IPRO 304

Integration of Process Improvements

Presenters:

Ryan Marx – C.S./E.C.E. 4th year

Joshua Willett – A.E. 4th year

Stefan Stevanovic – M.E. 4th year

Background

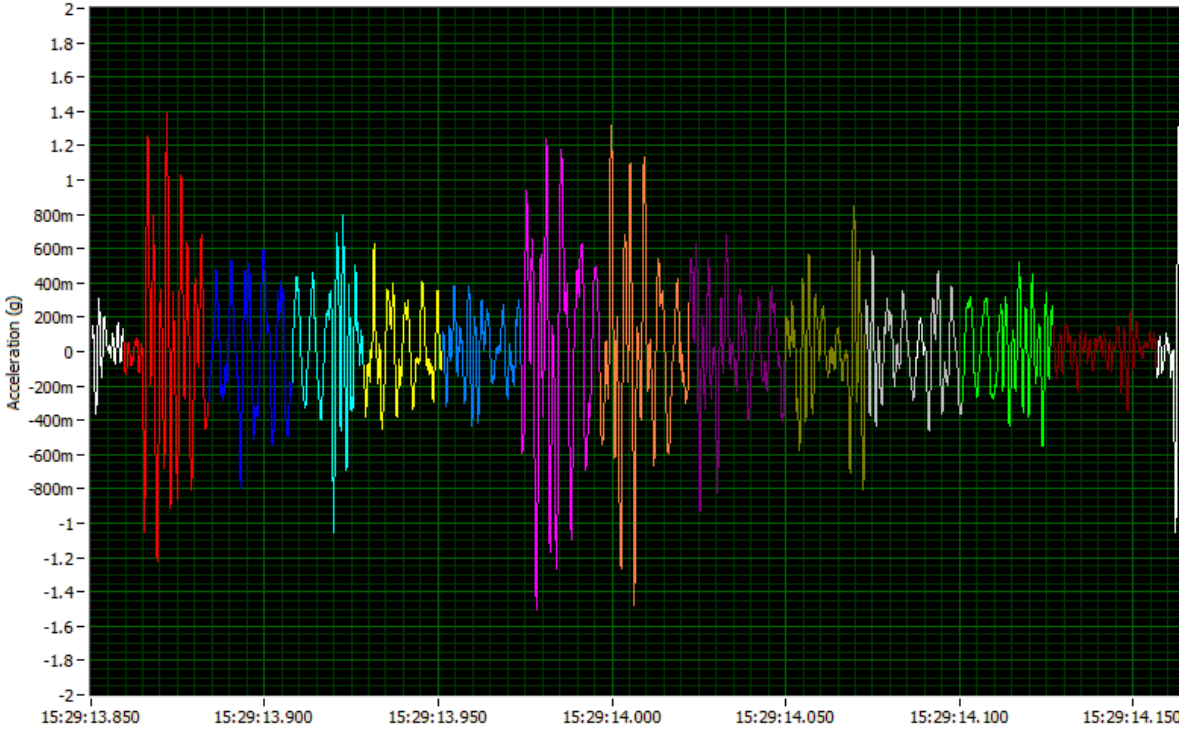
- Sponsored by A. Finkl and Sons.
  - CEO on IIT Board of Trustees
  - IIT alumni employed at A. Finkl and Sons.
- Project History
  - Created five semesters ago
  - Attempted many different approaches

