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A Paper Based of Analysis of the Proposed Project Work on Design of an Equipment For Testing Flat Belt, V-Belt And Rope Drive

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Abstract: *This paper investigates the need of an experimental set up which is part of a range design to both demonstrate and experimentally confirm basic engineering principles. It consists of a pulley wheel, two belts, a rope, a driving cable and two weight carriers.*
This equipment can be tested with Flat belt, V-belt and Rope with constant weight as T1 (kg) and varying weights as T2 (kg) at different wrap angle. The performance evaluation of this proposed equipment design is done by comparing the experimental results with theoretical analysis using similar procedures.
Keywords: *Investigate, Demonstrate, Performance evaluation, and comparing results.*

I. Introduction

From the Theory of Power Transmission in Belt Drive Systems, to find the toque, we will simply need to find the net moment (M) exerted by the two tension forces (T1, T2), where the radius of the pulley (R) is the moment arm.

$$M = (T1 - T2)R$$

To find the maximum power (P) we can transfer with the belt drive system, we will use the rotational definition of power, where the power is equal to the toque times the angular velocity (**w**) in radians per second. Unlike the torque, the power at the input and the output will be the same assuming no inefficiencies.

$$P = M\omega$$

The power (in kW) transmitted by a belt is

$$Power\ transmitted\ in\ kw = \frac{(T1 - T2)v}{1000}$$

Where;
V is the velocity in meter per second.
T1 is the initial tension on the tight side in Newton.
T2 is the initial tension on the slack side in Newton.
The equation that relates the coefficient of friction, the tension, the angle of wrap and the angle of groove is:

$$\frac{T1}{T2} = e^{\mu\theta cosec\beta}$$

Where:

μ	is the coefficient of friction.
θ	is the angle of wrap in radians.
	is the total angle of groove (β=90° for flat belt, β =30° for V- belt),

The proposed equipment's design is an experimental setup which enables detailed experimental study of the phenomena of power transmission by means of friction and operation of belt drive.

II. Aim and Objectives

To analyze the performance of this proposed equipment design by comparing the experimental results with theoretical analysis results using similar procedures.

III. Proposed design of the project

The proposed design as shown in Fig.1 consists of a wall mounted pulley wheel with a loaded belt. The pulley wheel has three machined grooves to suit a flat, V-belt, and a rope. Each belt fits into its respective groove during testing. For a given belt tension and angle of lap, a turning moment can be applied by adding weights to the pulley drive hanger # 2. The angle of lap can be easily varied by placing one end of each belt at different angular positions on the wall bracket. A removable pin and bar are used to enable the various angular positions to be achieved.

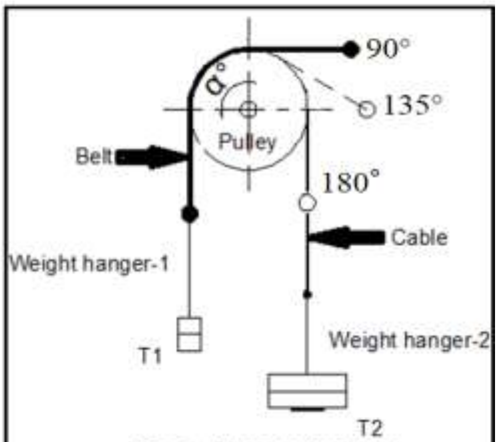
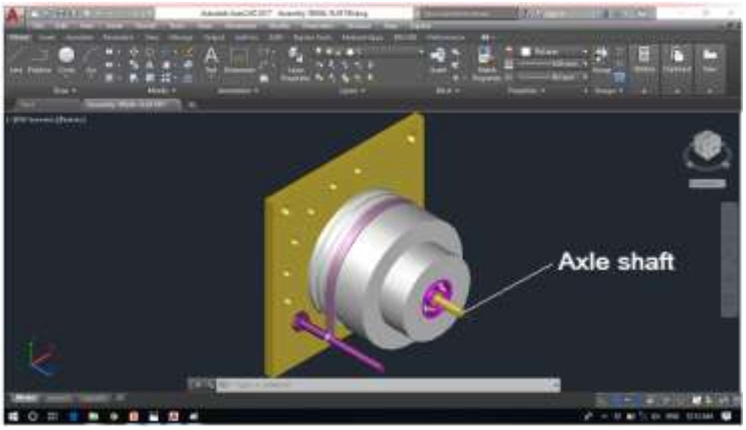


