IPRO 304:
Integration of Process Improvements for A. Finkl and Sons Co.

Team Members

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Sponsor

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A Finkl & Sons Co

- Founded 1879
- Processes 100,000 tons of steel annually
- Manufactures 100% of steel in Chicago
- Distributes to 18 countries around the world
- Steel Processes include
  - Melting
  - Re-melting
  - Forging
  - Heat Treating
  - Machining

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Finkl.com

Milling Machine in Operation
Kyle Gillmeister

Broken Insert
Kyle Gillmeister

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The Problem

Goals

Organization

The Strategy

Implementation

Current Analysis and Results

Conclusion

Next Steps

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Milling

- Typically the last stage of processing before distribution
- Smoothing and Finishing
- Multi-Million dollar annual process

Milling Machine

- 100+ year old process
- 18" Diameter milling head
- 18 Tungsten carbide inserts per machine

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Milling Machine in Operation
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Broken Insert Kyle Gillmeister

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Operational Problems

- Broken Inserts
  - Multi-Million dollar problem
  - Causes stress to machine and other inserts furthering damage
  - Damages finish resulting in re-milling and time loss

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Milling Machine in Operation
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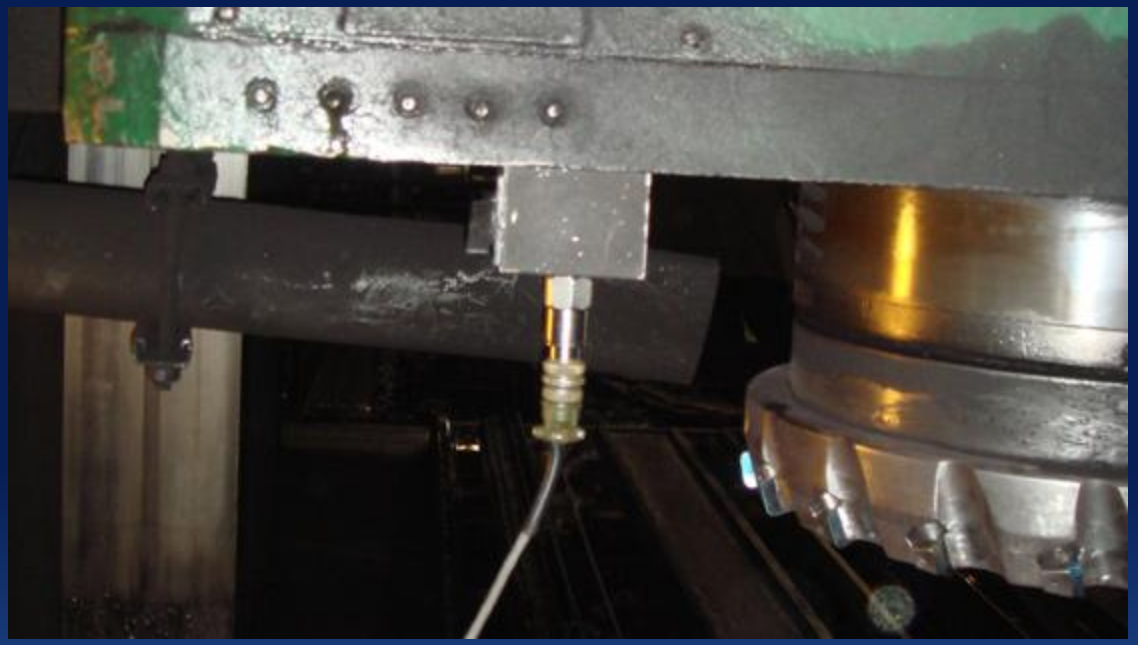
Detect and Notify

- Build on previous semesters work
  - Use of accelerometers and data acquisition software (labView) to detect failure
  - Use of data analysis software (diaDEM) for real time notification



Accelerometer Mounted on Milling Machine

Kyle Gillmeister

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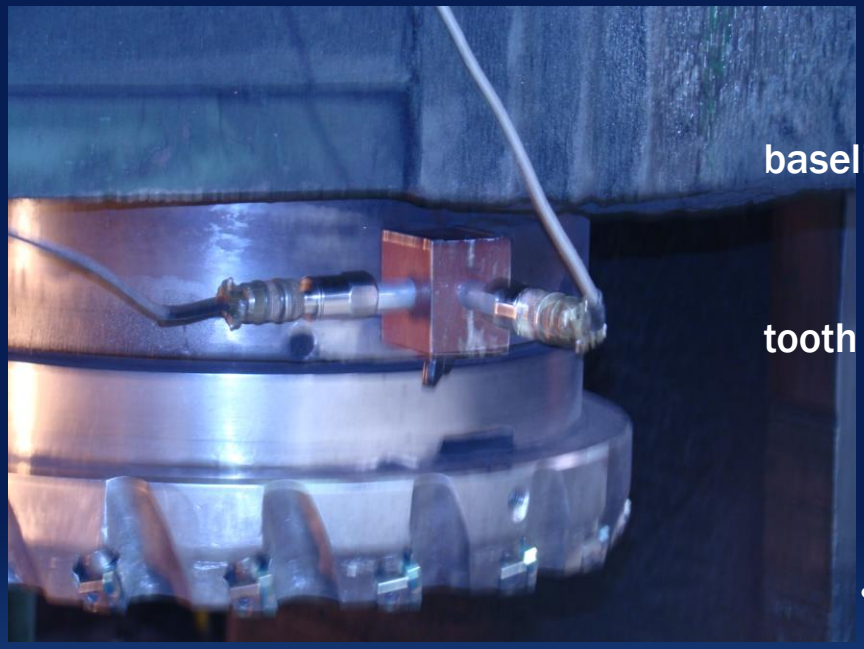
Accelerometer

- A device which measures acceleration
- In this case, vibrations caused by the milling machine



Accelerometer Mounted on Milling Machine Kyle Gillmeister

Data Sets

- Predetermined specific data sets
  - 0 Missing Teeth - baseline
  - 1 Missing Teeth – simulates broken tooth
  - 2 Missing Teeth - further risk to total s system failure
- Others as necessary

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Balance

- Project Leader: administration
- Three Sub-Leader:
  - Research- alternatives and other information
  - Data Collection- visit Finkl site for data collections and use of LabView software
  - Data Analysis- knowledge of the physics behind PSD and other analysis possible; use of DIAdem