Problem Statement

Broken carbide inserts from the machining operation incur significant costs

Previous Approaches

- Lasers, accelerometers, microphones
- Accelerometers proved most promising



Semester Objectives and Ethics

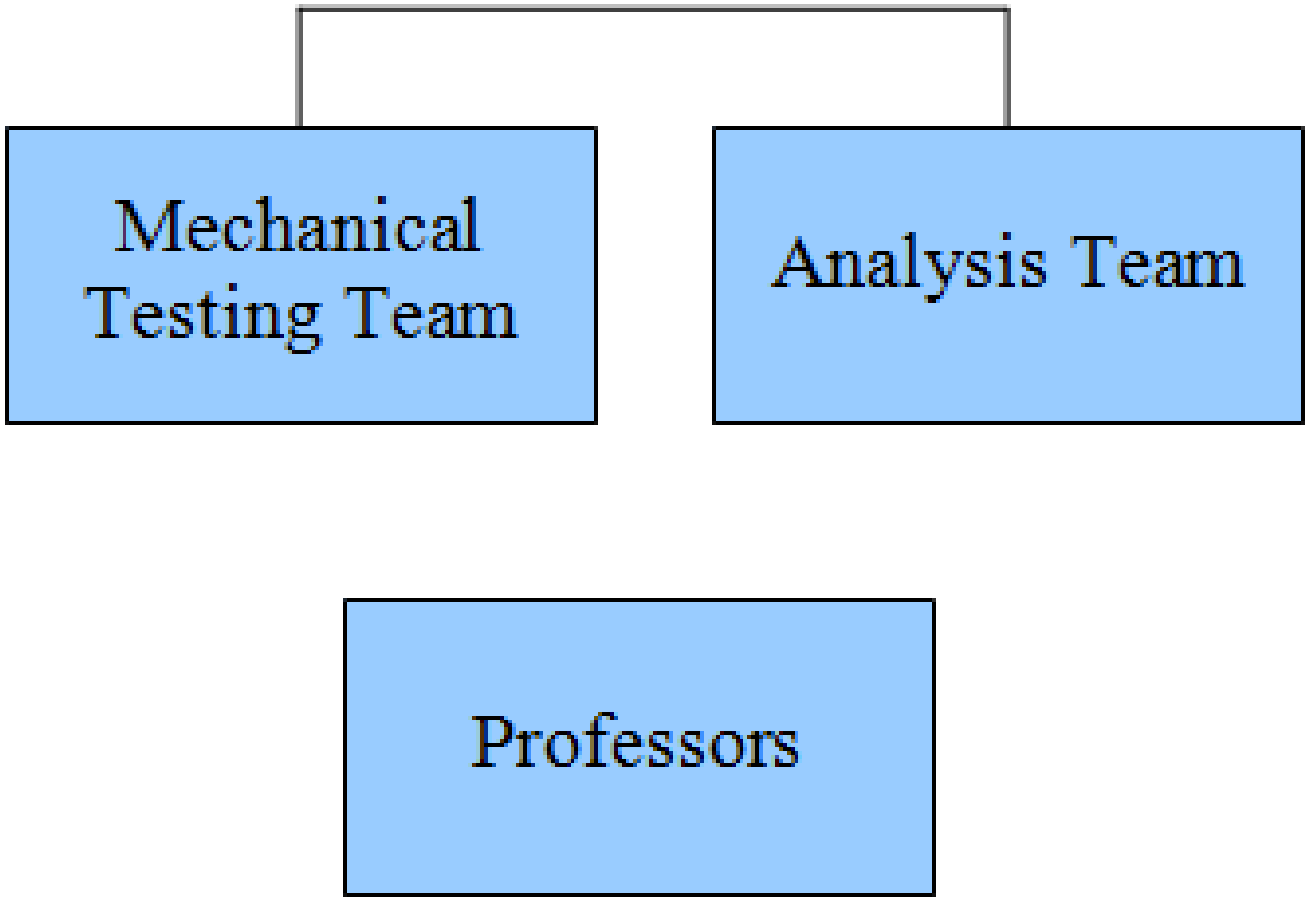
- Time-series is useful visual aid but need to augment it so an algorithm can be developed to detect a failure
  - Combine tachometer with accelerometers to synchronize spindle position with data
  - Revisit Fast Fourier Transform (FFT)

- Ethics
  - Non-Disclosure Agreement.
  - Reduction in Human Error
  - Cost Implications

Group Organization

Name	Year	Major	Team
Emmanuel Flores	4th year	Materials Science & Engineering	Mechanical Testing
Corey Hawker	4th year	Computer Science & Engineering	Mechanical Testing
Charles Loeppert	4th year	Mechanical Engineering	Analysis
Ryan Marx	4th year	Computer Science & Engineering	Analysis
Ricardo Rodriguez	4th year	Chemical Engineering / Chemistry	Mechanical Testing & Analysis
David Snyder	4th year	Materials Science & Engineering	Analysis
Stefan Stevanovic	4th year	Mechanical Engineering	Analysis
Joshua Willett	4th year	Aerospace Engineering	Mechanical Testing & Analysis

