



Ball Bearings Pursuing the Limits of Precision

The history of the Minebea Group is a chronicle of daily challenges in manufacturing with sincerity. This feature provides insight into how the Minebea Group's manufacturing philosophy was developed through the manufacture of ball bearings.

Japan's First Manufacturer Specialized in Miniature Ball Bearings

Minebea's history stretches back about 60 years to 1951, when the company began as Japan's first specialty manufacturer of miniature ball bearings with about 10 employees and a small factory.

At the time, miniature ball bearings were used mostly in aircraft instrumentation. Just after the Second World War, however, there were no Japanese manufacturers capable of producing this type of high-precision manufactured parts. The founders of Minebea decided to embark on the manufacture of miniature ball bearings based on the belief that aircraft demand would increase in the future, and that Japan needed the technological capability to manufacture this type of

high-precision product. The specialty of the product as well as the lack of adequate manufacturing equipment posed significant challenges for the founders, who relied on trial and error to overcome obstacles.

Despite the challenges, Minebea successfully established its manufacturing technology in the late 1950s thanks to the efforts of Japanese engineers. After the high-quality products were recognized in the U.S. market, Minebea's sales began to take off. In 1963, the company constructed the Karuizawa Plant and equipped it with state of the art machinery. This established the company's modern manufacturing foundation by enabling mass production of high-quality products. To respond to rising demand for Minebea products worldwide, the company expanded business to Singapore in 1972 and then to Thailand and China.

Today, the Minebea Group maintains eight ball bearing manufacturing plants worldwide, with approximately 10,000 employees involved in the business, and a monthly production of some 250 million ball bearings.



The company continued to grow through trial and error with President Seiichiro Takahashi at the helm



Expansion work on the Karuizawa Plant in the 1960s

The Function of Ball Bearings

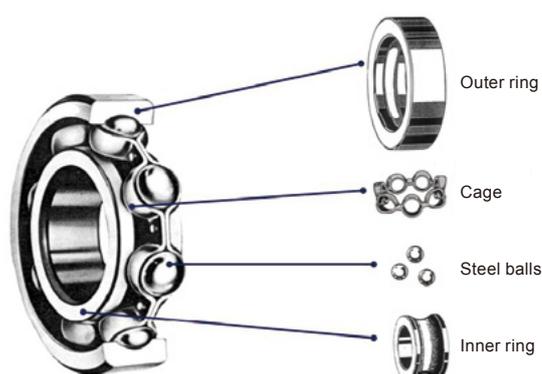
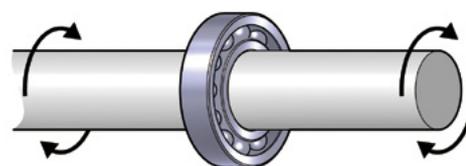
From car axles to electric fans and hard disc drives (HDDs), ball bearings are used in a wide array of machines for rotary motion. Ball bearings support rotary parts and reduce friction to facilitate the smooth operation of machines. The size of ball bearings can range from smaller than a grain of rice—small enough to fit inside a wristwatch—to over one meter in diameter for factory and power plant applications. Minebea specializes in the manufacture of miniature and small-sized ball bearings with an outer diameter of 30mm or less.

Structure of Ball Bearings

Ball bearings are comprised of four major parts: a large ring (outer ring), a small ring (inner ring), balls between the rings (steel balls), and a cage to prevent the balls from hitting each other. The modern structure dates back to around 1500, when Leonardo da Vinci invented ball bearings to reduce friction against the axles of horse-drawn carts. For more than 500 years, the ball bearing has been defined by this simple structure.

The Precision of a Ball Bearing

The main function of a ball bearing is to reduce friction and facilitate smooth rotation of an axis. Modern ball bearings test the very limits of precision. As an example, one of the key elements to making an ultra-precise ball bearing is the degree to which the groove where the balls roll can be made into a perfect circle. Minebea has achieved ultra-precision groove manufacturing which reduces the range of error from a perfect circle to one-one hundred thousandth of a millimeter.



