Design and development of a belt and pulley transmission system for a bitumen mixer machine

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Abstract
The belt and pulley transmission system is a crucial component in a bitumen mixer machine, functioning to transmit rotational power from the drive motor to the agitator shaft smoothly and with minimal vibration. An improper transmission design risks triggering slippage and excessive vibration, which can disrupt the homogeneity of the asphalt mixing process. This study aims to design an optimal pulley and belt transmission system for a 2 kg capacity bitumen mixer machine with a target agitator shaft rotation of 4000 to 5000 RPM. The design methodology was conducted through design requirement analysis and the calculation of transmission mechanical parameters based on a 1 HP, 3-phase, 2900 RPM electric drive motor. The design results established the use of a transmission system with a 2:1 pulley size ratio, utilizing a cast iron driver pulley with a diameter of 152 mm and a driven pulley with a diameter of 76 mm. To transmit this power, the system utilizes 1 unit of a rubber V-belt component with a standard market length of 1750 mm. Based on technical testing results, the designed transmission system is capable of operating safely and efficiently, as well as successfully accommodating the required rotation on the agitator shaft.

1. Introduction

Bitumen is a black or dark-colored viscous cementitious material, existing in solid or semi-solid form, which can be obtained naturally or as a product of industrial processing [1]. Asphalt is one of the substances classified within the bitumen group. In modern construction practice, asphalt is widely used in infrastructure development, particularly for road pavement [2]. The asphalt commonly used today is derived from petroleum distillation [1].

Along with the advancement of construction technology, continuous efforts have been made to improve pavement quality. The blending of asphalt with plastic waste has emerged as a significant innovation in enhancing the performance and sustainability of road pavements. The incorporation of plastic into asphalt bitumen can improve its mechanical properties, including increased strength, stiffness, and resistance to high temperatures. Beyond these technical benefits, the utilization of plastic waste in asphalt also contributes to environmental pollution reduction by helping to decrease the volume of non-biodegradable material, such as plastic waste that is not optimally processed [3]. The urgency of utilizing plastic waste in the construction industry, particularly in road pavement applications, becomes increasingly evident given the current state of environmental pollution in Indonesia. Environmental pollution caused by plastic waste has been a long-standing, inherited problem in Indonesia. At present, Indonesia is the world's second-largest contributor of plastic waste after China, generating approximately 8.96 million tons annually [4]. Furthermore, according to a report from the National Waste Management Information System (SIPSN), as shown in Figure 1, the total waste generation in Indonesia in 2024 reached 36.660.477 tons, of which approximately 67.59% remained inadequately managed. This indicates that plastic waste management in Indonesia is still relatively poor. Therefore, an innovative approach is required to help reduce the amount of improperly processed plastic waste, one of which is the utilization of plastic waste as a reinforcing material blended into asphalt.

The mixing process between bitumen and plastic waste requires controlled temperature and stirring speed to produce a homogeneous mixture. The bitumen mixer machine plays a crucial role in maintaining mixing temperature stability, ensuring that the plastic melts and disperses evenly throughout the bitumen. Optimal mixer performance directly affects the homogeneity, viscosity, and adhesive strength of the final mixture, which ultimately determines the quality and durability of the resulting road pavement.

One of the main components of the bitumen mixer machine is the transmission system, namely the pulley and belt. In this asphalt mixing machine, the pulley-belt system was selected as the transmission mechanism due to several advantages, such as quieter operation and easier maintenance and installation compared to chain or gear transmissions [5]; [6]. However, pulley-belt systems also present certain drawbacks, including the

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potential for slippage and excessive vibration when the design is improperly configured for instance, an incorrect determination of belt length (belt too long, resulting in insufficient gripping force on the pulley).

An improper design of the pulley-belt transmission system can cause performance disturbances in the machine, such as slippage and excessive vibration, which may hinder the mixing process. Factors that influence pulley performance include the accuracy of the pulley ratio, belt length, and the required number of belts. These aspects must be carefully designed to produce a stable, safe, and efficient transmission system. This bitumen mixer machine is used to mix liquid asphalt with a capacity of 2 kg and to maintain its temperature at 135°C for 15 minutes of mixing at a rotational speed of 4.000–5.000 RPM. The machine is driven by a 1 HP, 3-phase electric motor with a maximum rotational speed of 2.900 RPM, as stated on the nameplate. This study aims to design the pulley-belt transmission system required to enable the machine to operate in a stable, safe, and efficient manner.

2. Method

2.1. Design Stages

The design process of the belt and pulley transmission system for a bitumen mixer machine consists of several stages, as illustrated in Figure 1.

