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Design of an PIR (Passive Infrared) Based Sensor System in Tape Plant Extrusion Godet to Prevent Human Hand from Injuries During Machine Operations in FIBC, Manufacturing Plant at Flexituff Ventures International Limited (SEZ)

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***Abstract*: Occupational safety always plays a daring part in today industrial world as it generates lots of physical & psychological effects on workers and operators who are regularly exposed to industrial machines. Workers who operate and maintain machinery suffer amputations, fatalities and minor injuries. These machine-related injuries have excellent potential for eradication. Industrial machines are a major source of occupational incident and resulting to injuries. In this research part injuries related to tape extruder godet is monitored along with the study on its control measures in order to increase the protection as well as create safe working environment for the machine operators.**

***Keywords*: Safety, Injuries, Tape extruder, Godet, Polymer, Solidification, Cooling, Stretching, Microcontroller, ATmega328P, PIR motion sensor, Single Pole Double Throw (SPDT) relay.**

1. Introduction

Contactless detection of human limbs is a desirable feature for safety applications, especially at manually fed machines. Such machines (e.g., tape extruder godet) are often equipped with potentially dangerous rollers that are easily accessible by the operator, rendering these machines very prone to accidents. Injuries are unwanted which results in interference of normal activities and reduces the efficiency of workers and loss of production. This is the starting point and motivation for the work presented in this paper. The aim is to develop an adequate solution for the monitoring of dangerous areas at manually fed machines. This work highlights and shows the differentiation of work pieces from human limbs by categorizing the surface material of every object that enters the dangerous area.

2. Discussion

Human–machine interaction is one of the most salient topics today. Human presence detection or human sensing refers to technology used to determine if a person is present in a specific environment. This technology may be used in a range of applications, whether it's for industrial or home safety or security. When human presence detection works accurately, it enables impeccable background features and immediate security alerts.

But developing that level of precision has its own challenges. The major challenges is making the difference between detecting motion versus actual human presence. If the device or system relies merely on motion detection, it can lead to false positives—imagine if a machine went off every time a insect hopped past the sensor. Along with being extra exasperating, it would also wipe out its real purpose.

This is just an example of why it's so important for human presence detection to be as accurate as possible and with a strong understanding of the context, the right sensor setup, and the help of sensor-fusion software.

A. Processes in Tape Extruder Plant

1) Raw Material Blending and Mixing

It is the process which enables fine control over ingredient like poly-propylene, UV, callnet to ensure the final blend performs to specifications. Depending on the product requirements, pre blending or ingredient mixing is required prior to extrusion.

2) Feeding Polymer to the Extruder

Flood feeding is used to feed polymer to extruder in which resins material are placed in the hopper over the feed throat, allowing gravity and the screw to feed the formulation to the extruder.

3) Extrusion

After feeding, resins material gets melted and plasticated, conveyed forward, then melt is mixed, and formed into desired

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shape.

4) Shaping and Drawing

The last step in the extruder shapes the extrudate into the required cross section. As the extrudate exits the die, the polymer molecules, which were align in the die land area, relax and causing die swell.

5) Solidification and Cooling

Extrudate cooling is normally consummate with air, water, or contact with a cold surface. In tape extruder we use water for cooling purposes.

6) Godet

Godets are used as the additional stretching unit which lowers residual shrinkage of tapes. Elongation of tapes is done by passing them over two sets of rollers, called godet. Rollers are placed on either side of the hot air oven/hot plate and operating at variable speeds. Ratio of speed of second set of rollers, operating at higher speed, to that of first set is termed as stretch ratio. Elongation of tapes in presence of heat media results in molecular/chain orientation and thus greatly increases the strength of tapes.

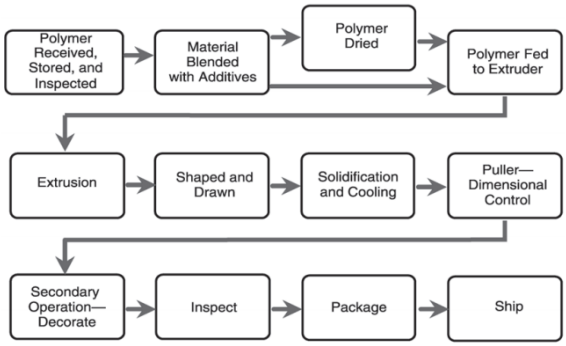

Fig. 1. Flowchart of Process involved in Tape Extruder

Fig. 2. Godet

B. Concept

Concept behind this project is to detect the presence of nearby objects without any human touch. Here we use the principle of light to detect the human limb entering unsafe working conditions. When PIR sensor detect changes in the amount of infrared radiation impinging upon it, which varies depending on the temperature and surface characteristics of the objects in front of the sensor, it passes signal to the microcontroller and takes action according to the conditions provided.

