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## MOTIVATION

- ◆ 2-4 million workers are exposed to vibrating tools annually.
- ◆ 50% of those workers develop related injuries.
- ◆ Associated costs are estimated in the hundreds of millions of dollars and growing.
- ◆ Injuries:
  - ◇ Hearing Loss
  - ◇ Hand Arm Vibration Syndrome
    - Whiteness of the fingers
    - Numbness
    - Reduction of feeling sensations
    - Diminished grip strength

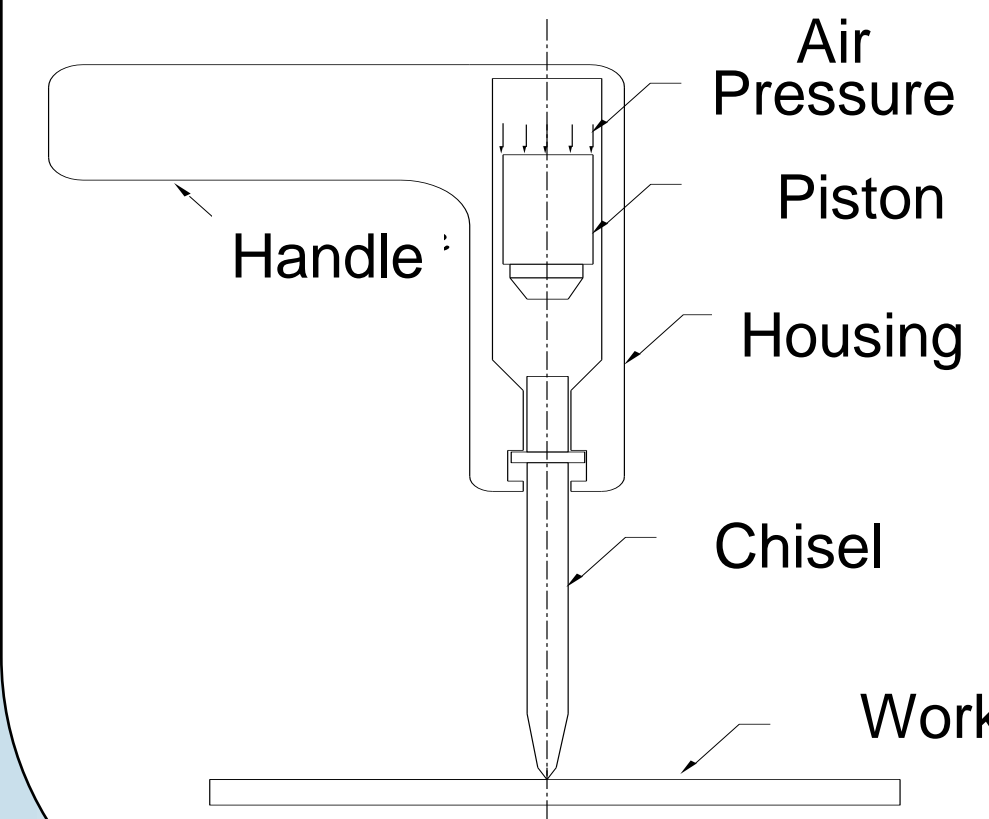


Hands of vibrating pneumatic hand-tool operator in later stages of irreversible Hand Arm Vibration Syndrome.

