Wing Mill Energy Harvesting

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Introduction

The wing mill is an alternative approach to the concept of wind powered energy generation, using flapping wings coupled to a spinning shaft instead of rotating turbine blades. In the sectioned diagram of the wing mill below, the flapping of the wings is coupled to a crankshaft via the 'connecting rod'. As the wings "see-saw" up and down around the pivot point near the gearing labeled in the diagram, they spin the crankshaft via this rod.

This design was developed in light of previous research done on oscillatory wing wind energy harvesters by McKinney and DeLaurier, Jones and Platzer, Lindsey and Davids. Elements of each – the idea of coupled pairs of wings, use of a four-bar linkage to control certain aspects of the mechanism, and numerical simulations providing a theoretical basis – were combined through an iterative process to create the design that was pursued by the Laboratory for Intelligent Machine Systems.

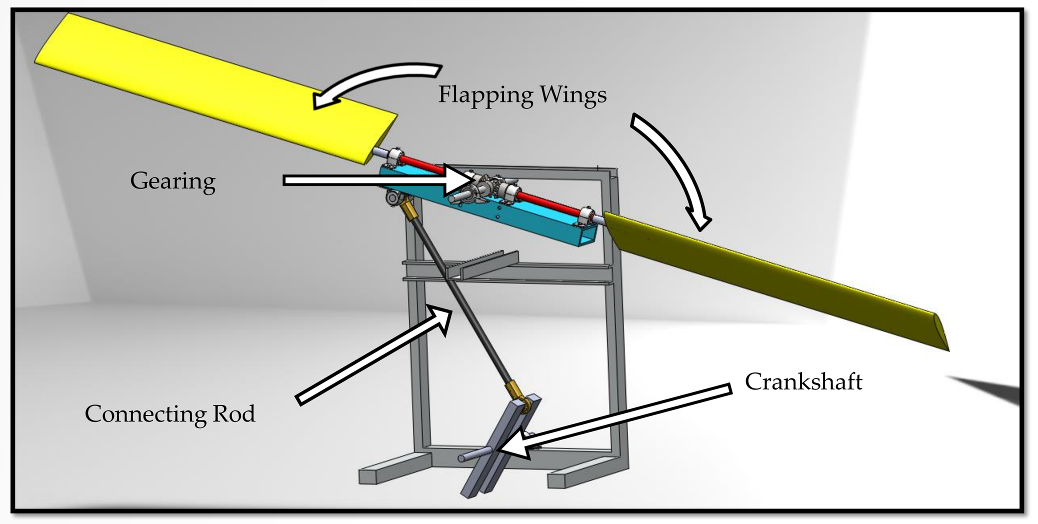


Fig.1 – Cross-section of the wing mill

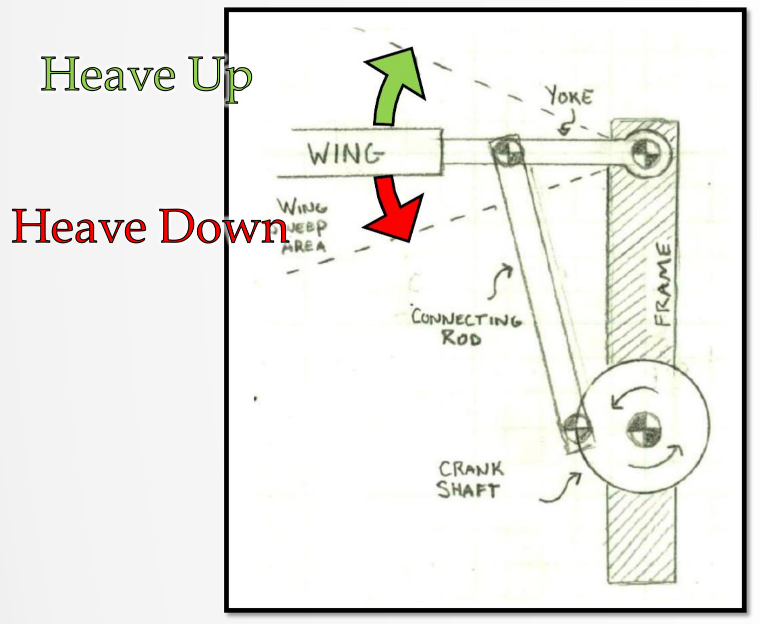
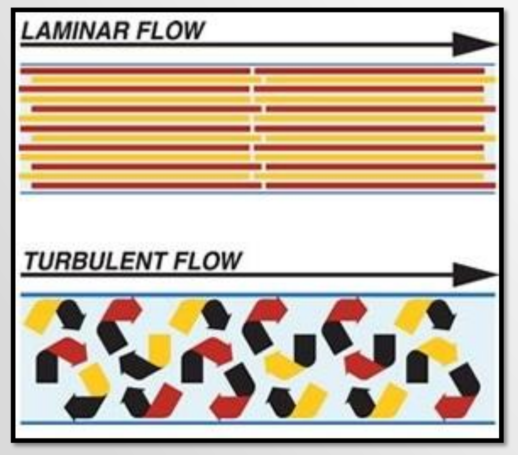


