Determining the Main Sizes of Gears to Drive Rubber Sheet Roll Grinding Machines on Speed Roll Rotation on the Roll Machine Unit Sheeter

Fransnazoan Sitorus [a,1,*], Dejoi Irfian Situngkir [a,2], Aji Mirwana [a,3], Nuzuli Fitriadi [b,4]

[a] Mechanical Engineering, Politeknik Teknologi Kimia Industri, Medan, Indonesia 20228
[b] Mechanical Engineering, Politeknik Aceh Selatan, Aceh, Indonesia 23711
[1] fransnazoan-s@kemenperin.go.id*; [2] joy.tungkir@gmail.com; [3] ajimirwana01@gmail.com; [4]nuzuli@poltas.ac.id
*Corresponding author

ARTICLE INFO

Article history:
Published
July 14, 2025

Keywords:
Roll Sheeter Machine
Roll
Gear
Rotation
Speed

ABSTRACT

This research aims to determine the main dimensions of the roll drive gear on the roll rotation speed in the roll sheeter machine. The roll rotation speed influences the quality and efficiency of the milling process to produce Ribbed Smoke Sheet. The results of the research show that the main sizes of gears on the roll sheeter machine are the gear module used is 8.34 mm, the diameter of the stitch is (150.12 mm), the inside diameter is (129.27 mm), the outside diameter is (166.80 mm), tooth height (18.76 mm), circle distance (26.18 mm), tooth width (125.10 mm), and tooth thickness (14.40 mm) and roll rotation speed on the roll sheeter machine (roll-1 =0.45 m/s), (roll-2 =0.49 m/s), (roll-3 =0.53 m/s), (roll-4 =0.57 m/s), (roll-5 =0.68 m/s), and (roll-6 =0.56 m/s).

I. Introduction

Ribbed Smoked Sheet is processed mechanically and chemically through several processing processes, namely latex receiving, dilution, freezing, milling, smoking, as well as sorting and packing. The rubber processing process is also carried out using a rubber latex lump grinding machine, the best grinding results depend on the roll distance on the machine and the machine capacity. Milling have varied shapes. The grinding process for the rubber raw material itself is usually ground using a roll with a rotation speed according to requirements.

The milling process uses a roll sheeter machine to make thin rubber sheets where a roll is used to press the quaqulum rubber sheets. On the roll sheeter machine there are 6 rolling rubber sheets where each rolling has 2 upper and lower rolls and each roll has a different rotation. On a roll sheeter machine there are several transmission components such as pulleys and belts, sprockets and chains, then gears. The rubber sheet grinding roll is driven by a gear to continue rotation. Gears are a type of transmission element that is important in transmitting power or rotation as well as in a transmission system between the driver and the driven. Gears are found on the roll sheeter machine which functions as a drive for the roll machine to continue the rotation of the electromotor towards the rubber sheet grinder roll [1].

The size of the gears affects the rotation speed of the rubber sheet grinding roll. Large gear sizes result in slow roll rotation, thereby reducing the productivity of the grinding process. Adhesion can occur between the sheet and the roll surface. If the small gear size results in roll rotation that is too fast, it can cause the rubber sheet to slip between the roll and sheet resulting in instability of the grinding process.

The roll sheeter machine is a means of producing Ribbed Smoked Sheet in the natural rubber industry in Indonesia. This machine is used to process frozen rubber latex into grooved rubber sheets with a thickness of ±3 mm. The roll sheeter machine used is "6 in 1", namely a machine consisting of 6 stations. The roll at stations 1-5 is in the shape of a polygon, while the roll at station 6 is in the shape of a multi-spiral. The roll rotation and the distance between the top roll and bottom

Vol. 10, No. 2, July-December 2025, pp 232-240

roll at each station are different, this is adjusted to the increase in length of the rubber sheet, from the initial thickness (30 mm) to (3 mm) at the end of the process [2].

