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The spline design of the power-train for the bicycle adopting the belt

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Abstract

Bicycles and electric bicycles, which are short-distance vehicles, do not generate exhaust gases that cause environmental pollution. Rather, they are in the spotlight because they have exercise effects that help the health of the human body while operating the bicycle. Power-trains of bicycle have traditionally used chains and sprockets, and they still have the largest market share. In the previous study, a new type of bicycle power-train was proposed. The power transmission medium of the proposed power-train device employs a belt. The core of the proposed new bicycle power-train is the configuration of the pulley. The core component of the proposed power-train pulley is a spline. In this study, the basic shape of the proposed power-train model and the basic role and design principles of the spline used in the configuration of the model were studied. The target splines are linear spline used for the central axis of the power-train pulley and helical spline for shifting. The linear spline is a basic shape, and the helical spline is an equation that can calculate the inclination angle and the shift range.

Keywords: *Belt, Power-train, Bicycle, Shift, Sleeve*

1. Introduction

The biggest issue in the world is climate change. The cause of climate change is global warming due to air pollution. One of the causes of air pollution is harmful emissions from transportation such as automobiles[1-4]. Bicycles and electric bicycles, which are short-distance means of transportation, do not generate exhaust gas, but rather exhibit a beneficial exercise effect on the human body. Eco-friendly bicycle power-trains have traditionally used chains and sprockets, which have led to specialized manufacturers of chains and sprockets, and their market share is also affected by these companies[5-8]. In the power-train using the chain and sprocket, the derailleur is used as the tool for shift. The derailleur is not operable in a stationary state, and the chain, which is a power transmission medium, has a problem of being deviated during operation. In the previous study, a new type of power-train model for bicycles was proposed, and the core configuration of the proposed model is a pulley installed in the driver and follower. In order to perform the basic role to transmit the rotational motion by the driving source, a linear spline was placed on the central axis of the pulley, and a helical spline

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was installed to perform the shift function[9-11]. The basic design and fabrication of a linear spline and a helical spline for shifting are described.

2. Proposed model

In the previous study, a new type of bicycle power-train model was proposed [1-3]. In the proposed model, a belt was applied as a power transmission medium. The appearance of the bicycle equipped with the proposed power-train device is shown in Figure 1.

Figure 1. The bicycle equipping the proposed power-train adopting the belt

The basic structure of the driving pulley and driven pulley of the power-train used for the power-train for the bicycle adopting the belt are as follows Figure 2.[1].

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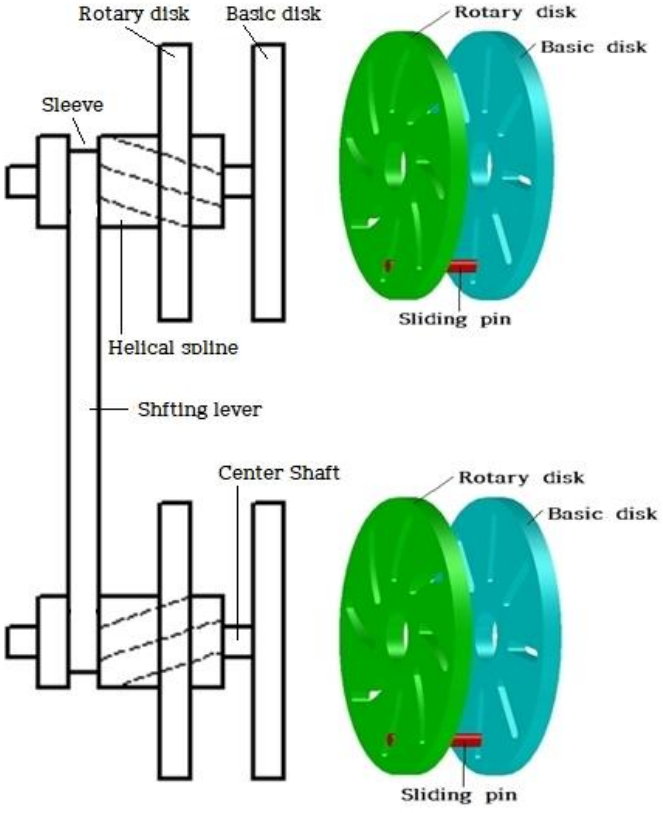

Figure 2. Proposed power-train for bicycle

The basic configuration of the pulley mounted on the driving part and driven part of the new model bicycle power-train uses the belt as the power transmission medium. Moreover, in the driving pulley and driven pulley, the basic disk and rotary disk are installed. The basic configuration of the pulley mounted on the driving part and follower of power-train are same as those of Figure 3.

