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DESIGN OF A MINI-CONVEYOR USING PULLEY-TO-PULLEY V-BELT TRANSMISSION SYSTEM

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Abstract

A conveyor system is a common piece of mechanical handling equipment that aids in the movement of materials from one another. Conveyors are especially useful in applications involving the transportation of heavy or bulky materials, which made them very popular in the material handling and packaging industries. This project described the current research on belt driven conveyor systems.

Keywords: Coefficient of friction, Belt load, Driver Pulley, Driven Pulley.

INTRODUCTION

A pulley is a wheel on the axle or shaft that is designed to support movement and change of direction of a taut cable or belt, or transfer of power between the shaft and cable or belt. In the case of pulley supported by a frame or shell that does not transfer power to a shaft, but is used to guide the cable or exert a force, the supporting shell is called a block, and the pulley may be called a sheave.

A pulley may have a groove between flanges around its circumference to locate the cable or belt. The drive element of a pulley system can be a rope, cable, belt or chain.

A conveyor system is a common piece of mechanical handling equipment that has applications involving the transport of heavy or bulky materials. Conveyor systems allow quick and efficient transport for a wide variety of materials, which make them very popular in the material handling and packaging industries. They also have popular consumer applications, as they are often found in supermarkets and airports, constituting the final leg of item/bag delivery customers.

Many kinds of conveying systems are available and are used according to the various needs of different indudtries. There are chain conveyors(floors and overhead)as well. Chain conveyors consist of enclosed tracks, I-Beam, towlinw, power&free, and hand pushed trolleys.

The earliest evidence of pulleys date back to ancient Egypt in the Twelfth Dynasty(1991-1802BCE)and Mesopotamia in the early 2nd millennium BCE. In Roman Egypt, Hero of Alexandria(c.10-70 CE) identified the pulley as one of six machines used to lift weights. Pulleys are assembled to form a block and tackle in order to provide mechanical advantage to apply large forces. Pulleys are also assembled as part of belt and chain drives in order to transmit power from one rotating shaft to another. Plutarch's lives recounts a scene where Archrmedes proved the effectiveness of compound pulleys and the block-and-tackle system by using one to pull a fully laden ship towards him as if it was gliding through water. The differential pulley was invented in1854 by Thomas Aldridge Weston from King's Norton

The pulleys were manufactured in collaboration with Richard and George Tangya. According to Richard Tangye's autobiography, the Westom differential pulley evolved from Chinese windlass, with an endless chain replacing the finite length of rope. He claimed that many engineering firms conceded on the difficulty of efficiently disengaging the chain from the teeth as the pulleys turned,but his firm developed a "pitch"chain which solved the issue.

Marketed as "Weston Differential Pulley Block with Patent Chain Guides", the pulley had good sales, namely, 3000 sets in 9 months. It was displayed in 5 sizes-from 10 long hundred weight (510kg)to 3 long tons(3000kg)-at the 1862 International Exhibition in London and received a medal for "original application,practical utility and success".

An iron monger challenged the Tangyes that the pulley had been in use for 30years before Weston's patent but the judge, William Page Wood ruled in favour of the Tangyes because the engaging mechanism was substantially different from the one presented as evidence. The Yale Lock Company acquired the patent rights in 1876.

A dumb pulley can lift very large masses a short distance. It consists of two fixed pulleys of unequal radii that are attached to each other and rotate together, a single pulley bearing the load, and as endless rope looped around the pulleys. To avoid slippage, the rope is usually replaced by a chain, and the connected pulleys by sprockets. The two sections of chains carrying the single pulley exert opposing and unequal torques on the connected pulleys, such that only the difference of these torques has to be compensated manually by pulling the loose part of the chain. This leads to a mechanical advantage: the force needed to lift a load is only a fraction of the load's weight.

At the same time, the distance the load lifted is smaller than the length of chain pulled by the same factor. This factor(the mechanical advantage MA) depends on the relative difference of the radii r and R of the connected pulleys. When the block of the pulley is fixed on a high platform, it is known as fixed. An extensible string passes over the grove where its one end is attached to the body to be lifted while the other end is free. When the block of the pulley is not fixed but carries the load, it is known as Movable. An inextensible string is tied around the groove where its one end is fixed to support while the other end is kept free to apply the effort. As the effort is applied, the block together with the load moves upward.

