Utilization of Brushless Direct Current (BLDC) Motor as A Drive for Rice Threshing Machine in Subak Empelan Farmer Group in Demulih Village, Susut, Bangli

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Abstract. *Subak* is a traditional farming community organization in Bali responsible for regulating irrigation systems. *Subak* Empelan, led by *Pekaseh*, is a well-maintained community consisting of 150 members who manage 97 hectares of rice fields. Due to limited water supply, rice planting is staggered. Harvesting, a time-consuming process, is still done manually by most farmers in Subak Empelan, using traditional tools. This method leads to lower yields, with approximately 40 kg of grain per 1 acre, taking eight people three hours to complete. The process is exhausting and costly, and farmers lack knowledge of modern, eco-friendly threshing tools. To address these challenges, a community service project will design a rice threshing machine powered by a Brushless Direct Current (BLDC) motor. This battery-operated motor allows the machine to be efficiently managed by just three people one operating the machine and two harvesting rice. This reduces harvest time to one hour and increases yields to 45 kg per 1 acre, with better quality grain. This project supports the government's green energy initiative while providing *subak* Empelan members with valuable training in modern technology. The initiative is expected to boost farmers' income, enhance their understanding of appropriate technology, and reduce environmental pollution.

Keywords: BLDC Motor, Rice, *Subak*, Threshing Machine

1 Introduction

Subak is a Balinese irrigation system that concerns customary law which has distinctive characteristics, namely; social, agricultural, and religious with determination and spirit of cooperation in efforts to obtain water to complete the water needs in producing food crops, especially rice and secondary crops. During the rice harvest season, groups of rice harvesters or farmers who want to harvest their rice individually still use many conventional/traditional harvesting tools. The way these traditional threshers work is by taking one handful or one clump of rice, then beating the rice against the thresher until the rice grains are completely detached from the panicle or in the term of Gebot. By using this tool, both farmers and groups of rice harvesters need quite a long time to

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harvest with dirty grain results (Kementerian Koordinator Bidang Kemaritiman dan Investasi, 2022). In addition, quantitatively the harvest results will be affected because many grains of rice are scattered in the rice fields, generally, the harvest results in the form of wet grains per acre of rice fields are obtained approximately 50 kg. Common obstacles experienced by farmers after harvest are the large number of crop losses while using inappropriate harvesting tools. The time needed to separate the rice grains from the panicles is quite long, requires a lot of human labor, and the harvest cost is quite high because the working time is longer and the work is less comfortable and tiring (Wandana & Hendri, 2020).

(a)

(b)

Figure 1. (a) Harvesting rice using conventional/traditional tools, (b) Separating the filled and empty rice grains

2 Methodology

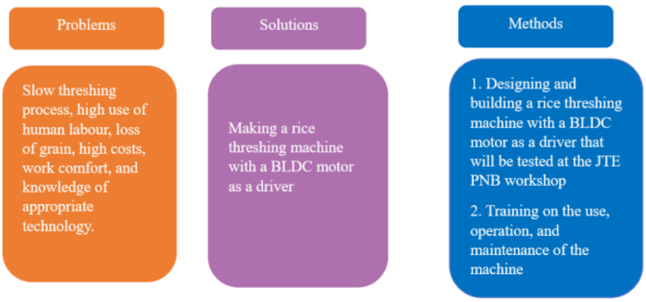

Figure 2. Research method

The main equipment used in the design of this rice threshing machine, such as:

2.1 Threshing Machine Frame

The machine frame is designed for the purpose of separating rice, panicles and straw and blowing empty chaff, thus, the rice is in good quality (Suhendra et al., 2019). The dimensions of the machine are 117 × 119 × 99 cm. The machine frame can be seen in Figure 3.

2.2 Machine Driver Motor

The threshing machine drive motor uses a DC motor with Brushless Direct Current (BLDC) Type Model BM1412ZXF. With Specifications: Power P = 800-Watt, Voltage 48 Vdc, Speed n = 50 km / h, Reduction Gear Torque = 5 Nmm, Length Dimension = 24.5 cm, Diameter 14.5 cm. The machine drive motor can be seen in Figure 4.

Figure 3. Threshing machine frame

Figure 4. BLDC Motor

2.3 Controller

The controller is a device or system that regulates and controls the operation of the BLDC motor, the controller capacity is 1000 W, 48 Volts.

2.4 Battery

The battery is the power source for the BLDC Motor, the battery capacity used is 80 AH, 48 Volts, consisting of 4 batteries with a capacity of 20AH, 12 Volts each. The batteries are connected in series. The battery can be seen in Figure 6.

