Principle and Application of Ball Transmission Mechanism

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Keywords: Ball, Transmission, Principle, Application, Bicycle

Abstract. Ball transmission mechanism is a new type power delivery structure. Based on the merits and demerits analysis of belt, chain, gear and fluid drive, the ball transmission mechanism is put forward. The structure and working process of same or reverse direction ball transmission mechanism were described, and an application example of ball transmission bicycle was given also. There are many characteristics, such as higher transmission accuracy and efficiency, flexible spatial distribution, lower cost, etc. for the new structure, who can replace many traditional transmission mechanism in many application fields.

Introduction

There are many kinds of traditional transmission mechanisms, such as belt drive, chain drive, gear drive and fluid drive, the relevant literature is numerous. Application of the belt drive is relatively extensive, it is normal used in larger wheelbase occasions that with overload protection function (sliding between the belt and pulley), and transmission is quit smooth. But it is seldom used in the high-power mechanical transmission because of low transmission efficiency and low driving accuracy [1-2] .Compared with the belt drive, chain drive can maintain an average drive ratio on account of no sliding and skidding, and a higher transmission accuracy, but it should not be applied in applications like high-speed, large load changes and rapid reverse [3-4]. Gear drive has many advantages such as large power range, high transmission efficiency, constant drive ratio, steady, safe and long service life. Compared with the belt drive and chain drive, the transmission accuracy of gear drive greatly improved; Also , it has some disadvantages that not suit for long-distance transmission of power, structural arrangement is not flexible, high manufacture and installation precision, and high cost[5-6]. Hydraulic and pneumatic are suitable for various distance occasions and the piping layout is very flexible, but they require high sealing, and the efficiency is low; The structural of the pump and motor is quite complex, that lead to high cost, additionally the pneumatic is difficult to achieve constant ratio transmission[7]. To sum up, a transmission mechanisms is absent which can be flexible arranged, transmits more accurate, has high efficiency and low cost. This thesis presents the principle of ball transmission mechanism and application examples.

Principle of Ball Transmission Mechanism

The ball transmission mechanism based on the transmission ball as the moving part, when the capstan rotates, it drives the transmission ball which in the gullet rolling or sliding in the fairway, the balls squeeze each other, and the transmission ball forward into the gullet of driven wheel along the raceway, then the speed and torque can be outputted, and achieve the power transmission eventually. The ball transmission mechanism can be divided into the same direction ball transmission mechanism and the reverse direction ball transmission mechanism.

Principle of the same direction ball transmission mechanism. Fig.1 and Fig.2 shows the main structure of same direction ball transmission mechanism, it includes the capstan, rear cover, transmission ball, driven wheel, front cover and so on. The transmission ball can slide smoothly in fairway that between the front and rear covers which play as a guiding role, and the matching mode between the fairway and the transmission ball are the clearance fit. The fairway connect the top of

capstan to the top of the driven wheel, and the bottom of capstan to the bottom of driven wheel that can ensure two wheels of the ball transmission mechanism rotate in the same direction.

