

## *Executive Summary*

The following report summarizes the work of the IPRO 347 team consisting of members studying various disciplines. The work conducted by this team spanned a fourteen week period spanning from August through December 2009.

The project focused on the needs of Smith & Richardson Inc., a small parts manufacturing company located in Geneva, IL with plants all across the world. Smith & Richardson, Inc. approached the IPRO group with two issues: determining an electronic process for determining tool life and tool wear, and developing a mechanism that will help automate a current semi-automatic manufacturing process.

The challenges of the IPRO group included the limited knowledge the personnel of Smith & Richardson Inc. had of their own systems. The tool room management team had to restructure the storage and usage records. The current system uses only hard copy forms with no easily accessible electronic copy. Smith & Richardson Inc. also utilizes various software systems for their tooling, inventory, and ordering operations. Smith & Richardson Inc. asked IPRO 347 to produce a viable database to interact with these systems and provide viable data.

The other challenge that Smith & Richardson approached this IPRO group with the task of producing a viable mechanized system to automate a current semi-automated process. Currently, the process requires a person to manually feed discs into a welding assembly to produce chaplets. The discs are made with a dimple to help facilitate welding. The operator must feel these discs for the dimple and insert them into the welder in the correct orientation. This task is highly repetitive and the efforts of the operator could be used elsewhere throughout the facility.

The IPRO group began the work by visiting the domestic plant in Geneva, IL. With this trip, the group gained valuable insight that could not be gained from the 'word of mouth' alone. After the visit, the group divided into two subgroups to work on the two different tasks. The groups did research in current database systems, tool property calculations, and current methods of automation.

The sub-teams were able to produce a product for the respective task.

## ***Purpose and Objectives***

I PRO 347 is working for Smith & Richardson Inc., a manufacturing company that produces precision machined parts and metal casting chaplets. Smith & Richardson Inc. asked I PRO 347 to work on two current issues: design and develop an interface between their inventory and tooling software programs, as well as design and implement a device that would help automate one of their production processes. The following paragraphs will describe these issues in further detail.

Smith & Richardson, Inc. develops many products for various companies via their machining equipment. Each of these products is a part of a complex manufacturing process, involving a set of machines, each of which is given specific instructions to utilize tools for special tasks. Each of these tools is picked from a large pool of resources, in order to most effectively manufacture the final products. Inherent in all manufacturing processes, one must take into account the wear on the tools used for manufacturing, as well as the number of tools in stock. Smith & Richardson, Inc. has requested the development of a tool management system to keep track of their tools, as well as to help predict tool life for preventive maintenance.

Smith and Richardson Inc., a manufacturing company that manufactures precision machined parts and metal casting chaplets. The second scenario requires that the group must identify methods, materials, and systems that can be used to automate a manual sorting and placement operation for the manufacture of casting chaplets, and to achieve a working prototype of the mechanism for Smith and Richardson Inc. As of now, this process is done manually by a worker. The worker has to feel around for protruding dimples on steel disks in order to correctly feed them into a welding machine.

Smith and Richardson Inc. wants this I PRO 347 to build a machine that eliminates the need for this position while at the same time, developing a viable interface between the varying systems throughout their facility. In order to accomplish these tasks, the team has:

- Researched existing mechanisms to evaluate their usefulness in our endeavor.
- Evaluated systems of our own design to see if they can better meet our objectives.
- Determined methods of implementation of the mechanism into the existing and mechanical setup.

## *Organization and Approach*

[Software – Meagan]

After visiting the plant on Friday, September 11th, the team brainstormed ideas for implementing a process to solve the problem presented to us. Examining the current system gave the team a further understanding of the problem.

At the outset, the IPRO team reviewed the background, qualifications, and strengths of its members which led to an organization designed to achieve the project's objectives. The whole team was divided into two groups: the mechanical team consisting of students studying engineering whose aim was to come up with a valid design and prototype that automates the welding process. (Refer to the roster of mechanical sub team members below.)

The team researched on methods to line up the discs in upright orientation, and having the dimples, which is in the center on one side of the discs all facing the same direction. A vibratory bowl, a machine that vibrates in a circular motion that lines up and drives small parts to ride along its spindle track, was considered to accomplish those tasks. Fortunately the sponsor, Smith & Richardson Inc. had an used bowl and delivered this equipment to the group. Later tests showed that the bowl worked as the team expected.

The second objective was to deliver the oriented discs to two plates facing each other where the welding process takes place. The team members worked as individuals developing different designs for the various stages of the problem: disc orientation, equal diversion of the discs to the two plates, and a track system.

Prototypes were initially desired to be made with rapid prototyping, however the machine in the MSI (Museum of Science and Industry) were down and we could not use it, while the one at IIT incurs a fee the group could not afford. As a result the final designs were all made up of sheet acrylics that could be cut out easily using the laser cutter in MSI.

In addition to this final report, the IPRO team's work is documented via a project plan, midterm presentation, final presentation and a brochure and exhibit/poster as part of the IPRO Projects Day event on Dec 4th, 2009. The project outcomes provide feasibility-related information, design, prototype and recommendations to Smith & Richardson Inc. The aim has been to fully automate the welding process.