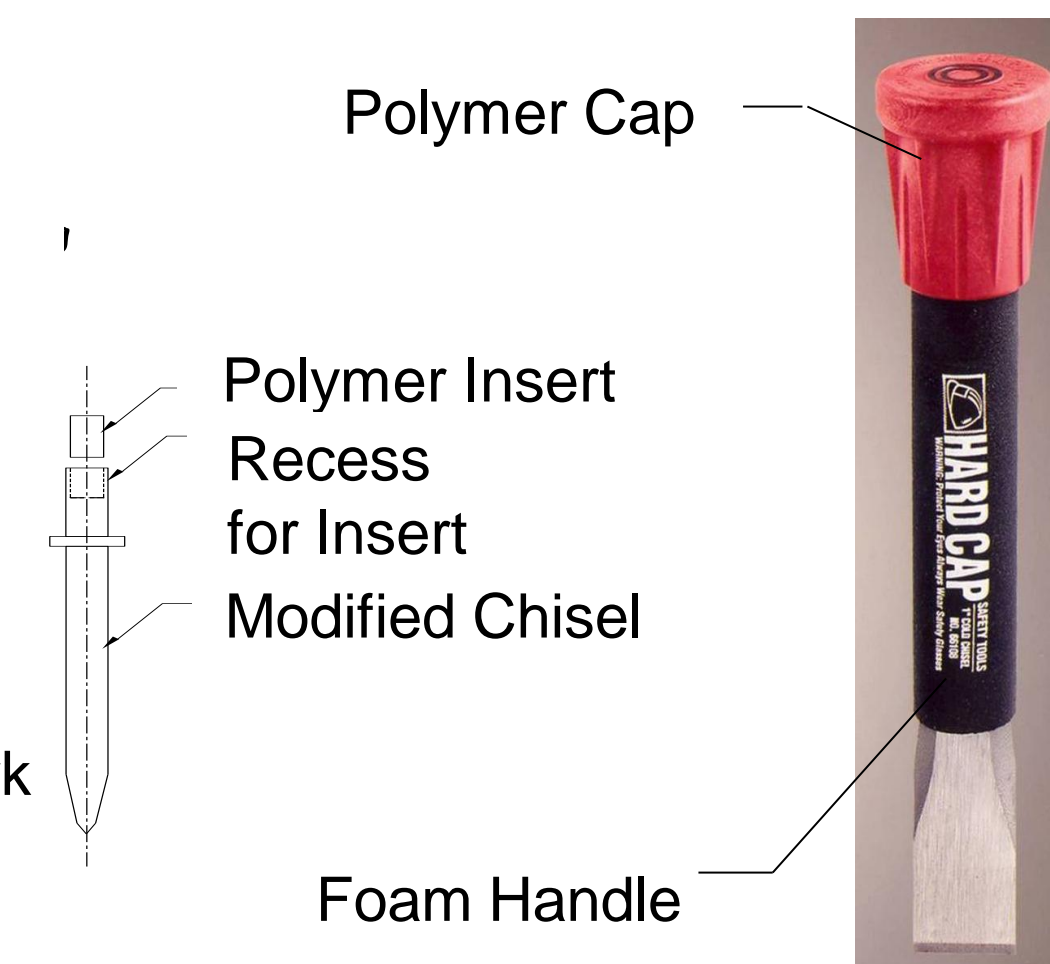
## CONCEPTUAL DEVELOPMENT

- ◆ Replace metal-to-metal contact in impact tools in order to achieve sound and vibration damping
- ◆ Use high-performance mineral and glass reinforced composite polymers at impact surface(s)