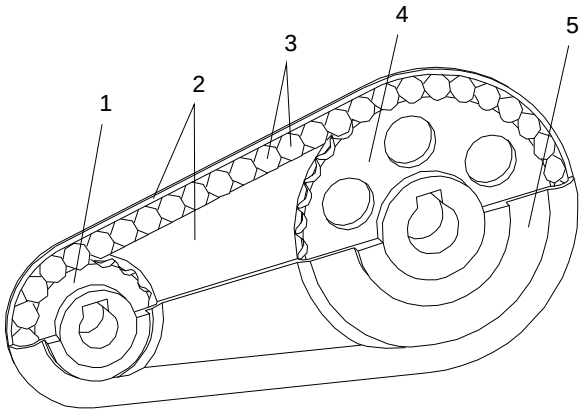

Fig.1 Principle of the same direction ball transmission mechanism

1-capstan; 2-rear cover; 3-transmission ball; 4-driven wheel; 5-front cover

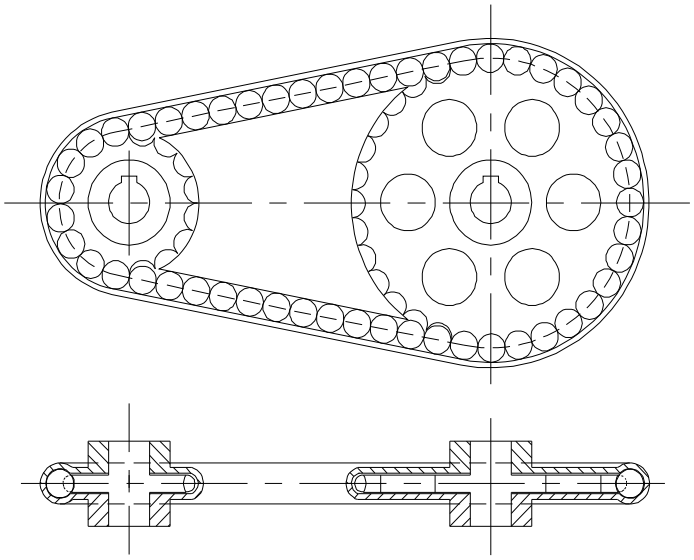

Fig.2 Cutaway view of the same direction ball transmission mechanism

Figure 3 shows the structure of ball wheel, the tooth surface form of ball wheel can be machined into spherical or cylindrical alveolar that was different from the traditional gear. The alveolar and ball have the equal radius and the depth of alveolar slightly less than the radius of the transmission ball, so they can completely engaged when the ball transmission mechanism delivers power. The thickness of the ball wheel is less than the diameter of the transmission ball, it ensures that the transmission ball move along the fairway continuously and smoothly.

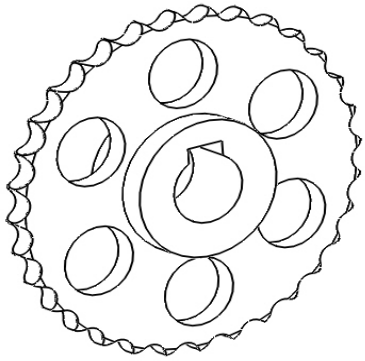

Fig.3 Chart of ball wheels

When the diameter of capstan smaller than the diameter of driven wheel, the speed of transmission will decelerate, otherwise the speed will accelerate. If the diameter is equal, the ball transmission mechanism delivers speed but not change it.

When the ball transmission mechanism is working, external power drives the ball wheel rotating around the axis of its own, the capstan and the driven wheel have the same rotational direction. The transmission ball moves to the other side of the capstan through fairway, after driving driven ball. And then the transmission ball moves into the alveolar of capstan, therefore, the power can be transmitted continuously. Lubricating oil or hydraulic oil can be used between the ball and fairway.

Principle of the reverse direction ball transmission mechanism. Fig.4 and Fig.5 show the principle of the reverse direction ball transmission mechanism. The basic structure is similar to the same direction ball transmission mechanism, but the difference is that fairway connects the top of capstan and the end of driven wheel, the end of capstan and the top of driven wheel are connected. Fairway staggers between two ball wheels, but not connected, so that the capstan and the driven wheel rotate in opposite direction.

