IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 12, Issue 4 Ver. I (Jul. - Aug. 2015), PP 43-47
www.iosrjournals.org

Experimental Investigation on the Performance of a Rope Belt Friction Apparatus

Stephen Tambari[1], Petaba Lemii Donaldson[2], Ibor Benjamin[3], Nzidee Lelesi[4]
[1, 2, 3,4] *Department Of Mechanical Engineering Rivers State Polytechnic, P.M.B 20 Bori.*

Abstract: *This project utilizes the Microsoft Excel Software to display the graphical representation of (profile) that shows the relationship between the ratio of belt tension and the lap angle. This work (experiment) was carried out in the mechanics laboratory to investigate the ratio of belt tensions when a rope passes over a flat pulley with a la angle of 180^0 and also to determine the coefficient of friction between the mild steel surface of the pulley and the cutting rope. Further investigation was also done on the variation in the ratio of belt tensions with; change of lap angles and also a change of groove angles. At the end of the investigation, it was discovered that; the ratio of the belt tensions gradually reduced over a constant lap angle of π in position on the wall plate. It was also verified that, the ratio of the belt tensions increases with variation in the lap and groove angles while the load, T, was kept constant on the slack side hanger.*
Keywords: *Rope-belt, Friction, Tension*.

I. Introduction

The rope-belt friction apparatus borders on belt friction which describes the friction forces between a belt and a surface, such as a belt wrapped around a bollard. When one end of the belt is being pulled only part of this force is transmitted to the other end wrapped about a surface. The friction force increases with the amount of wrap about a surface and makes it so the tension in the belt can be different at both ends of the belt. The apparatus (Rope bet friction) consists of a wall mounted fixed pulley with a loaded belt, rope, flat belt, V-belts (badly fitted and correctly fitted), weight hangers, weights of standard sizes. This equipment is part of a range designed to both demonstrate and experimentally confirm basic Engineering Principles. The setting up time is minimal, and all measurements are made with the simplest possible instrumentation, so that the student involvement is purely with the Engineering Principles being taught.

In practice, the theoretical tension acting on the belt or rope calculated by the belt friction equation can be compared to the maximum tension the belt can support. This helps a designer of such a rig to know how many times the belt or rope must be wrapped around the pulley to prevent it from slipping. Mountain climbers and sailing crews demonstrate a standard knowledge of belt friction when accomplishing basic tasks.

1.2 Purpose Of The Study

This study is aimed at investigating the ratio of belt tension when a rope passes over a flat pulley with a lap angle at 180^0 and to determine the coefficient of friction between the pulley and the rope. And a further investigation on the variation in change of lap and groove angles with the ratio of belt tensions.

1.3 Benefit Of Study

This work will be useful in the mechanics of machines laboratory of the department of mechanical engineering during students practical under friction and also, for researchers and final year project work.

II. Experimental Method

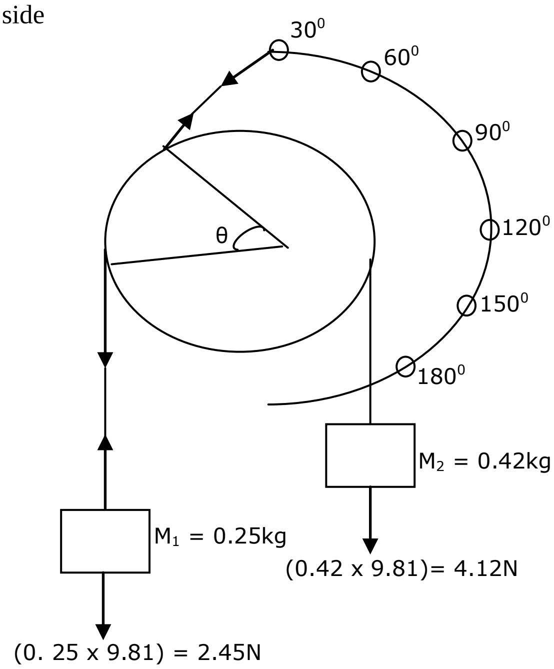
The apparatus was set and the flat pulley belt was locked over a 180^0 lap angle in position on the wall plate. A rope was hung over the pulley to give a lap angle of 180^0 and the load hangers were also hung to the end loops of the rope. Thereafter a known weight, T_1 was loaded to the slack side hanger hence, starting to add loads to the other hanger called T_2 until the rope slides very slowly. The values of the loads, T_1 and T_2 were recorded. The above procedure was repeated for five (5) different sets of loads, T_1 and T_2 respectively on the lap angles of 180^0. Then the lap angles were now varied beginning with: 30^0, 60^0, 90^0, 120^0, 1500 and 180^0, on a constant load of T_1 and T_2 was determine and recorded as the rope slides slowly and the lap angles were also recorded.

