Control Theory and Informatics
ISSN 2224-5774 (print) ISSN 2225-0492 (online)
Vol 2, No.2, 2012

Performance Evaluation of Locally Fabricated Slipping Machine for Natural Rubber Wood Processing

E.A. Fagbemi[1]; A.F. Iyayi[1]; P.O. Ayeke[1];

P.O. Akpaka[1]; p. Egbuson[1]; P. Chimekwene[1]; D.Y. Giroh[2]; A.F. Makinde[3];

T.C. Akintayo[4].

Research Support Services Department[1],
Research Outreach Department[2],
Tapping Unit[3],

Rubber Research Institute of Nigeria, P.M.B. 1049, Benin City, Edo State,

Mechanical Engineering Department, Federal University of Technology[4],

P.M.B. 704, Akure, Ondo State, Nigeria.

* E-mail of the corresponding author: emmanuelfagbemi@yahoo.com

Abstract

This research work evaluated the performance of the machine with respect to its purpose i.e. rubber wood processing and the scope of study was on transmission members (the electric motor, transmission belt, pulleys, saw blade and the shaft). The machine is made up of the following; the stand that made of angular iron bar of dimension 760mm by 860mm, the machine table measured 1200mm by 390mm made of plank and framed with angular bar. A sliding table capable of both transverse and longitudinal movement through a roller and screw lift respectively, the sliding table accommodates the following fixtures viz: electric motor, driving and driven pulleys of diameter 76mm and 67mm respectively, the shaft (45mm) that transmits motion to the blade holder that rotates the saw blades, Protective guide and transmission belt. Another important fixture/member of the slipping machine is a screw lift (an assembly of bevel gears, screwed bolt, and screwed nut). The sizes of saw blades available are 240mm, 220mm and 190mm diameter. The machine was evaluated and was able to cut rubber woods to the following sizes:

- RSKD-Rough Sawn kiln Dried Timber, 150mm width, 2400mm length, and thickness range from 25-75mm.
- FJS4S-Finger Jointed Four Side Planed Sections, 30-100mm width, 20-65mm thickness, length up to 2400mm/depend on specification.
- Other sizes on specific requirement.

Keywords: Rubber wood, slipping, performance, RSKD, FJS4S

1. Introduction

Rubber tree (Hevea Brasilienesis) had been grown and cultivated mainly for its latex production. The research work has shown that rubber wood has some potential industrial applications among

which are; furniture and cabinet making, flooring, packing cases, word carvings, wooden shuttle block, fiber boards, veneer and plywood. (Chudoff, Martin. 1984.)
Follow the wide application of rubber wood, Researchers are expected to further their studies on rubber wood, to enhance this work (research) a locally fabricated slipping machine was made available to support the studies
The properties that make rubber wood suitable for the above applications include hardness, texture, color (physical properties), bending, tensile strength and compressive strength (mechanical properties). (Chudoff, Martin, 1984) Different processes are carried out on the rubber wood after feeling to improve durability and dimensional stability of the wood. The processes include, sawing, preservative treatment and seasoning**.** (Chudoff, Martin, 1984)
For the scope of this work sawing process will be considered as one of the machines for the process is to be discussed.
The **Slipping Machine** is a circular sawing machine used for sawing straight-line oblong cuts in solid wood and sheet materials. The oblong cut refers to cutting in which the length of the wood is longer than the width. (Johannes Schollbach, 2011).
The machine is made up of the following components; the Stand, Machine Table, Receding Table, Motor, Motor Shaft, Screw Lift, Saw Blade, Sliding Table and Protective guard.

3. Machine Description

3.1 *The Shafts*

Shaft is a rotating member that used for the transmission of power, the shaft used is a solid type that also supports the pulleys and cutting blade. (R.S. Khurmi and J.K Gupta, 2004). The shaft is subjected to both torsion and bending loading as it transmits power and carry pulley. The pulley is positioned close to supporting bearing to reduce deflection and bending stress. The shaft is **45mm** in diameter, **300mm** long, **80mm** stepped turn (**40mm** screwed and **40mm** plain turned to accommodate saw blade washer) and also step turned at the other end to accommodate the driven pulley of diameter **67mm.**

3.2 *The Belt.*

The belt used has the following specification;

$$width = 12mm$$

$$heigth = 12mm$$

$$the\ pitch\ width(p) = 6mm$$

The belt has the following advantages:

- It has large range of speed ratio
- It has efficient above 96%
- It generates low heat
- Low maintenance is required and
- Hence quite in operation. (R.S. Khurmi and J.K Gupta, 2004).