Adaptability

- Ability to shift members from one group to another depending on work load

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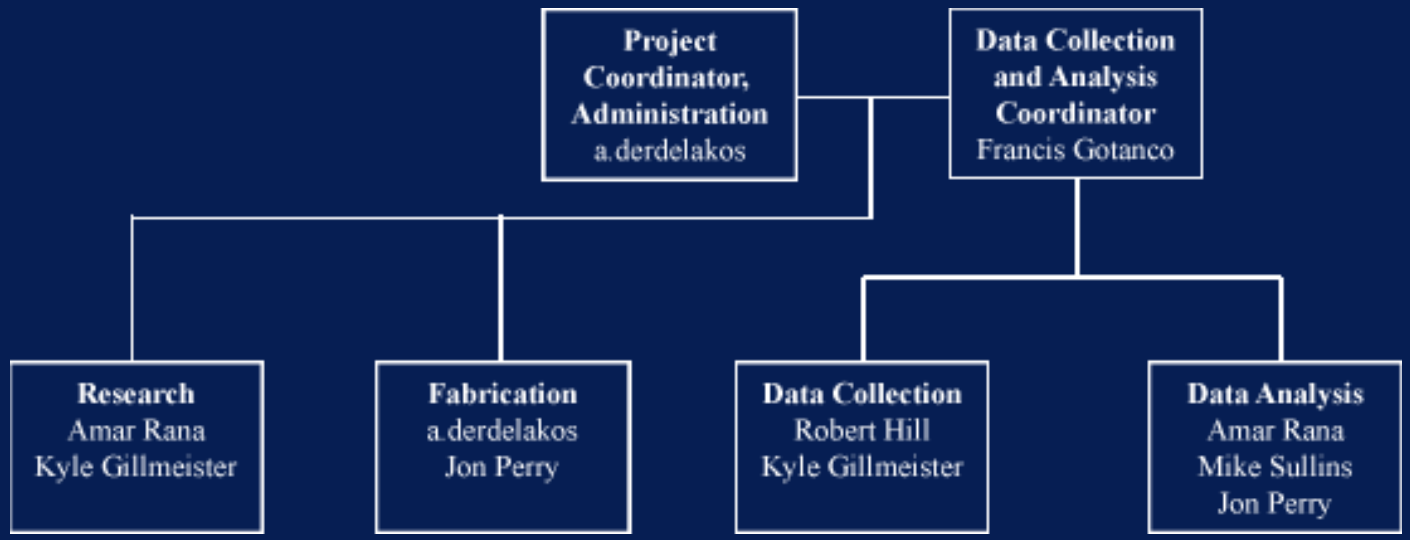

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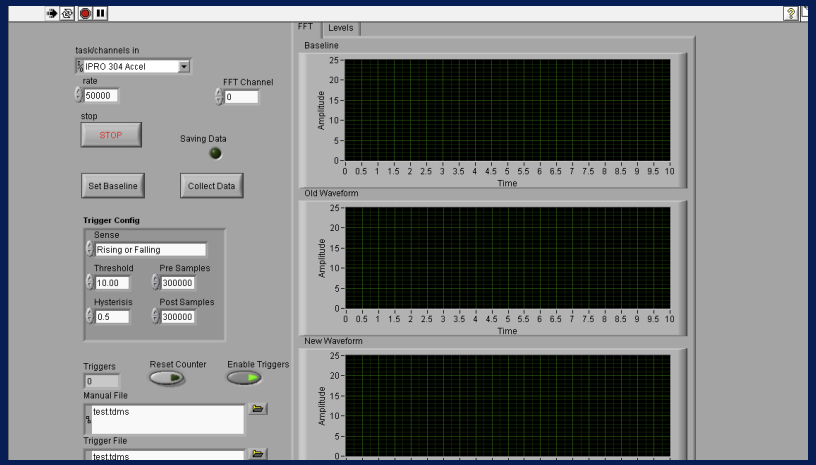
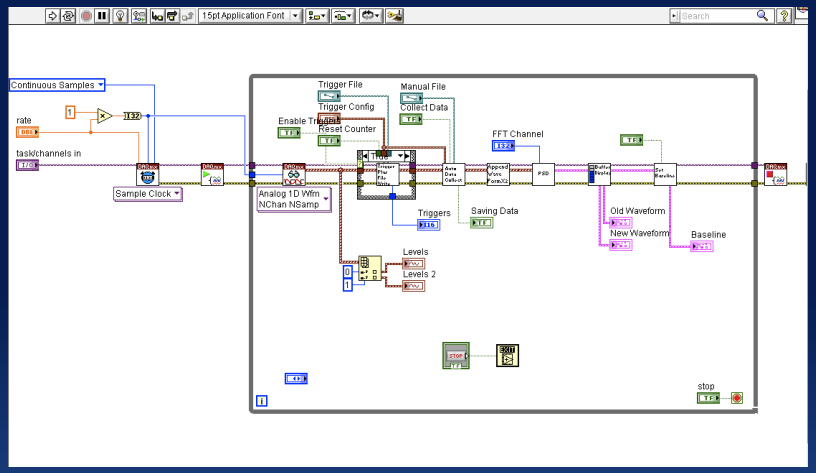
Collect Data

The accelerometer is connected to LabView; a data acquisition program that monitors and records data based on a set of parameters determined by its programmer.





