IPRO 321

Enhancing the Reliability and Performance of Paper Shredders

Midterm Report

Advisors: Dr. William Maurer
Dr. Sheldon Mostovoy

Team Members

Migun Choi
Justin Choriki
Steven Flicek
Yuxiong Huang
Tyler Inouye
Richard King
Plamen Marinov
Angad Nagwan
Garrett Nielsen
Leslie Obst
Vesna Pesik
Kyle Swaidner
Brandee Toyama
Nil Valls

Objectives

1. Develop a mathematical model that can estimate the torque required to shred several sheets of paper for a given paper shredder.
    - It was decided that the torque would be easier to determine then the force and therefore the objective was changed to estimating the torque.

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.
    - This objective has not changed. The goal of this team is still to find the most efficient gear train for the paper shredder.

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.
    - This objective has not changed either. It is still the goal of the team to use research and information from previous semesters to reduce the sounds of the shredder by 10 decibels.

4. Finish the construction of the torque measuring apparatus and begin running a series of experiments to determine the torque required to shred paper as a function of the number of sheets being fed. The results then need to be

compared with the torque team in order to determine the losses that cannot be accounted for with their alternative procedure of measuring torque.

- This is a new objective that has been added since the Project Plan. This is the subteam of the sound group who have been working on this measuring device the entire semester and their final objectives needed to be added in this report.

Team Breakdown for Objectives:

Torque Measuremment 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

Results to Date

Torque Measurement Team

The torque measuring team has thus far assisted subgroup 2 in completing approximate torque measurements for the determination of the torque values range and the required motor. The team has also gathered insight from Professor Mostovoy, collected some of the tools and instruments required for measurements, and dismantled the shredder casings. Then the measuring instruments were connected to the motor and the shaft, test runs were performed and adjustments were made to the system. Finally, the team analyzed the data and generated the experimental mathematical model with the data currently taken. Table 1. shows the data that the team has taken to this date.

Measurement #	V (v)	I (mA)	R/s	# of sheets
1	127.7	466	1.67	no load
2	127.7	576	1.41	1
3	127.6	639	1.38	1
4	127.6	740	1.26	2
5	127.6	743	1.27	2
6	127.5	898	1.03	3
7	127.5	905	1.04	3
8	127.5	1111	0.97	4
9	127.5	1081	0.99	4
10	127.5	1231	0.86	5
11	127.5	1215	0.88	5
12	127.5	1510	0.8	6
13	127.5	1405	0.8	6

Table 1.

The experimental equation that has been determined with the data that has been taken up to this time is:

$$\tau(n) = .465n^2 + 2.34n$$

Where n is the number of sheets to be shredded and τ(n) is the torque required to shred the paper.

Gear Train Team

At this point in the semester the team has obtained limited data for the application. As a group they first focused on familiarizing themselves with gears and the different types and their functions. After completing this the team then analyzed the current gear train in order to better understand what the manufacture is trying to accomplish with the current gear train. After analyzing the application, they proceeded to research different types of gears in order to obtain the most efficient and least noisy gear system for the application. The team has determined from their research that the current use of spur gears is the best type of gear for the application. They have also determined that the use of mostly metal gears is needed for the application.

For this application the team has found several options on the market that would apply to this situation. For the gear train the team has learned that they could replace each individual spur gear with a double helical gear or they could rearrange the gear train to use other gear types. They also learned that there are several widths of gears and need to determine the best width for the gears. Gears are also available in different types of materials but from the research done we have determined that the mix of plastic and metals gears that is currently used is the best option.

The results that the team has to date are limited and will be expanded upon in the upcoming weeks. Right now an excel file has been put together by the group to efficiently determine necessary parameters for the gears and gear train. (excel file attached). The information that the team will obtain as a group is essential to the application because of the direct application and need of an efficient gear train.

Sound Reduction Team

The team found that the majority of noise is coming from the lower frequencies and after testing the two shredders, the Royal brand shredder is more than twice as loud as the Ativa Shredder

During testing, the team measured dB levels over a range of frequencies (0-25000Hz) over a period of time. This is how it was determined that the lower frequencies make a majority of the noise. By taking snap shots of the graphs that were made, the team was able to come up with an average dB level.

Torque Apparatus Team

The torque measuring apparatus is merely one step away from completion and therefore almost ready for use.The unfinished model has been presented to the sponsor of the project during the midterm presentation and the sponsor was pleased with the progress of the team.

Revised Task/ Event Schedule

(The revised event schedule for the entire group was done using MS Project and is attached as a separate document with this report. This section will cover the tasks that each individual group still needs to complete)

Torque Measurement Team

Even though an experimental equation has been determined, the sponsor expressed the desire to explicitly know the relationship between the number of sheets, the required torque and the equation determined is precisely what he requested. More experiments will be performed on different motors and gear trains to insure that the results cover a wide range.

Once the equation has been determined it must be passed on to the other groups so they can determine the most efficient motor and gear train that can be presented to the sponsor as an option for his product.

