IPRO 304
Integration of Process Improvements

Fall 2010

Advisors: Professor W. Maurer and Professor S. Mostovoy
Sponsor: A. Finkl & Sons (Chicago, IL)
Prepared by: a.derdelakos

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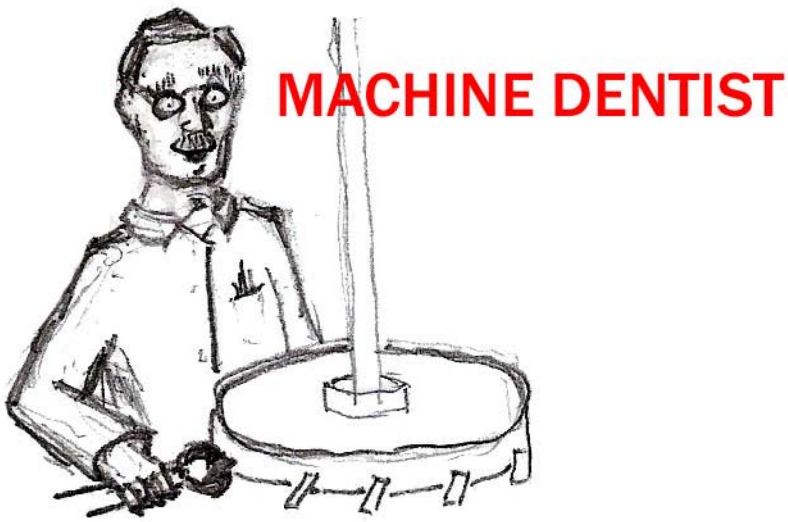
I. Team Charter

A. Team Information

Name	Contact Info e-mail Phone	Field of Study	Character Traits	Technical Skills / Technological Expertise	Weaknesses	Knowledge / Skills to develop	Expectations
Jon Perry	Perryjon1@iit.edu 571-228-0730	Mechanical Engineering	patience, creative, problem solving, diligence	some construction, design, programming / CAD, Inventor, SolidWorks, C++, Java, C#, some VB/VBA, all common programs, database and office backends, SQL server	Organization	CNC machining processes	Develop understanding of the machining process and organizational skills
Kyle Gillmeister	kgillmei@iit.edu 847-400-7417	Architecture	Time management, hardworking	Drawing / autoCAD, 3DSmax, Illustrator, Photoshop	Lack of knowledge in scientific fields	Knowledge in mechanical fields	Solve the problem or close the doors on proposed past solutions
Mike Sullins	msullins@iit.edu 815-685-5540	Psychology (pre – law)		Programming / Windows, Interact, Office	Technical Skills	Technical Skills	Meet proposed goals
Amar Rana	Arana5@iit.edu	ECE Double Major	Patience, precision, honesty, curious	Management, programming, mathematics / MS Office, Photoshop, Pspice, Java, C, Assembly	Knowledge of Materials and Mechanics	Gain knowledge related to material sciences and industry work	Gain excellent experience in professional working environment
Robert Hill	Rhill3@iit.edu 847-722-6668	Computer Science	Patience, problem solving, die trying attitude	Programming / C, C++, Visual Studio	Mathematics	Physics and use of meters	
Alexander Derdelakos	aderdela@iit.edu 734-620-4420	Architecture	Organized, honest, forthright,	Construction, fabrication, management / AutoCAD, 3DSmax, Illustrator, Photoshop, Flash, Dreamweaver, MS Office,	Overbearing, Alpha male	Data collection and analysis, advanced Excel	Conclude this project with decisive results
Francis Gotanco	Fgotanco1@gmail.com 847-338-9239	Material Science and Engineering	Work ethic, leadership, teaching	Open die forging and machine experience, metallurgy experience / MS Office, writing technical reports	Time, very busy schedule	Proficiency in data collection and analysis	Setting up a broken tooth detection system in place by the end of the semester

B. Team Identity

Team Logo



Team Motto: Saving Machines 1 Tooth at a Time.

