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Hydro Rice Milling Machine

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Abstract— It has been reported that 41% of the countryside and isolated areas in Sarawak which still have no electricity coverage, compared to only 10% in Peninsular Malaysia. Furthermore, most of the Sarawak rural communities are farmers and families are feeding on the harvesting of paddies. The harvesting of paddies in rural area of Sarawak is inefficiency as compared to other parts of the world due to insufficient supply of electricity. This study investigates the feasibility of of implementing hydropower generated rice milling machine in rural area of Sarawak through laboratory testing on minimum power required to run the rice milling machine and the power that can be supplied from the open channel. The results show that with the current open channel flume and the structure of the rice milling machine, it is feasible to replace traditional methods (beating or foot husk) and more modern methods (gasoline powered engine or electricity dependence rice miller) with the hydro rice milling machine.

Index Terms—harvesting of paddies, Hydropower, Open channel, Rice milling machine.

I. INTRODUCTION

Sarawak is blessed with high volume of rainfall every year and its topographic condition is hilly and mountainous. The northeast monsoon, usually between November and February, brings heavy rain, while the southwest monsoon from June to October is usually milder. The average annual rainfall ranges from 3,300 millimeters to 4,600 millimeters, depending on area [1]. These areas are rich in water; forest and other biological resources that sustain the livelihoods of many indigenous communities. Many of these communities are dispersedly located in these very remote and hilly and mountainous areas, making it challenging in terms of bringing development.

Job opportunity available is limited to Sarawak rural communities, in which many of them still involved in traditional industries such as agriculture and aquaculture. Most of the Sarawak rural communities are farmers and families are feeding on the harvesting of paddies while others are working as labors in the oil palm, construction and timber sectors in a small town to sustain their livelihood and support their families.

This study is carried out with the aim of helping the rural communities of Sarawak by means of introducing hydro rice milling machine which can increase the efficiency of the rice milling process as the rice milling industry is one of the utmost energy intense activities [2].

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II. APPARATUS

A. Open Channel Flume

The flumes are used to measure flow rate or discharge, Q in open channels. They typically have widths from a few centimetres to 15 meters or so. The water depth in the approach section of flumes typically can be between a few centimetres and about 2 meters. Flumes, compared to weirs, have the advantage of less head loss through the device, yet are more complicated to construct and more difficult to analyse. The flow in an open channel or in a closed conduit having a free surface is referred to as free-surface-flow or open channel flow [3]. Figure 1 shows the open channel flume being analysed in this study.

Figure 1 Open channel flume of rectangular channel with 300mm base width

B. Rice Milling Machine

Rice Milling Machine which mainly consist of a milling machine, a grinder, an electric motor or a diesel motor and a frame. As the machine is run by a single power supply, during the exact use, ones could only run the machine separately. A Rice Milling Machine system can be a simple one or two step process, or a multi stage process. In a one-step milling process, husk and bran removal are done in one pass and milled or white rice is produced directly out of paddy. In a two-step process, removing the husk and removing bran are done separately, and brown rice is produced as an intermediate product. In multistage milling, rice will undergo a number of different processing steps. Depending on whether the paddy is milled in the village for local consumption or for the marketing rice milling machine systems can be classified into the categories village rice mills and commercial mills. Rice milling machine can be categorized into small, medium and large size according to their power consumption, capacity, and weight as well as the packing size. Figure 2 shows the rice milling machine being analyzed in this study.

Figure 2 Rice milling machine used in this study

C. *Other Apparatus*

To find the depth or head of the flow in approach channel, h_1 and depth or head of the flow above hump, h_2, a depth gauge was used, which had vernier scale and allowed measurement to be taken to tenths of a millimetre. A digital tachometer is used to measure the number of revolution per minute, *N* of rice milling machine.

III. TESTING METHODS

A. *Open Channel Flume*

The only concern type of flow in this study is uniform steady flow as the discharge, *Q*, does not change with time and depth remains constant for a selected section. The equation given to calculate the discharge in the open channel flume are as in (1). Velocity of flow, *V* are as in (2) and power, P_w are as in (3).

$$Q = c_d A_1 A_2\left(\sqrt{2g\Delta h}\right) / \left(\sqrt{A_1^2 - A_2^2}\right) \quad (1)$$

where Q is the discharge in channel,
c_d is the coefficient of discharge,
A_1 is the cross-sectional area of pipe,
A_2 is the cross-sectional area of nozzle,
g is the gravitational force,
Δh is the difference between h_1 and h_2.

$$V = \left(\sqrt{2g\Delta h}\right) \quad (2)$$

where V is the velocity of flow,

$$P_w = (F \times V)/1000 \quad (3)$$

where P_w is the power that can be provided by the flow,
F is the force in flow.

The procedure carried out for the open channel flume testing is as shown below:

1. Base width, *B*, of rectangular channel is measured.
2. Power supply for the pump is switched on.
3. The valve is opened to maximum and allow for the circulating of flow from Reservoir 1 to Reservoir 2.
4. The flow is allowed to stable for at least 5 to 10 minutes to reduce the turbulence in the channel for more accurate reading.
5. The depth or head of flow from the approach channel, h1 is measured. It is the vertical distance between the datum and the water surface.
6. The depth or head of flow at the hump, h2 is measured. It is the vertical distance between the top of hump and the water surface.
7. The valve is closed gradually to take different sets of readings at different depth of flow.
8. The readings recorded are tabulated in Table 4.1.
9. Flow rate, *Q* at different depth of flow are calculated.
10. Velocity, *V* at different depth of flow are calculated.

