IPRO 321

Consumer Product Design & Performance Evaluation

Spring 2007

Sponsor

Mr. Seth Lewis

President

Consumer Paper Shredders

Goals

Optimize gear train to reduce gear failure

Design more commercially attractive paper shredder

Evaluate and advise improvements to enhance safety features

Reduce operating noise output by 10dB

Teams

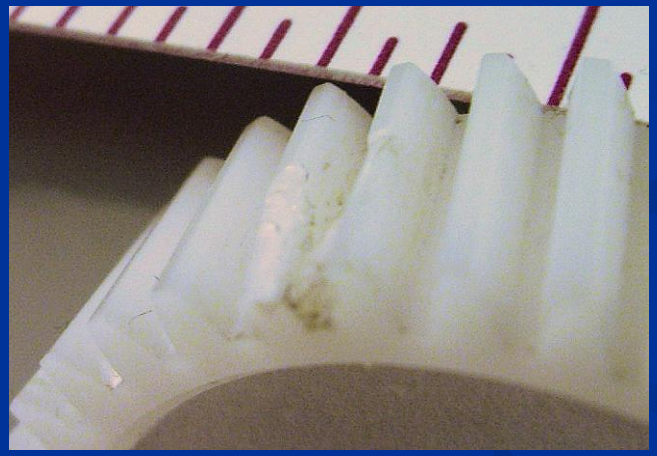
- Gears
  - Michael Tomsa
    Electrical Engineering
  - Dmitriy Zverev
    Mechanical Engineering
- Safety
  - Raisa Pelae
    Chemical Engineering
  - Garrett Strassler
    Aerospace Engineering
- Design
  - Julianna Kovacs
    Engineering Management
  - Chil-Woong Kwon
    Computer Engineering
- Sound
  - Richard King
    Computer Engineering
  - Donald Myers
    Computer Engineering
  - Gregory Mennenga
    Computer Engineering
  - Jianyu Chen
    Electrical Engineering

Gears

Goal: Evaluate the gears and minimize the gear failure at initial shredding cycle.

Gears

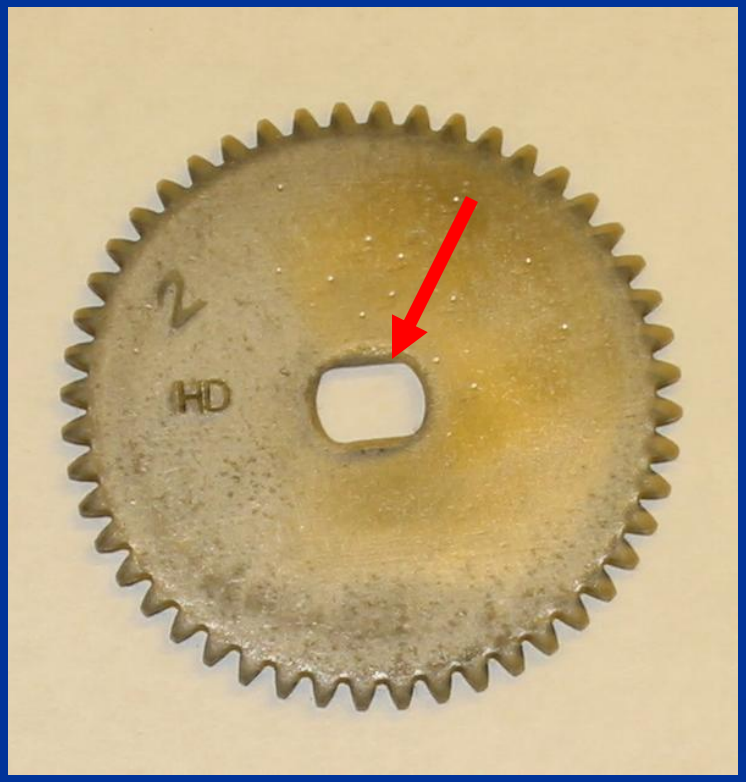
- Issue: Plastic Gear teeth fail at high loads



