Available online at www.sciencedirect.com

SciVerse ScienceDirect

Physics Procedia 25 (2012) 737 – 742

Physics Procedia

2012 International Conference on Solid State Devices and Materials Science

# Bionic Propulsion on Water and Measurement of Propulsion

Liu Yun, Zhao Si-yuan, Tu Shan-chao, Zhu Tian-yu and Li Rong-xiang

*Wuhan Mechanical Technology College Wuhan, Hubei Province, China*

**Abstract**

Traditional propulsion fashion on water are propeller propulsion and jet propulsion, but the efficiency relatively low. Used by biological propulsion, after the last million years of evolution, the maximum utilization of its power. Bionic propulsion system designed in this paper consists of two large travel umbrella wing plate in reciprocating linear travel agencies, led by the reciprocating motion along the vertical, in the water under the influence of backward movement of the wing disk automatically open, resulting in the pull forward , the forward movement of the wing disk automatically shut down to reduce water resistance. This paper designs a bionic propulsion and drag model for the static test and measurement test propulsion.



*Keywords:* Bionic; Propulsion; Measurement

## 1. Introduction

There is currently water propeller propulsion and jet propulsion. But the two propulsion efficiency are relatively low. Modern bionic technology for the development of new water propulsion system provides new ideas and new hope, the ocean used by biological propulsion, after the last million years of evolution, the maximum utilization of its power, the best way. Data indicate that fish in the sea by the fins and body torsion propulsion, jellyfish software squeeze and contraction by promoting the umbrella, and its advance is almost perfect, and promote efficiency of 98% or more. Results show that: the use of modern technology to develop biomimetic propulsion ship propulsion efficiency was much higher than its propeller propulsion efficiency, such as Massachusetts Institute of Technology in 1997, Weis-Fogh bodies mimic the construction of the "Proteus Penguin number" like the ship, tests showed that the two wings of the efficiency of propulsion system consisting of up to 87%, much higher than the propeller efficiency.

 doi:10.1016/j.phpro.2012.03.151

## 2. The basic principles of bionic propulsion

The basic working principle is an imitation of jellyfish in the water way forward, the two umbrella wing plate in the large stroke reciprocating linear travel agencies, led by the reciprocating motion along the vertical, in the water under the influence of backward movement of the wing disk automatically open , resulting in tension on the vehicle's forward, forward movement of the wing disc automatically shut down to reduce the flow resistance, so that reciprocating motion with the wing disc, has been the role of forward traction, so that the forward movement of the object.

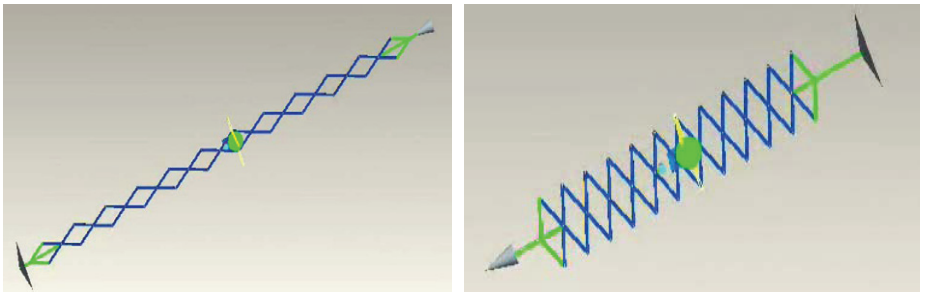

Fig.1 Whirligig transform reciprocate

Biomimetic propulsion on the wing with the approximate thrust is calculated as:

$$F = \frac{1}{2} C_D \rho A V^2$$

Where $\rho$ is fluid density; $F$ to thrust; $C_D$ is thrust coefficient; $A$ for the wing disc in the vertical velocity projection area; $V$ for the wing disc and the surrounding fluid relative velocity.

## 3. Bionic propulsion mode

The use of Pro / E software bionic propulsion for three-dimensional solid modeling. And work under the principle of underwater mode, combined with fluid dynamics, vibration control and multi-body dynamics and other basic theory, developed bionic propulsion model. Shown in Fig.2,

Fig.2 model of bionic propulsion

Mainly by promoting the model of bionic DC motor, variable speed, transmission organizations and agencies made great travel back and forth stretching. Model box size is $70cm \times 30cm \times 30cm$. DC motors are rated at 24V, rated current of 10A, has been the speed of the motor speed after the 400 rev / min, the deceleration gear ratio of 10 times. After this speed after the motor output speed of 40 rev / minute. $T = 1.5s$ ， $\omega = 4.19rad/s$

Expansion speed of the reciprocating motion of bodies is not uniform, so the speed of the expansion of institutions. Fig.3 shows the speed of reciprocating telescopic body plans on which each point of connection for the hinged, O point and the hinge bracket, A point of connection with the connecting rod and cam.

