

Design and Application of CNC6061 Aluminum Alloy Workpiece in the Uniformly Distributed Three Friction Wheel Launch Mechanism of Indoor Golf Game Machine

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Abstract: This study focuses on the CNC6061 aluminum-alloy workpiece in the uniformly distributed three-friction-wheel launching mechanism of indoor golf game consoles. First, the importance of indoor golf game consoles and launch mechanisms was introduced, and the key role of CNC6061 aluminum alloy workpieces in them was elaborated. In the Materials and Methods section, the reasons for selecting this material and the design points of the workpiece are explained, including the 3D modeling design based on functional requirements and structural features, as well as considerations of factors such as stress conditions, dimensional accuracy, and assembly requirements. The Results and Discussion section provides a detailed analysis of the performance of the workpiece and introduces the design iteration process of the workpiece. The first version had insufficient strength, whereas the third version had significantly improved performance through optimization measures, such as adding reinforcing ribs. The final launch mechanism adopts a two-stage, evenly distributed six-friction wheel design, and its structural composition and working principle are explained. Through simulation analysis and actual testing, the third version of the workpiece exhibited excellent performance, with a high safety factor, small stress, displacement, and strain values, stable speed, high accuracy, and no damage during launch testing, meeting the requirements for indoor golf game machine launch. This study validates the effectiveness of the optimized design, providing a reference for the design and manufacture of similar entertainment devices, and has important application value and promotion significance.

Keywords: Indoor golf game console, CNC6061 aluminum alloy workpiece, launch performance, simulation analysis, launch testing

1. Introduction

CNC6061 aluminum alloy [1] workpieces have good mechanical properties, processing performance, and corrosion resistance, which can meet the requirements of the launching mechanism in terms of strength, accuracy, and stability. By designing and optimizing the workpiece, the performance of the launch mechanism can be improved, thereby enhancing the overall experience of indoor golf-game consoles.

Indoor golf game consoles [2], which are entertainment devices that simulate real golf activities, are widely popular. It simulates the environment and rules of a golf course, allowing players to experience the fun of golfing indoors.

The launch mechanism, as its core component, directly affects the gaming experience and its authenticity. The uniformly distributed friction wheel launching mechanism [3,4] plays a crucial role in indoor golf game consoles. The organization achieves stable clamping and accelerated launch of golf balls by reasonably arranging three friction wheels, which can effectively control the launch speed and direction, thereby significantly improving the launch accuracy and stability of the golf balls.

The performance of the CNC6061 aluminum-alloy workpiece, as the core component of the launching mechanism, directly determines the operating effect of the entire launching mechanism. Notably, the uniformly distributed friction wheel has a self-centering function during the projectile launch process, which further enhances the accuracy of the launch. Specifically, the uniformly distributed friction wheel launching mechanism can be divided into two types: single-stage three-friction wheels and two-stage six-friction wheels (i.e., two-stage three-friction wheels). Among them, the dual-stage six-friction-wheel design performs better in stabilizing the projectile velocity, achieving higher launch accuracy than the single-stage three-friction-wheel design, and providing even better performance for indoor golf game consoles. CNC6061 aluminum alloy workpieces have good mechanical properties, processing performance, and corrosion resistance [5], which can meet the requirements of the launching mechanism in terms of strength, accuracy, and stability. By designing and optimizing the workpiece, the performance of the launch mechanism can be improved, thereby enhancing the overall experience of indoor golf-game consoles.

2. Materials and Methods

2.1. Material selection

CNC6061 aluminum alloy is a commonly used aluminum alloy material with good mechanical properties, processability, and corrosion resistance. Its main components include aluminum, copper, magnesium, silicon, and other elements, and its strength and hardness can be further improved through reasonable heat treatment processes. The CNC6061 aluminum alloy was selected as the material for the workpiece based on its comprehensive advantages in terms of strength, weight, and cost, which can meet the high-performance requirements of the indoor golf game machine launch mechanism for the workpiece. In terms of cost, the first version of the design had a workpiece cost of 120 yuan per piece, whereas the optimized second version reduced the workpiece cost to 100 yuan per piece, effectively reducing costs while ensuring improved performance.

2.2. Design of Workpiece

The design of the workpiece was based on the functional requirements and structural characteristics of the indoor golf game machine launch mechanism. In the design process, factors such as the stress situation, dimensional accuracy, and assembly requirements of the workpiece were fully considered, and Fusion360 3D modeling software [6] was used for design and simulation analysis. The main structure of the workpiece includes fixed, moving, and connecting parts. Through reasonable shape design and size optimization, the requirements of strength and accuracy can be met while minimizing the weight and improving the overall performance of the launching mechanism.

