Design Technology on HMT for a Tractor

D. S. Jung[1*], Y. B. Lee[1], J.W. Park[1] and H. Y. Jung[1]

[1] Institute, KIMM, Daejeon, Korea

[*]Corresponding author: jds667@kimm.re.kr

1. Introduction

As for tractors for agricultural machinery, market demand is steadily expanding due to labor shortages in rural areas. In addition, due to the expansion of farmland, small-scale tractor are being replaced by medium- and large-scale tractors. In line with the trend of enlargement of the tractor, the transmission must be equipped with mobility that can work even with high inclination and silence that provides a comfortable working environment for the driver.

HMT (Hydro-mechanical Transmission) is a mechanical transmission (Mechanical Transmission) combined with a hydraulic transmission (Hydro-static Transmission) to realize high mobility at low speed, and continuously variable transmission without shift shock. Made it possible. A mechanical transmission is composed of a planetary gear that separates or combines mechanical power and a clutch that determines the direction of mechanical power. The hydraulic transmission is composed of a hydraulic pump that controls the output speed and a hydraulic motor that converts hydraulic power into mechanical power.

In this research, we provide HMT design technology that is capable of stepless shifting, with two stages of forward and reverse gearing that are suitable for medium and large tractors.

2. Gear Train Design of HMT

Fig. 1 shows the HMT Gear Train, which is a combination of a mechanical transmission and a hydraulic transmission. The lower part of Fig. 1 corresponds to a mechanical transmission, which consists of planetary gears and a clutch.

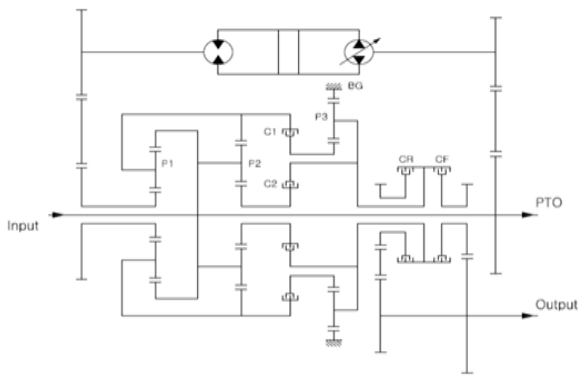

Fig. 1 Structure of Gear Train for HMT

$$\omega_{r1} = \omega_i \quad (1)$$

$$\omega_m = V_{pr} \times \omega_p \quad (2)$$

$$\omega_{s1} = R_m \times \omega_m \quad (3)$$

$$\omega_{c1} = (\omega_{r1} + R_1\omega_{s1}) / (1 + R_1) \quad (4)$$

$$\omega_{s3} = \omega_{c1} \quad (5)$$

$$\omega_{c3} = (R_3\omega_{s3}) / (1 + R_3) \quad (6)$$

P1 represents a primary planetary gear, P2 represents a secondary planetary gear, and P3 represents a tertiary planetary gear. C1 is a one-stage clutch, C2 is a two-stage clutch, CR is a reverse clutch. And CF is a forward clutch. The upper part of Fig. 1 corresponds to a hydraulic transmission and is composed of a hydraulic pump and a hydraulic motor. The hydraulic transmission is a closed-loop system, and the volume control of the hydraulic pump changes the speed of the hydraulic motor.

In the case of one forward gear and one reverse gear, the respective output speeds are calculated by the equations (1) to (6) if the one-stage clutch and the forward and reverse clutches are selected and the input speed is given. Here, it is the carrier speed of the third planetary gear that is directly coupled to the output gear.

In the case of two stages of forward and reverse, the respective output speeds are selected from the two-stage clutch and the forward and reverse clutches, and given the input speed, equations (1) to (3) and equations (7) to (5) Calculated by 10). Here, it is the carrier speed of the secondary planetary gear that is directly coupled to the output gear.