Fixed pulleys are a very common pulley. These pulleys are secured to a single spot. The name fixed is because the pulley itself remains stationary, attached to something like wall or ceiling, while the cord or rope passes through it. Because the pulley is fixed, the force that is applied on the force you are pulling, will be the same amount of force that is exerted on the opposite side. So why use a fixed pulley if it's capabilities are only to exert the same amount of force you, the user, applies? Well, the fixed pulley is very necessary because it changes the direction of the object; which can be very helpful

Movable Pulleys are yet another type of pulley. It differs from the fixed pulley because the actual pulley machine will move with the load. Because the pulley moves with the load, a moveable pulley with multiple force which the user applies to the machine in doing work on an object. These pulleys are often attached to the actual object, in contrast to the fixed pulley which is attached to something stationary. Unlike the fixed pulley, the movable pulley does not change the direction of the object, however it is helpful because of its implication of force on the opposite side of the user. This is ideal for heavier loads because you have to exert less force but that force gets multiplied

Compound pulley systems are a combination of both movable and fixed pulleys. This type of pulley system has the greatest success in moving your heaviest loads. it has the greatest multiplication of force. These compound systems can not only change the direction of the load, but also because of its use of compound pulleys,required less force to be exerted by the user.

The design of an efficient material handling system which will increase productivity and minimize cost entails the followings; designing the system for continuous flow of material(idle time should be zero);going for standard equipment which ensures low investment and flexibility; incorporating gravity stream in material stream framework; and ensuring the proportion of the dead weight to the payload of material taking care of gear at least[1,2].The transportation course influences the general expense of material taken care of. An effective material taking care of gear will decrease cost per volume of material transported and guarantee that materials are conveyed to the creation line securely.

The outline of belt transport framework includes determination of the right measurement of the belt transport parts and other basic parameter values in order to guarantee ideal effectiveness amid stacking and empty conditions. A portion of the segments are; Conveyor belt, engine, pulley and idlers, rollers, pneumatic chamber and so forth. The design of a belt conveyor system takes into consideration the followings: dimension, capacity and speed, roller diameter, belt power and tension, idler spacing, pulley diameter, motor, type of drive unit, location and arrangement of pulley, control mode, intended application and maximum loading capacity.

METHODOLOGY

The materials used for this work includes: Mild steel square pipes, angle iron, flat sheet, sprockets, chain and steel rollers. Other materials are PVC flexible (leather),V-belt pulleys, V-belt, Aerosol paints, bolts and nuts, electric motor and the metghodology is as follows:

The steel pipes are welded together by electric arc welding, then the electric motor is installed. The motor is fastened by bolts and nuts and the driver gear is installed on the motor shaft and the driven (idler)shaft inside the conveyor are installed. Bearings with proper lubrications are used to reduce friction and also noise

The first driver shaft on the conveyor is connected to the electric motor via a sprocket and chain. The required speed ratios are achieved by the size of a driver gear and the driven sprocket connected through the chain. The sprocket that is connected to the chain is attached to the driver shaft for the conveyor with a key. The driven (idler) conveyor shaft as shown is connected to the driver conveyor shaft on the other end via a v-belt drive. The driver conveyor shaft transmits the required power to the driven conveyor shaft via the belt drive. The conveyor belt is wrapped around both shafts and allowances is provided for the belt to roll.

While the belt is rolling, it will ‘convey’ load that is placed on it from point A to B as shown below. It can also convey load from point B to point A if an additional ‘idler’ gear is added to reverse the direction of the rotation. Reverse movement can also be achieved if the belt is configured as shown below.

The conveyor is then covered with sheet metal and is sprayed with rust proof aerosol (atomized) paint.