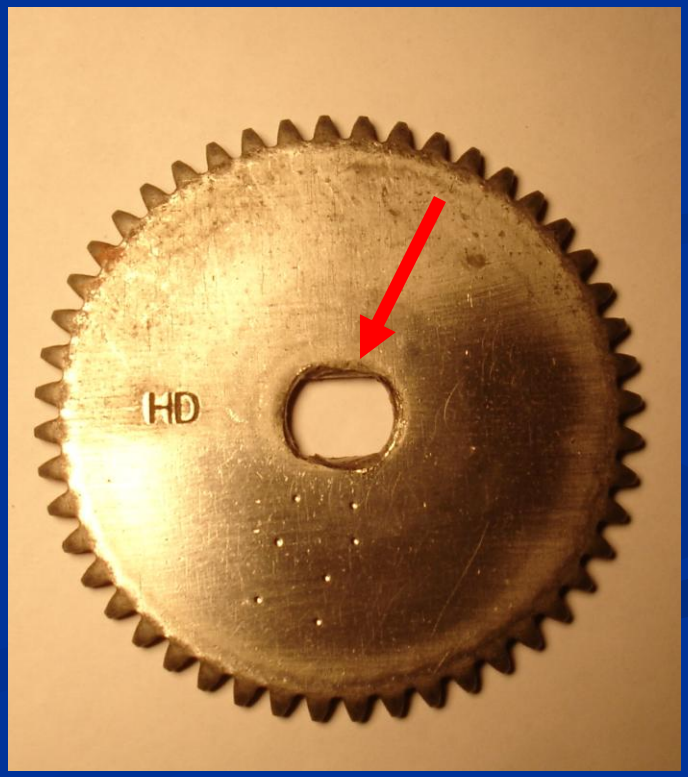
Nylon Gear Failures

Gears

- Issue: Center of the metal gears strips when paper shredder is jammed



Non -Stripped Gear



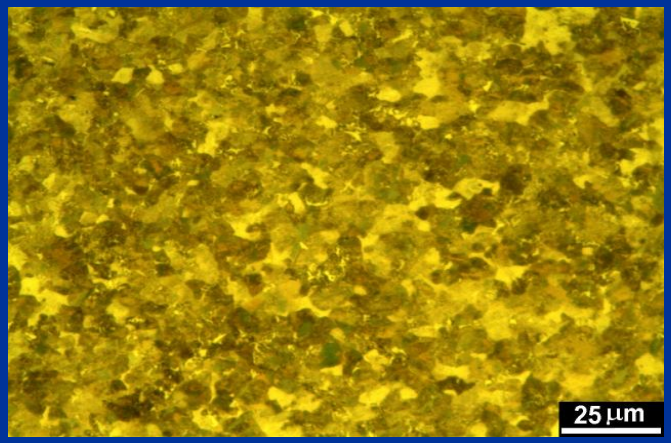
Stripped Gear

Gears

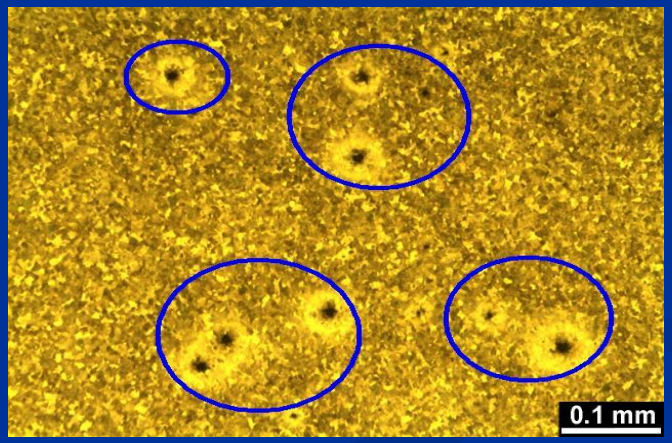
- Test Results
  - Plastic Gears
    - Chemical Analysis Test - Nylon
    - Torque Tests – Maximum Load 4 in-lb
  - Metal Gears
    - Rockwell Hardness Test B Scale ~ 90 (very soft)
    - Microstructure Test – Voids in the material
    - Chemical Analysis Test – 1.6% Carbon composition

Gears

- Carbon content ~1.6% - enough to heat treat the material to increase hardness and decrease voids.



1.6% CARBON



VOIDS

Gears

- Recommended Solutions
  - Plastic Gears
    - Lengthen Motor Worm/widen helical gear
    - Upgrade the material to glass-filled nylon
  - Metal Gears
    - Change shape of center hole on metal gear
    - Heat treat the gear to increase hardness

Design

Goal: To evaluate the current marketing offerings and price points and create new designs for a line of paper shredders.

Design

Our new design focuses on new shredder features and styles.

