IPRO 321

<Improving the Efficiency of a Paper Shredder>

Summer 2007

Project Plan

Advisor: Prof. William Maurer & Prof. Sheldon Mostovoy

Sponsor: Seth Lewis

1.0 Objectives

IPRO321, Enhancing Reliability and Performance of a Paper Shredder, is focused on designing a better, more reliable paper shredder without increasing cost. The objectives of this group, as set forth by the sponsor, Seth Lewis of the Manhattan Group, are:

1. To determine the amount of force needed to cut 6, 8, and 10 sheets of 20 lb. paper taking into account the length and width of the shred
2. To design an efficient gear train that optimizes the number of gears and minimizes the motor size
3. To develop acoustical sound dampeners to reduce the amount of noise created during the shredding process by 10 decibels.

The team will seek to accomplish these goals through the use of computer simulation, extended research, and laboratory testing and error. By the end of the semester the team anticipates having developed a mathematical model that will allow for the minimization of the amount of force used to shred various amounts of paper, to have built a gear train that works better and lasts longer, and to have noticeably reduced the amount of noise created by the shredder. The IPRO Team's goal is to implement all of these changes to create a shredder with improved performance, reliability, and life span without increasing cost.

2.0 Background

General Product Description

Document shredder machines, commonly referred to as paper shredders, have been used in the office environment for many years. Once sold and used exclusively in offices, paper shredders can now be found in consumers' homes. Reasons for the increased use of paper shredders by consumers may be the prevention of identity theft and for use in the home office. A paper shredder performs the same function whether the machine is used in the office or home. However, paper shredders for the office are typically larger in size and are designed for high usage, whereas shredders for the home are typically smaller and designed for light to medium usage.

Market Information

Approximately 20% of all households or about 22 million households, have at least 1 paper shredder. There were an estimated 10 million paper shredders sold for home and office use. The number of sales (home and office) is expected to increase approximately 20% per year (U.S. CONSUMER PRODUCT SAFETY COMMISSION). According to these sources, one of the reasons consumers are purchasing paper shredders for home use is to reduce the likelihood of identity theft.

Project Specifics

Summer 2007 IPRO 321 is a continuing IPRO, from last semester, aimed at improving the performance of the paper shredder and evaluate/design an implementation for the reduction of noise. This semester our sponsor, The Manhattan Group, directed the IPRO team to concentrate on only one specific Royal paper shredder, which they have provided us to work on.

The IPRO team had an opportunity to ask questions regarding the scope and expectations of the project, president of The Manhattan Group, Mr. Seth Lewis. The model of the paper shredder the team will be working on is the most popular model sold by Royal Consumer Information Products, Inc. The customers buy this model mainly for home use. The present mechanical design allows a gear train to withstand about 300 cycles at maximum sheet capacity, which should permit the shredder to operate longer than one year manufacturer's limited warranty, under the assumption of typical home use of the product.

The IPRO team this semester has access to the documents uploaded to the iKNOW website by the students involved in IPRO 321 from the previous semester. These documents will be utilized if applicable. One relevant item that has been learned from the documentation is that the measurement and calculation of the force produced by the shredder was not quantified last semester. The force was different in each measurement and the formula to calculate the force was not established.

Another item that the team is working on is setting up a meeting with one of the students that worked on this project last semester to tell us about the problems they were facing, so we can avoid repeating the same mistakes that they made and move forward quicker pace to achieve success in our project.

The team has established the list of the equipment needed to be purchased and has performed research in the Staples and Office Depot stores, to be more familiar with the products available on the shredder current US market that would allow us to see our model weaknesses. Additionally, the team disassembled the Royal shredder to see all the interior mechanisms and parts that will be working on during our design.

Our team contacted one of the employees of the Underwriters' Laboratories, and is waiting for his response regarding any help he can provide us. This contact may prove invaluable since UL provides the certifications for the paper shredders.

The team has been divided into three sub-teams according to the project opportunities provided by The Manhattan Group listed in the Goals section of this project plan. Additionally, the teams have agreed to switch between sub-teams if more human resources are needed in some sub-teams as the project progresses.