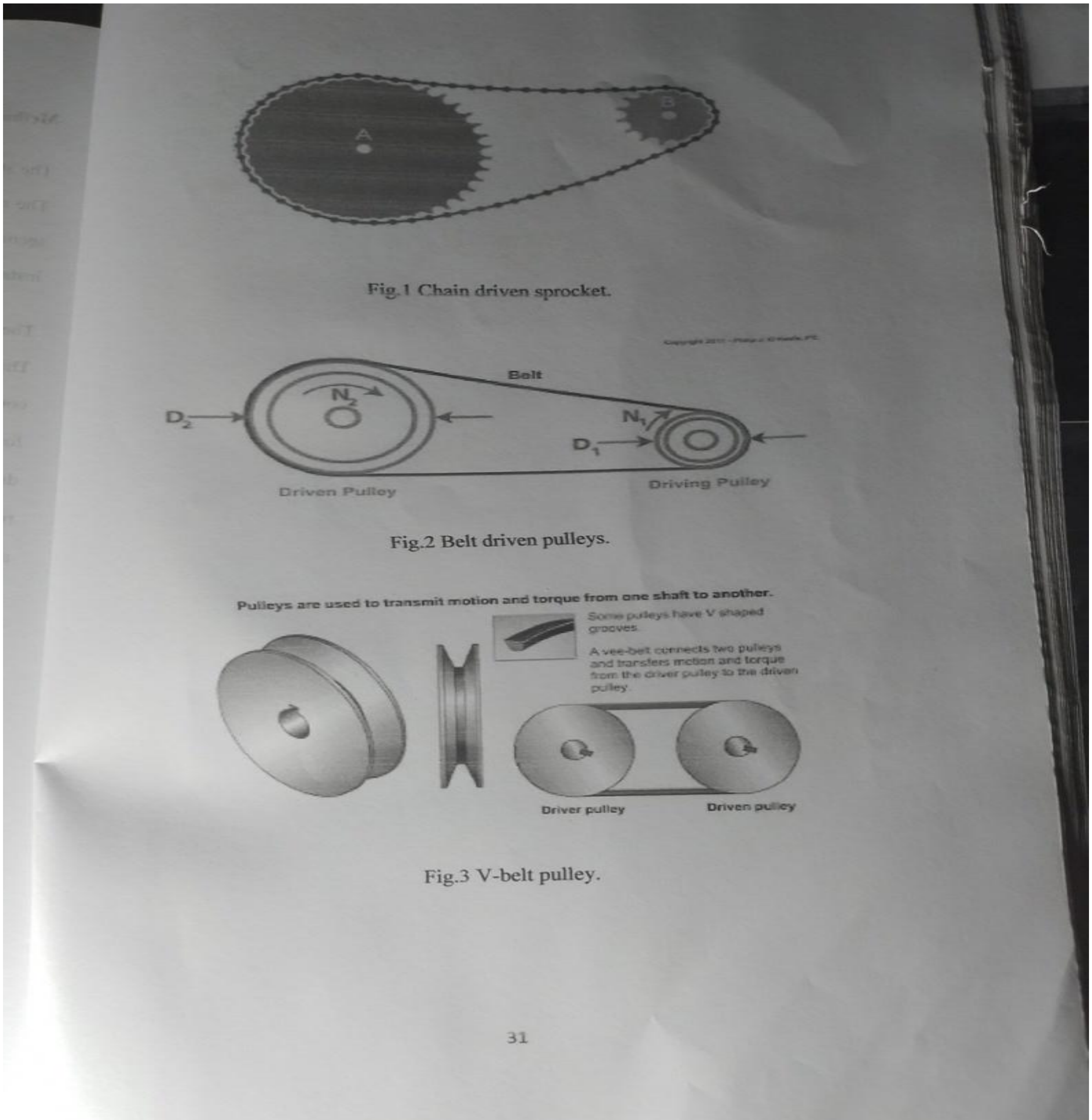


Fig. 2.1: The Pulleys

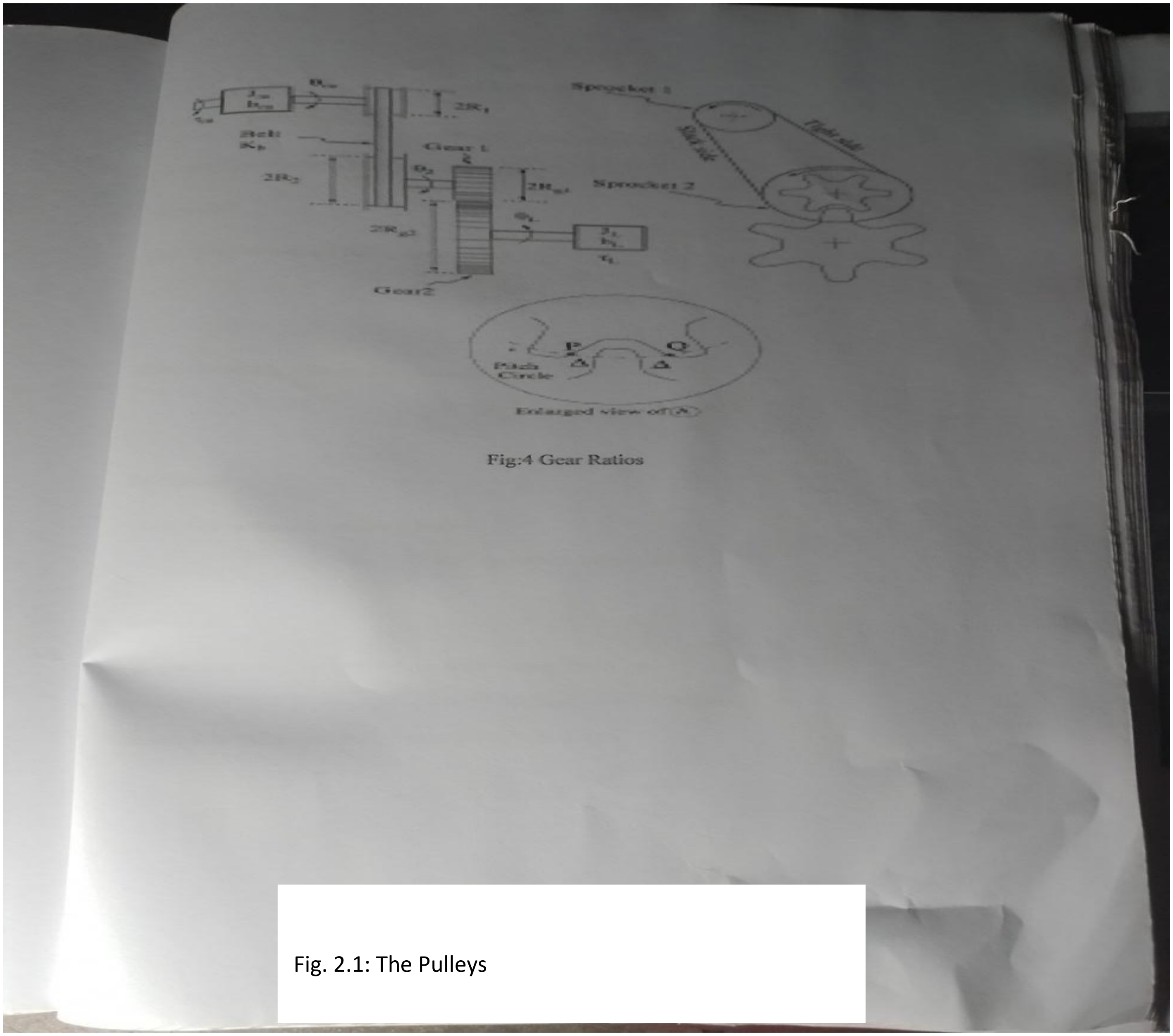


Fig. 2.1: The Pulleys

DESIGN AND ANALYSIS

The results have shown the following common calculations for Proper Design

i. **Belt Length**

When the head and tail pulley are the same size:

$$L = \frac{D+d}{2} \times 3.1416 + 2C$$

When one pulley is larger than the other pulley:

$$L = \frac{D+d}{2} \times 3.1416 + 2C + \frac{(D-d)2}{4c}$$

ii. **Belt Speed**

Expressed in feet per minute (FPM)

$S = D \times RPM \times .2618 \times 1.021$

iii. Belt load

At one time when the load is known per square foot:)

$P = G1 \times C \text{ (in feet)} \times W \text{ (in feet)}$

At one time when load is known by pounds per hour:

$$P = \frac{G2}{S \times 60} \times C \text{ (in feet)}$$

iv. Horsepower

Level Conveyors:

$$HP = \frac{F \times S \times (P+M)}{33{,}000}$$

Inclined Conveyors:

$$HP = \frac{(P \times B)+(P+M) \times F \times S}{33{,}000}$$

v. Effective Tension

Pull needed to move belt and load horizontally:

$E = F \times (P+M)$

vi. Tight Side Tension

Total tension to move belt and load horizontally:

$E2 = E + E1$

Driven pulley:17cm

Driver pulley: 17cm

Length of the belt: 142cm

Center to center distance: 55cm

Electric motor rating:0.75kw-1hp

vii. Stack Side Tension

Additional tension required to prevent slippage on drive pulley:

$E1 = E \times K$

The Coefficient of Friction

viii. Operating Tension

Determines the working strength of the belt to handle the job on per inch of width basis

