Design of simulation tools hybrid transmission mechanism

by Agustinus Purna Irawan

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Abstract. Simulation tool is a learning facility that presents learning experiences using artificial situations or system models so that one can understand certain concepts. This design aims to create a simulation tool as a learning media for planetary gear mechanisms in hybrid transmission systems. The method used in the design uses the reverse engineering method which is focused on the mechanism of the planetary gear, so that it can be made into a simulation tool. The planetary gear component design are based on data from Toyota Prius reference system using a torque ratio, with planning power of 15 kW and a rotation of 300 r/min. The planetary gear system consists of a sun gear with a diameter of 75 mm and 25 pieces of teeth, a planetary gear with a diameter of 54 mm and 17 pieces of teeth, and a ring gear with a diameter of 18 mm and 60 pieces of teeth. The result of design shows that the hybrid transmission simulation tool mechanism can function well as a learning medium with variations of 3 outputs. Keywords: Design, hybrid transmission mechanism, simulation tool.

1. Introduction

The increasing needs of Indonesian people are very significant, especially in the transportation sector. Increased demand in terms of transportation also raises a problem of fuel consumption and other aspects that affect environmental conditions. In dealing with these problems, knowledge about hybrid transmission will be needed to be be developed in order to overcome the problems as well as increasing needs in the transportation sector. Some important components that will be discussed are how to design a simple simulation tool mechanism about hybrid transmission in order to understand and maximize problem solving from all aspects needed. These designs would focus on hybrid transmission simulation tools and the design of mechanisms is using planetary gear as the center of the hybrid transmission system. One of the important things that must be considered regarding the design of this hybrid transmission simulation tool is the mechanism on the planetary gear that will be used as the center of the mechanism system, starting from the design of the gears, the amount of gears on the gear wheel are being used, and the resulting output [1-2].

2. Method

Method used in the design is reverse engineering method, done by following the procedure below:

a) Clarifying the planetary gear mechanism system
b) Simulation tools will focus on hybrid transmission that aims as learning material
c) Pick the material used in the planetary gear
d) Adjust design specifications of the simulation tools
e) Create a simulation tools and 3D model for animation

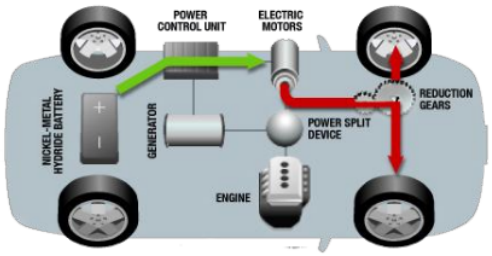


Figure 1. Hybrid Transmission Systems [3]

3. Result and Discussion

The configuration of the mechanism system of the planetary gear has a 1: 4 model comparison based on reference to the drivetrain Toyota Prius system. The planetary gear system used are composed of sun gear, planet carrier and ring gear. To determine the dimensions of the gear, it can be assumed the power ratio assumption, so that the ratio results from planetary gear will be obtained [4-6].

The planetary gear ratio is done with a 1: 4 model comparison based on torque at 1000 r/min rotation speed assuming the inertia of the gear mass is ignored. In order to simplify and determine the ratio based on a 1: 4 model comparison that suitable to the function, so it is assumed to use a hybrid parallel mode where the total torque generated is 31.77 Nm in which a list is made which is shown in Table 1.

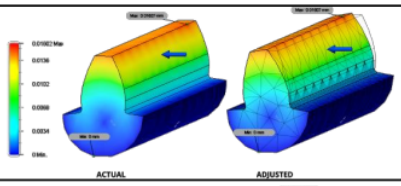
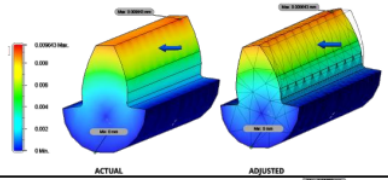
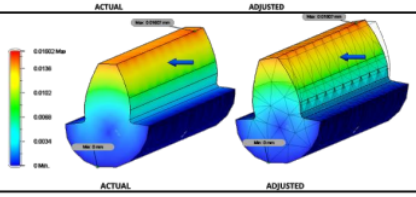
Table 1. Determination of Planetary Gear Set Ratio and Gear Pitch Radius

Gas Engine Torque (Nm)	Electrical Motor Torque (Nm)	Ratio Planetary Gear	Radius Sun Gear (Assumption) (mm)	Radius Ring Gear (mm)	Radius Planet Gear (mm)
17.44	14.33	4.6	40	184.6	72.3
17.84	13.93	3.6	40	142.6	51.3
18.24	13.53	2.9	40	114.9	37.4
18.64	13.13	2.4	40	95.3	27.6
19.04	12.73	2.0	40	80.6	20.3

The ratio that is suitable with the function when looking at the list in table 2 is the ratio of 2.4. If it is assumed that the gear module is 3, then the number of gears of sun gear, ring gear and planet gear in sequence are 26 pieces, 63 pieces, 18 pieces [7-8].