C. Team Purpose and Objectives

1. Team Purpose

During the milling operations at an industrial steel producer like A. Finkl & Sons (Chicago, IL), a substantial amount of time and money is lost due to the fact that cutting inserts break and without warning. The goal of this project is to devise an effective means by which a cutting insert breakage event can be quickly and reliably detected, thereby minimizing damage to the steel and other cutting inserts, and also freeing technicians to attend multiple machines at a time. This increases the productivity of their operations, and it has the potential to save A. Finkl & Sons substantial costs per year in time lost in rework and prematurely broken cutting inserts.

2. Team Objectives

The core objective is to automate the process by which cutting insert breaks are detected by creating a computer program that interfaces with the milling machinery. To accomplish this, our team will need to isolate a profile of the behavior of each cutting insert on the milling head, establish consistent breakage conditions, identify breakage detection criteria, and produce digital algorithms by which those breaks can be reliably detected. With consistently reliable detection parameters, the team will then need to produce a computer interface or AV alarm by which a technician can be alerted to the breakage.

D. Background

1. Information about the Sponsor

A. Finkl & Sons Co. was founded in 1879. It 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. Since the 1800s, the company has maintained a commitment to manufacture 100 percent of its products in Chicago. These products are distributed domestically and to more than 18 countries worldwide. They sell their products to other manufacturers, like plastic processors, die casting companies and closed-die forging plants. With more than 100 patents to its credit, A. Finkl & Sons' steel formulations and steelmaking technologies set worldwide standards. Their facilities are on the leading edge of technology, using the most automated processes in the world. In recognition of product quality, A. Finkl & Sons was the first integrated steel manufacturer in America to receive ISO 9000 certification.

2. Information about the Problem

As A. Finkl & Sons machines the steel during a milling operation, they rely heavily on the performance of the mill. Each milling machine has an eighteen inch diameter faceplate with eighteen tungsten carbide cutting inserts. The hardness of the steel being milled causes cutting inserts to chip, wear, or at times fail catastrophically. As a result, the surface finish of the steel can be substandard, and more stress will be placed on the remaining cutting inserts, making a systemic failure of all inserts highly probable. This poor surface finish also often forces operators to re-machine the part to meet customer specifications, and this leads to the loss of significant amounts of otherwise productive time.

3. Information about the Technology Used

The milling machines operated and owned by A. Finkl & Sons are manually operated. There are no computer based components of the machine; therefore, the solution will have to be implemented externally. Accelerometers, devices which measure acceleration, have been shown to be useful in the isolation of each cutting insert of a milling machine. With a known RPM of the milling machine, software can be designed to isolate each cutting insert from the accelerometer output. The software can be designed to record the history of each insert. In theory, a cutting insert's acceleration will differ if it becomes broken or chipped, allowing the software to display the insert failure to the milling machine operator.

4. Prior Investigations of Machine Tool Failure

The previous IPROs were able to isolate individual cutting inserts through accelerometer output. With an established baseline of performance with no broken cutting inserts, the IPRO members were able to see higher amplitude of acceleration when broken inserts were detected. However, the isolation and detection did not occur in real-time; it was only possible when analyzing the accelerometer data after collection.

E. Ethical Issues

This project aims to reduce human error during the machining process which, in turn, would increase productivity. In Corporate jargon this typically means the elimination of workforce which posse's potential ethical misgivings about the underlying purpose of the project; particularly in the current economic recession.

A. Finkl & Sons has asked IIT to find a reasonable solution to this problem and this team will conduct its research under their discretion. As sponsor of this project, A. Finkl & Sons rightfully holds that the team's findings are not intended to be shared outside of the IPRO setting, and any company methodologies or technical communications shared will be held in strict confidence.

F. Business Costs

A. Finkl & Sons must spend money to purchase new cutting inserts to continue their milling operations. The money spent per year on these cutting inserts is on the order of several hundred thousand dollars. If a solution is created to detect when an insert fails, the insert can be replaced immediately, reducing the risk of a systemic failure of other inserts. This saves money, time and productivity.

G. Practical Methodology

The team's current approach to solve the problem of cutting insert failure is through accelerometers. The challenge is to continue collecting data and use to devise a system for real-time insert monitoring, so an insert failure can be detected immediately.

