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Performance evaluation of tractor operated winnower using tachometer

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Abstract
A large number of farmers thresh paddy crop by hand or by a walk on it under feet of animals. Now a day's number of progressive farmers are using pedal-operated or hold on type threshers, which does not have a cleaning facility. In the present study, the performance of the tractor-operated winnower was evaluated at three different winnower fan rpm, which were 786, 918 and 1049rpmall the parts of were connected with the help of tachometer circuit diagram. From the results, found that optimum cleaning efficiency of 96 percent at winnower rpm of 918. Hence, tractor operated winnower can be operated at 918 rpm for high cleaning efficiency and winnower hopper can be adjusted at a distance of 60 cm from winnower fan axis to provide an optimum air velocity to the grain.

Keywords: Performance tachometer, arduino Uno, proximity sensor, anemometer, winnower

1. Introduction
Wind winnowing is a very ancient agricultural rehearsal developed by ancient peoples for separating grains from the chaff. It is also used for other purposes such as removing hay and chaff or other pests from stored grain. Threshing is the loosening of grain or seeds from the husks and straw is the step in the chaff-removal that comes before winnowing. In its simplest form, it involves throwing the mixture into the air so that the wind blows away the lighter chaff, while the heavier grains fall back down for recovery techniques included using a winnowing fan (a shaped basket shaken to rise the chaff) on a pile of harvested grain reported by Amar Singh, 1988 [1]. Usually, the crop is harvested at around percent moisture content and stacked. After harvesting the grain, it has to be dried in the field itself or at threshing yard followed by threshing the crop to separate the grain from ear head. The threshing material is a mixture of grain and chaff, which has to be separate the grain from the ear head reported by Anwar and Gupta, 1990 [2]. The threshed material is a mixture of grain and chaff, which has to be separated using air Hundalal *et al.*, (1984) [6]. An air separating was the first-grain cleaning method used by man. The "proverbial separation of the chaff from the grain was accomplished by winnowing a type of air separation". A mixture of grain and chaff were thrown into the air, the heavy grain fell almost straight back onto the reed tray, while the light chaff was moved laterally by the wind beyond the rim of the tray and fell on the ground. Winnowing can be done either by the natural breeze of air or by winnowing fans. Winnowing manually by dropping threshed material in the natural wind is time consuming, inefficient and drudgery to the operator. Although the performance of existing axial flow fan type winnowers, which are available in the market are satisfactory, but they require large floor area, high initial investment, cast and repetitive process of winnowing reported by Muhammad Aslan Chaudhary (1979) [9]. The increasing momentum of the green revolution in the country and acceptance of scientific and technical methods of improved farming, development of machines and equipment for timely operation is increasing on the farm.

Duffee (1926) [5] developed a blower with four and six blades and attached to a thresher. According to him as the number of blades increases the vibration decreases with less power requirement and smooth running. Raney and Liljedahl (1957) [11] stated that backward slant blades of the blower required less power because of better efficiency. Bilanski (1962) [3] measured the time required for seeds to fall various predetermined distances in the drip tubes using an electronic counter. He investigated the terminal velocity and aerodynamic properties of Alfa (material having a wide range of particle sizes). The display unit for the tachometer has only 2 digits and frequently, it will display on hundreds and thousands of revolutions. 10 pulses per revolution is simply gave by the times 10 converters and enables the same equipment to display tens and hundreds of revolution without complicating the electronics. In the project, an infrared transceiver1receiver is used which is mounted on a magnetic base and is angle adjustable to enable a good single to be established. To get more accurate reading, the x10 converter is used with. Kashayap and Pandya (1966) [7] studied air velocity requirement for winnowing operations and stated optimum air velocity range of 800-1300 ft./min for winnowing paddy grain with 1.3 ft. dia fan. Sharma (1978) [13] developed a power-operated paddy winnower. This winnower could winnow 350-600 kg/hr of cleaned paddy under normal conditions of operations. Kashayap and Pandya (1966) [7] obtained an optimum air velocity of 800-1300 ft./min based upon extensive experimental results for a winnowing of paddy grains with a 1.3 ft. diameter fan. By feeding grains and chaff separately and comparing the combined results with those for mixtures treated similarly, it was observed that there could be no possibility of any reduction in the air velocity requirement by increasing the height of free fall of grains and chaff above the air stream; whereas with inclined feed, depending upon the type of chaff, there was both decrease and increase in this requirement, though these results were greatly modified when the grains and chaff were present in a mixture.