III. Result And Discussion

Six consecutive experiments were done for each angles of wrap; it was observed that, the entire system was always at the state of equilibrium irrespective of the angle before ht rope slides slowly. It was discovered that, the ratio of the belt tensions gradually reduced over a constant lap angle of π in position on the wall plat. Also, the ratio of the belt tensions increased with variation in the lap and groove angles while the load, T_1 was kept constant on the slack side hanger. The results obtained is represented graphically using Microsoft excel on figures 2.0 and 3.0 respectively.

Experiment 1

For varying lap angles with a constant load, T_1 on the slack side



From the diagram above

T_1 = 2.45N and T_2 = 4.12N, $\theta = 30^0$

$$T_1/T_2 = 4.12/2.45$$

$$T_1/T_2 = 1.68$$

$$\text{In } T_1/T_2 = 0.52$$

Converting from degree to radians, we get

$$\theta = 30 \times \frac{\pi}{180} = \pi/6$$

$$\theta = \pi/6 \text{ rad}$$

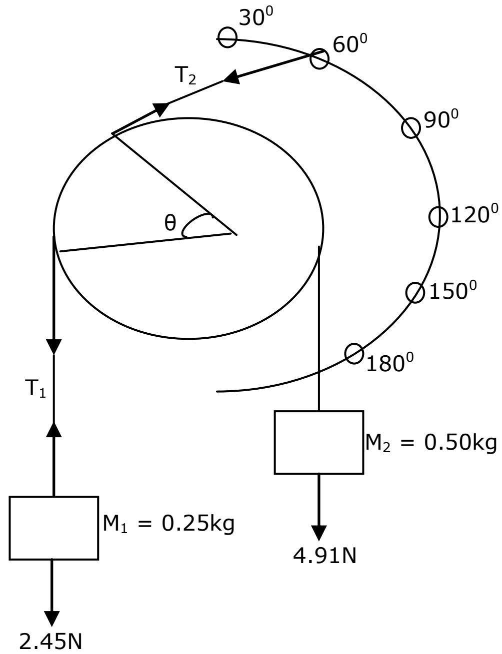
$$\left(\sin \theta/2\right)^{-1} = \left(\sin \pi/12\right)^{-1}$$

$$= (0.2588)^{-1} = \frac{1}{0.2588}$$

$$\left(\sin \theta/2\right)^{-1} = 3.86$$

Experiment 2

T_1 = 2.45N and T_2 = 4.91N, $\theta = 60^0$



$$T_1/T_2 = \frac{4.91}{2.45}$$

$$T_1/T_2 = 2.00$$

$$\text{In } T_1/T_2 = 0.69$$

$$\theta = 60 \times \frac{\pi}{180} = \frac{\pi}{3}$$

$$\theta = \frac{\pi}{3} \text{ rad}$$

$$\left(\sin \theta/2\right)^{-1} = \left(\sin \pi/6\right)^{-1}$$

$$= (0.5)^{-1} = \frac{1}{0.5}$$

$$\left(\sin \theta/2\right)^{-1} = 2.00$$

Experiment 3

$T_1 = 2.45N$ and $T_2 = 5.98N$, $\theta = 90^0$

$$\frac{T_1}{T_2} = \frac{5.98}{2.45}$$

$$\frac{T_1}{T_2} = 2.44$$

In $\frac{T_1}{T_2} = 0.89$

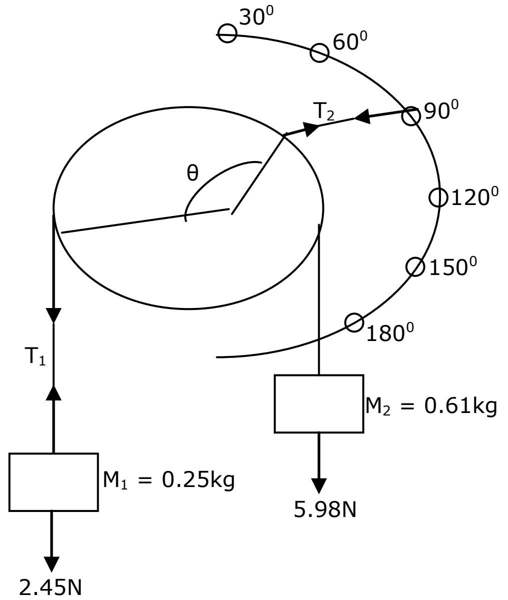
$\theta = 90 \times \frac{\pi}{180} = \frac{\pi}{2}$