Steps to The New Design:

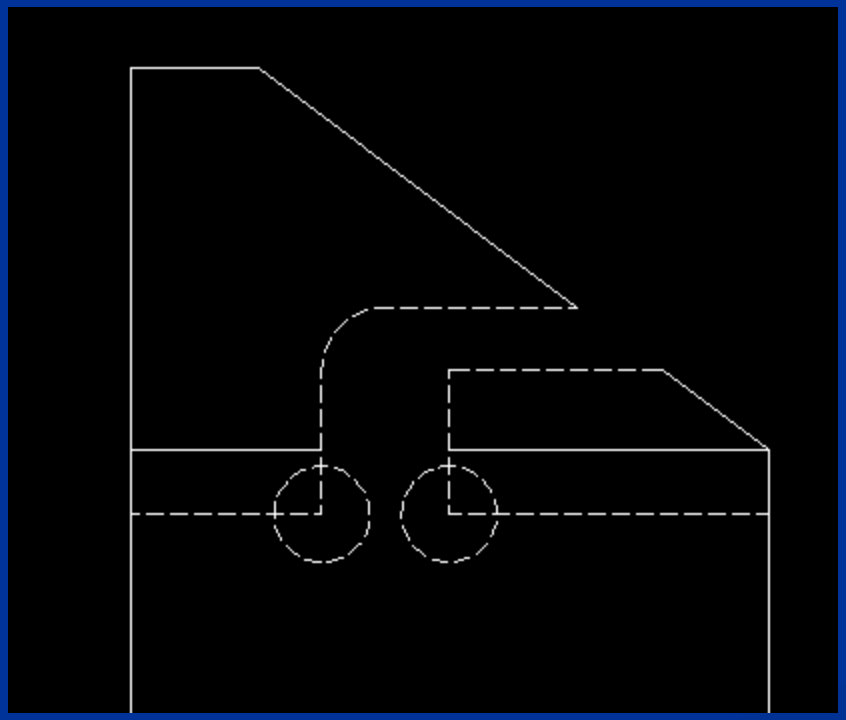
- Team formation
- Education and goal setting
- Gathering information
- Design optimization
- 3D Modeling

Design

- Lightweight Glossy Plastic
- Clear Grey Universal Plastic Bin
- 26” by 10” Dimensions
- 8-11 Sheet Shredder
- Attractive Design
- Reasonably Priced

Design

- **3D Modeling**
  - Unique Entry Way



Design

- **Other New Design Concepts**
  - Blue, Red and Yellow LED Lights in Entry Way

Blue = Shred

Yellow = Standby

Red = Reverse

Design

Bright Colors

Glossy Black

Bright White

Seasonal Colors

Safety

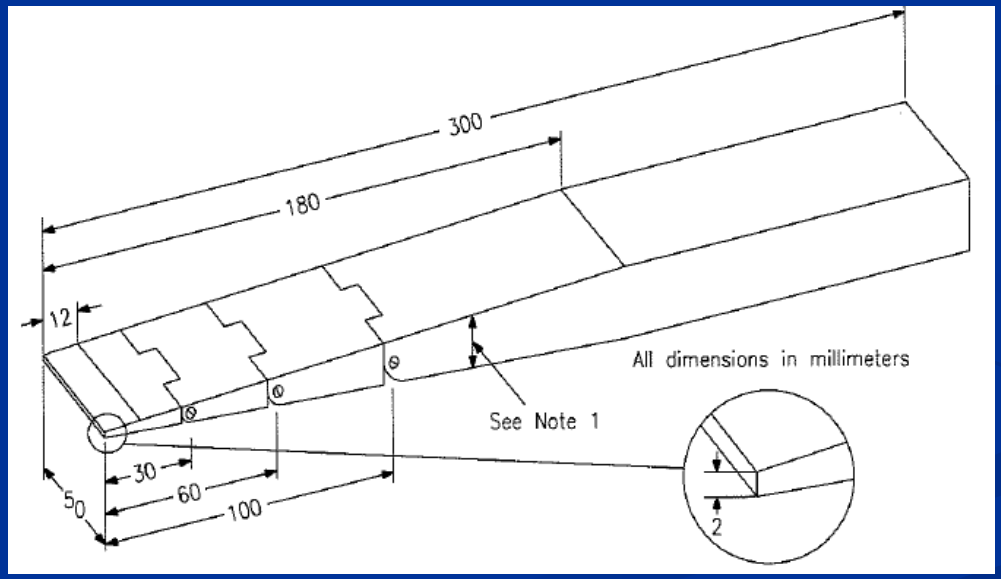
Goal: Evaluate the different models and advise improvements to enhance the safety features to exceed the 2007 UL Standards.

