

## Research Article

# Application Preparation of High-Performance Iron-Based Powder Metallurgy Sintered Materials in Sports Industry

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Nowadays, the rapid development of sports science and technology has brought about the vigorous development of the sports industry, which is worth studying for a long time in the future. This article aims to use metallurgical sintering technology to prepare high-performance iron-based powder materials and apply them in the traditional sports industry to produce new sports equipment. This article proposes a metallurgical sintering method, that is, the use of a process of powdered iron-containing materials through a series of operations to finally obtain a new agglomerate and to obtain the required new physical and mechanical properties of materials or products. A new type of material is made and used in the traditional sports industry to meet the high-quality needs of sports equipment in the current era. According to survey statistics, my country's sports industry has been developing rapidly in the past five years. It has increased from 1,901.13 billion yuan in 2016 to 2,869.35 billion yuan in 2020. Sports investment and financing events have also dropped from 313 to 105, but the entire sports industry's investment is getting bigger and bigger. The number of employees in the national sports industry has also exceeded the 2 million mark. In the future, the sports industry is also an industry with great potential for development.

## 1. Introduction

At present, traditional sports equipment mostly uses wood or metal materials. The physical properties of these materials limit the strength of sports equipment to a large extent. With the development of science and technology, new materials are widely used in various sports equipment and even become a key factor in determining the outcome of competitive sports. Based on the excellent characteristics of various new materials, such as high strength, specific modulus, light weight, wear resistance, good damping performance, and strong design ability, the performance of sports equipment has been significantly improved, and it has been widely used. Traditional exercise equipment has a short life span, low safety, and significant limitations. In this paper, sintering technology is used to prepare high-performance iron-based powder metallurgy materials, which are used in the traditional sports industry to manufacture fitness, rehabilitation, sports, and other sports equipment. In our country, science and technology have always been the primary productive forces, but in the sports industry, the rapid development

and progress of sports science and technology are the primary productivity of the sports industry. Since 1992, my country has vigorously developed sports science and technology, and with the continuous development of the times, sports science and other related sciences have gradually merged, which has led to the continuous production of new interdisciplinary subjects and the development of new science and technology and materials. In this context, the technology of this paper may be widely used in daily life in the future.

Through the preparation of high-performance iron-based powder metallurgy sintered materials, the traditional sintering technology is used to produce new high-performance iron-based powder materials, which are used in the sports industry to realize high-performance iron-based materials and the theory of sports fields. At the same time, the preliminary integration of the levels also preliminarily promotes the application research of high-performance iron-based materials and sintering technology in the field of sports equipment. In the follow-up, corresponding products can be produced and put into daily life

applications. Sports goods produced by applying advanced sports science and technology and materials are also very important in our daily lives. Not only is that, in competitive sports, sports equipment is also the top priority, which can completely affect a person's strength. Nowadays, with the rapid development of sports science and technology, the current sports industry is increasingly dependent on sports science and technology. As an emerging field of science and technology, high-performance iron-based powder metallurgy materials will be used in sports and even other fields in the future. Therefore, this article is based on this, with the topic of the application of high-performance iron-based powder metallurgy materials in the sports industry, theoretically studying the feasibility of this technology, and laying the groundwork for possible future development.

Shui et al. introduced a method of preparing iron-based friction materials directly from vanadium-containing titanium magnetite concentrates using in situ carbothermal reaction and sintering. The influence of Ni content (1-4%, mass fraction, the same below) on the microstructure and the mechanical properties and wear properties of iron-based friction materials were studied. The results show that the sintered sample is composed of iron matrix, graphite lubricating phase, and hard particles (mainly TiC). The former is mainly in the form of reflected electromagnetic wave energy to attenuate electromagnetic radiation, so that the transmitted electromagnetic wave energy is reduced; the latter is mainly in the form of absorption of electromagnetic wave energy to attenuate electromagnetic radiation, so that the electromagnetic wave return reflection energy is reduced. The matrix is mainly composed of layered pearlite with higher strength and higher hardness than ferrite. Compared with the sintered samples without Ni, the structure and performance of iron-based friction materials with different Ni content are improved to different degrees. The low Ni content (1%-2%) promotes the sintering process, exhibiting reduced pores and uniform distribution of lubricating graphite phase and hard particles. In addition, the hardness and wear performance are significantly improved. As the Ni content increases, when the Ni content exceeds 2%, not only the number of pores increases but also the graphite phase and hard particles segregate in the microstructure, resulting in a decrease in material hardness and wear resistance. In summary, when the Ni content is 2%, the structure and performance are the best. But he did not experiment with detailed data on other metals, compared the structure and properties of several different metals, and finally reached a conclusion [1]. Due to low cost, high availability, and high strength, iron-based composite materials have been widely used in many industrial applications such as bearings, camshafts, connecting rods, pulleys, various valves, and oil pump gears in automobiles and other industries. Mahdi and Mahmood aim to prepare Fe-10 vol. % Cu-(0-5) wt. % nano-Y<sub>2</sub>O<sub>3</sub> composite materials through powder metallurgy technology and study its physical and mechanical properties. The powder was mixed in a ball mill for 30 minutes and then uniaxial compacted at a 700 MPa room temperature for 3 minutes. The green sample was sintered at 1000°C for 1 hour. Not only is the absorption intensity greater

(-16.9 dB) but the absorption bandwidth is also wider (4.2 GHz). The results of Mahdi and Mahmood's research show that nanoyttrium oxide has a significant effect on the physical and mechanical properties of Fe-10%Cu composites. As the content of nanooxides increased from 0% to 3%, the bulk density increased by 0.92%, and the true porosity decreased by 6.4%. Mahdi and Mahmood increased Y<sub>2</sub>O<sub>3</sub> to 1%, the Vickers microhardness increased by 5.9% and then gradually decreased when it further increased by more than 1%. As the content of nanooxides increases from 0% to 3%, the wear rate is reduced by 21%. On the other hand, increasing Y<sub>2</sub>O<sub>3</sub> to 5% reduces the compressive strength by 47%. However, his research results do not have specific examples of combining with other industries to support his theoretical research results [2]. Over the years, technological development has had a huge impact on sports performance and has promoted the development of specific materials and manufacturing processes for sports-related products. In this context, Ribeiro et al. used the internal coupling effect of fiber-reinforced plastic (FRP) to design and develop a new snowboard technology using anisotropic layer design. This work involves the technical, economic, and environmental assessment of skis made of three alternative materials, namely, carbon, glass, and flax fiber-reinforced plastics. It shows how life cycle analysis can support product design and development by using innovative technologies to apply life cycle engineering methods to the ski design process. In this case, the material selection and fiber placement angle will have a significant impact on the stiffness of the resulting FRP, so in the three dimensions of the analysis, namely, cost, environment, and technology. Natural fiber is the most environmentally friendly choice, glass fiber is the best economically, and carbon fiber is the best in terms of technical performance. Therefore, Ribeiro et al. consider and weigh the importance attributed to each analysis dimension to allow aggregate analysis of alternatives and make informed decisions. His research is to use plastics for the manufacture of sports equipment and does not use metal to make a comparison to prove the diversity of experimental results [3, 4].