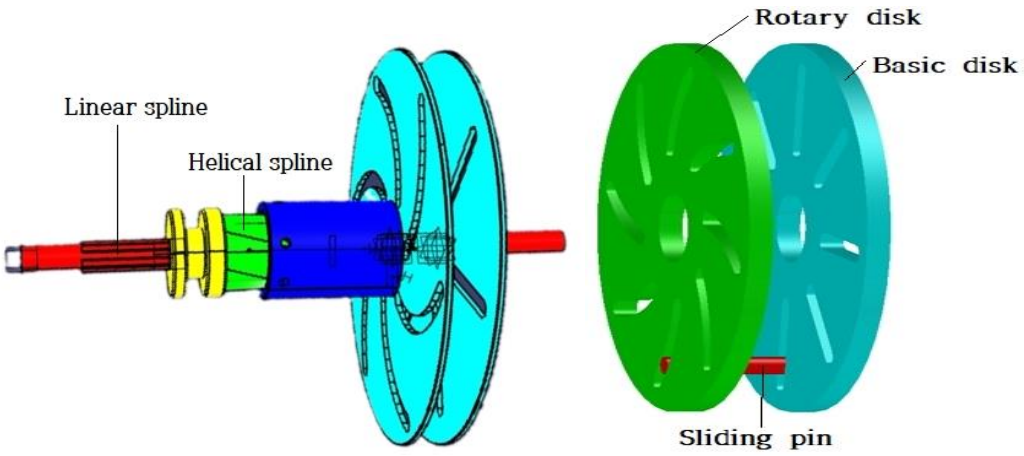

Figure 3. Pulley of proposed power-train

By using the power of the power source which becomes pulley since the power source of bicycle is man or the motor, the rotational motion is made. The central axis of pulley establishes the spline of the linear type in order to transfer the rotational motion by the driving source. Also, in order to perform shifting, a helical spline capable of moving in an axial direction is installed, which moves in the axial direction to induce rotation of the rotary disk, thereby changing a pitch radius of the sliding pin connected to the rotary disk and the basic disk.

Conventional bicycles also have a power-train that does not have a shift function, and a power-train that does not require a shift function does not require slots and helical spline formed on the basic disk and rotary disk in the proposed model.

3. Linear spline

At the center of the power-train pulley of the new form, the spline of the linear type installed the same like Figure 4.

Figure 4. Linear spline

This spline of the linear type smooths the rotational motion of pulley. The driving pulley or the driven pulley of power-train is proceed the rotational motion. The spline of the linear type installed at the central axis of pulley authentically can transfer the driving force occurring the rotational motion. The total length of the linear spline installed at the center of the pulley can be adjusted according to the used use, that is, the length

of the drive shaft or the driven shaft.

4. Helical spline

A key element of the proposed new type of bicycle power-train is the pulley, which is effective only when the shift can be performed by the driver's will. The reason for the shift is to increase the speed of the bicycle by the driver's will or to drive when the driver climbs the hill. The pulley type of the proposed power transmission device can move the helical spline in the axial direction of the pulley to perform the shift function by rotating the rotary disk and changing the position of the sliding pin. The shape of the helical spline is shown in Figure 5.

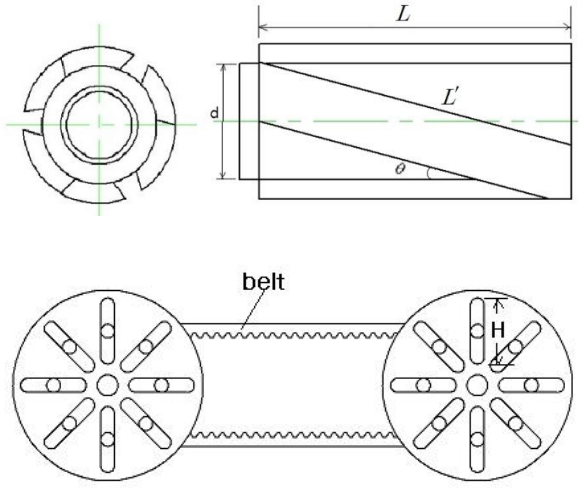

Figure 5. Shape of the helical spline

In Figure 5. if the inclination angle of the helical spline is θ, and the axial length of the spline is L, if you say slope length L', the following equation can be derived in the figure.

