Gear Analysis of Planetary Gear Automatic Transmission Based on Lever Method

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Abstract: A planetary gear automatic transmission is designed. It consists of two rows of single-stage planetary gear mechanisms and actuators. The parameters of the front and rear row of planetary gear mechanisms are exactly the same, and they can form 5 forward gears with reasonable transmission ratios. Through the lever method, the transmission ratio and rotation direction of each gear are analyzed to provide a basis for rational design of the gears of the planetary gear automatic transmission.

1. Introduction

Most modern automobile automatic transmissions use planetary gear mechanism type, which is composed of multiple rows of planetary gear mechanisms and related actuators. A single-row planetary gear mechanism consists of sun gear, gear ring, and planetary carrier. The planetary gear is provided on the planetary carrier, and the single-stage planetary gear mechanism refers to a first-level planetary gear that transmits power between the sun gear and ring gear [1]. The actuators mainly include clutches, brakes and one-way clutches, and different gears can be formed by performing different constraints on the sun gear, ring gear and planet carrier through the clutches and brakes and other actuators.
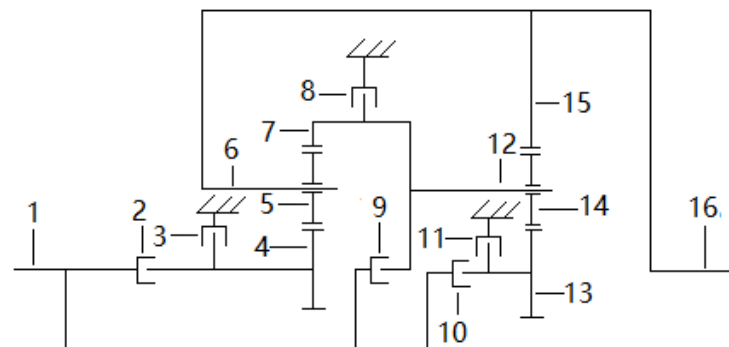

Fig.1 Composition and Transmission Principle Diagram

1-Power input shaft 2-Clutch C1 3-Brake B1 4-Front sun gear 5-Front planet gear 6-Front planet carrier 7-Front gear ring 8-Brake B2 9-Clutch C2 10-Clutch C3 11 -Brake B3 12-Rear planet carrier 13-Rear sun gear 14-Rear planet gear 15-Rear gear ring 16-Power output shaft

2. Composition and Transmission Principle

A double-row single-stage planetary gear automatic transmission is designed in this paper, and its principle is illustrated based on the lever method to calculate its transmission ratio [2]. The structure diagram is shown in Figure 1. The automatic transmission is composed of two-row single-stage planetary gear mechanism, clutch, and brake. The clutch and brake are all disc-type structures. The main components include: power input shaft 1, clutch C12, brake B13, front sun gear 4, front planet gear 5, front planet carrier 6, front gear ring 7, brake B28, clutch C29, clutch C310, brake

B311, rear planet carrier 12, rear sun gear 13, rear planet gear 14, rear gear ring 15, and power output shaft 16. The power input shaft 1 is integrated with the drums of clutch C12, of clutch C29, and of clutch C310; the hubs of clutch C12 and of brake B13, and the front sun gear 4 are integrated; the hubs of clutch C310 and of brake B311 and the rear sun gear 13 are integrated; the front gear ring 7, the hubs of brake B28 and of clutch C29, and the rear planetary carrier 12 are integrated; the power output shaft 16 is connected together with the front planetary carrier 6 and the rear gear ring 15.

The parameters of the sun gears and gear rings of the front and rear planetary gear mechanisms of the automatic transmission are exactly the same, and the reasonable configuration of the parameters can form 5 forward gears with a reasonable distribution of transmission ratios. The automatic transmission has the characteristics such as simple and compact structure, a small quantity of types of processed parts, low costs, a small quantity of actuators and little change in actuators during gear shifting.

