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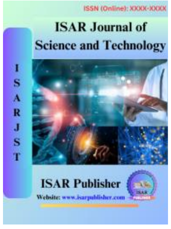

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Calculating time and energy in the Coffee Grinding Process using 1 Phase Motor to fit several amounts of coffee

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Abstract: Coffee grinding is an important process in the coffee industry to produce coffee grounds that are smooth and in accordance with consumer preferences. The motor power required to operate a coffee milling machine becomes a key factor in determining the performance and operational efficiency of the machine. This study aims to determine the time and energy needed to grind several kinds of coffee in the grinding process.

The method of calculating the time and energy needed to grind coffee beans becomes very important in order to be able to grind coffee. From these calculations, it is calculated based on the amount of coffee to be ground and the time required for grinding.The calculation results show that using the required motor power increases with an increase in the amount of coffee to be ground and a shorter grinding time. Therefore, the selection of motor power in accordance with the capacity and production needs of coffee grinding machines is crucial to ensure optimal performance and operational efficiency.[5][6]

This research contributes to the understanding of those influencing the timing of coffee grinding, in selecting motor powers that can determine the time for grinding their production.[7][8][9].

Keywords: Milling, time efficiency, Electric motor.

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I. Introduction

Coffee is a drink that is much liked by the people of Indonesia both from the upper class and those from the lower society like it. The coffee industry has grown rapidly around the world, with the demand for high-quality coffee continuing to increase. Behind a delicious cup of coffee, there is a complex process that involves various stages, one of which is the grinding of coffee beans. Coffee grinding machines play an important role in converting raw coffee beans into ready-to-brew coffee grounds.[1]

One of the key aspects in the design and operation of a coffee grinding machine is the determination of the time needed to be able to move the machine efficiently, produce consistent grinding results, and meet the desired production needs. Improper selection of motor power can result in efficient engine performance in energy consumption and even become very long time used for the coffee grinding process.[2][3]

In this study about calculating the time needed to grind coffee with motor power that matches the data on the coffee grinding machine becomes very relevant. By understanding the factors that affect motor power requirements, coffee producers can make more informed and effective decisions in choosing a motor that fits their coffee grinding machine. To determine the energy needed and the time[4]

The importance of determining the power of a proper 1-phase motor in the coffee grinding industry, highlights the factors to consider in the determination process. Thus, it is expected to provide a deeper understanding of the energy and time requirements for grinding coffee.

II. Method

In the system of optimizing the Coffee Grinding Process to get efficiency and also improve quality, it can be determined from the Motor Power to grind coffee, including:

2.1. Data:

The required data includes the amount of coffee to be ground and the desired time for the grinding process. This information can be obtained from existing production processes or can be estimated based on projected production needs.

At the time of coffee 1 kg

At the time of coffee 5 kg

At the time of coffee 10 kg

At the time of coffee 100 kg

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2.2. Determination of Energy Required:

The energy required to grind coffee in order can be calculated based on the energy required to turn coffee beans into coffee grounds. This energy can be estimated using empirical data or measurement results directly from existing coffee grinding machines.

To calculate the electrical energy consumed by motor power, we can use the following formula:

$E = P \times t$

where:

E is the electrical energy consumed by the motor, measured in kilowatt-hours (kWh).

P is motor power, measured in kilowatts (kW).

t is the time of use of the motor, measured in hours.

The above formula calculates electrical energy by multiplying the motor power by the motor usage time. It gives us the amount of electrical energy consumed by the motor over a period of time.

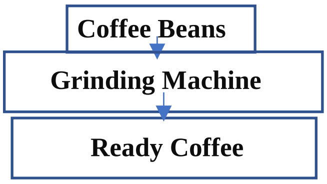

Fig 1.block scheme for a coffee grinder:

Explanation:

1. **Coffee Beans**: The initial stage in the coffee grinding process is the coffee beans that will be used as raw materials. These coffee beans can come from various sources and have different characteristics.
2. **Grinding Machine**: The coffee grinding machine is the main device in the grinding process. This machine is tasked with converting coffee beans into fine coffee grounds. Grinding machines can be manual, semi-automatic, or automatic, depending on the scale of production and the desired degree of fineness.
3. **Ready Coffee** : The end result of the grinding process is ready-made coffee grounds. These coffee grounds can be directly used to brew coffee in Block diagram This diagram provides an overview of the process flow in coffee grinding. Although simple, it reflects the main steps in the process.

