

DEVELOPMENT AND EVALUATION OF A BLOWER FOR CHOPPED WATER HYACINTH

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ABSTRACT

A blower was developed, fabricated and evaluated for blowing of chopped water hyacinth. The diameter, width and thickness of the casing of the blower were 0.70 m, 0.23 m and 3 mm respectively. Six radial blades of 4 mm thickness were fixed with blades arm of 0.275 m long, 38.1 × 6.35 mm angle bar. These angle bar were bolted to the back plate of thickness 20 mm. A conveyor was used to feed the material directly into the blower. Blowing operation was done at different speeds and feed rates. Regression analysis of total no-load power for operating the blower and total power for blowing chopped hyacinth were done. The capacity of the blower was 10.8 tons/hour at 180 kg/min feed rate and 1002 RPM. The total power consumption in blowing was 7.23 kW with equivalent amount of energy of 0.67 kWh/ton. The overall efficiency of the blower was 20.35 percent.

INTRODUCTION

Water hyacinth (*Eichhornia crassipes*), a free floating aquatic plant is a native of Brazil but has become widely distributed in the tropical, and sub-tropical zones. This aquatic weed causes lot of problems in navigation and fisheries. Water hyacinth has potential for exploitation as fish feed, soil additive, mushroom culture, paper pulp, biogas, sources of chemicals and removal of nutrients from water (Edwards, 1980).

Harvesting, chopping, off-loading and transportation of water hyacinth is a great problem. Cancelios (1981) reported some mechanical harvesters of water hyacinth and aquatic weeds. The floating harvester has limited capacity, and requires to be driven to the shore for unloading chopped or harvested water hyacinth. This operation is time consuming and the harvester remain idle during transportation. Only two types of water hyacinth harvester can directly off-load the material to the shore - the Allied Aquatic Harvester and the

Aquamarine Hyballer. The working capacity and the efficiency of these machines are high, but involve very high capital cost. These are not economically suitable for developing countries.

Water hyacinth is a bulk plant having density of 167 kg/m³ that does not pack well if put directly into a container. It also contains about 95% of water. Transportation is made easier by chopping and dewatering it. A potentially viable harvesting system could be a harvesting and processing boat which blows the processed hyacinth directly on to a towed barge. The barge, when full, could be taken to the shore for unloading. A blower would be required for blowing harvested hyacinth on to the towed barge. The blower can be developed by applying the concept of a forage blower. Simplicity in construction, dependability, high capacity and low space requirement are some of the criteria that requires to be considered in designing a blower.

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The objectives of this study was to develop, fabricate and evaluate the blower in handling chopped water hyacinth. The specific objectives of the study were :

1. To fabricate a prototype blower using locally available materials
2. To test the performance of the blower.
3. To determine the power and energy requirement for overall blowing system.
4. To determine the capacity and efficiency of the blower.

MATERIALS AND METHODS

The blower was developed at the Asian Institute of Technology, Bangkok, Thailand to work with the following conditions :

1. The blower should work with the hyacinth harvester and chopper previously developed by Kaewarakatsaengkul (1984) and Alam and Clough (1987).
2. The capacity of the blower should be 10 -12 ton/hr.
3. The power requirement of the blower should be not more than 1 kWh/ton.
4. The speed of the blower shaft should be 800-1000 rpm.
5. The machine should be simple in construction and easy to operate.

Basically, this blower consist of six radial blades, blades arm, shaft, back plate - all inside a casing and one conveyor that feed the material into the blower. For smooth running and less vibration six radial blades (Duffe, 1927) of 4 mm thickness and 22.4 mm width were chosen. Back plate was hexagonal and 20 mm thick cast iron (Fig. 1). The housing of the blower was concentric, with a radial clearance of 3 mm between the blades and the housing periphery (Kepner, 1980). The housing of the prototype blower was 70 cm in diameter and 23 mm in width (Fig. 2). The casing material was 3 mm thick mild steel sheet. The prototype housing was made in such way that it can be turned in any angle to see the effect of inclinations on throwing distance. In this connection four pieces of 6 mm thick mild steel semi-circular plates with 12.8 mm semi-circular slot were welded

to the housing to fix with the frame. Two bushes were welded on both sides of housing around the