Saxena *et al.* (1971) [12] stated that the power requirement of a blower used in local thresher varies between 35-85 percent of the total power required for thresher corresponding to the full load and no-load due to irrational and unscientific designs of blowers used in threshers. The machine consists of feeding truff, screen rubber roller, auger, feeding, and exit tuff. This was supported on both ends by self-aligning bearings. The screen was enclosed in a rectangular chamber with 4-section tray placed at the bottom to collect the separated grains. The PTO shaft of the tractor, which in turns drove the screen by a jackshaft, drove the auger. The screen to blade speed ratio was changed by changing the pulleys on the jacket shaft. Further, it was concluded that rotating cylindrical screen with an inner augur rotating at a faster speed is capable of separating grains from straw. The cylindrical screen was capable of transpiring the straw auxiliary and allowed a positive control on the tangential and axial crop motion.

Throwing the mixture against the wind at an angle of about 140° to the horizontal gives maximum separation. Increasing the air velocity, the through velocity and the height of release gives a near-linear increasing separation. He also stated that at 90°, the grain movement is near zero and the separation occurs mainly due to the movement of the chaff. However increasing the angle of throw increases the separation, mainly due to the extra movement of the grain against the wind. Increasing the height and air velocity have a nearest linear effect on the separation increasing the throw velocity has a slightly curvilinear effect. Hoshangabad winnower is a simple type of winnower, which does not require much training and skill to operate. The speed of the fan is kept about 200 to 350 rpm for pedal operated, while 1000 to 1500 rpm for electrically operated fan. It requires three persons to operate. The capacity of the machine is about 200 kg per hour Rajinder *et al.*, 1990 [10].

Kammar and Batagurki (2001) [4] studied the evaluation of different threshing methods for primary processing finger millet. The result stated that the cost of operation mainly depends on the time taken for threshing and winnowing. The operation cost increased as the grain moisture content increases beyond 12 per cent. This may be due to the easy separation of grains under less moisture content, hence the time required for threshing and winnowing is less.

Tabak (2004) [15] stated that the pressure drop due to airflow across seeds filled with cotton seeds depends on the airflow rate and thickness of seedbed. Petkevichius *et al.* (2008) stated that airflow should be less than the terminal velocity of grain to avoid grain being blown on to the straw walker in the maize threshing machine.

As we know that different crops have different physical and chemical properties. In the same way, the chaff of various crops has different physical properties like a different density, shape, etc. Hence, for the winnowing of various crops, the winnower speed needs to be different. Therefore, we need a tachometer to find the speed of winnower so that we can set the speed of winnower for different crops Srivastava, (1974) [14]. A tachometer is a sensor device used to measure the rotation speed of an object such as the engine shaft in a car and is usually restricted to mechanical or electrical instruments. This device indicates the revolutions per minute (RPM) performed by the object.

A digital tachometer is an optical encoder that determines the angular velocity of a rotating shaft or motor. Digital tachometers are used in different applications such as automobiles, airplanes, and medical and instrumentation applications. The word tachometer is derived from two Greek words: tachos means “speed” and metron means “to measure”. It works on the principle of a tachometer generator, which means when a motor is operated as a generator; it produces the voltage according to the velocity of the shaft. It is also known as revolution-counter, and its operating principle can be electromagnetic, electronic or optical-based. Power, accuracy, RPM range, measurements and display are the specifications of a tachometer. Tachometers can be analog or digital indicating meters; however, this article focuses only on the digital tachometers.

Winnowing of threshed crop is amongst such farming operation, where the farmer is more concerned in converting manual winnowing into mechanized winnowing to complete the operation timely and efficiently. In the absence of suitable winnowing machine, farmers have been doing the laborious job of winnowing threshed crop by traditional method, which means waiting for high velocity wind breeze hours together. This necessitates the development of power-operated winnowers that creates an artificial air velocity for winnowing threshed crop. The existing tractor operated axial flow type winnower which is locally manufactured and used for winnowing threshed crop in the farm is not working satisfactorily for winnowing and needs to be modified. Hence, in the present research paper is to modify the existing tractor operated axial flow fan type winnowers to increase the cleaning efficiency of winnowing material.

2. Materials and Methods

2.1 Tractor Operated Winnower

An improved method adopted by big farmers owns the tractor. A winnower is attached to the power source (PTO) which is operated by 35 HP Tractor.

2.2 Tachometer

A tachometer is a sensor device used to measure the rotation speed of an object such as the engine shaft in a car and is usually restricted to mechanical or electrical instruments.