The rotation of the upper and lower rollers uses a direct gear connection, this results in the distance between the upper and lower rolls not being able to be adjusted according to process requirements, so that the thickness of the rubber sheet produced is thick and the production process does not run properly.

Some problems that occur with older model roll sheeter machines are as follows: The diameter of the top roll and bottom roll decreases/wears due to use, the distance between the rolls cannot be adjusted because the gears no longer have clearance, the process is disrupted because the machine cannot adjust to the condition of the raw material, the product thickness is sheet rubber (5 mm), quality inspection rubber is difficult to do because the rubber sheet is too thick and the drying/curing process takes longer.

II. Research methods

A. *Roll Sheeter Machine*

The roll sheeter machine is a means of producing Ribbed Smoked Sheet in the natural rubber industry in Indonesia. This machine is used to process frozen rubber latex into grooved rubber sheets with a thickness of ±3 mm. The roll sheeter machine used is "6 in 1", namely a machine consisting of 6 stations. Figure 1. is a Roll Sheeter Machine (six in one).

Fig 1. Roll Sheeter Machine (six in one)

The components of a roll sheeter machine are devices that are interrelated in the work of a roll sheeter machine. The following are some of the roll sheeter machine components: Induction Motor, Belt, Pulley, Chain, Sprocket, Shaft, Bearings and Cogs [3].

To find out the pulley rotation, use the following formula:

$$\frac{n_1}{n_2} = \frac{d_2}{d_1} \quad (1)$$

n_1 = Electromotor rotation (rpm)
n_2 = Revolutions produced (rpm)
d_1 = Drive pulley diameter (mm)
d_2 = Diameter of the driven pulley (mm)

To determine the rotation of the driven sprocket, the following formula:

$$\frac{n_1}{n_2} = \frac{z_2}{z_1} \quad (2)$$

n_1 = Electromotor rotation (rpm)
n_2 = Revolutions produced (rpm)
z_1 = Number of drive sprocket teeth
z_2 = Number of driven sprocket teeth

B. *Gears*

Gears are machine elements that can transmit power and rotation. Aspects that must be considered in this planning are the effects caused by power transfer and rotation. In transferring power and rotation, several tools that act as power and rotation transfers are belts and chains. Gears are machine elements that can transmit power and rotation. Aspects that must be considered in this planning are the effects caused by power transfer and rotation. In transferring power and rotation, several tools that act as power and rotation transfers are belts and chains.

This gear used in this research is differential, gear clarification can be seen in Figure 2.

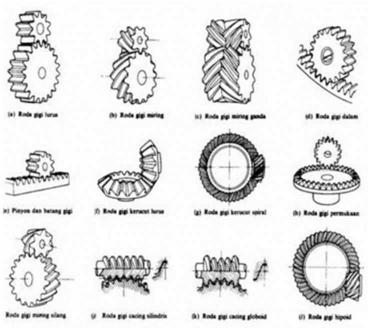

Fig 2. Gear clarification

C. *Main Sizes of Gears*

Terms you need to know in gear design that need to be: Pitch circle (pitch circle), Smaller gear pinion in a gear pair, Pitch circle diameter (pitch circle diameter), Diametral Pitch (number of teeth per pitch diameter), Distance to the circumference (circular pitch), Module (ratio between the diameter of the pitch circle and the number of teeth), Addendum (addition), Dedendum (dedendum), Working Depth, Permission Circle, Pitch point, Operating pitch circle, Additional loop, Dedendum circle, Space width, Pressure angle (pressure angle), Total depth (total depth), Tooth thickness (tooth thickness), Space width (tooth space), Counterattack, Side of the head (tooth face), Foot side (tooth side), Top of the head (upper plane), Tooth width (face width). Figure 3. is a Main sizes of gears [4].