We Own This



Project Plan

ID	Task Name	Duration	Start	Finish	Predecessors	Classification	Individuals Involved
Project Tasks							
1	Familiarize with Previous Work	3 weeks	1/12/2010	2/2/2010		All Teams	All
2	Meet with Finkl Contact	1 day	2/4/2010	2/4/2010	1	All Teams	All
4	Identify Breakage Conditions	2 weeks	2/9/2010	2/23/2010	1,2	Mechanical Testing	Mechanical Team
5	Build Test Procedure	2 weeks	2/23/2010	3/9/2010	4	Mechanical Testing	Mechanical Team
6	Identify Milling Head RPM	1 week	3/2/2010	3/9/2010	5	All Teams	All Teams
8	Isolate Cutting Insert Profiles	3 weeks	3/9/2010	3/30/2010	4,5,6	Data Analysis	Analysis Team
9	Synchronize cutting insert profile with RPM	2 weeks	3/16/2010	3/30/2010	6,8	Data Analysis	Analysis Team
10	Identify criteria for breakage event	2 weeks	3/30/2010	4/13/2010	9	Data Analysis	Analysis Team
11	Mid-semester Presentation to Finkl	1 day	late March?		10	All Teams	David/Chuck
12	Onsite Testing at Finkl	3 weeks	4/1/2010	4/20/2010	10	All Teams	All
13	Develop algorithm to evaluate operation and identify breakage based on criteria	2 weeks	4/6/2010	4/20/2010	10	Analysis	Analysis Team
Presentations							
7	Midterm Review	1 day	3/2/2010	3/2/2010	3	Presentation	TBD
16	Final Presentation	1 day	4/23/2010	4/23/2010	14,15	Presentation	Stefan/Ryan/Joshua
17	IPRO Day	1 day	4/23/2010	4/23/2010	14,15	Presentation	All
18	Finkl Presentation	1 day	4/23/2010	4/23/2010	17	Presentation	TBD
Deliverables							
3	Project Plan	2 days	2/3/2010	2/5/2010	2	Deliverable	David/Ryan/Stefan
14	Abstract/Brochure	2 days	4/17/2010	4/19/2010	3	Deliverable	Ricardo, All
15	Poster	2 days	4/17/2010	4/19/2010	3	Deliverable	Ricardo, All
19	Final Project Report	2 days	4/28/2010	4/30/2010	16	Deliverable	TBD

The Wishful Thinking

- Study previous work
- Develop testing procedure to build upon results from last semester
- Collect data using Haas CNC Machine at IIT
- Develop technique for detecting failure event
- Repeat testing at A. Finkl and Sons
- Present Data to A. Finkl and Sons

Experimental Setup

- Components
  - Two single-axis accelerometers
  - Triaxial accelerometer
  - Laser tachometer
- Analysis techniques using LabView
  - Time domain
  - Frequency domain (FFT)
  - Power Spectral Density (PSD)

