Indian National Society for Aerospace and Related Mechanisms
BANGALORE CHAPTER

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From the Editor

It gives me immense pleasure to place before you this edition of E-newsletter. This edition of E-newsletter brings the article titled "*Flapping wing mechanism for a bird sized aerial vehicle: design and fabrication*". This article presents a minaturised flaping wing mechanism driven by a brushless DC motor with wing flapping frequency of about 16 Hz. This has a provision for the wing rotation about the span axis. The paper presents the details of a prototype model realised to demonstarte its function.

This newsletter is intended to be a platform for the exchange of information regarding the current developments, new ideas and novel concepts in the area of mechanisms and related field through active participation of members. I request all INSARM members to actively contribute technical articles related to mechanisms to enhance the technical value of the e-new letter.

With best regards,

Dr. B.P. Nagaraj
Chief Editor

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Quote:

"You are not here merely to make a living. You are here in order to enable the world to live more amply, with greater vision, with a finer spirit of hope and achievement. You are here to enrich the world and you impoverish yourself if you forget the errand"

Woodrow Wilson

FROM INSARM BANGALORE CHAPTER

FLAPPING WING MECHANISM FOR A BIRD SIZED AERIAL VEHICLE: DESIGN AND FABRICATION

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INTRODUCTION

Mankind has since ages appreciated the flying beings from insects to birds and has tried to imitate them to generate better aerodynamic efficiency and forces. In tune with the current research happenings in design and development of Flapping Wing Air Vehicles at the conceptual and application level, an attempt has been made to work on design of miniaturized flapping wing mechanisms focusing on expanding their usage as surveillance and spying bots with better agility in flight. Since it is the nature's adaptation of flight throughout the evolution trends, flapping winged configuration, through various experimental evidences, proved out to be the most efficient flight compared to fixed wing flight displaying more agility.

The aim was to learn and effectively design a mechanism that can flap at a frequency till 16 Hz and further improvise the current design to impart wing rotation about span axis by changing the links.

MECHANISM DETAILS

After clearly understanding the critical terms that govern a flapping wing flight, we started designing the mechanism for simple flapping.
The mechanism developed was equivalent to "Delfly II" [1] parameters mentioned in Table 1.

PARAMETER	VALUE
Wing flapping frequency	3-16 Hz
Flapping Angle	48^0
Wing Length	140 mm
Wing Area(one wing)	11950 mm^2
Aspect Ratio	3.5
Mean Chord length	80 mm

Table 1: Delfly II Parameters

The aim was to fabricate a mechanism same as Delfly II.

To flap the mechanism at this frequency a brushless DC servo controlled motor, Hobbyking model with 2.5-5.0 V & 3.5 A.
Following deductions were made prior to designing the model in solid-works.

Flapping frequency required (max) : 16 Hz

Maximum motor speed: 25000 rpm

Operating motor speed: 17000 rpm

Gear Ratio: 284/16 = 17.75

Using above calculations, we used a gear ratio of 18. Further the mechanism was modeled in SolidWorks for simple flapping as shown in Fig. 1.

Fig. 1: Front View of the Simple Flapping Mechanism

Similarly, for rotation about span wise axis a different mechanism was designed in SolidWorks and fabricated using Rapid Prototyping(RPT). The design is inspired from a flying insect beetle [2]. The model was so designed to restrict the angle of attack to 10^0. The designed mechanism is shown in Fig. 2 (Front view) and Fig. 3 (Side view at a different flapping angle).

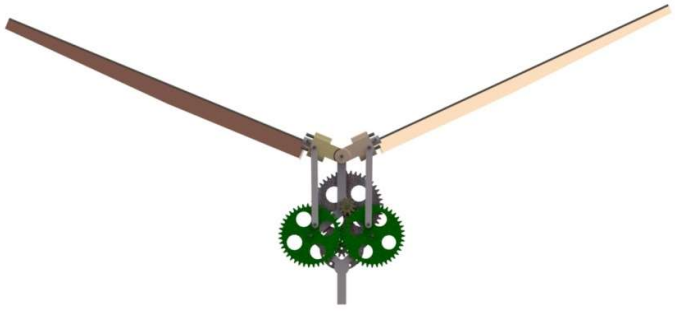

Fig. 2: Front View of Flapping Mechanism with rotation about span axis (Rotation angle)

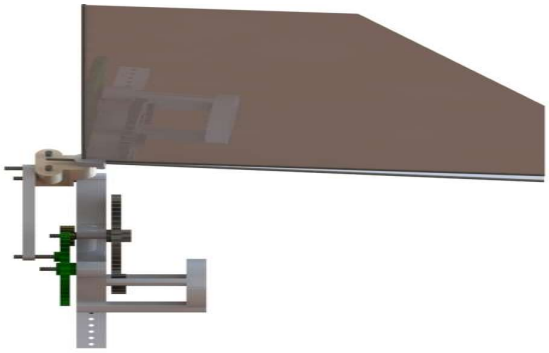

Fig. 3: Side View of Flapping Mechanism With Rotation (At a different flapping angle)

To explicitly understand the difference between the simple flapping mechanism and flapping mechanism with rotation about span axis refer to Fig 4. Here we can observe that the link connecting the crank to the leading edge of the wing is different for both the mechanism. In the simple flapping mechanism there is no provision made to restrict the rotation of wing about their span axis but in flapping mechanism there are two protrusion provided in the link which restrict the rotation about wing span to 10^0. In the latter case the wing at the end of each stroke, due to its inertia tend to rotate about its span axis but the same is restricted by the modified link to 10^0 thus providing an angle of attack of 10^0 at the end of each stroke.

Link for producing simple flapping motion

Link for producing additional wing rotation

Fig 4: Links for two different flapping mechanism

The designed model was fabricated in RPT machine using a tool tip of T10 thickness which gives a precision of 10 microns, the material used was Acrylnitrile-butadiene-styrene(ABS) which is a thermoplastic material having high strength. The designed models were able to flap at a highest frequency of 16 Hz for a test time of 30 seconds [3]. The motor used for the purpose doesn't show the sign of temperature rise for the test time and material used to make the structure was able to withstand the vibrations produced, overall we were assured that the

following setup could be used as experimental setup to see for the effects of various parameters on a bird's flapping aerodynamics.

CONCLUSIONS

Experiments were performed using both the mechanism discussed and they showed good conformity with the literature. The additional rotation about span axis led to an increase in aerodynamic forces. Further research will be focussed on addressing other parameters that affect the aerodynamic force generation in a bird's flight.

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FORTH COMING CONFERENCES

1. 11th National Conference and exhibition of Aerospace and Defense Related Mechanisms (**ARMS 2018**) to be held at BITS Pilani, Hyderabad Campus, Hyderabad, Telangana on Nov 16-17, 2018.

   Abstract Submission: 20th July, 2018

   Website: https://arms18.asllab.in

INVITATION FOR ACTIVE PARTICIPATION

We invite you to send technology news, technical articles, members' news and suggestions/comments on e-newsletter and the web contents to Chief Editor to improve the newsletter. The technical articles may be limited to 400 words only in MS Word format with two photographs. The direct extracts from references may be avoided. Kindly provide your e-mail & mail address to enable us to contact you.

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