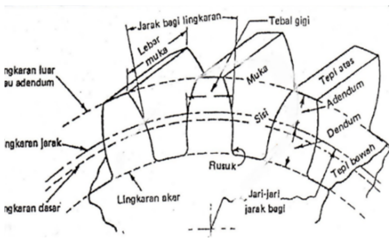

Fig 3. Main sizes of gears

The main sizes of gears can be calculated using the following formula:

Puncture Diameter:

$$dt = z \times m \quad (3)$$

dt = Plug Diameter (mm)
z = Number of teeth
m = Module (mm)

Module Based on Material Strength:

$$m = \sqrt[3]{\frac{45617 \, x \, N}{\lambda \, x \, C \, x \, z \, x \, n}} \quad (4)$$

m = Module (mm)
N = Motor Power (HP)
z = Number of teeth
n = Revolutions (rpm)

Vol. 10, No. 2, July-December 2025, pp 234-240

λ = Installation Factor Price
C = Constant Price of Material (Kg/cm2)

Wear Based Module:

$$m = \sqrt[3]{\frac{445500 \times N}{\lambda \times z_1^2 \times k \times n_1} \times \frac{i+1}{i}} \quad (5)$$

m = Module (mm)
N = Motor Power (HP)
z = Number of teeth
n = Revolutions (rpm)
λ = Installation Factor Price
k = Wear Cost
i = Gear Ratio

Number of Teeth:

$$z = \frac{dt}{m} \quad (6)$$

z = Number of teeth
dt = Plug Diameter (mm)
m = Module (mm)

Outer Diameter:

$$dl = m \times (z + 2) \quad (7)$$

dl= Outer Diameter (mm)
m = Module (mm)
z = Number of Teeth

Inside Diameter:

$$dd = dt - 2{,}5 \times m \quad (8)$$

dd = Inside Diameter (mm)
dt = Plug Diameter (mm)
m = Module (mm)

Tooth Height:

$$L = 2{,}25 \times m \quad (9)$$

L = Tooth Height (mm)
m = Module (mm)

Gear Width:

$$b = \lambda \times m \quad (10)$$

λ = Fitting Factor
m = Module (mm)

Distance for Circles:

$$t = \pi \times m \quad (11)$$

t = Distance to Circle (mm)
m = Module (mm)

Tooth Thickness:

$$h = 0{,}55 \times t \quad (12)$$

t = Distance to Circle (mm)
h = Tooth Thickness (mm)

The cross-section of the teeth on the gear can be seen in Figure 4.

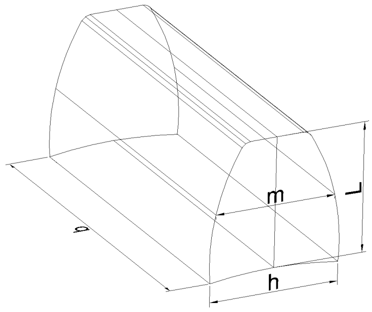

Fig 4. Cross-section of teeth on a gear

III. Method

A. *Roll Grinder*

A roll machine consisting of 2 units of rolls placed in parallel directions and rotating in the opposite direction to the direction of the compressive force pressing on the material that enters between the roll gaps. Ribbed Smoked Sheet will be rolled and inserted into both roll gaps. The Ribbed Smoked Sheet enters because one of the rolls moves by utilizing the rotation of the drive motor, so the Ribbed Smoked Sheet enters the gap between the rolls. In this rolling process, the length and width of the Ribbed Smoked Sheet increases, but the thickness of the workpiece will decrease [5].

Rolling is a deformation process where the thickness of the workpiece is reduced using compressive force and using two or more rolls. The roll rotates to pull and press the Ribbed Smoked Sheet in between. In the rolling process, Ribbed Smoked Sheet is subjected to high compression stress originating from the roll pinch movement and surface shear stress as a result of friction between the rolls. Roll is a tool for flattening Ribbed Smoked Sheet which consists of two rolls driven by an electromotor which is passed to the drive transmission, the way the sheet is inserted into the roll so that a thin Ribbed Smoked Sheet is obtained [6]. Picture of the grinder roll can be seen at Figure 5.