In this paper, metallurgical sintering technology is used to prepare high-performance iron-based powder materials and apply them in the traditional sports industry to produce new sports equipment. The sintering method refers to adding various iron-containing powdery substances to a certain amount of solvent, fuel and water, after stirring, fusion and granulation, it is put into the sintering equipment, so that the material undergoes a series of physical and chemical changes, and finally presents a dense combination.. It can be seen that the impedance matching and attenuation characteristics of absorbing materials are mainly determined by the values of dielectric constant and magnetic permeability of the materials. In addition, the material matrix ratio, material thickness, geometric effect, and other factors also affect the absorbing effect of the absorbing material. In the traditional sports industry, most of the metal and wood materials are used for the production of sports equipment. Such products are not only bulky but also have certain disadvantages in other properties. And the sports equipment made of the

new high-performance iron-based powder material we use has the characteristics of light weight, good quality, and good torsion resistance and can even be used in professional competitions. Through the rapid development of the sports industry in recent years, coupled with the continuous innovation of sports science and technology, various disciplines, industries, and sports are blended with each other, and newer technologies are used in the sports industry.

## 2. Preparation Method of High-Performance Iron-Based Powder Metallurgy Sintered Material

**2.1. Sintering Method.** The sintering method is a traditional handicraft process, that is, a traditional firing process that converts the original powdery raw material into a dense combination. In the early days, people have begun to use the sintering process to produce many things, such as porcelain, powder metallurgy, refractory materials, and high-temperature materials. These products are widely used in our daily lives. Under the general production situation, after the powdery object is formed, a polycrystalline material can be obtained after a sintering method, which is a dense combination. It can increase the loss of electromagnetic waves inside the material and thus improve the wave absorption performance of the material, which provides a guiding direction for designing the composition and structure of wave-absorbing composites. Under microscope observation, it can be seen that its structure includes pores and crystals. [5]. The sintering process may affect the properties of the original material, because it will affect the size of the pores of the object, the size of the crystalline particles, and the distribution and shape of the grain boundaries. The specific process of the sintering method is shown in Figure 1.

Since the particle size is related to the sintering temperature and the holding time of the peak temperature, SEM is used to observe the microstructure of sintered silver under different process conditions, and the particle size is counted according to the linear interpolation method [6]. With the increase of sintering current or energization time, the size of silver particles after sintering increases significantly. The effect of different cladding layer thicknesses on the magnetic properties was investigated by varying the experimental cladding silicon oxide process with the help of a silane coupling agent for the activation of iron-nickel alloys of micron size. It was found that the saturation magnetization strength of the material decreased with increasing the cladding layer thickness, while the effect on the coercivity was not significant. Since grain growth is caused by grain boundary migration, the grain boundary migration rate can be expressed by the following formula:

$$V_a = M_a \times F_a. \quad (1)$$

Among them,  $M_a$  represents the mobility of the grain boundary;  $F_a$  represents the driving force. And the relationship between  $M_a$  and temperature can be expressed by the

following formula:

$$M_a = \frac{(D_a * \omega)}{(K * T * W_a)}. \quad (2)$$

Among them,  $D_a$  is the diffusivity of the grain boundary;  $W_a$  is the boundary width;  $\omega$  is the atomic volume;  $K$  is the Boltzmann constant;  $T$  is the absolute temperature [7]. The driving force  $F_a$  can be expressed as follows:

$$F_a = A \times \frac{\sigma_a}{D_g}. \quad (3)$$

Among them,  $\sigma_a$  is the surface energy;  $D_g$  is the average particle size. Grain boundary diffusion can lead to grain growth, as described in the above formula. Therefore, the grain boundary migration rate is proportional to the grain growth rate, that is,  $dD_g/dt$ .

$$\frac{dD_g}{dt} = \frac{A \times \sigma_a \times D_a \times \omega}{(K \times T \times W_a \times D_g)}. \quad (4)$$

After formula integration, you can get

$$D_g^2 - D_{g0}^2 = k \times t. \quad (5)$$

Among them,  $D_{g0}$  is the grain size when  $t$  is equal to zero? Therefore, we can conclude that when the energization time is extended or the sintering current is increased, the migration rate of the grain boundary will increase, resulting in an increase in the grain size. Especially when the electrification time is 180 s, it can be found that the silver particles have obvious coarsening [8].

Although the current sintering peak temperature is high, the very short sintering time inhibits the growth of sintered silver particles. Formulated by haulage:

$$\sigma = \sigma_0 + kd^{-a}. \quad (6)$$

Among them,  $\sigma$  is the shear strength;  $\sigma_0$  and  $k$  are constants independent of size;  $d$  is usually between 0.5 and 1.

The Heywang-Jonker model proposes that the barrier height ( $\phi$ ) and acceptor state density ( $N_s$ ) of the sample can be estimated from the resistance temperature  $R-t$  curve. According to semiconductor theory, the relationship between barrier height ( $\phi$ ) and grain boundary resistance:

$$\rho = \rho_0 \exp\left(\frac{e\phi}{kT}\right). \quad (7)$$

Among them,  $\rho_0$  is a constant,  $e$  refers to the basic charge,  $T$  is the Kelvin temperature, and  $k$  is the Boltzmann constant [9]. When the sample temperature is lower than the Curie temperature  $T_C$ , the potential barrier is offset by the spontaneously polarized electrons of the ferroelectric phase. When the temperature rises above the