Four threaded holes were designed in the middle of each workpiece. The two threaded holes at the rear were mainly used to strengthen the fixed connection between the workpiece and the pan tilt, ensuring that the workpiece could be stably installed on the pan tilt during operation, avoiding problems such as a decrease in accuracy or equipment damage caused by looseness. The two threaded

holes on the upper part were used to fix the single-shot limit mechanism, which could accurately control the number and position of the launches, ensuring fairness and accuracy in the game. The design of this threaded hole not only meets the installation requirements of different components but also facilitates the quick disassembly and assembly of workpieces, greatly improving the maintenance efficiency and ease of use of the equipment.

2.3. Structure and Working Principle of Launching Mechanism

The launch mechanism of the indoor golf game console adopts a uniformly distributed three-friction wheel design, including three polyurethane friction wheels with an outer diameter of 60 mm. It is powered by a DJI 3508 motor rotor and connected to the front and rear workpieces using carbon fiber boards. The motor was fixed on the board to launch 42 mm golf-shaped pellets. The workpiece plays a crucial role in connecting and supporting the mechanism, ensuring the stable operation of the friction wheel and the effective transmission of power. The working principle of The launching mechanism accelerates and launches the projectile by driving the friction wheel to rotate through a motor, achieving the simulated hitting effect of a golf ball.

3. Results and Discussion

3.1. Performance analysis of workpieces

By analyzing the mechanical properties, processing performance, and corrosion resistance of CNC6061 aluminum-alloy workpieces, the results show that the material can meet the high-performance requirements of indoor-golf-game machine-launch mechanisms for workpieces. After heat treatment, the strength and hardness of the workpiece were significantly improved, and it could withstand the impact and friction forces during the launch process. Simultaneously, the CNC6061 aluminum alloy has good processing performance and can achieve high-precision processing requirements, ensuring the dimensional accuracy and surface quality of the workpiece.

3.2. Design iteration of workpieces

3.2.1. First Edition Workpiece Design

When designing the first version of the workpiece as shown in Fig 1, first version of workpiece design, basic stress and assembly requirements were considered; however, there were shortcomings in terms of strength. In the final competition test, one of the workpiece legs was broken. This indicates that the design of the first version of the workpiece still requires improvement in terms of strength and reliability, with a unit price of 120 yuan.

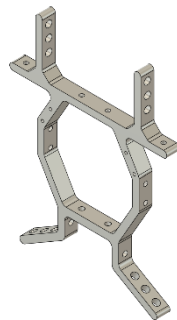


Figure 1: First version of workpiece design

3.2.2. Second Edition Workpiece Design

An optimization design was performed for the second version of the workpiece as shown in Fig 2, second edition Edition Workpiece Design to address the issues present in the first version. By increasing the thickness of the load-bearing part of the workpiece, the structural strength and durability of the workpiece were further improved. Simultaneously, the side connection part of the workpiece was optimized to improve its connection reliability with the motor and other components and to facilitate quick disassembly and assembly. The unit price of this version was 140 yuan.

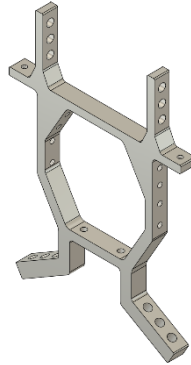


Figure 2: Second Edition Workpiece Design

3.2.3. Third Edition Workpiece Design

In response to the issues with the first version of the workpiece, as shown in Fig 3, third Edition Workpiece Design, an optimized design was implemented for the second version of the workpiece. By adding reinforcing ribs, optimizing the cross-sectional shape, reducing the workpiece volume, and other measures, the stress part is more concentrated, further improving the structural strength and durability of the workpiece. The unit price of this version was 100 yuan.