$\theta = \frac{\pi}{2}$ rad

$$\left(sin\,{}^{\theta}/_{2}\right)^{-1} = \left(sin\,{}^{\pi}/_{4}\right)^{-1}$$

$$= \frac{1}{0.7071}$$

$$\left(sin\,{}^{\theta}/_{2}\right)^{-1} = 1.41$$



Experiment 4

$T_1 = 2.45N$ and $T_2 = 8.53N$, $\theta = 120^0$

$$\frac{T_1}{T_2} = \frac{8.53}{2.45}$$

$$\frac{T_1}{T_2} = 3.48$$

In $\frac{T_1}{T_2} = 1.25$

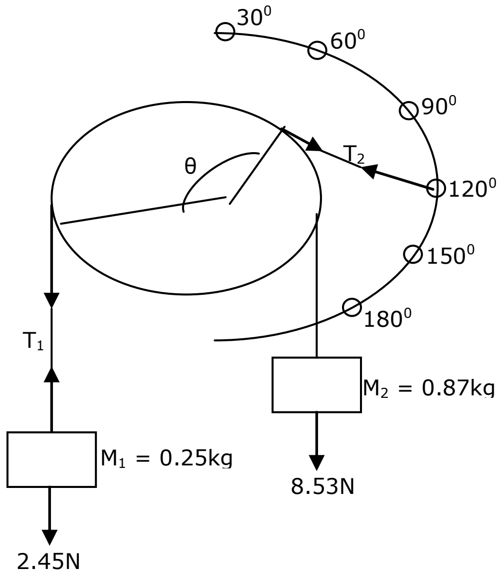
$\theta = 120 \times \frac{\pi}{180} = \frac{2\pi}{3}$

$\theta = \frac{2\pi}{3}$ rad

$$\left(sin\,{}^{\theta}/_{2}\right)^{-1} = \left(sin\,{}^{2\pi}/_{6}\right)^{-1}$$

$$= \frac{1}{0.866}$$

$$\left(sin\,{}^{\theta}/_{2}\right)^{-1} = 1.15$$



EXPERIMENT 5

$T_1 = 2.45N$ and $T_2 = 10.69N$, $\theta = 150^0$

$$\frac{T_1}{T_2} = \frac{10.69}{2.45}$$

$$\frac{T_1}{T_2} = 4.36$$

In $\frac{T_1}{T_2} = 1.47$

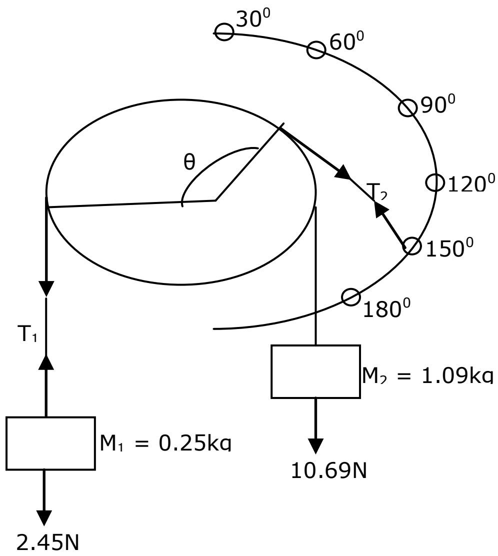
$\theta = 150 \times \frac{\pi}{180} = \frac{5\pi}{6}$