2.5 Miniature Circuit Breaker (MCB) Direct Current (DC)

The protection equipment uses a 20A DC MCB, which functions to protect the electrical circuit of the rice threshing machine. MBC DC can be seen in Figure 7.

Figure 5. Controller

Figure 6. Battery

2.6 The Measuring Instrument

The measuring instruments used were DC Ampere pliers, Tachometer and AC/DC Ampere pliers. The relay used is adjusted to the voltage source, namely a DC relay with a coil working voltage of 48 Vdc.

Figure 7. MCB DC

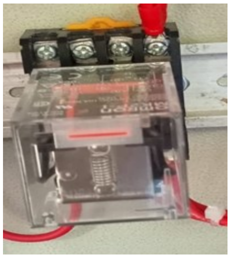

Figure 8. Relay 48 Vdc

2.7 Component Assembly and Installation Process

Assembling the Machine Frame. Procurement of the threshing machine frame is still separate from one part to another thus it needs to be reassembled**.** It can be seen in Figure 9.

Assembling the BLDC Motor Control Circuit. The control circuit components consist of: voltage source (battery), Miniature Circuit Breaker DC 20 A, Push button NO and NC, DC relay 48 Vdc and controller (Harjono & Widodo, 2021). It can be seen in Figure 10.

Figure 9. Assembling the machine frame

Figure 10. Panel control

Installing the Panel Box. The Box Panel is installed at the front of the threshing machine so that the user or operator could operate it easily and can be seen in Figure 11.

Installing the BLDC Motor. The BLDC motor is installed behind Box Panel, can be seen in Figure 12.

Figure 11. Installing the panel box

Figure 12. Installing BLDC motor

Installing the Battery on the Panel Box and Connected the Battery. Installed 4 batteries with a capacity of 12V 20 ah for each of it. These 4 batteries are installed in series to obtain a voltage of 48V according to the working voltage of the BLDC Motor.

Machine Wheel Welding Process. Assembling the machine wheels with the rice threshing machine frame.

Figure 13. Installed the batteries

Figure 14. Machine wheel welding process

Battery Voltage Measurement. The aim is to ensure that the battery is still normal.

Motor Current Measurement, Component Voltage and Motor Speed. The purpose is to determine the size of the motor current and voltage on the components such as voltage measurements on the relay coil, controller input terminal, the BLDC motor terminal, and motor rotation speed (Jatmiko et al., 2018; Ma'arif et al., 2022).

Figure 15. Measurement of source voltage magnitude

Figure 16. Measuring motor current, component voltage and motor speed

BLDC Motor Installation Wiring Diagram. The BLDC Motor Power Circuit has three conductors coloured blue, yellow and green. The BLDC motor is controlled from the Controller, the blue, yellow and green conductor that came out of the controller were connected to the conductors in the BLDC motor. The control circuit is a circuit that will control the BLDC motor as a whole. From the dc MCB to the BLDC motor point circuit. The NO push button is the ON push button of the control circuit, while the NC push button is the OFF-push button of the circuit. A48 Vdc relay is used to connect the supply to the power in the controller. The gas pedal is a switch for adjusting the speed of the BLDC motor (Glowacz, 2021; Jatmiko et al., 2018; Mahmud et al., 2020; Mohanraj et al., 2022; Nayak & Shivarudraswamy, 2022).

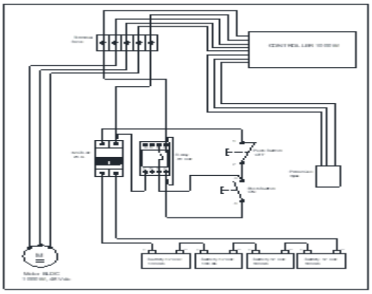

Figure 17. BLDC motor installation wiring diagram

2.8 Checklist Commissioning Test of BLDC Motor Control and power Circuit

A checklist commissioning test is needed to ensure that all circuits are connected according to the circuit diagram in the design which is carried out after the circuit is assembled or before the circuit is tested with a voltage source

Table 1. Commissioning test checklist

No	Item verification	Result	
		Connected	Disconnected
1	Battery cables + and – with MCB input	√	-
2	MCB output with NC push button	√	-
3	NC Output with NO push button input	√	-
4	NO output with R 48Vdc coil	√	-
5	NO input with 1 child relay contact terminal	√	-
6	NO output with 3 child contact relay terminals	√	-
7	Terminal 3 child relay contact with input + Controller	√	-
8	Cable –MCB output with input - controller	√	-
9	The three controller output cables with BLDC motor input cables	√	-
10	Throttles controller cable with gas pedal	√	-
11	Battery cable jumper	√	-

3 Result and Discussion

After the commissioning test was carried out and it was stated that all the circuits were connected properly, the measurement was continued on each component which was displayed in the measurement results table and the rice threshing machine was tested.