3.0 Methodology

The Royal Manufacturing Company is currently facing performance and reliability issues with its line of paper shredders and has hired The Manhattan Group as a consultant in order to improve on these issues. First, the shredders have a high failure rate, initially 10-12% and now it is at about 6%, compared to the rest of the shredders in the economy price range. This leads to poor performance ratings and bad word of mouth from consumers. Second, the shredders are very loud, operating at approximately 75 dB, and the Manhattan Group claims the noise level is very important to the consumers. The IPRO team will attempt to come up with a way to predict the amount of force required to shred paper based on three inputs (paper length, paper width, and the desired amount of paper to shred), come with a reliable gear train based on this force, and lower the amount of noise produced by the paper shredder without adjusting the building cost of the product by more than twenty to thirty cents.

The IPRO team has been split into three sub-groups to handle the problems. The force team is going to find a way to isolate the amount of force from the motor. This will allow the team to come up with an equation to predict the amount of force required to shred the paper. Previous semesters have tried different methods to find this force, but their results have been inconclusive. The force team is going to have to use previous knowledge to avoid making the same mistakes and come up with an effective way to get conclusive readings. Otherwise, the desired equation will not work. The final goal of the force team is to create a computer simulation program using Java to help the gear train team.

The gear train will attempt to optimize the number of gears and minimize the size of the motor based on the computer simulation program from the force team. From the predictive modeling program, the new gear train should be cost effective and bring down the overall price so that the noise team can work with the cost of the machine.

The goal of the noise team will be to find a way to reduce the amount of noise from the machine by a minimum of ten decibels. A lot of research has been done by previous semester IPRO teams on this subject and their knowledge is a great starting place for this sub-group. While the other sub-groups are working on their respective problems, the noise team is going to be testing different materials and methods to reduce the noise and will need to document the cost to do the changes.

All three teams should keep excellent notes for documentation. In order to prevent overlap from previous and future semesters, the sub-groups should type everything in Microsoft word 2003 with clear and concise day to day notes. Items that specifically need to be addressed such as price differences, successes and failures for trials, etc. need be clearly outlined and the results easily found and readable.

The three teams' goals coincide because both the force team and the gear train team are finding ways to lower the cost so that the noise team has more than just pennies to work with in lowering the noise generated. The results from the three teams should be a paper shredder for the same price with more features and better reliability. Along the way, the sub-groups' documentation will make the IPRO team's job of deliverables easier because sub-group leaders will be able to compile relevant findings to the poster, final paper, and final presentation.

4.0 Expected Results

This project has a very specific goal and that is to improve the efficiency of a paper shredder. Unfortunately something as simple as a paper shredder still requires a large amount of work to improve its efficiency as specified by our client. The main goals given to us were determined to be most important in increasing a product's value in the market. The goals are to determine the forces required to shred certain amounts of paper (which has never really been measured), to develop an efficient gear train that will last longer than current generation shredders, and finally, to decrease the sound given off by the shredder.

This group will have to study the paper shredder's gear train to improve life span of its gear system. We will also have to do extensive acoustics testing on the paper shredder to properly isolate the problem areas to make a quieter paper shredder. This will also tie into research we must do to determine the amount of force it requires to shred a certain amount of paper to formulate equations which will help solve many of the problems faced by modern paper shredders.

We expect several types of data to accomplish our task set. We must first find out the forces required to shred certain amounts of paper. Next, we need to figure out the forces required for the most efficient and cost-effective gear train. Last, we need consistent audio readings from the paper shredder. These readings will help determine the actual sound pressure level (SPL) of the paper shredder in certain areas. An important part of this research will also incorporate studying other models of paper shredders to compare the characteristics of competing products and to see how they are implemented in these other products.

With this data we should be able to make a gear train that will require the fewest parts and last a specified life cycle. It will meet the objectives of needing to cost-effective, durable, and reliable. With the acoustics data, we need to be able to isolate the sounds coming from the paper shredder and make an overall quieter product. Whether we do that with the sound readings we take, or by redesigning the shredder, it just needs to be done.

With all of this, our final goal as a group is to assemble a working prototype of our specially modified paper shredder that will meet our clients' goals of higher efficiency without increasing costs much, if at all. Because the goals are so focused, it will be easy to judge or rate the effectiveness of our research and subsequent modification of the paper shredder.

