

WHF009

Moment of Inertia and Blade Energy Calculations



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1	December 2011	
1a	January 2013	Para 4.2: "30s" corrected to "30 oscillations"

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For further information regarding this publication, please contact the Secretary:

Contact details can be found at:
<http://www.worldhovercraftfederation.org>

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1. INTRODUCTION

1.1 General

- A. The terms Fan and Propeller are interchangeable for the purposes of this document.
- B. This method is based on the Bifilar Pendulum method and may be used to calculate the Moment of Inertia of any fan or propeller.
- C. The moment of Inertia must be known in order to calculate the kinetic energy of the fan.
- D. The Kinetic energy is required in order to know which level of containment guarding is required to comply with construction regulations WHF002.

1.2 Reference Publications

Ref No.	Title	Issuing Organisation
WHF002	Construction Regulations for Racing Hovercraft	World Hovercraft Federation

Table 1-1:- Reference Publications

2. PROCEDURE

2.1 Fan Assembly

Assemble the required number of fan or propeller blades into the required hub, in the intended configuration.

2.2 Fan Suspension

- A. Fit a symmetrical suspension fixture to the fan hub (see diagram in appendix A), it should be as light as possible in order not to induce errors in the results.
- B. Suspend the fan on 2 thin wires or strings approx. 2m long. This length is not critical, however it does need to be accurately measured.
- C. The wires should be 0.3m apart, centred about the fan centre. This gives a radius (R) of 0.15m.
- D. It is imperative that the fan lies horizontally.

