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Group M2.03 – Lighthouse Project

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Sponsor: Center for High Performance Systems

Background

The West Texas Lighthouse for the Blind is a manufacturing facility in San Angelo, Texas that employs people who are blind or have severely impaired vision. The Lighthouse was established in 1963 as a non-profit organization and now has over 60 team members.

Define

The current pneumatic press system operates at a sound level of around 110-120 dB leading to an unsafe environment for operators. Our goal is to reduce this to under 85 dB because OSHA requires employers to implement hearing conservation programs if a work environment exceeds 85 dB's. Also, we will formulate ways to actively collect audio data for implementation into a digital twin and to collect and compare data.

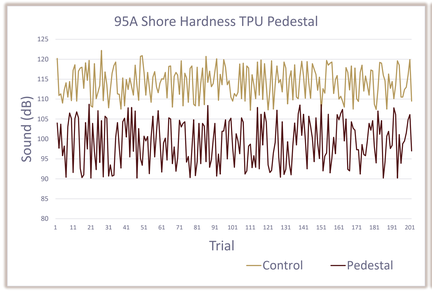
We identified 3 major points within the press that contributed to unsafe audio levels.

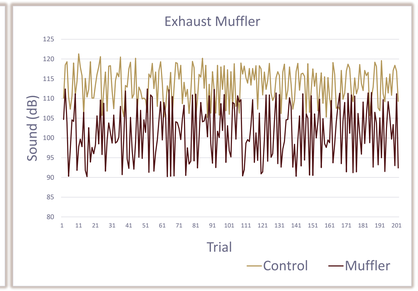
To address these points of interest, we will hardware, adjusted the punches settings, or implemented pre-existing hardware specifically tailored to each POI. These improvements include exhaust mufflers, vibration & sound dampening pedestals, and air pressure adjustments.

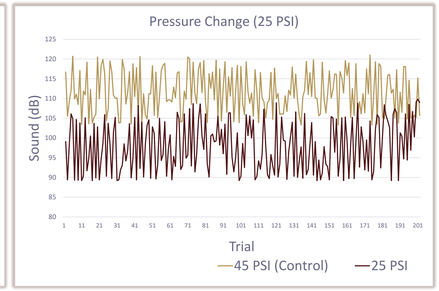
Measure

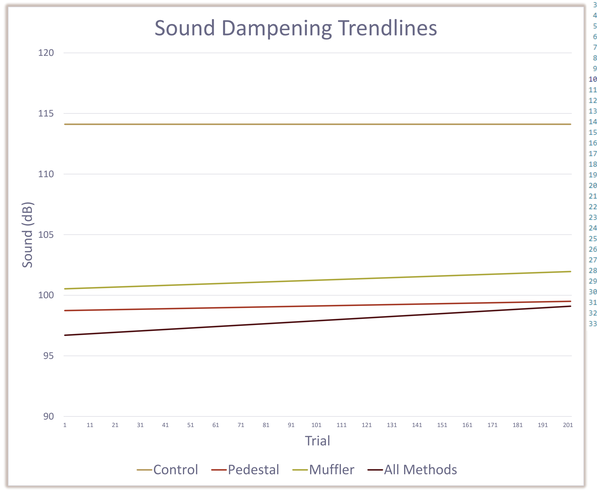
To collect data and monitor the sound level of the sound dampening improvements, we created a portion of a future digital twin with our dB meter. The device collects real-time data readings and inputs them directly into the system. Along with the dB meter, an accelerometer was used to collect some of our baseline data along with tests of implemented improvements