An Endless Passion for High-quality Manufacturing

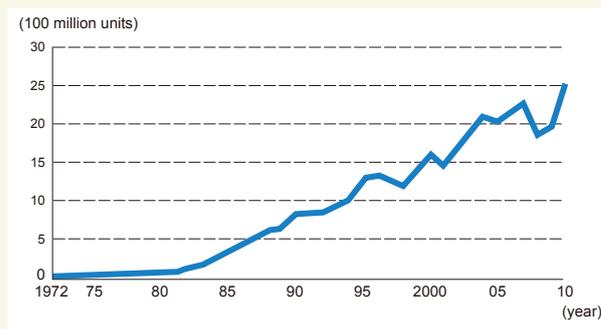
The most important performance measure in judging a ball bearing is the extent to which it reduces friction and facilitates smooth and easy rotation. Ball bearings may end up in aircraft, automobiles, precision machinery and many other end products, but no matter the application, it is important to maintain smoothness and minimize friction. Changes in the times brings diversification and complexity in end products and machine types along with new performance requirements for ball bearings, including miniaturization, higher rotation speeds, durability and duration, as well as noise reduction.

We have succeeded in responding to new requirements by carefully reviewing all of our product processes, from development and design to manufacture and inspection, and making steady, painstaking improvements. Since the structure of a ball bearing is very simple, however, improving the ball bearing has required enhancing the precision of the ball bearing components to their absolute limit. In order to do this, we decided to manufacture not only the critical inner and outer rings in-house, but the other components as well. Currently, Minebea also manufactures the cage, shield, and balls in-house. Additionally, to ensure the smooth rotation of the ball bearings, we have developed proprietary lubricants. We have also developed in-house a grinding machine which can be controlled to sub-

micrometer (one-ten thousandth of a millimeter) precision, along with assembly equipment. To vertically integrate the business, we have enhanced the sophistication of the manufacturing capability and automated the manufacturing line. Today, nearly all the manufacturing equipment used in the grinding, polishing, and assembly processes were developed in-house.

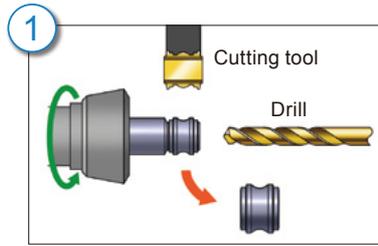
While the design and quality of a product may be outstanding, if the price is too high, customers won't buy it. To improve cost-competitiveness, we evaluate the manufacturing processes from every angle, and strive to shorten the time from order to delivery while raising the yield. Another way we strive to beat the competition on price is to invest heavily in machine maintenance to ensure that our manufacturing equipment operates in optimal condition. This is another benefit of vertically integrating our business.

▶ Annual Ball Bearing Production

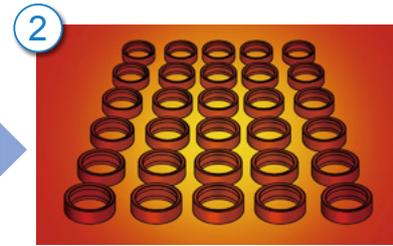


Ball Bearing Manufacturing Processes

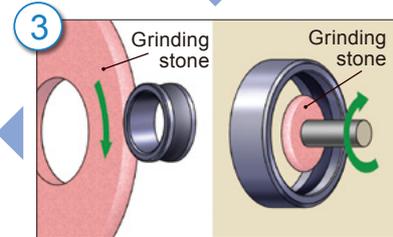
The manufacture of a ball bearing can be divided into five major processes.



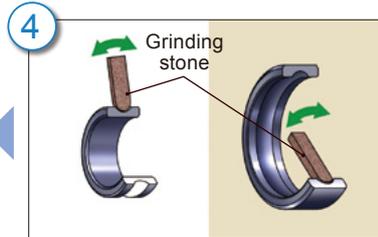
1 Cutting
Ring-shaped parts are cut from the raw material rods using drills and cutting tools.



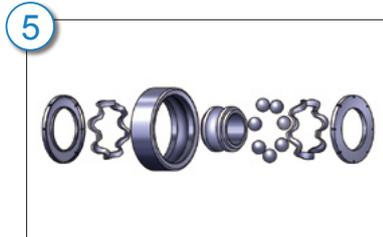
2 Heat Treatment
Process for hardening the parts in order to enhance their durability and long-life.