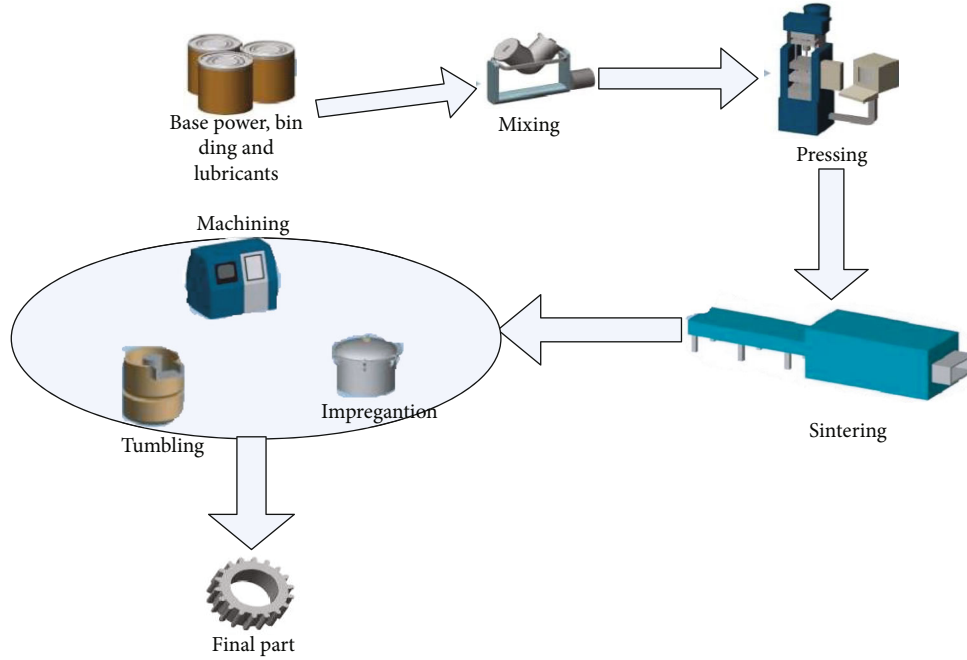


FIGURE 1: Preparation process of sintering method.

Curie temperature  $T_C$ ,

$$\varphi = \frac{eN_S^2}{8\varepsilon_0\varepsilon_r N_d}. \quad (8)$$

$N_S$  is the acceptor state density,  $N_d$  is the donor doping concentration,  $\varepsilon_r$  is the relative permittivity, and  $\varepsilon_0$  is the vacuum permittivity. By (7) and (8), the resistance  $\rho$  can be expressed as

$$\rho = \rho_0 \exp\left(\frac{eN_S^2}{8\varepsilon_0\varepsilon_r N_d kT}\right). \quad (9)$$

**2.2. Powder Metallurgy Methods.** Powder metallurgy is a traditional process that uses metal powder or a mixture of metal powder and nonmetal powder as raw materials for smelting and uses technical means such as sintering and forming to finally produce metal materials, composite materials, and various other types of products. Mean is as shown in Figure 2. Powder metallurgy is a kind of powder sintering technology; ceramic firing in daily life also belongs to this technology, so most of the powder metallurgy methods or techniques can also be applied to the production of ceramic materials. The powder metallurgy method has many advantages and benefits. However, in high-frequency field applications, on the one hand, due to the skinning effect of soft magnetic alloy materials, the electric field is mainly concentrated on the surface of the material, which can create uncontrollable hazards. It can solve the problem of the urgent need to develop new materials to replace the original materials. Soft magnetic metal nanoparticles have gained wide interest in applications such as catalysts, biosensors, clinical medicine, super-

capacitors, water treatment, and microwave absorbing materials due to their potential properties. It will play a very important role in future life [10].

The Archimedes drainage method is used to detect the density  $\rho$  of each sample, and the surface is treated with wax to improve the accuracy of the test. Use BSM-200.4 electronic analytical balance to measure the quality [11]. Calculate the sample density according to formula ((10), where  $m_1$  is the mass of the sample in air (g),  $m_2$  is the mass (g) after sealing wax,  $m_3$  is the suspended mass in water (g), and  $\rho_w$  is the density of water ( $\text{g}/\text{cm}^3$ ).  $\rho_{\text{wax}}$  is the density of paraffin wax ( $\text{g}/\text{cm}^3$ ).

$$\rho = \frac{m_1}{m_2 - m_3/\rho_w - m_1/\rho_{\text{wax}}}. \quad (10)$$

The porosity of the sintered matrix is the key parameter of the infiltration amount in the subsequent copper infiltration process. After the density of the sintered matrix is measured, the matrix porosity  $\varepsilon$  can be calculated according to formula (11) [12].  $\rho_0$  is the theoretical density of the sintered matrix ( $\text{g}/\text{cm}^3$ ), and  $\rho$  is the measured density of the sintered matrix ( $\text{g}/\text{cm}^3$ ).

$$\varepsilon = \left(1 - \frac{\rho}{\rho_0}\right) \times 100\%. \quad (11)$$

The material composition of the working layer and the nonworking layer of the bimetal valve seat ring is different, and the thermal expansion coefficient is different. Therefore, the radial shrinkage rate  $k$  of the two layers of materials needs to be tested before and after copper infiltration [13]. A screw micrometer (accuracy: 0.01 mm) is used to measure

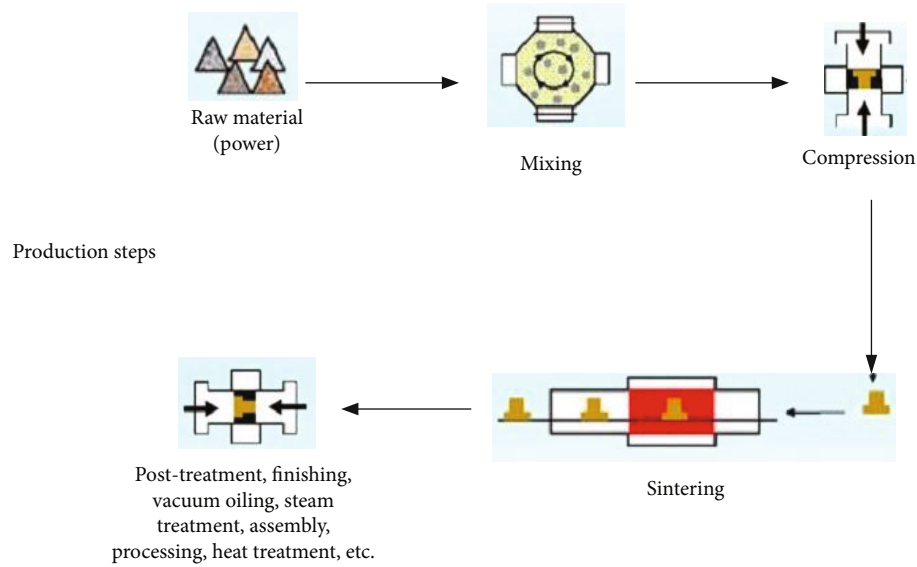


FIGURE 2: Detailed production steps of powder metallurgy method.

the size of the sample before and after the copper infiltration and calculated according to formula (12),  $d_1$  is the diameter before copper infiltration (mm), and  $d_2$  is the diameter after copper infiltration (mm).

$$k = \left( \frac{d_2 - d_1}{d_1} \right) \times 100\%. \quad (12)$$

The strength of ring-shaped powder metallurgy parts is often tested by crushing test. The ring-shaped sample is subjected to radial load until it is crushed to obtain the maximum load  $F$ , and the crushing strength is calculated by formula (13). Among them,  $F$  is the maximum load ( $N$ ),  $D_1$  is the outer diameter of the ring (cm),  $h$  is the height of the ring (cm), and  $e$  is the thickness of the ring (cm).

