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A REVIEW OF HELICOPTER REDESIGN

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ABSTRACT

In this conference article a review of helicopter redesign is carried out in order to view performance of possible new redesign studies. Redesign in this article is considered as small changes in helicopter geometry in order to increase flight performance. For this purpose several redesign studies previously examined in the helicopter literature is summarized and classified. The redesign studies in scope are tip shape, trailing edge flaps, blade taper, and some other passive and active morphing approaches. Advantages of these redesigns are shortly mentioned. Then, our redesign studies are listed and briefly summarized. Some, numerical results after obtained redesign studies done by both other researchers and us are given. At the end, future studies about redesign are remarked after using existing redesign studies.

INTRODUCTION

The exceptional combination of hover and forward flight proficiency makes the helicopter one of the most multipurpose types of aircraft. Yet these exceptional proficiencies give rise to the need to reach a negotiation in many aspects of the design, and the aerodynamic design of the rotor is no exception. The helicopter rotor must be both effective in hover and proficient of carrying a useful payload in cruising flight. The design of the rotor blade and other sub-sections has a powerful influence on the overall performance, vibration and acoustics of the helicopter, and also fuel consumption. The redesign studies were followed for this reason previously in the literature.

Redesign studies were followed in different perspectives. Some of them redesigned main rotor and some other redesigned other sub-sections. Blade tip design, blade taper design, blade root chord design are some examples of blade redesign studies. During these designs the main purpose were not fixed. In some studies vibration and acoustics were in primary purpose and in some others the fuel consumption was in primary purpose. For example, in Oktay and Sultan, 2013 passive morphing was considered on helicopter main rotors in order to save fuel consumption. In their article the passively morphing parameters were blade chord length, blade flapping spring stiffness, blade linear mass density, blade length, blade twist, and main rotor angular speed. In their study for the 40 kt straight level flight condition, around 30% of the

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helicopter control energy save with only 5% changes on passive redesign parameters was obtained. It is very vital to note that for their article the redesign parameters do not vary during flight. In different article of Oktay and Sultan, 2014 active morphing was considered. The redesign parameters were blade chord length, blade length, blade twist, and main rotor angular speed. In their article for the 40 kt straight level flight, around 85% of the helicopter control energy save with only 5% changes on active redesign parameters was obtained. The main alteration between passive and active morphing redesigns is that in the active circumstance the helicopter redesign parameters change during flight, but in prescribed interval (e.g. +- 5%). However, in the passive circumstance the helicopter redesign parameters do not vary over flight period.

METHOD

Other Existing Redesign Studies

In helicopter literature several redesign studies have been followed. There are many different existing classifications in the helicopter literature. In this conference article blade tip shape redesign studies, trailing edge flap studies, blade taper studies, some other different passive and active morphing studies and finally moving horizontal tail idea is considered.

Blade Tip Shape Studies:

Blade tip shape redesign studies have been followed for several purpose in the helicopter literature before. For example, in Brocklehurst and Barakos, 2013 it was shown that ogee tip can be considered in order to reduce rotor noise and another study is that Hansford [Hansford, 1987] to get structural load characteristics of the new composite ((British Experimental Rotor Programme) BERP blade is used to check against to the standard metal blade to examine vibration and loads. It is investigated that the BERP blade have a considerably special features such as good maneuver capability.

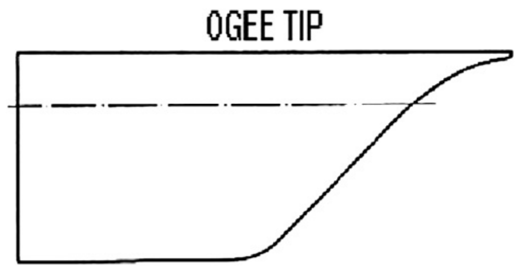

Figure 1: Blade Tip Shape Design (Taken from [Brocklehurst and Barakos, 2013])

Blade Trailing Edge Flaps:

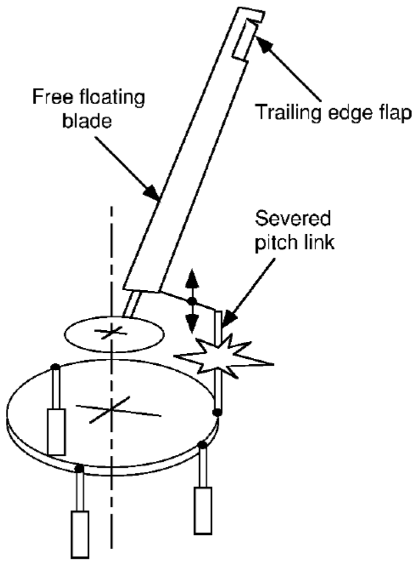

Figure 2: Blade Trailing Edge Flaps (taken from [Celi, 2003])

In Celi, 2003 the practicability of using trailing-edge flaps to reconfigure a helicopter rotor blade following a failure of the pitch link is addressed making the blade free floating in pitch and otherwise uncontrollable.