$T=\frac{E2}{W}$

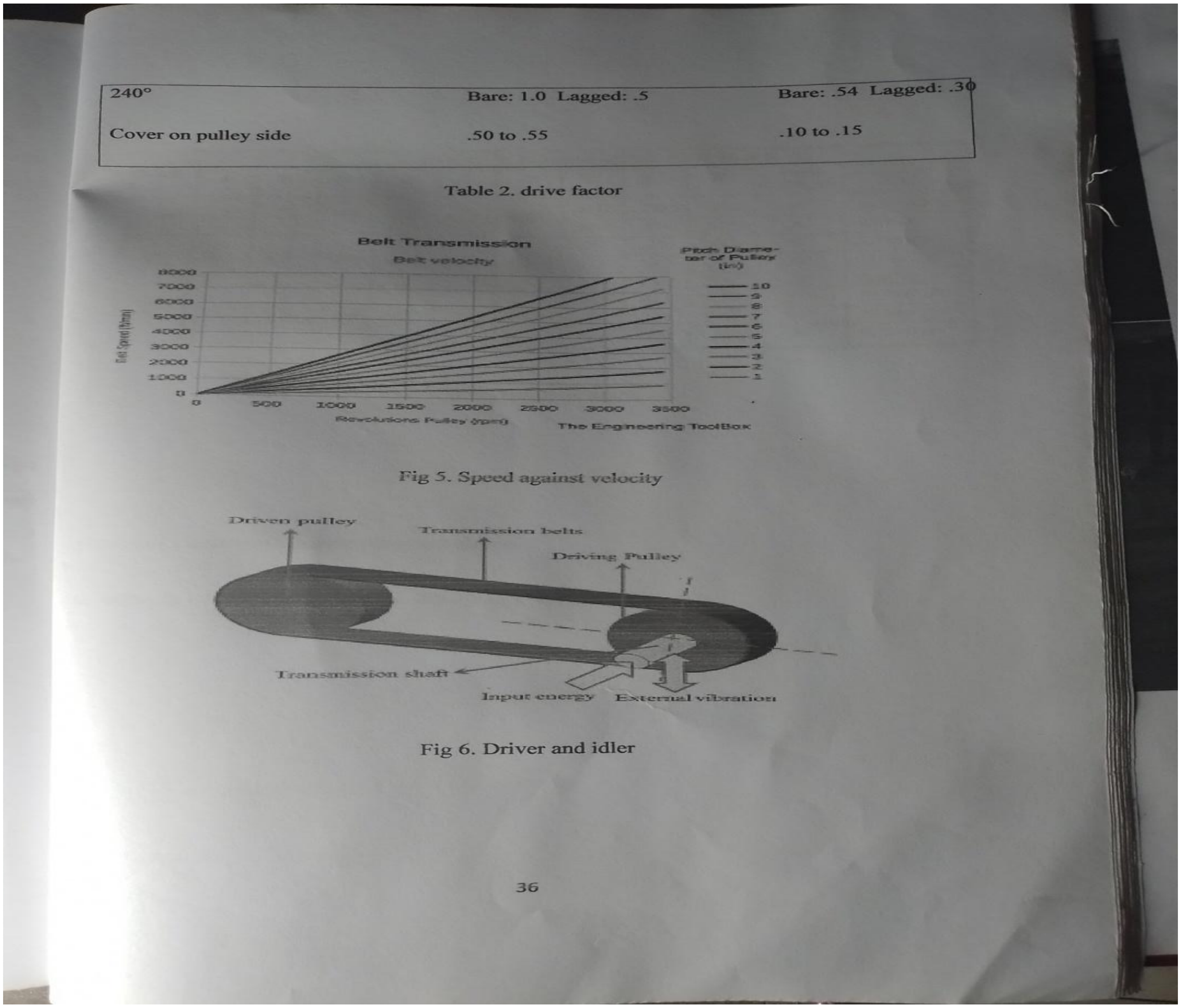
Table 3.1: Working Strength of Belts

Belt	Steel of Aluminium	Metal Rollers
Friction surface on pulley side	0.30 to 0.35	0.10 to 0.15
Bare duck on pulley side	0.20 to 0.25	0.10 to 0.15
Cover on pulley side	0.50 to 0.55	0.10 to 0.15

Table 3.2: Coefficient of friction

The Drive Factor "K"

Belt wrap on drive pulley	Screw Take-up	Gravity Take-up
180 ◦	Bare:1.6 Lagged:1.0	Bare: .84 Lagged:.50
220◦	Bare:1.2 Lagged: .6	Bare:.62 Lagged:.35
240◦	Bare:1.0 Lagged	Bare:.54 Lagged:.30
Cover on pulley side	.50 to.55	.10 to .15