$$K = \frac{F(D_1 - h)}{eh^2}. \quad (13)$$

In order to detect the interface bonding strength of the two layers of the bimetal seat ring, a tensile strength test is required [14]. Calculate the tensile strength according to formula (14).  $F_b$  is the maximum load ( $N$ ) that the sample bears when it is broken, and  $S_0$  is the original cross-sectional area of the sample (mm).

$$\sigma = \frac{F_b}{S_0}. \quad (14)$$

Collision theory collision-contact reaction is a necessary condition for the reaction between molecules. The higher the concentration of the substance participating in the chemical reaction is the greater the probability of collision, and the faster the chemical reaction. Therefore,

there are

$$v = kC_A C_B. \quad (15)$$

Pulverization and products are two items included in powder metallurgy technology. Pulverizing is mainly a metallurgical process, that is, its literal meaning; while products are through metallurgical processes, and finally, products are obtained [15]. The powder products in our daily life are often beyond the scope of ordinary metallurgy and materials. Usually, they are combined with multiple disciplines of technology, which may include machinery, mechanics, materials, and environment, and are multiple disciplines. Especially in this era, 3D printing technology is very developed, and current metallurgical technology often includes CAD, mechanical engineering, control engineering, materials science, and computer technology, which makes metallurgical technology a very demanding and professional knowledge. Powder metallurgy technology is now very common and widely used in factories, as shown in Figure 3 for the powder metallurgy process.

**2.3. Sports Industry.** The sports industry is a whole industry that integrates the provision of sports products for the society, the organization of sports activities, and the economic sector that includes sports. The sports industry is a very important sector in our country and an indispensable part of the national economy. Like other industries, the sports industry focuses on market performance and economic benefits. But at the same time, it also has its own unique characteristics different from other industries [16]. For example, the important function of their products is to enhance the physical quality of the people, promote the development of social production, promote the national spirit, and ultimately realize the overall development of individuals and the overall progress of social culture. In a broad sense, the

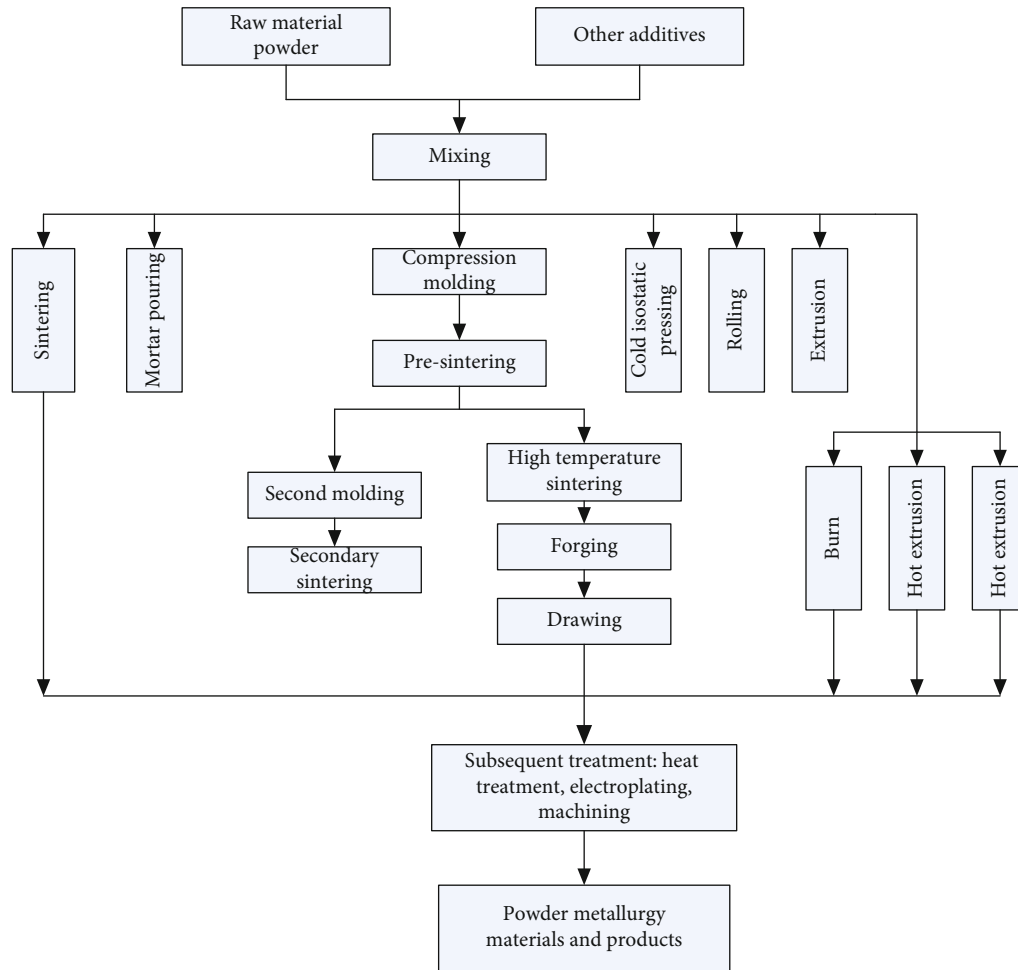


FIGURE 3: Brief introduction diagram of powder metallurgy process.

sports industry includes all business activities related to sports, including the production and management of sports equipment products and sports service products; in a narrow sense, sports products refer to the “sports service industry” or “energy Some sports companies that enter the market but are also profitable” [17]. The industrial chain of the sports industry is the lifeblood of it. It is the general idea of all sports and its derivative industries. All sports industries are developed around it. The sports industry chain is shown in Figure 4.

### 3. Experiments of Metallurgical Materials in the Sports Industry

**3.1. Hardware Design.** This experiment is to apply high-performance iron-based powder through sintering technology and finally successfully prepare the material for application in the sports industry. In the experiment, the current sintering technology was used to realize the connection process between the IGBT chip and the silver-plated copper substrate and the DBC substrate [18]. Therefore, 99.95% of the copper purchased in this paper is cut into a substrate with a size of  $22\text{ mm} \times 15\text{ mm} \times 1.5\text{ mm}$  according to the size of the matching chip. In order to avoid the oxidation problem of the bare cop-

per substrate during the sintering process, the cut copper is electroplated, and  $5\text{ }\mu\text{m}$  silver is plated in each direction [19]. As shown in Figures 2 and 3, the processed silver-plated copper and DBC substrate and the IGBT chip are used in the experiment, the IGBT chip size is  $6.5\text{ mm} \times 4.87\text{ mm} \times 0.12\text{ mm}$ . The IGBT chip and the DBC substrate are quickly sintered and connected by an integrated device to realize the connection between the IGBT chip and the substrate. Among them, the power supply adopts AC-DC-AC-DC conversion technology (IGBT inverter technology), microcomputer control technology, and modern power electronic technology; the time control can reach millisecond precision; and the control response and control accuracy are greatly improved. Due to the use of DC output, its manufacturability is significantly improved [20]. Sintering is one of the most critical parts. The process flow chart of the sintering system is shown in Figure 5. It can process powdered metal or nonmetal materials through specific methods such as firing and finally successfully obtain a dense combination and successfully applied to sports equipment [21].