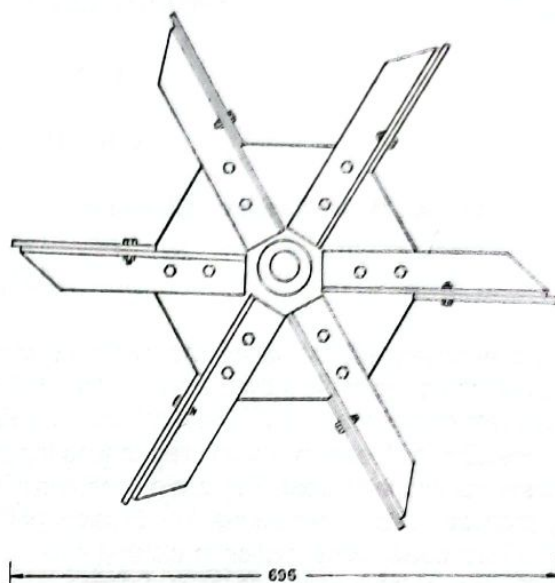
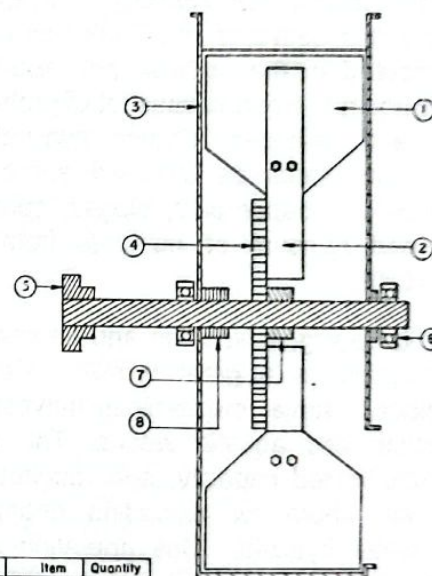


Fig. 1 Back plate with blades



Part no.	Item	Quantity
1	Blade	6
2	Blade arm	6
3	Casing	1
4	Backplate	1
5	Coupling	1
6	Bearing	2
7	Hub	1
8	Bush	2

Fig. 2 Sectional view of the blower assembly

shaft so that it could be rotated without disturbing the required clearance between the blades tip and the housing. The inlet side cover of the blower was bolted to the housing, so that it can be easily dismantled. The blower outlet diameter was 229 mm. Diameter and length of the shaft was 38 mm and 60 mm respectively. In order to reduce vibration and breaking, balancing was done by trial and error method.

The water hyacinth plants were collected from nearby canal and chopped with chopper developed by Alam (1988). The blower was tested at Asian Institute of Technology, Bangkok. Water hyacinth feed rate was varied from 1 to 2.5 kg/sec with three tests for each feed rate. Each sample was blown at 6 different preset speeds of 403, 549, 656, 764, 888 and 1002 RPM. The total power requirement was measured by a watt meter. Power for blowing chopped water hyacinth, was the difference between total power requirement of the blower at load condition and no-load conditions. Total power requirement at no-load condition consisted of : (i) power requirement for running the motor, (ii) power for overcoming friction and windage losses and (iii) for air movement. The power for zero feed rate was considered to be the power developed by the blower at no-load condition. The total power requirement for blowing water hyacinth consisted of (a) power required to overcome friction of chopped water hyacinth against the blower casing (b) power required to accelerate the material. The analytical expression for the energy losses was of the form (Blevins, 1956) :

$$P_f = m a Q V^2 (0.469 \times 10^{-9}) \dots\dots\dots (1)$$

$$P_{ke} = Q V^2 (2.347 \times 10^{-9}) \dots\dots\dots (2)$$

- where, P_f = average power due to friction, (kW).
- P_{ke} = average power for kinetic energy, (kW).
- m = coefficient of friction between the chopped materials and the housing.
- a = angle subtended by the average arc of housing periphery rubbed by the chopped materials, in degree.
- V = peripheral speed of impeller, (m/min).

Capacity of the blower

The capacity was calculated by using the following expression,

$$\text{Capacity} = \frac{\text{Weight of the materials (ton)}}{\text{Time of operation (hr)}}$$

Energy requirement

The energy was calculated by using the following expression :

$$\text{Energy} = \frac{\text{Total power required (kW)}}{\text{Capacity (ton / hr)}}$$

The total power required was calculated from sum of the total mechanical power for operating the blower and the power required to blow water hyacinth at a recommended speed of 1002 RPM and capacity (150 kg/min).

Efficiency of the Blower

The efficiency was determined using the following expression:

$$\text{Efficiency} = \frac{\text{Power required to accelerate the material}}{\text{Total input power}}$$

RESULTS AND DISCUSSION

No-load power

Data pertaining to total mechanical power requirement for operating the blower at no-load condition is presented in Fig. 3. Power requirement increased rapidly with speed because the power components (moving air, kinetic and friction energy) varied as the cube of the speed. Regression analysis of total mechanical power losses and motor speed readings gave the following regression equation :

$$P_m = 441.152 + 0.16112 \times 10^{-5} N_m^3$$

The coefficient of correlation, $r = 0.997$. Regression analysis of the components of total no-load power requirement (Fig. 4) without blowing any water hyacinth reveals that

1. total no-load power requirement for operating blower varies as the cube of the speed of the blower.
2. Power for running the motor is linear with the motor speed.
3. Power losses from the bearing, bush, shaft friction and windage is linear with the speed of the blower.