3 Grinding
A grinding stone is used to grind the surfaces of parts to the required dimensions and precision. Dimensions such as the outer and inner diameters and the width are ground to micrometer (one-thousandth of a millimeter) precision, as is the groove, a key internal structure formed between the inner and outer rings in which balls run.



4 Honing
The groove between the outer and inner rings in which the balls run is honed to nanometer (one-thousandth of a micrometer) precision.



5 Assembly Process
The outer ring, inner ring, balls and cage are assembled, oil or grease is applied to aid smooth rotation, and covered by a shield. This is the process where exactly the right parts are assembled to meet the customer's specific requirements.

Manufacturing Uniform Products Around the World

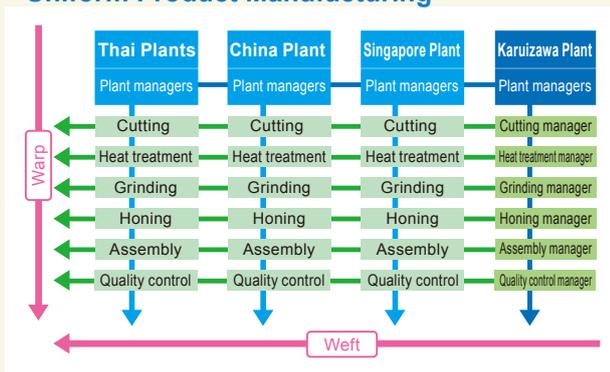
The manufacture of miniature ball bearings requires extremely delicate and sophisticated precision, and simply using the same materials and manufacturing equipment does not guarantee that uniform products will be produced. Minebea has introduced a proprietary “warp and weft” approach to ensure that all of its eight manufacturing plants worldwide produce a uniform quality of products.

The “warp” in this system is the vertical examination of all the manufacturing processes along the machine direction by each plant manager to ensure thorough manufacturing management on the basis of Minebea’s long-accumulated integrated manufacturing know-how. The “weft” in this system is the dispatch of managers for each of the manufacturing processes from the

Karuizawa Plant, the “mother plant,” to the seven overseas plants to ensure with an objective eye that processes are horizontally deployed throughout the world. One of the features of this system is the frequent visits by the Karuizawa Plant managers to the overseas plants, much as if they were visiting a plant next door, to oversee and train local employees. The combination of this warp and weft enables Minebea to achieve a manufacturing system which guarantees uniform products and high productivity.

The implementation of uniform product manufacturing may appear as though Japanese methods are being thrust unilaterally on overseas sites. At Minebea, however, we have established basic policies of respecting the culture and customs of local communities to the extent possible when localizing our product manufacturing. We actively promote local employees to management positions and operate local plants on the basis of locally developed management and employees. We believe that transplanting Japanese methods to local communities overseas is best achieved by customizing the methods to fit the local community to the extent possible. This enables know-how to be implemented overseas in a relatively short time.

► An Image of the “Warp and Weft” Concept for Uniform Product Manufacturing



Sweating It Out Together to Build Teamwork

Minebea’s purpose in expanding its business overseas has never been simply to access labor pools. We have expanded from the standpoint of making a long-term investment to mass produce better products. Based on this policy, we install the latest machinery when

constructing new overseas plants and, as previously mentioned, we actively promote the localization of management. We also spare no effort in investing in the future through the time and effort put into employee training.

We believe that training employees works best by having them witness the processes firsthand at the manufacturing sites. When we construct new plants, we not only provide classroom training to local employees, but we provide practical on-the-job (OJT) training at operating plants. Following the OJT, engineers from the Karuizawa Plant visit each plant on a routine basis to provide direct, repeated training sessions to employees and share their know-how. In each of the plants, a spirit of friendly competition among employees is deeply rooted. These friendly rivalries advance innovation and spur the development and acquisition of new technology. Innovations made at plants are validated at the Karuizawa Plant, the mother plant, and quickly rolled out to all plants.

Though Minebea does not have a special technology achievement awards or honors program, the passion employees have for getting involved in research on new technology reflects a shared approach to manufacturing which transcends language and culture. When plants are constructed overseas, Japanese dispatched to support the new operations sweat it out alongside the local employees pushing mops and doing other chores, creating feelings of unity. This sense of being a part of the global "Team Minebea" generates unwavering bonds of trust among employees.

