IPRO 321 – Fall 2007
Enhancing the Reliability and Performance of Paper Shredders

Project Plan

Objectives:

1. Determine the amount of force to cut 6, 8, 10 sheets of 20 lb paper, taking into account the width and length of the shred. Once the amount of force is determined, develop a computer simulation model that can predict the amount of force required based upon the following variable inputs: number of sheets, shred width, and shred length.
2. Through computer simulation or prototype development, design an efficient gear train that optimizes the number of gears and minimizes the motor size based upon data obtained from previous semester's data. The goal is to develop and simulate a gear train that can withstand 500 cycles at maximum sheet capacity.
3. Develop acoustical sound dampeners or "tune" the shredder to reduce the amount of noise created during the shredding process, leveraging information obtained from previous semesters' data. The goal is to reduce the noise output by 10 decibels.

Background:

Spring semester 2007, President Mr. Seth Lewis of the Manhattan Group came to IIT seeking advice regarding the improvement of his paper shredder. The paper shredders are manufactored in China and sold across the world, including the United States, under the Royal brand name. Each year, over a million of these paper shredders are sold. Consumers seek quiet and long lasting paper shredders at the lowest possible price. Mr. Seth Lewis's has ask us once again, the students of ipro 321 and Professor Maurer, for the third semester straight to further seek potential methods and problems in his shredders. These problems include measuring force required to cut paper, gear optimization, and sound reduction. The MMAE lab and machine lab will be used extensively for gear and materials testing. Software resources, sound measuring equipment, and equipment in the EE lab will be used as well.
Potential legal and/or ethical issues will involve patents and idea ownership. Since this is a sponsored IPRO, all discoveries will be property of Mr. Seth Lewis and the Manhattan group. There potentially could be a situation where this IPRO will be unable to provide necessary information to the IPRO office regard work and progess due to ethics.

Methodology:

As a group we decided that the best way to handle the objectives given was to split up into three teams, one team per task.

Paper Force Team

A. The team will work together to develop a mathematical model that can estimate the force required to shred several sheets of paper for a given paper shredder.

B. Experimental data will be acquired by measuring the shredder's power consumption (voltage and current) and angular speed. The torque will be determined using the relationship below. The diameter of the cutters will be measured in order to obtain the force. Several tests will be performed varying the number of sheets. In addition, the torque data from subgroup 2, acquired through mechanical means, will also be used as to verify the validity of the method. Following the datataking, for several amounts of sheets the data will be fit to an appropriate function. Such a model is expected to estimate the behavior of the force required to shred different amounts of paper sheets for a given paper shredder. This strategy has high chances of being completed successfully within a month, according to time and supply constraints.

C. The results from both methods will be compared and evaluated for accuracy. Appropriate adjustments will be made.

D. The results will be documented into a scientific report with graphical aids such as plots and tables.

E. The same procedure will be repeated for different shredders and results will be compared.

Gear Train Team

A. For a given shredder given to the group by the Manhattan Group, the gear ratio and motor size may not be the most efficient setup for the maximum sheet capacity. As a group we will work to obtain the most efficient gear train and motor for the given application.

B. For the problem stated above the team has determined a proper course of action in order to solve the given problem. As a group we plan to first research gear types and the pros and cons of each one. When the team has been given power data from group 1 the team will then look into motors that will provide the given power with the least amount of cost. After the team has decided on a gear train and motor they will compare to the current gear train and motor to determine whether there can be any improvements without extra costs.

C. For the given application the best testing will be done using computer simulations and also possibly real world simulations of a possible gear train. The team will first need to determine whether the most efficient gear train and motor will even be feasible and if it is then the group will purchase and build this gear train. This

built gear train and motor set will then be tested using restrictions of maximum paper load of 6 sheets and maximum repetitions of 500 cycles.

D. The group has planned to record all results on an excel spreadsheet for further analysis and comparing to the current gear train and motor set.

E. The team will then determine whether the desired gear train and motor will be efficient and durable enough to withstand regular shredder usage within the current cost bracket.

F. The team has currently not decided who will do each IPRO deliverable. The team hopes to work on these as a group in order to achieve the most complete and effective deliverable for the given requirements.

Sound Team

A. The problem is to develop acoustical sound dampeners or tune the shredder to reduce the noise output created during the shredding process by 10 decibels.

B. In order to achieve this goal, the sound sub-team will first determine the amount of sound produced by the paper shredding by measuring both the decibel level and the frequency. To do this, the team must first get the testing equipment, learn how to properly use the testing equipment, and come up with an appropriate testing procedure. The team will then look into a variety of options to reduce the amount of noise. These options include sound insulation or dampening, grommetting, and sound deflection. Each of these options will be researched and then tested by fitting the paper shredder with the design developed by the team.