3.3 *The Screw Jack*

This is assembly of the bevel gear, screw bolt, and screw-nut, this allow the slipping machine to move both upward and downward to accommodate varieties of sizes of rubber timber. The maximum height of the rubber wood timber that the machine can accommodate is **120 mm.** (Encyclopedia Britannica Ultimate reference suit, 2011.)

3.4 *The Stand*

The stand bears the machine table and movable sliding table. It is measured $\mathbf{760mm}$ by $\mathbf{860mm}$ by $\mathbf{630mm}$.

3.5 *Machine Table*

The machine table is directly attached to the stand and serves to direct the work piece to the saw blade; it covers ½ widths of the stands.

3.6 *The Guard Hood*

The guard hood is a protective device and an important fixture of the slipping machine that covers the saw blade above to deflect chips flying to escape during operation.

3.7 Electric Motor

The motor is situated on the sliding table, it has motor Shaft and attached to it is a pulley that transmits motion through the belt to the saw blade.

4. Machine Construction

4.1 *Design Calculation*

4.1.1 *The Belt*

Length of the belt is given as:

$L = \frac{\pi}{2}(D_2 + D_1) + 2C + \frac{(D_2-D_1)^2}{4C}$--------------------------- (4.1) (R.S. Khurmi and J.K Gupta, 2008,)

[Driving pulley Diameter $D_1 = 76mm = 0.076mm$

Driven Pulley Diameter $D_2 = 67mm = 0.067mm$*]*

Sheaves Centre (c):

$C = \frac{1}{2}(D_2 + D_1) + D_1 = 147.5mm$-------------------------- (4.2) (R.S. Khurmi and J.K Gupta, 2008,)

L = $519.86mm$

I. *Tension in the belt:*

$\frac{T_1}{T_2} = e^{\alpha\mu}$-- (4.3)

α =*Wrap angle in radian (* $= 180 - 2\beta$ *from the diagram)* --------------------------- *(4.4a)*

$\beta = \sin^{-1}[\frac{R-r}{c}]$ ------------------------------------ (4.4b)

$= 1.7478^0$

$\alpha = 176.50 * \frac{\pi}{180}$

$= 3.08 radian$

$\frac{T_1}{T_2} = 4.96$

$T_1 = 4.96096 T_2$------------------------------------ *(4.5)*

II. *Power is given as:*

$P = \left(\frac{T_2 - T_1}{1000}\right)V$ ------------------------------------ (4.6) (R.S. Khurmi and J.K Gupta, 2008,)

$V = \frac{\pi DN}{60}$ (N=1000rpm) -------------------------- (4.7)

$= 3.979\, {}^{m}/_{s}$

$T_2 – T_1 = \frac{2.2*1000}{V}$ (The motor used is rated $2.2kw$)

$T_2 – T_1 = 552.79N$

$T_2 = 140.59N$

$T_1 = 697.33N\ from\ equation\ (5)$

4.1.2 *The Shaft*

Pulley:

Volume of the pulley $(V_p) = \frac{\pi w D_2^2}{4}$--- (4.8)

Volume of groove on the pulley $(V_g) = D_2 ph\pi$ -- (4.9)

Net volume of the pulley $(V_{net}) = V_p - V_g$ -- (4.10)

Force by the pulley $(F_p) = \rho V_{net} * g$ ------------------------------------ (4.11)

$V_p = 0.0000462m^3,\ v_g = 0.0000152m^3,\ V_{net} = 0.000031m^3,\ F_P = 2.38N$

4.1.3 *The Saw blade:*

Weight of the blade:

$W_b = \pi l \rho g(r_2^2 - r_1^2)$ -------------------------------- (4.12)

[$l = thickness\ of\ the\ blade = 2mm,\ r_1 = bored\ radius = 21mm$

$r_2 = external\ radius = 120m,\ \rho = density\ of\ the\ mild\ steel = 7840\ kg/m^3$]

$W_b = 6.75N$

I. *Blade supports:*

Weight of the blade supports:

$W_S = 2\pi l \rho g(r_2^2 - r_1^2)$ -------------------------- (4.13)