This block scheme includes the main steps in the coffee grinding process, from coffee beans to becoming ready-made coffee grounds. Each stage has an important role to play in ensuring the quality and consistency of the final result.

By following this methodology, coffee producers can determine the appropriate motor power for their coffee grinding machines, which in turn will support efficient and productive operations in the coffee industry.Choosing an electric motor for a coffee grinding machine can involve several factors, including the power required, speed, torque, and energy efficiency of the time it takes to grind the coffee. Here are some examples of electric motor specifications that can be used for coffee grinding machines:

Motoric data

1. **Single Phase Electric Motor**: Single phase motor can also be an option for coffee grinding machine. Here are sample specifications for a single-phase electric motor:
   - Tegangan: 220V - 240V
   - Daya: 0.5 HP - 3 HP
   - Speed: 1400 - 2800 RPM
   - Frequency: 50 Hz - 60 Hz
   - Insulation Classification: F or H
   - Protection Type: IP55 (dust and water resistant)

III. Results and Discussion

3.1. Determination of Energy Required:

The energy required to grind coffee in order can be calculated based on the energy required to turn coffee beans into coffee grounds. This energy can be estimated using empirical data or measurement results directly from existing coffee grinding machines.

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t is the time of use of the motor, measured in hours.

We will try each combination of frequency and slip values within a given range, and then use the above formula to calculate the speed of the motor.

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P is motor power, measured in kilowatts (kW).

t is the time of use of the motor, measured in hours.

The combination of synchronous frequency and speed values to obtain the appropriate number of poles.

For example, we can try frequencies of 50 Hz to 60 Hz and synchronous speeds of 1400 to 2800 RPM:

1. For 50 Hz frequency and 1400 RPM synchronous speed:

$$P=\frac{120\times 50}{1400}$$

$$P\approx 4,29$$

2. For 60 Hz frequency and 1400 RPM synchronous speed:

$$P=\frac{120\times 60}{1400}$$

$$P\approx 5,14$$

3. And so on for different combinations of synchronous frequency and speed values within a given range.

By trying several combinations of synchronous frequency and speed values within a given range, we can determine the number of poles that may be appropriate for the requested motor speed range.

To calculate the speed of a single-phase motor with the number of poles 6, a frequency range of 50 Hz to 60 Hz, and a slip range of 0.02 to 0.05, we can use the general formula for the speed of a single-phase motor:

$$N=\frac{120\times f\times (1-s)}{P}$$

where:

N is the motor speed in RPM.

f is the frequency of the electrical system, in hertz (Hz).

P is the number of poles of the motor.

s is the slip motor.

We will try each combination of frequency and slip values within a given range, and then use the above formula to calculate the speed of the motor.

For example, we would try frequencies of 50 Hz to 60 Hz and slips 0.02 to 0.05 for the number of poles 6:

1. For 50 Hz frequency and 0.02 slip:

$$N=\frac{120\times 50}{6}\times(1-0.02)$$

$$N\approx 995.83RPM$$

2. For 60 Hz frequency and 0.02 slip:

$$N=\frac{120\times 60}{6}\times(1-0.02)$$

$$N\approx 1195.00RPM$$

3. And so on for different combinations of frequency and slip values within a given range.

By trying several combinations of frequency and slip values within a given range, we can determine the motor speed that may be appropriate for the number of poles 6 and the requested frequency range.

To calculate the time it takes to reach a certain speed with a certain torque, we need to use additional information about the acceleration of the motor. If we have that information, we can use the formula:

$$t=\frac{N-N0}{\alpha}$$

where:

t is the time it takes to reach speed *N*,

N is the final speed to be achieved (in RPM),

N0 is the initial speed (in RPM), and

α is the acceleration of the motor (in RPM/s²).

However, without information about the acceleration of the motor, we cannot calculate the time it takes to reach a certain speed. Additional data or motor model is required to calculate the exact required time.

Using the given value:

$N=995.38\ RPM$ (final speed),

$N0=0\ RPM$ (initial speed), and

$\alpha=0.4\ RPM/s^2$ (acceleration),

We can calculate the time (t) required:

$$t=\frac{995,38-0}{0,4}$$

$$t\approx\frac{995,38}{0,4}$$

$$T\approx 2488.45s$$

So, the time required to reach a speed of 995.38 RPM with an initial speed of 0 and an acceleration of 0.4 RPM/s² is about 2488.45 seconds.