2.3 Construction

The tachometer consists of:

- Proximity sensor
- Arduino Uno
- Potentiometer
- Battery

- LCD 16×2
- Switch
- Jumper cables

2.3.1 Proximity Sensor
A proximity sensor is a sensor able to detect the presence of nearby objects without any physical contact. A proximity sensor often emits an electromagnetic field or a beam of electromagnetic radiation (infrared or instance) and looks for changes in field or return signal. The object being sensed is often referred to as the proximity sensor target. Different proximity sensor targets demand different sensors. For example, a capacitive proximity sensor or photoelectric sensor might be suitable for a plastic target; an inductive proximity sensor always requires a metal target.

Fig 1: Proximity Sensor

2.3.2 Arduino Uno
The Arduino Uno is a microcontroller board based on the ATmega328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started.

Fig 2: Arduino Uno

2.3.3 Potentiometer
A potentiometer sensor measures the distance or displacement of an object in a linear or rotary motion and converts it into an electrical signal. TE Connectivity (TE) manufactures various types of potentiometers including linear potentiometers, rotary sensors and encoders, and cable-actuated position sensors called string pots. The depth of our portfolio helps solve various application solutions with a variety of customizable variables including measurement range, output signal, and electrical connections.

Fig 3: Potentiometer

2.3.4 Battery
A 9-volt battery is used to supply the power into the tachometer.

2.3.5 LCD16 X 2
LCD (Liquid Crystal Display) screen is an electronic display module and finds a wide range of applications. A 16x2 LCD means it can display 16 characters per line and there are 2 such lines. In this LCD, each character is displayed in the 5x7-pixel matrix. This LCD has two registers, namely, Command and Data.

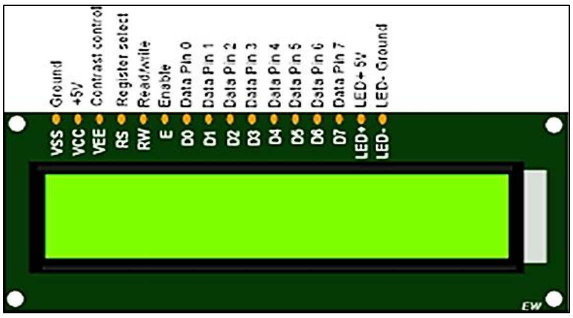

Fig 4: LCD 16×2

2.3.6 Jumper Wires
Jumper wires are used for making connections between items on your breadboard and your Arduino's header pins. Use them to wire up all your circuits

Fig 5: Jumper cables

2.4 Circuit Diagram

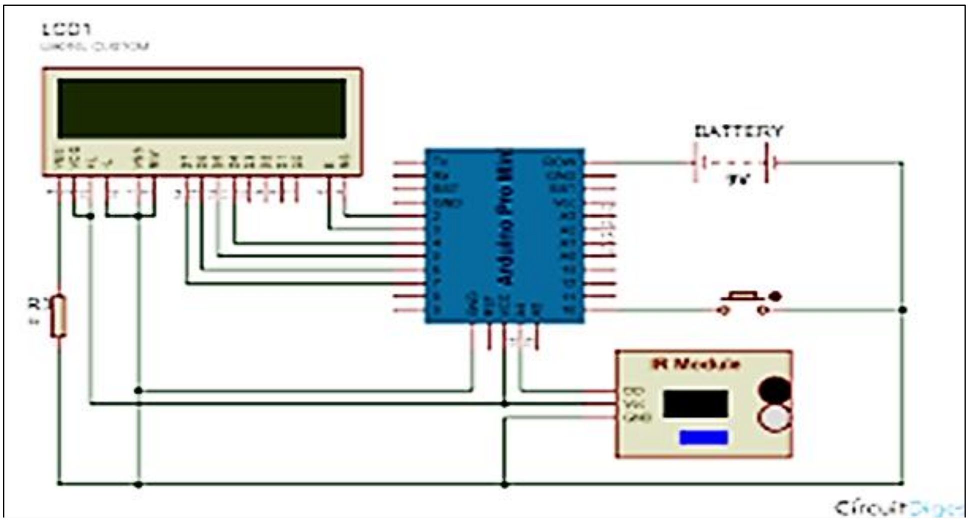

Fig 6: Circuit diagram

As shown in the above tachometer circuit, it contains Arduino Pro Mini, proximity sensor module, buzzer and LCD. Arduino controls the whole process like a reading pulse that proximity sensor module generates according to object detection, calculating RPM and sending RPM value to LCD. With the help of the circuit diagram shown above, the LCD potentiometer, switch, battery, proximity sensor and Arduino Uno were connected with the help of jumper cables.

