# Brief Analysis of The Development Problems and Future Trends of The "Asphalt-Based" Carbon Fiber Industry

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**Abstract:** This article deeply analyzes the asphalt-based carbon fiber industry, covering technology, problems and market trends. On the technical level, it discusses the characteristics of raw materials and key points of spinning, stabilization, carbonization and other processes. The industry development faces problems such as high cost, difficult quality control and fierce market competition. This material is widely used in aerospace, automobile, sports and other fields, and the market demand continues to grow. In the future, technological innovation, cost reduction and market expansion will be the key, emphasizing cooperation to promote the development of the industry.

**Keywords:** Asphalt-Based Carbon Fiber; Technical Process; Development Challenges; Market Trends

## 1. Introduction

Carbon fiber, a representative of high-performance fiber materials, has made great achievements in aerospace, automobile manufacturing, sports equipment and other fields with its high strength, high modulus, low density and excellent high temperature resistance. Among them, asphalt-based carbon fiber, as an important member of the carbon fiber family, has gradually become a hot spot in industry research with its unique performance advantages and wide application potential. However, on the development path of the asphalt-based carbon fiber industry, there are also many challenges and problems, such as raw material costs, production processes, market applications and other bottlenecks that need to be broken through. Therefore, an in-depth analysis and research on the development status and future trends of the asphalt-based carbon fiber industry is not only related to the sustainable and healthy development of the industry, but will also provide strong support for promoting the upgrading of related industries and scientific and technological progress.

## 2. Technical Overview of Asphalt-based Carbon Fibers

### *2.1 Raw Materials*

The raw materials of asphalt-based carbon fibers are mainly petroleum asphalt or coal tar asphalt. Petroleum asphalt has a wide range of sources and relatively low cost, but may require further processing in terms of performance. Coal tar asphalt contains more aromatic compounds, which is conducive to the formation of high-quality carbon fibers, but the source is relatively limited and the processing process is complicated. Asphalt from different sources has differences in composition. For example, the proportion of saturated components, aromatic components, colloids and asphaltene in petroleum asphalt is different from that in coal tar asphalt.

### *2.2 Production Process*

#### *2.2.1 Spinning Process*

The main spinning methods of asphalt-based carbon fibers are melting spinning and solution spinning. Melt spinning is to heat the asphalt to a molten state and then extrude it through a spinneret to form fibers. This method is simple in process, but has high requirements for the fluidity and stability of the asphalt. Solution spinning is to dissolve the asphalt in an appropriate solvent to make a spinning solution, and then spin it. Solution spinning can better control the diameter and performance of the fiber, but the cost of solvent recovery is high.

#### *2.2.2 Carbonization Treatment*

Carbonization, key in asphalt-based carbon fiber production, involves high-temp heating under inert atmosphere to remove non-carbon elements, boosting carbon content and crystallinity. At 1000-2000°C, it enhances mechanical properties. Optimal at ~1500°C, balancing strength (2-3GPa) and toughness (200-300GPa), without surface defects. This ensures high-performance carbon fiber.

## 3. Problems in the Development of the Asphalt-Based Carbon Fiber Industry

### *3.1 Cost Issues*

#### *3.1.1 Raw Material Costs*

The cost of raw materials for asphalt-based carbon fibers is mainly reflected in two aspects. First, coal tar pitch, as an ideal raw material for high-quality carbon fibers, is restricted by the coal processing industry. The uneven geographical distribution of coal resources and the fluctuations in processing scale directly lead to frequent price fluctuations in coal tar pitch, increasing the uncertainty and cost risks of raw material procurement. Secondly, although petroleum asphalt has a relatively wide source, it needs to go through a cumbersome and costly refining process to meet the high standards of carbon fiber production. This link not only increases the direct cost of raw materials, but also increases the production cycle and complexity, further pushing up the overall cost. In the current market environment, the cost of raw materials for high-quality asphalt-based carbon fibers has accounted for 30% to 40% of the total cost, becoming one of the key factors restricting the development of the industry.

#### *3.1.2 Production Process Costs*

The high cost of production processes is also a major challenge facing the production of asphalt-based carbon fibers. In the solution spinning process, the construction and operation of the solvent recovery system requires huge investment and high maintenance costs, which places strict requirements on the financial strength and technical level of the enterprise. During the carbonization process, the high energy consumption of high-temperature equipment and the continuous use and replenishment of inert gas constitute a major burden in the production cost. According to statistics, the production process cost has accounted for 50% to 60% of the total cost, of which energy costs account for 30% to 40% of the production process cost. This high production cost not only compresses the profit margin of enterprises, but also limits the expansion of production scale and the improvement of market competitiveness. It is an important problem that the industry needs to solve urgently.

### *3.2 Quality Control Issues*

#### *3.2.1 Fluctuation of Raw Material Quality*

The quality of asphalt is greatly affected by the source of raw materials and production process. Different batches of petroleum asphalt or coal tar asphalt may have significant differences in composition and performance, which brings difficulties to process control in the carbon fiber production process and easily leads to unstable performance of the final product. For example, changes in the impurity content in asphalt may affect the continuity of spinning and the quality of the fiber.