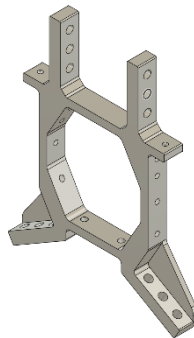


Figure 3: Third Edition Workpiece Design

3.3. Final Launch Mechanism Design

3.3.1. Structural composition

In this study, the fourth edition launch mechanism innovatively adopted a two-stage uniformly distributed six-friction wheel design as shown in Fig 4, dual stage six friction wheel launching

mechanism which involved stacking two uniformly distributed three-friction wheel structures in front and behind to optimize the launch performance. It mainly consists of the following components:

Polyurethane friction wheels [7,8]: Three polyurethane friction wheels with an outer diameter of 60 mm were evenly distributed, and their stable operation on the same plane was ensured through precise installation technology. Polyurethane materials have a high coefficient of friction and good wear resistance, which can provide stable friction for projectiles and achieve precise acceleration launches.

CNC6061 aluminum alloy workpiece: As a key component of the launch mechanism, this workpiece has been optimized and designed to have good strength and stability. Its main structure includes a fixed, moving, and connecting part. Through reasonable shape design and size optimization, the aim is to reduce the weight as much as possible while meeting the strength and accuracy requirements. Four threaded holes were designed in the middle of the workpiece. The lower two threaded holes of the rear workpiece were used to strengthen the fixation between the workpiece and pan tilt, ensuring the stability of the launching mechanism during operation. The upper two threaded holes were used to fix the single-shot limit mechanism, which not only facilitated the installation and disassembly of the components but also improved the overall performance of the launch mechanism.

DJI 3508 motor rotor: As a power source, the DJI 3508 motor rotor has the characteristics of high torque and high efficiency, which can provide strong power support for the friction wheels. The motor rotor is connected to the front and rear workpieces through carbon fiber sheets, ensuring stable power transmission and a compact launch mechanism.

Carbon fiber board [9]: used to connect the front and rear workpieces, with the characteristics of light weight and high strength. The use of a carbon fiber board not only reduces the overall weight of the launch mechanism but also improves its rigidity and stability, ensuring the precise coordination of various components during the launch process.

Single-shot limit mechanism: composed of printed parts, bearings, torsion springs, and other components, installed at the upper threaded hole of the workpiece. This institution is used to limit the launch of only one projectile at a time, ensuring the accuracy and safety of the launches. Simultaneously, the single-shot limit mechanism also has the function of centering the projectile before contacting the friction wheel, allowing the projectile to simultaneously contact three friction wheels as soon as it exits the single-shot limit, further increasing the accuracy of the launch. The assembly method is as follows.

First, by using plug screws and anti-loosening nuts to achieve a high-precision gap fit with the third version workpiece, as well as an interference fit [10] with the carbon fiber board, the positioning accuracy of the carbon fiber board was significantly improved. The single-shot limit printing parts were also fixed with interference-fit screws and workpieces, further improving the overall positioning accuracy. In addition, the rotor of the DJI 3508 motor was fixed with interference-fit screws and carbon fiber sheets to ensure the stability and reliability of the motor.

3.3.2. Working principle

When the motor starts, the DJI 3508 motor rotor drives six polyurethane friction wheels to achieve a precise synchronous rotation. The 42 mm golf-shaped projectile was placed in the single-shot-limit mechanism, and the projectile was precisely centered by the limit mechanism before coming into contact with the friction wheel, ensuring that once the projectile exited the limit mechanism, it could simultaneously make close contact with the three friction wheels of the first stage. At this point, a strong frictional force is rapidly generated between the friction wheel and the projectile, causing the projectile to accelerate instantly and leap precisely to the second-level friction wheel. The main function of the second-level friction wheel is to further stabilize the velocity of the projectile to achieve a more uniform and stable hitting effect for simulating a golf ball at the moment of launch.

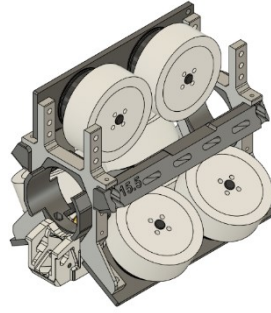


Figure 4: Dual stage six friction wheel launching mechanism

This launch mechanism is further mounted on a rotatable gimbal as shown in Fig 5, dual level six friction wheel gimbal design with an adjustable pitch angle range of 45° to 20° . The gimbal is further mounted on a Mecanum wheel [11] chassis as shown in Fig 6, design of a dual stage six friction wheel robot vehicle, forming a golf shooting robot with omnidirectional mobility and precise launch capability. By precisely controlling the speed and direction of the motor, the firing speed and direction of the projectile can be flexibly adjusted, thereby meeting the strict requirements of indoor golf game consoles for firing performance and providing players with a more realistic and enjoyable gaming experience.