Fig. 2 – Wing mill flapping motion (Termed "heave" here)

Previous work on a scaled model of the wing mill suggests that this design could approach the efficiency of a typical wind turbine. Parameters such as the angle through which the wings sweep, the angle at which the wings pitch in order to generate lift, and the angle at which they are offset from one another on the crankshaft were all relevant considerations in the design of this specific iteration. These, as well as mechanical efficiencies must be investigated in order to maximize power output of the system overall. Generating energy from the wing mill ccan then be made possible by driving a generator off of the spinning crankshaft, similar to a traditional wind turbine.

Motivation

Traditional horizontal axis wind turbines (HAWTs), the kind most closely associated with wind power are widespread, but have significant drawbacks, technologically and sociologically. They are designed to be the most efficient at high wind speeds and in very smooth, steady winds. This is why they are typically found on large plains or offshore on tall towers. Anywhere the wind flows past a large surface, whether it be the ground or a skyscraper, it becomes very mixed and unsteady.



This is called turbulence and it precludes the use of traditional HAWTs in packed, urban areas or very near to the ground. Additionally, the wake of each turbine (as seen above) reduces the efficiency of other turbines downwind. Our project seeks to overcome these limitations by proving the feasibility of a supplement to traditional wind power – a turbine that can be used in cities, nearer to where power is in the greatest demand, as well as nearer to the ground, making it easier to harvest wind power in rural or suburban areas where a large wind farm would be frowned upon by its neighbors due to noise or unsightliness.

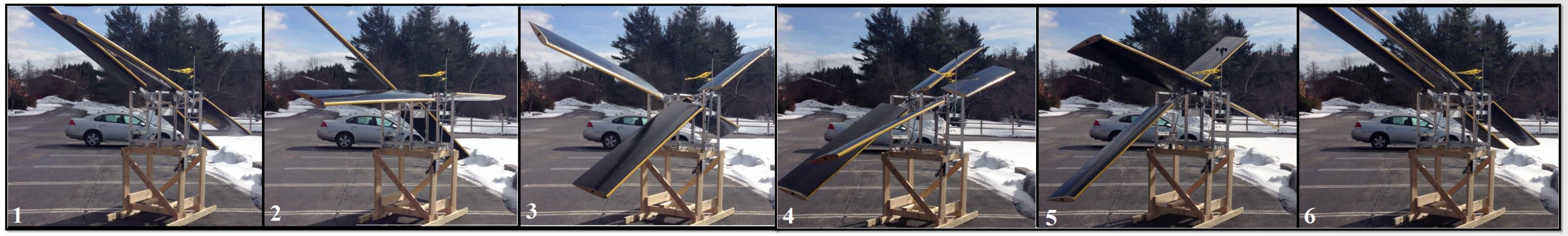


Fig. 3 – Motion of the wing mill through one cycle. – *[1] The wing mill begins with slightly pitched wings and the wind pushes the front wing downwards [2]. Once the wings have reached the bottom of the cycle [3], the wing pitches are reversed to create lift [4,5] and move back to its original position (6). The rear set of wings is 90 degrees offset from the front set.*