LabView: National Instruments

Francis Gotanco

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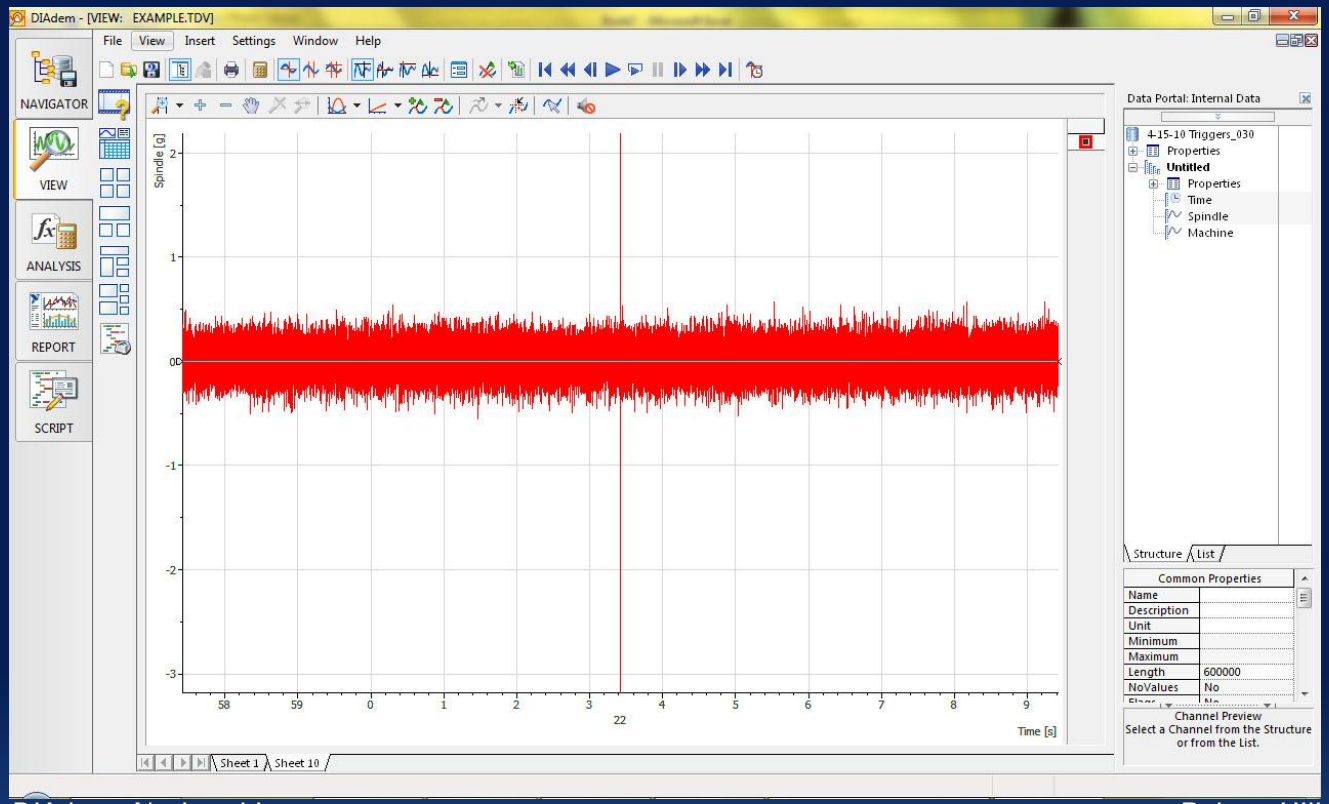
Analyze Data

The data collected in our trials is then sent to DIAdem, a data analysis program that processes and extracts information for use by the team to determine the most distinguishable properties for the detection of insert damage and breakage.



DIAdem: National Instruments

Robert Hill

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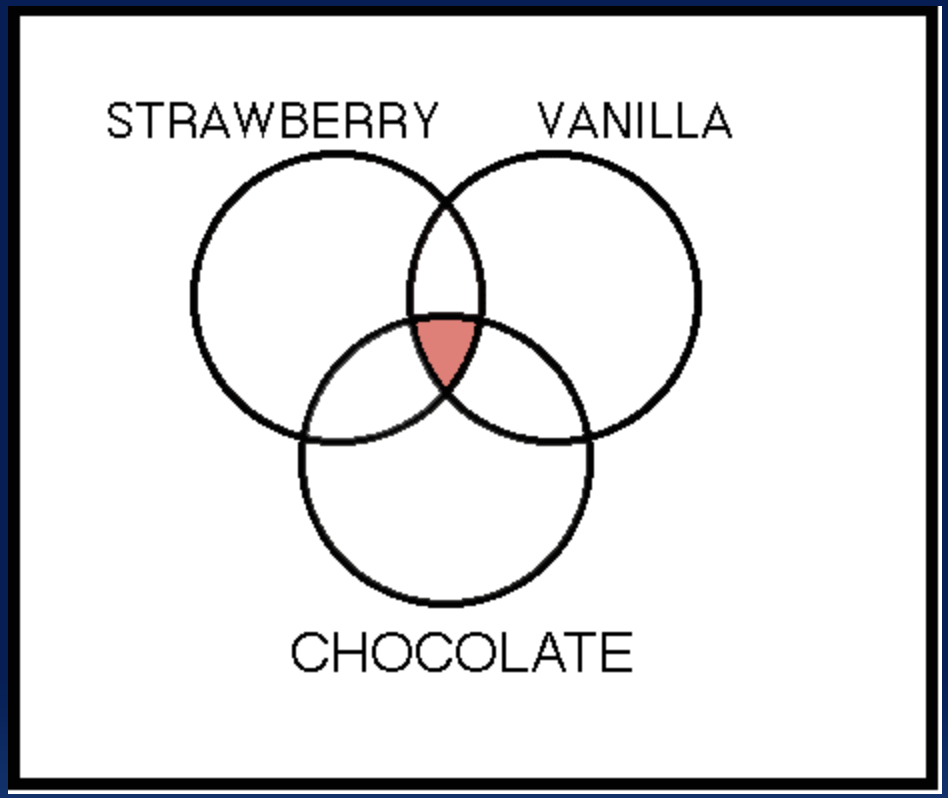
Checks and Balances

It has been determined that the most effective way to reach our goal in such a noise polluted environment is to have a series of several checks so as to avoid false alarms.