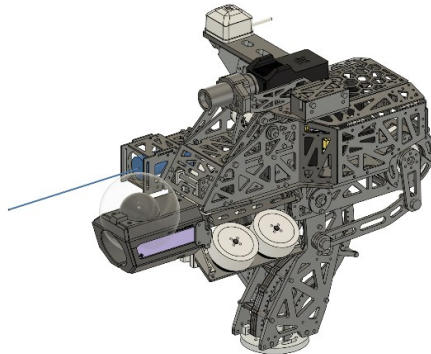


Figure 5: Dual level six friction wheel gimbal design

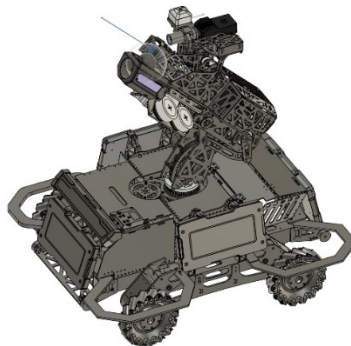


Figure 6: Design of a dual stage six friction wheel robot vehicle

3.4. Simulation results of workpieces

3.4.1. Simulation prerequisites

In this study, we conducted a force simulation analysis on a fixed workpiece to comprehensively evaluate its performance during the launch of a golf ball. However, in actual use, when a golf ball is used as a projectile and pressed and launched through a polyurethane friction wheel, its force is influenced by various factors, including the weight of the golf ball, its unique shape, different materials, the set launch angle, and the friction coefficient between the polyurethane friction wheel and the golf ball. The complexity and uncertainty of these factors make it difficult to accurately determine the forces exerted on the workpiece. In addition, the force exerted on the single-shot limit device was much smaller than the force transmitted to the workpiece by the friction wheel compression. Therefore, in the simulation analysis, we chose to ignore the degree of force exerted on the single-shot limit device to focus more on the influence of the main force factors on the performance of the workpiece.

Meanwhile, in the simulation process of this study, considering that the fixing method of the upper friction wheel is through screws and two 304 stainless steel two-way hexagonal column nuts, to simplify the simulation process and improve simulation efficiency, I chose to merge these two hexagonal columns with the workpiece. This processing method ensures the accuracy of the simulation results while effectively reducing the complexity of the simulation model, making the simulation process more efficient and convenient.

To conduct the simulation analysis, the possible force range that the workpiece may experience was estimated based on the empirical data of similar products and preliminary experimental results. I selected force values ranging from 10N to 50N with an interval of 10N for the simulation, namely 10N, 20N, 30N, 40N, and 50N. This setting can comprehensively evaluate the performance of a workpiece under different stress levels. During the simulation process, these five sets of force values were applied, and the stress, strain, displacement, and other responses of the workpiece were observed under different stress conditions.

It should be emphasized that owing to the uncertainty of the force magnitude, there may be certain errors and uncertainties in the simulation results, especially under high-stress conditions, where the stress and deformation of the workpiece may be more affected. However, through this targeted simulation analysis, we can still gain a preliminary understanding of the performance of the workpiece under different stress conditions, providing important guidance and reference for subsequent design optimization and experimental research in the future. In the future, we can further determine the actual force magnitude of the workpiece through more accurate measurement methods and experimental data to improve the accuracy and reliability of the simulation results.

3.4.2. Simulation Methods

In this study, the static stress function of the Fusion 360 software was used to simulate and analyze the workpiece. Aluminum 6061 was used as the material, and structural constraints were applied to the screw holes connected to the gimbal. Simultaneously, structural loads of 10N, 20N, 30N, 40N, and 50N were applied in five directions at the through hole where the assembly was subjected to force. Through simulation, key indicators such as the safety factor, stress, displacement, and strain were statistically analyzed, and the maximum, minimum, and average values of the three workpieces were compared to evaluate their performance differences.

3.4.3. Simulation results

The following are the statistical data of the simulation results, as shown in table I.

