Design and Construction Multi Output Power Transmission with Single Prime Mover on Agricultural Products Machine

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Abstract. Manufacturing agricultural products by the farmers, people or person who involve in medium industry, small industry, and households industry still be done in separately. Although the power on prime mover is enough, in operations, prime mover was only to move one of several agricultural products machine. This study attempts to design and construct power transmission multi output with single prime mover; a single construction that allows prime mover move some agriculture products machine in the same or not. This study begins with the determination of production capacity and the power to destroy products, the determination of resources and rotation, normalization of resources and rotation, the determination of the type material used, the size determination of each machine elements, construction machine elements, and assemble machine elements into a construction multi output power transmission with single prime mover on agricultural products machine. The results show that with a input normalization 4 PK (2984 Watt), rotation 2000 rpm, the strength of material 60 kg/mm², and several operating consideration, thus obtained size of machine elements through calculation. Based on the size, the machine elements is made through the use of some machine tools and assembled to form a multi output power transmission with single prime mover.

1. Introduction

Power transmission has been applied to various machinery operating systems because it is a group of elements machine that can transfer power from the driving element into driven elements.

Main elements of power transmission usually consisting of gears, pulley, belt, shaft, spin, bearing, and additional element. In the design a power transmission, each element cannot designed alone but it is integrated with other elements that forms the transmission. Every size of elements affected to the other element.

Generally, power transmission found in the market today is mono output power transmission with single prime mover. This kind of model is used to vary a rotation and changes the direction of rotation and reduction or the addition of moment on the wheel gear that is driven. The application of these transmitting is as in vehicles motor, instrument lift system, machine tools, and other machines.
Needs of a system for transmitting today is widespread. Besides rotation variation, changes the
direction of rotation, reduction or additional of moment on a gear driven, also power transmission is
used to move various machine with the same machine (multi output with single prime mover).

It is needed a system transmitting power that can be used to move some machines in and or not at
the same time with the same machine. A transmitting technique were very rare in the local and the
national market.

Theories used in the design and making is commonly associated with statics structure, machine
elements, technique material, and material mechanics.

2. Method

2.1. Early Design

The prototype of early transmitting power multi output with single prime mover that would be
checked is shown in figure 1. This prototype has the principle of as follows:

The first, power and rotation are transmitted from the shaft of prime mover to the mover shaft of
clutch (1). The mover shaft of clutch (1) continues power and this rotation to the mover shaft of wheel
gear (3) through a clutch (2).

A clutch (2) can control the use of (decided or connects) the power and rotation that is transmitted
from the mover shaft of clutch (1) to the mover shaft pinion gear (3) assisted by lever (10).

Movement lever (10) discharges and connects of the pinion gear (4) and wheel gear (5), done through
a movement into and forward sheets of this book. The shaft of pinion gear (3) mounted fused with a
pinion gear (4) through connection pin, so that power and rotation on the shaft of the pinion gear (3)
is equal to the power and rotation on the wheel gear (4). The pinion gear (4) continue power and
rotation to the driven shaft (6) through a wheel gear (5). The driven shaft (6) that is mounted fused
with a wheel gear (5) through connection spie, so that power and rotation on a wheel gear (5) is equal
to the power and rotation on the driven shaft (6). Power and rotation will distributed to the each
agricultural machine.

![Figure 1](image)

**Figure 1.** Early prototype of power transmitting multi output with single premover on the agricultural
products machine.

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2.2. Design Process

Design process of the transmitting is done in different stages. Every stage can be described as follows.

1. Determine based on the production capacity, rotation, and other value that have been known to the
processing (shown in the problem and figure 4) agricultural commodity products with the equation

\[
m = \frac{N_{mp}}{v^2}, \quad N_{mp}, \quad m, \quad \text{dan} \ v \ \text{is the power processors agricultural commodities (kw), production}
\]

\[
\text{capacity (kg/s), and speed of wheels steamroller (m/s).}
\]
1. Power and rotation transmitted.
2. Corection factor.
3. Load condition.
4. Power and moment of design.
5. Horizontal and vertical load.
6. Reaction on the bearing.
7. Drawing of bending moment area.
8. Total of bending moment.
9. Strength of shaft material.
10. Save factor.
11. Corection bending and twist factor.
12. Strains concentration on the spie and shaft stage.
13. Bending strains allowed.
14. Shaft Diameter (ds).
15. Radial deflection.
16. $\theta : \theta_{\text{max}}$.
17. Calculation of lateral deflection.
18. $y : y_{\text{max}}$.
19. Weight of each part of element rotated.
20. Critical rotation each part of element rotated.
21. Total of critical rotation ($N_\infty$).
22. $n/N_\infty : 0,6-0,7$.
23. Shaft Diameter.
24. Shaft material.
25. Tangential force.
26. wide (b) and tall (t) spie.
27. depth of spien on the shaft.
28. strength of spie material.
29. Save factor.
30. Surface pressure of spie allowed.
31. Sher stress allowed.
32. Length of spie based shear stress allowed ($L_1$).
33. Length of spie based surface pressure allowed ($L_2$).
34. Biger of $L_1$ and $L_2$.
35. Length of spie $L_\varepsilon$.
36. $b/d_s : 0,25 - 0,35$
    $L_\varepsilon/d_s : 0,75 - 1,5$.
37. Wide of spie.
38. Thick of spie.
39. Length of spie.
40. Material of spie.

