

# Research and Application of Device for Simulation Sports Training based on Cycle Condition

Jian Zhao

Jilin Engineering Vocational College, Siping, 136001, China

**Abstract.** the slope simulation method of the spiral mechanism, the rubbing transmission, the resistance simulation method of magnetic particle brake loading on the rear wheel is proposed by anglicizing the road sports conditions and resistance of the actual cycling. the structure design, loading design and control design of the road sports condition simulator is designed. the structure of putting the motor forward and forcing the big sprocket rotation through the chain transmission, and the method of the frequency converter regulates the rotational speed of the motor within the range of certain frequency, PLC programming the rotation rules is adopted. The complete device is applied to athletes sports training of the national bicycle team at ordinary times after debugging successfully.

## 1 Introduction

Scientific training methods should be combined with modern training equipment. In training, coaches should be able to master the basic parameters of athletes riding and physiological conditions in order to address the weak link, scientific and effective guidance training. Cycling training in the outdoor sports venues, the training of athletes by the weather and climate impact. Rain, wind, snow and other bad weather athletes are not normal training, long winter and rainy season greatly affected the coaches of the training program, the quality of the circle of training.

Sprint stage, is the most tired athletes, due to the lack of training equipment related to athletes usually can not effectively sprint special training, resulting in China's elite athletes in the race sprint stage slower than the other, losing the game. Therefore, the National Cycling Team urgently needs a high-quality cycling simulation trainer, improve training conditions, improve the quality of training, improve the game results.

The indoor cycling simulator can simulate different outdoor road conditions, and has the same body posture and force feeling, pedalling frequency and the exertion of the athlete as the outdoor training and competition. 1. Bike simulation trainer can be free to set the requirements of different coaches and their changes in traffic conditions, and changes in the simulation of different driving force of the athletes feel and body posture to be consistent with the actual outdoor training. 2. The simulator can also be free to set the athlete's pedalling force size and frequency. Athletes should be able to easily set the parameters of the above changes in the riding, but also by the trainer with a radio remote control of the above parameters. 3. The training device also need to have security protection device, when the pedal

rotation speed exceeds the athlete's ultimate capacity, the safety clutch can be separated from their own, so athletes will not be pedal injury.

## 2 Introduction of Bike Simulator

Bicycle movement is a semi-mechanized project, bicycle simulation training equipment need to take into account the bike's own movement and human movement changes, so the problem is more complex. The domestic bicycle simulation training device is less developed, most of the training products are developed abroad.

Europe and the United States on the bicycle simulation training device research earlier, as early as the seventies and eighties there have been many bicycle simulation training device patented product. At present, Nanyang University in Singapore and Korea University of Science and Technology have developed an advanced interactive simulation training device.

The bicycle simulator developed by the Korea University of Science and Technology is shown in Figure 1, which mainly includes four sub-systems.

### 1. Motion generation simulation system

The system uses a six-degree-of-freedom Stewart platform consisting of six freely-extendable struts and an up-and-down platform. The platform is driven by a motor and has two processors (PC and DSP) for digital servo control of the motion platform. The two processors communicate with each other through the dual-channel memory RAM installed in the DSP chip and connect with the PC bus . For high-speed motion control, the amount of computation is very large.

### 2. Vehicle steering force simulation

There are two forces on the bicycle handlebar: active and passive. This system consists of an MR clutch and a

brushless DC motor to produce these two forces. The connection of the bicycle to the clutch and the electric motor.

When an active force is generated, the motor is running and the MRF (Magneto-Rheological Fluid) clutch transmits the torque to the handlebar. When the resistance is generated, the motor is stopped and the MRF clutch acts as a damper. In both cases, the magnitude of the force is controlled by the current input to the MRF clutch. MRF clutch maximum output torque is 5Nm, the control frequency can reach 2Hz.

### 3. Pedal resistance system control

To feel real, a pedal resistance system is used to simulate the actual riding resistance, which includes ground friction, air resistance, and resistance to human inertia. The drag system also generates the motive force to simulate the accelerating force at the downhill. In the pedal drag system, the torque applied by the rider to the pedal is estimated, and the rotational speed of the speed control sprocket, which is calculated by the bicycle power module, is then routed. The pedal resistance system consists of an AC servo motor, a flywheel, and an MR brake. The motor simulates the accelerating inertia of the downhill and the brakes produce a drag torque. This resistance system is placed between the Stewart platform and the rear wheel.

