IPRO 321
ENHANCING RELIABILITY AND PERFORMANCE OF A PAPER SHREDDER

Team

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THE MANHATTAN GROUP

Background

•IPRO 321 is sponsored by The Manhattan Group. Mr. Seth Lewis, the President of the company, initiated the IPRO by asking IIT students to help improve the performance and reliability of the Royal brand paper shredder. The project is in its third semester and encouraging results have enabled the IPRO to continue further.

•There are numerous kinds of paper shredders available in the market today. Offices, homes, schools, etc. have been increasingly using paper shredders to safely dispose of important documents, CDs, credit cards, etc. However, the need for progress is evident. Most paper shredders are noisy as well as expensive. Customers are demanding better paper shredders in terms of cost and efficiency, as well as low noise levels.

•The Royal brand paper shredder is aiming to enter the market as a low cost paper shredder that offers value for money. The students of IPRO 321 have helped improve the noise levels as well as the gear train in order to create an efficient product.

Objectives

▪DETERMINE TORQUE – Determine the amount of torque needed to cut various amounts of 20 lb paper.
▪OPTIMIZE GEAR TRAIN – Design an efficient gear train that optimizes the number of gears and minimizes the motor size necessary to withstand 500 cycles at maximum sheet capacity.
▪REDUCE NOISE – Develop acoustical sound reduction methods to reduce the amount of noise created during shredding.

Torque

Two methods were used to measure the torque required to shred paper.

1) Electrical Method
• A voltmeter and ammeter were simultaneously connected to the shredder motor to determine the power input under various loads. By combining these results with the rotational speed found with a tachometer, the applied torque was found.
• One piece of information obtained from this method is that the motor speed radically decreases under heavy load.
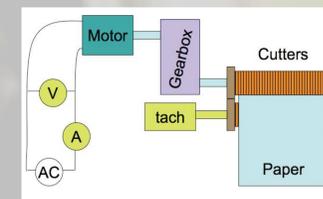
2) Mechanical Method
• A testing apparatus was designed and created that utilizes strain gage rosettes to provide an accurate measure of the applied torque.
• The device was calibrated using known weights applied with a measured moment arm. The resulting calibration constant provides a direct link between output voltage and torque, allowing computer software to record the testing data.
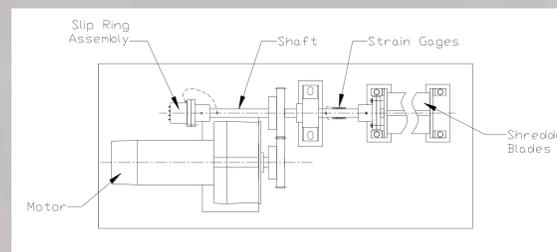
The data provided by these two testing methods will allow the manufacturer to correctly size all elements of the shredder, including the motor and gear train. This will result a net benefit in terms of both cost savings and performance.

Applied Torque vs. Load

Motor and Gear Train Losses

With Losses
$y = 1.844x^2 + 8.512x + 5.308$

Without Losses
$y = 1.844x^2 + 8.785x$

Electrical Data
$y = 4.122x^2 + 20.75x + 51.64$
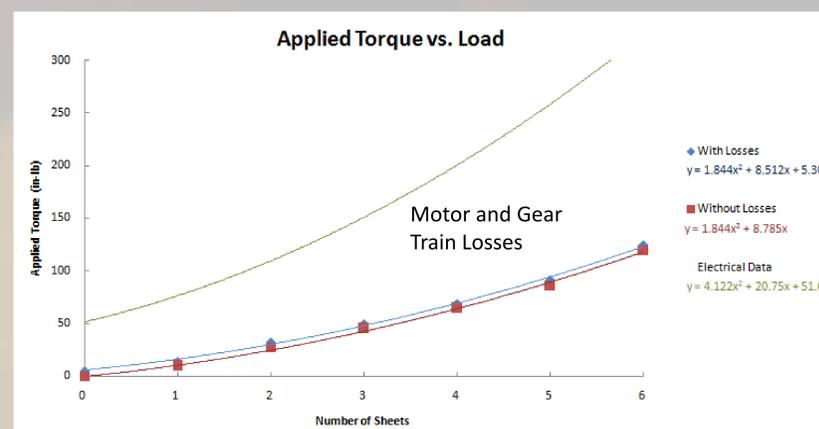
Gears

•Research was done on the different gear types to determine which best suits the paper shredder.
•Using data from the torque analysis, a spreadsheet was created to determine the theoretical stresses on the individual components of the gear train.
•The gear train of the Royal shredder was tested to the point of failure. Ten sheets over the rated capacity were required to break a gear, showing that sufficient strength is present for normal operation.

Royal Shredder   Ativa Shredder

Sound

•Measurements were taken to analyze the impact of varying the number of sheets being shredded on sound output. Large loads drastically reduced the operating speed, effectively quieting the shredder.
•Individual components were selectively removed or isolated to localize the points of maximum sound production. The first gear, with its very high RPM, was found to be the primary source of noise.
•Tests showed that the DC motor used in the Ativa shredder produces a lower sound level than the AC motor found in the Royal shredder.

Royal vs. Ativa Sound Levels   Localization Tests
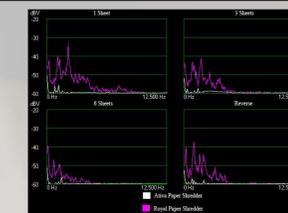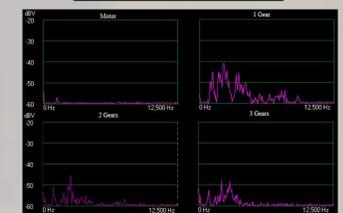
Recommendations

•Replacing the current motor with one which is slower and has greater torque will reduce noise and allow a more consistent operating speed.
•The gear train has sufficient strength to withstand normal operation. No changes are needed for reliability, but they may be necessary for maximum noise reduction.
•The maximum shredding capacity should not be increased. Shredding 8 sheets required nearly twice the torque of 6 sheets, the current maximum. This would add a large expense for a small gain.