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Executive Summary

The goal of the project was to redesign a problematic adjustable pitch propeller prototype. Problems with the adjustable pitch propeller included the following: difficult blade transition from full forward to full reverse, excessive wear on rotator tool due to point loading, complex assembly that made it difficult to replace parts and excessive vibrations which complicated the balancing of the propeller. The proposed solution consists of modifications to individual components of the system.

The track on the rotator tool was changed from a straight track to a curved track. This design would allow for maximum rotation of the blades, a full ninety degrees, along with a greater transfer of force from the translation of the outer housing to the change in pitch of the blades. To attenuate the effects of the vibration, lengths of straight track were placed at the beginning and the end of the curved track to provide locking positions at full forward and full reverse. The stub shaft was the next component in the assembly to be modified. The main modification consists of breaking the stub shaft into separate components which would simplify the manufacturing process and repairing the system.

The proposed cost of materials for the redesign of the adjustable pitch propeller prototype was calculated to be $678.36. The proposed project schedule, pending proposal approval, is to order all necessary parts and materials and begin building the prototype on January 5, 2006.

Introduction

The purpose of this project is to redesign the adjustable pitch propeller. Upon reviewing the previous iterations of the adjustable pitch propeller design and compiling background research it was determined that the current design had merit, but required improvement by altering key aspects of the design. There were several flaws that limited the functionality of the propeller. The parts most analyzed for change were the rotator tool, stub shaft and the outer housing.

The rotator tool in the original design had several problems that need to be addressed. The rotator tool consisted of a blade on top of a thin cylinder. In each face of the blade was a straight track on a slight slant that was used to adjust the pitch of the propeller blades. Upon review, the straight tracks were noted to allow only a 30 to 45 degree pitch change in the blades. This limited the performance of the propeller. Additionally, the material used in the construction of the rotator tool was too soft, allowing the vibration of the blade pins to pit the sides of the tracks. These pits in the sides of the tracks would then prevent the blade pins from sliding smoothly in the tracks when shifting from forward to reverse and back.

In the original design, the stub shaft, the blade and the pin were all part of one component. The blade was welded directly to the stub shaft off center with the pitch pin protruding out of the other side of the shaft. This method of construction prevented the balancing of the blades across the propeller axis since the two blades were not of equal weight. This imbalance caused significant vibration during operation. The one component assembly also required the replacement of the entire assembly if the blade was damaged.

The components most crucial to the spinning of the propeller as well as the adjustment of the pitch of the blades were given priority. Parts less crucial to the system were reviewed last. Each component was analyzed independently to identify modifications that would improve efficiency of the propeller. Each modification was prioritized and then analyzed to ensure compatibility with the remaining components of the propeller. Next, the subsystems were reviewed to ensure that, following modification of the individual components, the subsystem assemblies would still function properly. Finally, the entire system was analyzed and reviewed to ensure that the system was safe, functional and feasible, and ensuring all changes would not cause a problem with the assembly as a whole.

Technical Plan

The rotator tool was the first component analyzed. The track was changed from a straight track to a curved track (see Figure 1). Using the distance from the center of the tool to the edge as a radius, the track was curved down a full quarter circle. This design would allow for maximum rotation of the blades, a full ninety degrees, along with a greater transfer of force from the translation of the outer housing to the change in pitch of the blades. To attenuate the effects of the vibration, lengths of straight track were placed at the beginning and the end of the quarter circle to provide locking positions at full forward and full reverse.