**3.2. Software Design.** This experiment also carried out corresponding data collection, data analysis, data processing, and summary work on the computer system, combined with

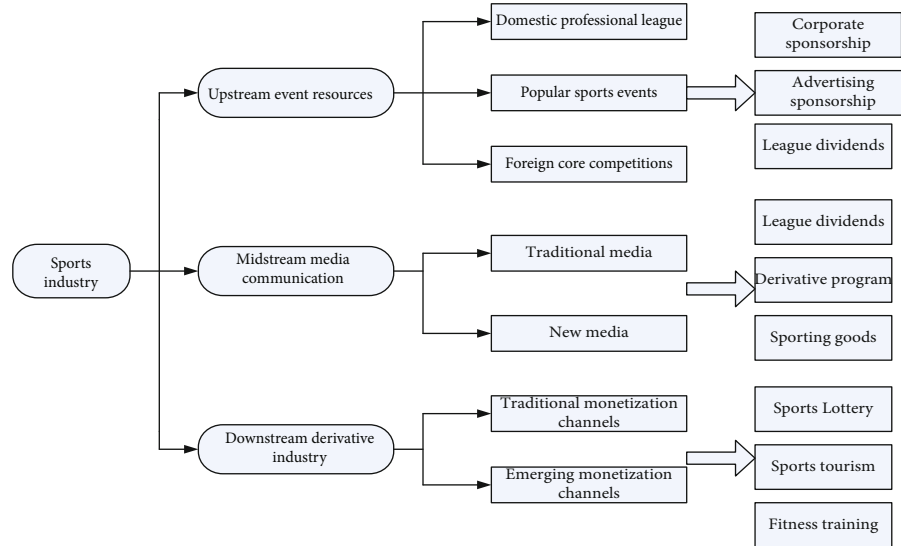


FIGURE 4: Overall block diagram of the sports industry chain.

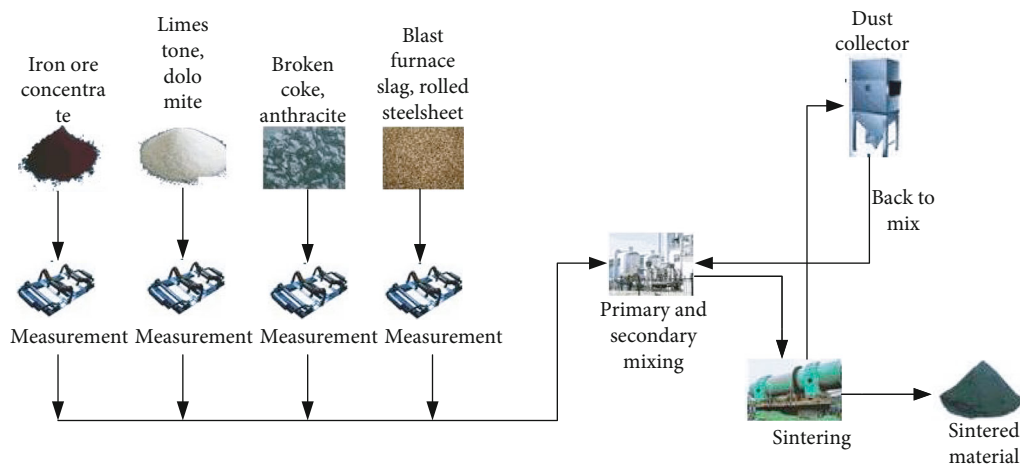


FIGURE 5: Schematic diagram of the process flow of the sintering system.

computer technology, communication technology, network technology, etc., and finally successfully prepared a high-performance iron-based metallurgy that meets the requirements [22, 23]. The transient thermal resistance value of the connection sample between the IGBT chip and the substrate is used to characterize the thermal performance of the sintered silver joint. Transient thermal resistance is characterized by a transient thermal resistance test system independently developed by our laboratory. This system includes a test circuit board that drives and controls IGBT chips, an oscilloscope (TektronixDPO4104B) for real-time monitoring of IGBT output waveforms, and a test circuit for IGBT chips. Collector-emitter programmable DC power supply (RIGOLDP1116A) with heating current, high-efficiency water-cooled heat sink, PVC still air box to avoid the influence of air disturbance on the test results, integrated test control, data acquisition, and data processing software pack-

age and computer carrier [twenty three]. In order to verify the feasibility of the nanosilver connection sample between the IGBT chip and the substrate obtained by the current-assisted sintering method, this paper uses a double-pulse test device for electrical switching characteristics to characterize the electrical switching performance of the IGBT postwelded sample connected with the nanosilver solder paste, as shown in Figure 6 below.

**3.3. Overall Design.** This article is in the traditional sports industry, in the field of sports equipment and sports equipment, the use of high-performance iron-based powder metallurgy materials through traditional sintering technology, and finally a composite polymer material [24]. Up to now, most of the sports, fitness, and entertainment equipment we use in our daily life are designed and manufactured by metal materials or wood, but the physical characteristics of