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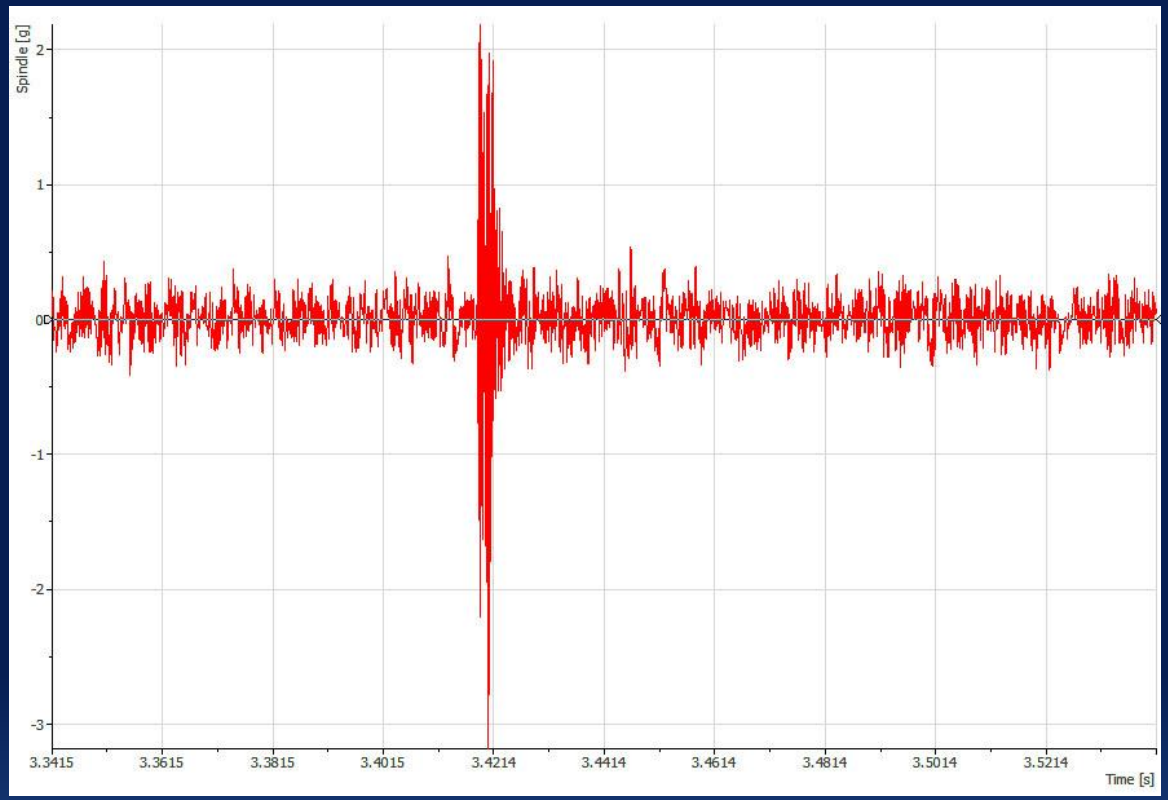
Check 1: The Trigger

It is understood that in a typical scenario when an insert fails, it fails catastrophically. This destruction of a carbide insert results in a significant shock to the system that is easily identified by the monitoring program.



DIAdem: National Instruments

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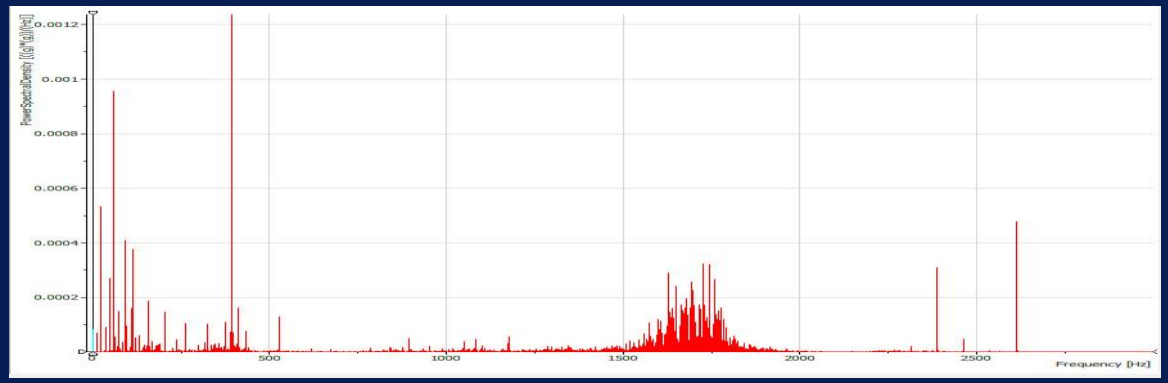
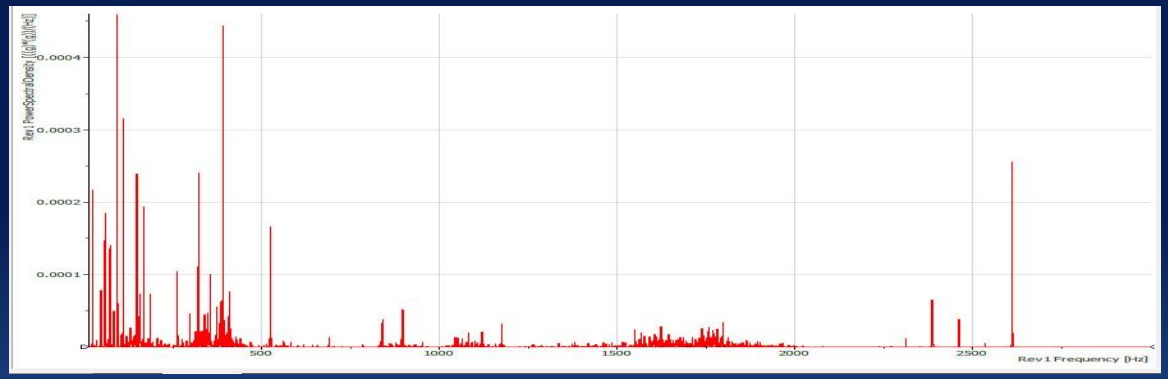
Check 2: Pre / Post Trigger Waveform Analysis

Reacting to a trigger the program saves a predetermined amount of data from before and after the event. This data is split into full rotational increments; these increments are then integrated to produce the Power Spectrum Density (PSD) for analysis.



Pre-Trigger PSD Robert Hill



Post-Trigger PSD Robert Hill

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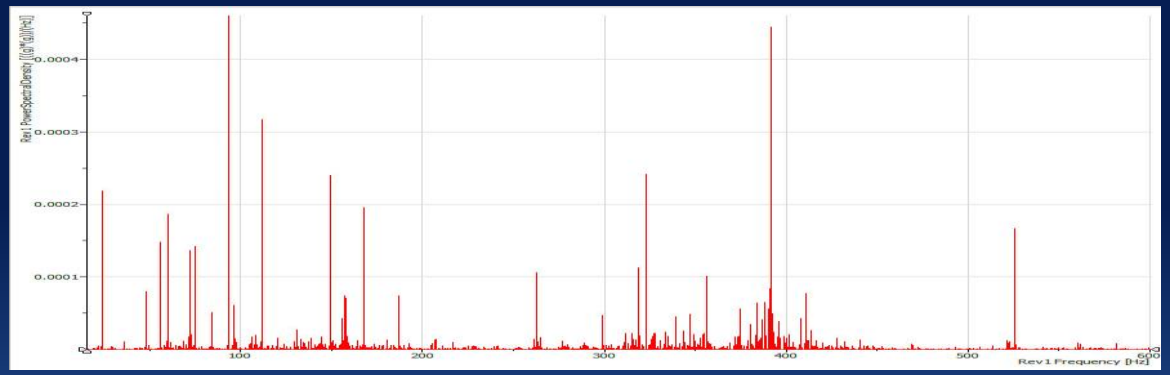
Check 3: Limited Frequency PSD

By zeroing in on specific frequencies we can be more assured that the changes are attributed to the actual milling process rather than fluctuations from the environment or machine.