5.0. Project Budget

General	**Projected cost**
Competitive shredders	$100.00
20 lb Paper	$10.00
Posters	$50.00
Other supplies	$50.00
Contingencies	$200.00
Force Team	
Various Instruments & supplies	$200.00
Amp meter	$100.00
Gear Optimization Team	
Various Instruments & supplies	$200.00
Acoustic Team	
dB Meter	$70.00
Passive Acoustic Materials	$30.00
Total	$1010.00

As stated above, this is only a projection. The final cost can vary +/- $100.00

6.0 Schedule of Tasks and Milestone Events

Task Name	*Duration*	*Start*	*Finish*	*Resource Name*
Preliminaries	3.5 days	6/5/2007	6/9/2007	
Learning Objectives Test	1 day	6/5/2007	6/5/2007	
IPRO Games	0 days	6/9/2007	6/9/2007	
Project Initiation	8 days	6/5/2007	6/15/2007	
Brainstorming	1 day	6/5/2007	6/15/2007	
Meeting with Sponsor	1 day	6/5/2007	6/15/2007	
Research previous semester's deliverables	1 day	6/5/2007	6/15/2007	
Contact Previous IPRO Members	1 day	6/5/2007	6/15/2007	
Project Plan	5.5 days	6/14/2007	6/21/2007	
Assign Sections	1 hr	6/14/2007	6/14/2007	
Objectives	2 days	6/17/2007	6/20/2007	Kelly
Background	2 days	6/17/2007	6/20/2007	Sebastian
Methodology	2 days	6/17/2007	6/20/2007	Joey,Adam
Exepected Results	2 days	6/17/2007	6/20/2007	Mike
Project Budget	2 days	6/17/2007	6/20/2007	Saul
Schedule of Tasks / Milestones	2 days	6/17/2007	6/20/2007	Mithun,Luke
Individual Team Member Assignment	2 days	6/17/2007	6/20/2007	Yemi
Designation of Roles	2 days	6/17/2007	6/20/2007	Erik
Compilation / Revision	2 hrs	6/20/2007	6/21/2007	
Goal 1: Force-Load Relationship	25 days	6/14/2007	7/19/2007	Adam,Joey,Sebastian
Consulting	25 days	6/14/2007	7/19/2007	
Determine which forces are needed to be measured & machinery to measure them	25 days	6/14/2007	7/19/2007	
Determine force required to shred certain amounts of paper (equation)	25 days	6/14/2007	7/19/2007	

Goal 2: Gear Train Optimization	25 days	6/14/2007	7/19/2007	Luke,Saul,Yemi
Consulting	25 days	6/14/2007	7/19/2007	
Determine gear train materials and properties of these materials	25 days	6/14/2007	7/19/2007	
Construct Free Body Diagram of gear train	25 days	6/14/2007	7/19/2007	
Determine why gears fail	25 days	6/14/2007	7/19/2007	
Combine all data to make a more efficient gear train	25 days	6/14/2007	7/19/2007	
Goal 3: Noise Reduction	25 days	6/14/2007	7/19/2007	Dan,Erik,Kelly,Mike
Consulting	25 days	6/14/2007	7/19/2007	
Set up equipment to measure acoustic data	25 days	6/14/2007	7/19/2007	
Determine where the most sound is coming from	25 days	6/14/2007	7/19/2007	
Determine how to reduce noise in the problem areas	25 days	6/14/2007	7/19/2007	
Test results	25 days	6/14/2007	7/19/2007	
Miscellaneous Goals	25.5 days	6/14/2007	7/19/2007	
Cost analysis of parts	25 days	6/14/2007	7/19/2007	
Meet with Seth Lewis to go over preliminary findings	25 days	6/14/2007	7/19/2007	
Combine improvements to build final solution	25 days	6/14/2007	7/19/2007	
IPRO Deliverables	0.5 days	7/25/2007	7/26/2007	
Final Report	0 days	7/26/2007	7/26/2007	
Presentation	0 days	7/26/2007	7/26/2007	
Poster	0 days	7/25/2007	7/25/2007	
CD-ROM	0 days	7/25/2007	7/25/2007	
Conclude	1.25 days	7/26/2007	7/27/2007	
IPRO Day	0 days	7/27/2007	7/27/2007	
Debriefing	0 days	7/26/2007	7/26/2007	
Pizza Party	0 days	7/26/2007	7/26/2007	