Safety

- Issue:
  - According to the CPSC: finger amputations of young children are among the most serious injuries

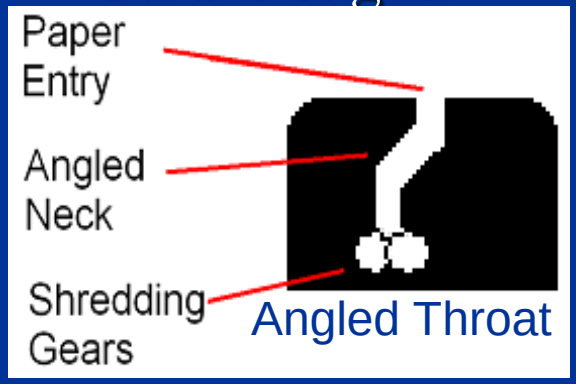
Safety

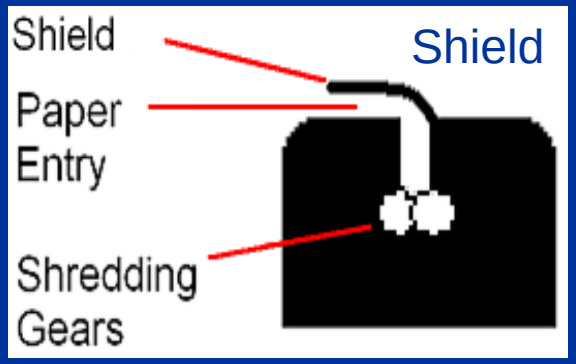
- Procedure:
  - Manufactured a finger probe according to UL Standard
  - Check for UL Standard compliance



Safety

- Possible new safety features to exceed the UL Standards:
  - New Designs:



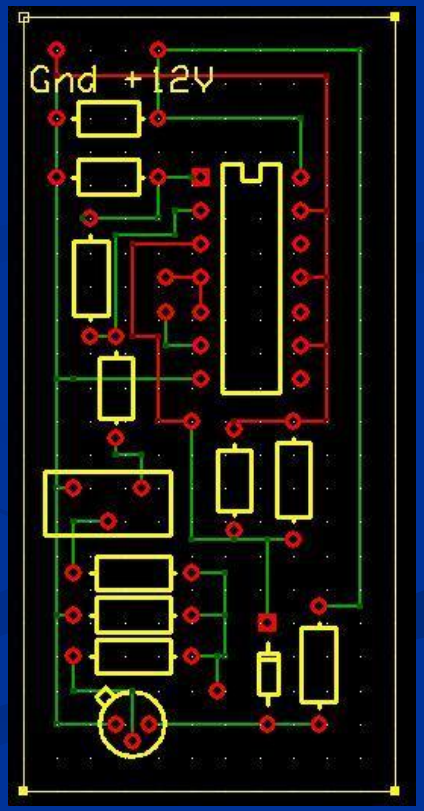


  - Touch Sensors:
    - Disables motor when touch sensors detect fingers near shredding gears
    - May conflict with Fellows SafeSense™ pending patent

Safety

- Capacitive Touch Sensor:
  - Detects Human Touch through change in Capacitance
  - Based on design ideas from edn.com

PARTS	COST (1)	COST (500)	COST (1000)
40106 Hex Inverting Schmitt Trigger	$0.26	$0.16	$0.13
2n5457 JFET	$0.12	$0.061	$0.052
10K Linear Potentiometer	$0.28	$0.22	$0.21
1N4148 Diode	$0.02	$0.009	$0.007
4 x Capacitors (2x1nF, 2x0.1uF)	$0.10	$0.05	$0.03
6 x Resistors (6.8k, 2x10K, 100K, 1M, 10M)	$0.04	$0.02	$0.016
TOTAL Per Unit:	$1.32	$0.77	$0.62



Source: Mouser Electronics (www.mouser.com)

Sound

Goal:

To reduce the general noise output with a target of 10db reduction.