PIR sensor which itself does not emit energy but passively receives it through photo diodes. The dome of PIR sensor acts as a Fresnel or plano-convex lens, which focuses infrared light on a back-to-back photodiode. This photodiode positioning can then connect to the gate on a transistor, generatong a digital output.

Here if the PIR senses the heat (i.e., the human limb comes in the field of view) then microcontroller gets HIGH value while LOW in other conditions. Based on the digital signal from the 2 PIR Sensor, ATmega328P then triggers according to the conditions provided.

When the human limb comes in the field of view of First PIR sensor an alert turns on alert light gets turn on. The light stays on for a present amount of time, and will get switched off if no movement is detected within a specified time period. This will alert the working that his hand is in dangerous area.

When the human limb comes in the field of view of Second PIR sensor the siren gets turn on alerting everyone around the machine and it also cuts off the power supply of the machine to prevent further damage to the operator.

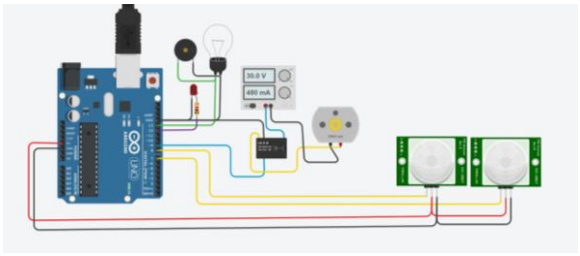

Fig. 3. When no hand is involved

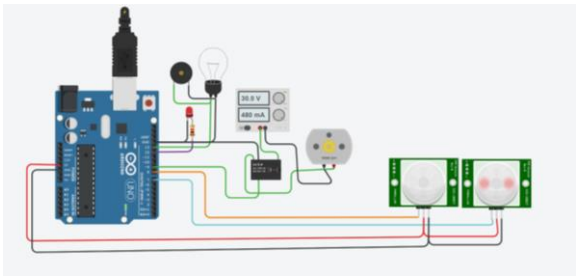

Fig. 4. When hand has crossed first sensor and alert light has turned on

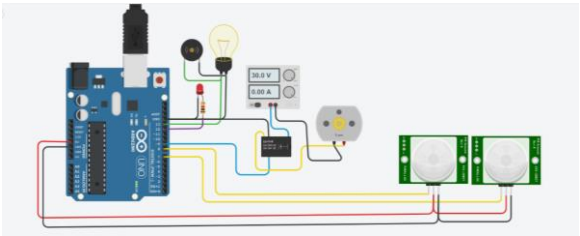

Fig. 5. When hand has crossed both sensors and alert light, siren has turned on and motor supply gets cut off

C. Sensors Powering Human Presence Detection

Here's a list of different sensors involved in human presence detection:

Ambient light sensors: These sensors detect light of the nearby environment. They can measure the light reflecting from

any nearby body to detect human presence from a distance. They're often used to automatically activate devices, such as computers or mobile phones, without the operator needing to actually press a button.

Ultrasonic proximity sensors: They emit ultrasonic waves and measure the time it takes to return to analyse distance to the sensor. They tend to work well in utmost environmental conditions, but they have a finite detection range. You may have seen these used to determine when a human enters or leaves the vicinity of a device.

InfraRed proximity sensors: InfraRed proximity sensors rely on infrared (IR) light to analyse distance and identify figures. It is the mostly used in surveillance and security applications.

Capacitive proximity sensors: These sensors generate their own electrostatic field. However, when an object comes near the sensor, it changes the sensor's capacitance, resulting change in amplitude. This change triggers or activate an output switch.

Time-of-flight sensors: These sensors emit a signal that reflects off a surface and determine the time it takes to return to the sensor. It is similar to the IR proximity sensor; however, time-of-flight sensors include various types of signals, including lasers, IR, and ultrasound. Time-of-flight sensors use an array of light-sensing pixels to determine relative distances from the object, designing a range map. This allows for complex and descriptive view of what it's pointing at than the simpler proximity sensor.

Passive IR detectors: PIR sensors detect anything whose temperature is above absolute zero and emit infrared radiation. It doesn't actively emit infrared light, but instead looks for changes in surrounding environment. This can lead to false positives for human presence detection, but it can be efficiently used in a context where only humans would be present.

These sensors on their own aren't enough to precisely detect human presence. Understanding context and how to integrate sensors can help make them more precise and accurate.

D. Electronic Components

1) ATmega328P

Atmel® ATmega328P is a high performance and low power CMOS 8-bit AVR microcontroller that's able to attain the most single clock cycle execution of 131 powerful instructions. It is based on the AVR® improvised RISC architecture. ATmega328P achieves throughputs approaching 1MIPS per MHz allowing the system designer to optimize power consumption versus processing speed.