3. Gear Analysis Based on Lever Method

Assuming that the number of teeth of the sun gear is Z_1 and the number of teeth of the gear ring is Z_2, $\alpha = Z_2/Z_1$ can be made, and the speed of the power input shaft 1 is a constant value. When on the neutral, all actuators do not work and there is no power output. The following are the actuators, transmission ratio values and lever diagrams for each gear. The transmission ratio of each gear is calculated according to the equation of motion relationship. The horizontal axis of the lever diagram represents the relative positional relationship of each element, and the vertical axis represents the speed and direction of each element [3].

(1) Gear 1: The clutch C_12 and brake B_28 work, and the transmission ratio of gear 1 is $i_1 = 1 + \alpha$; the lever diagram is shown in Figure 2 [4].
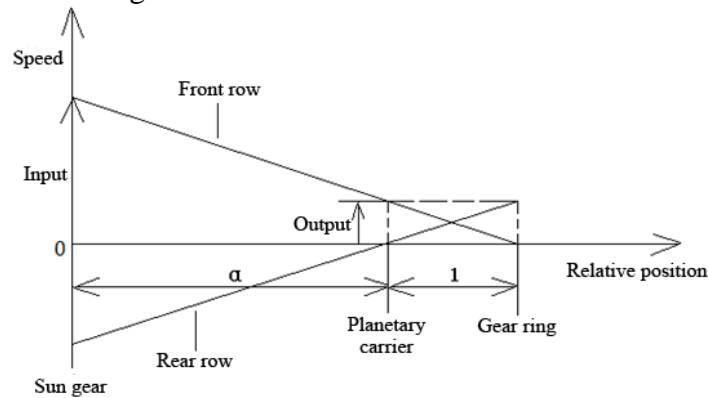

Fig.2 Gear 1 Lever Diagram

(2) Gear 2: the clutch C12 and brake B311 work, and the transmission ratio of gear 2 is $i2 = 1 + \alpha / (1 + \alpha)$; the lever diagram is shown in Figure 3.
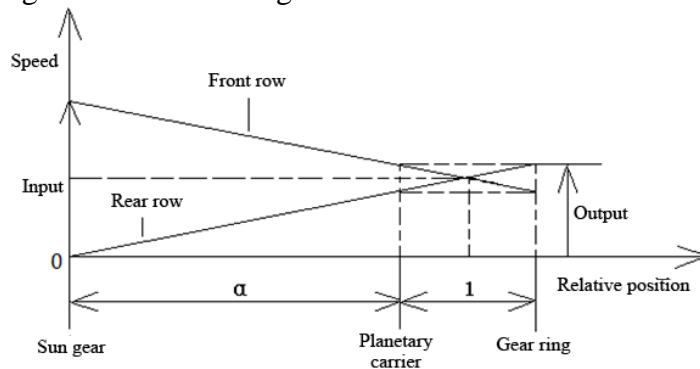

Fig.3 Gear 2 Lever Diagram

(3) Gear 3: the brake B13 and clutch C29 work, and the transmission ratio of gear 3 is $i3 = 1 +$
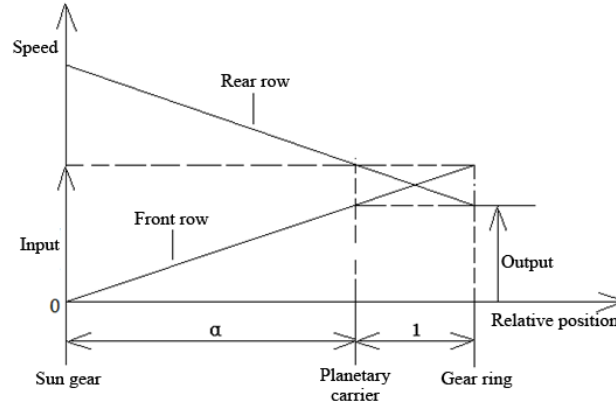
$1/\alpha$; the lever diagram is shown in Figure 4.