Table 1: statistical data of the simulation results

Simulation	Statistical value				
	Force (N)	Value	Part 1	Part 2	Part 3
safety factor	10	max	15	15	15
		min	15	15	15
		average	15	15	15
	20	max	15	15	15
		min	7.988	15	15
		average	11.494	15	15
	30	max	15	15	15
		min	5.326	13.271	15
		average	10.163	14.136	15
	40	max	15	15	15
		min	3.994	9.953	15
		average	9.497	12.477	15
	50	max	15	15	15
		min	3.195	7.962	15
		average	9.098	11.481	15
stress(MPa)	10	max	17.212	6.907	2.920
		min	0.001	0	0
		average	8.607	3.454	1.460
	20	max	34.425	13.815	5.839
		min	0.001	0.001	0.001
		average	17.213	6.908	2.920
	30	max	51.637	20.722	8.759
		min	0.002	0.001	0.001
		average	25.820	10.362	4.380
	40	max	68.850	27.630	11.679
		min	0.003	0.002	0.001
		average	34.427	13.816	5.840
	50	max	86.063	34.538	14.599
		min	0.004	0.002	0.002
		average	43.034	17.270	7.301
displacement(mm)	10	max	0.052	0.017	0.002
		min	0	0	0
		average	0.026	0.009	0.001
	20	max	0.104	0.034	0.005
		min	0	0	0
		average	0.052	0.017	0.003
	30	max	0.156	0.051	0.007
		min	0	0	0
		average	0.078	0.026	0.004
	40	max	0.208	0.068	0.010
		min	0	0	0
		average	0.104	0.034	0.005

Table 1: (continued).

Strain	50	max	0.260	0.085	0.012
		min	0	0	0
		average	0.130	0.043	0.006
	10	max	0	0	0
		min	0	0	0
		average	0	0	0
	20	max	0	0	0
		min	0	0	0
		average	0	0	0
	30	max	0.001	0	0
		min	0	0	0
		average	0.001	0	0
	40	max	0.002	0	0
		min	0	0	0
		average	0.001	0	0
	50	max	0.002	0	0
		min	0	0	0
		average	0.001	0	0

3.4.4. Simulation data analysis

3.4.4.1. Distribution of force

- Workpiece 1: As show in Table 1, under all force values (10N, 20N, 30N, 40N, 50N), the maximum force value of Workpiece 1 was 15N, and the minimum and average force values were relatively high. This indicates that workpiece 1 has a relatively uniform distribution of force, but the overall force is high.
- Workpiece 2: The maximum force value of Workpiece 2 was 15N at all force values, but the minimum and average force values were relatively low, especially when the average force values were 15N and 11.494N at 10N and 20N, respectively. This indicates that the distribution of stress on workpiece 2 is relatively concentrated, and there is a problem of excessive local stress.
- Workpiece 3: The maximum force value of Workpiece 3 was 15N at all force values, and the minimum and average force values were relatively low, particularly when the average force values were 15N and 11.494N at 10N and 20N, respectively. This indicates that the distribution of force on workpiece 3 is relatively uniform, but the overall force is small.

3.4.4.2. Safety factor

- Workpiece 1: The safety factor is relatively high at all force values, especially at 30N and 40N, with minimum safety factors of 5.326 and 3.994, respectively, indicating that Workpiece 1 is relatively safe in design and can withstand large loads.
- Workpiece 2: The safety factor is also high at all force values, especially at 30N and 40N, with minimum safety factors of 13.271 and 9.953, respectively, indicating that Workpiece 2 is also very safe in design and can withstand large loads.
- Workpiece 3: The safety factor is 15 at all force values, indicating that Workpiece 3 is designed to be very safe and can withstand large loads.

3.4.4.3. Stress distribution

- Workpiece 1: The stress values are relatively high at all force values, especially at 30N and 40N, with maximum stresses of 68.850 MPa and 86.063 MPa, respectively, indicating that Workpiece 1 has a problem of excessive local stress when subjected to stress.
- Workpiece 2: The stress values were relatively low at all stress values, especially at 30N and 40N, with maximum stresses of 27.630 MPa and 34.538 MPa, respectively, indicating that Workpiece 2 had a relatively uniform stress distribution and small local stresses when subjected to stress.
- Workpiece 3: The stress values were relatively low at all stress values, especially at 30N and 40N, with maximum stresses of 11.679 MPa and 14.599 MPa, respectively. This indicates that Workpiece 3 has a very uniform stress distribution under stress with small local stresses.

3.4.4.4. Displacement

- Workpiece 1: The displacement values are relatively large at all force values, especially at 30N and 40N, with maximum displacements of 0.208 mm and 0.260 mm, respectively, indicating that Workpiece 1 undergoes significant deformation under stress, which can affect its functionality.
- Workpiece 2: The displacement value was relatively small under all force values, especially at 30N and 40N, with maximum displacements of 0.068 mm and 0.085 mm, respectively, indicating that Workpiece 2 deformed less under stress and could maintain good stability.
- Workpiece 3: The displacement values were relatively small at all force values, especially at 30N and 40N, with maximum displacements of 0.010 mm and 0.012 mm, respectively, indicating that Workpiece 3 underwent very little deformation under stress and could maintain high stability.