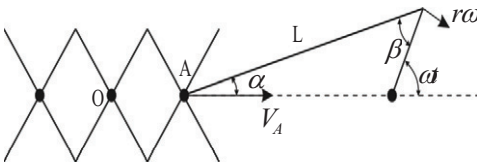


Fig.3 Telescopic body velocity analysis

Use $V_A$ and $r\omega$ the rod was equal to the projection

$$V_A \cos\alpha = r\omega \cos(\frac{\pi}{2} - \beta)$$

$$V_A \cos\alpha = r\omega \sin\beta$$

$$V_A = \frac{r\omega \sin\beta}{\cos\alpha}$$

$$\sin\alpha = \frac{r\sin\omega t}{L} \qquad \cos\alpha = \sqrt{1-\sin^2\alpha}$$

So

$$\sin(\alpha+\beta) = \sin\omega t$$

$$\sin\alpha\cos\beta + \sin\beta\cos\alpha = \sin\omega t$$

$$\cos\beta = \sqrt{1-\sin^2\beta} \text{ ， } a = \sin\alpha \text{ ， } b = \cos\alpha$$

$$\sin^2\beta - 2b\sin\omega t\sin\beta + \sin^2\omega t - a^2 = 0$$

$$\sin\beta = b\sin\omega t + \sqrt{(b^2-1)\sin^2\omega t + a^2}$$

Telescopic mechanism at both ends of the 8 sets of the same body by the connection made.

$$r = 65mm \text{ ， } L = 360mm \text{ 。}$$

Therefore, the speed at both ends of wing disc

$$V = 8V_A = \frac{8r\omega\sin\beta}{\cos\alpha}$$

Fig.4 shows the speed of the reciprocating motion of wing disc diagram. Can be seen in the rated voltage and current circumstances, the wing plate movement cycle $T = 1.5s$ ， $\omega = 4.19rad/s$ .

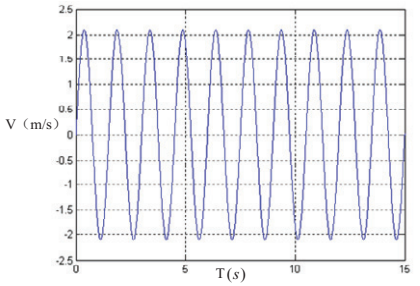


Fig.4 reciprocating velocity

## 4. Static delay model test

In the hydrostatic motor driven by the shore model shown in Figure 5-5 ahead in the water, amphibious vehicles get through the test model of bionic propulsion in the water by the resistance.Respectively $0.5m/s$ , $1m/s$ , $1.5m/s$ , $2m/s$ , $2.5m/s$ velocity pull model, force sensors can be measured by the corresponding resistance, the data listed in Table 1.

Fig.5 Model test plan

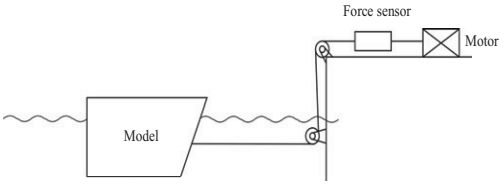


Fig.6 Sketch map of dragging model in hydrostatic water

Table 1 Spdde-resistance table

| V | 0.5 *m/s* | 1 *m/s* | 1.5 *m/s* | 2 *m/s* | 2.5 *m/s* |
|---|---|---|---|---|---|
| F(*N*) | 10.1 | 40.2 | 88.6 | 158.7 | 252.3 |

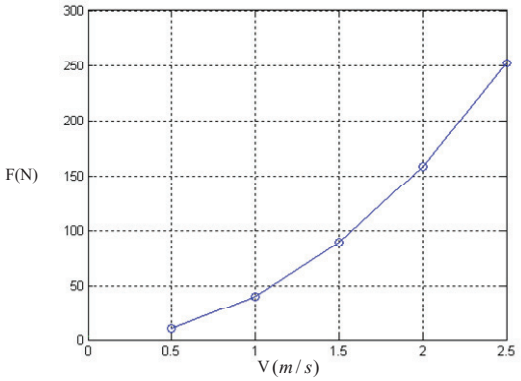


Figure 7 Curve of resistance - speed

Fig.7 is the data in Table 1, the second fitting curve, the curve fitting equation was

$$T = 42.4857V^2 - 6.8771V + 3.46$$

On the style to adapt to the range $0.5m/s < V < 2.5m/s$, speed unit is $m/s$, the unit of resistance is $N$.

## 5. Conclusion

The traditional method of propulsion of amphibious vehicles have been described, and explain its low efficiency, presented the advantages of biomimetic propulsion and basic principles. This paper designs a bionic propulsion and drag model for the static test and measurement test propulsion.

## References

[1] Lei Jan-yu, Pan Yu-tian, Ma Xin-mou. Reseach on Propulsion Device of amphibious vehicles[J]. Machine manage and exploitation.2005(2)

[2] Teng N. H.. The Development of a Computer Code For the Numerical Solution of Unsteady, Inviscid and Incompressible Flow over an Airfoil. Master's thesis, U.S. Naval Postgraduate School, Dept. of Aeronautics and Astronautics, 1987.

[3] Birch J. M. and Dickinsion M. H.. Spanwise Flow and the Attachment of the Leading-edge Vortex on Insect Wings. Nature, 2001(412): pp729-733

[4] Platzer M.F., Jones K.D. and Lund T.G.. Experimental And Computational Investigation Of Flapping Wing Propulsion For Micro-Air Vehicles. Symposium of Low-Reynolds Number Vehicles, University of Notre Dame, Indiana, 2000

[5] Bhattacharya, K. and James, R. D.. Theory of Thin Films of Martensitic Materials with Applications to Microactuators. J.Mech.Phys.Solids, 1999(47): pp531-576

[6] Sun Mao，unsteady lift mechanisms in insect flight, advances in mechanics, Vo32 No. 3 2002

[7] Liu LAN, Fang Zong-de, Hou yu, Aerodynamic modeling and analysis of flapping-wing MAV, journal of aerospace power, Vo20, Feb 2005

[8] Zeng rui, Ang hai-song, Mei Yuan, Ji jian. Flexibility of flapping wing and its effect on aerodynamic characteristic. Chinese journal of computational mechanics, Vo22, 2005

[9] Ramamurti R. and Sandberg W. Simulation of Flow about Flapping Airfoils using Finite Element Incompressible Flow Solver. AIAA J., 2001(39): pp253–260