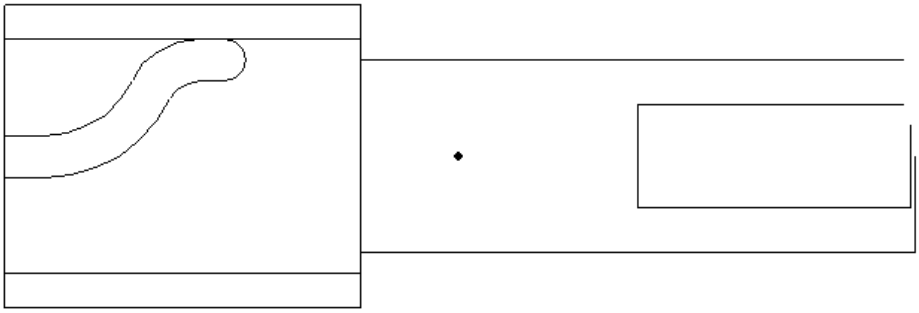

Figure 1. Curved Slot Rotator Tool

The stub shaft was the next component in the assembly to be modified. The first modification was to break it into separate components. This separation of the stub shaft into the blade, the pin and the stub shaft, would allow for easier manufacturing and repair of the system as a whole. The first step was to separate the pin from the shaft. Since the pin was composed of the same material as the stub shaft, the pin was weak. By separating the pin from the shaft, a stronger material could be used for the pin without incurring the increased cost of constructing the entire shaft and pin from the same material of increased strength. The blade (see Figure 2) was also removed from the stub shaft to allow for easier construction and replacement of the blades. Since the old component was so difficult to balance it was determined that the new blades needed to be manufactured together or from the same mold. A flat blade shape was chosen using the outline of the original blade.

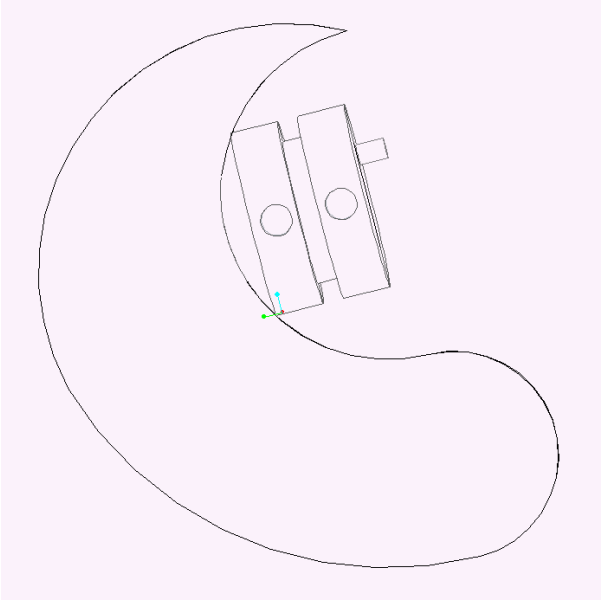

Figure 2. Blade, Stub Shaft & Pin

The outer housing (see Figure 3) was the last part to be modified. It was determined that the track was the primary problem. This track was removed and bolts were added to hold the new stub shaft in place. The size of the sphere at the top was increased to allow for the larger rotator tool and the base cylinder was also increased to allow for the wider base of the rotator tool. Changes to the rest of the assembly were made only to allow for size changes.

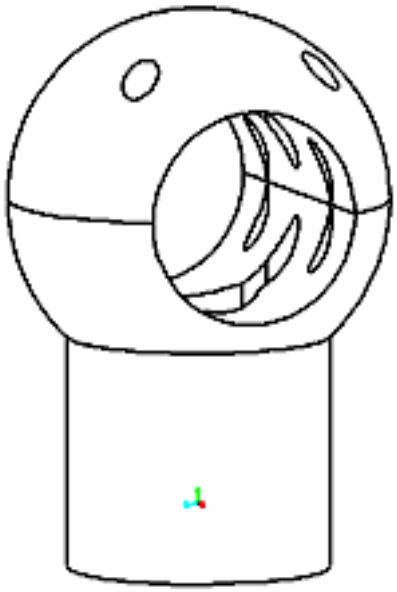

Figure 3. Outer Housing

Management Plan

This section consists of the proposed schedule and necessary costs associated with completion of the project. The schedule consists of the following:

- 12/10/05: Order all necessary parts and materials.
- 01/05/06: Begin building design prototype
- 01/25/06: Start testing design prototype