### Pneumatic Air Hammer:



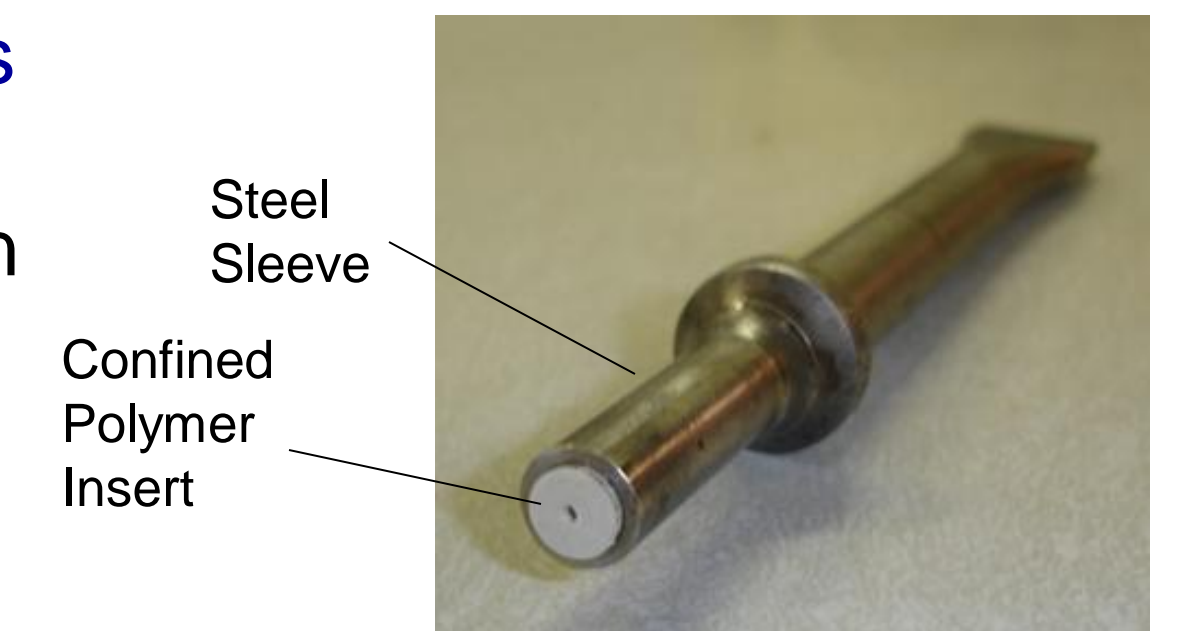
### Hand-Struck Chisel:



## MATERIAL CONSIDERATIONS

### Desired Material Properties

- ◆ High Stiffness
  - ◇ Force Transmission
- ◆ High Strength
  - ◇ High Stresses Involved
- ◆ High Toughness
  - ◇ Impacts
  - ◇ Tool Longevity



- ◆ Confined Compression
- ◆ Higher Realized Stiffness
- ◆ Effective Elastic Modulus ( $E'$ )

### Engineering Polymers

- ◆ High Toughness
- ◆ High Flexural Modulus
- ◆ High Strength

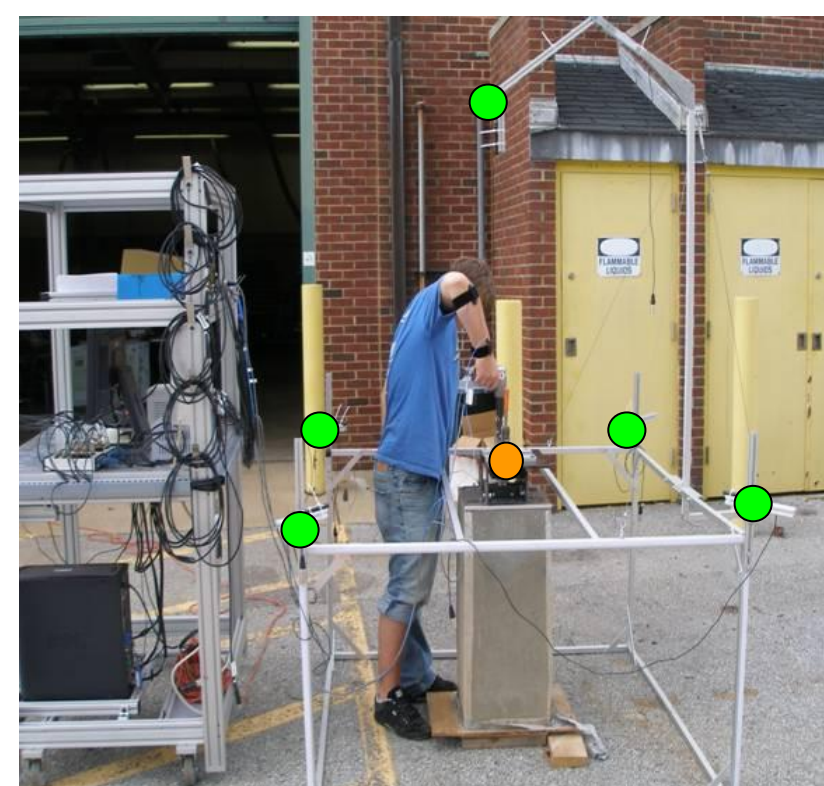
$$E' = E \left[ 1 - 2 \frac{\nu^2}{1 - \nu} \right]^{-1}$$

where:

$E'$  = Effective Modulus  
 $E$  = Rated Tensile Modulus  
 $\nu$  = Poisson's Ratio

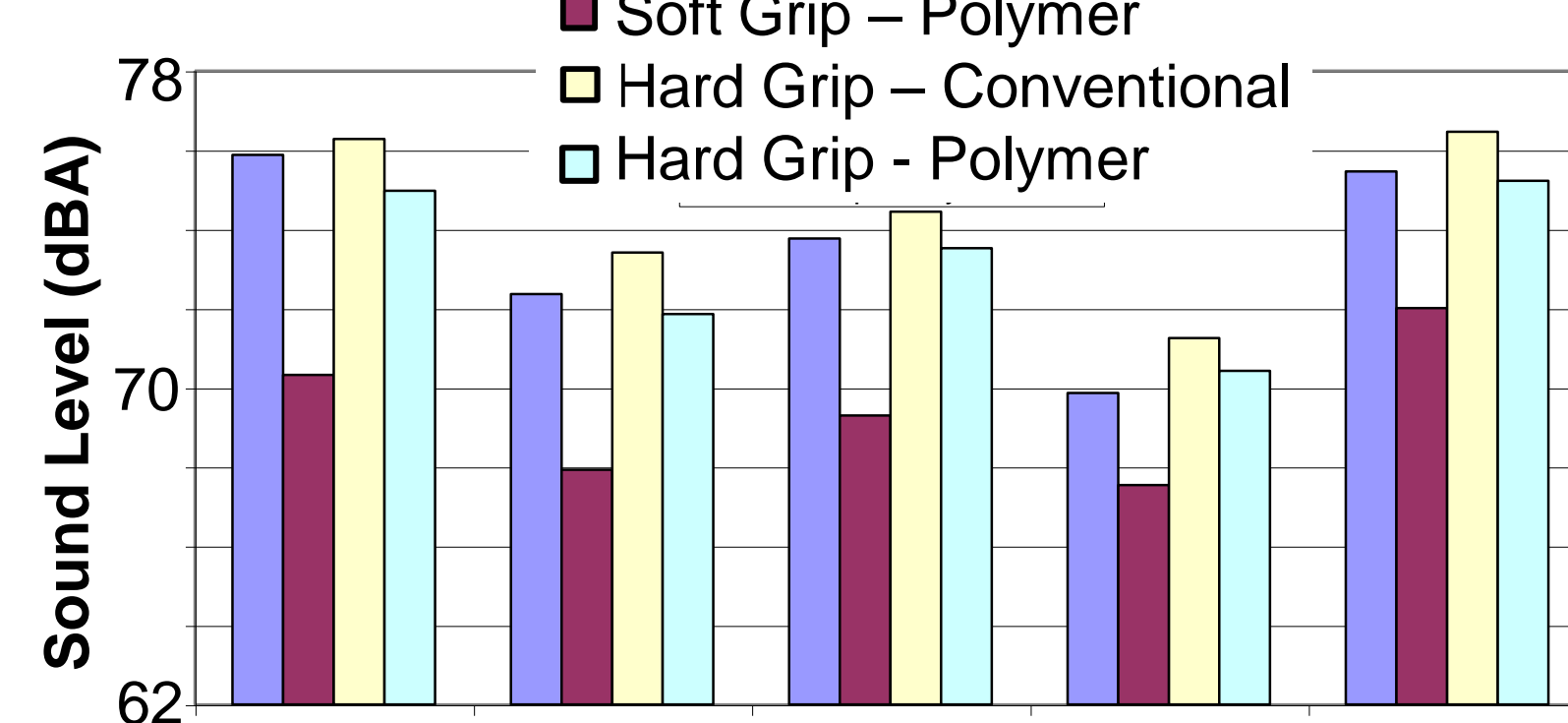
## SOUND & VIBRATION TESTING

### Pneumatic Air Hammer:

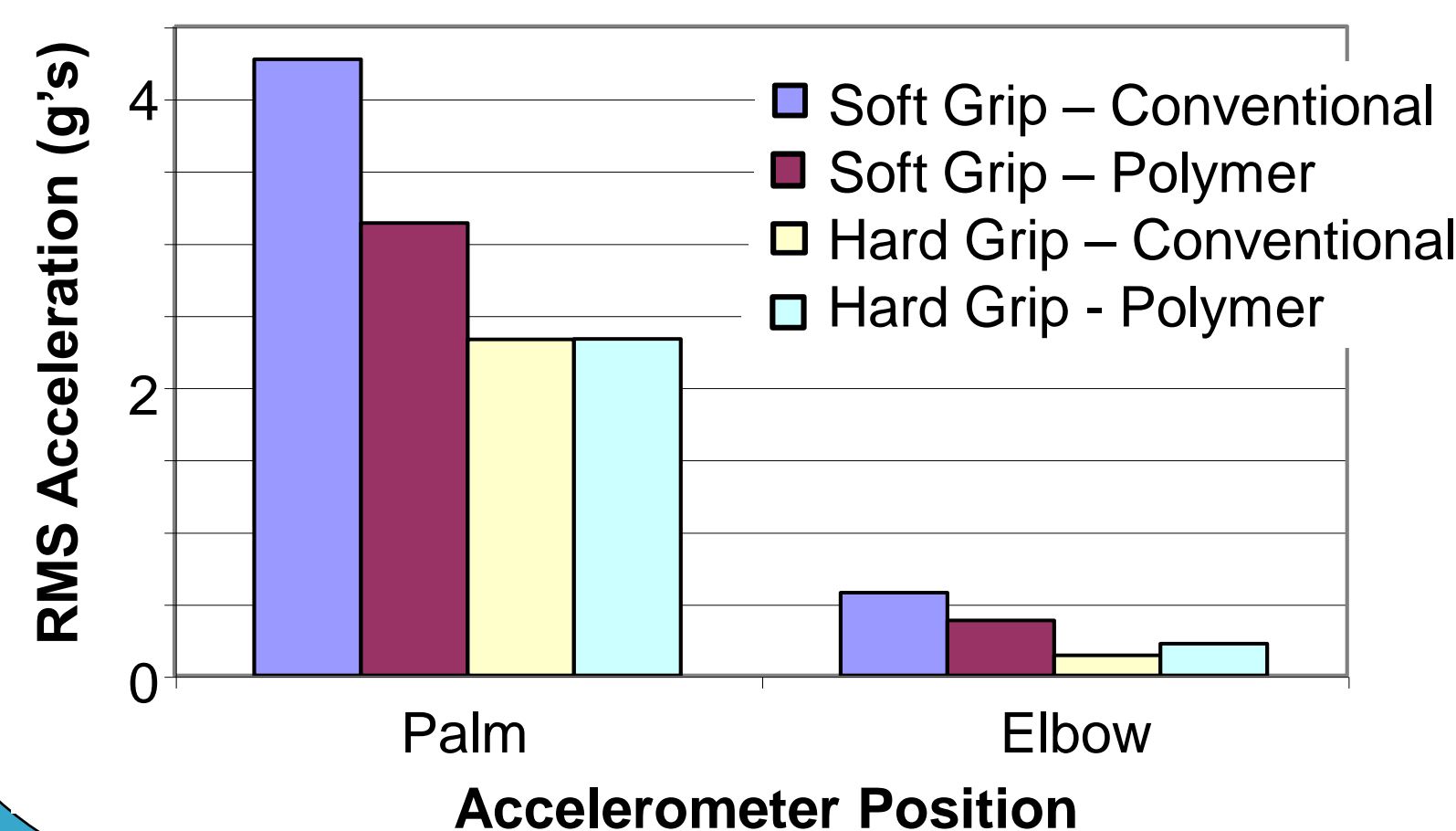