H. Team Value Statements

1. Team Behavior

IPRO 304 holds a code of ethics as fundamental to maintaining an honorable and respectable presence inside and outside of the classroom. Members of IPRO 304 shall conduct themselves in accordance with the ethics standards stated below:

- Conduct research and classroom discussion in a manner that is consistent with accepted honor and decency. Maintain an awareness of applicable laboratory and industrial safety codes.
- Be civil and respectful in professional and academic interactions, avoiding discrimination of any kind.
- Maintain the highest standards of conduct and integrity when representing IIT and the IPRO program.
- Be constructive and supportive in evaluating the work of other students.
- Encourage the free and open exchange of ideas and information from all students.

2. Issues and Challenges

Members of this group will address conflicts within applicable group or sub-group settings. If this fails to address the issue, the conflict will be taken up by the team as a whole, in the presence of the advisors to ensure effective resolution and maintain civility.

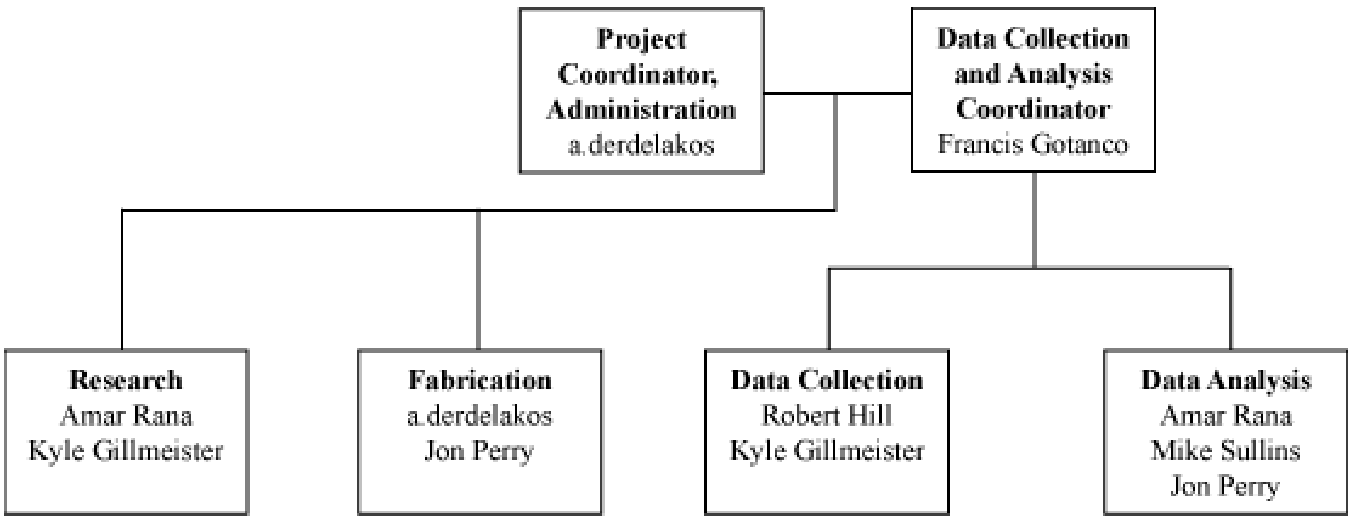
II. Project Methodology

A. Work Breakdown Structure

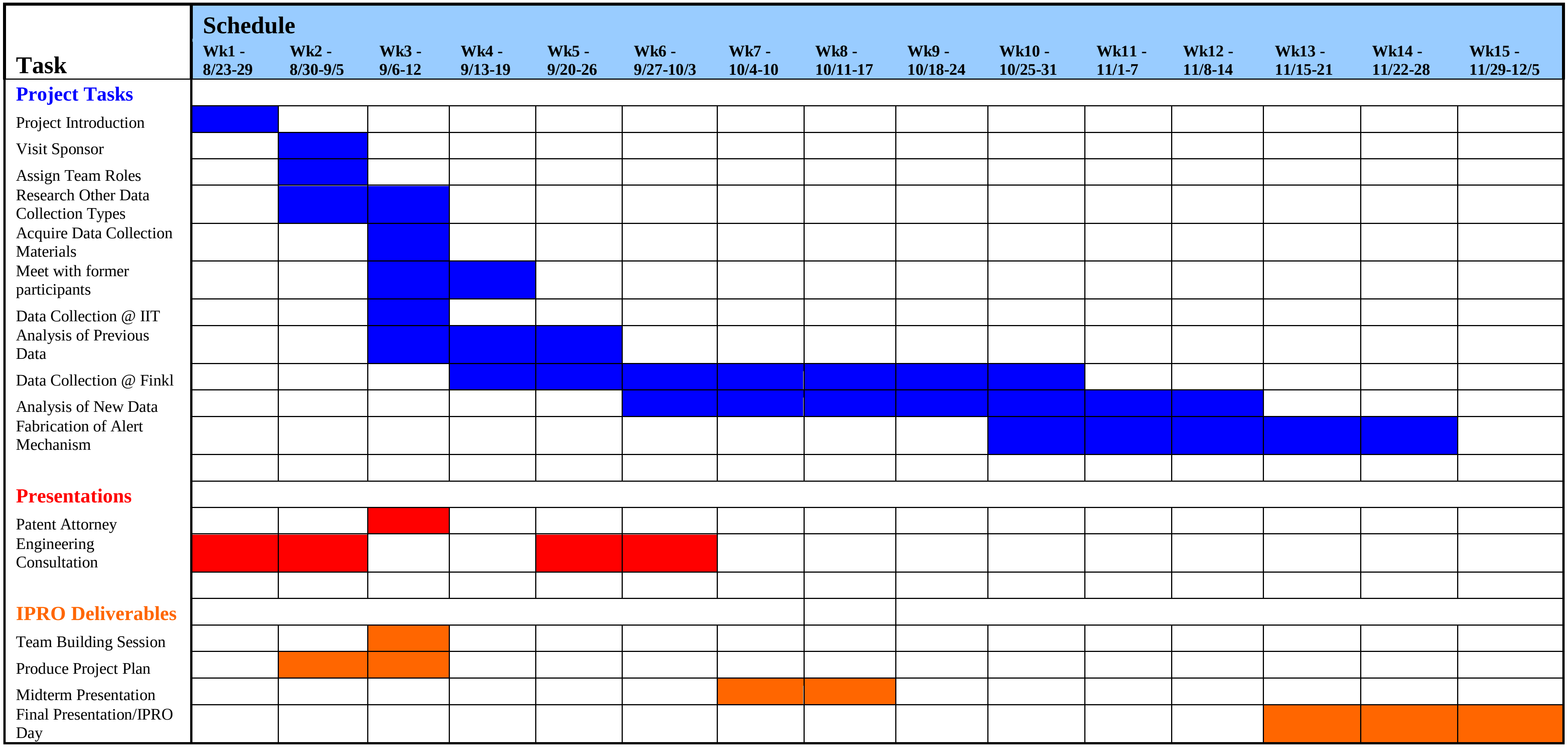
1. Problem Solving Techniques

The underlying focus of the semester will be to develop a system of detecting when a cutting insert has broken during a face milling operation. In order to do this the groups will focus on 3 main tasks: 1 – develop a data collection technique using accelerometers at the IIT milling facilities that can easily be refitted at A. Finkl & Sons' main milling facility; 2 – design an analysis method based on data collected in previous semesters as well as data that will be collected that can interpret irregularities in the milling process and identify the presence of broken inserts; 3 – fabricate a digital program or other alert system that notifies an operator when a milling insert is faulty or broken.

2. Team Structure



3. Gantt Chart



B. Anticipated Results

1. Details on Anticipated Activities

We will spend the 1st several weeks familiarizing ourselves with the project on order to achieve a viable plan for the semester. Once the plan is in place and the necessary materials, hardware and software has been acquired we will begin to test our procedure at the IIT milling facility. Concurrently the data analysis team will begin to decipher the information available from previous semesters. Once confidence has been achieved in the data collection procedure the group will begin a weekly trip to A. Finkl and Sons' facility for on site collection. As the results become more apparent a decision will be made between the group and interested parties at A. Finkl and Sons for further development of the alert system.