[$l = thickness\ of\ the\ blade = 10mm,\ r_1 = bored\ radius = 11.5mm$

$r_2 = external\ radius = 25mm,\ \rho = density\ of\ the\ mild\ steel = 7840\ kg/m^3$]

$W_S = 2.38N$

II. *The Bolt:*

Weight of the bolt

$W_o = \pi l \rho g(r_2^2 - r_1^2)$ ------------------------- (4.14)

[$l = thickness\ of\ the\ blade = 14mm\ \ r_1 = bored\ radius = 9.5mm$

$r_2 = external\ radius\ acro\ \ ss\ flat = 16mm,\ \rho = density\ of\ the\ mild\ steel = 7840\ kg/m^3$]

$W_o = 0.561N$

Total load on the shaft $= W_b + W_s + W_o + F_P$

$= 12N$

4.2. General Force Representation

a. *Vertical Consideration*

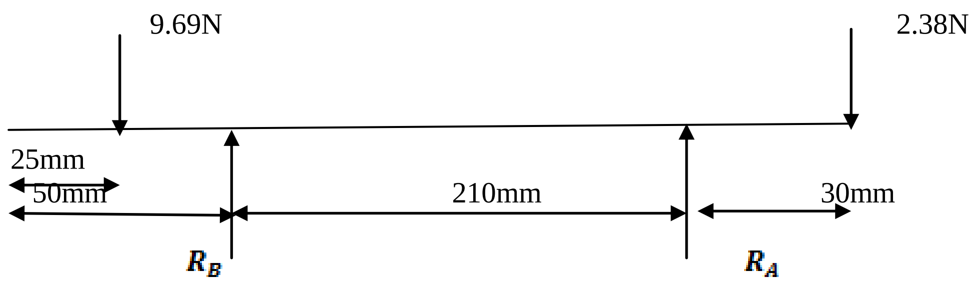


Diagram 1: Vertical Force Representation

Take moment about point A

$R_B = 10.5N$

$R_A = 1.57N$

4.2.1. Shear Force Calculation:

The Shear force and the bending moments for vertical loading are summarized thus;

Table 1: Shear Force and the Bending Moment for Vertical Load

POINTS	SHEAR FORCE	BENDING MOMENTS
1	2.38N	ONm
A	0.81N	0.0714Nm
B	-9.69N	0.2415Nm
2	0N	0Nm

Source: data analysis

b. *Horizontal Consideration*

Horizotal loading is produced due to the pull (tension) of the belt on the pulley against the shaft and force against the cutting surface (Centrifugal Force).

Total tension on the Shaft $\varepsilon T = T_0 = 697.33 + 140.59 = 837.92N(Calculated)$

Cutting force = Centrifugal Force $F_G = \frac{mv^2}{R} = 110.4N\ (calculated)$----------- (4.15)

$$m = \frac{weigth\ of\ the\ blade}{accln.due\ to\ gravity} = \frac{6.75(calculated)}{9.81},\ [R = r_2 - r_1 = 99mm, v = 3.97m/s(from\ equation\ 7)]$$

Control Theory and Informatics
ISSN 2224-5774 (print) ISSN 2225-0492 (online)
Vol 2, No.2, 2012

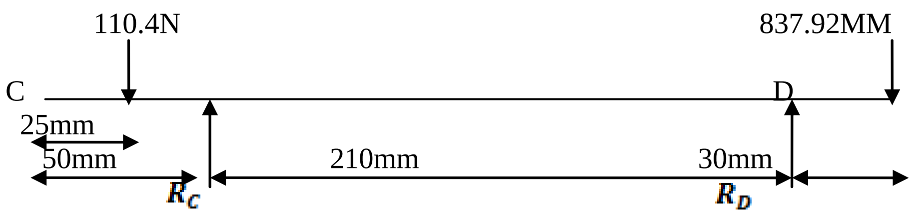


Diagram 2: Horizontal Force Representation

Taking moment about R_D

$R_C = 3.81N$

Taking moment about R_C

$R_D = 944.48N$

4.2.2. Shear Force Calculation:

The Shear Force and the Bending Moments for horizontal loading are summarized thus;

Table 3: Shear Force and the Bending Moment for Horizontal Loading.