3.1 The Measuring Instrument

The measuring instruments used were DC Ampere pliers, Tachometer and AC/DC Ampere pliers.

(a) (b) (c)

Figure 18. (a) AC ampere pliers, (b) DC ampere pliers, and (c) Tachometer

3.2 The Battery Voltage Measurement Results

Battery voltage measurement aims to ensure that the battery voltage is in accordance with the working voltage of the component. The number of batteries is 4 units installed in series.

Table 2. Battery voltage measurement results

Aki 1 (Vdc)	Aki 2 (Vdc)	Aki 3 (Vdc)	Aki 4 (Vdc)
13.26	11.6	13.34	13.33
Total 51.54 Vdc			

The battery voltage was measured before the circuit and motor were turned on. From Table 2 it could be explained that the results of the voltage measurements of each battery, namely battery 1 13.26 Vdc, battery 3 13.34 Vdc, and battery 4 13.33 Vdc exceed the voltage listed on the battery nameplate, while on battery 2, namely 11.6 less than the voltage listed on the battery nameplate, the results of the series connection of the four batteries obtained a measurement result of 51.54 Vdc, this also exceeds the working voltage of the components used.

3.3 The Voltage Measurement Result on Components

The Voltage Measurement Result on Components aims to determine the magnitude of the voltage on the component, whether it is by the working voltage of each component.

Table 3. The component voltage measurement results

No	Component	Voltage (Vdc)
1	Relay MK2P	49.94
2	Controller	49.88
3	Motor BLDC	49.82

The magnitude of the voltage on each component exceeded the component's working capacity

3.4 The Results of Current, Voltage, and Motor Speed Measurements without load or zero load.

This measurement aims to determine the amount of current required by the motor so that the motor can rotate. Likewise, to determine the amount of voltage and rotational speed of the BLDC motor before being loaded.

Table 4. Results of current, voltage, motor speed measurements zero load.

No	Current motor (A)	Motor voltage (Vdc)	Motor speed (RPM)
1	0.14	45.40	100
2	0.2	45.43	200
3	0.5	45.45	464.5

From Table 4, It could be explained that the faster the motor rotation, the greater the current and voltage required. Thus, motor speed, current, and voltage were directly proportional.

3.5 The Results of Measurement of Current Voltage and Motor Speed with Threshing Cylinder Load

This measurement aims to determine the current, voltage, and motor speed when the rice threshing machine is operating but has not yet been used to thresh rice.

Table 5. Results of current, voltage, and loaded motor speed measurements

No	Current motor (A)	Voltage motor (Vdc)	Speed motor (RPM)
1	0.26	45.45	98.5
2	0.4	45.50	198.5
3	0.8	45.59	462.5

From Table 5, it could be explained that the faster the motor rotation speed, the greater the current and voltage. If it was compared the motor speed under loaded and unloaded conditions, it could be seen that the motor current was greater under loaded motor conditions. Voltage, when the motor was loaded was greater than the motor voltage when unloaded. While the motor speed decreased under loaded conditions.

3.6 Results of Observation of Threshing Machine Work

The threshing machine was operated by 3 members, 1 person operated the machine and 2 others cut and carried the rice to the threshing machine. In 1 hour, the threshing machine produced 45 kg of clean grain.

3.7 Battery Working Time Calculation

The threshing machine was operated at the highest speed of 462.5 rpm, while the measured motor current was 0.8 A. The battery capacity used was 20 Ah 48 Vdc, thus:

$$\frac{\text{Battery capacity}}{\text{load current}} = \frac{20\text{ Ah}}{0.8\text{ A}} = 25\ hours \tag{1}$$

This threshing machine with a battery capacity of 20 Ah can be operated for 25 hours.

4 Conclusion

The conclusions that could be drawn from the implementation of the Community Service activities of the Appropriate Technology Institution scheme of the *subak* Empelan farmer group in Demulih Village with the title of utilizing BLDC motors as a driver for this rice threshing machine were as follows:

a. The implementation of PKM went well and smoothly according to plan from socialization to partners, the process of designing and building rice threshing machines, training in machine operation and evaluation of PKM implementation.
b. The performance of the rice threshing machine greatly helps the problems experienced by farmer groups such as the time needed by farmer groups to thresh rice grains can be accelerated which previously took 3 hours for a rice field area of 1 Are with a threshing machine only needed 1 hour, the human power needed was only 3 people from the previous 8 people, the harvest was also more than 40 kg per Are with this machine produced 45 kg per Are, costs were less because the time needed was faster, fatigue experienced in the threshing process could be reduced and gained knowledge about threshing machines.

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