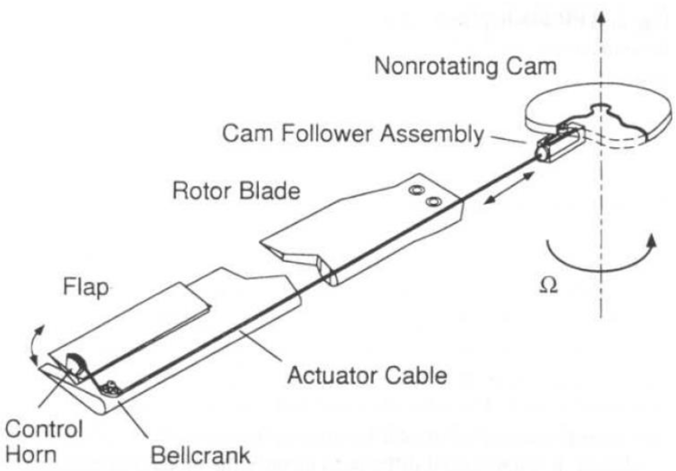

Figure 3: Blade Trailing Edge Flaps (taken from [Milgram et al., 1998])

Blade Taper:

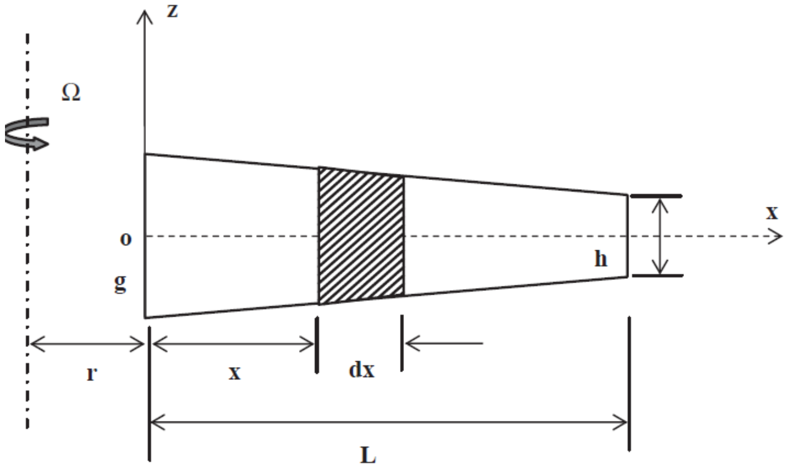

Figure 4: Blade Taper Design (taken from [Ozdemir and Kaya, 2006])

Other Passive and Active Morphing Applications:

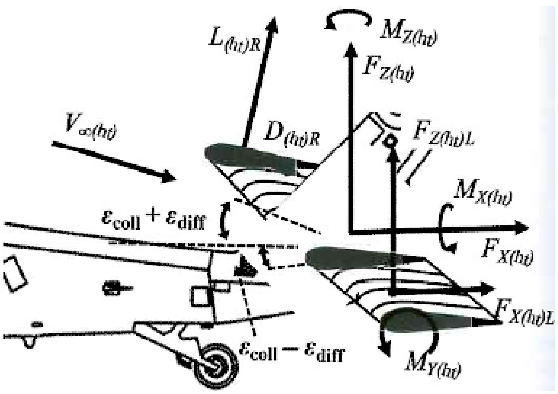

Figure 5: Moving Horizontal Tail (taken from [Bluman and Gandhi, 2010])

Our Redesign Studies

Passive Applications:

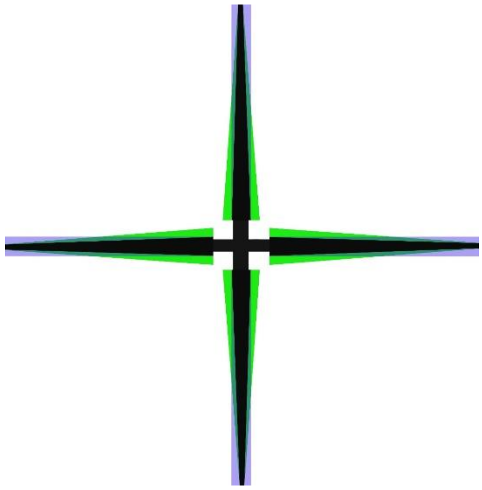

Figure 6: Blade Taper and Root Chord Length (taken from [Oktay and Sal, 2017])

Active Applications:

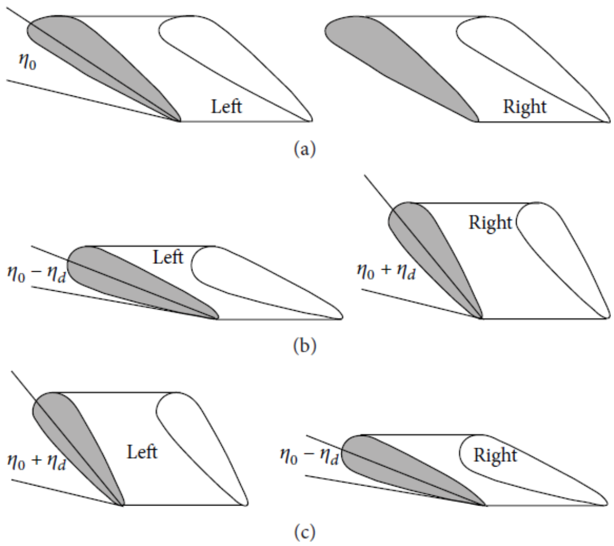

Figure 7: Moving Horizontal Tail (taken from [Oktay and Sal, 2015])

RESULTS

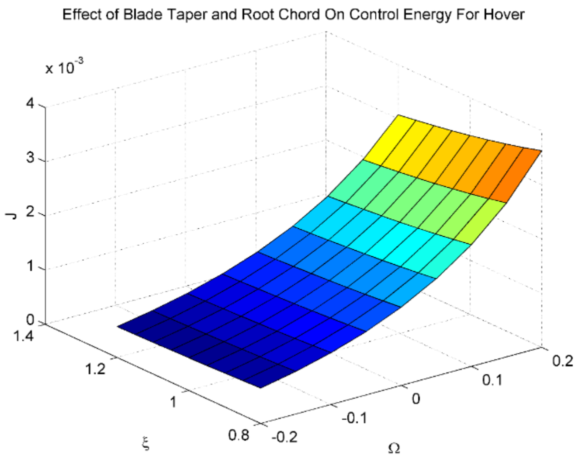

Figure 8: Effect of Blade Taper and Root Chord Length on Energy (taken from [Oktay and Sal, 2017])

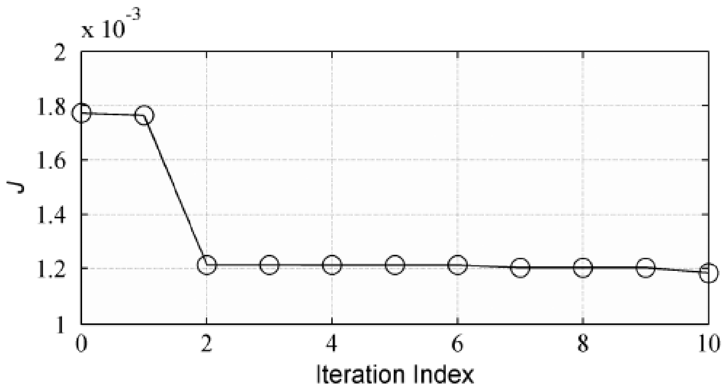

Figure 9: Effect of Blade Passive Morphing on Energy (taken from [Oktay and Sultan, 2013])

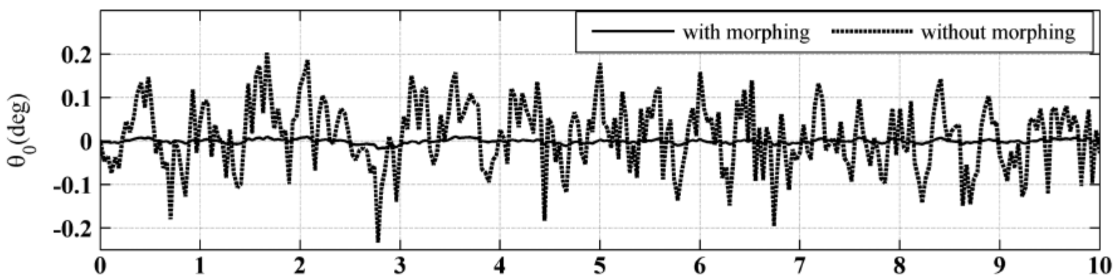

Figure 10: Effect of Blade Active Morphing on Collective Response (taken from [Oktay and Sultan, 2014])

CONCLUSIONS

In this conference article a review of helicopter redesign was followed for viewing performance of possible new redesign studies. For this intention several redesign studies previously considered in the helicopter literature was listed and classified. The redesign studies in scope were tip shape, trailing edge flaps, blade taper, and some other passive and active morphing approaches. Advantages of these redesigns were briefly mentioned. Then, our redesign studies were given and shortly summarized. At the end, it is decided that for future studies blade taper in active case and wing tip designs such as ogive shape will be considered for more energy and fuel consumption.

Acknowledgement

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