POINTS	SHEAR FORCE	BENDING MOMENTS
3	837.92N	0Nm
D	-106.58N	25.14Nm
C	-110.37N	2.76Nm
4	0N	0Nm

Source: data analysis

Maximum Bending Moment:

$M_b = \sqrt{M_V^2 + M_H^2} = 25.14Nm$ ---------------------------- (4.16)

Torsion Moment:

$T_r = M_t = T_2 - T_1 \left[\frac{d_1}{2}\right] = 21.01Nm$----------------------- (4.17)

Diameter of a rotating shaft is given as:

$d^3 = \frac{16}{\pi\tau^2}\sqrt{[(k_b m_b)^2 + (k_t m_t)^2]}$ -------------------------- (4.18)

$d = 18.5mm$

4.3. *Lift System*

Lift system is designed such that, it lifts the sliding table on which the electric motor and the saw blades are located. The system is made of assembly of the worm gears in mesh and the screw jack. The specification of the gears and the screw jack are summarized below. The system enables the machine table to accommodate varieties of work piece in height via upwards movement of the sliding table.

The system is hand wheel operated used where extremely high capacity is required or a need for a very precise up/ down control and also has self-locking safety. (Dongguan Nosen Mechanical and Electrical Equipment co., Ltd, Houjie Town, China. http//www.screwjack.com.on)

5. Performance Test

Major preventive maintenances were done on the machine such as; cleaning and lubrication of the all transmission parts. The machine was set into motion via non-selective Electric motor that transmit motion to the transmission belt and finally to the saw blade through the saw blade shaft. The performance result on the blank rubber tree wood is enumerated below;

Table 4: Performance Test of the Machine

S/N	SAMPLE (BLANKWOOD)	FINAL PRODUCT
1	A	RSKD-Rough Sawn kiln Dried Wood, 150mm width, 2400mm length, and thickness range from 25-75mm.
2	B	FJS4S-Finger Jointed Four Side Planed Sections, 30-100mm width, 20-65mm thickness, length up to 2400mm/depend on specification.
3	C	Other sizes on specific requirement.

Source: data analysis

5.1. *Evaluation*

The performance evaluation table that compares the Slipping Machine with other existing circular Machine is shown below:

Table 5: Evaluation of the Machine

S/N	MACHINE TYPE	EVALUATION
1	Table Circular Machine	Used to cut straight-line oblong, cross and angular cuts as the most common circular sawing machine.
2	Double-Format Circular	Used for straight-line and parallel form cuts particularly of

	Sawing Machine	the sheet material in furniture construction.
3	Slipping Circular Saw	Used for straight-line, oblong, cross and angular cuts depend on the operators' skills.

Source: Chudoff, Martin. (1984) and data analysis



Fig. 1 Fig.2 Fig. 3


Fig. 4 Fig.5

Source: Chudoff, Martin. (1984) and data analysis

6.0. Conclusion

The locally fabricated sliping machine for rubber wood processing has excellent mechanical performance with the efficiency upto 75%. The value of design parameters corresponded with the actual demmensions of the machine; the length of the belt, the shaft diameter in respect to the total maximum load on it.

Therefore, the machine is best fit its design purpose of cutting the rubber wood into specimens sizes for research studies.

Refrences

Chudoff, Martin. 1984. Tropical Timbers of the World. USDA Forest Service.Ag.Handbook No. 607.[html_files/heveab1new.html.]

Johannes Schollbach: Operation on Band and Circular Sawing Machines-Mechanical Woodworking Techniques. Trainee Handbook of Lesson. Institut fur Berfliche Entwicklung e.V. pg_2,4,10.

R.S. Khurmi and J.K Gupta, 2004, Theory of Machine, Eurasia Publishing House (PVT) LTD, Ramnagar, New Delhi-110055.

MLA Style: "Differential Gear" Encyclopaedia Britannica. Encyclopaedia Britannica Ultimate reference suit. Chicago: Encyclopaedia Britannica Ca, 2011.

APA Style: Differential Gear (2011) Encyclopaedia Britannica. Encyclopaedia Britannica Ultimate reference suit. Chicago.

R.S. Khurmi and J.K Gupta, 2008, Machine Design, Eurasia Publishing House (PVT) LTD, Ramnagar, New Delhi.

Dongguan Nosen Mechanical and Electrical Equipments co., Ltd, Houjie Town, China, [http/www.secrewjack.com.on]. pg. 6-14.