Fig.4 Gear 3 Lever Diagram

(4) Gear 4: the clutch C12 and clutch C29 work, and the transmission ratio of gear 4 is i4 = 1; the lever diagram is shown in Figure 5.
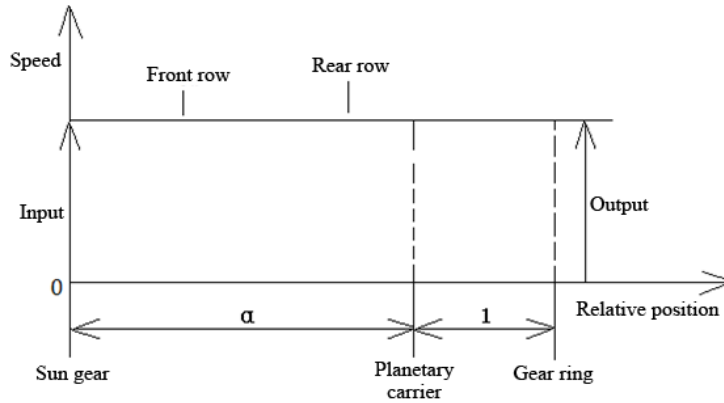

Fig.5 Gear 4 Lever Diagram

(5) Gear 5: Clutch C29 and brake B311 work, and the transmission ratio of gear 5 is i5 = $\alpha/(1 + \alpha)$; the lever diagram is shown in Figure 6.
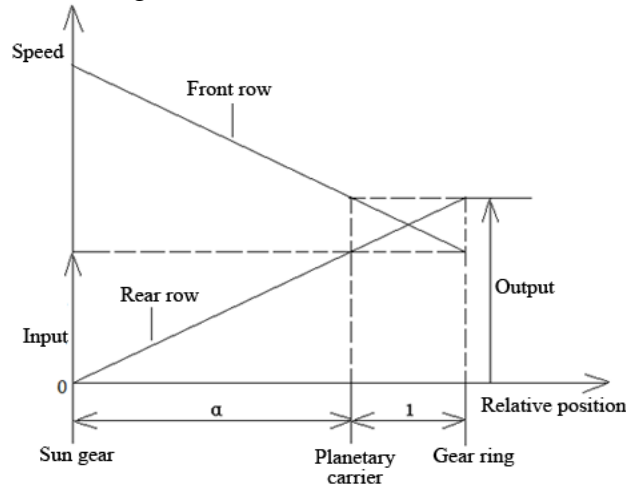

Fig.6 Gear 5 Lever Diagram

(6) Reverse gear [R gear]: The brake $B_2 8$ and clutch $C_3 10$ work, and the transmission ratio of the reverse gear is $i_R = -\alpha$; the lever diagram is shown in Figure 7.
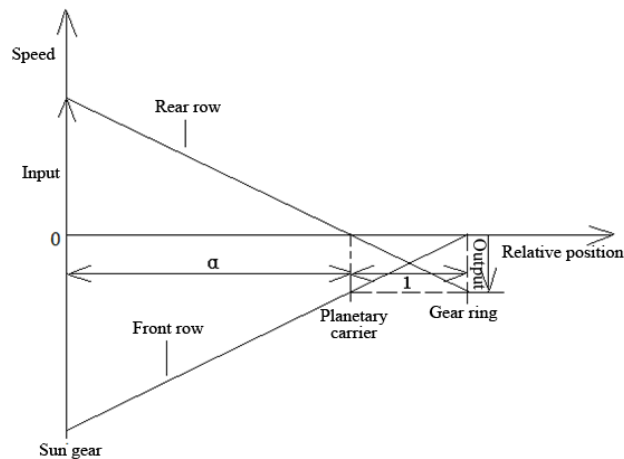
Fig.7 - Reverse Lever Diagram

4. Conclusion

The transmission analysis method of the double-row single-stage planetary gear automatic transmission based on the lever method is explored in this paper [5]. It has been verified that the gear analysis on the planetary gear automatic transmission through the lever method can effectively simplify the structure of the planetary gear automatic transmission and reduce the design, manufacturing and maintenance costs of the automatic transmission.

References

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