Fig 5. Roll Grinder

Measurement of the rotation speed of the grinding machine was carried out on each grinding roll (top roll and bottom roll) and the rotation of the electric motor. This is done because the roll speed is different. The rotation of the roll can be determined by knowing the rotation of the gear which drives the roll [6].

$$v = \frac{\pi . d . n}{1000.60} \tag{13}$$

v = Roll speed (m/s)

d = Roll diameter (mm)
n = Revolution (Rpm)

B. *Observation Data*

Menentukan ukuran-ukuran utama roda gigi terhadap kecepatan roll maka perlu data pengamatan berupa spesifikasi peralatan yaitu:

Roll Sheeter Machine

a. Roll sheeter machine type : Six In One
b. Type of material being ground : Sheet Rubber
c. Roll sheeter machine capacity : 350 Kg/Hour

Electromotor

a. Brand : TECO
b. Type : AEEBKB04001FMB
c. Power : 10 HP
d. Phase : 3
e. Rotation : 1450 Rpm
f. Voltage : 380 V
g. Current : 14.1 A

Shaft And Roll

a. Shaft Diameter : 40 mm
b. Shaft Material : Cast Iron
c. Shaft Length : 300 mm
d. Roll Diameter : 150 mm
e. Roll Material : Cast Iron and Aluminum
f. Roll Length : 760 mm

Gears and Pulleys

a. Number of Teeth of Gear 1 (z1) : 18
b. Number of Teeth on Gear 2 (z2) : 18
c. Gear Material : St 60 Steel
d. Installation Factor (λ) : 15
e. Gear Ratio Number (i) : z_2/z_1 = 18/18 = 1
f. Material Constant Price (C) : 85 Kg/cm^2

Pulleys

a. Drive Pulley Diameter (d1) : 90 mm
b. Riven Pulley Diameter (d2) : 510 mm
c. Pulley Material : Cast Iron

Sprocket

a. Number of Sprocket Teeth (z1) : 13
b. Number of Sprocket Teeth (z2) : 38
c. Number of Sprocket Teeth (z3) : 25
d. Number of Sprocket Teeth (z4) : 24
e. Number of Sprocket Teeth (z5) : 29
f. Number of Sprocket Teeth (z6) : 30
g. Number of Sprocket Teeth (z7) : 27
h. Number of Sprocket Teeth (z8) : 29
i. Number of Sprocket Teeth (z9) : 28
j. Number of Sprocket Teeth (z10) : 30
k. Number of Sprocket Teeth (z11) : 28
l. Number of Sprocket Teeth (z12) : 31

Schematic of the roll sheeter machine can be seen in Figure 6.

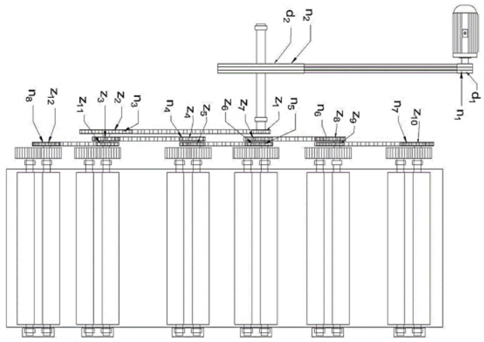

Fig 6. Roll Sheeter Machine

IV. Results and Discussion

Calculating the Main Sizes of Gears in a Roll Sheeter Machine Unit

1. Module (m) based on material strength

$$m = \sqrt[3]{\frac{45617 \text{ x N}}{\lambda \text{ x C x z x } n_3}}$$

$$= \sqrt[3]{\frac{45617 \text{ x } 10 \text{ HP}}{15 \text{ x } 85 \text{ Kg/cm}^2 \text{ x } 18 \text{ x } 87{,}53 \text{ Rpm}}} = \sqrt[3]{\frac{456170}{2008813{,}5}}$$

$= \sqrt[3]{0{,}227}$ = 0,610 cm; m = 6,10 mm

2. Based on wear

   To find the value (k) we have to interpolate because the value (k) is based on the rotation of the fifth roll gear obtained from the calculation on page 35, namely 87.53 Rpm.