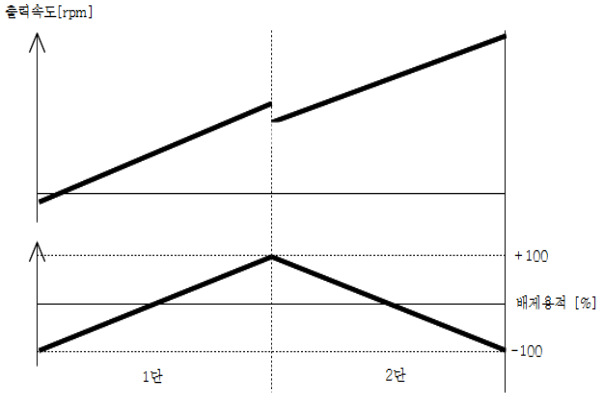

Fig. 2 Output Speed & Pump Displacement

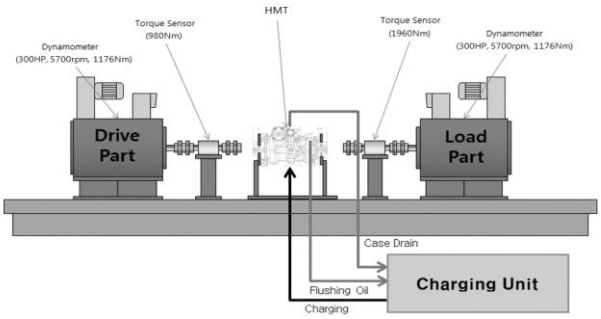

Fig. 3 Lay_out for Test Equipment

$$\omega_{c1} = (\omega_{r1} + R_1\omega_{s1}) / (1 + R_1) \quad (7)$$

$$\omega_{r2} = \omega_{c1} \quad (8)$$

$$\omega_{c2} = \omega_{c1} \quad (9)$$

$$\omega_{s2} = (1 + R_2)\omega_{c2} - \omega_{r2} / R_2 \quad (10)$$

Fig. 2 shows the output speed of the HMT due to the change in the volume of the hydraulic pump, where the output speed increases as the volume of the hydraulic pump increases in the first stage, and the mental decline in the hydraulic pump

3. Test and Result

Fig. 3 denotes a driving unit that controls an input speed and a load unit configuration HMT test apparatus that controls an output load. The Charging Unit supplies hydraulic power to the HST and Clutch internally configured by the HMT. In this test, the input speed of HMT applied 1500 rpm in consideration of the rated condition of a 90 kW engine. Fig. 4 shows the power transmission efficiency of the HMT in one forward gear stage in which the HST is operated at maximum power. In order to maximize hydraulic power at one or two stages of high speed, the efficiency is displayed at the lowest level compared to other speed sections. Fig. 5 shows the power transmission efficiency of the HMT in the forward one stage in which the HST is operated at the minimum power. The efficiency is displayed at the highest level because hydraulic power is not used at one or two stages and medium speed. When the vehicle travels at a constant speed, fuel efficiency can be improved if this section is appropriately utilized.

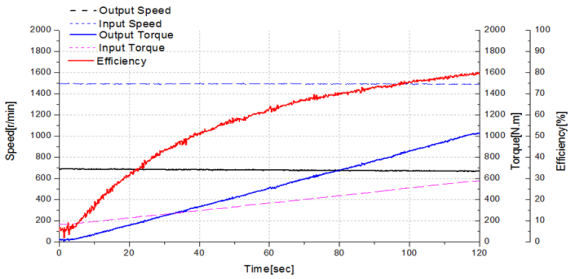

Fig. 4 Transmission Efficiency by Mechanical Power & Hydraulic Power

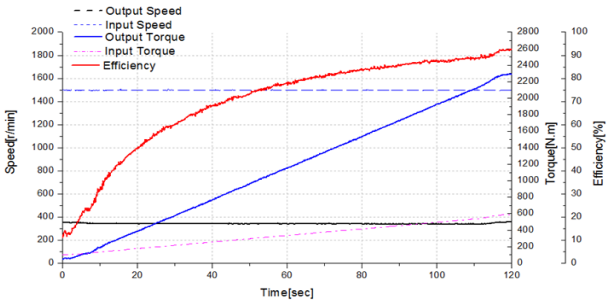

Fig. 5 Transmission Efficiency by Mechanical Power

4. Conclusion

In this study, the mechanical transmission and hydraulic transmission were combined to provide the design technology of HMT, and the function and performance were confirmed through experiments to demonstrate the effectiveness of the product.

1. We designed a two-speed and two-speed reverse continuously variable transmission consisting of 3 planet gears, 4 clutches and HST.
2. It meets the high mobility required by medium and large tractors, has little shift shock, and can have a quiet ride.
3. It was designed to minimize the operation of HST to reduce fuel consumption and control the running mode at a constant speed.

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