Gear Train Team

There are no major changes to the original plan. They have only refocused their efforts on gear train efficiency and less effort on reducing noise. There are no changes in the subgroups or other tasks related to the group.

Sound Reduction Team

The team needs to continue taking measurements to determine where the sound is coming from in the shredder. They need to determine if the noise is coming from the motor or from the gears.

After it is determined where the sound is coming from, different changes need to be made to either the gears (through grommetting, etc…) or the motor to decrease the noise by several dB.

Torque Apparatus Team

During the next class period, the final changes and improvements will be made on to the model and it will then be completed. Then it will be used to take torque measurements of the shredders.

Task Assignments

Torque Measurement Team

Team Member	Tasks
Nil Valls	1. Electrical Setup 2. Supplies 3. Measurements 4. Data Analysis
Yuxion Huang	1. Supplies 2. Measurements 3. Paperwork
Vesna Pesik	1. Electrical Setup 2. Measurements 3. Documentation

Gear Train Team

There are no changes to the plan and roles of team members. This is due to the fact that the team has had a pretty clear view of main objective from the start as well as a good plan of progress. They haven't been able to dive into work due to waiting on progress of other groups. The current roles and designations work the best for each member of the group so there's no need to change anything.

Sound Reduction Team

The team is going to continue working together in the measurements and the research to determine the most efficient way to reduce the sound of the shredder.

Torque Apparatus Team

The torque apparatus team is working simultaneously together to ensure that the apparatus gets completed quickly and accurately.

Barriers and Obstacles

Torque Measurement Team

In the first couple of weeks of the IPRO, the team wasn't sure how to measure the torque. It wasn't until after consulting Dr. Mostovoy, that it was decided to use the conservation of energy. Therefore, the team wasn't able to get started right away because a measurement method needed to be determined.

Once the method was determined, the measurements were not able to be completed because the proper instruments were not available to the team. They once again turned to Dr. Mostovoy and he quickly aquired the tachometer that was needed.

Finally, during the measurements, the team found that no matter how the electrical circuit was set up, the ammeter and voltmeter would not work. After careful examination, they found that a wire on the PCB was disconnected and soldered properly to make it work.

These were all obstacles that have been encountered to date; however, there are remaining obstacles in the experimentation. The team most experiment on different motors and there may be some problems loading and unloading the motors. Also, as more data is obtained, the data pattern may no longer fit the existing equation. These are obstacles that the team hopes to overcome in the next few weeks.

Gear Train Team

The obstacles that have been encountered are as follows

1. Lack of team member knowledge of gears
2. Not having the correct equipment readily available
3. Waiting for progress from other groups

Solutions to overcome obstacles

1. Each member has done individual research and also contacted companies to learn more about the use of gears and their applications
2. This was not in the team's control and was mainly seen by the other groups. They stayed on the professors as well and faculty of lab in order to get proper tools
3. Helping other groups to accomplish their tasks and maintaining a patient attitude since the team understands that they cant get immediate results

As of right now there are no immediate barriers that will prevent the team from accomplishing the objective but it is also understood that things may unexpectedly come up. When an obstacle comes up the group will sit down to have a brainstorming meeting to determine best way to overcome the obstacles while minimizing the effect of the work as a group.

Sound Reduction Team

The first barrier that the sound team had to overcome was that the team wasn't really familiar with the shredder and the ways that the sound can be reduced. The team needed to research their options for reducing the sound. The team was able to come up with possibly insulating the shredder, grommetting the gears, or using sound deflection.

The next obstacle that needed to be overcome was obtaining the proper test equipment and learning how to use it. After discussing the tools that the team needed with IIT staff, they were able to obtain the necessary equipment to measure the sound coming from the shredder. Then the team had to spend a class period learning how to set up the equipment and how to properly use it. It took some time, but the team was able to overcome the obstacle.

The future obstacles are obviously just getting the tests done and getting results for the sponsor by the end of the semester.

Torque Apparatus Team

The first obstacle was that detailed design specifications and drawings had to be created in order to have parts custom made in the IIT machine shop. After brainstorming and consultations with professors from the department, these detailed drawings were made and given to the machine shop.

Next, prefabricated parts from various vendors had to be found, matched with other parts, and purchased. After close examine of the design, the required parts were selected and orders were placed with several different vendors.

Finally, one remaining obstacle is to conclude construction of the apparatus. After the machine shop finishes with the fabrication and assembly of the components, strain gauges must be installed and then calibrated. This will finalize the construction stage and will allow the testing stage to begin.

Conclusion

In conclusion, the team as a whole has made progress towards obtaining the objectives given to them by the sponsor. However, there is still plenty of work to be done to completely obtain the objectives. There was a meeting with the sponsor where he told the group that he can see progress being made in each separate team and he feels that the teams need to start collaborating to achieve the goals. Therefore, with some collaboration and hard work, all the objectives can be fully met.