Deflection that occurs in gears using materials S45C can be calculated with gears of 5mm width and height of 5.3 mm with elongation of materials 200 GPa, can be seen at Table 2 [9-10].

Table 2. Deflections on Spur Gears Planetary Gear

Components	Simulation Results	Deflection
Sun Gear		$\frac{16\ x\ 12{,}715.4N\ x\ 5^3}{200{,}000MPa\ x\ 50.63mm\ x\ 5.3^3}$ $Deflection = 0.017mm$
Planet Gear		$\frac{16\ x\ 7{,}665.17N\ x\ 5^3}{200{,}000MPa\ x\ 50.63mm\ x\ 5.3^3}$ $Deflection = 0.010mm$
Ring Gear		$\frac{16\ x\ 12{,}715.4N\ x\ 5^3}{200{,}000MPa\ x\ 50.63mm\ x\ 5.3^3}$ $Deflection = 0.017mm$

Based on the calculation results, the specifications of the design of the hybrid transmission simulation tool mechanism can be illustrated as Figure 2 and details output at Table 3.

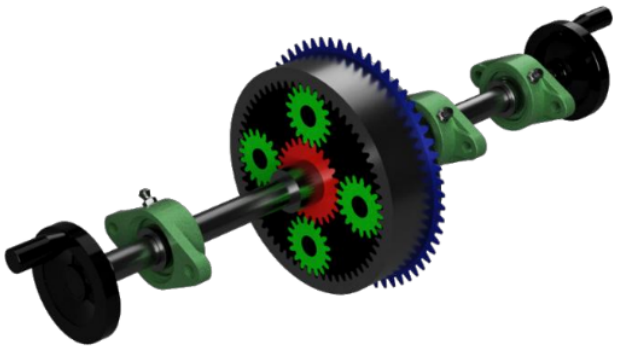


Figure 2. Planetary Gear Set Design Illustration

Table 3. Output Specifications of Simulation Tool Design

Maximum Power	Torque @300 r/min	Planetary Gear Ratio	Drive System
15 kW	47.8 Nm	2.4	Handwheel

The mechanism used in this planetary gear system is manual, so it will be rotated by the handwheel. Overall design of the design of the hybrid transmission simulation tool mechanism as can be seen in Figure 3.

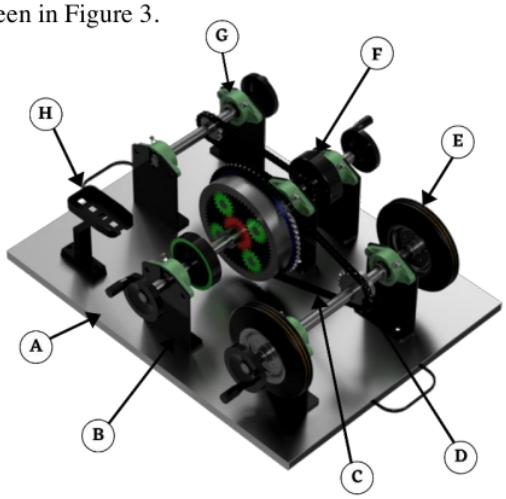


Figure 3. Design of Simulation Tools Hybrid Transmission Mechanism Illustrations

A. Simulation Field : used for placing other parts
B. Support Plate : used for keeping the planetary gear in place
C. Roller Chain : part of the transmission systems
D. Sprocket : used for transmit the power from roller chain transmission
E. Wheel : used for simulation wheel
F. Model Simulation Engine/Generator : used for simulation engine/generator
G. Bearing : support for keeping all the shafts in place
H. Tachometer Holder : used for holder of sensor tachometer to aim at the wheel

The test results of the design of simulation tool hybrid transmission mechanism that will be carried out, based on the power planning 15 kW with a rotation of 300 r/min, include 3 outputs produced, moreover the test results obtained can be seen in Table 4 [11-14].

Table 4. Design of Simulation Tools Hybrid Transmission Mechanism Test Result

Sun Gear	Planet Carrier	Ring Gear	Velocity	Torque	Rotational Direction
Hold with Inverse Input	Input (96 r/min)	Detained	534 r/min ↑	Decrease ↓	Same as Input
If two members parts are held together, speed and direction are the same as power input. 1: 1 movement immediately occurs.					
If no members parts are detained or locked together, the output does not occur. The result is a Neutral condition.					

4. Conclusion

The results of the design of simulation tools hybrid transmission mechanism, it can be concluded that the design of simulation tools hybrid transmission mechanism in accordance with the design objectives, as a learning medium to add insight into the hybrid transmission system and planetary gear mechanism that capable to work well to produce 3 variations of output.

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