### 4. Visual simulation system

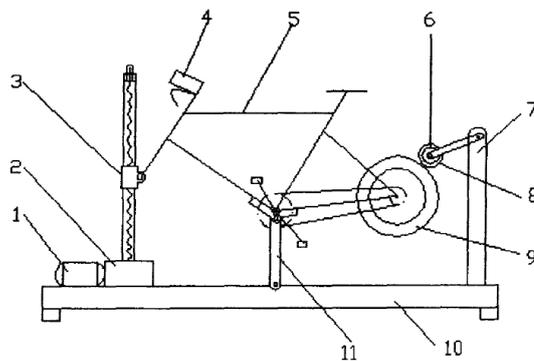
In order to better produce simulation results, a virtual campus of the real scene. In this campus model, the geographic features and buildings are modelled separately. First, a 1: 5000 campus scene map was scanned as a basic image, and then the road and geographic features were made using the related software.

### 5. System integration

The integration of the system focuses on information exchange and coordination between images, platform movements, handlebar forces and foot-resistance systems to produce real visual effects.

## 3 Structural Design of Road Condition Simulation Trainer

The road condition simulator uses the racing frame as the basic frame, and uses the crank-slider mechanism to simulate the slope movement. In this mechanism, the frame for the connecting rod, the shaft support for the rocker, screw vice for the mobile pair. Motor by worm gear reducer drive screw rotation, the nut will move up and down along the rail, the body also with the swing, so that cyclists sense of slope movement. The flywheel is mounted on the rear frame to simulate the kinetic energy of the bicycle. A friction wheel is fixed above the flywheel. The friction wheel is coaxial with the magnetic powder brake and transmits the braking torque by the friction between the flywheel and the friction wheel. Structural design, including simulation of structural design and loading load simulation structure design, the overall layout shown in Figure 1.



1-motor; 2-worm reducer; 3-front axle lifting device; 4-control display device; 5-frame; 6-magnetic powder brake; 7-loading support; 8-friction wheel; 9 – flywheel; 10-A bottom bracket; 11-a central shaft supporting device  
**Figure 1.** The scheme of the road condition simulator.

## 4 Determination of Simulated Equations for Road Condition Simulator

For the sake of research, it is assumed that neither the road surface nor the wheels are deformed. When a person stepping on the car, a force couple moment is applied to the wheel by the transmission of the chain, trying to rotate the rear wheel. Due to the wheel and the ground between the role of adhesion, in the non-sliding rolling, the road will inevitably exert a force on the wheel, the direction of the same direction with the bike, which is driving the bicycle driving force, that is, the driving force. The main force is transmitted from the lower edge of the wheel to the axle of the wheel, trying to push the wheel forward. When the driving force is increased enough to overcome the resistance of the bicycle at rest, the rear axle begins to move forward, at which time the rear wheel rolls along the road while the front wheels roll and the bicycle begins to move forward. After the start of the bicycle, its driving condition depends on the driving force and the driving process of the relationship between the various resistance. When the bicycle is running, the value of the driving force must be equal to the total resistance of the bicycle. The main resistance to air resistance, rolling resistance, acceleration resistance and slope resistance.

In the test system, with the power meter measuring the torque applied to the crank, with the sensor to measure the crank speed, the product of the two people is the power applied to the bicycle. When a torque is applied to the crank, the strain gauge in the crank integrated device will feel a slight deformation. Sprocket integrated disc internal contact switch, crank every rotation, the contact switch is fixed in the frame of the magnetic sensor excitation time.

The measured torque and speed values are digitized in the crank integrated device and converted to a high frequency pulse width modulation electronic signal which is fed to the metal coil inside the sprocket assembly disc, the secondary coil fixed to the frame This signal is sensed and passed to the microprocessor in the power controller via a cable where the processor calculates the speed of rotation and the average torque of the crank in one

rotation, multiplying the two to obtain the power value, On the LCD display shows the reading. The total mechanical energy calculation is obtained by integrating the power over the entire training and testing process.

When the wheel rotates one turn, the contact switch fixed to the front fork is excited once by the magnet mounted on the bar, thus obtaining the wheel speed. Through the power controller input wheel circumference, the microprocessor will calculate the speed of bicycle travel.

## 5 BT-ATS power car special ability training

We use the BT-ATS power car for cycling athletes special ability training, to overcome the previous traditional practice of some special means and models. Special ability is good or bad, to a certain extent, the results of cycling athletes have a direct impact. In the actual training and competition process, the most important for cyclists is the ability to special good or bad. Special ability is the special level reflected by the athletes in the riding process, often expressed as the athletes in the higher frequency of riding a long time to maintain a certain power demonstrated by the special ability. It is found that the speed of the bicycle can be increased more effectively by improving the pedalling technique of the athletes and improving the pedalling frequency to increase the transmission ratio and the lower limb strength while keeping the rhythm unchanged. At the same time doing work also increased the power output, improved cardiovascular function. The ability to improve the specific sports and training competition results are inseparable.