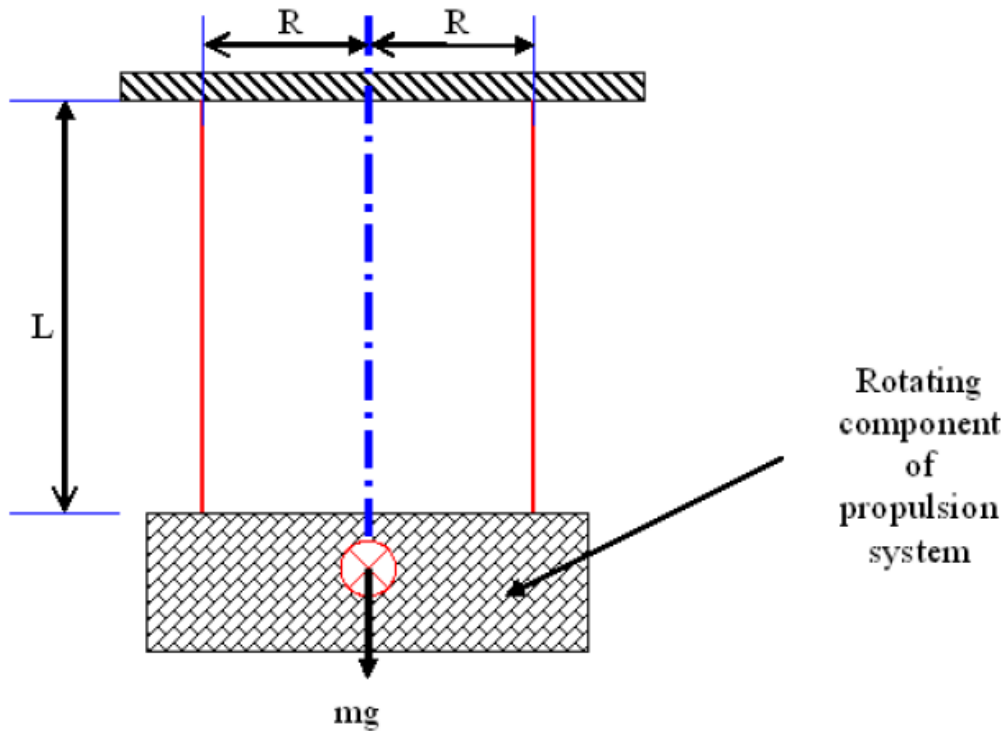


Figure 2-1:- Setup of the Suspended Fan

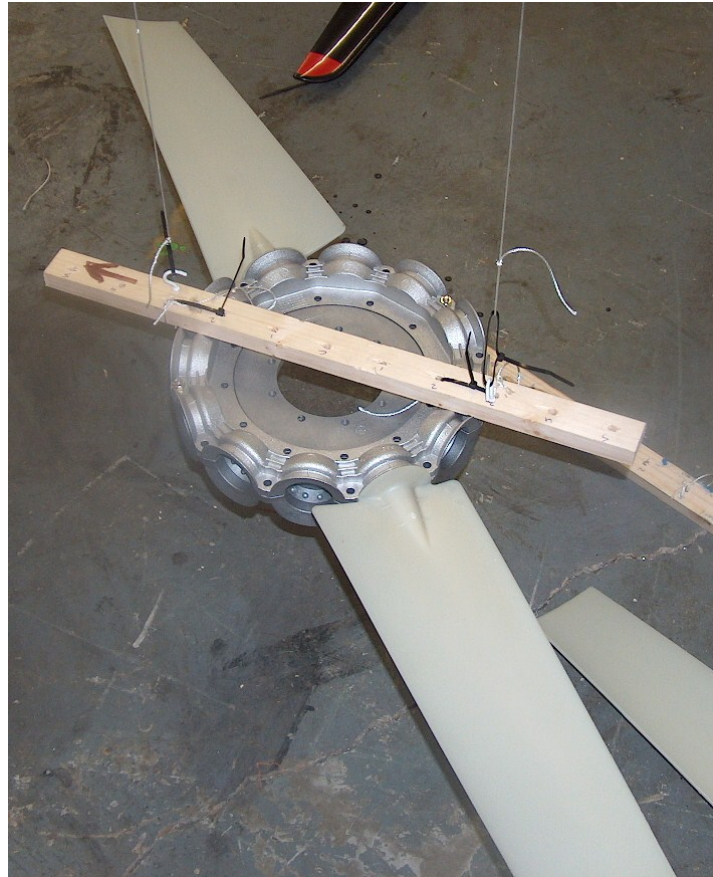


Figure 2-2:- Example of a fan suspended

2.3 Measuring the time period

- A. Rotate the fan on it's horizontal axis by approx. 10 degrees, and measure the time required for 30 complete oscillations.
- B. One complete oscillation is complete when the fan returns to it's original position, whilst rotating in the same direction.
- C. Calculate the time for one oscillation by dividing the measured time by 30. This gives the oscillation time (T_n)
- D. It is imperative that the time is measured accurately, to achieve an accurate result.
- E. It is worth conducting the experiment three times to get an average reading for the time.

2.4 Weight

Weigh the fan accurately in kg, and record the result. This is mass (m)

2.5 Calculation

A. The moment of Inertia J is given by the formula:

$$J = \left(\frac{T_n}{2\pi}\right)^2 \frac{mgR^2}{L}$$

B. Where:

- T_n = Oscillation Time from section 2.3.
- m = mass of fan from section 2.4.
- g = Acceleration due to gravity = 9.81
- R = Radius of the suspension beam from section 2.2C = 0.3
- L = Length of suspension strings from section 2.2B = 2

C. This gives:

$$J = \left(\frac{T_n}{2\pi}\right)^2 \frac{m \times 9.81 \times 0.3^2}{2}$$

2.6 Result

The result (J) from the calculation above will give the moment of inertia (MOI) in kgm^2

3. ENERGY CALCULATION

3.1 Calculation

A. Before the energy can be calculated, the angular velocity (ω) must be calculated.

B. The angular velocity (ω) per blade is given by the formula:

$$\omega = 2\pi \frac{V}{60}$$

C. Where:

- V = speed of the fan in rpm

D. The rotational Energy (E_R) per blade is given by the formula:

$$E_R = \frac{1}{2}J\omega^2$$

E. Where:

- J = Moment of Inertia from section 2.5.
- ω = angular velocity

3.2 Result

The result (E_R) from the calculation above will give the energy per blade in Joules

4. MOMENT OF INERTIA EXAMPLE

4.1 Setup

A 2 blade fan weighing 4.2kg, the strings are 0.3m apart, and are 2m long.

4.2 Time Measurement

The fan was oscillated 30 times, with an average T of 175 seconds for 30 *oscillations*, which gives a T_n of 5.8333s.

4.3 Calculation

The Moment of inertia is 0.4 kgm^2

5. BLADE ENERGY EXAMPLE

5.1 Setup

The fan is fitted to a craft with a fan speed of 2500 RPM.

5.2 Angular velocity

The angular velocity is 261.8 rad/s

5.3 Energy

The energy is 13708 J