To calculate the power required by the motor at a certain speed, we can use the formula:

$$P=\frac{T\times\omega}{1000}$$

where:

P is the motor power in kilowatts (kW),

T is the torque produced by the motor in Newton meters (Nm), and

ω is the angular velocity of the motor in radians per second (rad/s).

However, to use this formula, we need to know the value of the torque produced by the motor at a certain speed. Without this information, we cannot calculate the power required.

If you have data on the torque-speed characteristics of the motor (for example, the torque-speed curve), you can use that data to determine the torque at 995.38 RPM. From there, we can calculate the power required.

To find the torque required by the motor at a certain speed, we can use the basic formula:

$$T = \frac{P \times 1000}{\omega}$$

where:

T is the torque required by the motor in Newton meters (Nm),

P is the motor power in kilowatts (kW), and

ω is the angular velocity of the motor in radians per second (rad/s).

However, to use this formula, we need to know the value of motor power and motor angular velocity at the same time.

To calculate the torque at a certain speed with various motor power values, we can use the formula:

$$T=\frac{P\times1000}{\omega}$$

where:

T is the torque required by the motor in Newton meters (Nm),

P is the motor power in kilowatts (kW), and

ω is the angular velocity of the motor in radians per second (rad/s).

However, keep in mind that a given motor speed is in RPM (rotations per minute), so we need to convert it to rad/s by multiplying it by 2π./60

calculates the torque required at a speed of 995.83 RPM with a range of power ratings from 0.5 HP to 3 HP.

1. Power conversion to kilowatts:

   1 HP=0.7457 kW

   So, for power ranges from 0.5 HP to 3 HP:

   - For 0.5 HP:

     $P=0{,}5\times0{,}7457\ kW$

   - For 3 HP:

     $P=3\times0{,}7457\ kW$

2. Convert speed to rad/s:

   $\omega=995{,}83\times602\pi$

3. Calculate torque for each power value:

   $$T=\frac{P\times1000}{\omega}$$

Calculates the torque required for a speed of 995.83 RPM with a range of power ratings from 0.5 HP to 3 HP:

1. Power conversion to kilowatts:

   HP=0.7457 kW

   For 0.5 HP: $L=0.5\times0.7457\ kW$

   $L\approx0.37285\ kW$

   For 3 HP: $L=3\times0.7457\ kW$

   $L\approx2.2371\ kW$

2. Convert speed to rad/s:

   $\omega=995{,}83\times2\pi/60$

   $\omega\approx103.94\ rad/s$

3. Calculate torque for each power value:

   - For 0.5 HP power: $T=\frac{0.37285\times1000}{103{,}94}$

     $T\approx3.58\ Nm$

   - For 3 HP power: $T=\frac{2.2371\times1000}{103{,}94}$

     $T\approx21.53\ Nm$

So, the torque required for a speed of 995.83 RPM with a motor power of 0.5 HP is about 3.58 Nm, while for a 3 HP motor power is about 21.53 Nm.

To calculate the energy required by a motor with various power values in a certain time span, we can use the formula:

$E=P\times t$

where:

E is the energy required by the motor in kilowatt-hours (kWh),

P is the motor power in kilowatts (kW), and

t is the time of use of the motor in hours (hours).

The time obtained is in seconds, so you can convert it to hours by dividing it by 3600 (because 1 hour = 3600 seconds).

Energy required to power 0.5 HP (as 0.37285 kW) and 3 HP (as 2.2371 kW) in 2488.45 seconds:

1. Convert time to hours:

   $$\text{Waktu (jam)}=\frac{2488.45}{3600}$$

2. Calculate the energy for each power value:

   - For 0.5 HP power:

     $E=0.37285\times Time\ (hours)$

   - For 3 HP power:

     $E=2.2371\times Time\ (hours)$

Energy required to power 0.5 HP and 3 HP in 2488.45 seconds:

1. Convert time to hours:

   $$\text{Waktu (jam)}=\frac{2488.45}{3600}$$

Time (hours)≈0.6912

2. Calculate the energy for each power value:

- For 0.5 HP power (as 0.37285 kW):

  $E=0,37285\times 0,6912$

  $E\approx 0.2579kWh$

- For 3 HP power (as 2.2371 kW):

  $E=2,2371\times 0,6912$

  $E\approx 1.5453kWh$

So, the energy required for 0.5 HP power in 2488.45 seconds is about 0.2579 kWh, while for 3 HP power is about 1.5453 kWh.