**Figure 2.** Flow chart of shaft design

**Figure 3.** Flow chart of spie design
**Figure 4.** Flow chart of gear design

- 41. Gear modul, m
- 42. Pressure angle, α
- 43. Kelonggaran sisi
- 44. Kelonggaran puncak
- 45. Tooth number, Z₁ and Z₂
- 46. Ratio of gear, i
- 47. Diameter pitch
- 48. Axis distance
- 49. Out diameter
- 50. In Diameter
- 51. Depth of cut
- 52. Form factor of gear
- 53. Radial speed
- 54. Tangensial force
- 55. Diaanamis factor

- 56. Naterial of gear
- 57. Strength of material
- 58. Gear surface hardness

- 59. Bending strains allowed.
- 60. Strains factor
- 61. Load bending allowed
- 62. Surface load allowed
- 63. Maximum load.
- 64. Wide, b

- 65. \[ \frac{b \cdot m \cdot (6-10)}{d/b} : 1,5 \]

- 66. Gear modul
- 67. Sudut tekan pahat
- 68. Axis distance
- 69. Main size of gear
- 70. Gear material

- **Figure 5.** Flow chart of pulley and belt design

- 71. Belt area selection
- 72. Minimum Pulley Diameter
- 73. Pitch diameter
- 74. Out diameter
- 75. Naf diameter
- 76. Belt velocity

- \[ > \]

- \[ v : 30 \]

- \[ \leq \]

- \[ < \]

- \[ C : (d_k + D_k)/2 \]

- 77. V belt selection
- 78. Power transmission of belt
- 79. Nominal number and belt length
- 80. Axis distance
- 81. Contak angle
- 82. Correction factor
- 83. Number of belt

- 84. Belt area
- 85. Length of belt
- 86. Number of belt
- 87. Distance ox shft axis
- 88. Out diameter of pulley
2. Determine the total power \( N_{\text{pmt}} \) agricultural products machine by means of add up all power in each agricultural products machine.

3. Determine power of prime mover by multiplication between the total \( N_{\text{pmt}} \) power of agricultural products machine with a correction factor \( f_c \), in the equation, \( N_{\text{pm}} = N_{\text{pmt}} \times f_c \).

4. Normalize power by determine power prime mover on the market \( N \) approximated-larger than the results of \( N_{\text{pm}} \) power.

5. Determine the strength of material allowed in a design by divide tensile strength of maximum with a factor of security.

6. Determining the size of the parts power transmitting construction system based power and rotation of prime mover and strength of material allowed. Design process consecutively on the other element such the shaft, spie, gear, bearing, pulley and belt, and the clutch a completely shown in figure 2, 3, 4, 5, 6, and 7.

7. Make a picture of complete design based on the measurement known have been obtained from the calculation by following norms that is on the international standard organization (ISO). This picture is complete results implementation of early design and having equal work principle.
2.3. **Building Process**

Building process of the power transmitting based used to the tools machine and bench work.

3. **Result**

The results of the study of form and the element size, elements that have been made, and models building power transmitting multi output with single prime mover shown on the figure 8, 9, 10, and 11.

4. **Analysis**

There are many methods that can be done to determine the power on a system. The methods is usually different because adapted to characteristic of load, the input power assumption, the output power desired, as well as the type of works to be performed. The determination of power and rotation required in this planning is still done manually because of the lack of an instrument for the purposes. The determination of power and rotation required in research is based on two items. The first, according to the production capacity, and the second based on power the product destroyer. The both power according production capacity and production destroyer totaled and normalized. Power normalized usually approximated-larger than power and rotation available in the market. Power and rotation the results of this normalization used in the process of design. A method to determination of power has been including of all part fund.

The selection of the materials used in this design was preceded by market survey. Results of the market survey get the materials widely available in the market is steel with the tensile strength 60 kg/mm$^2$ (ST 60), so as the process of making and applying to the community easy to do. A measure on all elements for power transmitting that calculated and made is based on material with tensile strength 60 kg/mm$^2$. A kind of other material used for making these transmissions suggested to replanning. Material with the condition of 60 kg/mm$^2$ used in the design and manufacture indicates the material will damage if axial load larger than 60 kg in one square mili meter. To avoid the load of more in power transmitting, the strength of material has been divided by safe factor around 5.6. This value shows that these materials is broken if the charges imposed him around 5.6 times as large.