Fig. 1. Proposed design

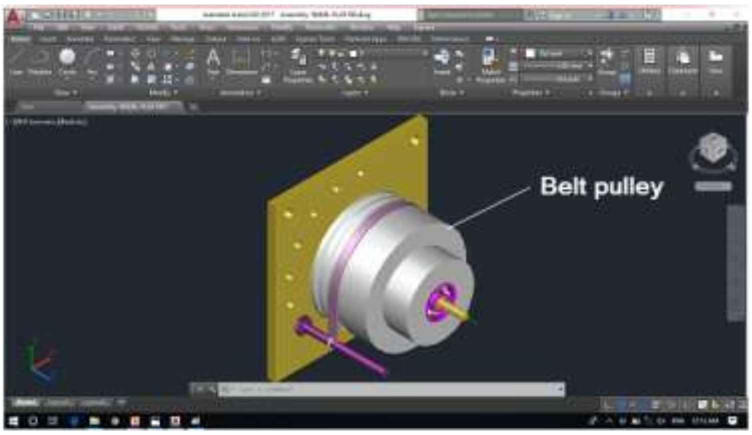
IV. Components of proposed equipment

Following are the components of proposed equipment design identified from the above figure-1.

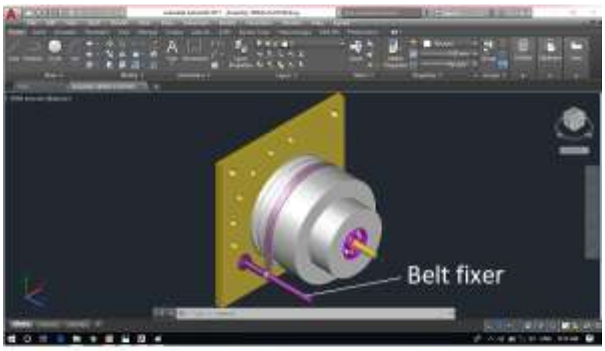
4.1. Axle shaft.



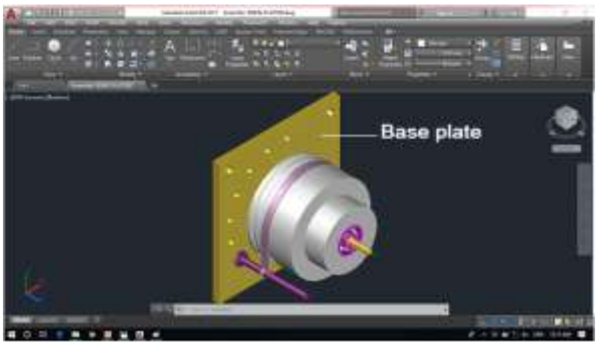
4.2. Belt pulley.



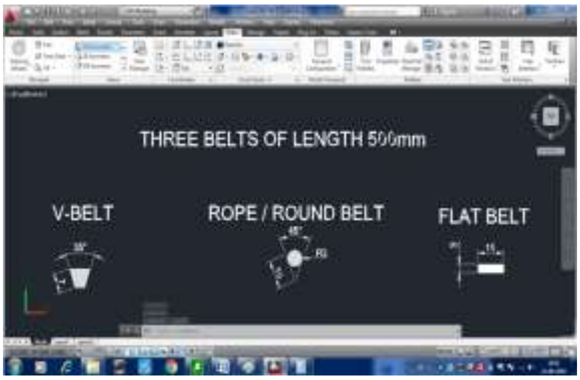
4.3. Belt fixer.



