iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 7 **Issue:** XI **Month of publication:** November 2019

DOI: http://doi.org/10.22214/ijraset.2019.11019

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177
Volume 7 Issue XI, Nov 2019- Available at www.ijraset.com

Modelling and Optimization of Flapping Wing Mechanism in Micro Air Vehicle

Thorrikonda Ramadevi[1], Dr. G. Satish Babu[2]
[1]M-Tech student, [2]Professor, Department of Mechanical Engineering, JNTUH College of Engineering, Hyderabad

Abstract: In this paper, for flapping wing mechanism in micro air vehicle, single crank double rocker mechanism is used. When equal length of rockers are used there is a deviation from actual path to desired path. To overcome this situation, the rocker lengths are optimized such that it removes the deviations from actual path to desired path. This mechanism is also modeled and simulated in working model 2D.

Keywords: Flapping wing, single crank double rocker

I. INTRODUCTION

In the last century, people have deconstructed and remade the standard of flight. From these standards rose various classes of aerial vehicles, extending from airplanes to helicopters to lightweight flyers. To the extent headways have come, man-made flying machines are still outflanked by the agility, maneuverability, and dependability of flying creatures and insects. These flexible flyers are the motivation for another class of bio-propelled flight. As of late, progressions in understanding of flapping wing flight has empowered new advancement in this field. Through these mechanical headways, the Flapping Wing Micro Air Vehicle intends to investigate the benefits of flapping wing flight and reproduce the stability, agility, and maneuverability saw in nature.

As of late, Micro Air Vehicles (MAVs) have been proposed to give ongoing intelligence, surveillance and reconnaissance (ISR) to the war-warrior without the constraints and gigantic coordinations impression of kept an eye on trip in a littler bundle. MAVs are self-sufficient vehicles with a greatest element of 15cm or less, weighing 90g or less. They can be effectively conveyed by little battle units and flown in kept spaces. MAVs will give a natural intelligence, surveillance and reconnaissance (ISR) capacity to little battle groups in the field, lessening or disposing of their dependence on bigger UAVs that are sought after, and expanding the group's autonomy.

II. LITERATURE REVIEW

Rajkiran Madangopal, Zaeem A. Khan, Sunil K. Agrawal[1] presents ,that they have proposed a straightforward mechanical flapping instrument dependent on thoughts got from the investigation insects and the learning picked up from test flying models

Sai K. Banala, Sunil K. Agrawal[2] explained this paper, they presented a mechanism to produce out-of-plane fluttering and bit of the wing without depending on structural flexibility of the wing

Matt McDonald Sunil K. Agrawal[3] displayed a technique for utilizing a robotic flapper to choose a spatial, non-circular, wanted way for a flapping wing dependent on streamlined execution, at that point enhance a circular 4R system to surmised this way

J P Whitney and R J Wood[4] exhibits a conceptual design process for hovering flapping-wing vehicles. An energy-based bookkeeping of propulsion and aerodynamics is joined with a one level of-opportunity dynamic flapping mode

III. METHODOLOGY

The geometric relations between the links are used to find out equations of flapping angle and angular velocity. MATLAB iterations are to determine minimum flapping angle for different range of link lengths .Optimizated flapping angle and angular velocity are found out.This mechanism is modelled and simulated in working model 2D.

A. Mathematical Modelling

The figure shows the schematic diagram of single crank and double rocker mechanism.The geometrical equations derived from the mechanism are explained here

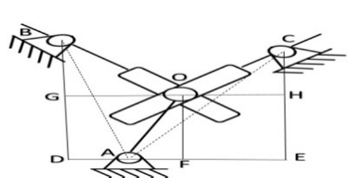


Fig:Schematic diagram of crank and double rocker mechanism

In the above given figure

AO=r AB=L_1 AC=L ∠GOB=$\boldsymbol{\phi}_1$ ∠HOC=$\boldsymbol{\phi}_2$ ∠FAO=ɵ

Geometrically from the above figure $\tan\phi_1 = \frac{l_1 \sin\alpha - r\sin ɵ}{l_1 \cos\alpha + r\cos ɵ}$ (1)