#### *3.2.2 Difficulty in Quality Control During the Production Process*

In the production links such as spinning, stabilization and carbonization, the parameter control of each link has a vital impact on the quality of carbon fiber. Due to the complexity of the process, slight parameter deviations may cause problems such as internal structural defects and uneven performance of the fiber. For example, uneven temperature during the stabilization process may lead to excessive or insufficient local oxidation of the fiber, affecting the strength and modulus of the carbon fiber.

## 4. Application Fields and Market Demand of Asphalt-Based Carbon Fiber

### *4.1 Aerospace Field*

#### *4.1.1 Application Situation*

In the aerospace field, asphalt-based carbon fiber has unique application value due to its high modulus and good thermal stability. It can be used to manufacture structural components of aircraft, such as wings, fuselage frames, etc., which can reduce the weight of the structure and improve the performance of the aircraft. For example, in some satellite structures, the use of asphalt-based carbon fiber composites can reduce the weight by 20%-30%, while improving the stiffness and thermal stability of the structure.

#### *4.1.2 Market Demand Trend*

With the continuous development of aerospace technology, the demand for high-performance materials continues to increase. In the future, with the research and development and production of a new generation of aircraft, the demand for asphalt-based carbon fiber is expected to grow at an annual rate of 10%-15%. Especially in the field of hypersonic aircraft, which has extremely high requirements for material performance, asphalt-based carbon fiber has broad application prospects.

### *4.2 Automobile Industry Field*

#### *4.2.1 Application Situation*

In the automobile industry, asphalt-based carbon fiber can be used to manufacture automobile parts, such as body frames, engine hoods, etc. Its high strength and low density characteristics help to achieve lightweight vehicles and improve fuel efficiency. At present, some high-end automobile brands have begun to try to use asphalt-based carbon fiber composites to replace traditional metal materials. For example, BMW uses a small amount of asphalt-based carbon fiber in the body structure of some of its models, which reduces the weight of the vehicle by 10%-15%.

#### *4.2.2 Market Demand Trend*

With the increasing global requirements for automobile energy conservation and emission reduction, automobile lightweighting has become a development trend. The application of asphalt-based carbon fiber in the automotive industry is expected to be further expanded. It is expected that in the next 5 years, the demand for asphalt-based carbon fiber in the automotive industry will increase by 20%-30% per year.

## 5. Future Trends in the Asphalt-Based Carbon Fiber Industry

### *5.1 Technological Innovation Trends*

#### *5.1.1 Raw Material Modification Technology*

In the future, researchers will focus on developing more efficient asphalt modification technology to improve the performance and quality stability of raw materials. For example, by adding specific additives or adopting new pretreatment methods, the spinnability and carbonization properties of asphalt can be improved, and the impact of raw material quality fluctuations on carbon fiber production can be reduced.

#### *5.1.2 Production Process Optimization*

In terms of production technology, the spinning, stabilization and carbonization processes will be continuously optimized. For example, developing new spinning equipment and processes to improve spinning efficiency and fiber quality; improving temperature control and atmosphere adjustment technology during stabilization and carbonization to reduce quality defects in the production process. Through process optimization, it is expected that the strength and modulus of carbon fiber will be further increased by 10% - 20%.

### *5.2 Cost reduction Trend*

In the asphalt-based carbon fiber industry, economies of scale are the key driving force for reducing production costs and enhancing market competitiveness. With the gradual expansion of the production scale of enterprises, a series of cost optimization effects have begun to emerge. Large-scale procurement of raw materials can not only enhance bargaining power with suppliers, thereby reducing the procurement cost of raw materials, but also ensure the stability of raw material supply and reduce the risks caused by price fluctuations. At the same time, large-scale production can more effectively share equipment investment, maintenance and daily operating costs, significantly reducing the production cost of unit products. According to industry analysis, when the annual output of an enterprise exceeds the 1,000-ton mark, the production cost is expected to be reduced by 20% to 30%. This significant cost advantage will win a broader market space for the enterprise.

### *5.3 Market expansion Trend*

In the international market, asphalt-based carbon fiber companies will strengthen cooperation and competition. On the one hand, through international cooperation, enterprises can share technology and resources and improve their own competitiveness. For example, technical cooperation between Chinese and foreign enterprises can promote the exchange and improvement of asphalt-based carbon fiber production technology. On the other hand, in international competition, enterprises will continue to improve product quality and reduce costs to compete for a larger share of the international market.

## 6. Conclusion

The asphalt-based carbon fiber industry has great potential, but faces challenges such as high cost, difficult quality control, and fierce competition. Through technological innovation, cost reduction, and market expansion, it is expected to overcome difficulties and achieve sustainable development. In the future, with the growth of demand in aerospace, automobiles, and other industries and the development of new fields, its position will become more prominent. The government, enterprises, and scientific research institutions need to strengthen cooperation, jointly promote the development of the industry, and increase R&D investment and policy support.

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