7.0 Individual Team Member Assignments

Yemi Babatola *Mechanical Engineering*
- Pro/E, AutoCAD, Matlab
- Various mechanical related projects
- Artistic skills sharpened by being comics editor of TechNews for a year

Kelly Bergren *Applied Mathematics*
- Knowledge of Maple and Microsoft Office
- Access to materials and tools through work in hardware store
- Pays attention to detail

Luke Cho *Mechanical Engineering*
- AutoCAD, Pro/E, MS Project, Adobe Photoshop
- Mechanical analysis experience from previous projects and 400 level MMAE courses
- Multicultural Experience

Erik Dill *Computer Information Systems*
- All around computer skills through years of study of computers and computer systems
- Leadership skills through military service
- Creative and a quick learner

Saul Esparza *Electrical Engineering*
- Industry experience working for De La Rue
- Experience with electrical systems and circuits
- Experienced at time management and multitasking

Michael Kim *Computer Engineering*
- Knowledgeable about sound dampening and isolation through work on car vibration reduction
- Experience with AC motors with good understanding of how they work
- Familiar with the circuitry board in use

Daniel Mendez *Electrical Engineering*
- Experience with electrical systems through higher level electrical engineering courses
- Goal oriented
- Helpful and resourceful

Mithun Michael *Electrical Engineering*
- Java, C++, MS Project
- Interest in acoustic dampening
- Hardworking, Task oriented

Joey StClair *Computer Science*
- Java, Sound analysis software
- Programming skills acquired through years of classes and project
- Inquisitive, Desire to discover force equations that no one has ever accomplished

Adam Stultz *Biomedical Engineering*
- Biomedical Engineering background makes for an innovative mind
- Dexterous and good at constructing models
- Motivated by challenges

Sebastian Zielinski *Computer Engineering*
- Experience designing computer simulations
- Knowledge and experience with computer system analysis
- Multicultural experience and people skills

Team Leader

Luke Cho

Sub-Teams

Force-Load Relationship
- Adam Stultz
- Joey St. Clair
- Sebastian Zielinski (Sub team Leader)

Gear Train Optimization
- Luke Cho
- Saul Esparza (Sub team Leader)
- Yemi Babatola

Noise Reduction
- Daniel Mendez
- Erik Dill (Sub team Leader)
- Kelly Bergren
- Michael Kim
- Mithun Michael

Sub-team Responsibilities Breakdown

Force-Load Relationship: Determine the amount of force needed to cut 6, 8, and 10 sheets of 20 lb. paper taking into account the length and width of the shred

Gear Train Optimization: Design an efficient gear train that optimizes the number of gears and minimizes the motor size

Noise Reduction: Develop acoustical sound dampeners to reduce the amount of noise created during the shredding process by 10 decibels

Individual Member Responsibilities

Force-Load Relationship:
- Consulting (Sebastian)
- Determine forces needed to be measured & machinery to measure them (Adam, Joey)
- Determine force required to shred certain amounts of paper (Adam, Joey, Sebastian)

Gear Train Optimization
- Consulting (Luke, Saul)
- Determine materials and material properties (Saul, Yemi)
- Gear Mechanical analysis/determining failure modes of gears (Luke, Yemi)
- Combine data to make a more efficient gear train (Luke, Saul, Yemi)

Noise Reduction
- Consulting (Kelly, Erik)
- Set up equipment to measure acoustic data (Michael)
- Determine where the most sound is coming from (Mithun, Erik)
- Determine how to reduce noise in the problem areas (Daniel, Micheal)
- Test results (Kelly, Daniel, Mithun)

8.0 Designation of Roles

Assign Meeting Roles:

Minute Taker: Kelly Bergren

Agenda Maker: Joey StClair

Timekeeper: Adam Stultz

Assign Status Roles:

Weekly Timesheet Collector: Erik Dill

Master Schedule Maker: Luke Cho

Assign Other Roles:

IPRO Office Liaison: Daniel Mendez

iGroups File Manager: Yemi Babatola