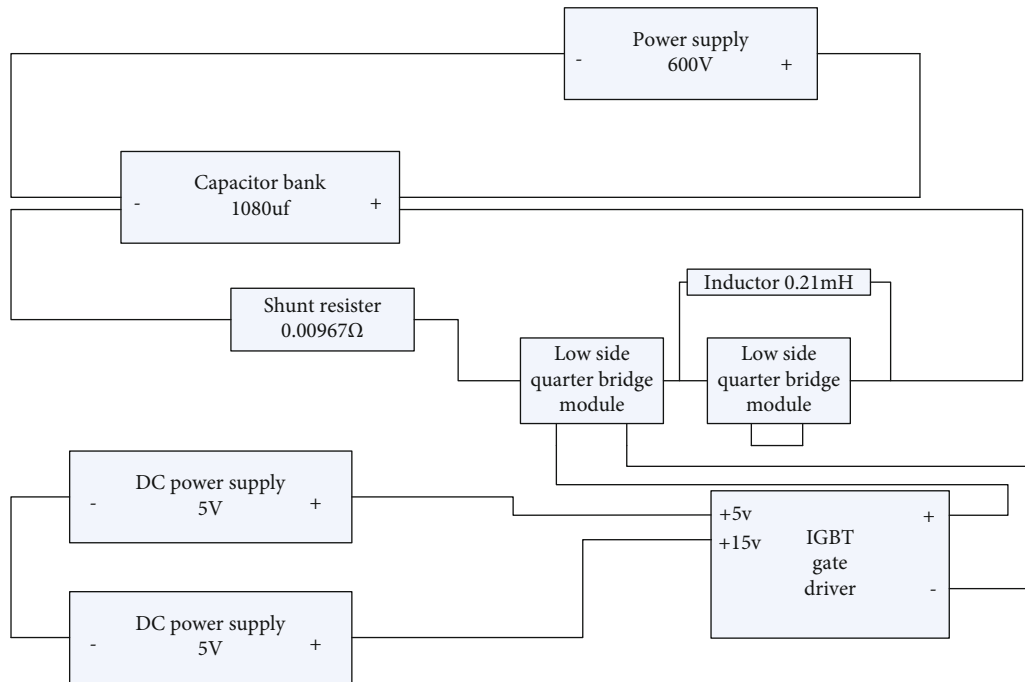


FIGURE 6: Circuit diagram of the double pulse test device.

these materials themselves have led to the strength of the manufactured appliances. With the continuous advancement of science and technology and the continuous successful research and development of various new materials, various new materials have also been widely used in the production of various sports equipment, even in some sports competitions [25]. According to the excellent properties of various new materials, such as high strength, special measurement, light weight, good wear resistance, strong damping performance, and strong design, various materials are widely used in the production of sports equipment.

#### 4. Data Analysis and Discussion Based on Experiments

*4.1. Data Analysis Based on Sintering Technology.* With the progress of the times and the continuous discovery and utilization of various new materials, and the continuous development of various manmade materials in daily life, the scope of cemented carbide continues to develop and expand. And the performance requirements of cemented carbide are constantly improving. In the 1990s, the research and preparation of cemented carbide with extremely small nanostructured carbides became a huge hot spot. After many inspections, people found that without changing the binder phase content, when the grain size of tungsten carbide is less than  $1\ \mu\text{m}$ , the hardness and strength of the cemented carbide can be significantly improved. And the growth rate has also declined. This leads to a significant reduction in grain size, especially the carboxyl groups of nanocrystalline cement. Hardness and durability will evolve a lot. The German Dust Metallurgical Company has established a grading

standard for cemented carbide according to the particle size, as shown in Table 1.

The specific production stages of sintering technology: (1) low-temperature presintering stage. At this stage, it is necessary to produce metal or nonmetal recovery and absorb gas and volatilize water and then carry out the exclusion and decomposition of the embossing; (2) at this stage, there will be a chemical phenomenon called recrystallization. The deformed crystals in the particles will recover and produce a new type of crystal. At the same time, oxides on the surface will be reduced and sintering will be formed at the interface is the completion stage of high-temperature insulation. At this stage, a large number of closed pores will be formed, and at the same time, the full flow and diffusion of the gas will be completed, so that the size and number of small pores will decrease, but the density of the entire sintered body will be greatly increased. The specific situation is shown in Figure 7.

The stacking fault energies of some metals and alloys are shown in Table 2. Through detailed data, it is found that iron is a typical face-centered cubic crystal structure with low stacking fault energy. During the fusion process, the nanoiron grains follow the grain boundary moves and develop, so the nanoiron paste has the matching conditions during the fusion process. Many twins were found in the joint made of silver nanoiron alloy. The nanoiron glue was continuously irradiated with an electron beam at about  $200^\circ\text{C}$ . According to TEM observation, a large number of twins were formed at the edges of the iron particles. However, the number of twins will decrease over time until they disappear completely.

The conversion rate between different metals is different. In this experiment, we used several metals and alloys, such



TABLE 1: Cemented carbide grain size classification standards of the society of powder metallurgy.

Alloy grain size	Nanocrystalline	Ultrafine crystal	Submicrocrystalline	Fine grain	Medium crystal	Coarse crystal	Extra coarse crystal
WC grain size ( $\mu m$ )	<0.2	0.2 ~ 0.5	0.5 ~ 0.8	0.8 ~ 1.3	1.3 ~ 2.5	2.5 ~ 6.0	>6.0

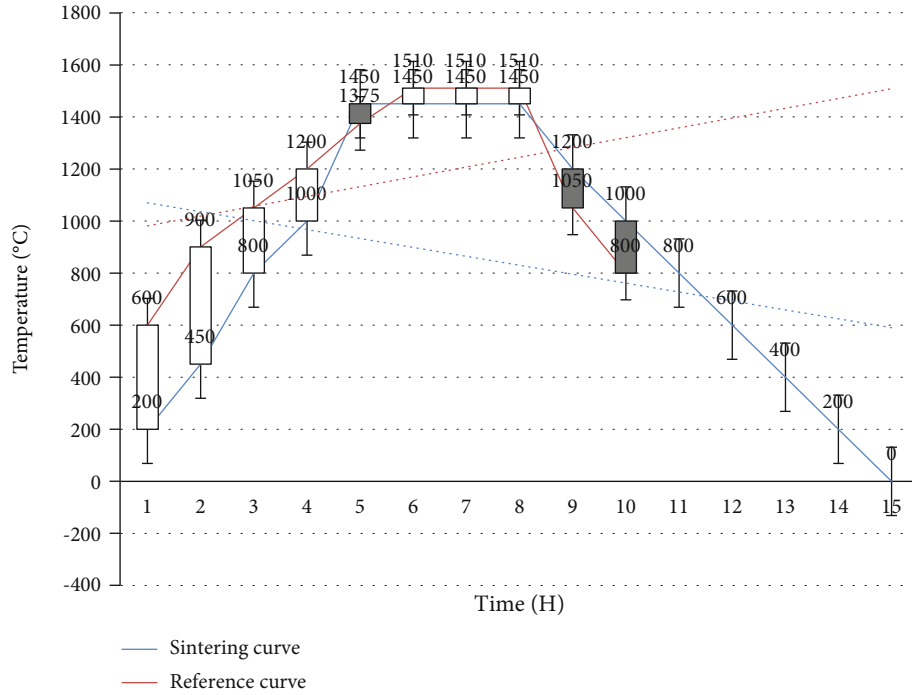


FIGURE 7: Reference curve of sintering process.

TABLE 2: Stacking fault energy values of some metals and alloys.

Material	Ni	Al	Fe	Cu	Au	Ag	Stainless steel
Stacking fault energy (mj)	400	200	18	70	60	20	15
Stacking fault energy (mj)	400	200	18	70	60	20	15

as gold, silver, copper, iron, and stainless steel. The conversion rates between them are high and low. In the experiment, we are studying high-performance iron-based metallurgical materials, so we value the conversion rate of iron or the conversion rate of iron-containing alloys. The conversion rates of different metals at different temperatures are shown in Figure 8.