$$m = \sqrt[3]{\frac{445500 \text{ x N}}{\lambda \text{ x } z_1^2 \text{ x k x } n_1} \text{ X } \frac{i+1}{i}}$$

$$= \frac{x-x_1}{x_2-x_1} = \frac{y-y_1}{y_{2-1}} \quad = \frac{87{,}53-50}{100-50} = \frac{y-42}{34-42} = \frac{37{,}53}{50} = \frac{y-42}{-8}$$

So the (k) value for St 60 steel and based on rotation is 36. Calculates module (m) based on wear:

$$m = \sqrt[3]{\frac{445500 \text{ x N}}{\lambda \text{ x } z_1^2 \text{ x k x } n_1} \text{ X } \frac{i+1}{i}}$$

$$= \sqrt[3]{\frac{445500 \text{ x } 10 \text{ HP}}{15 \text{ x } (18)^2 \text{ x } 36 \text{ x } 87{,}53 \text{ Rpm}} \text{ X } \frac{1+1}{1}} = \sqrt[3]{\frac{4455000}{15314248{,}8} \text{ x } 2}$$

$= \sqrt[3]{0{,}581}$ m = 0,834 cm; m = 8,34 mm

Two module calculations (m), the largest is taken so that the module used is m = 8.34 mm for 5000 working hours. This module is also used to find other measurements. Because the gear ratio used is 1:1, the sizes of gears one and two will be the same.

3. Puncture diameter of a pair of gears
   dt = Z . m; = 18 . 8.34mm; = 150.12 mm
4. Inner diameter of a pair of gears
   dd = m . (z1 – 2.5); = 8.34 mm . (18 – 2.5); = 129.27 mm
5. Outer diameter of a pair of gears
   dl = m . (z1+2); = 8.34 mm . (18 + 2); = 166.80 mm
6. Tooth height on a pair of gears
   L = 2.25 . m; = 2.25 . 8.34mm; = 28.76 mm
7. Distance between the circles in a pair of gears
   t = π . m; = 3.14 . 8.34mm; = 26.18 mm
8. Width of the teeth on a pair of gears
   b = λ . m; = 15 . 8.34mm; = 125.10 mm
9. Thickness of the teeth on a pair of gears
   h = 0.55 . t; = 0.55 . 26.187mm; = 14.40 mm

Calculation of Roll Rotation Speed in Roll Sheeter Machines

Rotation of Each Transmission On The Roll Sheeter Machine

1. Pulley rotation
   $\frac{n_1}{n_2} = \frac{d_2}{d_1}$ $\frac{1450 \text{ Rpm}}{n_2} = \frac{510 \text{ mm}}{90 \text{ mm}}$
   n_2 = 255,88 Rpm
2. Rotation of the sprocket and gears connected to roll 5
   $n_3 = z_1.n_2/z_2$ = 13 . 255,88 Rpm/38 = 87,53 Rpm
3. Rotation of the sprocket and gears connected to roll 4
   $n_4 = z_3.n_3/z_4$ = 25 . 87,53 Rpm/30 = 72,94 Rpm
4. Rotation of the sprocket and gears connected to roll 3
   $n_5 = z_5.n_4/z_6$ = 27 . 72,94 Rpm/29 = 67,90 Rpm
5. Rotation of the sprocket and gears connected to roll 2
   $n_7 = z_7.n_5/z_8$ = 28 . 67,90 Rpm/30 = 63,37 Rpm
6. Rotation of the sprocket and gears connected to roll 1
   $n_7 = z_9.n_6/z_{10}$ = 28 . 67,90 Rpm/31 = 57,23 Rpm
7. Rotation of the sprocket and gears connected to roll 6
   $n_7 = z_{11}.n_7/z_{12}$ = 24 . 87,53 Rpm/29 = 72,43 Rpm

