Servo Motors in Manufacturing

Servo motors are often required in machines that put labels on containers because they cannot only move the labeling tape a specified distance but can also provide the torque and speed necessary to overcome the friction of the dispensing head and the inertia of the large roll of labels. Once a roll of labels is loaded and accurately aligned with the label motor's initial position, a controller program commands the motor to move at line speed until the label is applied.
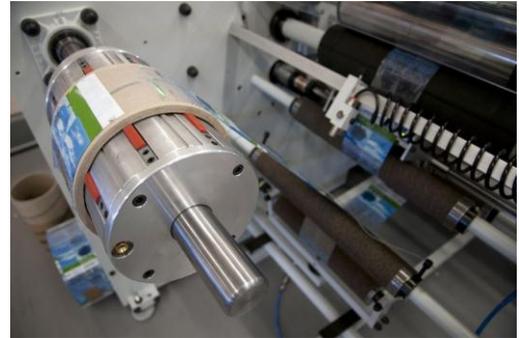
Shrink Sleeve Labeler Machine
© Moreno Soppelsa| Dreamstime.com

Task: You will use the Function Plane with a large gear to simulate a labeling machine. The gear will represent the drum that pulls the label tape through the labeling machine. Your task will be to construct a function that can be used to control the motion of this drum so that it will apply the label at the correct speed and time.

Additional Materials: Servo Sprocket and chain, paper ruler template, labels.

Math Machines Program:

Function Plane

Activity Files: Label00x

There are two parts to this activity.

Case 1: The input variable of your function should be time, **t**. The labels are 3 cm long with the conveyor traveling at .5 cm/sec.

Case 2: Labeling systems typically have motion controllers that can accept input from an encoder mounted to the conveyor to reference its speed. Introduce additional variables and create a function that will automate the program further by allowing the operator to input the conveyor speed along with length of the labels.

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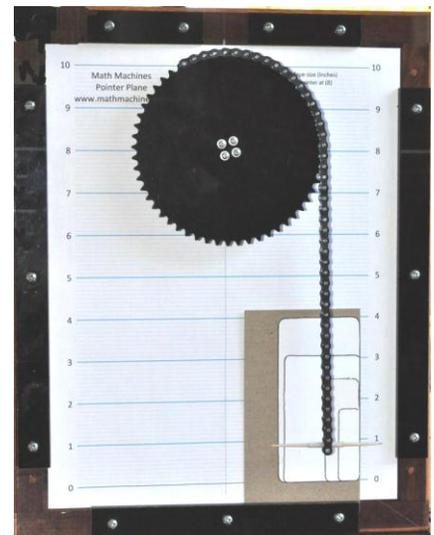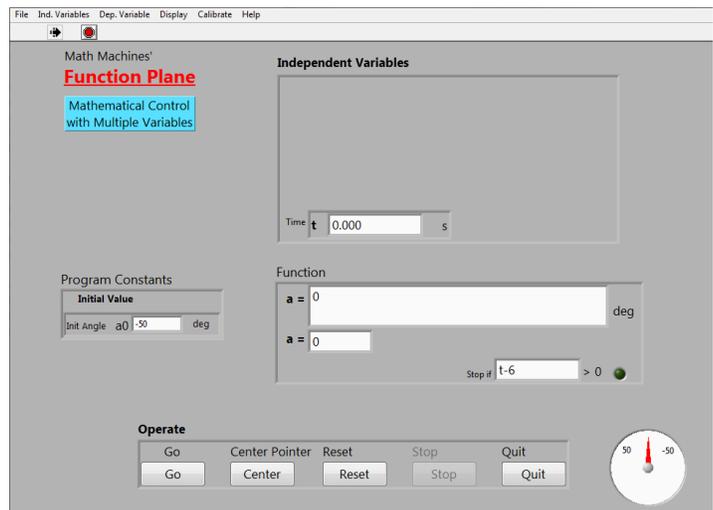
Labeling Machine: The servo motor rotates a drum (ratchet gear pulley) that pulls label tape from the supply roll and feeds it into a system of spindles. The spindles rotate each bottle as the label is being applied and the remaining tape is then wound up on a take-up wheel.

Servo Motor: The labeling tape is threaded through the system where the beginning of each label is positioned so that it can be applied to the bottle in the correct place. A photo sensor will let the controller know when the bottle is in position so that it can operate the servo. The program will operate the servo to rotate the drum to an initial position, pull the label tape the length of one label at the correct line speed and then rotate back to the same initial position to wait for the next bottle. Note: A ratchet gear inside the drum prevents the roll of tape from moving as the servo moves back to its initial position.
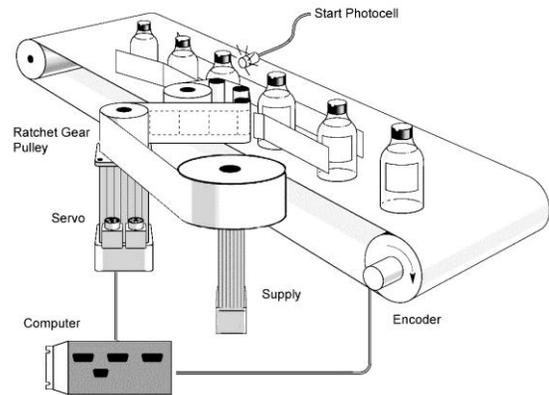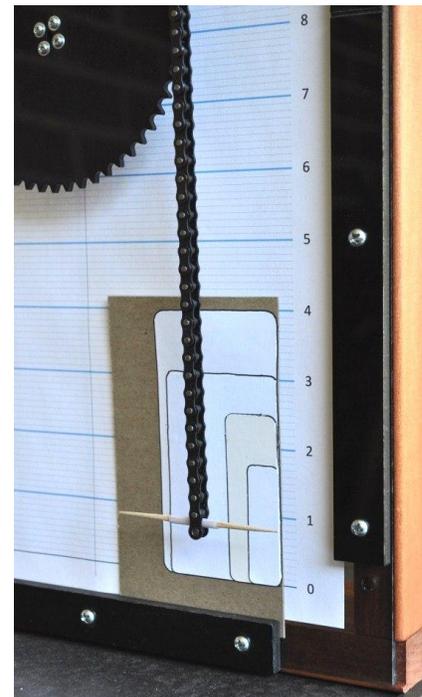
The labeling process:

1. The label motor moves to its initial position **a0**.

2. When a bottle is in position, the motor moves at line speed, pulling the tape the length of one label.
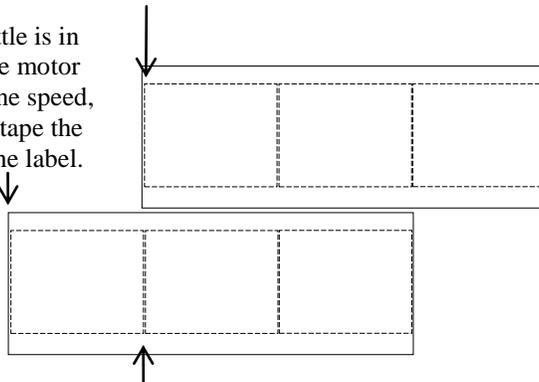
3. A ratchet gear keeps the tape from moving backward when the servo moves back to its initial position **a0**

In our simulation, the gear represents the drum that the servo rotates and the chain, the label tape. To see that the servo is operating the drum correctly, the gear must position the end of the chain at the beginning of the label and rotate the length of one label at the correct speed.

<u>Case 1:</u> The input variable of your function should be time, **t**. The labels are 3 cm long with the conveyor traveling at .5 cm/sec.

<u>Activity File:</u> Label001

1. To operate the servo as prescribed in the labeling process, construct a function that inputs time 't' and outputs angle positions that will move the servo to an initial position **a0** (bottom of label which is 0 in the picture) and then moves at line speed for the exact time it takes to apply the label. You will also need to set the "timeout" to the correct value.

   <u>Note</u>: Considering the setup shown in the picture, you may want the initial position of the servo to be '-50°' and lined up with the 0 at the bottom of the label.

2. When you have constructed your function and have tested it, write it in the space provided below along with values placed in the "initial angle" & "Conditional Stop" windows.

   a = _____ **a0** = _____ **Conditional Stop** = _____

   For future software design engineers, document carefully how the function was constructed.

3. What are the variables?   INDEPENDENT: _____   DEPENDENT: _____

   What is the domain and range? DOMAIN: _____   RANGE: _____

4. Graph your function over its domain on a piece of graph paper. Be sure and label the graph's axes.

5. Explain what both the slope and intercept values mean in the context of the problem.

Case 2: Labeling systems typically have motion controllers that can accept input from an encoder mounted to the conveyor to reference its speed. Create a function that will automate the program further by allowing the operator to input the speed of the conveyor, '**r1**', and the length of the label, '**r2**'.

Activity File: Label002
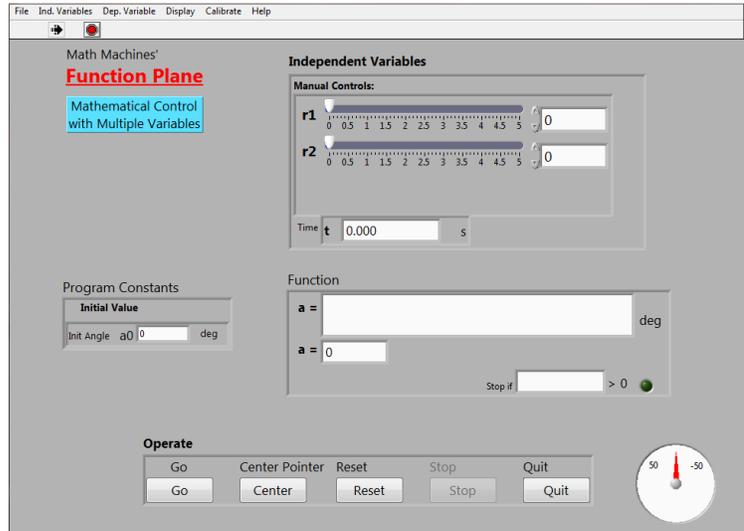
6. Define the additional input variable as described in Case 2 and adjust your function above along with the Conditional Stop inequality to accommodate it. After you have tested this new version for several variations and have verified that it works as expected, record it below. Document carefully how the function was constructed.

    a = _____ **a0**= _____ **Conditional Stop** = _____

    For future software design engineers, document carefully how the function was constructed.

7. Explain what value there is in introducing 'r1' & 'r2' to this labeling process.