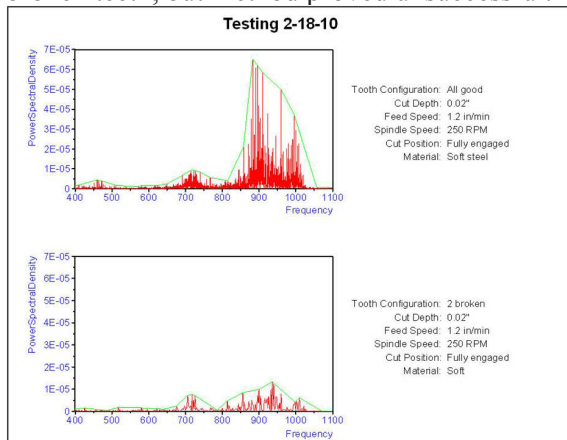


## Test Plan

The approach to this project is to attach a 3-D accelerometer (equipment that measures acceleration in x,y,z planes) to measure the change in the amplitude of certain frequencies as a function of time. When the amplitude changes, due to a broken carbide insert, the machine will be stopped by a computer command, and the carbide insert will be replaced. The group anticipates that the frequency drop will be low enough to show when the insert breaks. A tachometer (a laser that measures rotations per minute) will also be used to synchronize the cutting inserts with the observed frequency signal profile. The main focus will be to find out how to correlate when a carbide insert has broken off of a face mill to the frequency vs. time data output. A second possible method to discover broken teeth is to measure the temperature of the metal shards being discarded. The idea behind the latter is that with no broken teeth, the cutting will be done at a certain temperature, and if a tooth breaks, there will be a higher stress on the remaining teeth to compensate for the broken tooth. This added stress should increase the cutting temperature, which could be correlated to the number of broken teeth, but method proved unsuccessful.



## Data Analysis

Power Spectral Density (PSD) analysis (an analysis of the power carried in the cutting frequencies) has shown considerable promise, and using it we have been able to identify the presence of broken inserts. When all good inserts are present, all cutting frequencies have a certain overall power spectrum called a power spectrum density. Individual inserts have a unique power spectrum within its cutting frequencies, and the power spectrum of each insert adds up to form the overall PSD. Analysis of the PSD of one block of time with the previous block for a change in PSD over a certain threshold should allow for effective breakage detection. Looking at the results, there is a huge PSD drop when going from no broken teeth to two broken teeth. A program can be set up to stop the milling machine after a threshold level is crossed.

## Conclusions

After the PSD is obtained the peaks are connected. The connected peaks reveal a line of which the integral can be taken to give the area under the curve. It is the change in the area under the curve which is compared. The PSD can monitor gradual tooth breakage. A trigger system will capture catastrophic tooth breakage. Once the machine noise frequency range is established, it may be possible to monitor if the machine is being abused or not.

## Next steps

The next step is to attempt to recreate the lab results at Finkl, testing will be more difficult due to the fact that the mills are a lot larger, and the machine noise is compounded by other machines in the room emitting their own frequencies. Results are yet to come.



**IPRO** It takes a team!  
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IPRO 304

## Integration of Process Improvements



### Team Roster

- Emmanuel Flores
- Corey Hawker
- Charles Loeppert
- Ryan Marx
- Ricardo Rodriguez
- David Snyder
- Stefan Stevanovic
- Joshua Willet

### Advisers

- Prof. W. Maurer
- Prof. S. Mostovoy

### Sponsors



ILLINOIS INSTITUTE  
OF TECHNOLOGY

## Team Purpose

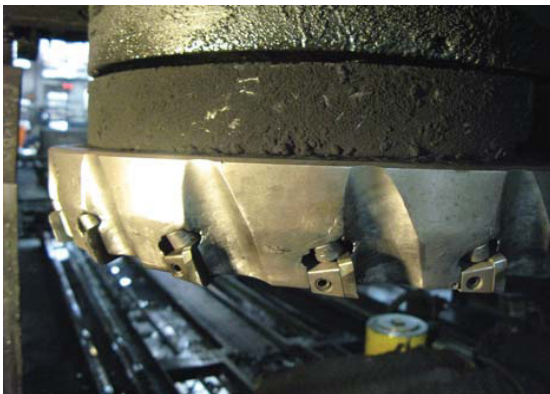
The goal this semester is to create a procedure that can call the attention to a technician when a carbide insert breaks off the face mill during operation. Completing this task will increase productivity and reduce cost for A.Finkl and Sons.

## Background

A. Finkl & Sons Co. was founded in 1879. Finkl is the world's leading supplier of forging die steels, plastic mold steels, die casting tool steels and custom open die forgings, processing 100,000 tons of steel each year. These products are distributed domestically and to more than 18 countries worldwide.

## Mechanical Failure

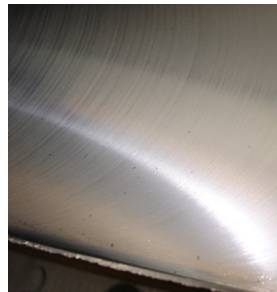
Since Finkl processes steel, they need to quality control check each piece of steel. One of the machines takes the top layer off of the metal using an 18-inch faceplate with 18 carbide inserts. Sometimes the carbide inserts break due to stress and the shape of the metal. Each machine has an assigned technician who will stop the machine and fix the carbide inserts. However, sometimes the technician does not realize right away that the carbide insert is broken.



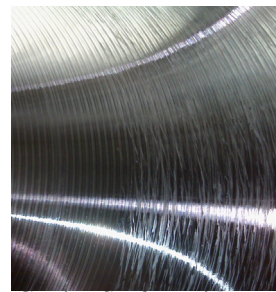
A. Finkl & Sons Mill

## Mechanical Failure (cont.)

It may take three or four carbide inserts to break before the technician replaces the broken carbide inserts. The steel that is going through will need to be reprocessed as a result because the non-uniform surface finish casts doubt about steel's quality. Another facet is that the technicians have to wait on the steel going through the machine. This means wasted man hours watching the metal go through, instead of doing something more productive for the company.



Cutting Surface with no Broken Teeth



Cutting Surface with Several Broken Teeth

## Objective

The objectives are to create a test plan that determines when a tooth breaks, and implement this test plan both in the lab and at Finkl. Productivity will increase by reallocating the technician to make better use of his/her time instead of overseeing the cutting procedure. Cost will be reduced by implementing an automatic stop program when a tooth breaks, the broken tooth will quickly be replaced to prevent breaking of the other teeth due to the increased stress.



Technician Replacing a Broken Tooth



Broken Tooth



HAAS CNC Mill Head

## Basic Organization and Tasks

Mechanical Testing Team

- Collect data from the HAAS CNC machine & from the milling machine at Finkl.

Analysis Team

- Analyze data using sophisticated software such as Labview or Matlab.

## Ethics

The cost implications are significant for this issue. This project aims to reduce human error which, in turn would increase productivity. Finkl has asked IIT to help them with this problem and this IPRO will conduct this project solely with Finkl. Finkl has promised IIT that they will not terminate any positions with the successful automation of this process improvement plan.

## Implementation of Test Plan

Small scale testing will be done at IIT, in a setup similar to the one used at Finkl. This will determine the feasibility of our testing. If successful, we can determine a insert detection methodology to present to Finkl.