Pre-Trigger Limited Frequency PSD Robert Hill



Post-Trigger Limited Frequency PSD Robert Hill

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Unpredictable Testing

A difficulty arises in the implementation testing for such a procedure due to the unpredictable nature of insert breakage.

Data Collection Session (October 2010) Kyle Gillmeister

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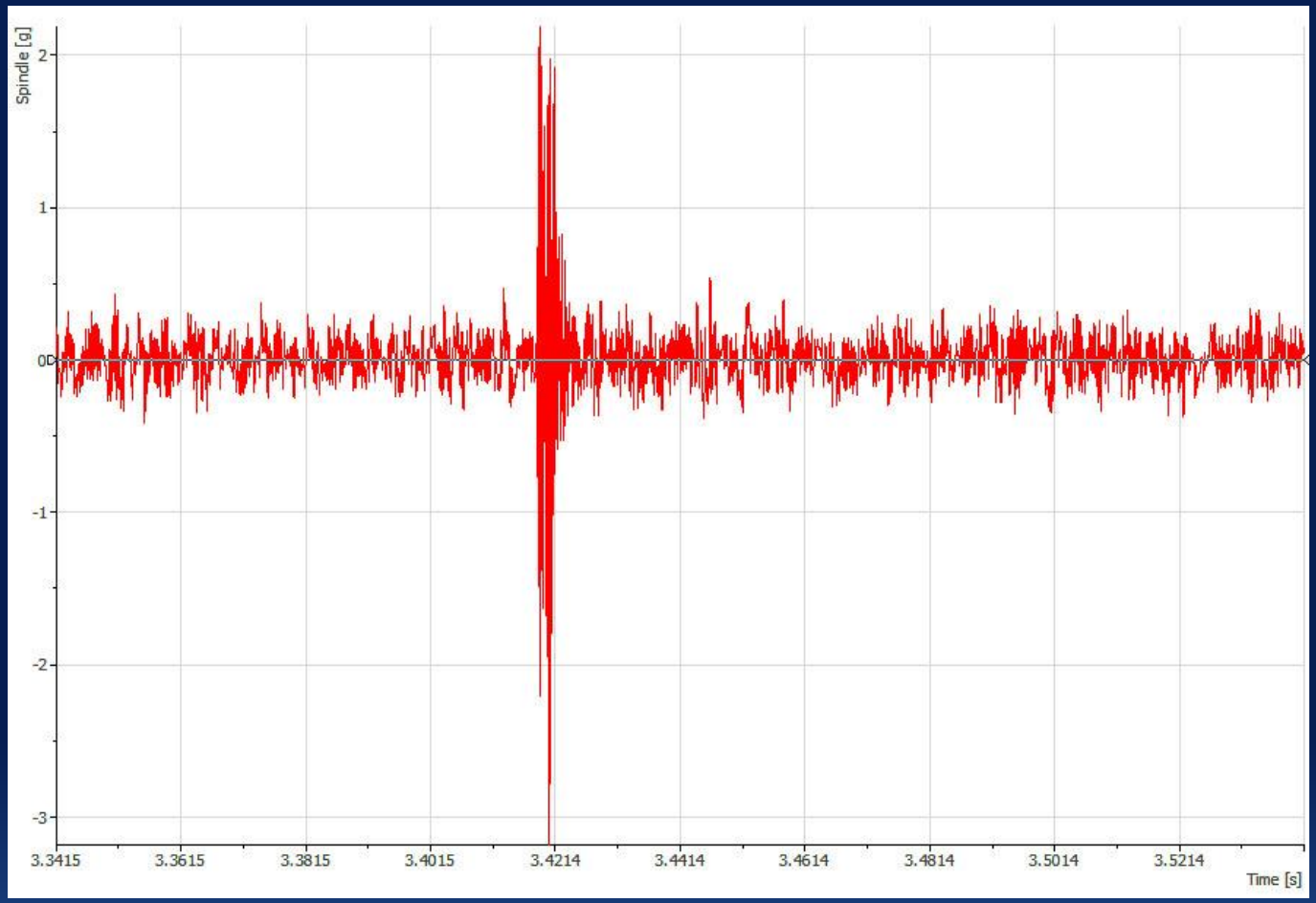
Trigger Testing

At this time we have ample data to conclude that the trigger threshold will occur above 1.0g.



Event Peak

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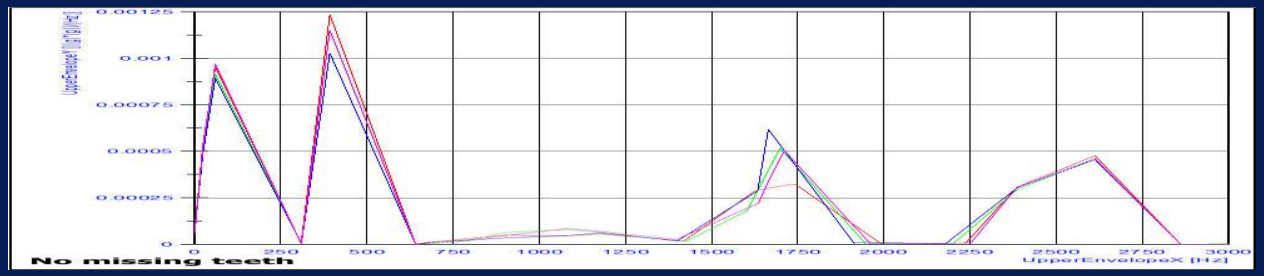
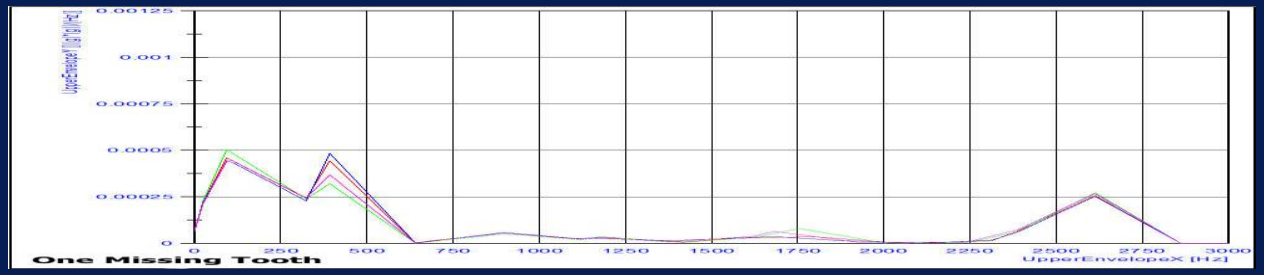
Pre/Post Trigger analysis and Limited Frequency PSD