2.5 Experimental Procedure

The proximity sensor was fixed at a distance of 5mm from the winnower fan and for safety purposes; the LCD of tachometer was fixed at a proper distance from the winnower fan. Whether all of the connections were checked is tight or not. After the adjustment were made, the experiment was conducted. Winnower fan speed measured for different rpm with tachometer assisted. The air velocity was varied depending upon the speed of the winnowing fan. The time taken to winnow a known amount of ragi at combination of different fan speeds (607, 762 and 955 + 2 rpm) and at different air velocity were recorded. It requires six people to operate; two persons to collect the bhusa from the heap, two women are required to drop the mixture with the help of a basket and two more women to remove the trash (big size chaff/straw particles collected at the bottom) from the heap of winnowed grains. The same winnowing method followed for every treatment in three replications, the weight of the winnowed grain, chaff and dust were recorded separately for each treatment in three replications. The average was calculated and analyzed.

With the help of an anemometer and inch tap, the air velocity was measured at different distances from the winnower fan. An anemometer is a device used for measuring air velocity and is a common weather station instrument. The term is derived from the Greek word anemos, which means wind, and is used to describe any wind speed instrument used in meteorology.

Fig 7: Anemometer

2.6 Parameters Recorded

The following observations were recorded and parameters computed during the study

a. Speed of the winnowing fan (rpm, tachometer reading)
b. Speed of the engine (rpm)
c. Speed of PTO (rpm)
d. Weight of grain before winnowing (Kg)
e. Weight of grain after winnowing (Kg)
f. Weight of impurities/chaff after winnowing (Kg)
g. Weight of grain present in the chaff (Kg)
h. Weight of chaff/impurities present in the grain (Kg)
i. Seed moisture content (%)
j. Air velocity at different distance and height (m/s)

3. Results and Discussion

Testing was carried out in order to find out winnower cleaning efficiency for different crop at different winnowing fan speed. During the test, the sample of grain from the main outlet and straw was taken to determine various parameters during the 30-minute test. The samples were taken from an outlet at three intervals i.e. at 5th, 15th and 25th minute of the test. The samples were analyzed and the following parameters were determined.

3.1 Determination of Output Capacity

The clean grains are collected at main and subsidiary outlet. The output capacity was determined by measuring the weight of clean grains converted into an hour basis.

3.2 Measurement of Energy Requirement

The energy requirement for winnowing was measured by analog-type energy meter.

3.3 Measurement of Winnower Cleaning Efficiency

The testing of the tractor-operated winnower was carried out with wheat grain with a grain ratio of 0.95. The fan speed was measured and found to be 785.6 rpm and the airflow rate was 6.8 m/s. Two moisture content levels of paddy were 14.80 per cent and 15.13 per cent, respectively. The performance was carried out at three-winnower fan speed, which are 785.6, 918 and 1049 rpm, respectively, and the details are shown in Table.1. Cleaning efficiency at the main outlet was found to be 95.19 percent, 96.9 percent and 94.7 percent for the first second and third fan speed respectively. The performance of the winnower was found cleaning satisfactory as far as cleaning efficiency output capacity and power consumption is concerned.

Table 1: Performance of power-operated paddy winnower.

S.No.	Particular	Sample 1	Sample 2	Sample 3
1	Speed of engine, (RPM)	600	700	800
2	Speed of PTO, (RPM)	196.4	222.5	262.28
3	Speed of winnowing fan, (RPM)	785.6	918	1049.12
4	Weight of sample before winnowing, (kg)	29.15	23.5	26.50
5	Weight of grain after winnowing, (kg)	27.75	22.71	25.68
6	Weight of chaff/impurity after winnowing, (kg)	14	0.72	0.82
7	Weight of grain present in chaff, (kg)	0.6 0	0.41	0.49
8	Weight of impurity present in grain, (kg)	0.1	0.095	0.92
9	Grain moisture content, (w.b)	12%-15%	12%-15%	12%-15%
10	Air velocity, (m/s)	6.8	7.5	8.2
11	Time required for winnowing (s)	43	37	32
12	Feed rate (kg/hr)	2279.675	2279.675	2279.675
13	Opening of hopper, (cm)	2.4	2.4	2.4
14	Height of dropping grain, (cm)	121	121	121
15	Clean grain distance (cm)	63	88	93
16	Grain ratio	0.95	0.96	0.98
17	Recovery	0.98	0.98	0.98
18	Purity	0.99	0.99	0.99
19	Winnowing index	097	097	097
20	Cleaning efficiency	95%	96%	94.7%

3.4 Air velocity in front of winnowing fan at a fan speed of 607 + 2 RPM (650 engine rpm)

The observations presented in Table.2.Shows that at a height (from the ground level) of 80 cm and a distance of 60 cm from the fan axis (In front of a fan) the maximum air velocity was found to be 7.3 m/sec. Further, the lower air velocity (1.7 m/s) was found to be at 260 cm distance from the fan (front side) similar results observed in Kayal and Pandya (1966) [8].