Measure







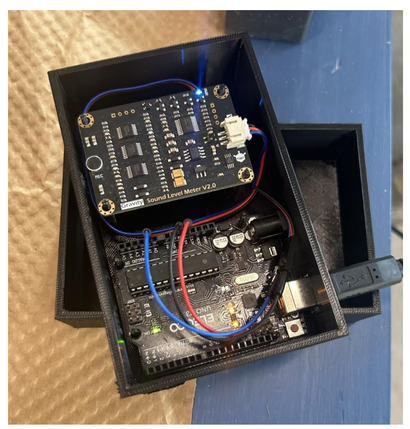



```
#define SoundSensorPin A1
#define BuzzerPin 9
#define VREF 5.0
#define ADC_RESOLUTION 1023.0
#define SAMPLE_COUNT 10
#define SAMPLE_INTERVAL 150
#define WARNING_THRESHOLD 120.0  // Single high-level warning threshold
#define FILTER_SIZE 3  // Faster response to short bursts

unsigned long previousMillis = 0;
float readings[FILTER_SIZE] = {0};
int index = 0;

// Function to discard initial unstable readings
void discardInitialReadings(int count) {
    for (int i = 0; i < count; i++) {
        analogRead(SoundSensorPin);
        delay(5);  // Short delay to allow stabilization
    }
}

// Function to get a smoothed reading with peak detection
float getSmoothedReading() {
    float sum = 0;
    float peakValue = 0;  // Track the highest single reading

    for (int i = 0; i < FILTER_SIZE; i++) {
        float reading = analogRead(SoundSensorPin);
        readings[index] = reading;
        index = (index + 1) % FILTER_SIZE;
        sum += reading;

        // Store the highest value detected for peak detection
        if (reading > peakValue) {
            peakValue = reading;
        }
    }

    float avgVoltage = (sum / FILTER_SIZE) / ADC_RESOLUTION * VREF;
    float peakVoltage = peakValue / ADC_RESOLUTION * VREF;

    // Use peak value if it's significantly higher than the average (short burst)
    if (peakVoltage > avgVoltage * 1.2) {
        return peakVoltage * 50;  // Convert peak voltage to dBA
    }

    return avgVoltage * 50;  // Default to smoothed value
}

void setup() {
    Serial.begin(115200);
    pinMode(BuzzerPin, OUTPUT);
    digitalWrite(BuzzerPin, LOW);

    discardInitialReadings(5);  // Remove transient noise before starting
}

void loop() {
    unsigned long currentMillis = millis();

    if (currentMillis - previousMillis >= SAMPLE_INTERVAL) {
        previousMillis = currentMillis;

        float dbValue = getSmoothedReading();  // Get stable dB value

        Serial.print("Sound Level: ");
        Serial.print(dbValue, 1);
        Serial.println(" dBA");

        if (dbValue >= WARNING_THRESHOLD) {
            Serial.println("🚨 WARNING: High Noise Level! 🚨");
            for (int i = 0; i < 5; i++) {  // Buzzer alerts 5 times
                digitalWrite(BuzzerPin, HIGH);
                delay(200);
                digitalWrite(BuzzerPin, LOW);
                delay(100);
            }
        }
    }
}
```

Improvements

95 Shore Hardness TPU Pedestal

Exhaust Muffler



Decibel Meter

Acknowledgements

A big thanks to Noe Tavira, Lorenz De Robles, and Aaditya Baniya

Measure

For our testing purposes we conducted a total of 200 punches for each session and observed the noise level and vibrations in each. We chose this format of testing because it mimics a normal workday for the press and gives us enough data to accurately reflect upon the operation of the system. The testing allowed us to individually then collectively implement improvements then observe and compare how much noise and vibrations the press made after improvements.

Improvements

Each one of our improvements addresses a point of interest that creates sound in the system. In the case of the dB meter, it collects sound data within the system for testing and observation. The TPU pedestal addresses contact between the table and press. Next, the muffler addresses exhaust port noise from press operation. Lastly, decreasing the operating pressure addresses excessive contact force between the piston and punch on the press.

Analyze

Measurement	Control Mean (dB)	Test Mean (dB)	T-Test Result
Pedestal Sound	114.11	99.12	Significant
Pedestal Vibration	49.15 m/s^2	49.04 m/s^2	Not significant
Muffler	113.34	101.25	Significant
Pressure	111.55	97.90	Significant
All Methods	114.11	97.90	Significant

Meet the team