<b>IPRO 347: Developing a Tool Crib Management System &amp; Feed Mechanism for Semi-Automated Welding Process, Mechanical sub team (Fall 2009)</b>		
Name	Major	Skills & Strength
Chiu, Daniel	Aerospace/Mechanical	Fluid Mechanics, Thermodynamics, Heat and Mass Transfer, Microsoft Office, Pro-

	Engineering	graming, AutoCAD, CadKey, KeyCreator, Qualified to use Crown Hall Shop, Handtools, Power Tools, Soldering
Cicero, Joseph	Mechanical Engineering	Statics, Dynamics, Materials, Thermodynamics, Technical Drawing, AutoCAD, Excel, Matlab, Power Tools, and Welding
Hill, Ross	Mechanical Engineering	Statics, Dynamics, Materials, Thermodynamics, Technical Drawing, AutoCAD, SolidWorks, Free Hand Drawing, Basic Construction, Hand and Power Tools
Lee, Woong-Kyo	Aerospace Engineering	Fluid Mechanics, Thermodynamics, Heat and Mass Transfer, Engineering Materials and Design, Aerodynamics
Xu, Ran	Mechanical Engineering	Dynamics, Materials, Thermodynamics, Fluid mechanics, Technical Drawing, AutoCAD, SolidWorks, Basic Construction, hand tools, trilingual in chinese, cantonese and english

Table 1. Mechanical sub team profile

## *Analysis and Findings*

The tool room management system did a great deal of research this semester. As the understanding of project requirements changed throughout the semester, different alternatives were examined. The first being a way of using the Visual Estitrack software that Smith & Richardson, Inc. already owned to do the tasks that they desired. The second was creating a new stand-alone application that would run alongside the company's current system. Lastly, a method of pulling data from Visual Estitrack and using it in a separate program the group would create.

Visual Estitrack is a very thorough shop management system sold by Henning Software. The ability to keep track of tools is a module that is already included in the system Smith & Richardson, Inc. has set up. The problem arises with the fact that there is no way to automatically calculate tool-wear life or populate the tool fields with data from the sales portion of their software. After multiple communications with Henning Software, it was clear that this functionality was possible, but only with modifications that Henning Software could make. They would be glad to make the changes but charge one hundred dollars an hour to do custom modifications. This is too large of an expense and therefore a new plan was devised.

Due to the multiple features that Smith & Richardson, Inc. desired for their tool management system, the next thought was to ignore their current system and to develop a stand-alone application that would calculate their tool-wear life. This application was designed and began its development stage when a new piece of information about Visual Estitrack was learned by the group. Visual Estitrack is built using a Visual FoxPro database, so it may be possible to pull information from the current system.

Visual FoxPro is a data-centric, object oriented, and procedural programming language. It has its own database engine so it can be a replacement for SQL. According to research done by the IPRO team, it should have been possible to import the FoxPro tables into Microsoft Access. Unfortunately, Henning Software was not very cooperative with helping another organization access the database behind Visual Estitrack. Therefore this idea of pulling data directly from Smith & Richardson, Inc.'s already populated database did not work well and a stand-alone program was reassessed.

The final product to be presented to Smith & Richardson, Inc. is a Microsoft Access application that will calculate and predict tool-wear life. It is run on user inputted data, and will have low accuracy until it has a history of tool use. The graphical user interface is created through Access so no database knowledge is required to use the system. Tool-wear life is calculated using an estimation process. A part's quantity is multiplied by both the material coefficient and the number of cuts for a tool in order to determine the approximate use for a tool. This is then stored on a per-tool basis so that when that tool breaks, it is known how much use it had prior to breaking. This data relies on an average number however, so until a sufficient amount of data is put into the system, it will not be accurate.

The mechanized automation team was able to develop and implement the designs to perform the desired tasks. The task of orienting all of the discs into one track system was performed using a vibratory bowl (see Figure 1) provided by the client. The vibration of the bowl ensures that the discs pass through in the correct orientation and single-file. The right hand side of Figure 1 shows the mechanism by which stacked and incorrectly oriented discs fall back into the bowl to be reprocessed.



Figure 1. The vibratory bowl and the exclusionary component.

From Figure 1, the exclusionary component allows the dimple-up disks to pass while the dimple-down disks fall back into the bowl.

The next stage of the process is to develop a rail system that not only effectively carries the discs, but to incorporate a device that will divide the discs into two separate tracks. These tracks will then feed into the welding plates. The flipper is the device that divides the discs and the concept is simple. The falling disc makes contact with the middle arm, causing a moment. The flipper will then rotate and the disc will leave the apparatus. The flipper is then ready to send the next disc into the opposite track assembly. This flipper is shown in Figure 2.