2) HC SR501 PIR Motion Sensor

HC SR501 PIR motion sensor also known as Pyroelectric, Passive infrared or IR motion sensor. A passive infrared sensor is an electronic sensor that computes infrared (IR) light radiating from objects in its field of view. PIR sensors detect general movement, but do not give details of who or what has moved. The term passive means that PIR devices do not radiate energy for detection purposes. They work by detecting infrared radiation (radiant heat) emitted by or reflected from nearby bodies present.

It is a very small approximately 3x2.2 cm sized printed circuit board with the PIR motion sensor mounted on the front side and covered by a white composite compact (Fresnel) lens that increases the performance of the lens. It works on the principle of electromagnetic radiation. Every objects with a temperature above absolute zero emit heat energy in the form of electromagnetic radiation, this radiation isn't visible to the human eye but it can be detected by electronic devices build for such a purposes.

3) SPDT Relay

Single Pole Double Throw (SPDT) Relay contains 2 coil terminals and common terminal, then 2 switching terminals N/O (Normally Open), N/C (Normally Close). In idle condition common terminal connected in N/C terminal. When the coil gets required DC supply then coil gets Magnetically Energized and this magnetic flux force attracts common terminal lever which is made of iron and makes the connection to N/O terminal, now the N/C becomes open.

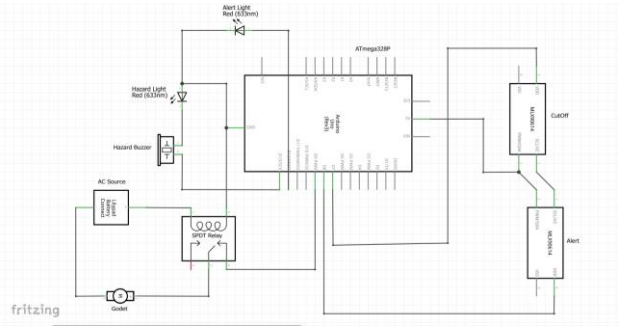

Fig. 6. Schematic diagram of circuit

```
int pir;
int pir2;
void setup()
{
  pinMode(7, INPUT);
  pinMode(12, OUTPUT);
  pinMode(9, OUTPUT);
  pinMode(8, INPUT);
  pinMode(13, OUTPUT);
  Serial.begin(9600);
}

void loop()
{
  pir2 = digitalRead(7);
  pir = digitalRead(8);
  Serial.print("This is PIR value ");
  Serial.println(pir);
  if (pir2 > 0)
  {
    digitalWrite(12, HIGH);
  }
  else
  {
    digitalWrite(12, LOW);
  }
  if (pir > 0)
  {
    digitalWrite(9, LOW);
    digitalWrite(13, HIGH);
    for (int i = 1; i > 0; i = 1)
    {
      tone(13, 204, 150);
      delay(500);
    }
  }
  else {
    digitalWrite(9, HIGH);
  }
}
```

Fig. 7. Code

E. Working

- Make the connections as per the schematic diagram and switch on the circuit.
- The PIR sensor is powered and it detects the IR rays emitted from any human being.
- This PIR sensor has a range of 7 metres. We can adjust the pot provided for the sensor to vary this distance according to the situations.
- When any human is detected, in first PIR sensor outputs a logic HIGH value i.e., voltage of 3.5V to 5V to ATmega328P Pin 8.
- When any human is detected, in first PIR sensor outputs a logic HIGH value i.e., voltage of 3.5V to 5V to ATmega328P Pin 7.
- As soon as the microcontroller detects logic HIGH on Pin 8, it makes the Pin 12 HIGH for a duration of time. During this time, the alert light is activated. And as soon as the microcontroller detects logic HIGH on Pin 7, it makes the Pin 13 HIGH which turns on the siren light. At this point the machine supply also gets cut off.
- A relay is also connected at Pin 9 because the machine is operated at very high voltage while ATmega328P cannot handle such high voltage therefore a relay is used to control the power of the machine.

3. Conclusion

The objective of this work was met. Developing sensor-based systems for improving safety has recently gained significant momentum in today's world. In particular, vision-based monitoring systems have become mainstream research in safety and security from hazards. This study has provided an outline of recent advancements in the domain as they associate to safety risk management and has identified golden opportunities for future work.

Sensor-based systems can be used for automated continuous monitoring of industrial machineries. They can be used to proactively prevent accidents by informing workers or operators of an incoming hazard or risk. Additionally, such systems can be used to inform safety managers or site supervisors of unidentified, or newly appearing potential risks or hazards. As a result, necessary controls can be applied on time to prevent accidents.

Although a considerable number of publications are reviewed to cover sensor-based systems thoroughly, future research should examine state-of-the-art techniques and technologies used in different sectors and consider their applicability to tackle safety challenges.

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