NORTHERN ARIZONA UNIVERSITY

College of Engineering, Informatics, and Applied Sciences

Design4Practice (D4P) Program

To: Professor Anthony Nix

From: Martin Dorantes

Due: 5/1/2020

Re: EGR365 Project

Introduction

The purpose of this project was to design a speed reducing gear train rotating at 2000 rpm down to 300 rpm resulting in a power transfer of 15 kW. This write up contains how and why decisions were made in order to get the designed system, along with the pros and cons of my system. Once the shaft was designed, a cost analysis was performed to calculate if this system would be an ideal price for a customer to pay to build the system. One of our team members, Trent Todd, created a working excel template that the team could use for the AGMA analysis for chosen gears in our individual design. The other deliverables included are that excel file, final engineering drawing of my shaft, and the AGMA work done on paper to show my calculations.

AGMA Gear Analysis

The process started with gear selection through the website link Dr. Nix provided. Each gear chosen had to satisfy the speed and power transfer requirements. When there was a gear & pinion set that was seen to satisfy these conditions is where the AGMA analysis started. The biggest help being the excel template for safety factor for contact and bending stresses was the component to either pass or fail the required needs for the project. Unfortunately, my gear & pinion set did not satisfy AGMA standards and three out of the four gears used would have broken due to the stresses exceeding what is allowed. One reason the set could have failed is because of the sizes chosen. Going into this project, I was blindly choosing gears to just satisfy speed and power requirements but failed to think farther ahead that sizing is an important factor when designing a gear train.

The best component of my design is that one gear did not fail under the cycles of stress applied on the gear. The other three gears failed due to the applied stresses. Another con to the design was cost. As in my cost analysis, the price is high for a flawed system. The original shaft design had many flaws. Taking the advice of my peers and Dr. Nix, I was able to design a shaft that would not fail under the bending and contact stresses. The safety factors of the shaft exceeded that of what was contained in the instructions, resulting in a working shaft to transmit the required power. I added fillets on the shaft to ease placement of the bearings and gears. I added how the gears would fit onto the shaft through press fits so they are not freely moving about the shaft sections. SolidWorks also has a function to easily access volume and mass of the shaft, very helpful when analyzing cost and creating the engineering drawing. I chose a low-carbon hardened steel for the shaft due to the properties that lead to the success of a working shaft to support the power transmission. The original drawing contained flawed dimensions and the tolerances were not easy to read. I dimensioned the drawing differently than the original to better communicate tolerances, types of fit, and general dimensions. I also added a table that refers to the shaft fillets types and sizes to ease the viewing and avoid a crowded drawing.

For future design requirements, I now see how important it is to allot enough time to precisely analyze every aspect before creating a design system. I realize this is what leads to failures in machinery in the real world, and some that lead to costing people's lives.

Cost Analysis

Cost of uncut shaft (1566 Carbon Steel, unit 1346K37): $22.89
Cost of Pinion (KSSG3-18J19): $123.74 - Cost of Gear (KSS2.5-46J35): $121.51

Shaft	**Vol** $\pi r2h$ **(mm^3)**	**Vol** $\pi r2h$ **(in^3)**
Uncut		9.42478
Final Cut	86617.66	5.28573
Removed material		**4.13904**

Time needed to remove material on a 1in diameter shaft

4.13904 in^3 / 1.05 in^3/min = **3.94 min**

Setup Machine

I am using assumptions of one tool to outline the general cut of the shaft & two tools for different sized fillets:

3 tools = **87.0 min**

Advance turret to next tool

0.1 minute per tool = **0.3 min**

Load part & fixture

Weight = 2.67 lb ~ 5.2 lb = 0.39 min + 0.26 min = **0.65 min**

Steps	**Time (min)**
Material Removal	3.94
Machine Setup	87.0
Advance to other tools	0.3
Load part & fixture	0.65
Total	**91.89**

Must account labor cost:

Total time = 91.89 (min) * (1/60) (hr/min) * 75 ($/hr) = **$114.86**

Labor & Parts	**Cost**
Labor	$114.86
Uncut shaft	$22.89
Pinions	$247.48
Gears	$243.02
Total	**$628.25**

This is not an ideal cost for this system. This is a very expensive cost to design and cut a system for this level of project. This price would more likely turn a customer away.

"McMaster-Carr," Rotary shaft, [Online]. Available: https://www.mcmaster.com/1346k37. [Accessed 30 April 2020].

“Stock Drive Products/Sterling Instrument,” Metal Spur Gears, [Online]. Available: https://shop.sdp-si.com/catalog/?brand=qtc&cid=p591&__hstc=93114562.1b17744cb6ff75f655517cc01c10aa8e.1583859530416.1583859530416.1583859530416.1&__hssc=93114562.3.1583859530417&__hsfp=2728621402. [Accessed 30 April 2020].

Project Conclusion

Before the project assignment, my level of understanding of gears and shafts was mediocre. After running through the processes of analysis and AGMA standards, even though my design overall failed, the satisfaction of understanding these concepts increased so much more. I was able to take away a new understanding of gears and shafts more than what came from lectures. The best learning technique is through hands-on applied work, trial-and-error, and failure setting the pathway to success. This showed me how real-world engineers must be efficient in their calculations and how quickly components will change that affect the overall design. It proves that programming software is a huge help when setting up formulas and all the work is done there. Thank you for such a great semester and stay safe this summer!