- Microphones
- Work Piece

### Sound Data



### Vibration Data



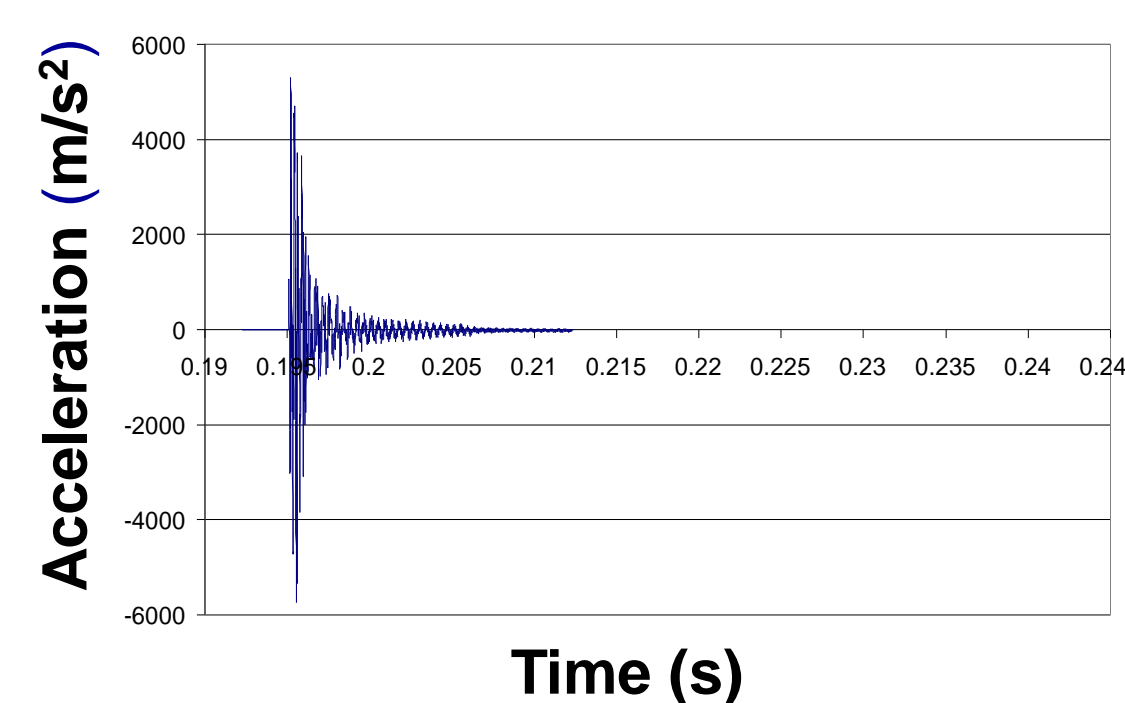
### Microphone Position



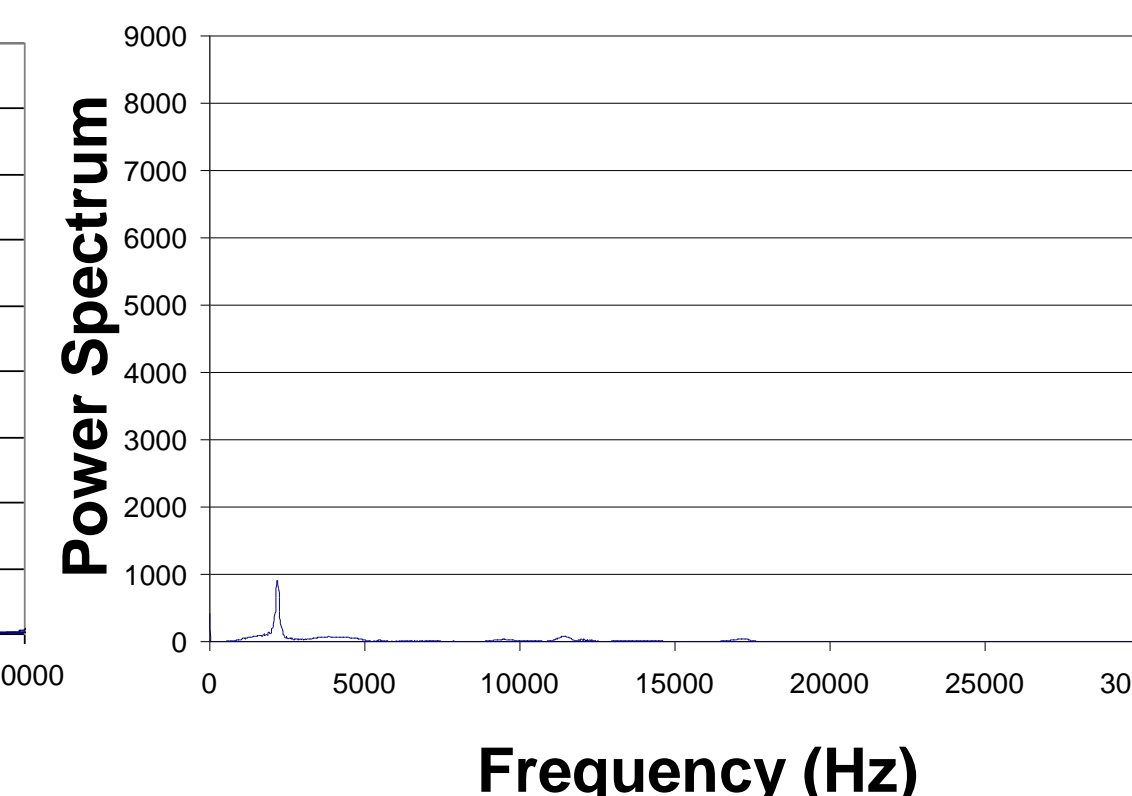
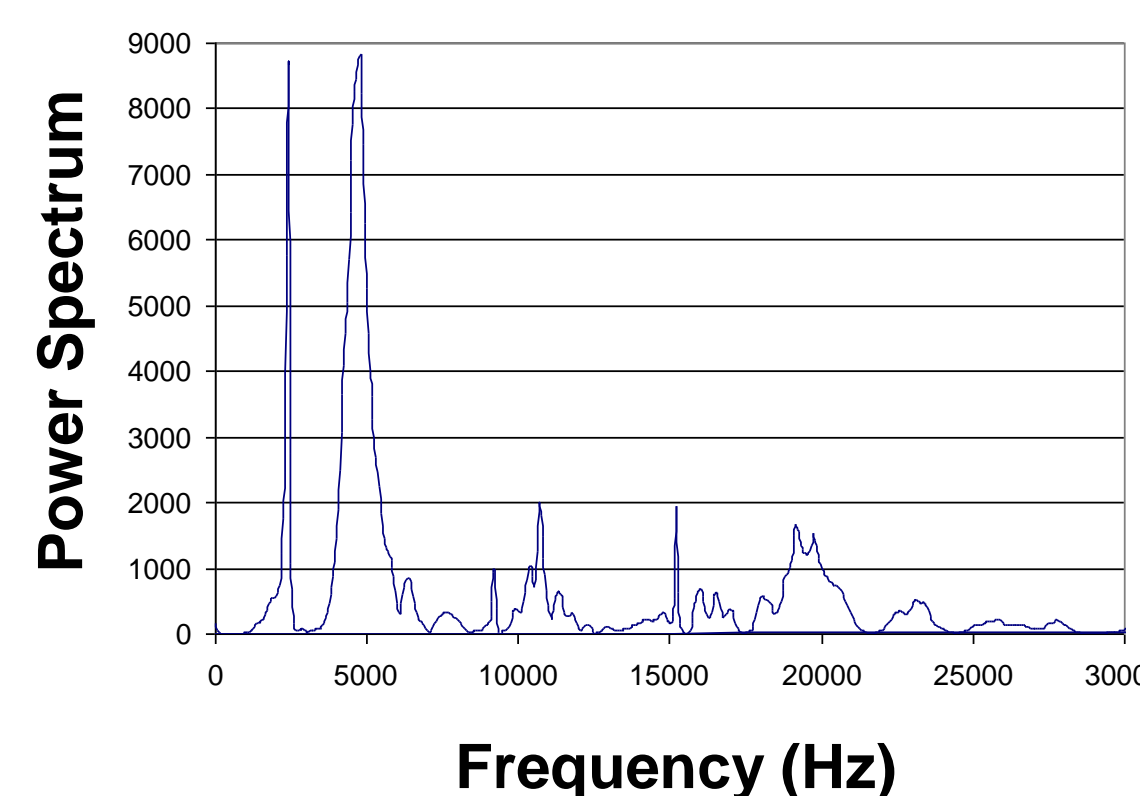