Table 2: Air velocity at different speed and distances

S. No.	Distance from winnower fan	Air velocity at Engine RPM 650	Air velocity at Engine RPM 700
1	60	7.3	7.8
2	80	7.3	8.6
3	100	4.5	7.8
4	120	5.5	6.5
5	140	4.7	5
6	160	3.5	5.1
7	180	3	4.9
8	200	2.8	2.8
9	220	2.6	2.3
10	240	2.1	2.1
11	260	1.7	1.9

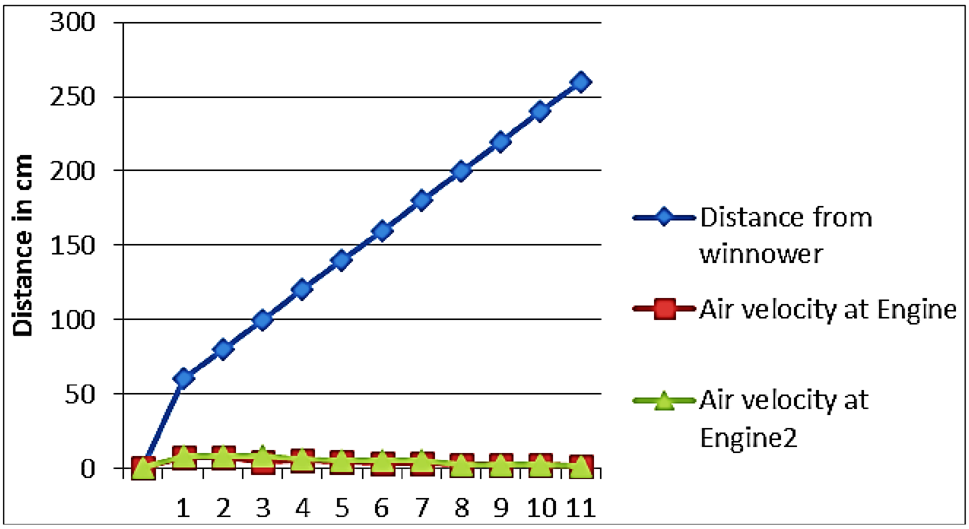

Fig 8: Comparison between air velocities at different engine speed at a uniform distance

4. Summary and Conclusion

Winnowing is the process of separating the grain from a mix of bhusa and grain by natural wind or artificially created air blast. This operation is normally done by using natural wind (manual winnowing). One of the main difficulties faced by the big and medium farmers is the non-availability of suitable winnowing technology to separate the grain from impurities. The farmers generally winnow the threshed crop by manual method but this method was time and labor-consuming involves a lot of drudgery in winnowing operation and also cost of operation this method depends on labour availability and favorable weather condition.

Hence, the introduction of mechanical winnower each and important and valuable step. A tachometer is a sensor device used to measure the rotation speed of an object such as the engine shaft in a car and is usually restricted to mechanical or electrical instruments. We used tachometer to measure winnower fan rpm. Performance of tractor-operated winnower was evaluated at three different winnower fan rpm, which were 786, 918 and 1049 rpm. Cleaning efficiency at main outlet was found to be 95.19 percent, 96.9 percent and 94.7 percent for first second and third winnower fan speed respectively. The optimum cleaning efficiency of 96 percent was found at winnower rpm of 918. This proves that winnower cleaning efficiency increases at the beginning with winnower fan rpm but later on, it decreases with the continuous increase of winnower fan rpm. Air velocity also measured at different speed distances from winnower fan. The maximum air velocity was found to be 7.3 m/sec at a distance of 60 cm from the fan axis (In front of fan). Further, the lowest air velocity (1.7 m/s) was found to be at 260 cm distance from the fan (front side). Hence tractor operated winnower can be operated at 918 rpm for high cleaning efficiency and winnower hopper can be adjusted at a distance of 60 cm from winnower fan axis to provide an optimum air velocity to the grain.

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