Sound

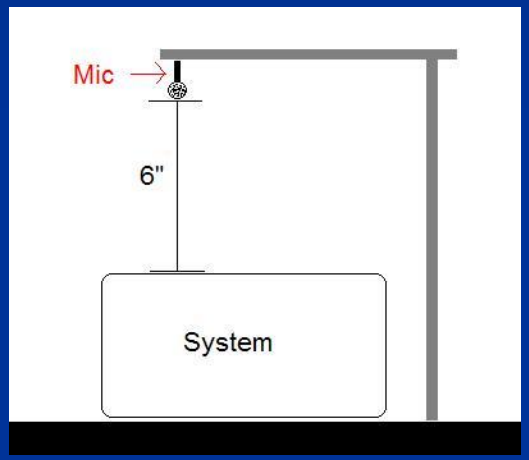
- Issue:
  - Many consumers report that they are dissatisfied with the level of noise produced by paper shredders.

Sound

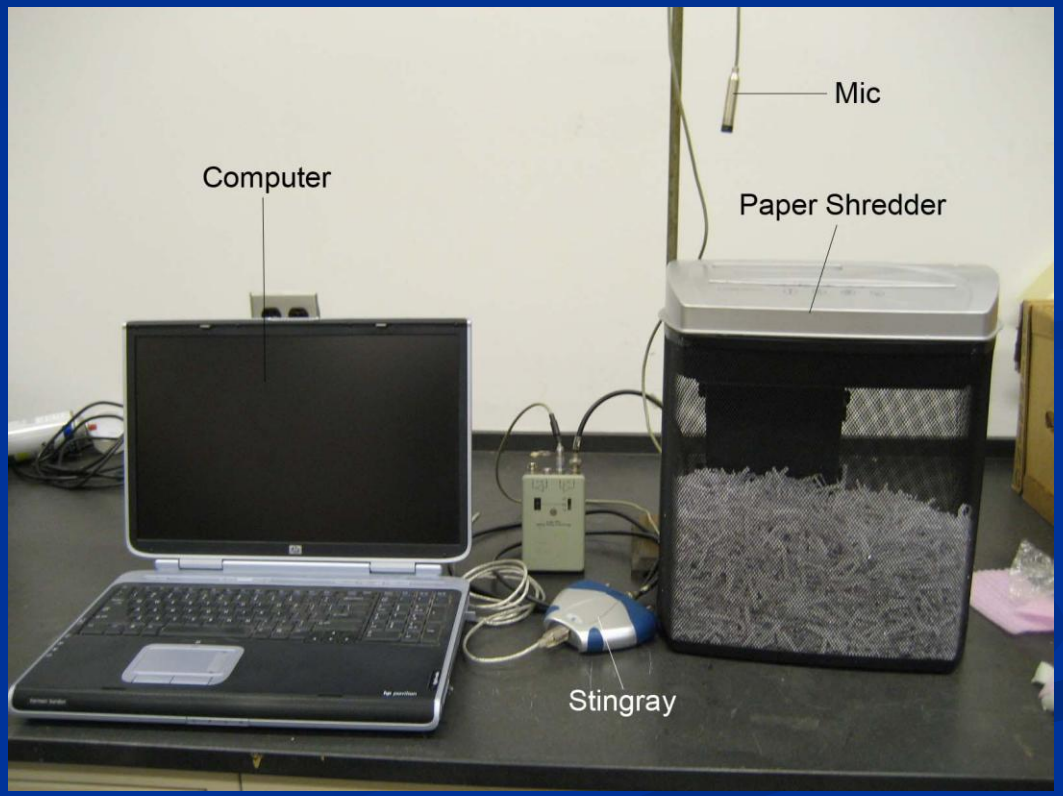
- Investigated Solutions:
  - Active Noise Cancellation
  - Passive Noise Correction
  - Noise Dampening
- Constraints
  - Costs must be less than cost to upgrade to DC motor (~$3.00 per unit)