3.4.4.5. Strain

- Workpiece 1: The strain values are relatively large at all force values, especially at 30N and 40N, with maximum strains of 0.002 and 0.002, respectively, indicating that Workpiece 1 undergoes significant deformation under stress, which can affect its functionality.
- Workpiece 2: The strain value was relatively small under all force values, especially at 30N and 40N, with maximum strains of 0 and 0, respectively, indicating that Workpiece 2 deformed less under stress and could maintain good stability.
- Workpiece 3: The strain values are relatively small at all force values, especially at 30N and 40N, with maximum strains of 0 and 0, respectively, indicating that Workpiece 3 undergoes very little deformation under stress and can maintain high stability.

3.4.5. Comprehensive evaluation

3.4.5.1. Workpiece 1

Although the safety factor is relatively high, the stress and displacement values are large as shown in Fig 7, the first version of the 50N simulation of the workpiece, indicating that there is a problem of excessive local stress and deformation when it is under stress, which affects its function.

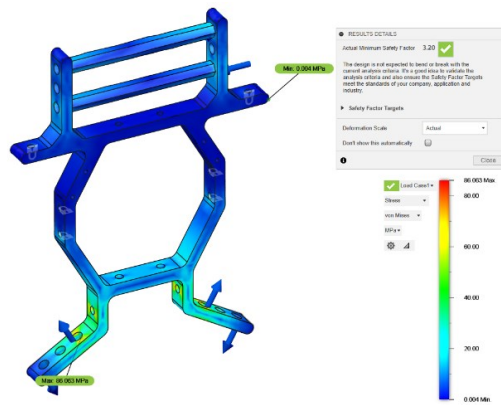


Figure 7: The first version of the 50N simulation of the workpiece

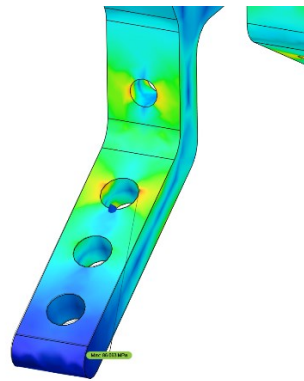


Figure 8: At the maximum stress point of the first version of the workpiece

When conducting the simulation analysis under a force of 50N, the simulation results of the first version of the workpiece clearly showed that the fracture occurred at the location of the maximum stress value. Further observations revealed that the stress concentration phenomenon at this location was obvious, with stress values far exceeding the reasonable range that the material could withstand as shown in Fig 8, at the maximum stress point of the first version of the workpiece. This result indicates that there were obvious unreasonable aspects in the design of the first version of the workpiece, which led to excessive stress concentration and ultimately caused fracture problems, seriously affecting the performance and service life of the workpiece [12].

3.4.5.2. Workpiece 2

The safety factor is relatively high, and the stress and displacement values are relatively small, indicating that the stress distribution is relatively uniform and the deformation is small when it is under stress, and it can maintain good stability.

3.4.5.3. Workpiece 3

It has the highest safety factor, with small stress and displacement values, indicating that its stress distribution is very uniform and deformation is very small when under stress as shown in Fig 9, third edition workpiece 50N simulation situation, and it can maintain high stability.

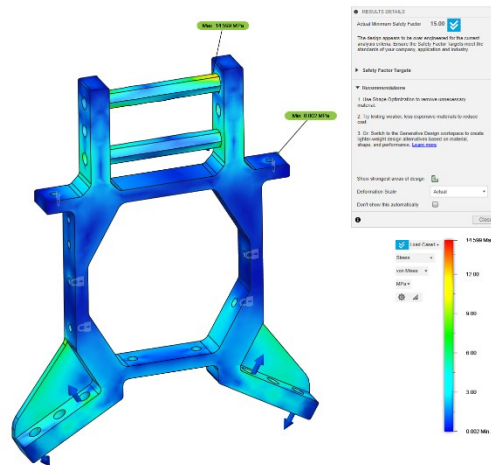


Figure 9: Third edition workpiece 50N simulation situation

Under a force of 50N, the third version of the workpiece demonstrated excellent design advantages through simulation analysis. The simulation results showed that there was no stress concentration phenomenon in the workpiece structure, and the stress distribution was uniform and reasonable. This indicates that the third version of the workpiece effectively avoided the problem of excessive stress concentration in the design, significantly improving the performance and service life of the workpiece. A uniform stress distribution not only reduces the risk of local damage to the material but also enhances the reliability of the workpiece during long-term operation, providing a solid guarantee for the stable operation of the launch mechanism.