List of the diagrams

List of Figures

List of Tables

NOMECLATURES

D_1 = driving pulley diameter (76mm)

D_2 = driven pulley diameter (67mm)

L = length of the belt (m)

C = sheaves centre (m)

d = shaft diammeter (m)

$\alpha =$ wrap angle (radian)

$\mu =$ co − efficient of friction. (0.52 for rubber seed)

$\rho =$ density of the mild steel $\left(7480\ ^{Kg}/_{m^3}\right)$

$g =$ acceleration due to gravity $\left(9.81\ ^{m}/_{s^2}\right)$

$P =$ power of the motor (KW)

$V =$ velocity of the belt $(^{m}/_{s})$

$N =$ speed in revolution per minute

$T_1 =$ tension on the tight side (N)

$T_2 =$ tension on the slack side (N)

$V_p =$ volume of the pulley (m^3)

$V_g =$ volume of the groove on the pulley (m^3)

$V_{net} =$ total volume (m^3)

$F_p =$ force excerted by pulley on shaft (N)

$W_b =$ weigth of the blade(N)

$W_S =$ weigth of the blade support (N)

$W_0 =$ weigth of the bolt (N)

$R_A =$ force reaction at A (N)

$R_B =$ force reaction at B (N)

$T_0 =$ total tension on the shaft (N)

$F_G =$ centrifugal force (N)

$R_C =$ force reaction at C (N)

$R_D =$ force reaction at point D (N)

$M_b =$ maximum bending moment (Nm)

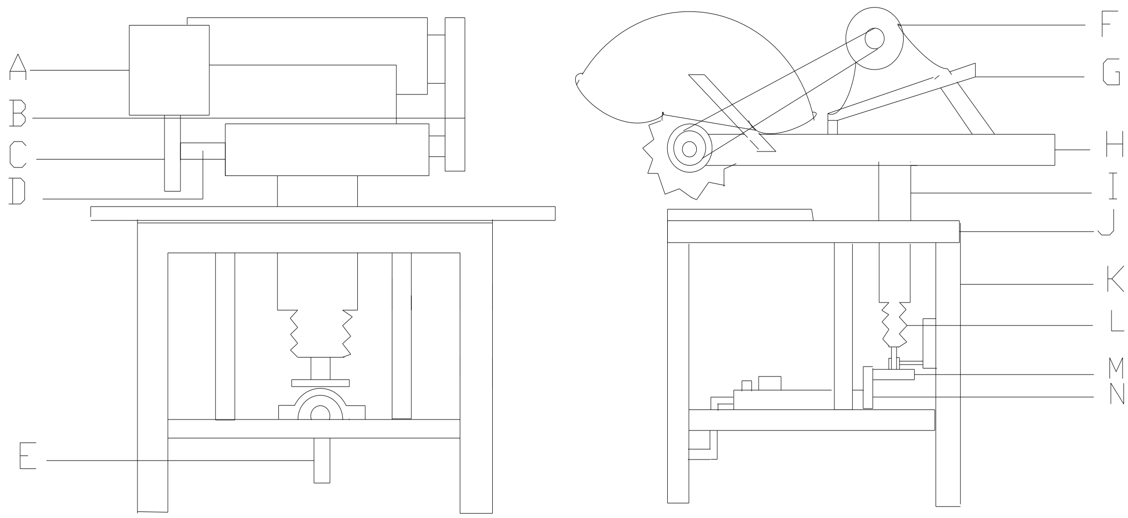
$M_v =$ vertical bending moment (0.2415Nm), $\tau = 45$Mpa[6]

$M_H =$ horizontal bending moment (25.14Nm)

$T_r =$ torsional moment (Nm)

$K_t =$ combined shock and fatigue factor as applied to torsion (1.65 ASME Code)

$K_b =$ combined shock and fatigue factor as applied to bending (1.75 ASME Code)



LOCALLY FABRICATED SLIPING MACHINE

A – BLADE GUIDE.
B – TRANSMISSION BELT.
C – CIRCULAR BLADE.
D – BLADE SHAFT.
E – GEAR LEVER.
F – ELECTRIC MOTOR.
G – MOTOR SEAT.
H – SLIDING TABLE.
I – SCREW JACK ASSEMBLY.
J – MACHINE TABLE.
K – MACHINE STAND.
L – SCREW BOLT.
M – BEVEL GEAR 1.
N – BEVEL GEAR 2.