$$\cos\theta = \frac{L}{L'} \qquad \therefore L' = \frac{L}{\cos\theta} \tag{1}$$

The height of a right triangle with L'as hypotenuse is as follows.

$$H = \frac{L}{\cos\theta} \times \sin\theta \tag{2}$$

In the above equation (2), H is a moving distance rotated by the operation of the helical spline, and the shifting may be performed by dividing the moving distance by the number of shifting stages. Since the length of the power transmission medium belt always constants, it makes sense to leave identically the shift stages number of follower and driving part. In the design of a helical spline, the operating distance of the helical spline should be determined in consideration of the number of shift stages and the slot length of the basic disk, and a shift lever connecting the driving pulley and the driven pulley can be easily installed by placing a sleeve at the end of the helical spline. The helical spline establishing sleeve in the end same like Figure 6.

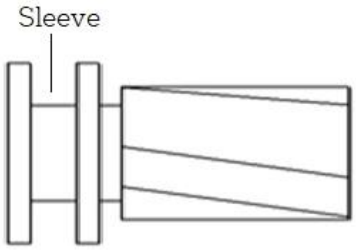

Figure 6. Helical spline equipped sleeve

Helical splines introduced into the drive pulley and the driven pulley must have opposite slopes, since increasing the pitch radius in the drive pulley requires the opposite pitch radius to be smaller in the driven pulley. In addition, shifting can be performed with a shift lever connecting the drive pulley and the sleeve of the sloping spline in the driven pulley. Based on these contents, the configuration of the power-train device is expressed as Figure 7.

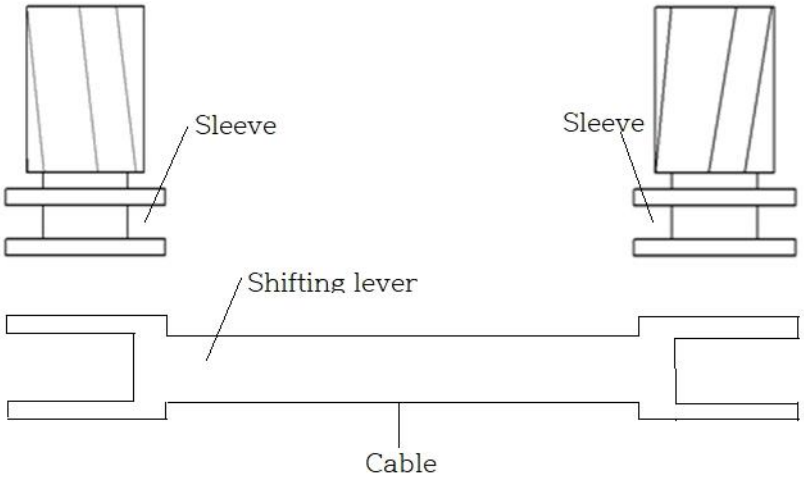

Figure 7. Shifting lever connected driving pulley and driven pulley

5. Conclusion

In the author's previous study, a new type of bicycle power-train model using a power-train as a belt was presented. In the proposed model, the core component of the pulley is a pulley, and the main components of the pulley are a linear spline used in the central axis and a helical spline performing the shift function. In this study, the design and manufacturing methods of the linear and helical splines used in the proposed power-train for bicycles were studied and the following contents were obtained.

(1) The proposed power-train device for a bicycle can smoothly rotate using a linear spline on the central axis of a pulley.

(2) A helical spline is installed on a linear spline which is a central axis so that the pulley of the power-train device has a shift function.

(3) When the pulley of the proposed power-train device is introduced into the driving part and the driven part, the helical splines must have inclinations in opposite directions.

(4) The helical spline should be set in consideration of the number of shifts and slot length.

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