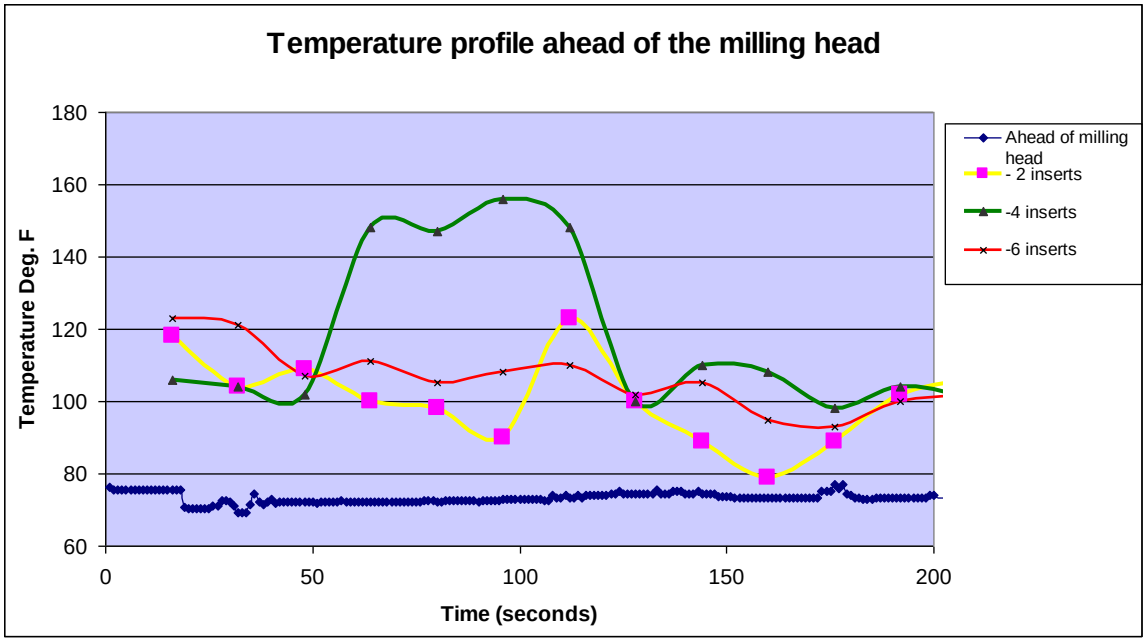
Laboratory Testing

- Same accelerometer placement as previous semester
  - Spindle
  - Machine
- Milling conditions:
  - Depth of cut: 0.02 – 0.04 in
  - Spindle speeds: 200 – 400 rpm
  - Feed rates: 1.2 – 2.5 in/min
  - Teeth: all good – 3 broken

Challenges

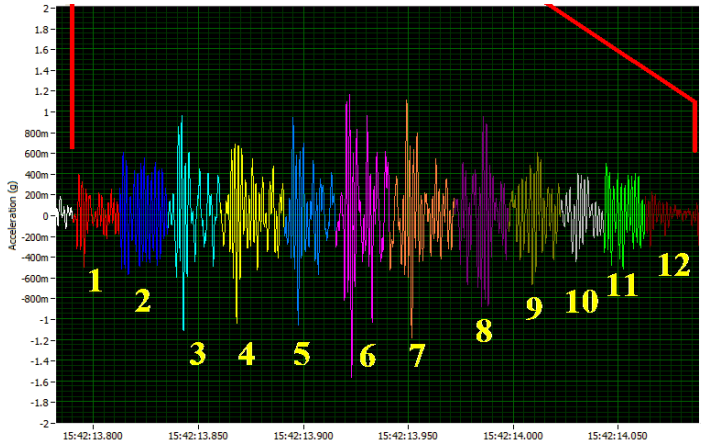
- Producing breakage event unlikely at our facilities
- Differences between Haas and Finkl milling machines
- Timing constraints in analyzing data

Infrared Thermometer Approach

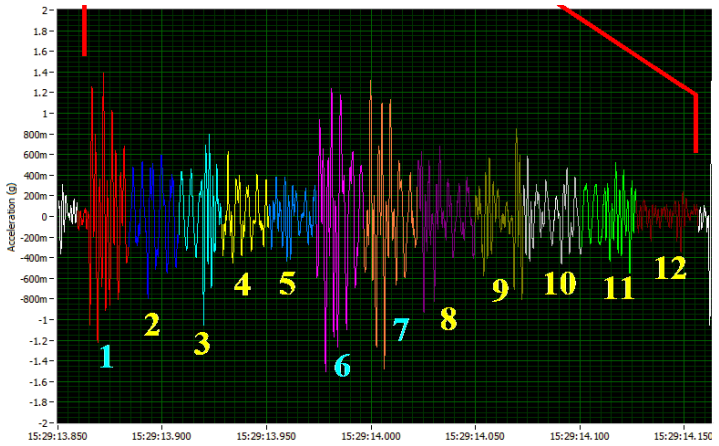


Power Spectrum Density (PSD) Analysis

- Analysis of the power carried in the cutting frequencies
- Has shown considerable promise
- Real-time comparison would allow for effective failure detection