Sound

Apparatus and Setup



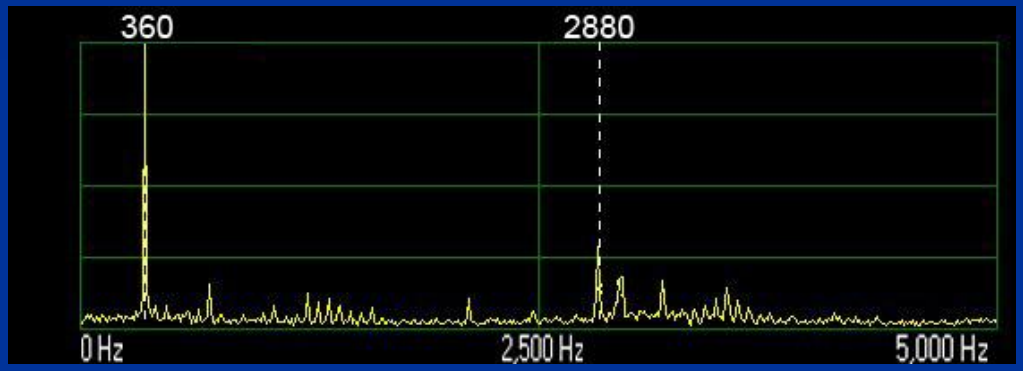
Data Capture Equipment



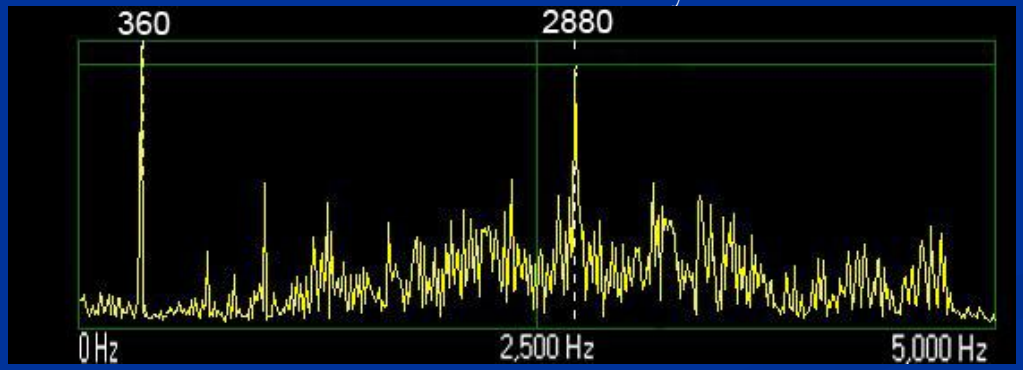
Sound

- Initial Test Results:

Motor Only



Gear Train and Motor Only

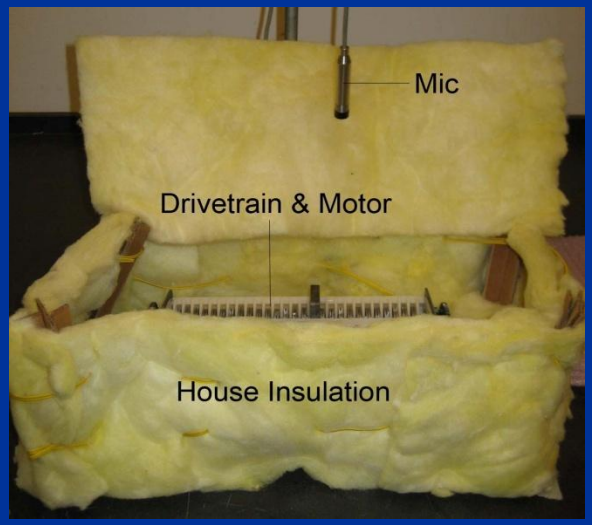


- Motor Noise:
  - 360hz- 3rd harmonic of power output
  - 2880hz- Vibration from carbon brushings
- Majority of Audible due to motor vibrations transmitted through Gear Train