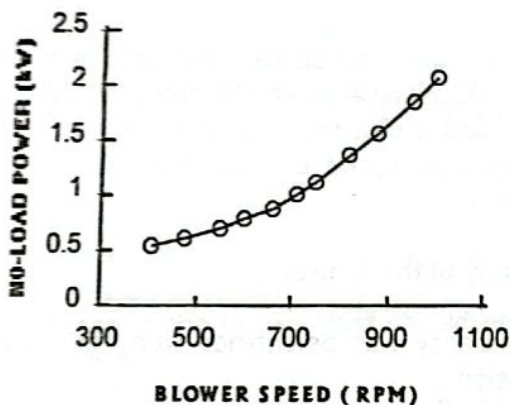


Fig. 3 Total power required to operate the blower at no-load at different motor speeds

Blowing Power

Graphical representation of the total power versus feed rate at constant speed (1002 rpm) and total power versus speed at constant feed rate (150 kg/min.) are presented in Fig. 5 and Fig. 6. The regression equations are of the form :

$$P_{tp} = a + b F \quad \text{for constant speed and}$$

$$P_{tp} = a + b (N_b)^3 \quad \text{for constant feed rate}$$

where P_{tp} = total power
 a = intercept

b = constant

F = feed rate (60-150 kg/min.)

N_b = blower speed (403 - 1002 rpm)

The regression analysis of the components of the total power requirement for blowing water hyacinth indicates that total power for blowing varies linearly with the feed rate at constant speed and varies as the cube of the speed at constant feed rate (Fig. 5 and Fig. 6).

Analysis of the Power Requirement

The power required by the blower has the following components :

- a) bearing, bush, shaft friction and windage losses
- b) power for air movement at zero feed rate
- c) power for accelerating the materials and
- d) power loss due to friction between the materials and the casing.

The power required for air movement and bearing, shaft, bush, and windage losses (at no-load) is presented in Fig. 4). The power requirement of the kinetic energy changes and the materials friction was calculated using the equation (1) and (2). All the components of the total power is presented in Fig. 7. The theoretical power was quite close to the observed power. A major amount of power was lost in the friction between the water hyacinth and the casing of the blower (friction power). The higher friction power might be due to material friction between the blades and 'hairpinning' of the long cut materials over the edge of the blades which also caused excessive wedging and friction within the casing.

Capacity and Energy Consumption

Various feed rates were tried to identify the optimum capacity. The blower was found to be over loaded at the rate of 3.5 kg/sec. Excessive vibration was observed from the blower and also from the motor. But for 3 kg/sec the blower was running smoothly at 1002 rpm. The calculated capacity of the blower at 1002 rpm was 3 kg/sec or 10.8 ton/hr and the total