3.5. Actual photos of the workpiece



Figure 10: The first version of the physical image of the workpiece

These images can visually display the structural design and total mass of the workpiece. As shown in Fig 10, the first version of the physical image of the workpiece, the total weight of the first version workpiece was 70.7 g, and as shown in Fig 11, The first version of the physical image of the workpiece, the total weight of the third version workpiece was 114.9 g, providing more intuitive evidence for the study.

As shown in Fig 12, dual level six friction wheel robot vehicle, this photograph of the robot clearly shows the specific position of the launch mechanism in the vehicle, visually presenting the overall design, structural layout, and actual production effect of the robot.



Figure 11: The first version of the physical image of the workpiece



Figure 12: Dual level six friction wheel robot vehicle

3.6. Launch Test Results

3.6.1. Test prerequisites

During the launch test, the fourth-version gimbal was equipped with a third-version workpiece. The specific testing prerequisites were as follows, as shown in Fig 13, launch premise.

- RF: 0.5 rounds per second
- Test distance: 5m
- Theoretical friction wheel speed: 5128rpm
- Actual friction wheel speed: 5128rpm
- Data volume: 30 rounds

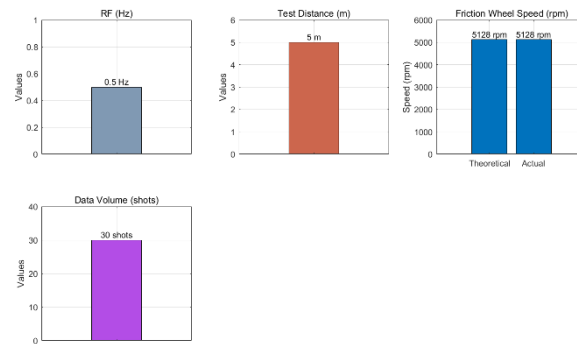


Figure 13: Launch premise

3.6.2. Test result statistics

The specific data of the test results are as follows, as shown in Fig 14, test result statistics.

- Average speed: 16.0374603 m/s
- Maximum speed: 16.1137447 m/s
- Minimum speed: 15.9724398 m/s
- Horizontal Walk: 6.5mm
- Vertical walking: 8.5mm

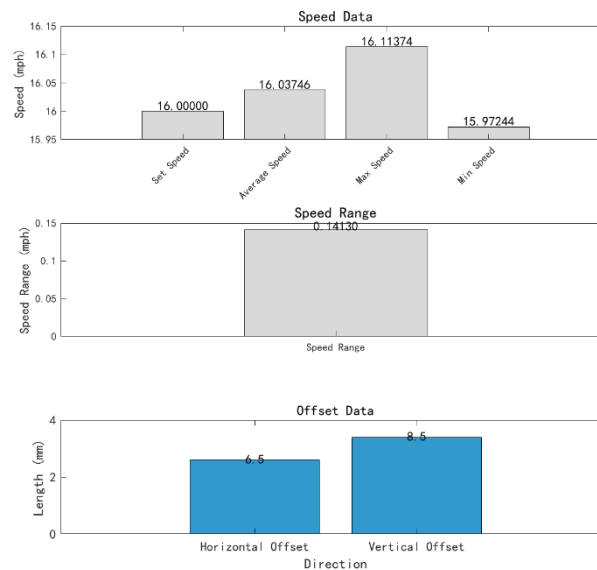


Figure 14: Test result statistics

3.6.3. Analysis of Test Results

Based on the analysis of the above data, the following conclusions can be drawn:

3.6.3.1. Speed stability

Based on the average, maximum, and minimum speeds, the launch speed remained within a relatively stable range with minimal fluctuations. This indicates that the launch mechanism has a good

performance in controlling the velocity of the projectile, ensuring consistency in the velocity of each launch.

3.6.3.2. Accuracy performance

The horizontal and vertical walks were 6.5 and 8.5 mm, respectively, indicating that the transmitting mechanism performed well in terms of accuracy. A smaller walk value indicates that the projectile's landing point distribution after launch is more concentrated, which is crucial for improving the accuracy of the game and the player's experience.