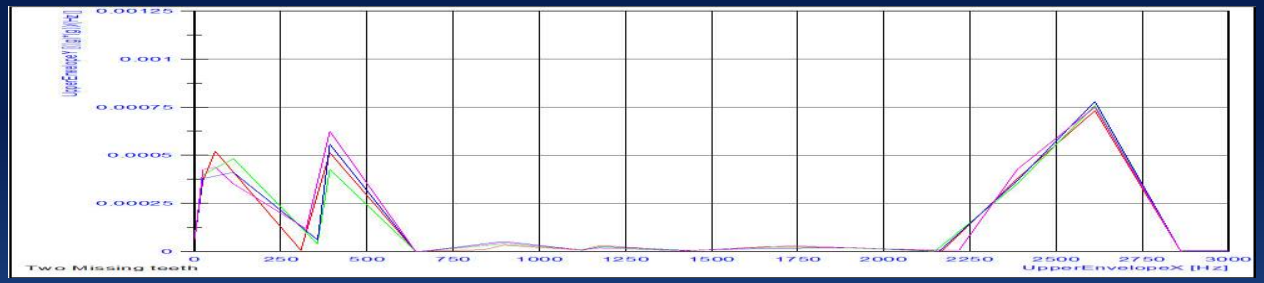
Due to the unpredictable nature of insert breakage we must collect data under the scenarios that we know occur after an insert breakage.



0 inserts missing — Robert Hill



1 insert missing — Robert Hill



2 inserts missing — Robert Hill

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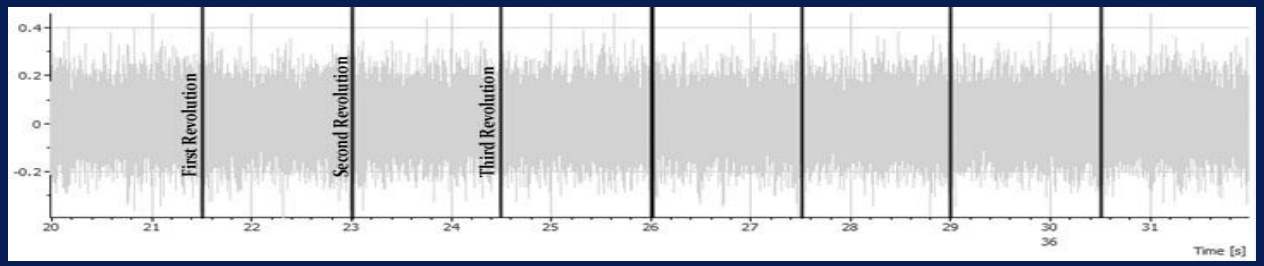
Pre/Post Trigger analysis and Limited Frequency PSD

After collecting the data under these different scenarios we increment the waveforms into rotational segments.



0 inserts missing

Robert Hill

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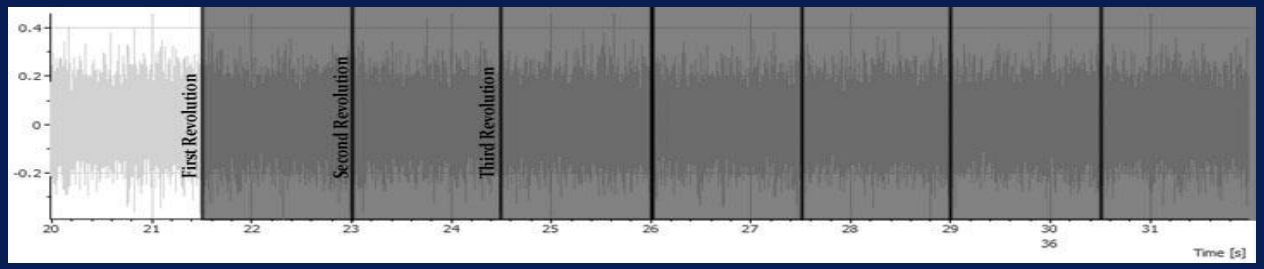
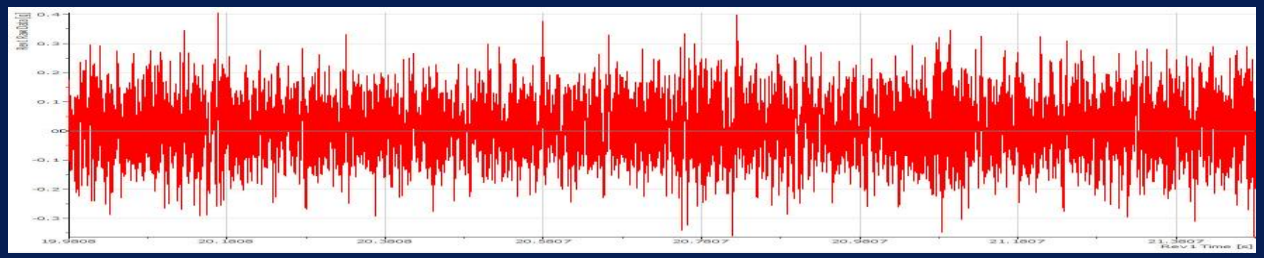
Pre/Post Trigger analysis and Limited Frequency PSD

We can then focus on the waveform of a single rotation of the milling head.