$\theta = \frac{5\pi}{6}$ rad

$$\left(sin\,{}^{\theta}/_{2}\right)^{-1} = \left(sin\,{}^{5\pi}/_{12}\right)^{-1}$$

$$= \frac{1}{0.9659}$$

$$\left(sin\,{}^{\theta}/_{2}\right)^{-1} = 1.04$$



Experiment 6

$T_1 = 2.45N$ and $T_2 = 12.95N$, $\theta = 180^0$

$$\frac{T_1}{T_2} = \frac{12.95}{2.45}$$

$$\frac{T_1}{T_2} = 5.28$$

$$\text{In } \frac{T_1}{T_2} = 1.66$$

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

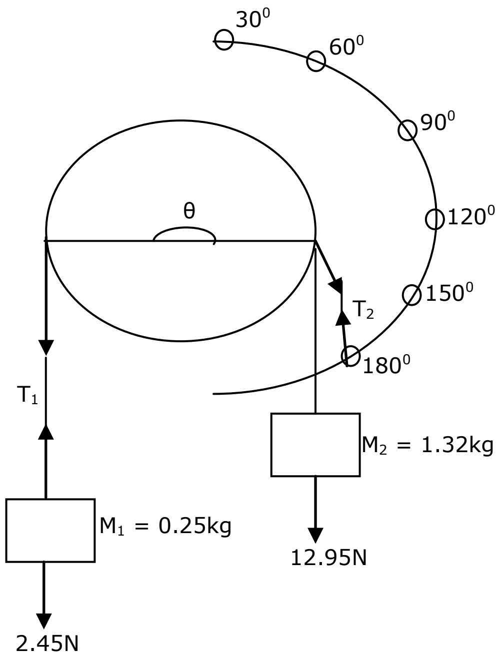
$\theta = \pi$ rad

$$\left(\sin \theta/_2\right)^{-1} = \left(\sin \pi/_2\right)^{-1}$$

$$= 1$$

$$\left(\sin \theta/_2\right)^{-1} = 1$$

$$\left[\frac{T_1}{T_2}\right]^{-1} = e^{\mu\theta}$$



Taking $\log_e$ from both sides, we have

$$\log_e \left[\frac{T_1}{T_2}\right]^{-1} = \log_e e^{\mu\theta}$$

$$\log_e \left[\frac{T_1}{T_2}\right]^{-1} = \mu\theta \log_e e$$

$$\log_e \left[\frac{T_1}{T_2}\right]^{-1} = \mu\theta$$

Dividing both sides by θ, we obtain

$$\mu = \frac{1}{\theta} \log_e \left[\frac{T_1}{T_2}\right]^{-1}$$

From the table of values where θ = π, T1 = 2.45 and T2 = 12.95N respectively.
Upon substituting these values into the derived expression above, we compute.

$$\mu = \frac{1}{\pi} \log_e \left[\frac{2.45}{12.95}\right]^{-1}$$

$$= \frac{-1}{\pi} \log_e 0.189$$

$$= \frac{-1}{\pi} (-1.666)$$

$$= \frac{1.666}{3.142}$$

$\mu = 0.53$

Table 1: Test analysis result obtained for flat belt at constant lap angle

Lap angle		Tension, T1 (1x9.81)N	Tension, T2 (1x9.81)N	T_1/T_2 (N/N)	In T_1/T_2 (N/N)
θ^0	θ(rad)				
180	π	0.25	1.32	5.28	0.72
180	π	0.50	1.97	3.94	0.60
180	π	0.75	1.92	3.89	0.59
180	π	1.00	3.58	3.58	0.55
180	π	1.25	4.19	3.35	0.53

TABLE 2: Test analysis result obtained for flat belt at varying lap angles

Lap angle		Tension, T1 (1x9.81)N	Tension, T2 (1x9.81)N	T_1/T_2 (N/N)	In T_1/T_2 (N/N)	$\left(\sin \theta/_2\right)^{-1}$
θ^0	θ(rad)					
30	$\frac{\pi}{6}$	2.45	4.12	1.68	0.52	3.86
60	$\frac{\pi}{3}$	2.45	4.91	2.00	0.69	2.00
90	$\frac{\pi}{2}$	2.45	5.98	2.44	0.89	1.41
120	$\frac{2\pi}{3}$	2.45	8.53	3.48	1.25	1.15
150	$\frac{5\pi}{6}$	2.45	10.69	4.36	1.47	1.04
180	π	2.45	12.95	5.28	1.66	1.00