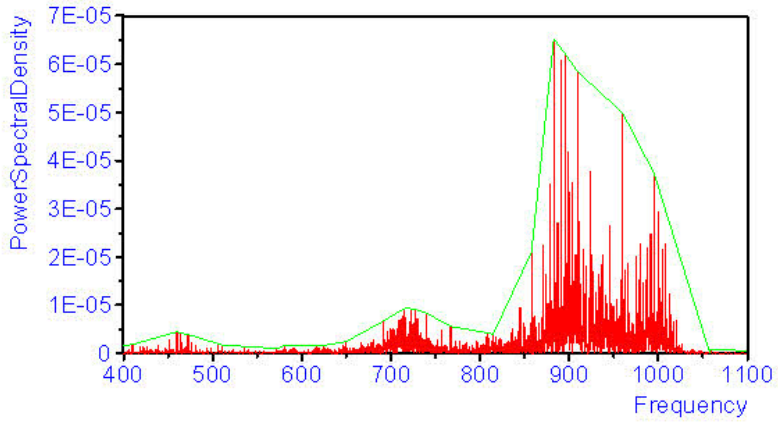
Above: View Showing Each Tooth During 1 Rotation CNC Machine - 0 Broken Inserts



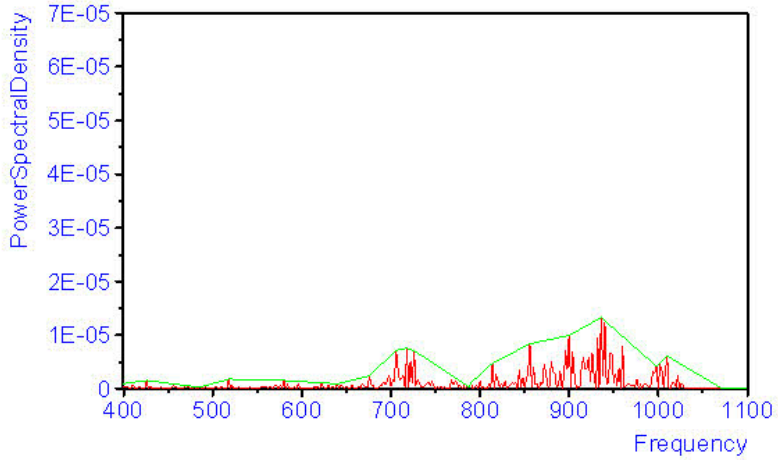
Above: View Showing Each Tooth During 1 Rotation CNC Machine - 3 Broken Inserts

Real-Time PSD Analysis

Testing 2-18-10



Tooth Configuration: All good
Cut Depth: 0.02"
Feed Speed: 1.2 in/min
Spindle Speed: 250 RPM
Cut Position: Fully engaged
Material: Soft steel



Tooth Configuration: 2 broken
Cut Depth: 0.02"
Feed Speed: 1.2 in/min
Spindle Speed: 250 RPM
Cut Position: Fully engaged
Material: Soft

Benefits to a PSD System

- From what we've seen, it works!
- In theory, a PSD system would work on the initial scale cuts and interrupted cuts
- While testing, other aspects of machine performance can be monitored

Potential Monitoring System

- PSD to monitor gradual tooth wear/failure
- Trigger system to capture catastrophic insert breakage
- Once machine noise frequency range is established, it may be possible to monitor if machine is being operated out of its recommended feed and speed envelope

Accomplishments and Results

- Can successfully detect insert failure on Haas machine
- Initial testing at A. Finkl and Sons. Facility
  - PSD shows promising data

Conclusions

- There are changes in PSD when broken inserts are present on the Haas
- PSD method works for various cutting conditions (as observed during Haas machine testing)

Future Work

- Streamline analysis methodology
- Continue experimentation at A. Finkl and Sons
- Create working software for real-time analysis

Acknowledgements

- A. Finkl & Sons
  - Guy Brada – Chief Metallurgist
  - Liz Bilitz– Liaison to IIT students
- PCB Piezotronics
  - Keith Crawford – Field Application Engineer
- Illinois Institute of Technology
  - Craig Johnson – Machine Shop Supervisor
  - Russ Janota – Director of Operations Mechanical Behavior

Questions?