Besides safe factor imposed in power planning early, each element like the shaft, spie, gear, pulleys, and belt has also nominates other factors like moment excess, power excess, of notches factor, and others which can ensure security operation power transmitting.

Based on the boundary conditions on designing a gear that maximum speed of the gear was 12.5 m/s so from the design and making obtained that rotation allowed occurring in the mover shaft of 5971.338 rpm. The rotation suggested in power transmitting was 2000 rpm is still safe.

In the methods of design and manufacture of the shaft, a shaft treated as the spindle that defines that the shaft of the results of this design punter load only. The shaft is not designed for bending load. This is done because of the distance between the position of bearing and load is very close so that the bending load assumption that happened on the shaft can be neglected.

Conditions consider to be imposed on power transmitting should be taken to obtain safety operation. In the design power transmitting, the time of surgery that can be imposed on this system maximum 8 hours/day. This time operations taken based on working time standards. If system should be operate greater than the time limit that eligibility operate system to be reviewed.

Because power transmitting will be applied on the agricultural products machine that already exists then design power transmitting is based on measurements and other provisions that are found on previous machine. In terms of the power determination, repeated calculations done for ascertaining the power used industry actors. Power that often used by industry actors (5.5 PK) is far higher than on the power of research results (4 PK). This showed that with the power transmitting research result if fitted on agricultural products machine unit hence:
1. Fuel consumption of prime mover 4 PK is less than prime mover 5.5 PK. Efficiency prime mover powerless 4 PK larger.

2. At the same time prime mover 5.5 PK is only able to manage one kind of products and prime mover 4 PK is installed power transmitting can process three types of agricultural products different. The time it takes to producing at prime mover 4 PK is installed power transmitting will be small given prime mover 5.5 PK without power transmitting.

3. Based on analysis of the second point above so production capacity in prime mover defenseless 4 PK is that has been mounted power transmitting greater with a production capacity of on prime mover defenseless 5.5 is without power transmitting.

Power transmitting multi output with single prime mover obtained to research has specifications as follows:

1. Input power : 4 PK
2. Input rotation : 2000 rpm
3. Rotation ratio : 2
4. Mechanical efficiency : 57 %
5. Unit input : one
6. Unit output : triple
7. Prime mover : combustion engine

5. Conclusion
Based on input power 4 PK (2984 watt), rotation of prime mover is 2000 rpm, strength of material 60 kg/mm², as well as some consideration operate that will be worn on power transmitting hence the type of machine elements size the results of research and planning this as follows:

1. The results of research a picture 2nd depicted and shown in appendix 1.

2. The results of actual prototype power transmitting multi output with single prime mover ready applied is presented in figure 11.

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Note:

- Diameter of shaft, $d = 12\, \text{mm}$
- Tolerance value = $e8$
- Length of spie, $L = 12\, \text{mm}$
- Wide of spie, $b = 4\, \text{mm}$
- Thick of spie, $t = 4\, \text{mm}$
- Depth of spie slot, $t_1 = 2.5\, \text{mm}$
- Number of bearing = 6001ZZ
- Nominal capacity dynamic specification of bearing = 400 kg
- Nominal capacity static specification of bearing = 590 kg

Figure 8. Design result of shaft, spie, and bearing

Note:

- $b = \text{tooth wide} = 2m = 4\, \text{mm}$
- $t = \text{tooth thick} = 1.5708\, m = 3.14\, \text{mm}$
- $a_m = \text{Adendum} = 1m = 2\, \text{mm}$
- $d_m = \text{Dedendum} = 1.25m = 2.5\, \text{mm}$
- $r = \text{radius} = 0.4m = 0.8\, \text{mm}$
- Working depth ($b_1$) = 2m = 4 \, \text{mm}
- Depth working total = $2.25m = 4.5\, \text{mm}$
- Minimum tolerance = 0.25 m = 0.5 mm
- $r_1 = \text{radius of diameter pitch of pinion gear} = 20\, \text{mm}$
- $r_2 = \text{radius of diameter pitch of wheel gear} = 40\, \text{mm}$
- $Z_1 = \text{Number of tooth of pinion gear} = 20$
- $Z_2 = \text{Number of tooth of wheel gear} = 40$
- $x = \text{distance ofshaft axis} = 60\, \text{mm}$
- $n_1 = \text{Rotation of pinion gear} = 2000\, \text{rpm}$
- $n_2 = \text{Rotation of wheel gear} = 1000\, \text{rpm}$
- $F_n = \text{Normal Force}$
- $F_t = \text{Tangential force}$
- $F_r = \text{Radial force}$

Figure 9. Design result of gear

Figure 10. Result design pulley and belt
Spesification of power transmitting

1. Input Power : 4 PK
2. Input rotation : 2000 rpm
3. Ratio : 2
4. Mechanical efficiency : 57 %
5. Input unit : 1 unit
6. Output unit : 3 unit
7. Kind of prime mover : combustion engine

**Figure 11.** Construct result of power transmitting multi output with single prime mover