0 inserts missing – waveform of acceleration Robert Hill



0 inserts missing – 1st revolution Robert Hill

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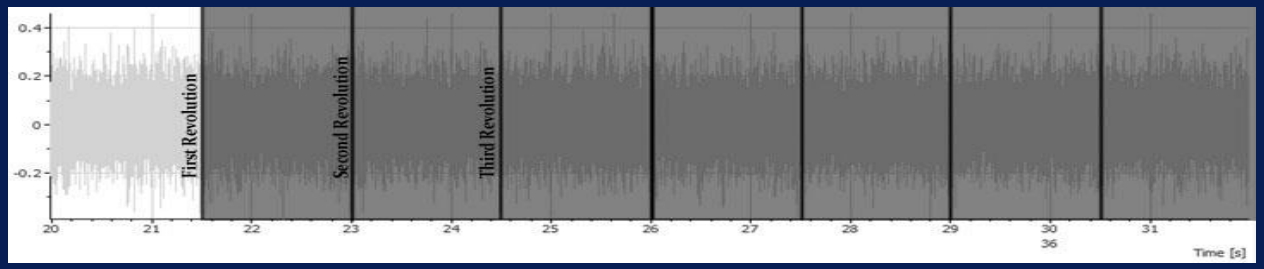
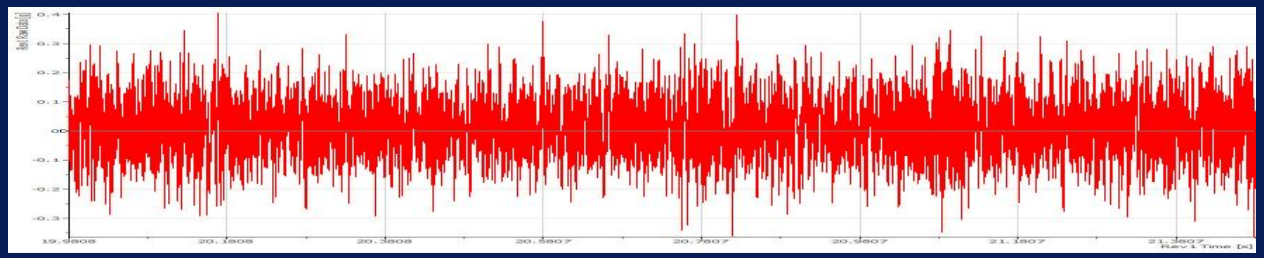
Pre/Post Trigger analysis and Limited Frequency PSD

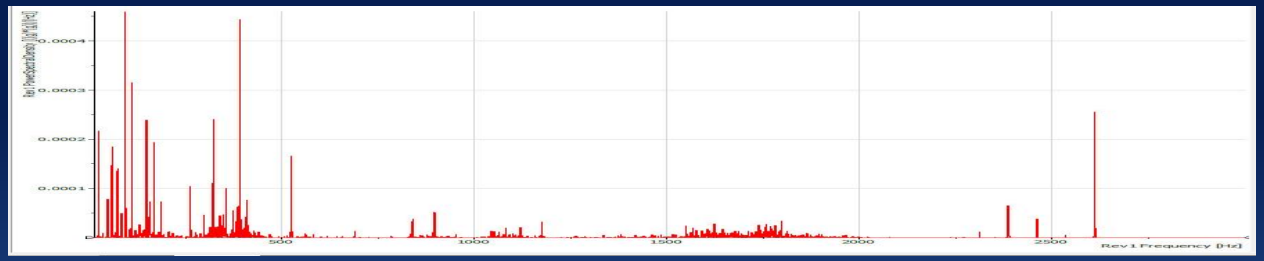
The analysis is then applied and a PSD is produced.



0 inserts missing – waveform of acceleration Robert Hill



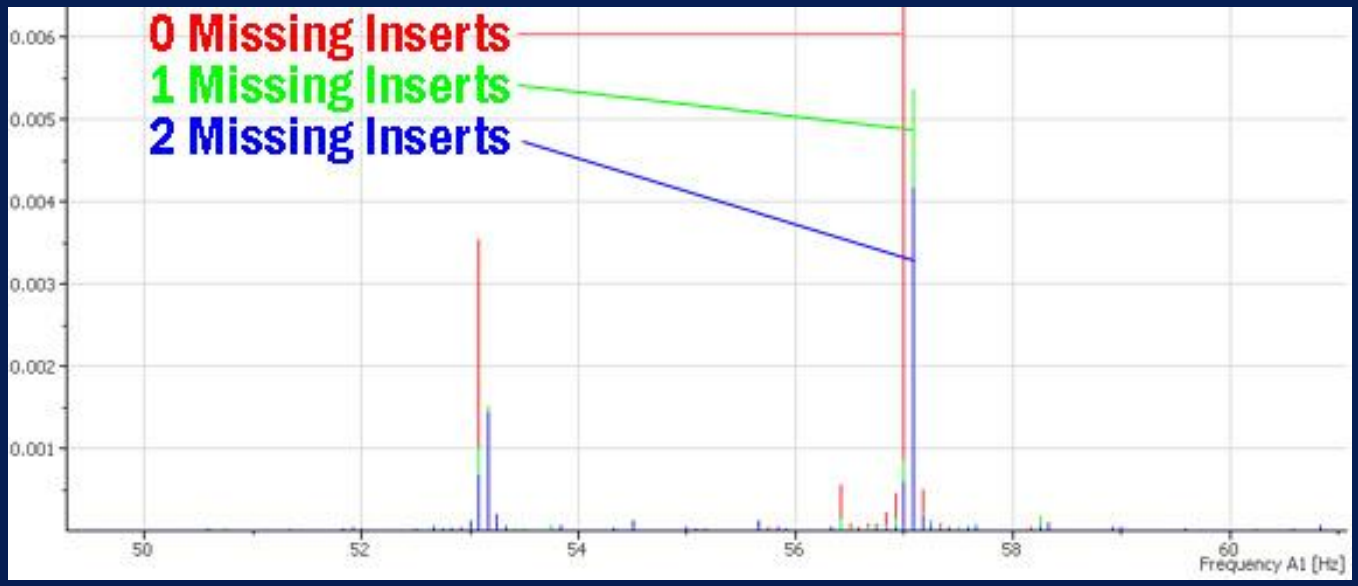
0 inserts missing – 1st revolution Robert Hill



0 inserts missing – 1st revolution - PSD Robert Hill

Pre/Post Trigger analysis and Limited Frequency PSD

When the PSD from different data sets are compared a power drop is seen as inserts are removed.