4.5. Base plate.



4.6. Three types of belt



V. Technical Data for proposed equipment

Dimensions:
Base bracket: 150 x 180 mm
Fixing holes: Distance: 120 x 160 mm
Diameter: Ø 5 mm
Belt Pulley: Ø 120 mm
Lap angles: 0 to 180° adjustable in steps of 22.5°.
Flat belt
Material: Leather
Cross section: 10 x 2.2 mm
V-belt
Material: rubber/tissue lined
Cross section: 5 x 3 mm
Round belt
Material: hemp
Diameter: Ø 3 mm
Weights set
Weights: 0.5 N, 1 N, 2 N, 5 N
Weights hanger, own weight: 1 N

VI. Experimental analysis of the proposed equipment

The proposed equipment enables detailed experimental study of the phenomena of the phenomenon of power transmission by means of belt friction and operation of belt drive.
This equipment setup facilitates investigation of the following topics:
Relationship between belt tension, belt friction and lap angle (Eytelwein formula for rope friction)
1. Friction of different materials
2. Difference between flat belt and V-belt
Experimental analysis refers to an in-depth look at the various properties that can be used to describe a belt / belt drive system. They include quantities such as:
1). Angle of lap
2). Friction coefficient
3). Belt tensions and driving force
4). Torque
5). Power transmitted

6.1. First Experimental analysis

The objective of this experimental analysis is to compare various belts (flat, round and V-belt) to investigate above mentioned topics and also to justify the application and limitation of the various belt under our study.

Procedure

1. Mount the flat belt over the appropriate groove and set the angle at θ° with the help of belt fixer
2. Hang the weight hanger to belt and load the belt with T1 = 15 N.
3. Pull the driving rope over the belt pulley and hang the weights hanger to it
4. Increase the driving weight gradually until the belt tends to rotate, not down the necessary driving force (T) to put the system at this state.
5. Repeat the previous steps for round belt and V belt for the same Lap angle and with same pre-loading (T1 = 15 N).

The experimental value of coefficient of friction (μ) between belt and pulley can be calculated by:

$\mu = \frac{1}{\theta} \ln[\frac{T_1}{T_1 - T}]$= ....N. (For V & round belt)

$\mu = \frac{1}{\theta cosec\beta} \ln[\frac{T_1}{T_1 - T}]$= ....N. (For V & round belt)

Following table show the experimental observations for Flat belt, V-belt and Round belt for different lap angle 90^o, 135^o and 180^o.

For V-Belt

V-Belt				Findings
180	135	90	Θ°	Lap angle Θ in degrees
3.14	2.35	1.57	$\frac{\pi}{180} \times \Theta°$	Lap angle Θ in radians
60	60	60	2β	Groove angle 2β in degrees
15	15	15	T1	Pre-load
14	13	11	T	Force (T) from Experiment
0.43	0.42	0.42	μ	(μ)from Experimental(μ)
Highest				Comparison of belts for their capability to transmit frictional power.

For Flat Belt

Flat Belt				Findings
180	135	90	Θ°	Lap angle Θ in degrees
3.14	2.35	1.57	$\frac{\pi}{180} \times \Theta°$	Lap angle Θ in radians
180	180	180	2β	Groove angle 2β in degrees
15	15	15	T1	Pre-load
11	9	5	T	Force (T) from Experiment
0.42	0.38	0.25	μ	(μ)from Experimental(μ)
Lower				Comparison of belts for their capability to transmit frictional power.

For Round Belt

Round Belt				Findings
180	135	90	Θ°	Lap angle Θ in degrees
3.14	2.35	1.57	$\frac{\pi}{180} \times \Theta°$	Lap angle Θ in radians
45	45	45	2β	Groove angle 2β in degrees
15	15	15	T1	Pre-load
12	11	5	T	Force (T) from Experiment
0.19	0.21	0.09	μ	(μ)from Experimental(μ)
Lowest				Comparison of belts for their capability to transmit frictional power.