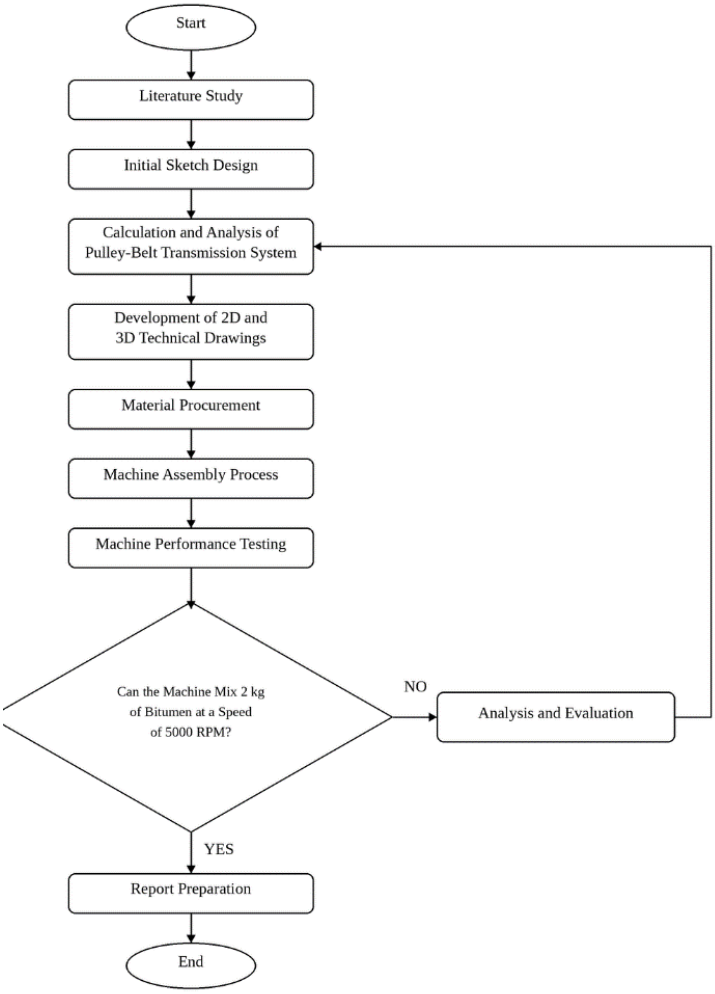

Figure 1. Flow Diagram Design Process

2.2. Literature Review

A bitumen mixer machine is a machine used in the process of blending bitumen asphalt with aggregates or other reinforcing agents [7]. This machine operates by stirring the bitumen through shaft rotation transmitted from the motor via a transmission system [8]. During the mixing process, an electric heating system is simultaneously activated to raise the asphalt temperature to the desired level.

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2.3. Calculation of the Pulley-Belt Transmission System

The transmission system calculation aims to obtain a design suitable for the bitumen mixer machine, as well as to prevent unwanted failure or damage resulting from improper transmission system design [9]. The machine employs a 1 HP, 3-phase electric motor with a maximum rotational speed of 2.900 RPM, which is transmitted through a pulley-belt system with a pulley size ratio of 1:2, enabling the agitator shaft output to reach a maximum of 5.800 RPM. This 1:2 ratio was selected to accommodate the required agitator shaft speed range of 4.000–5.000 RPM.

2.4. Sketch Design

The sketching process was carried out based on the data and information obtained during the project initiation phase. The resulting sketches served as the reference for subsequent 2D and 3D technical drawings. The sketch of the bitumen mixer machine is shown in Figure 2.

2.5. Development of 2D and 3D Technical Drawings

The 2D and 3D design drawings were developed after obtaining specific references from the preceding sketching process and calculations. The design drawings were prepared in detail, including complete dimensions for each machine component. The 2D and 3D design drawings of the bitumen mixer machine are shown in Figures 3.3 and 3.4, respectively.

2.6. Material Procurement

Procurement is a systematic process undertaken to fulfill the goods or services required within a work plan [10]. For the material procurement process of the bitumen mixer machine, a Bill of Materials (BOM) was prepared to support a structured and systematic procurement process. A Bill of Materials contains information regarding product composition, including material specifications, dimensions, and the quantities required for the production process [11].

2.7. Machine Assembly Process

The machine assembly process was carried out after all preparatory stages including sketch design, technical drawings, and material preparation were completed. This process was conducted carefully and safely to avoid workmanship errors and occupational accidents, comprising: Material cutting process; machine fabrication process; and finishing and painting process.