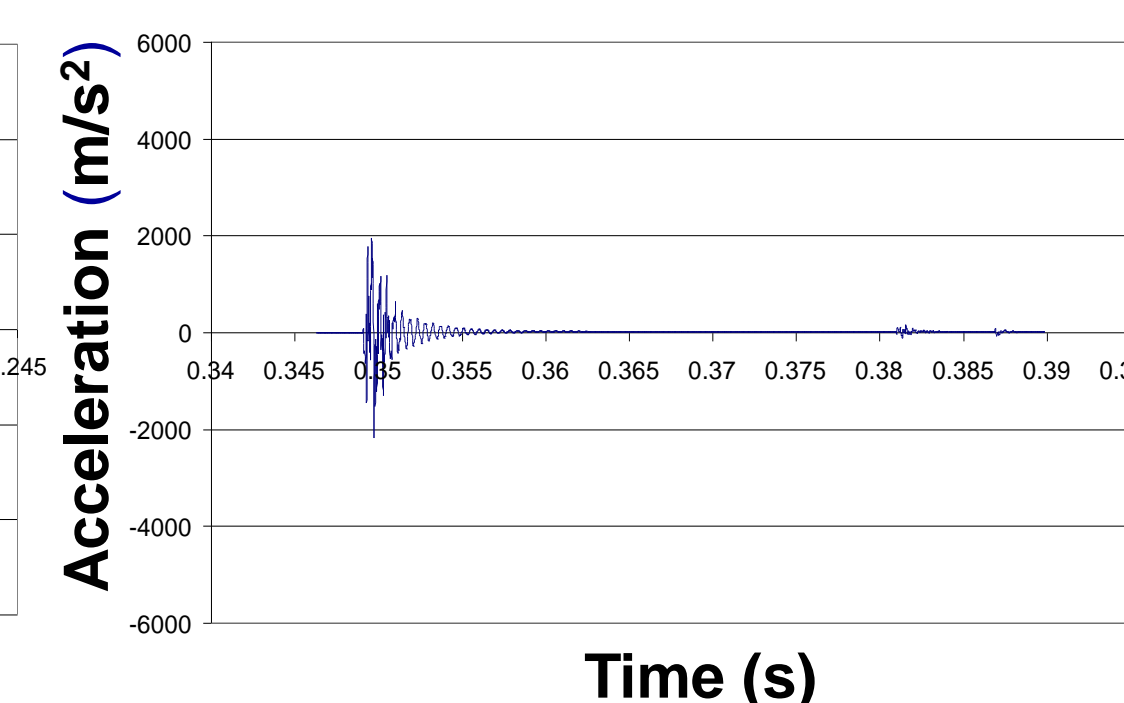
- Accelerometers

### Hand-Struck Chisel:

#### Conventional Chisel



#### Capped Chisel with Foam



## CONCLUSIONS

- ◆ Material Selection
  - ◇ Mineral Reinforced Polymer Composites

While the strength and stiffness of the mineral reinforced composites are lower than some glass reinforced polymer composites, the toughness is crucial to durability
- ◆ Sound & Vibration Emissions
  - ◇ Both significantly reduced
- ◆ Geometry
  - ◇ Confined Compression – greater stiffness

### Future Work:

- ◆ Quantify the cutting effectiveness (i.e. cutting) of prototype

## ACKNOWLEDGEMENTS

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