Preliminary study on the preheating time of fusion pressure the preheating temperature, sintering current, and excitation time basically determine the range of parameters to be discussed in the fusion process. On this basis, the mechanical and thermal properties of the interface between the IGBT chip and the substrate are mainly investigated. The microstructure of the gold-plated copper

rods with different fusion current activation time preheating temperature and different preheating time is shown in Table 3 to ensure the reliability of the experimental data. At least 5 samples are repeated for each group of experiments, and finally, the average value of each group of experimental data is taken as the final result.

In the traditional sports industry, most of the materials used are heavy, wear-resistant, and cheap, such as iron, aluminum, wood, and other materials. The sports equipment made in this way is very heavy, and resistant to torsion, the performance such as hitting feedback is not very good, but the price is cheap, so many people may discard it after using it once, which also causes a certain degree of pollution. However, in this research, we used the new technology to produce high-performance iron-based metallurgical materials. This material is used in the production of sports equipment, making the new sports equipment light in weight, wear-resistant, and resistant to torsion. And many other features, and when damaged, we can also recycle the secondary production. After in-depth research on the application scenarios of high-performance iron-based materials, I calculated the expected improvement ( $p$ ) of this material in the field of sports equipment for other projects, as shown in Table 4, that is, under

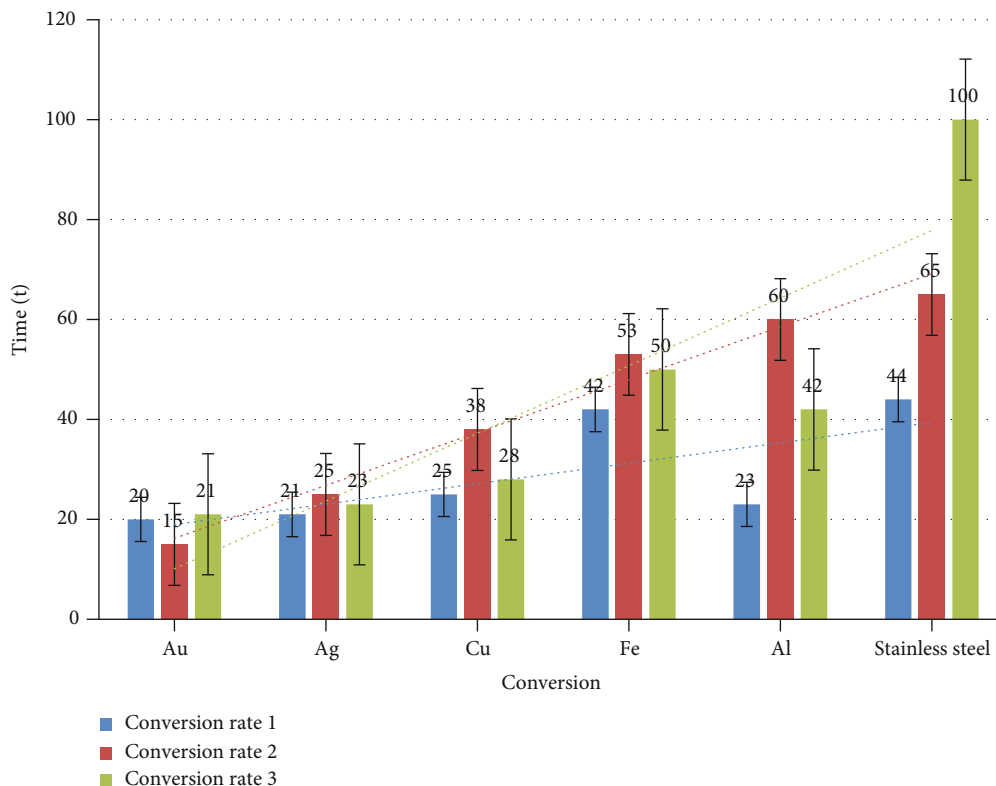


FIGURE 8: Comparison of conversion rates of different metals.

TABLE 3: Summary table of sintering process experiment.

Condition no.	Current (kA)	Current-on time (s)	Predrying temperature (°C)	Predrying time (min)
1	1.2	150	90	20
2	1.6	150	90	20
3	2.0	150	90	20
4	2.4	150	90	20
5	2.0	90	90	20
6	2.0	120	90	20
7	2.0	180	90	20
8	2.0	150	60	20
9	2.0	150	120	0
10	2.0	150	150	10

theoretical conditions, calculate the sports performance of using high-performance iron-based materials in the direction of improving the performance of a certain aspect based on previous data, and compare them with the sports performance of sports equipment using existing composite materials, expressed as a percentage. A theoretical expected value is called the expected lift.

The sports industry is a very important sector in our country and an indispensable part of the national economy. Like other industries, the sports industry focuses on market performance and economic benefits. But at the same time, it

also has its own unique characteristics different from other industries. For example, the important function of their products is to enhance the physical quality of the people, promote the development of social production, promote the national spirit, and ultimately realize the overall development of individuals and the overall progress of social culture. With the daily needs of people for sports, sports are not only for physical health. With the rapid development and improvement of sports and related industries, sports have also become a consumer product for people's daily leisure and entertainment. Sports investment and financing have become more and more frequent with the improvement of the sports industry. Figure 9 shows the actual situation of my country's sports industry investment and financing in the past five years.

The sports industry is a very promising industry, and damage to sports and fitness equipment in our daily lives is also a very important aspect. As shown in Table 5, according to estimates, in 2019 alone, the total output value of the national sports industry was 2,948.3 billion yuan, a very significant increase compared to 2018. The construction of daily sports facilities reached more than 20 billion yuan, and the current price increased by 41.7%, accounting for 1.9% of the added value. According to data, from 2016 to 2020, the output value and added value of my country's sports industry are increasing year by year, and many new brands and emerging sports are produced in my country every year. The specific data is shown in Figure 10.

TABLE 4: Comparison of high-performance iron-based materials and traditional alloys.