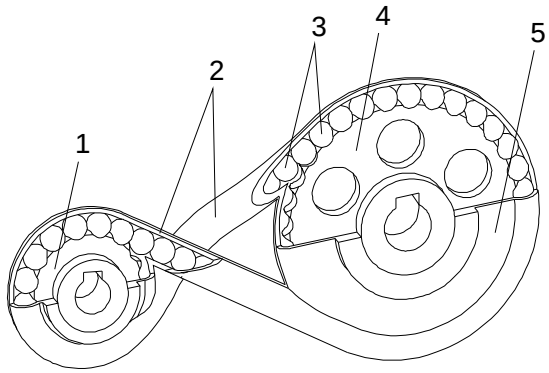

Fig.4 Reverse direction ball transmission mechanism

1-capstan; 2-rear cover; 3-transmission ball; 4-driven wheel; 5-front cover

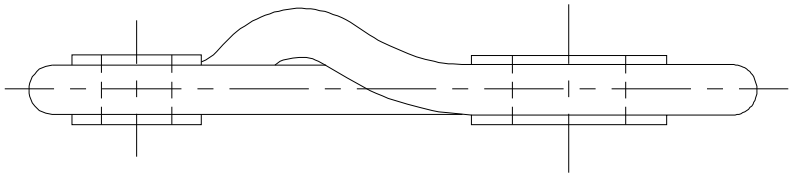

Fig.5 Plan view of the reverse direction ball transmission mechanism

Application of Ball Transmission Mechanism

The ball transmission mechanism is suitable for occasion that path complex, high precision, far distance, smaller loads and so on. The ball transmission mechanism can be used in the gear chamber of engine to replace part of the gear to deliver power, simplified engine gear chamber structure or in some fixed-ratio transmission situations to instead belt drive, chain drive and gear, etc. Bicycle is a transportation tool commonly used in people's daily life; the chain can't be fully tensioned because of chain drive type, then the chain often appear some fault like dropped out or broken. The driving system of bicycle is not completely sealed up, so it works in harsh environment. Chain and chain wheel wear because of the situation of insufficient lubrication, it greatly shortens the service life of the drive system. If bicycle uses the ball transmission mechanism, the above drawbacks will be overcome; fig.6 shows the structural principle of ball transmission bicycle.

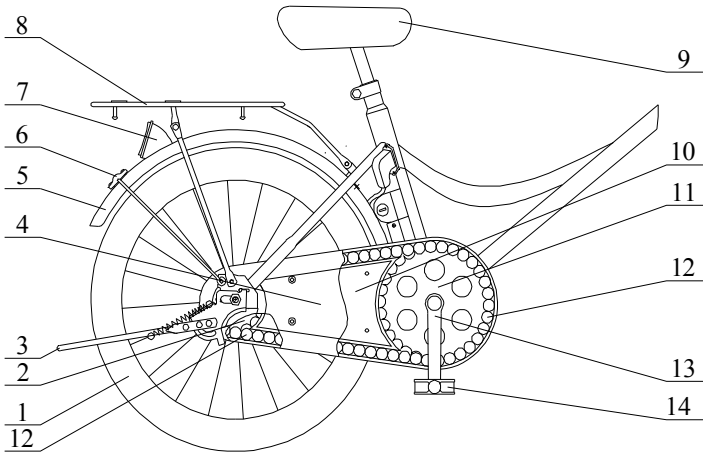

Fig.6 Ball transmission bicycle

1-rear wheel; 2-driven wheel; 3-the rear support; 4-front cover; 5-rear fender; 6-clay deduction; 7-reflector; 8-rear bracket; 9-saddle; 10- rear cover; 11-capstan; 12-transmission ball;13-crank; 14-pedal

When external force was applied to the pedal, the crank drives capstan rotating around the center shaft, the capstan drives the transmission ball moving in the gullet along the fairway. The balls squeeze each other, so that the transmission ball forwards into the gullet of driven wheel along the raceway that promotes the driven wheel rotates and outputs speed and torque. After the transmission balls driving the driven wheel, the transmission balls moves to the other end of the driving wheel, and then into the gullet capstan, so it can guarantee the ball transmission run continuously. Since the front and back covers of the drive system can sealing good, grease can be added to the fairway to ensure that the drive system lubricate sufficiently, reduce the friction coefficient and improve system life. Ball transmission bicycle can work in harsher environment, vibration and noise of the system is very small.

Conclusions

Ball transmission mechanism is a new type power delivery structure that based on the transmission ball as the moving part, it has the same direction ball transmission mechanism and reverse direction ball transmission mechanism.

Ball transmission mechanism has the characteristics of fluid, belt, chain and gear drive. It has some characteristics like a high transmission accuracy and efficiency, space layout flexibility, low cost, small noise and so on. I can replace the existing drive mechanism in some occasions.

Acknowledgments

The authors gratefully acknowledge the financial support from the National Natural Science Foundation Natural Science Foundation of the Shandong Province of the P. R. of China (No. 51575286) and Provincial Natural Science Foundation of the Shandong Province (No. ZR2014EEM031).

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