0,1,2 missing inserts: 50-60Hz – comparison PSD

a.derdelakos

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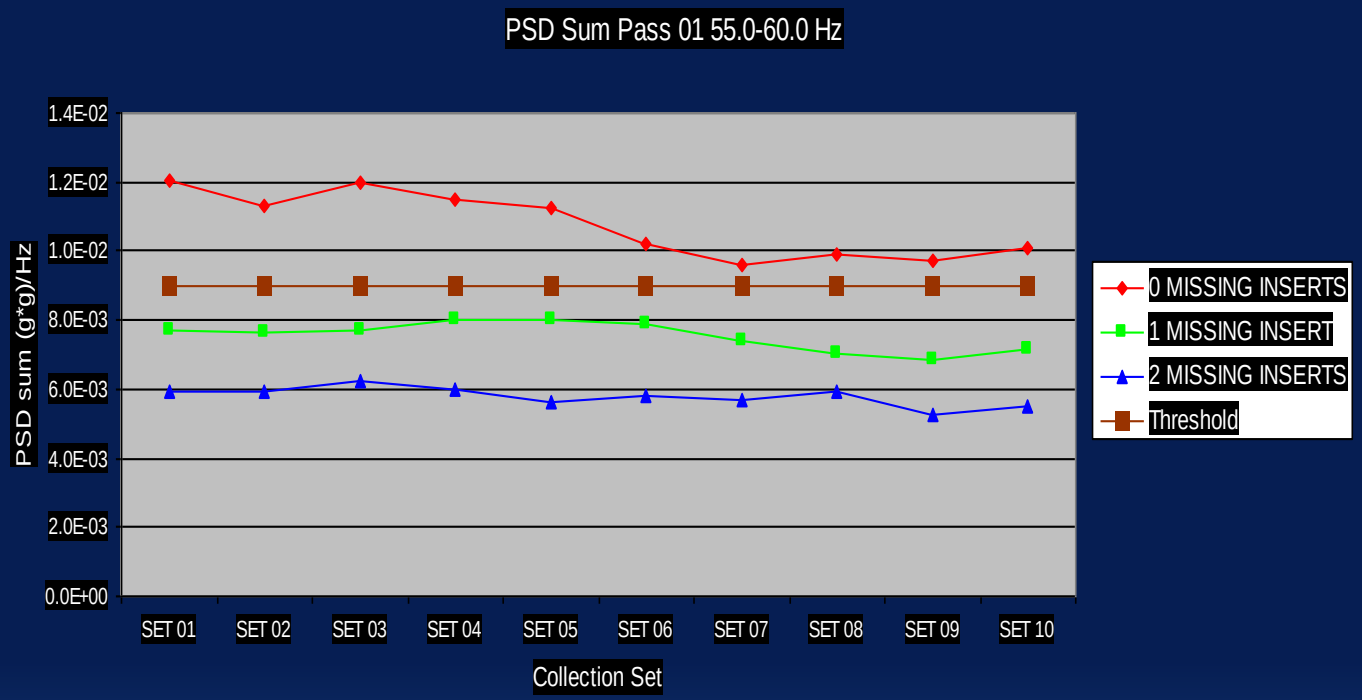
Pre/Post Trigger analysis and Limited Frequency PSD

As this process is repeated across many sets of data a pattern emerges. From this pattern a threshold can be determined that distinguishes a when an inserts is broken or damaged.



0,1,2 missing inserts: 50-60Hz – comparison PSD

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Pre/Post Trigger analysis and Limited Frequency PSD

Successful but inconsistent results as a consequence of the data collection method.

Data Collection Session (October 2010) Kyle Gillmeister

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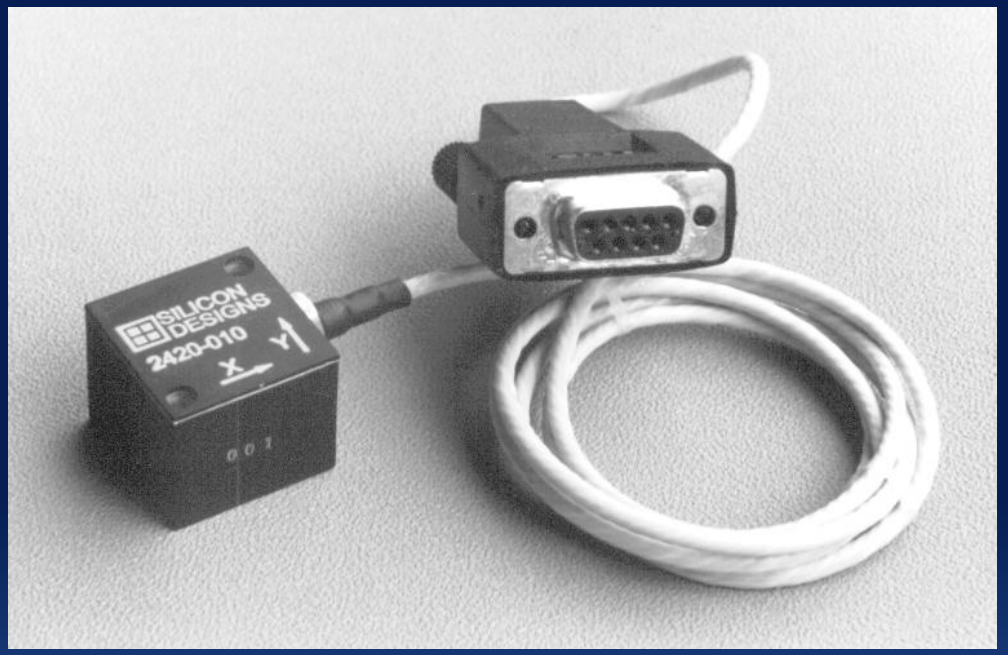
Further Testing

Based on the results gathered this semester we recommend:

1. A triaxial accelerometer be used for further data collection.
2. The accelerometer must be permanently affixed to the milling machine.



Triaxial Accelerometer Silicon Designs

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Further Testing

With a new method of analysis much new data is needed to prove the legitimacy of this discovery. The same idea must be tested on a number of different variables.

Variables to consider

- Milling Machine
- RPM
- Feed Rate
- Cut Depth
- Material Properties
- etc.

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Acknowledgments

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Keith Crawford

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