3.6.3.3. Practical application

Combined with the testing prerequisites, such as RF and testing distance, these results indicate that the transmitting mechanism can meet the requirements of indoor golf game consoles in practical applications. The stable launch speed and high-precision landing point distribution provide players with a realistic and enjoyable gaming experience.

3.6.4. Visualization of Test Results

The following is an actual picture of a shooting walk recorded on carbon paper. It can be visually observed that both the horizontal and vertical walks of the shooting are relatively small as shown in Fig 15, horizontal Walk Record on Carbon Paper and Fig 16, vertical walking recorded on carbon paper, which further verifies the high-precision performance of the launching mechanism. From the figure, it can be seen that the landing-point distribution of the projectile is concentrated in a small range, which not only meets the shooting requirements but also provides strong data support for subsequent optimization and improvement.

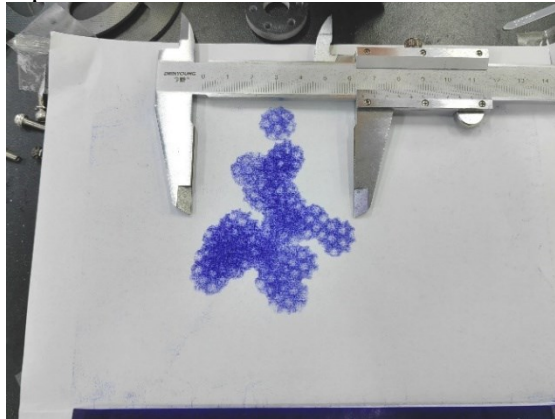


Figure 15: Horizontal Walk Record on Carbon Paper

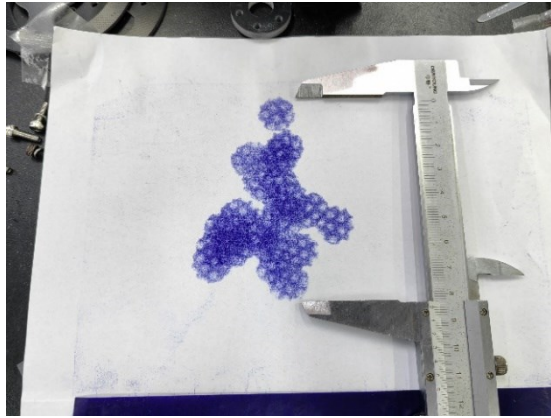


Figure 16: Vertical walking recorded on carbon paper

3.6.5. Test Summary

During the debugging process conducted in the laboratory, strict tests were performed on different versions of the workpiece. The test results indicated that the first version of the workpiece experienced fracture during the launch test, revealing its shortcomings in terms of strength and reliability. However, the optimized third version of the workpiece performed well in hundreds of launch tests without damage. In addition, the third version of the workpiece successfully passed the tests of two large-scale competitions, demonstrating its outstanding performance and stability.

This comparative result demonstrates the effectiveness of the optimized design. The third version of the workpiece has significantly improved strength and stability, and when mounted on a two-stage six-friction-wheel gimbal, it can achieve high launch accuracy. This not only meets the performance requirements of the indoor golf game console launch mechanism but also provides strong support for the precise launch and stable operation of the game console. In summary, the optimized design of the third version of the workpiece performed well in practical applications, providing a valuable reference for the design and manufacture of similar entertainment equipment.

4. Conclusion

Based on in-depth research on the design and application of a CNC6061 aluminum-alloy workpiece in a uniformly distributed three-friction-wheel launching mechanism of an indoor golf game machine, the results show that the workpiece exhibits excellent performance and reliability. During the research process, it was found that the first version of the workpiece had insufficient strength in its design, leading to failures such as fractures in practical applications. However, the third version of the workpiece, which was carefully optimized and designed, did not suffer any damage after hundreds of launch tests, and its performance was stable and reliable. This significant improvement not only extends the service life of the workpiece but also enhances the overall performance of the launch mechanism.

This study verified the effectiveness of the optimized design through practice, providing a valuable reference for the design and manufacture of similar entertainment devices. The research results indicate that the third version of the workpiece has significantly improved strength and stability and can better meet the performance requirements of the indoor golf game machine launch mechanism. Applying it to a dual-stage six-friction wheel gimbal can achieve higher launch accuracy, providing strong support for the precise launch and stable operation of game consoles. In summary, this study not only solves practical problems but also has important application value and significance.

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