Sound

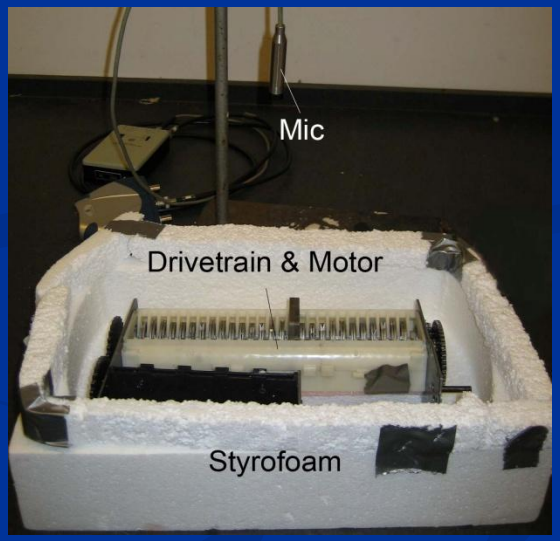
- Insulations Tests

Household Insulation

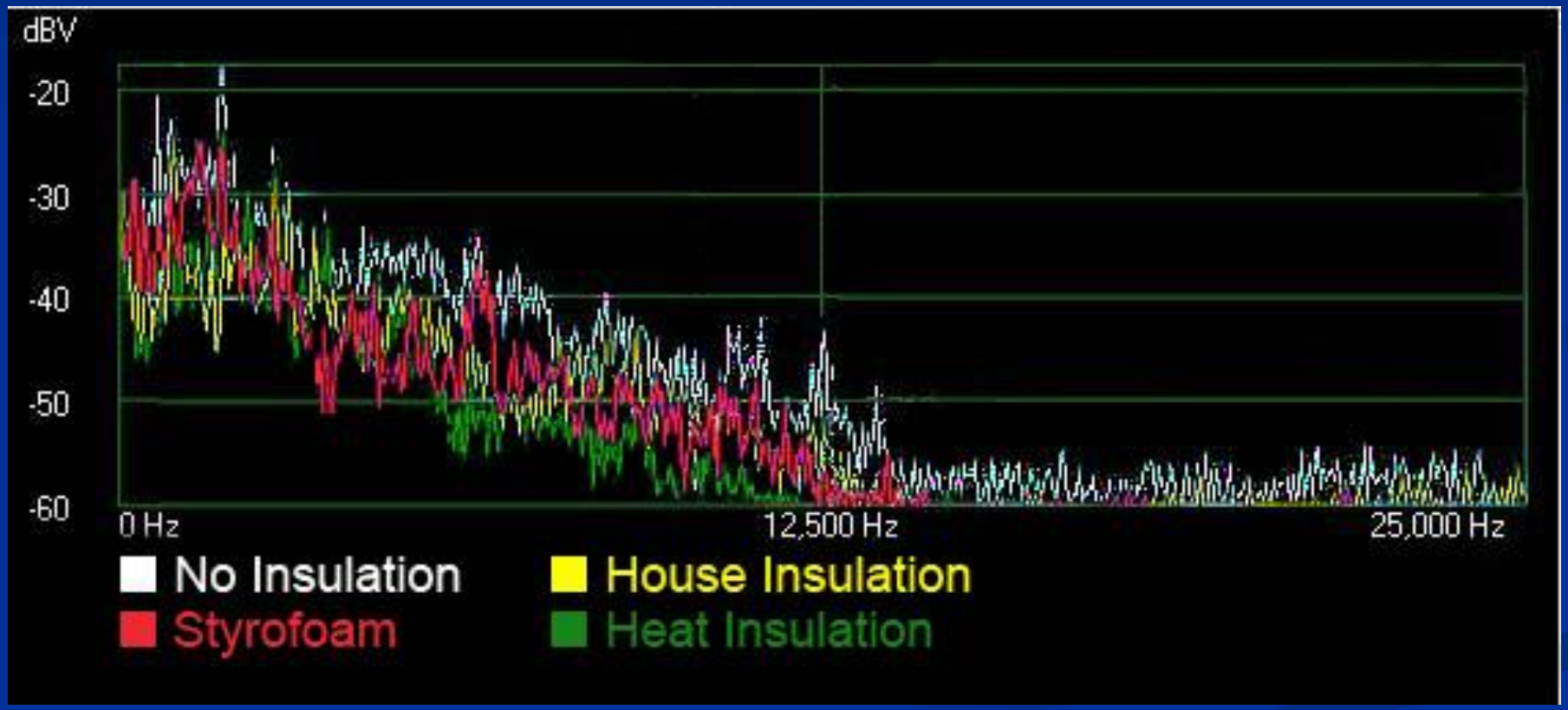


Heat Insulation

Styrofoam



Sound


dBV
-20
-30
-40
-50
-60
0 Hz
12,500 Hz
25,000 Hz
No Insulation
House Insulation
Styrofoam
Heat Insulation

Sound

- **Recommendations**
  - Active Noise Cancellation
    - High cost
  - Passive Noise Correction
    - Noise is from the motor vibration
      - Addition of a flywheel
  - Noise Dampening
    - Noise transmitted through case and out from throat
      - Recommend angled or shielded throat.

Suggestion for Future Work

- Determine the amount of force and torque required for shredding different amounts of paper.
- Design an efficient gear train that optimizes the # of gears and minimizes the motor size.
- Based on current results, develop acoustical sound dampeners.