6.2. Second Experimental analysis

The objective of this experimental analysis is to investigate the above mentioned topics by calculating the dependence on lap angle (θ) for flat belt, round belt and V-belt.

Procedure

1. Put the flat belt over the appropriate groove and set it at an angle of 90° with the help of the belt fixer (Fig. 1).
2. Hang the weights set in the belt and load it with Pre-load T1 = 15N.
3. Put the driving rope on the belt pulley and hang the weights hanger to it. (Fig.1).
4. Increase the driving weight gradually until the belt pulley tends to rotate. Note down this as measured driving force necessary to put the system at this state.
5. Move the belt fixer at other angle positions at a time and repeat the experiment for each case.

The driving force (T) and coefficient of friction between belt and pulley can be calculated by:

$T = T1\left(1 - \frac{1}{e^{\mu\theta}}\right)$= ………...…… N. (For Flat belt)

$T = T1\left(1 - \frac{1}{e^{\mu\theta cosec\beta}}\right)$= ....N. (For V & round belt)

$\mu = \frac{1}{\theta}\ln[\frac{T_1}{T_1 - T}]$= ....N. (For V & round belt)

$\mu = \frac{1}{\theta cosec\beta}\ln[\frac{T_1}{T_1 - T}]$= ....N. (For V & round belt)

Following table show the findings of experimental observations for Flat belt, V-belt and Round belt for different lap angle 90°, 135° and 180°.

For V-Belt

V-Belt				Findings
180	135	90	θ^{o}	Lap angle Θ in degrees
3.14	2.35	1.57	$\frac{\pi}{180} \times \theta^{o}$	Lap angle Θ in radians
60	60	60	2β	Groove angle 2β in degrees
15	15	15	T1	Pre-load
0.45	0.45	0.45	μ	(μ)Standardized value of coefficient of friction
14.11	13.19	11.34	Tc	Force (T) theoretically calculated from std values
14	13	11	Tm	Force (T) Measured Experimentally
0.43	0.42	0.42	μ	(μ)from Experimental(μ)
Highest				Comparison of belts to transmit driving force.

For Flat Belt

Flat Belt				Findings
180	135	90	θ^{o}	Lap angle Θ in degrees
3.14	2.35	1.57	$\frac{\pi}{180} \times \theta^{o}$	Lap angle Θ in radians
180	180	180	2β	Groove angle 2β in degrees
15	15	15	T1	Pre-load
0.35	0.35	0.35	μ	(μ)Standardized value of coefficient of friction
14.61	14.03	12.58	Tc	Force (T) theoretically calculated from std values
11	9	5	Tm	Force (T) Measured Experimentally
0.42	0.38	0.25	μ	(μ)from Experimental(μ)
Lower				Comparison of belts to transmit driving force.

For Round Belt

Round Belt				Findings
180	135	90	θ^{o}	Lap angle Θ in degrees
3.14	2.35	1.57	$\frac{\pi}{180} \times \theta^{o}$	Lap angle Θ in radians
45	45	45	2β	Groove angle 2β in degrees
15	15	15	T1	Pre-load
0.3	0.3	0.3	μ	(μ)Standardized value of coefficient of friction
13.72	12.63	10.61	Tc	Force (T) theoretically calculated from std values
12	11	5	Tm	Force (T) Measured Experimentally
0.19	0.21	0.09	μ	(μ)from Experimental(μ)
Lowest				Comparison of belts to transmit driving force.