Sports	Sports equipment	Expected lift
Single parallel bars	High-performance iron-based materials	52.3%
Single parallel bars	Traditional alloy	51.3
Dumbbells	High-performance iron-based materials	17.7%
Dumbbells	Traditional alloy	17.3%
Shot put	High-performance iron-based materials	28.0%
Shot put	Traditional alloy	27.4%

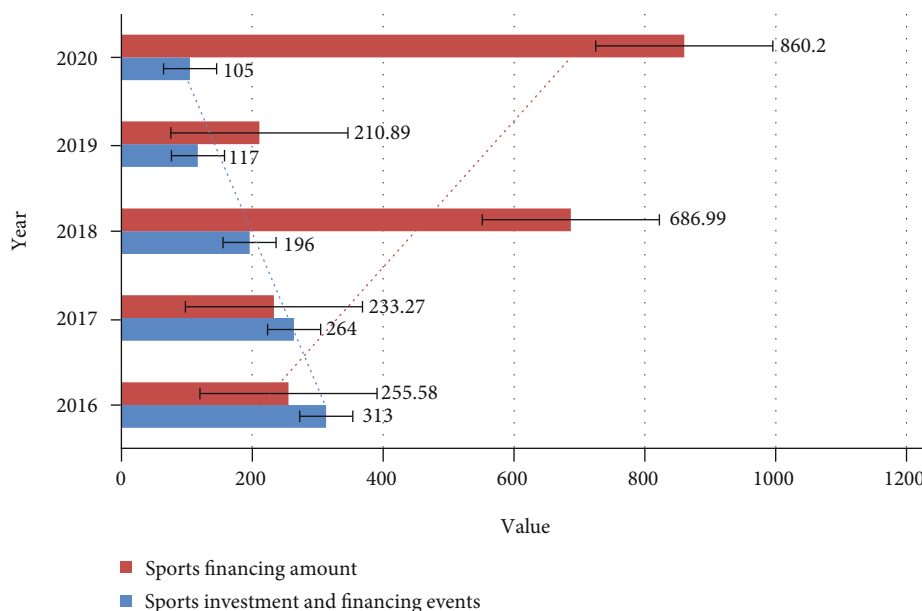


FIGURE 9: China's sports investment and financing events and financing amount from 2016 to 2020.

TABLE 5: 2019 national sports industry status.

Category name	Total (100 million yuan)		Structure (%)	
	Total output	Value added	Total output	Value added
Sports industry	29483.4	11248.1	100.0	100.0
Sports service industry	14929.5	7615.1	50.6	67.7
Sports goods and related products manufacturing	13614.1	3421.0	46.2	30.4
Sports facilities construction	939.8	211.9	3.2	1.9

4.2. Discussion. Sintering technology is a traditional handicraft process, that is, a traditional firing process that converts the original powdery raw material into a dense combination. This article uses sintering metallurgy to produce high-performance iron-based powder materials and then applies them to the sports industry. Its ferrite grains are very small and can only be embedded in amorphous carbon, which makes the ferrite not play the role of lower coercivity. These are two unrelated industries, but through the rapid development of the sports industry in recent years, coupled with the continuous innovation of sports science and technology the integration of various disciplines, industries, and sports

make this topic very meaningful for research. For different applications, it is necessary to choose different substances to be compounded with FeNi alloy to meet the application requirements. In the early days, people have already begun to use the sintering process to produce many things, such as porcelain, powder metallurgy, refractory materials, and high-temperature materials. These products are widely used in our daily lives and widely used in our daily lives. In this experiment, we applied this method to produce a new type of material for sports equipment, which can enable the industry to produce new sports equipment with good quality and strong functionality for use in our daily lives, and

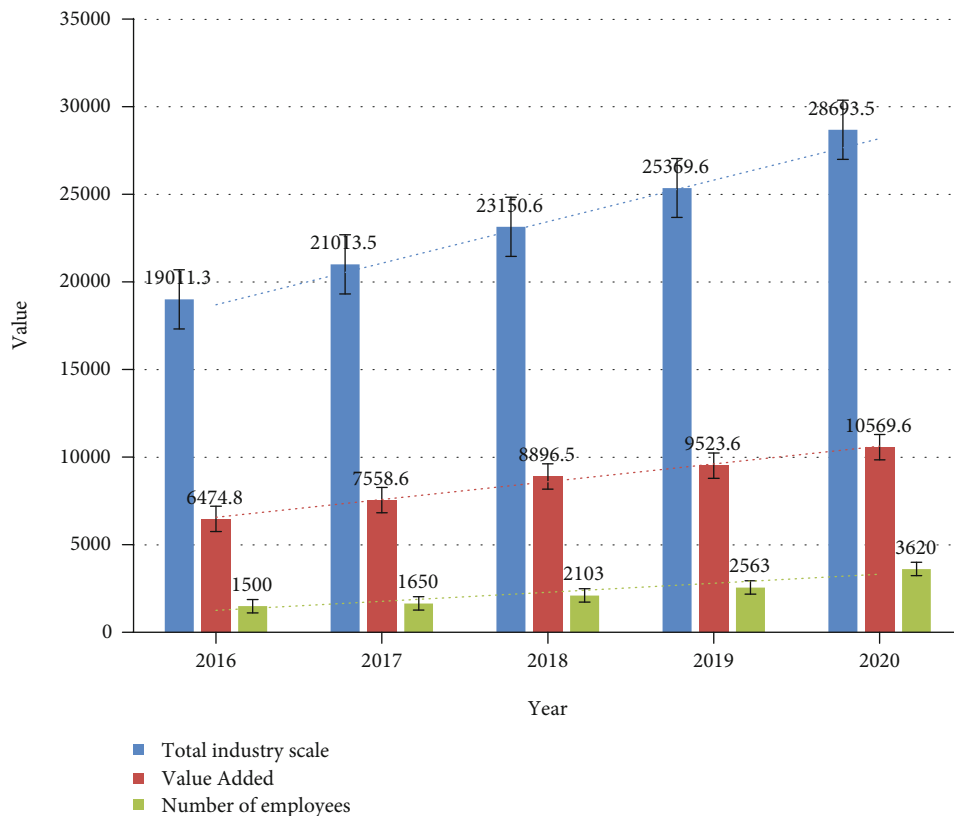


FIGURE 10: Statistics on the scale and increase of China's sports industry from 2016 to 2020.

possibly used in sports equipment. In professional competitions, according to recent trends, this situation is very possible.

## 5. Conclusions

This article is based on the traditional sports industry, using the sintering method to produce high-performance iron-based powder metallurgy materials, which are used in the development of related sports equipment in the current sports industry. The sintering metallurgical method is a very traditional method, which has been widely used in daily life by our working people since ancient times. Since the beginning of the 21st century, various emerging industries have developed vigorously. As one of the pillars of our country, the sports industry has also begun to develop rapidly. At this stage, it continues to integrate with all walks of life to develop new sports science and technology. Traditional sports equipment basically uses materials such as metal or wood, which are not only cumbersome but also of low quality. In this era of rapid development, they are on the verge of being eliminated. Based on this, we want to design and develop a new type of material for the production of sports equipment, using traditional technology and the current rapid development of the industry. Although our research is still in the theoretical stage, as long as we develop it and realize it, it is believed that it will be widely used in the sports industry for a long time in the future.

## Data Availability

No data were used to support this study.

## Conflicts of Interest

There are no potential competing interests in our paper.

## Authors' Contributions

The author has seen the manuscript and approved to submit to your journal.

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