2.8. Testing

Following the assembly process, machine testing was conducted to determine whether machine performance had reached optimal levels in accordance with the target specifications.

a. No-load testing

No-load testing was performed by operating the machine in an empty condition (without material load) to evaluate the machine's initial performance and the mechanical stability of its basic components, including the motor, transmission system, bearings, and shaft.

b . Loaded testing with pure bitumen (without reinforcing material)

This test was conducted by operating the machine with the kowi (mixing vessel) filled with pure bitumen material, without any reinforcing additive. This test served to evaluate the machine's capability to stir hot liquid bitumen and to assess the performance of the heating system.

c. Loaded testing with bitumen and reinforcing material

This test was conducted using a mixture of bitumen and reinforcing material in the form of processed plastic powder. The procedure involved introducing pure liquid bitumen into the kowi, followed by the addition of the plastic powder mixture, after which the machine was activated. This test served to simulate the machine's operational performance when used with a bitumen-reinforcement material blend, as intended for actual field application.

2.9. Analysis and Improvement

Following the testing process, a performance analysis of the machine was conducted. If the machine's performance was found to be suboptimal or inconsistent with the target specifications, an improvement process was carried out to refine the machine's condition and performance.

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2.10. Report Preparation

All results from the design, assembly, and testing stages were documented in the form of a scientific report. The report includes the background, literature review, design methodology, results and discussion, as well as conclusions and recommendations. This report was prepared in accordance with scientific writing guidelines and supported by valid references and technical evidence, including relevant figures.

3. Results and Discussion

3.1. Calculating actual power

To find the actual power, the actual power and power in the transmission are first calculated by looking for the total torque that occurs, which is the sum of the running torque and no-load torque at the time the machine is operating.

3.1.1. Calculating Loadless Torque on the mixer shaft

Before calculating the amount of unloaded Torque on the mixer shaft, first a calculation is carried out to find the angular speed of the mixer shaft with a rpm (n) value of 5000 rpm according to the client's request. Here is a series of calculations to find the No-load Torque. Calculating the angular speed of the stirring shaft with Equations (1).

$$\omega = \frac{2 \times \pi \times n}{60} \quad (1)$$

With known parameters: n = 5000 rpm, then the value ω is:

$$\omega = \frac{2 \times \pi \times 5000}{60}$$

$$\omega = \frac{3.1415.9}{60} = 523.6 \text{ rad/s}$$

Calculating moments of inertia with Equations (2).

$$\text{I} = \frac{1}{2} \times m \times r^2 \quad (2)$$

With known parameters:

m = 2.26 Kg $(mass\ of\ mixer\ shaft)$

r = 0.0375 m $(length\ of\ blade)$

Then the value of the moment of inertia is:

$$\text{I} = \frac{1}{2} \times m \times r^2$$

$$\text{I} = \frac{1}{2} \times 2.26 \times 0.0375^2$$

$$\text{I} = 0.001589\ Kg.m^2$$

Once the moment of inertia is known, the next step is to calculate the acceleration with the Equation (3).

$$\alpha = \frac{\omega}{t} \quad (3)$$

With known parameters are:

ω = 523.6 rad/s

t = 2 s $(time\ the\ shaft\ needed\ to\ moving\ at\ start)$

So, the acceleration values are:

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$$\alpha = \frac{\omega}{t}$$

$$\alpha = \frac{523.6}{2} = 261.8\ rad/s^2$$

After knowing the value of the moment of inertia and acceleration, the value of torque without load can be determined using the Equation (4).

$$T = I \times \alpha \quad (4)$$

With known parameters:

$I = 0.001589\ Kg.m^2$

$\alpha = 261.8\ rad/s2$

Then the value of T is:

$T = I \times \alpha$

$T = 0.001589 \times 261.8$

$T = 0.416\ Nm$

3.1.2. Calculating Running Torque

The value of running torque is the amount of torque that occurs by taking into account the load of bitumen when the engine is operating normally. Before determining the running torque value, first calculate the cross-sectional area of the blade and the fluid resistance force. Here is a series of running torque calculations. Calculate the cross-sectional area of the stirring shaft blade blades using the Equation (5).

$$A = n \times (P \times L) \quad (5)$$

With known parameters:

$n = 4\ (number\ of\ blade)$

$P = 0.0375\ m\ (length\ of\ blade)$

$L = 0.015\ m\ (width\ of\ blade)$

Then the value of A is:

$A = n \times (P \times L)$

$A = 4 \times (0.0375 \times 0.015)$

$A = 0.00225\ m^2$

Once the value of the cross-sectional area of the blade is known, the next step is to calculate the angular velocity of the blade tip using a series of Equations (6):

With known parameters:

$\omega = 523.6\ rad/s$

$r = 0.0375\ m$

Then the value is:

$$v = \omega \times r \quad (6)$$

$v = 523.6 \times 0.0375$

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v = 19.635 m/s

Once the angular velocity value of the blade tip is known, the next step is to calculate the fluid resistance force using a series of equations:

$$\tau = \mu \times \frac{v}{gap} \text{ and } F_{fluid} = \tau \times A \quad (7)$$

With known parameters [12]:

μ = 0.5 $Pa.s$ ($viscosity\ of\ bitumen$)

v = 19.635 m/s

gap = 0.020 m ($distance\ beetwen\ top\ of\ blade$ and $wall$)

A = 0.00225 $m2$

The gap value is illustrated in the following Figure 2.