B. *Rice Milling Machine*

The forces required to turn the gear of the rice milling machine is determined by first knowing the minimum torque required to turn on the gear. The length of pedal to the centre of gyration, r is 0.2 m as shown in Figure 3. The circumference of the rotation, *C* are as in (4). The torque, τ required to turn the gear of rice milling machine are as in (5) and the power required to run the rice milling machine, P_r are as in (6).

$$C = \pi \times d \quad (4)$$

where C is the circumference of rotation,
π is a mathematical constant equal to 3.14159,
d is the diameter of circle of the rotation.

$$\tau = F_r \times D \quad (5)$$

where τ is the torque required to turn the gear of rice milling machine,
F_r is the force required to turn the gear of rice milling machine,
D is the distance moved.

$$P_r = (\tau \times N / 9.5488) / 1000 \quad (6)$$

where P_r is the power required to run the rice milling machine,
N is the number of revolution per minute of rice milling machine.

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Figure 3 Side view of the rice milling machine

IV. RESULTS AND DISCUSSION

The readings recorded in the laboratory testing are shown in Table 1. The powers that can be provided at different flow rate are shown in Table 2.

From (4):

$C = \pi \times d$

$= 3.142 \times 2r$

$= 3.142 \times 2(0.2)$

$= 1.2568$ m

Given that $F_r = 10$ N, from (5):

$T = Fr \times D$

$= 10 \times (1.2568 / 4)$

$= 3.142$ Nm

$T = 3.142$ Nm and $N = 70$ rpm

From (6):

$Pr = (T \times N / 9.5488) / 1000$

$= (3.142 \times 70 / 9.5488) / 1000$

$= 0.023$ kW

The power required to run the rice milling machine is 0.023 kW while the maximum power that can be provided by the open channel flume is approximately 0.128 kW. The results shows that with the current open channel flume and the structure of the rice milling machine, it is possible to run the rice milling machine smoothly as the maximum power that can be provided by the open channel flume, Pw is higher than the power required to run the rice milling machine, Pr.

V. CONCLUSIONS

This study is integrated research in which it required both knowledge in civil engineering and some knowledge in mechanical engineering. For civil engineering, the understanding in open channel flow is crucial while for mechanical engineering, the understanding in mechanical energy and power conversion are crucial. This study does not take into consideration of the efficiency of turbine and the losses in energy. The result obtained in this paper is limited only to specific open channel flume and rice milling machine used. The results shows that with the current open channel flume and the structure of the rice milling machine, it is possible to run the rice milling machine smoothly as the maximum power that can be provided by the open channel flume, P is higher than the minimum power required to run the rice milling machine, P1. It can be concluded that it is feasible to replace traditional methods (beating or foot husk) and more modern methods (gasoline powered engine or electricity dependence rice miller) with hydro rice milling machine.

Table 1 Flow Rate, Q and Velocity, V at Different Depth or Head of Flow

B (m)	h_1 (m)	h_2 (m)	$\Delta h = h_1 - h_2$ (m)	$A_1 = \frac{\pi}{4} d_1^2$ ($\times 10^{-3}$ m^2)	$A_2 = \frac{\pi}{4} d_2^2$ ($\times 10^{-3}$ m^2)	c_d	Q (m^3/s)	V (m/s)
0.3	0.206	0.110	0.096	8.4948	5.4367	0.98	0.009515	1.372414
0.3	0.165	0.074	0.091	8.4948	5.4367	0.98	0.009265	1.336196
0.3	0.147	0.060	0.087	8.4948	5.4367	0.98	0.009059	1.306499
0.3	0.122	0.042	0.080	8.4948	5.4367	0.98	0.008687	1.252837
0.3	0.103	0.026	0.077	8.4948	5.4367	0.98	0.008523	1.229122

Table 2. Power, P_w Provided at Different Flow Rate

Q (m^3/s)	F (N)	V (m/s)	Power, P_w (kW)
0.009515	93.34	1.372414	0.12812
0.009265	90.86	1.336196	0.12145
0.009059	88.84	1.306499	0.116112
0.008687	85.19	1.252837	0.10677
0.008523	83.58	1.229122	0.102766

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VI. APPENDICES

Appendix A: Example of Calculation on Discharge, Q and Velocity of flow, V

$B = 0.3$ m ; $h_1 = 0.206$ m ; $h_2 = 0.110$ m $c_d = 0.98$; $g = 9.81$ m/s $\Delta h = h_1 - h_2$ $= 0.206 - 0.110$ $= 0.096$ m	
$A_1 = \frac{\pi}{4} d_1^2$ $= \frac{\pi}{4}(0.104^2)$ $= 8.4948 \times 10^{-3}$ m^2	Given: $d_1 = 104$ mm
$A_2 = \frac{\pi}{4} d_2^2$ $= \frac{\pi}{4}(0.0832^2)$ $= 5.4367 \times 10^{-3}$ m^2	Given: $d_2 = 83.2$ mm
$Q = c_d \frac{A_1 A_2(\sqrt{2g\Delta h})}{\left(\sqrt{(A_1^2 - A_2^2)}\right)}$ $= 0.98 \frac{(8.4948 \times 10^{-3})(5.4367 \times 10^{-3})(\sqrt{2(9.81)(0.096)})}{\left(\left(\sqrt{(8.4948 \times 10^{-3})^2 - (5.4367 \times 10^{-3})^2}\right)\right)}$ $= 0.009515$ m^3/s	
$V = \sqrt{2g\Delta h}$ $= \sqrt{2(9.81)(0.096)}$ $= 1.372414$ m/s	

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