Therefore left rocker flapping angle $1\,\phi_1\,(ɵ) = \tan^{-1}\frac{l_1 \sin\alpha - r\sin ɵ}{l_1 \cos\alpha + r\cos ɵ}$ (2)

Similarly, $\tan\phi_2 = \frac{l_2 \sin\beta - r\sin ɵ}{l_2 \cos\beta + r\cos ɵ}$ (3)

Therefore right rocker flapping angle $1\,\phi_2\,(ɵ) = \tan^{-1}\frac{l_1 \sin\alpha - r\sin ɵ}{l_1 \cos\alpha + r\cos ɵ}$ (4)

On deriving equations 2 and 4 respectively we get angular velocities of left and right rocker respectively.

$\frac{d\phi_1}{dt} = \omega_1$ where w_1 is the angular velocity of the left slotted lever

$\frac{d\phi_2}{dt} = \omega_2$ where ω_2 is the angular velocity of the right slotted lever

$\frac{dɵ}{dt} = \omega$ where ω is the angular velocity of the crank

Therefore angular velocity left slotted lever *is* $\sec^2\phi_1 \frac{d\phi_1}{dt} = \frac{l_1 r\cos(\alpha+ɵ) - r^2}{(l_1 cos\alpha + r\cos ɵ)\text{^}2}\frac{dɵ}{dt}$

$$\omega_1 = \frac{l_1 r\cos(\alpha + ɵ) - r^2}{(l_1 cos\alpha + r\cos ɵ)\text{^}2}\cos^2\phi_1 . \omega$$

We get angular velocity right slotted lever $\sec^2\phi_2 \frac{d\phi_2}{dt} = \frac{l_1 r\cos(\beta+ɵ) - r^2}{(l_1 cos\beta + r\cos ɵ)\text{^}2}\frac{dɵ}{dt}$

$$\omega_2 = \frac{l_2 r\cos(\beta + ɵ) - r^2}{(l_2 cos\beta + r\cos ɵ)\text{^}2}\cos^2\phi_2 . \omega$$

As crank is smaller, the lesser wil be the amplitude of Δ $\boldsymbol{\phi}$(ɵ) and Δω (ɵ) but more driving torque will be needed.Therefore length of crank should be optimal.

B. *Objective*

1) To establish the relation between the links,develop model for a four bar linkage of a flapping wing and determine the relations for the flapping angle and the corresponding angular velocity in terms of crank angle and link lengths
2) To develop the objective function,in the optimal design of mechanism and the simulation of flapping wing mechanism

C. *Methodology Steps*

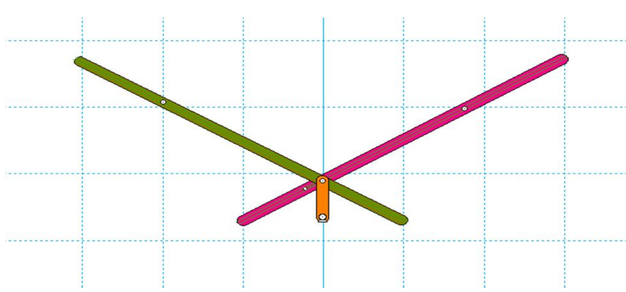
1) Input-output relation of the single crank double rocker mechanism of the flapping wing have been developed
2) The MATLAB optimization tool box(in particular fmincon()function)is to be used for the optimal design of linkage
3) Working Model 2D is the software package is used for the modeling of flapping wing mechanism

D. *Objective Function*

Minimize:Δ $\boldsymbol{\phi}$ = ϕ1 (α) - ϕ2 (β)

Δ ω = ω1 (α) - ω2 (β)

IV. MODELLING USING WORKING MODEL 2D



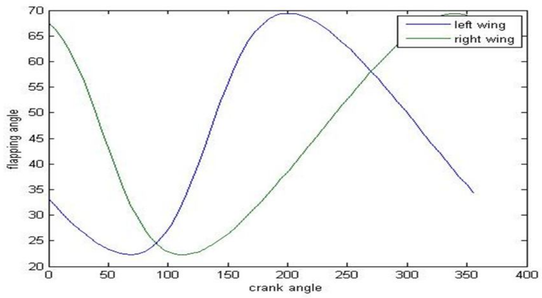
The above figure is modeled by using Working Model 2D. In this mechanism the crank makes a full rotation and the remaining 2 rockers takes the inputs from it. Crank is independent and rockers are dependent crank.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177
Volume 7 Issue XI, Nov 2019- Available at www.ijraset.com