Figure 2. Illustration of the gap on the blade

Then the value is:

$$\tau = \mu \times \frac{v}{gap}$$

$$\tau = 0.5 \times \frac{19.635}{0.020} = 490.87\ Pa$$

Then the value is: F_{fluida}

$$F_{fluid} = \tau \times A$$

$$F_{fluid} = 490.87 \times 0.00225$$

$$F_{fluid} = 1.104\ N$$

Once the value is known, then the value of the Running Torque $Ffluida$ can be calculated using the Equation (8).

$$T_{running} = F \times r \quad (8)$$

With known parameters:

F = 1.104 N

r = 0.0375 m

Then the value is:

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$T_{running} = F \times r$

$T_{running} = 1.104 \times 0.0375$

$T_{running} = 0.0414\ Nm$

So, the amount of torque of the stirring shaft when running is 0.0414 Nm.

3.1.3. Calculating total torque

After the value of T and is known, the total torque can be known using the Equation (9):

$$T_{total} = T + T_{running} \quad (9)$$

With known parameters:

$T = 0.416\ Nm$

$T_{running} = 0.0414\ Nm$

Then the value is:

$T_{total} = T_{running} + T$

$T_{total} = 0.0414\ Nm + 0.416\ Nm$

$T_{total} = 0.4574\ Nm$

3.1.4. Actual power

Once the total torque is known, then the actual power value that occurs can be calculated using the Equation (10):

$$P_{\text{actual}} = T_{total} \times \omega \quad (10)$$

With known parameters are:

$P_{actual} = 0.4574 \times 523.6$

$P_{actual} = 239.5\ watt$

So, the actual power that occurs in this bitumen mixer machine is 239.5 watts. So that a 1HP 746-watt electric motor is enough to meet the power needs of a bitumen mixer machine. Because the required power is only about 32% of the motor rated power (239.5 W out of 746 W), the selected motor provides a considerable power reserve. This safety margin allows stable operation and reduces the likelihood of overload during prolonged mixing [14].

3.2. Determining the Diameter and Ratio of the Pulley

This bitumen mixer machine uses a belt and pulley transmission system, where there are two pulleys attached to the drive shaft and the mixer shaft respectively. The type of drive used is a 1 HP 3 Phase electric motor with the maximum speed stated on the motor nameplate is 2900 RPM. During the stirring process, the speed of the drive motor will be set using the inverter to 2500 RPM. Then the rotation will be passed by the transmission system to the mixer shaft in a ratio of 1:2 so that the mixer shaft will rotate 5000 RPM. The diameter and ratio of the pulley are determined by the following Equation (11) relationship:

$$\frac{N_1}{N_2} = \frac{d_2}{d_1} \quad (11)$$

Based on the data of the drive motor, a survey was conducted in the market regarding the size of the pulley available for the drive motor shaft. A pulley driver (d_1) is obtained with a size of 6 inches or 152 mm or 0.152 m. Thus, the diameter of the pulley driven (d_2) is determined by the following calculations:

$d_2 = \frac{N_1 \times d_2}{N_1} = \frac{2500 \times 152}{5000} = 76$ mm = 3 inch

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So, the pulley on the mixer shaft (d2) uses a pulley with a size of 3 inches or 76 mm or 0.076 m for a 1:2 ratio.

3.3. Calculating the length of the belt

After knowing the diameter of the pulley in the transmission system, the next step is to find the required belt length. This calculation is done to prevent the belt from being too tight or too loose so that the transmission system can continue the rotation optimally. The following is the sequence of calculations to find the required belt length can be seen in Figure 3. Known parameters:

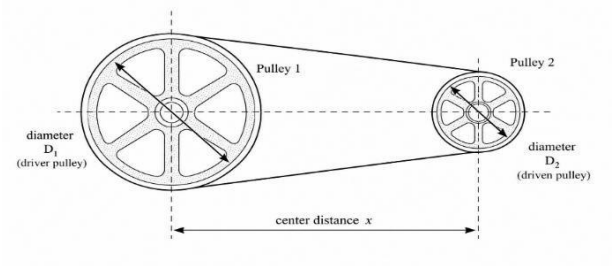

Figure 3.Illustration of Pulley and Belt transmission system series

$r_1 = \frac{d_1}{2} = \frac{0.152}{2} = 0.076$

$r_2 = \frac{d_2}{2} = \frac{0.076}{2} = 0.038$

$x = 685\ mm = 0.685\ m$

Once the above parameters are known, the belt length is calculated using the Equation (12):

$$L = \pi\ (r_1 + r_2) + 2x + \frac{(r_1 - r_2)^2}{\mathrm{x}} \quad (12)$$

$L = \pi\ (0.076 + 0.038) + 2 \times 0.685 + \frac{(0.076 - 0.038)^2}{0.685}$

$L = \pi\ (0.114) + 1.37 + 0.002$

$L = 1.73\ m$

So, the belt length required for the transmission system of the bitumen mixer machine is 1.73 m long.

3.4. Finding the weight of the belt per unit length

Belt weight data per unit length is used to determine the amount of centrifugal stress that occurs in the belt. Before calculating the weight of the belt per unit length, the belt specification is explained, namely the cross-sectional area of the belt and the density of the material that makes up the belt as follows in Figure 4:

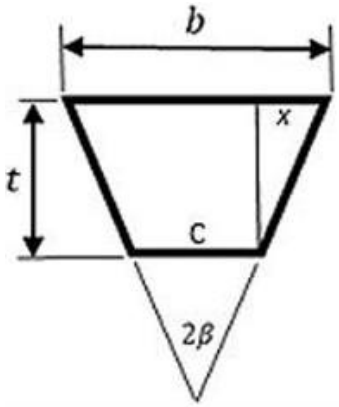

Figure 4. Belt Cross-section

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The belt used in this transmission system uses a belt with type A-67 rubber material with the following belt dimension specifications. Known parameters:

Upper width (a) = 12.5 mm

Lower width (b) = 6 mm

Belt thickness (t) = 9 mm

After knowing the above parameters, the cross-sectional area of the belt can be calculated by the Equation (13):

$$A = \frac{1}{2} \times (a + b) \times t \quad (13)$$

$$A = \frac{1}{2} \times (12.5 + 6) \times 9$$

$$A = \frac{1}{2} \times 18.5 \times 9$$

$$A = 83.25 \text{ mm}^2 \approx 0.00008325 \text{ m}^2$$

So, the cross-sectional area of the transmission belt used is $83.25 \text{ mm}^2 \approx 0.00008325 \text{ m}^2$. After knowing the area of the belt cross-section, the weight of the belt per meter can be calculated: Known parameters:

Area = $83.25 \text{ mm}^2 = 0.00008325 \text{ m}^2$

Length = 1

Density = 1140 kg/m^3

Based on known parameters, the weight of the belt per meter can be calculated by the Equation (14):

$$m = \text{Area} \times \text{Length} \times \text{Density} \quad (14)$$

$$m = 0.00008325 \times 1 \times 1140$$

$$m = 0.095 \text{ Kg/m}$$

So, the belt weight per unit length (m) in this bitumen mixer machine is 0.095 Kg/m

3.5. Calculating the linear velocity of the belt

The linear velocity of the belt is calculated by the following Equation (15):

$$v = \frac{\pi \times d \times n}{60} \quad (15)$$

With known parameters are:

$d = 0.152\ m$

$n = 2500\ rpm$

Then the value of v is:

$$v = \frac{3.14 \times 0.152 \times 2500}{60}$$

$$v = \frac{1193.8}{20} = 20 \text{ m/s}$$

So, the linear speed belt on the transmission system of this bitumen mixer machine is 20 m/s.

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3.6. Calculating centrifugal stress on the belt

The centrifugal tension on the transmission belt is calculated using the following belt calculations. Known parameters:

m = 0.095 Kg/m

v = 20 m/s

After knowing the above parameters, the centrifugal tension is calculated using the Equation (16):

$$Tc = m \times v_2 \quad (16)$$

Tc = 0,095 × 202

Tc = 38 N

So, the magnitude of the centrifugal tension on the transmission belt of the bitumen mixer machine is 38 N

3.7. Calculating the maximum tension on the belt

The maximum tension on the transmission belt, is calculated using the following belt calculations: Known parameters [13]:

σ = 2.8 MPa

A = 83.25 mm^2

Once the above parameters are known, the maximum tension on the belt can be calculated using the Equation (17):

$$T = \sigma \times A \quad (17)$$

T = 2.8 × 83.25

T = 233.1 N

So, the maximum tension of the transmission belt in a bitumen mixer machine is 233.1 N.