2. Anticipated Data and Testing

The team anticipates that accelerometer data combined with the rpm of the milling spindle will allow a time-series profile to be created corresponding to each cutting insert. In addition, LabView will analyze this data from the accelerometers. The group hopes to compare the current profile of each insert to its preceding profiles in real-time. A significant change in an insert's profile would signify that it has failed. The group will present testing results and findings to A. Finkl & Sons and attempt to replicate the results on their machines. It is expected that lab results will match the on-site machinery results, specifically pertaining to the algorithm correctly identifying when an insert breaks. The team will conduct this experiment at each machine and test the system for a few weeks to ensure that the broken cutting inserts can be detected with confidence.

3. Potential Products

The team wishes to develop a system what will increase A. Finkl & Sons machining productivity from this experimentation by fabricating an alert system that will notify a machine operator to a broken or faulty insert. It is possible that a streamline version of this system may be a potential product, and it will be the proprietary of A. Finkl & Sons by virtue of their sponsorship status.

4. Potential Outputs from Each Project Task

The potential outputs from the first phase of testing are to create a test plan and obtain analyzed data. The time-series profile of each cutting insert will be identified and exploited to detect insert failures. The output from the second phase of testing is to obtain A. Finkl & Sons' approval of the test plan and the analyzed data corresponding to the first phase testing. Finally a program will be developed and alert system fabricated to maximize productivity and quality control the milling process.

5. Anticipated Results of Deliverables

The group anticipates the experiment, carried out on the milling machines at A. Finkl & Sons, will result in a working program that, when interfaced with the milling machines, effectively detects and notifies the operator when cutting inserts break. By the end of the semester we hope to have a working prototype in place.

6. Summary of the Challenges, Risks and Assumptions

The initial challenge involves combining milling machine rpm information with accelerometer time-series data to identify the data profile for each cutting insert. The assumption made is that an insert's profile will differ significantly from its previous profiles once it has been broken. Then, the team must face the difficult task of developing an algorithm to identify a profile change and signal that an insert has broken. Once a working prototype program has been developed, the team must then show that it works in the industrial setting of A. Finkl & Sons' machining facilities, which undoubtedly present very different situations than the controlled setting of a laboratory.

As with any heavy machinery, the milling equipment used in this project must be operated with the highest concern for safety. Powerful cutting forces produce high temperature steel chips from the work-piece that are vigorously ejected in all directions, so safety gear such as glasses and appropriate clothing must be used. Improper operation can lead to entanglement of loose clothing or body parts into the milling machine, so machinery will only be operated by trained individuals.

The proposed method for detecting broken cutting inserts during the milling operation requires the assumption that each cutting insert will register a unique profile, and that the profile will only change significantly when the insert breaks. This ignores the possible effects of other various parameters, but it is the intent of this experiment to mitigate the effects of those parameters so as to justify this assumption.

7. Expected Incorporation of Results for a Proposed Solution

The first set of testing will be conducted at an IIT laboratory using a scale milling set-up that is similar to that used at A. Finkl & Sons. The results provided by this testing will allow for a better understanding of the difference in cutting insert profiles and help determine if they can potentially be used to detect insert failures. With this information, it will be determined whether the current approach is successful in determining when a cutting insert is broken by means of the output frequencies measured by accelerometers. If the results for the scale testing are found to be successful, testing will proceed at A. Finkl & Sons. Using the milling machines at the facility, the difference in time series profiles of the cutting inserts will be measured to determine if the assumptions made are valid and whether profiles can be used to detect broken cutting inserts. Given that the results are conclusive with a functional algorithm identified, a procedure and recommendation will be proposed to A. Finkl & Sons regarding the determined process and the desired equipment to perform the given process.

C. Designation of Roles

- **Project Coordinator, Administration**
    - a.derdelakos
- **Data Collection and Analysis Coordinator**
    - Francis Gotanco
- **Data Collection**
    - Robert Hill
    - Kyle Gillmeister
- **Data Analysis**
    - Amar Rana
    - Mike Sullins
    - Jon Perry
- **Research**
    - Amar Rana
    - Kyle Gillmeister
- **Fabrication**
    - a.derdelakos
    - Jon Perry