C. Once some suitable options have been developed, they will be implemented and tested using the same equipment used to find the baseline paper shredder noise.

D. The results of the research and testing will be documented using the appropriate software. Some of the equipment comes with software that needs to be installed on a computer, so the results can easily be saved during testing. Other programs such as Microsoft Excel can be used to record other data.

E. The test results will be analyzed by looking at the frequency and decibel levels of each of the various tests. Since the goal is to lower both the frequency and decibel level, the tests that produce the lowest decibel level and frequency would be the most desirable.

F. The deliverable reports will be generated by dividing the work among the team and then putting together a final version.

Expected Results:

The different subteams will coordinate their work in order to obtain the desired results.

A. A mathematical model is expected to be developed to estimate the force required to shred several sheets of paper for a given paper shredder. In our case, it will be the shredders provided by the Manhattan Group. This model will be realized by performing experiments that will calculate the torque and forces associated with varying number of sheets fed into the shredder.
B. The group working on gears is going to work towards determining the most efficient gears that can be used in the shredder. The gears with the most endurance and durability will be chosen to be used in the shredders. Gears with increased power and reduced noise and wear are expected to be identified by the students.
C. The team working on sound reduction will be expected to develop a system to considerably reduce the noise produced by the shredder. This will be achieved through experimentation with insulation or dampening, use of grommets and research into sound deflection. A testing procedure will be used to efficiently determine the best solution to reduce the noise.

Project Budget:

Shredding Head Testing Apparatus	$450
Alternative Shredders	$100
IPRO Day Materials	$300
Miscellaneous Equipment and Supplies	$200
Total	$1050

Schedule of Tasks and Milestones:

ID	Name	Duration	Start	Finish
1	Initiation	11.333d	8/27/2007 15:00	10/3/2007 15:30
2	Paper shredder opportunity indentify	2.d	8/27/2007 15:00	8/29/2007 16:30
3	Define project objective and information required	2.d	9/3/2007 15:00	9/5/2007 16:30
4	Brainstorm and grouping into 3 groups	2.d	9/10/2007 15:00	9/12/2007 16:30
5	Initial planning complete	1.333d	9/17/2007 15:00	9/19/2007 15:30
6	Analysis and decision by the potential approach by group	2.d	9/19/2007 15:30	9/26/2007 15:30
7	Tools and equipment collection	2.d	9/26/2007 15:30	10/3/2007 15:30
8	Development and execution	10.667d	10/3/2007 15:30	11/7/2007 16:30
9	Individual group development	6.667d	10/3/2007 15:30	10/24/2007 16:30
10	Group 1 measure the torque and develop the simulation	6.667d	10/3/2007 15:30	10/24/2007 16:30
11	Group 2 design the gear chain	6.667d	10/3/2007 15:30	10/24/2007 16:30
12	Group 3 develop acoustical sound damper	6.667d	10/3/2007 15:30	10/24/2007 16:30
13	Assembly	4.d	10/29/2007 15:00	11/7/2007 16:30
14	Choose optimum solution	2.d	10/29/2007 15:00	10/31/2007 16:30
15	Solution chose	.d	10/31/2007 16:30	10/31/2007 16:30
16	Product trial run and debug	2.d	11/5/2007 15:00	11/7/2007 16:30
17	Product released	.d	11/7/2007 16:30	11/7/2007 16:30
18	Close project	2.667d	11/12/2007 15:00	11/19/2007 16:00
19	Documentation	1.333d	11/12/2007 15:00	11/14/2007 15:30
20	Presentation	1.333d	11/14/2007 15:30	11/19/2007 16:00

Individual Team Member Assignments:

Name	Major/Minor	Skills and Strengths	Academic Interests/ Experience	Team
Migun Choi	Industry Technology and Management	1. Enjoys challenges 2.Still learning English	Interested in many different fields	Gear Train
Justin Choriki	Mechanical Engineering	1. Experience in graphics 2. Generally good with 3D visualization	Interested in working with Mechanical Systems	Gear Train
Stephen Flicek	Mechanical Engineering/ Management	1.Autocad 2. Experience in group projects	Teaching Assistant	Sound Reduction
Yuxiong Huang	Industry Technology and Management	1. Good at data analysis 2. Lack of knowledge in mechanics and electronics	1. Interested in Lean Manufacturing, supply chain 2. Experience as an Industrial engineer in electronics manufacturing industry	Paper Force
Tyler Inouye	Electrical Engineering	1. Good with Electrical Components 2. Time Management 3. Organization Skills	1. Interested in Power Electronics and power systems 2.Award winning IPRO 342	Gear Train
Richard King	Computer Engineering/ Business Management	1. Good at planning 2. Resourceful and respectful 3. Works well under stress 4. Good listener and likes public speaking 5. Does not mix personal time with work time.	2 years of collective experience in Industry	Sound Reduction
Plamen Marinov	Mechanical Engineering	1.Very Broad CAD skills 2.Hard worker and great at multi tasking 3. Perfectionist 4. Very neat	Experience in CAD	Sound Reduction and Torque apparatus