Design

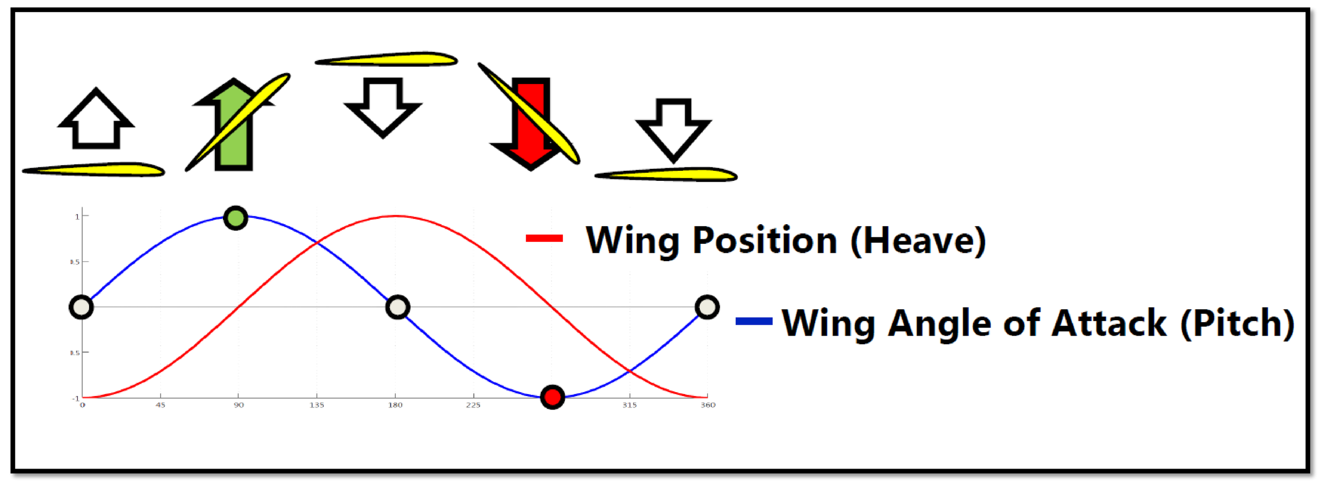
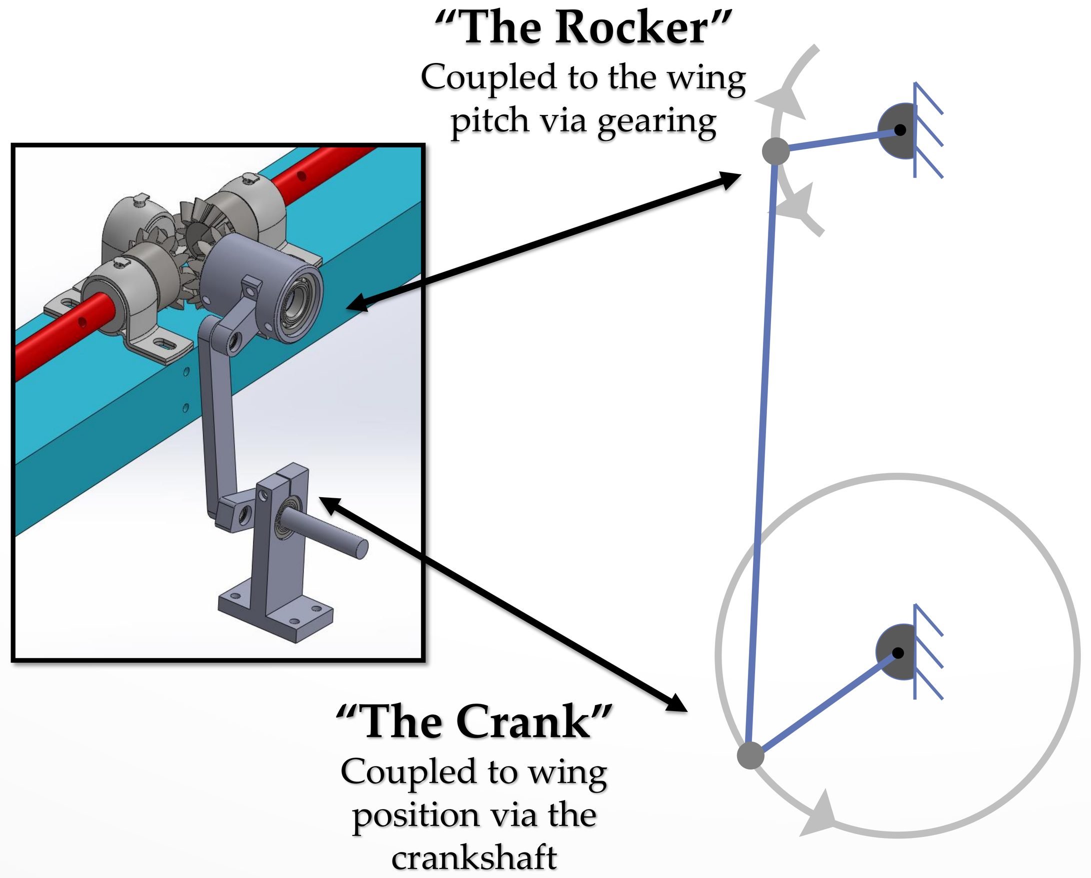