Rotation of Each Transmission On The Roll Sheeter Machine

1. Menghitung kecepatan *roll* 1
   $v = \frac{\pi.d.n_7}{1000.60}$
   $= \frac{3{,}14.100\, mm.87{,}53\, Rpm}{1000.60} = \frac{26955{,}33}{60.000}$ = 0,45 m/s
2. Menghitung kecepatan *roll* 2

$$v = \frac{\pi.d.n_6}{1000.60}$$
$$= \frac{3{,}14.100\,mm.63{,}37\,Rpm}{1000.60} = \frac{29847{,}27}{60.000} = 0{,}49 \text{ m/s}$$

3. Menghitung kecepatan *roll* 3

$$v = \frac{\pi.d.n_5}{1000.60}$$
$$= \frac{3{,}14.100\,mm.67{,}90\;Rpm}{1000.60} = \frac{31980{,}9}{60.000} = 0{,}53 \text{ m/s}$$

4. Menghitung kecepatan *roll* 4

$$v = \frac{\pi.d.n_4}{1000.60}$$
$$= \frac{3{,}14.100\,mm.72{,}94\,Rpm}{1000.60} = \frac{34354{,}74}{60.000} = 0{,}57 \text{ m/s}$$

5. Menghitung kecepatan *roll* 5

$$v = \frac{\pi.d.n_3}{1000.60}$$
$$= \frac{3{,}14.100\,mm.87{,}53\,Rpm}{1000.60} = \frac{41226{,}63}{60.000} = 0{,}68 \text{ m/s}$$

6. Menghitung kecepatan *roll* 6

$$v = \frac{\pi.d.n_8}{1000.60}$$
$$= \frac{3{,}14.100\,mm.72{,}43\,Rpm}{1000.60} = \frac{34114{,}53}{60.000} = 0{,}56 \text{ m/s}$$

V. Conclusion

The results of research to obtain surface roughness values (Ra) and optimum cutting conditions in dry machining of ST37 Determining the Main Sizes of Gears to Drive Rubber Sheet Roll Grinding Machines on Speed Roll Rotation on the Roll Machine Unit Sheeter, where the results of the analysis of the tests are concluded as follows:

1. From the calculation results, it is obtained that the gear module used is 8.34 mm, then based on this module the other main sizes of the gears are obtained, including the diameter of the plug is 150.12 mm, the inner diameter is 129.27 mm, the outer diameter is 166 mm. .80 mm, tooth height is 18.76 mm, circle distance is 26.18 mm, tooth width is 125.10 mm, and tooth thickness is 14.40 mm.
2. From the calculation results, it is obtained that the gear module used is 8.34 mm, then based on this module the other main sizes of the gears are obtained, including the diameter of the plug is 150.12 mm, the inner diameter is 129.27 mm, the outer diameter is 166 mm. .80 mm, tooth height is 18.76 mm, circle distance is 26.18 mm, tooth width is 125.10 mm, and tooth thickness is 14.40 mm.

References

[1] Luntungan, Frans ST., MT. 2013. *Pembuatan Roda Gigi*. Politeknik Negeri Manado.
[2] Parjono, Sirod Hartono. 1991. "Gambar Mesin dan Merencanakan Praktis". Yogyakarta.
[3] Sularso. 1997. Dasar Perencanaan dan Pemilihan Elemen Mesin. Jakarta. Pradnya Paramita.
[4] Syahputra, Yudi. 2019. *Pembuatan Mesin Bola Penghancur* (Ball Mill). Tugas Akhir. Medan. Universitas Muhammadiyah Sumatra Utara.
[5] Umar Sukrisno. 1984. "Bagian-bagian Mesin dan Merencanakan. Jakarta. Erlangga.

Vol. 10, No. 2, July-December 2025, pp 240-240

[6] Wibawa Kresnandi, Sigit Yoewono. 2012. *"Modifikasi Mesin Roll Sheeter Untuk Memperbaiki Kinerja Mesin Pengolah Getah Karet"*. Jurusan Teknik Manufaktur, Politeknik Manufaktur Negeri Bandung.