To calculate the time it takes to grind 1 kg of coffee using 21.53 Nm of torque, 995.83 RPM speed, and 0.5 HP motor power, we need to follow a few steps:

Step 1: Convert speed from RPM to rad/s:

$\omega=995,83\times 2\pi/60$

$\omega\approx 104.05rad/s$

Step 2: Calculate the energy required to grind the coffee:

$E=T\times\omega$

$E=21.53Nm\times 104.05rad/s$

$E\approx 2241,46Joule$

Step 3: Convert motor power into energy:

$P=0.5\times 0.7457$

$P\approx 0.37285kW$

Step 4: Determine the grinding time:

$t=\frac{E}{P}$

$t=\frac{2241,46}{0,37285}$

$T\approx 6007.93s$

So, the time needed to grind 1 kg of coffee with 21.53 Nm of torque, 995.83 RPM speed, and 0.5 HP motor power is about 6007.93 seconds or about 1.67 hours.

To calculate the time needed to grind 10 kg of coffee using 21.53 Nm of torque, 995.83 RPM speed, and 3 HP motor power, we will follow these steps:

Step 1: Convert motor power from HP to kilowatts (kW):

$P=3\times 0.7457$

$P\approx 2,2371kW$

Step 2: Convert speed from RPM to rad/s:

$\omega=995,83\times 2\pi/60$

$\omega\approx 104.05rad/s$

Step 3: Calculate the energy required to grind coffee:

$E=T\times\omega$

$E=21,53Nm\times 104,05rad/s$

$E\approx 2241.46Joule$

Step 4: Convert motor power into energy:

$P=2,2371kW$

Step 5: Determine the grinding time:

$t=\frac{E}{P}$

$t=2,23712241,46$

$T\approx 1002.32s$

So, the time needed to grind 10 kg of coffee with 21.53 Nm of torque, a speed of 995.83 RPM, and a motor power of 3 HP is about 1002.32 seconds or about 16.7 minutes.

TABEL 1: Motor Power 0.5 HP with frequency 50 HZ

No	1	2	3	4	5	6	7
1	Energy Joule	Coffee weight (kg)	Slept	Slept	Speed rad/s	Power conversion (Kw)	time
2	2241,46	1	0.02	0,05	104,05	2,2371	6007.93 (1.67 minutes)
3	2241,46	5	0.02	0,05	104,05	2,2371	6007.93 (1.67 minutes)
4	2241,46	20	0.02	0,05	104,05	2,2371	6007.93 (1.67 minutes)
5	2241,46	100	0.02	0,05	104,05	2,2371	6007.93 (1.67 minutes)

TABEL 2: Motor Power 3 HP with frequency 50 HZ

No	1	2	3	4	5	6	7
1	Energy Joule	Coffee weight (kg)	Slept	Slept	Speed rad/s	Power conversion (Kw)	time
2	2241,46	1	0.02	0,05	104,05	2,2371	1002,32(16,7 minutes)
3	2241,46	5	0.02	0,05	104,05	2,2371	1002,32(16,7 minutes)
4	2241,46	20	0.02	0,05	104,05	2,2371	1002,32(16,7 minutes)
5	2241,46	100	0.02	0,05	104,05	2,2371	1002,32(16,7 minutes)

IV. Conclusion

The determination of motor power in a coffee grinding machine is an important aspect in the design and operation of such machines. Various factors need to be considered to determine the right motor power according to production needs and the characteristics of the coffee beans used. Based on the previous discussion, several conclusions can be drawn:

1. For torque required for a speed of 995.83 RPM with a motor power of 0.5 HP is about 3.58 Nm, while for a motor power of 3 HP is about 21.53 Nm and

   The motor power must be adjusted to the needs of the coffee grinding machine production.
2. The time required to reach a speed of 995.38 RPM with an initial speed of 0 and an acceleration of 0.4 RPM/s² is about 2488.45 seconds.
3. From the calculations obtained that from 1 kg .5 kg 10 kg and 100 kg with 0.5 HP motor power the time needed is about 6007.93 seconds or about 1.67 hours.

   From the calculations obtained that from 1 kg .5 kg 10 kg and 100 kg with motor power3 HP the time needed is about 1002.32 seconds or about 16.7 minutes.

   Where with 21.53 Nm of torque, speed of 995.83 RPM,

By paying attention to the proper use of electric motors it can make, coffee manufacturers can determine the right motor power for their coffee grinding machines. This will support efficient, productive, and sustainable operations in the coffee industry

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