Fig. 4 – Desired wing position and pitch



Design

Using the below linkages that co predict the wing motions produc +/- 20 degrees, t ained four bar and were able to e is a plot of the scillating between

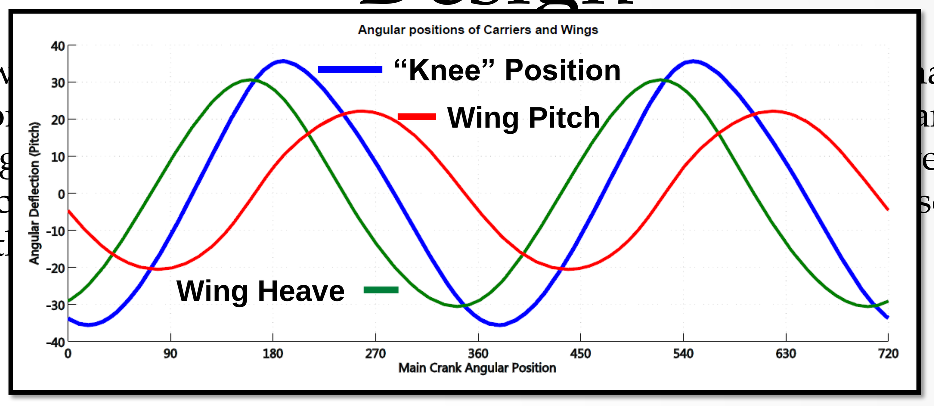


Fig. 8 – Predicted output from kinematic analysis of proposed linkage

Future Considerations

At this point in the project, more testing is needed – minor problems holding us back in data gathering must be overcome such that we can test the wing mill at multiple operating points and thus gain enough data to fill out a characteristic power curve for our system.
Also, a platform on which much faster iteration through experimental variables should be developed – many questions on the pitch, phase offset, and spacing between the sets of wings arose during the semester, but physical iteration at this scale is simply not practical. Though there is still more to learn about our current system, more potential exists in small-scale research into the most efficient configuration for the sets of wings.

Conclusion

Tests so far have proven that the concept of an oscillatory wing wind energy harvester is feasible, however much work is needed in order to make it anywhere near economically practical for use on a wide scale. Again, the end goal for the wing mill is to create a supplement to traditional HAWTs and not a replacement for them. Since we are currently an order of magnitude below the theoretical limit for harvesting power from the wind, wing mills can't foreseeably dominate traditional turbines, but instead work into their own niche where large, loud turbines cannot be established.

Acknowledgements

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