Cost Sheet for Raw Materials (Ideal Materials)

Item	Justification	Part	Quantity	Part Number	Price Each	Total Price	Location
316 Stainless Steel Rod Stock 2.5" Diameter 12" Length	Stock material	Stub Shaft (Non-Pinned)	1	89325K673	$139.41	$139.41	**McMaster-Carr**
316 Stainless Steel Rod Stock 2.5" Diameter 12" Length	Stock material	Stub Shaft (Pinned)	1	89325K673	$139.41	$139.41	
316 Stainless Steel Rod Stock 0.5" Diameter 36" Length	Stock material	Translation to Rotation Pin	1	89325K852	$18.21	$18.21	
440C Stainless Steel Sheet 0.125 Thickness 24" X 12"	Stock material	Blades	1	9575K332	$255.19	$255.19	
6061 Aluminum Rod Stock 4.5" Diameter 6" Length	Stock material	Hub Parts	3	1610T44	$70.59	$211.77	
6061 Aluminum Rod Stock 5.0" Diameter 12" Length	Stock material	Hub Parts	1	8974K981	$125.78	$125.78	
316 Stainless Steel Rod Stock 2.5" Diameter 12" Length	Stock material	Rotation Tool	1	89325K673	$139.41	$139.41	
316 Stainless Steel Socket Drive Cap Screw Partially Threaded 1/4-20 3" Length (Pack of Five)	Purchased Component	Hub Assembly	2	92185A557	$8.98	$17.96	
316 Stainless Steel Socket Drive Cap Screw Partially Threaded 1/4-20 1.5" Length (Pack of Ten)	Purchased Component	Stub Shaft Assembly	1	92185A546	$7.62	$7.62	

Total Materials Cost **$1,054.76**

Cost Sheet for Raw Materials (Minimized Cost Materials)							
Item	**Justification**	**Part**	**Quantity**	**Part Number**	**Price Each**	**Total Price**	**Location**
304 Stainless Steel Rod Stock 2.5" Diameter 12" Length	Stock material	Stub Shaft (Non-Pinned)	1	89535K691	$67.90	$67.90	**McMaster-Carr**
304 Stainless Steel Rod Stock 2.5" Diameter 12" Length	Stock material	Stub Shaft (Non-Pinned)	1	89535K691	$67.90	$67.90	
440 Stainless Steel Rod Stock 0.5" Diameter 12" Length	Stock material	Translation to Rotation Pin	1	88985K961	$10.72	$10.72	
410 Stainless Steel Sheet 0.25 Thickness 24" X 12"	Stock material	Blades	1	1316T46	$100.81	$100.81	
6061 Aluminum Rod Stock 4.5" Diameter 6" Length	Stock material	Hub Parts	3	1610T44	$70.59	$211.77	
6061 Aluminum Rod Stock 5.0" Diameter 12" Length	Stock material	Hub Parts	1	8974K981	$125.78	$125.78	
304 Stainless Steel Rod Stock 2.5" Diameter 12" Length	Stock material	Rotation Tool	1	89535K691	$67.90	$67.90	
316 Stainless Steel Socket Drive Cap Screw Partially Threaded 1/4-20 3" Length (Pack of Five)	Purchased Component	Hub Assembly	2	92185A557	$8.98	$17.96	
316 Stainless Steel Socket Drive Cap Screw Partially Threaded 1/4-20 1.5" Length (Pack of Ten)	Purchased Component	Stub Shaft Assembly	1	92185A546	$7.62	$7.62	

Total Materials Cost	**$678.36**
Total Savings	**$495.66**

Conclusions

At the present time there are no adjustable pitch propellers available on the market for the given function. This document has proposed extensive modifications to the existing adjustable pitch propeller prototype. Optimization analysis of the new design has shown that these modifications will produce a fully functional prototype that shall meet all necessary design requirements. Pending proposal approval, the next steps in the process is to order all necessary parts and materials; which will be followed by the building of the prototype beginning on the 5th of January, 2006.