

Fastener Basics: Tech & Application

As core basic components in mechanical manufacturing, construction engineering, the automotive industry, and other fields, fasteners are known as the "grain of industry." Their technical level directly affects the stability, safety, and service life of products. Seemingly simple in structure, fasteners such as bolts, nuts, and screws embody core technologies across multiple fields, including materials, processing, connection, and testing. Mastering these fundamental technologies is not only a prerequisite for professionals in the fastener industry but also crucial for ensuring the quality of downstream products. Starting from the basic classification of fasteners, this article systematically analyzes core technical points, combines them with practical application scenarios, and outlines technical application standards and common issues to provide comprehensive and practical technical references for industry peers.

1. Core Classifications and Basic Characteristics of Fasteners

The classification of fasteners must integrate dimensions such as structure, purpose, and connection methods. Different types of fasteners have significantly different technical requirements and application scenarios, which is the primary prerequisite for mastering basic technologies. Classified by structural form, the most common categories include six major types: bolts, screws, nuts, washers, pins, and rivets, each with a clear technical positioning and applicable scenario.

As the core component for detachable connections, the key technical points of bolts lie in thread precision and load-bearing capacity. Classified by head shape, they include hexagon head, cylindrical head, and countersunk head bolts. Among them, hexagon head bolts are widely used in heavy-duty scenarios such as machinery and construction due to their uniform stress distribution and ease of assembly and disassembly. The core difference between screws and bolts is that screws do not require mating nuts and can be directly screwed into the threaded holes of the connected parts. They are suitable for lightweight, low-load connections. Common self-tapping screws and wood screws require thread designs that balance penetration power and connection firmness.

As mating components for bolts, the inner diameter thread precision and hardness of nuts must strictly match those of the bolts to avoid issues such as thread stripping and pull-out. Classified by purpose, they include standard nuts, locknuts, and anti-loosening nuts. Anti-loosening nuts solve the problem of connection loosening in vibrating environments through technologies like increasing friction and mechanical locking, making them core supporting components in high-end equipment and the automotive sector. The core function of washers is to distribute pressure, protect the surface of connected

parts, and assist in anti-loosening. Their thickness, hardness, and material must be reasonably selected based on connection loads and the material of the connected parts. The technical points for commonly used flat washers and spring washers lie in dimensional precision and elastic recovery capability.

In addition, pins and rivets are mostly used for non-detachable connections. The technical focus of pins is diameter precision and positioning accuracy. Rivets must ensure strength and sealing after riveting, making them suitable for scenarios with high reliability requirements, such as aviation and household appliances. Mastering the basic characteristics of various fasteners is the foundation for subsequent technical application and selection.

2. Core Fundamental Technical Points of Fasteners

The fundamental technology of fasteners runs through four core links: material selection, processing technology, thread technology, and connection principles. Technical control in every link directly determines the performance and service life of fasteners, and it is also core content that industry professionals must master.

(1) Material Selection Technology

Materials are the foundation of fastener performance. Different application scenarios have varying requirements for strength, hardness, corrosion resistance, and high-temperature resistance. Reasonable material selection is the first step in ensuring fastener reliability. Currently, common fastener materials are mainly divided into four categories: carbon steel, alloy steel, stainless steel, and non-ferrous metals, with significant differences in technical characteristics and application scenarios.

Carbon steel is the most commonly used fastener material, featuring low cost and good machinability. Classified by carbon content, it includes low-carbon, medium-carbon, and high-carbon steel. Medium-carbon steel (e.g., Grade 45 steel), after quenching and tempering treatment, offers moderate strength and hardness, suitable for normal load scenarios. High-carbon steel (e.g., Grade 65 steel) has higher hardness and is suitable for high-strength connections, but its toughness is relatively poor, requiring strict control over processing technology. Alloy steel (e.g., 40Cr, 35CrMo) enhances strength, hardness, and wear resistance by adding alloying elements like chromium and molybdenum. It is suitable for complex scenarios involving heavy loads, high temperatures, and vibrations, such as automotive engines and construction machinery. The core technical point lies in the coordinated control of alloy element ratios and heat treatment processes.