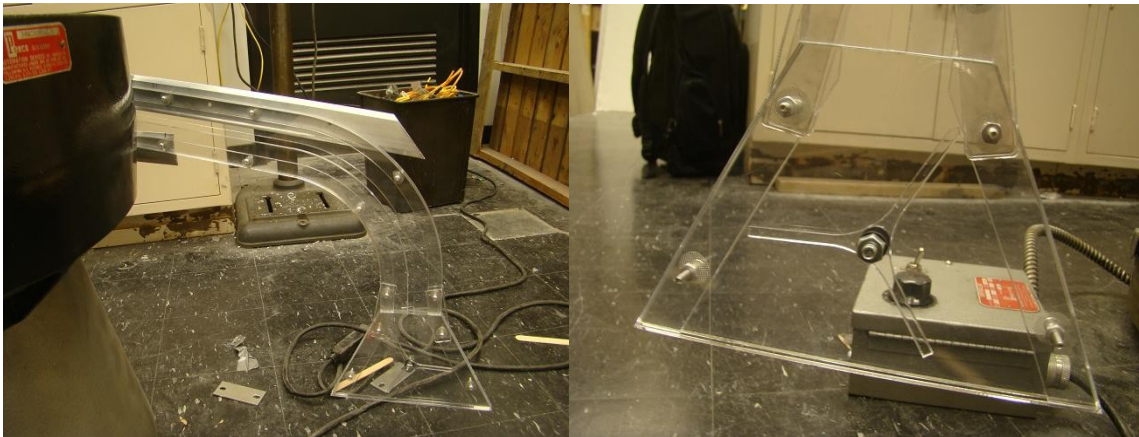


Figure 2. The prototype showing the track leaving the vibratory bowl and the flipper mechanism to divert the sorted discs into two directions.

The next step was to feed the discs from the flipper into the welding assembly. This proved to be the most challenging part of this project. After materials research and discussion, the most prudent move was to rotate both tracks from the flipper by 90 degrees. This ensures that the discs travel the same distance. The track will also have a section that is interchangeable depending on the size disc. This method proves more useful than the previous setup that Smith & Richardson, Inc. had used in the past.

## ***Conclusions and Recommendations***

In the end, the tool crib management team was able to assist their sponsor, Smith & Richardson Inc., through providing them with a database system that will predict the remaining lifetime of their tools and store an electronic record of their tool inventory.

Before enlisting IIT's help, Smith & Richardson Inc. had no means of predicting when any of their tools would fail during production. The failure of a tool could have been somewhat of a surprise, which meant they might not have been ready with a replacement. Not having a replacement ready could seriously hinder their progress on that project and could potentially affect other projects lined up after it. Thus, it was crucial that they be aware of when a tool was expected to fail.

In this way, the database system that was delivered to the sponsor will further streamline their production, for it is capable of predicting when a specific tool will fail. Such a prediction is made possible by the program's ability to keep track of past experience with each tool. Each tool will be entered into the database system along with information about its use, which is to be added whenever it is used. Once that tool fails, the information regarding its lifetime will be taken into account by the system. After the system has gathered enough information about how long that type of tool is capable of lasting, given a particular use, it will be able to predict an average remaining lifetime for the tools of that type that are still in use. As these predictions become more accurate over time, the sponsor will be better able to order tools ahead of time and make their production process run more smoothly.

The database system will also provide Smith & Richardson Inc. with a better way to keep track of their tools. The system includes a tool inventory system, which should be a great improvement over their current paper-based system. This is mainly due to the fact that with a paper-based system there is an increased risk of information being lost. Also, right now space is being wasted on a paper storage system, along with time when something must be found. Thus, the tool inventory system will add security to the sponsor's records while increasing office space and productivity.

If Smith & Richardson Inc. decides that further changes to their electronic system would be beneficial, it might be best for them to collaborate with the manufacturer of their main software system, Hennings Software. This recommendation is based on the fact that their productivity with any added software would be greatly increased if it could communicate and exchange information with their existing software.

One of the tool crib team's primary goals throughout the semester was to find a time efficient way of transferring data between the sponsor's current system and the additional system that the team was creating. This involved testing many different data scraping and OCR applications, among others, but in the end an acceptable solution was not found. This means that, unless Hennings Software is enlisted to help, all data must be manually entered into the new software, even if it already exists in another part of the system. Such repetitive data entry would be tedious and inefficient.

At the end of the semester, the mechanical team designed, developed, and implemented a workable device that solved the problem of automating the desired process. Before Smith & Richardson Inc. consulted with IIT, the process required an attendant to perform the task manu-

ally. This task requires little skill, but is crucial to the production of chaplets. This new device will help Smith & Richardson Inc. become more efficient such that the attendee can now focus his attention on other aspects of Smith & Richardson Inc. production facilities.

Should this portion of IPRO 347 need to continue, the team should spend time researching materials to ensure a long life for all of the parts. The apparatus is currently made from acrylic which has a lower fatigue life compared to metals.

Another recommendation for future teams would be to look into the layout of the system. The system implemented by IPRO 347 Fall 2009 requires the vibratory bowl to be suspended above the current welding apparatus. This could present some safety issues.