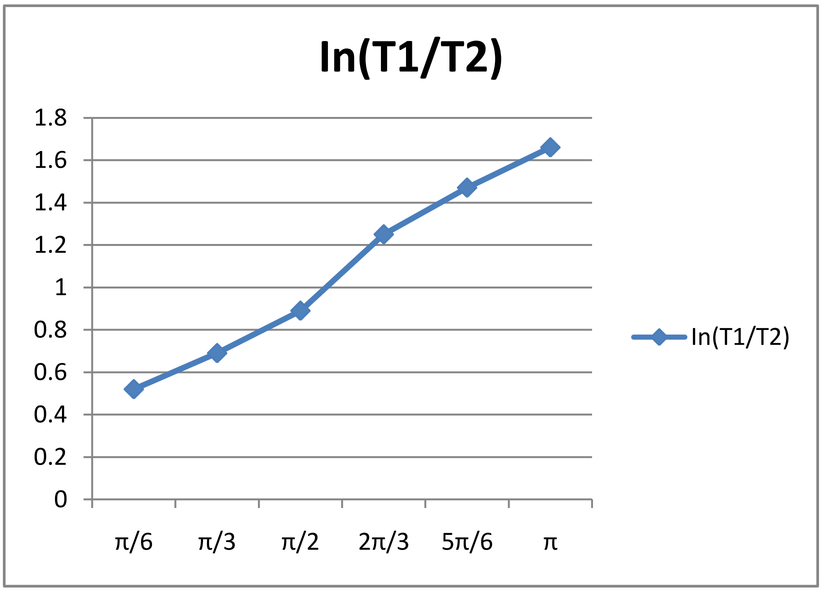


Figure 7: Graph of ln(T1/T2) Vs Lap angle, Θ

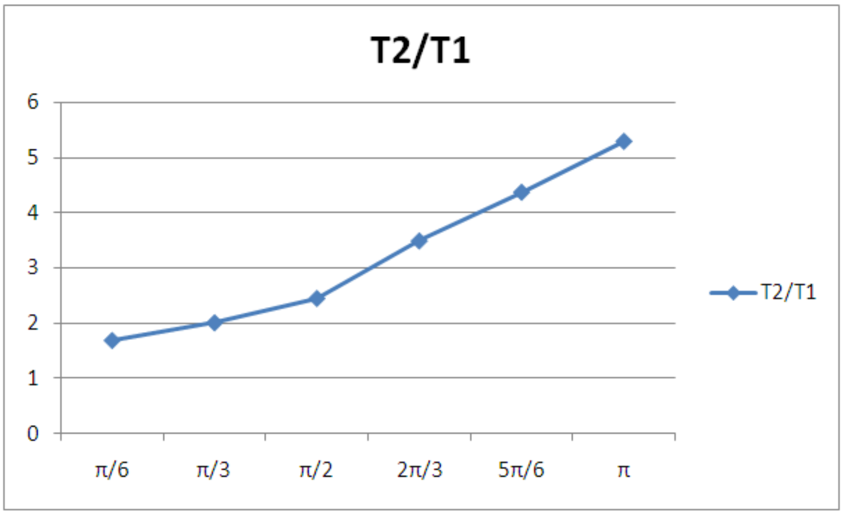


Figure 8: Graph of T1/T2 Vs Lap angle, Θ(rad)

IV. Conclusion

From the graph of In $\left[\frac{T_2}{T_1}\right]$ against θ, the relationship between the ratio of belt tension and the lap angle is linear while the graph of $\left[\frac{T_2}{T_1}\right]$ against θ depicts a curvilinear relationship between the ratio of belt tension and the lap angle. Also, from this experiment, the coefficient of friction for flat belt = 0.53. Which means that the coefficient of friction is influenced by the angle of contact between the belt and the pulley.

References

[1]. Ahaway, Stephen W (1999): The Mechanics of Friction in Rope, Tudor Times Ayer Publishing, dorth dakota.
[2]. Mann, Herman (2005): Belt friction, Ruhur University. http://www.esrruhur.nibochum.de/rt1/currentcourse/node57.html.
[3]. Durowoju M.O, Sangotayo E.O, Orowole I.A; Performance Evaluation of friction Belt Apparatus Using Indigenous Materials: International Journal of Modern Engineering Research (IJMER).
[4]. Chandoo (2010) Couloumb belt friction; Missori University of Science and Technology.
[5]. Belt tension theory (2010) CKIT – The Bulk Materials Handling knowledgebase.