The core advantage of stainless steel fasteners (e.g., 304, 316) is strong corrosion resistance, making them suitable for harsh environments like moisture, acids, and alkalis, such as marine engineering and food machinery. The

technical point lies in controlling the chromium and nickel content in the material to avoid intergranular corrosion. Non-ferrous metal (e.g., copper, aluminum) fasteners are lightweight and have good electrical conductivity, suitable for lightweight and conductive scenarios in electronics and aviation. The focus of their processing technology is to avoid deformation and cracks during processing.

(2) Processing Technology

The processing technology of fasteners directly affects their dimensional precision, surface quality, and mechanical properties. Core processes include five links: cold heading, hot heading, turning, thread processing, and heat treatment, each with strict technical specifications.

The cold heading process is the core technology for mass production of fasteners, suitable for head forming of bolts and screws. Its technical points involve controlling cold heading temperature, pressure, and mold precision. By forming materials through cold plastic deformation, it boasts advantages such as high efficiency, high material utilization, and good mechanical properties. Currently, mainstream cold heading equipment in the industry can achieve automated production with precision controlled within $\pm 0.01\text{mm}$. The hot heading process is suitable for large-sized, high-strength fasteners. It forms materials after heating to soften them, requiring control over heating temperature and holding time to avoid defects like oxidation and decarburization that affect fastener strength.

Thread processing is one of the core technologies of fasteners, and thread precision directly affects connection reliability. Common processes include thread rolling, turning, and tapping. Thread rolling offers high efficiency and precision, suitable for mass production; its technical points lie in the precision of thread rolling dies and the control of rolling pressure. Thread turning is suitable for high-precision, special-specification fasteners, requiring control over thread pitch and tooth profile precision to avoid issues like cross-threading and thread stripping. Heat treatment is key to enhancing fastener strength and hardness. Common processes like quenching, tempering, and carburizing require reasonable parameter adjustments based on material characteristics and performance requirements. For instance, carburizing treatment of alloy steel fasteners can enhance surface hardness and wear resistance, extending service life.

(3) Fundamental Thread Technology

Threads are the core structure of fastener connections. Their technical parameters, including pitch, tooth profile, and precision grade, directly determine connection firmness and interchangeability. Common thread types include metric threads, pipe threads, and trapezoidal threads. Metric threads (e.g., M series) are the most widely used, featuring a triangular tooth profile

and uniform pitch, suitable for general connections. Pipe threads are mainly used for pipeline connections, requiring sealing performance, and their tooth profiles differ significantly from metric threads. Trapezoidal threads have strong load-bearing capacity, suitable for heavy-load and transmission scenarios.

Thread precision grades are classified into 4H, 5H, 6H, etc. The higher the precision, the smaller the dimensional error and the stronger the connection reliability. High-end equipment and aerospace fields typically use high-precision threaded fasteners, and their precision control requires professional testing equipment. Additionally, thread surface treatment technology is also crucial. Common processes like galvanizing, chrome plating, and phosphating can enhance corrosion resistance and surface hardness while increasing friction between threads to assist in anti-loosening.

(4) Connection and Anti-Loosening Technology

The core function of fasteners is to achieve component connection. Connection reliability and anti-loosening performance are the core requirements of fundamental technology, and different application scenarios require different connection and anti-loosening methods. Common connection methods include bolted, screwed, riveted, and pinned connections. Among them, bolted connections are the most widely used due to their detachability and strong load-bearing capacity. The technical point lies in controlling the preload. Insufficient preload leads to connection loosening, while excessive preload may cause bolt fracture.

Anti-loosening technology is key to fastener application, especially in vibrating and impacting scenarios. Common anti-loosening methods are divided into three categories: mechanical, friction, and chemical. Mechanical anti-loosening (e.g., split pins, tab washers, anti-loosening nuts) locks threads through mechanical structures, offering high reliability and suitability for heavy-load and vibrating scenarios. Friction anti-loosening (e.g., spring washers, lock washers) increases friction between threads; it features simple structure and low cost, suitable for ordinary scenarios. Chemical anti-loosening (e.g., threadlockers) locks threads through adhesive curing, offering good sealing performance and suitability for complex scenarios like high temperatures and moisture.