240°	Bare: 1.0 Lagged: .5	Bare: .54 Lagged: .30
Cover on pulley side	.50 to .55	.10 to .15

Table 2. drive factor

Fig 5. Speed against velocity

Fig 6. Driver and idler

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Fig 3.1: Belt dimensions

Table 3.3: Groove Dimensions

v-Belt	GROOVE DIMENSIONS IN INCHES									
	A	B	C	D	E	V	T	U	W	Angle of Groove	Used of Datoms
A-B	1/2	1/2	.115	.206	.6125	.5053	.1377	.2379	.6123	34◦	3.4 to 7.0
							.1241	.2040	.6259	38◦	Over 3.0
							.121	.402	.878	37◦	7.0 to 7.9
C	11/16	1	.200	.200	.757	.780	.113	.380	.887	36◦	BUO to 12.0
							.106	.358	.895	38◦	Over 12.0
D	1/8	1⅕	.300	.300	1.076	1.076			1.259	34◦	12.0 to 12.9
										38	Over 17.0

General theory of conveying machine

Capacity, Q – load per metre of machine length*Rate of conveyor

(q. kg/m) (v. m/s)

=q*v. kg/s

=3600/1000qv tons per hour--------(1)

Hourly capacity=3.6qvtons/hour

ix. For the bulk load:

If the load has a bulk weight of r tons ions per cubic m is conveyed in a continuous stream having a cross sectional area of square m, then

q=1000Fr $(\frac{tons}{m3})$*m^2

$= Fr\frac{tons}{m}$

$= 1000fr\frac{kg}{m}$--------(2)

When the material is conveyed in a tough or tube having cross sectional area of F0 sq m. loading efficiency (Ψ)

Then,

F=F0Ψ

q=1000F0yΨ--------------(3)

When the material is moved in separate container each having a volume 10 liters, filled to a capacity i liters and the containers are spaced a meters apart

$Q = \frac{iy}{a}$

$= \frac{i0\Psi y}{a}$kg/m

x. For unit loads:

If the unit loads having a weight of G/kg each are conveyed in lots of z prices and the spacing between the units or lots is a meter.

$Q = \frac{G}{a}\frac{kg}{m}$

or correspondingly,

$q= \frac{Gz}{a}$

Substituting the value of q in equation(1)

$$Q=3.6qv\frac{\text{tons}}{\text{hr}}$$

$$=3.6 \quad *(\quad \frac{Gz}{a} \quad)*v \quad \frac{tons}{hr}$$

[For unit loads]

Now material in a container stream

(from equation 1)

$$=3.6*1000h\Psi y*v$$

For separate containers,

$$Q=3.6(\frac{i}{a})$$

$$=3.6(\frac{i0}{a})vy\Psi$$

(from equation 1)

If the time interval between separate loads lots is T-1 seconds,then the capacity per hour is

$$Q=\left(\frac{G}{1000}\right)*\frac{3600}{}t1=3.6(\frac{G}{a})v$$

$$=3.6*(\frac{G}{a})*(\frac{a}{}t1)\ [v=\left(\frac{a}{}t1\right);t1=(\frac{a}{v})]=3.6(\frac{G}{}t1)$$

$$=3.6(\frac{Gz}{}t1)$$

[if z=lot size]

The capacity of continuous conveying machine is sometimes expressed by the number of pieces conveyed per hour.

Hence the hourly capacity is

$$Z=(\frac{3600}{}t1)=\frac{3600v}{a}[t1=\frac{a}{v}sec]$$

Or when lots of z pieces are conveyed

$$Z=\frac{3600zv}{a}$$

If the G is the weight of a separate load in kg, the capacity expressed in units of weight is

$$Q=\frac{Gz}{1000}$$

tons per hour

CONCLUSION

This study explains the various systems of conveyors available for use. It also highlighted properties of a particular conveyor, that makes it the best option amongst all the other conveyors available for selection for the performance of a function at hand. A conveyor is a machine that is used to meet some standards for optimal and efficient performance, it also helps to reduce stress and fatigue in industries by assisting in moving various types of loads from one point to another, in terms of production and other applicable aspects.

The time required to construct a conveyor from start to finish ranges from 5-17 working hours, depending on the workers and some other factor including the method employed .The designing operations are the most critical in the manufacture process as any error or omission can lead to the failure of a component, and consequently, the machine as a whole.

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