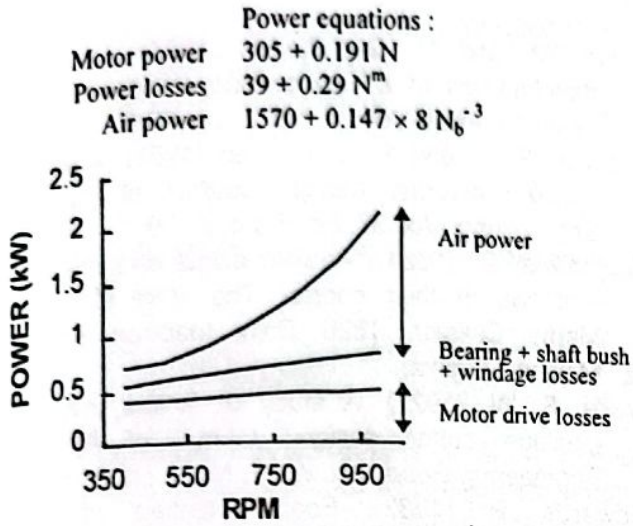


Fig. 4 Components of no-load power vs speed relationship

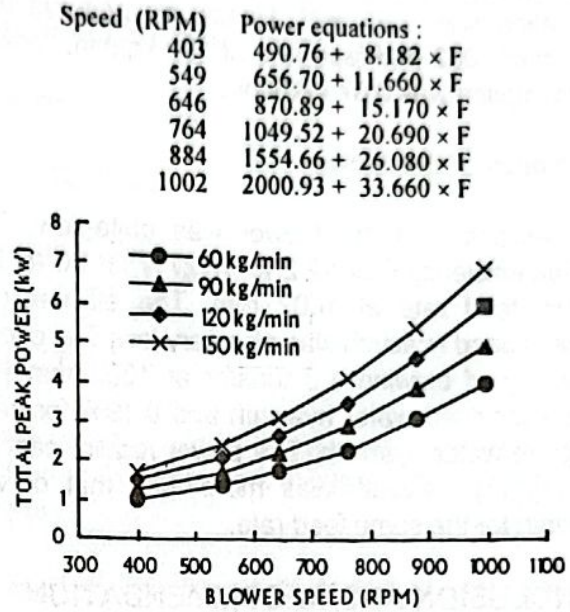


Fig. 6 Total power for blowing water hyacinth at different feed rate vs blower speed

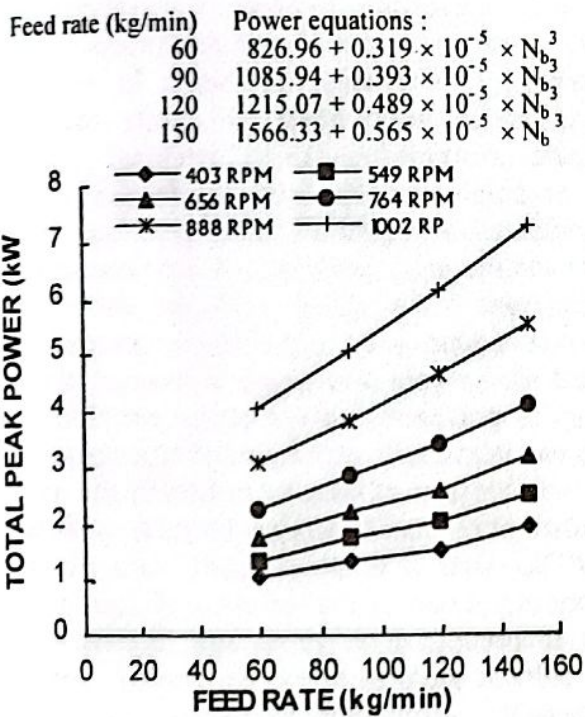


Fig. 5 Total power for blowing water hyacinth at different speed vs feed rate

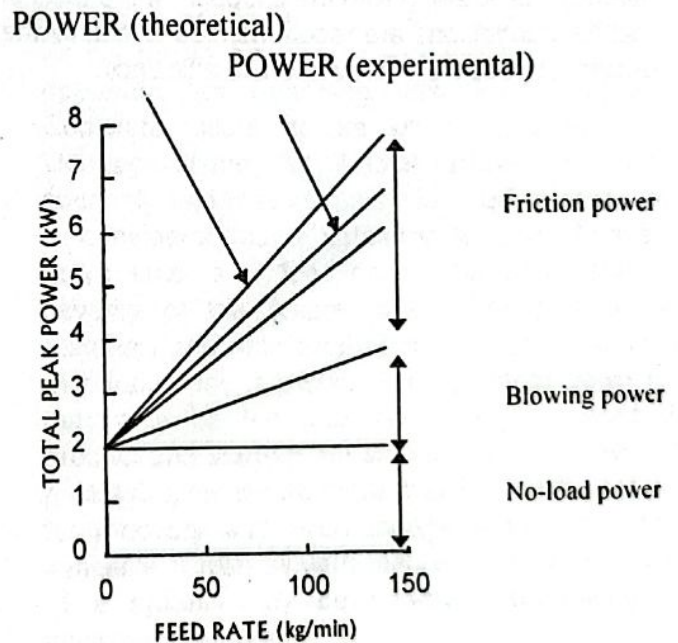


Fig. 7 Total power and components of blowing power vs feed rate at 1002 RPM

average power consumption for continuous blower operation was 7.23 kW. Hence at recommended speed of 1002 and feed rate of 150 kg/min, energy consumption was 0.67 kWh/ton.

Efficiency of the Blower

The efficiency of the blower was quite low. The overall efficiency was 12.2 to 18.27% for 60 to 150 kg/min feed rate at 1002 rpm. The efficiency of blowing dried hyacinth was also very low. The overall efficiency of blowing 1.8 tons/hr at 1002 rpm was 4.68% for dried water hyacinth and 8.19% for fresh chopped water hyacinth. The power requirement for blowing dry hyacinth was more than that of wet hyacinth for the same feed rate.

CONCLUSION AND RECOMMENDATION

The performance of the blower was quite satisfactory. The blower could be installed on a harvester boat along with the chopper. More tests in real field conditions are recommended to modify the design for possible improvement in efficiency.

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