3.8. Finding a large angle contact belt

The magnitude of the contact angle of the belt (α) can be found by the following calculation Known parameters:

d_1 = 0.152

d_2 = 0.076

x = 0.685

After knowing the above parameters, the contact angle of the belt can be calculated with the Equation (18):

$$\sin \alpha = \frac{d1 - d2}{2x} \quad (18)$$

$$\sin \alpha = \frac{0.152 - 0.076}{2 \times 0.685}$$

$$\sin \alpha = \frac{0.076}{1.37}$$

$\sin \alpha$ = 0.0554

α = 3.18°

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So, the magnitude of the contact angle belt on the transmission system of this bitumen mixer machine is 3.18°

3.9. Finding the angle of the belt circumference

The magnitude of the circumference of the belt (θ) can be found using the following calculation: Known parameters:

α = 3.18°

After knowing the above parameters, the magnitude of the belt circumference angle can be calculated using the Equation (19):

$$\theta = 180° - 2\alpha \quad (19)$$

θ = 180° − 2 × 3.18°

θ = 180° − 6.36°

θ = 173.64°

Then the unit conversion from degree (θ) to the radian unit (rad) is carried out with the Equation (20):

$\theta = 173.64° \times \frac{\pi}{180}$

$\theta = 3.03\ rad$

So, the amount of belt circumference angle (θ) in this bitumen mixer machine is 3.03 rad.

3.10. Calculating the tension on the tight side and the sagging side of the belt

The magnitude of the tension on the tight side and the loose side of the belt can be found by combining 2 equations with the following calculation. Known parameters [13]:

μ = 0.0

$\theta = 3.03\ rad$

β = 40° : 2 = 20°

After knowing the above parameters, the tension of the sagging side can be calculated using the Equation (20):

$$2.3\log\left[\frac{T_1}{T_2}\right] = \mu.\ \theta\ cosec\ \beta \quad (20)$$

$2.3\log\left[\frac{T_1}{T_2}\right]$ = 0.30 × 3.03 $cosec$ 20°

$2.3\log\left[\frac{T_1}{T_2}\right]$ = 2.657

$\log\left[\frac{T_1}{T_2}\right] = \frac{2.657}{2.3}$

$\log\left[\frac{T_1}{T_2}\right]$ = 1.155

$\frac{T_1}{T_2}$ = 14.29 (antilog)

$T_1 = 14.29 \times T_2$

After the above values are known, the value is calculated using the second equation, with the calculation: $T_1\ dan\ T_2$, known parameters:

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T_{actual} = 0.4574 Nm

r = 0.038 m

After knowing the above parameters, the tension on the tight side of the belt can be calculated by an Equation (21):

$$T_{actual} = (T_1 - T_2) \times r \quad (21)$$

$$0.4574 = (T_1 - T_2) \times 0.038$$

$$T_1 - T_2 = \frac{0.4574}{0.038}$$

$$T_1 - T_2 = 12.037\ N$$

$$(14.29 \times T_2) - T_2 = 12.037\ N$$

$$13.29 \times T_2 = 12.037\ N$$

$$T_2 = \frac{12.037}{13.29}$$

$$T_2 = 0.906\ N$$

Once the size of $T2$the belt is known, then the value T_1 of the belt can be found by calculating. Known parameters:

T_2 = 0.906 N

After knowing the above parameters, the tension of the sagging side can be calculated using the Equation (22):

$$T_2 = \frac{T_1}{14.29}$$

$$T_2 = 14.29 \times T_2$$

$$T_1 = 14.29 \times 0.906\ N$$

$$T_1 = 12.9\ N$$

So, the amount of stress on the tight side of the transmission belt of the bitumen mixer machine (T_1) is 12.9 N while the amount of stress on the sagging side of the belt (T_2) is 0.906 N. The amount of the stress value of the tight side of the belt is also declared SAFE considering that the maximum tension value (T) is far above the value, which is equal to T_1 233.1 N.

3.11. Calculating the actual belt speed

The actual belt speed can be calculated using the following calculations. Known parameters:

T_1 = 12.9 N

T_2 = 0.906 N

P_{actual} = 239.5 $watt$

After knowing the above parameters, the speed can be calculated using the Equation (23):

$$P_{actual} = (T_1 - T_2) \times v \quad (23)$$

$$239.5 = (12.947 - 0.906) \times v$$

$$239.5 = 11.185 \times v$$

$$v = \frac{239.5}{11.184} = 21.4\ m/s$$

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3.12. Calculating the number of belts required

Before looking for the number of belts needed in the transmission system, we must first look for the power transmitted per belt by calculating. Known parameters:

$T_1 = 12.9\ N$

$T_2 = 0.906\ N$

$v = 21.4\ m/s$

After knowing the above parameters, the power transmitted per belt can be calculated using the Equation (24):

$$(T_1 - T_2)\ v \tag{24}$$

$(12.9 - 0.906) \times 21.4$

$239.3\ W \approx 0.2393\ kW$

So, the amount of power that can be transmitted per transmission belt in this bitumen mixer machine is 0.2393 kW. Once the amount of power transmitted per transmission belt is known, then calculating the required number of belts can be calculated using the calculation. Known parameters:

$Actual\ Power = 0.2395\ kW$

$Power\ transmitted\ per\ belt = 0.2393\ kW$

Once the above parameters are known, the required number of belts is calculated by the Equation (25):

$$\frac{\text{Actual Power}}{\text{Power transmitted per belt}} \tag{25}$$

$$\frac{0.2395\ \text{kW}}{0.2393\ \text{kW}} = 1.0008 \approx 1\ Belt$$

So, the number of belts required in the transmission system of a bitumen mixer machine is 1 belt

3.13. Bitumen Mixer Machine Testing

The testing process of this machine aims to measure the performance of the pre-assembled bitumen mixer machine. This testing process is carried out in two stages. The first stage is with bitumen without a mixture of reinforcing materials, and the second stage is with bitumen with a mixture of reinforcing materials in the form of plastic. This engine testing process measures the performance of each engine component, especially the engine transmission system components, namely belts and pulleys, whether it can channel rotation from the drive motor to the mixer shaft properly and safely [15].

Testing with pure bitumen

This test is carried out to ensure that the transmission system components can deliver the rotation from the drive motor to the mixer shaft safely and without excessive vibration. At this stage of testing, liquid bitumen without a reinforcing material that has been heated to a temperature of 160 is used. This test also measures the performance of °Cthe inverter and thermostat in the temperature control system and stirring speed. A machine test picture can be seen in Figure 5.



Figure 5. Machine Testing Process

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The test results show that every component of the bitumen mixer machine such as the belt and pulley transmission system is able to distribute the rotation from the drive motor to the mixer shaft safely and without excessive vibration. The rotation speed of the transmission system is also constant without a hitch. Control elements such as inverters can also perform their functions well in stirring speed control [16]. The thermostat can also perform its function of a temperature control element belt that keeps the temperature stable during the stirring process. An image of when the machine is operating can be seen in Figure 6.



Figure 6. Bitumen mixer machine while operating

Testing with bitumen and reinforcement materials

This test is carried out to ensure that the stirring process runs well so that it can produce an even mixture of bitumen and reinforcing materials. In this stage of testing, liquid bitumen and a reinforcing material in the form of plastic powder were used (Figure 7).



Figure 7. Bitumen mixer machine test process using a mixture of reinforcing materials

The test results show that the final result of the mixture between bitumen and reinforcing materials can be mixed evenly without any clumps or air bubbles. This shows that the rotation speed of the stirring shaft is constant and stable during the stirring process and the temperature control is running well so that the temperature remains stable and does not decrease during the stirring process. A picture of the mixture of reinforcing materials and the final result of the stirring process can be seen in Figure 8 and Figure 9.

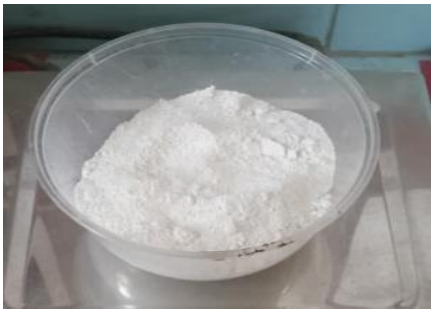

Figure 8. Mixture of reinforcing materials in *bitumen*

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Figure 9. Final result of the stirring process

4. Conclusion

Based on the results of the design, manufacturing, and testing processes of the bitumen mixer machine, it can be concluded that the machine utilizes a 1 HP (0.746 kW) electric motor as its driving source. Based on the calculations performed, the actual power transmitted through the belt transmission system during operation is 0.2395 kW per belt, indicating that the transmission system is safe and reliable when using a single transmission belt. Furthermore, the designed transmission system employs a type A-67 rubber belt with a total length of 1.73 m. In addition, the pulley system is constructed from cast iron, consisting of a 152 mm diameter drive pulley (driver) and a 76 mm diameter driven pulley. These specifications demonstrate that the transmission system has been appropriately designed to support the operational requirements of the bitumen mixer machine effectively and safely.

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Declaration of Conflicting Interests

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Data Availability

The datasets generated during and/ or analysed during the current study are available from the corresponding author on reasonable request.

