30P	01
6	Button Start – LA38	01
7	Button Stop – LA38	01
8	Alarm Buzzer	01
9	Aptomat – LSC6	01
10	CPU Zen	01
11	Adapter – 220VAC/24VDC	01
12	Vibrating hopper driver	01

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13	Relay- Omron	02
14	Dimmer Unit DC-100W	01
15	Contactor - Chint NXC-09	02

4.4. Operating principle of the model

To start the system, we press the Start button. At this point, the system is powered on and indicates readiness for operation.

In the event that sensor1(product packaging detection sensor) does not have power, the Zen controller will actuate, and the conveyor system for transporting loose blanks will not operate. Additionally, an alarm will sound until the product packaging stage is detected by sensor1.

If sensor1 has power, the Zen controller will initiate the start of the conveyor system for transporting loose blanks. The operator will adjust the vibration table controller (frequency adjustment) to suit the type of loose blank requiring sorting.

To stop the system, press the Stop button.

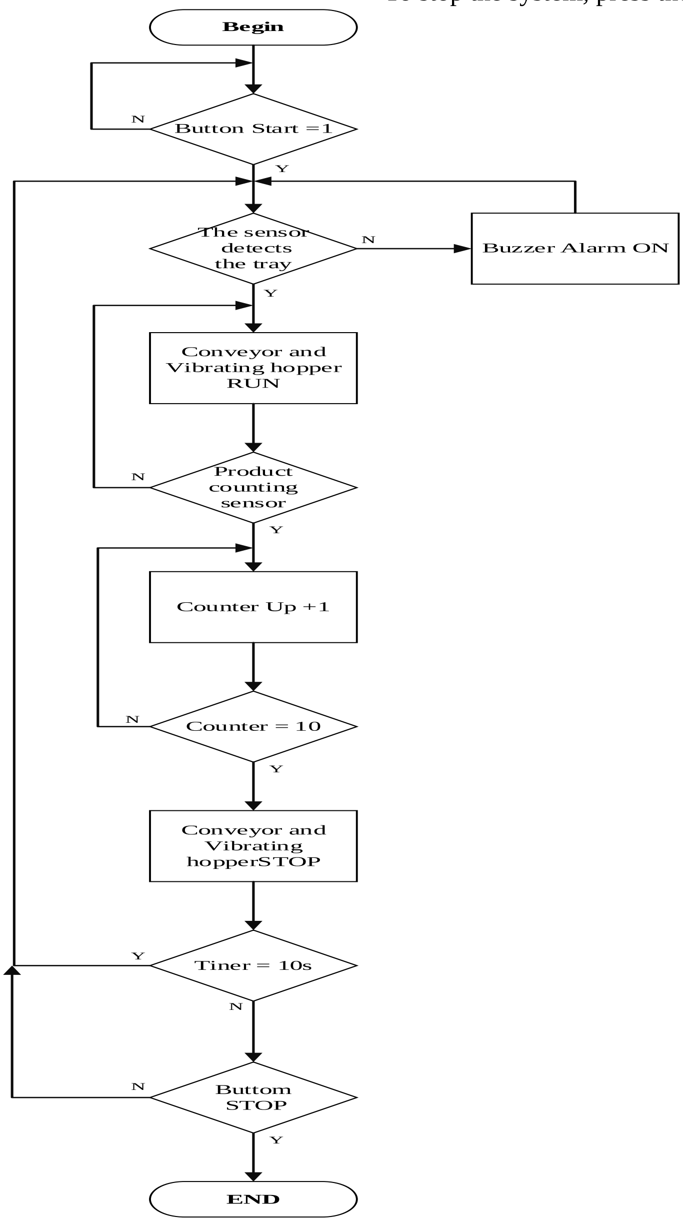

Figure 9. Flowchart of the solution algorithm

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The loose blanks meeting the standard are discharged from the vibrating hopper and conveyed to the product transport conveyor. Shaped blanks are transported from the conveyor through sensor2 (blank counting sensor), which counts up to the set quantity of 10 blanks. At this point, the system pauses for 10 seconds to carry out the bagging process.

In the event that after 10 seconds, sensor CB1 at the packaging stage does not detect anything, the system will sound an alarm for the operator. When the operator proceeds with bagging, sensor CB1 will detect the bag and turn off the alarm, and at the same time, timer block T1 will count for 10 seconds.After 10 seconds, the system will resume operation.

5. Complete system model

Image of completed system model

Figure 10. Completed model

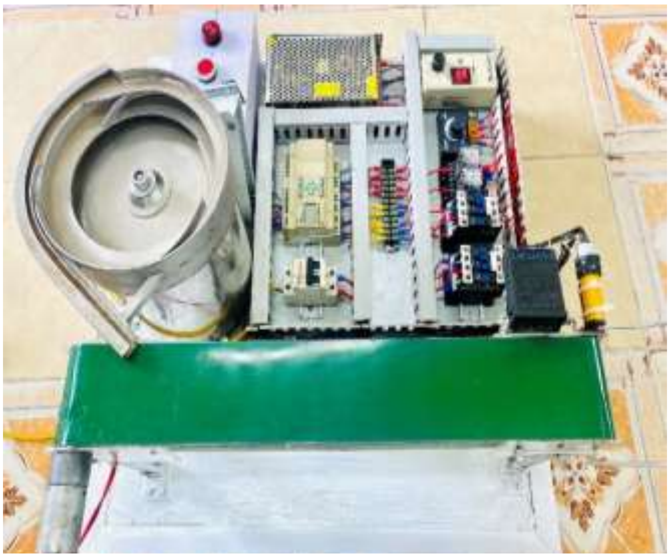

Figure 11. Completed model

III. CONCLUSIONS

The paper proposed and constructed a feeder model, utilizing the Zen controller to regulate the mechanisms. The authors' team validated the existing theory through the construction of a physical model. In the near future, the authors will further optimize the design to facilitate its application in industrial production.

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