VII. Theoretical Analysis Of The Proposed Equipment

Theoretically, Driving force necessary to overcome the friction between belt and pulley is given by:

$T = T1\left(1 - \frac{1}{e^{\mu\theta}}\right)$= …………...…… N. (For Flat belt)

$T = T1\left(1 - \frac{1}{e^{\mu\theta cosec\beta}}\right)$= ....N. (For V & round belt)

And the coefficient of friction between belt and pulley can be calculated by:

$\mu = \frac{1}{\theta}\ln[\frac{T_1}{T_1 - T}]$= ....N. (For V & round belt)

$\mu = \frac{1}{\theta cosec\beta}\ln[\frac{T_1}{T_1 - T}]$= ....N. (For V & round belt)

Following table show the findings of theoretically calculated driving force for Flat belt, V-belt and Round belt for different lap angle 90^o, 135^o and 180^o.

For V-Belt

V-Belt			
180	135	90	Θ^o
3.14	2.355	1.57	{π/180)×Θ^o
60	60	60	2β^0
0.45	0.45	0.45	μ
15	15	15	T1
14.11	13.19	11.34	T=T1(1-(1/e^μθcosecβ))

For Flat Belt

Flat Belt			
180	135	90	Θ^o
3.14	2.355	1.57	{π/180)×Θ^o
0.35	0.35	0.35	M
15	15	15	T1
10.0019	8.42154	6.34142	T=T1(1-(1/e^μθ))

For Round Belt

Round Belt			
180	135	90	Θ^o
3.14	2.355	1.57	{π/180)×Θ^o
45	45	45	2β
0.3	0.3	0.3	μ
15	15	15	T1
13.7203	12.6322	10.6188	T=T1(1-(1/e^μθcosecβ))

8.1. Findings from first experimental analysis

This experimental analysis will give us calculated friction coefficient for different belts under our study and with this determined coefficient of friction we will compare the various belts. And on the basis of friction coefficient we will be justifying belts use and it's limitations of application.

8.2. Findings from second experimental analysis

This experimental analysis will give us a clear idea and understanding that upon increasing the angle of lap θ° the ratio of tension (T1/T2) as well as force necessary to overcome the friction also increases over proportionally.

It means if the numbers of belts or ropes wound are doubled from 2π to 4π then forces also increase this is called force amplification.

This effect can be used in many applications. Besides the application in belt drive it can be used in force amplification in winches, conveyors in mountain works or in anchorage of ships to poles.

VIII. Comparative analysis of the experimental results with theoretical results

1. Investigate the capability of the various belts on the basis of their coefficient of friction.
2. Comparison of capability of the various belts to transmit driving force.

Round Belt	Flat Belt	V-Belt	Findings
Lowest	Lower	Highest	Comparison of belts for their capability to transmit frictional power.
Lowest	Lower	Highest	Comparison to belts on the basis of transmitting driving force.

Performance evaluation of the proposed equipment

Is being done by comparing the experimental results with theoretical analysis using similar procedures and it is found:

1.The experimental results are almost equal to the theoretical result hence the theoretical results are verified and theoretical formulae and relations corresponding to theory of power transmission through various type of belt under our considerations are proved, verified and all result are satisfactory.

2. Investigations of the belt tension ratio in case of various types of belt drives have been done.
3. Investigation of coefficient of friction for Flat belt drive, V-belt drive and Rope drive are carried out and found satisfactory.
4. Studied how the groove shape affects the coefficient of friction.
5. Understood the effect of the wrap angle over the belt tension ratio.
6. Determined the effect of the belt tensions on power that can be transmitted by belt drive.
7. Compared the power transmission capability of Flat belt, V-belt and Rope drive.

IX. Conclusion

This work will be aimed at evolution of a technique for studying the torque and power transmitting capability of power transmission belt drive systems. This proposed equipment design will enable the designer to both demonstrate and experimentally confirm basic engineering principles. It will be used to carry out test experiments which will help to investigate: the ratio of belt tension when a rope passes over pulleys of different V-angles, to determine the coefficient of friction between the pulley and cotton rope, and to assess the variation of belt tension ratio with lap angle.

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