Pedalling action is the bicycle movement in the key technical action, is also the most complex and most difficult to master the action. In the use of BT-ATS power car training or testing when the athletes do not have a good pedal technology will make it strong in the means of content likely to cause physical harm, especially the cyclist foot joints, knees and skeletal joints, if Long pedalling technology is not standardized or even cause premature end of the sports career. So we must pay attention to standard pedalling technology. In the actual riding or training in the BT-ATS power pedal technology better athletes can achieve the minimum energy consumption of the output more power to achieve higher speed. So cycling athletes must improve pedal technology.

## 6 Method of Pedalling for Cyclists

Bicycle pedal there are three ways: freestyle, front toe down and rear heel press. Most of the excellent athletes in our country have adopted the freestyle pedalling method. This freestyle pedalling method, foot rotation in the course of a week, is based on different parts, step on the joint angle also changes with. Feet in the highest point A, the heel slightly drooping 8 degrees, and then forced down the force gradually increased to point B, the soles of the feet into parallel relationship with the ground, pedalling force the most. And then down, the force

gradually reduced into the relaxation area down, the muscles began to relax, slightly raised his heels, to the C point, the heel gradually mentioned about 15 degrees. When the foot back to D point and parallel to the ground. Up, heel and then quickly brought up, loop into the A point. Freestyle pedal, in full compliance with the principles of biomechanics, forced the direction of rotation and pedal rotation formed when the tangent line, reducing the knee and thigh force amplitude, effectively improve the pedal frequency instantly through the relaxation area, to avoid death The presence of points. Thigh muscles and small muscle groups can also be an instant relaxation. However, this pedal method is not easy to grasp. Before the tiptoe pedal approach: In particular, relatively high speed athletes to use more than the front tiptoe pedal method of the overwhelming majority. This pedal mode is always downward during the entire pedal rotation. Foot range of activities is very small, particularly conducive to improve the pedal frequency, the athletes as long as the heart learned to learn it is easier, but the leg muscles will always be in a relatively tight state is not conducive to the relaxation of the leg muscle group recovery.

After the heel down pedal method is a little toe up, heel down 7-14 degrees. This method is rarely used in general athletic training and competition, only a small part of the players in the training or race riding excessive adjustment force will be used when the heel down pedal method. It is characterized by changes in muscle strength in a short time, get a short break, to restore the effect of muscle fatigue.

## 7 BT-ATS power car in the bicycle speed training on the edge

The change of bicycle speed training means has always been a major topic of concern to trainers. We use BT-ATS power car training to change the intensity, frequency and periodicity of the stimulus so as to make the nerve center of cycling athletes form good dynamic shaping, The speed of cycling athletes has greatly improved.

If too short in this distance will not play the role of speed, if it is too long with endurance characteristics, the loss of the meaning of bicycle speed training. Incubate the acceleration capability with a distance of at least the same distance as the acceleration phase. In the absolute speed training is generally used in the distance of 500m-1000m better, of course, in the BT-ATS power car can also use other speed means, such as the ability to train 3km sprint, speed training may also add a few 3km Sprint riding, but the athletes riding at this distance, the excitement of the nervous system is very high, relatively abundant physical strength, no significant reduction in riding speed, although with endurance characteristics, but the speed of the Development and improvement still has a forward role, but this speed training in BT-ATS power car can not repeat too many times, if repeated too much will be away from speed training this track.

Speed training, the sense of rhythm training in speed training, we realize the good action rhythm is also an

important factor in achieving excellent results, when the rider pedaling required rhythm, will make him produce a sense of rhythm, and this A sense of rhythm that can make him ride in the ride to play a smooth speed, but also the relative savings in physical strength, improve excitability, to achieve the purpose of technical action to relax and rationalize. Through a sense of rhythm training, athletes acceleration, relaxation and cycling movements have a certain significant increase. This kind of exercise if arranged in the excitement of the athletes in general time, can play a role in mobilizing nervous system excitement. The optimal timing of speed training is to be arranged when the cyclist is in good athletic state because the flexibility of the nerve, the stretching of the muscle, the elasticity and the biochemical mechanism are important factors constituting the speed, so if the speed training is arranged in the athlete's fatigue, Not only the above factors are not fully displayed, and because the nervous system in a dark state of the deeper, lower muscle elasticity, loss of movement of the original frequency and amplitude, in this state for speed training, not only for speed Will not achieve the promotion of the role of the passage of time will also form a speed barrier to the entire training adverse effects.