Angad Nagwan	Mechanical Engineering/ Business	1. Good Mathematical Skills 2. Oral and Written Communication skills 3. Microsoft Office 4. Lab Equipment Usage	1. Experience with lab equipment 2. Experience in developing reports 3. Experience in creating presentations.	Sound Reduction
Garrett Nielson	Electrical Engineering	1. Organizational Skills 2. Time Management 3. Teamwork skills	1. Interested in Power Electronics and power systems 2.Award winning IPRO 342 3. 4 years lab experience with electrical components	Gear Train
Leslie Obst	Mechanical Engineering/ Aerospace Engineering	1.Microsoft Word and Excel	Interested in Aircraft Design	Sound Reduction
Vesna Pesik	Electrical Engineering	Good at analyzing and designing electrical circuits	Interested in circuit design	Paper Force
Kyle Swaidner	Aerospace Engineering	Experience with electric motors and gear drives	Experience with electric motors and gear drives	Sound Reduction
Brandee Toyama	Mechanical Engineering	1. Microsoft Word and Excel 2. AutoCad 3. Weakness in Oral Speaking	Interested in Mechanical Design and how Mechanical Systems work.	Gear Train
Nil Valls	Physics and Aerospace Engineering	1. Resourceful 2. High applicability of majors to this IPRO 3. First time in this IPRO and not familiar with the materials.	Engineering Experience in Design and Construction	Paper Force

Team Breakdown:

Paper Force Team	Gear Train Team	Sound Reduction Team
YuxiongHuang	Brandee Toyama	Stephen Flicek
Vesna Pesik	Justin Choriki	Richard King
Nils Valls	Migun Choi	Angad Nagwan
	Tyler Inouye	Leslie Obst
	Garrett Nielson	Kyle Swaidner
		Plamen Marinov

Subteam

Torque Apparatus
Plamen Marinov
Kyle Swaidner

- this subteam was created to work with Dr. Mostovoy on the design of a new apparatus that will measure the torque required to shred the paper. This new method is required because the data for the torque from previous semesters was inconsistent. This apparatus will provide a new and more efficient method of measuring the torque. The machine will assist the other teams achieve their goals.

Resources
1. Seth Lewis – *president of The Manhattan Group and sponsor of our IPRO.*
2. Professor William Maurer- *faculty advisor from the Industrial Technology and Management Department*
3. Professor Sheldon Mostovoy- *faculty advisor from the Mechanical, Materials and Aerospace Engineering Department*
4. Bijaya Dhungana – *Teaching assistant for this IPRO.*
4. Opeyemi Babatola – *IIT student who was on this IPRO team in previous semesters.*
5. Luke Cho - *IIT student who was on this IPRO team in previous semesters.*

Individual Tasks

Team 1.

Team Member	Task
Yuxiong	Background and Documentation
Vesna	Electrical Instrumentation and Measurements
Nil	Data Fitting

Team 2.

Team Member	Task
Garrett	Research different materials and the effects of heat on the ears
Tyler	Research different materials and the effects of heat on the ears
Migun	Researching the efficiency of helical and spur gear
Justin	Researching gear ratio and frequencies and creating a program that will calculate the frequency depending on the gear.
Brandee	Researching worm gears as an alternative solution.

* The team will be researching until they receive proper data to begin their calculations

Team 3.

Team Member	Task
Angad	Visiting Office Depot and inquiring about different paper shredders. Buy another paper shredder to compare to the shredders that we are trying to improve.
Richard	Researching different types of insulation Researching methods of sound deflection
Stephen	Aquiring the essential lab equipment to measure the decibels given off by the shredder. Researching insulation
Leslie	Researching different types of insulation and putting together reports.

Subteam.

Team Member	Task
Plamen	Working with Dr. Mostovoy to create an apparatus that measures torque.
Kyle	Working with Dr. Mostovoy to create an apparatus that measures torque.

* The apparatus team hopes to have the machine built by Oct. 23rd so measurements can be taken

Designation of Roles:

Position	Name	Duties
IPRO Office Liason	Migun Choi	Communicates with the IPRO office and ensures that all important information from the IPRO office is passed on to the rest of the team.
Minute Taker	Leslie Obst	Takes important notes during the class periods and keeps track of what each team is doing in order to keep the rest of the team and IPRO office updated on the status of the project

As a team, we decided that these were the two most important jobs that needed to be assigned. We decide what needs to be discussed every week and we allbensure that the meetings are done on time. Each team is responsible for giving a summary every week of what tasks need to be accomplished and the expected finish date of these tasks. This will keep everyone on the team up to date on the status of the entire project.