Declaration on AI Use

The authors declare that no artificial intelligence (AI) or AI-assisted tools were used in the preparation of this manuscript.

References

[1] F. P. Firdaus, "Pengaruh Penggunaan Styrofoam (FS) pada Campuran RAP (Reclaimed Asphalt Pavement) AC-WC terhadap Parameter Marshall," B.S. thesis, Universitas Komputer Indonesia, Bandung, Indonesia, 2020.

[2] R. Setiowati and M. F. Putra, "Struktur biaya produksi aspal Buton untuk kebutuhan infrastruktur sebagai substitusi impor," *Jurnal Teknologi dan Manajemen*, vol. 21, no. 1, pp. 35–42, 2023, doi: 10.52330/jtm.v21i1.94.

[3] K. P. Dwijayanti, A. J. Kyla, and J. D. Ansusanto, "Penerapan kembali limbah plastik sebagai alternatif bahan konstruksi jalan yang ramah lingkungan dan berkelanjutan," *Jurnal Rekacipta*, vol. 1, no. 1, pp. 35–42, 2024, doi: 10.24002/jrc.v1i1.9589.

[4] S. D. Meyrena and R. Amelia, "Analisis pendayagunaan limbah plastik menjadi ecopaving sebagai upaya pengurangan sampah," *Indonesian Journal of Conservation*, vol. 9, no. 2, pp. 96–100, 2020.

[5] J. R. Pangayow, S. Tangkuman, and M. Rembet, "Perancangan sistem transmisi gokar listrik," *Jurnal Poros Teknik Mesin Unsrat*, vol. 5, no. 1, 2016.

[6] A. S. Putra, "Perhitungan pulley dan V-belt pada perancangan sistem transmisi mesin pencacah eceng gondok untuk alternatif pakan ternak," *Gorontalo Journal of Infrastructure and Science Engineering*, vol. 5, no. 1, pp. 14–20, 2022.

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This work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License
ISSN: 3110-1577

[7] N. Martina, M. F. R. Hasan, and Y. Setiawan, "Pengaruh serbuk ban bekas sebagai campuran agregat halus pada campuran aspal porous," *Wahana Teknik Sipil: Jurnal Pengembangan Teknik Sipil*, vol. 24, no. 2, pp. 144–152, 2019, doi: 10.32497/wahanats.v24i2.1731.

[8] F. A. Adam and D. Wulandari, "Rancang bangun alat pengaduk aspal dari limbah plastik menggunakan motor bensin," *Jurnal Rekayasa Mesin*, vol. 7, no. 2, pp. 5–9, 2022, doi: 10.26740/jrm.v7i02.46037.

[9] E. Erwin, "Konsep perancangan kualitas sistem transmisi conveyor," *Jurnal Kajian Teknik Mesin*, vol. 2, no. 2, pp. 106–117, 2017.

[10] R. Rahayu and T. S. Murtinah, "Pelaksanaan pengadaan barang/jasa secara elektronik di Unit Layanan Pengadaan Biro Umum Sekretariat Presiden," *Journal of Business Administration Economic & Entrepreneurship*, pp. 57–67, 2022.

[11] E. F. Ginting, K. Ibnutama, and M. G. Suryanata, "Implementasi DES (Data Encryption Standard) untuk penyandian data Bill of Material pada Divisi Produksi PT Siantar Top, Tbk," *SAINTIKOM: Jurnal Sains dan Komputer*, pp. 161–166, 2019.

[12] A. Almusawi, B. Şengöz, D. K. Özdemir, and A. Topal, "Predicting mixing and compaction temperatures of polymer modified bitumen," *Celal Bayar University Journal of Science*, vol. 16, no. 3, pp. 265–272, 2020.

[13] R. S. Khurmi and J. K. Gupta, *A Textbook of Machine Design (SI Units)*. New Delhi, India: Eurasia Publishing House (PVT.) Ltd., 2005.

[14] Electric & Machinery PTE Ltd., *IE3 Three-Phase TEFC Premium Efficiency Motors PA & PE Series*. Singapore: Electric & Machinery PTE Ltd., 2024.

[15] A. Setiawan, R. Wijaya, A. Subeno, A. B. Affandi, T. Okviyanto, and F. M. Dewadi, "Design of Coconut Milk Pressing Machine with Two Screw Shafts to Improve Extraction Efficiency and Quality," *Jurnal Konversi Energi dan Manufaktur*, pp. 78–95, 2026.

[16] I. Hassan, K. Sayed, M. D. Alanazi, H. A. Ziedan, and M. Abdelsattar, "A comprehensive review of power converter topologies and control techniques for welding power supply applications," *Discover Applied Sciences*, vol. 7, no. 9, Art. no. 1036, 2025.

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