Therefore, we in the entire training cycle arrangements, the general speed training courses scheduled for Monday or after the appropriate adjustments to resume the first training session. In short, as far as possible, the speed training courses arranged in the period of over-recovery, so that athletes can show a high level of competition, showing high energy, high excitability, thereby enhancing the cycling speed training effectiveness.

## 8 BT-ATS power car in the training means the advantages

BT-ATS power car 8 seconds training means This means the main purpose of training in the energy system, along with high resistance to improve lactic acid resistance. If you decide to use 36x26 gear ratio, then the muscle nervous system efficiency than muscle strength to give priority. The number of exercises can be started in situ 12 times at this stage, practice at this time for 6 seconds ++2 seconds (best effort) (can be within 7 seconds shift) using the smallest bicycle and BT-ATS Power car 26 teeth on the rear flywheel, recovery time in the practice interval of 2 minutes 45 seconds, each practice interval of 3 minutes. It is important to maintain the same posture while practicing a horse and maintaining a posture throughout the process. It is easy to do in the 3 minutes of the practice and should use the same gear ratio as the game. A series of low-frequency training in this training phase is the use of the largest bike tooth plate and BT-ATS power car 12-15 on the fly after the device. The training season can use high frequency training, using the smallest bike tooth plate and BT-ATS power car on the 26 teeth of the fly after each exercise should be in the upper training intensity effect will be very obvious.

BT-ATS power car 30 seconds training means This means the main purpose of training is lactic acid-resistant

ability of the energy system and muscle nervous system strength. This is a high-intensity training and a variety of training forms of bicycle training. Training can be started in the practice of the number of times in this stage of 6 - 10 times, practice at this time for 30 seconds +3 seconds (best) (can be within 7 seconds shift) using the smallest bicycle and BT -ATS power 26-tooth car after the flywheel, recovery time in the practice interval of 5 minutes -20 minutes. Up to 2 times a week training. Ask for a practice mount and maintain a pose throughout the exercise. This training session begins with a 10-second period of low intensity followed by a 5-second increase in intensity to the last 5 seconds of the highest intensity. The same gear ratio as in the race should be used. This series of low-frequency exercises, Of the bicycle tooth plate and BT-ATS power car 12-15 teeth on the fly after the device. The training season can use high frequency training, using the smallest bicycle disk, and the BT-ATS power car on the 26-tooth fly after the device, using the test power data. Each exercise should be in the upper exercise intensity. BT-ATS power car 5 points Training means The main purpose of this training is to improve the anaerobic capacity of the energy system and the efficiency of the muscular nervous system, which is to improve the training intensity and variety of training forms of bicycle training.

The number of practice sessions is three to ten times during this period. The duration of the exercise is 5 minutes and the recovery time is 5-10 minutes in the interval. The interval between exercises is 10 to 15 minutes. Such training may take place once a week. It is important to maintain the same posture while practicing the mount and maintaining a posture throughout the exercise. The same gear ratio as the race should be used. The training phase can use high frequency training, the use of the smallest bicycle tooth plate, and BT-ATS power car on the 26-tooth fly after the device. The target should have a cadence of 120-140 beats per minute, and each exercise should be of medium to high intensity.

## 9 Conclusion

(1) On the basis of consulting a large amount of literature and data, the overall design of working simulator and sprint simulation trainer is put forward according to the requirement of development. The design of slope simulation simulator and simulation load structure And the design of the control principle. The frame structure design, the cadence control design and the security protection design of the sprint simulation trainer are completed. After the assembly of the prototype production, the prototype debugging is carried out, and the shortcomings are improved.

(2) Establishing the kinematics model of the working condition simulation structure, and obtaining the relation equation between the vehicle frame angle and the nut lift. On the basis of analyzing the actual running resistance of the bicycle, the experimental results show that the rotational speed of the crankshaft is between the air resistance and the rolling resistance torque. The dynamic model of the bicycle and the dynamic model of the

simulator were established, and the loading equation of the magnetic brake was deduced.

(3) In the design of road simulation trainer, a kind of original slope and resistance simulation method is adopted, and the corresponding matching load is realized by PLC programming and control. According to the domestic and international research, the simulation training of this project has not appeared. The structure of the device, indicating that the device is an innovative product.

(4) sprint simulation trainer is designed according to the special needs of our athletes, which uses a small sprocket and clutch torque limiter, simplifies the transmission, the athletes to achieve effective security protection, the structural design can That is an innovation.

(5) The successful development of the simulation trainer can provide a set of advanced training equipment for the Chinese cycling team to solve the practical difficulties of the coaches and athletes in daily training. At the same time, the coaches have mastered the training of the athletes. To help coaches effective implementation of the training program, improve the athletes competition results, enhance the strength of the Olympic Games won the title played a role.

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