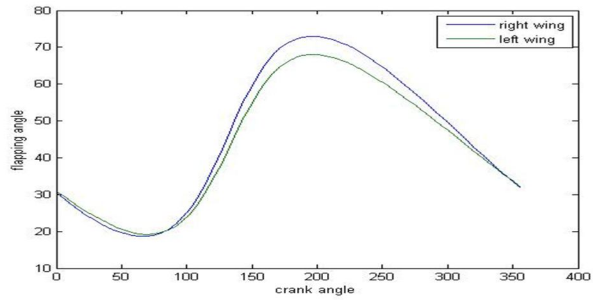
V. RESULTS AND DISCUSSION

Before the optimization :L1=35mm L2=35mm α=β =60°
After the optimization:L1=43mm L2=42mm α = 42° β = 45°.

A. Comparison of flapping Angles

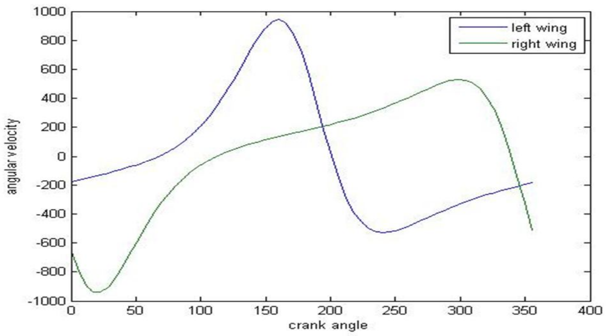


Before optimization

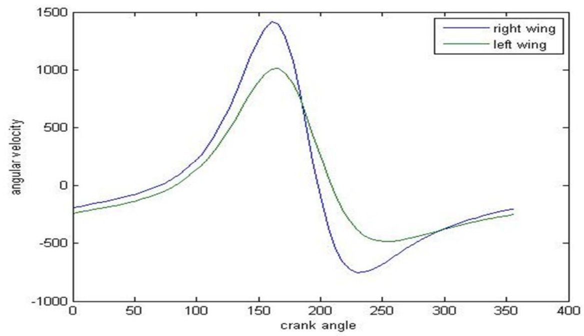


After optimization

B. Comparison Of Angular Velocities



Before optimization



After optimization

Table: 5.1Comparison of key parameters

Parameters	Before optimization	after optimization
Max flapping angle difference(◦)Max|Δ$\boldsymbol{\phi}$|	40.1	4.6
Max Angular velocity difference(rad/s)Max|ω|	950	403
Flapping angle span(◦)Ψ	58	34

VI. CONCLUSION AND FUTURE SCOPE

A. The kinematic analysis is performed on the single crank double rocker type flapping wing mechanism and the flapping angles of the mechanism are obtained for the input crank angles.

B. The future work includes determination of link lengths of the mechanism for a specified range of flapping angles of the mechanism.

REFERENCES

[1] Madangopal, R., Khan, Z., and Agrawal, S., 2005, "Biologically Inspired Design of Small Flapping Wing Air Vehicles Using Four-Bar Mechanisms and Quasi-Steady Aerodynamics," ASME J. Mech. Des., 127(4), pp. 809–816.

[2] Banala, S. K. and Agrawal, S. K., "Design and Optimization of a Mechanism for Out of Plane Insect Wing Like Motion with Twist," Journal ofMechanical Design, Transactions of the ASME,August 2005, Vol. 127, No. 4, 841-844.

[3] McDonald, M., and Agrawal, S. K., 2010, "Design of a Bio-Inspired Spherical Four-Bar Mechanism for Flapping-Wing Micro Air-Vehicle Applications," ASME J. Mech. Rob., 2(2), p. 021012

[4] J P Whitney and R J Wood (2012), "Conceptual design of flapping wing micro air vehicles", IOP Publishing Ltd, Vol.1748-3182/12/036001, pp 1-8.