Continuing to Meet the Changing Demands of New Eras

Minebea's manufacturing approach has remained unchanged since the company's founding, even to the present day, when the company has risen to hold the world's No. 1 share in the miniature ball bearing market. That approach can be summarized as the provision of products and technology society needs, by optimal means—in the simplest terms, manufacturing higher quality products, at a lower price, faster, and in greater quantities than the competition. Amid changing eras, however, the demand for better bearings—which are often called the "backbone" of industry—never stops.

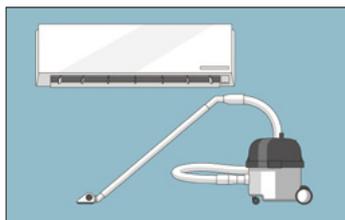
For example, Minebea has succeeded in enhancing the corrosion-resistance of bearings more than 20 times the traditional level to meet demands for products which can be used in healthcare-related equipment exposed to water, blood, and chemicals. We continue to research the miniaturization of HDD bearing width from 2mm to 1mm as notebook PCs reach the limit of thinness. As a further example, we continue to develop ball bearings for turbo chargers, which can reduce the environmental burden of automobiles, in order to meet demands for products which can operate stably under severely high temperatures and high rotational speeds.

At Minebea, we are acutely aware of the importance of our responsibility to supply products as a leading bearing manufacturer. In 2011, during the massive flooding in Thailand, some of our bearing manufacturing plants were idled for about two weeks. We responded by increasing production at manufacturing plants in other locations. In fact, even before this crisis, we had established a structure in which we strategically stock parts and products to ensure that we can continue to supply customers without delay even with a one-month suspension of manufacturing operations. This structure ensures that any crisis has a minimal affect on customers.

The 60-year history of Minebea since its founding has been a chronicle of simple and sincere manufacturing challenges. That history has nurtured a unique manufacturing philosophy which emphasizes manufacturing higher quality products, at a lower price, faster, and in greater quantities than the competition. This will remain the central credo by which Minebea contributes to society and fulfills its responsibilities into the future. Minebea will continue to take on new manufacturing challenges in order to respond to the needs of its customers, employees, local communities, and other stakeholders and meet society's expectations.

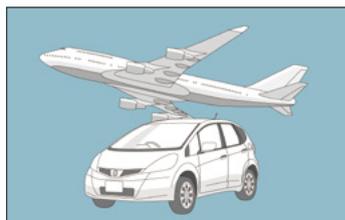
Uses of Ball Bearings

Ball bearings are used in a vast array of machines which support our daily lives. They can be found throughout society, from such household appliances as air conditioners and vacuum cleaners, to such vehicles as aircraft and automobiles, and such information communications equipment as personal computers and copy machines.



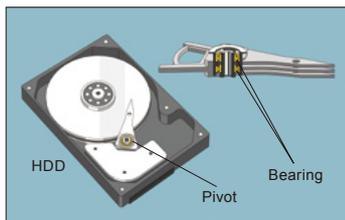
Household Appliances (air conditioners, vacuum cleaners, etc.)

The use of ball bearings helps to reduce friction within the machines and contribute to energy efficiency as well as reduce noise and support quiet operation.



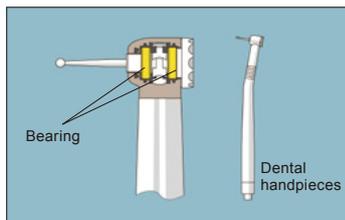
Vehicles (automobiles, aircraft, etc.)

Long-life bearings contribute to the reliability of vehicles. A standard automobile has more than 100 bearings, requiring a variety of performance needs.



Information Communications Equipment (HDDs, copy machines, etc.)

As PCs become slimmer, the pivot used in HDDs (the bearing supporting the magnetic head actuator) has also needed to become slimmer, with a current thinness of about 1 millimeter.



Other (dental handpieces, etc.)

Bearings are also used in a wide range of other places throughout society. For the handpieces used in dentist offices, the bearings must be able to support high-speed rotation and withstand rust and corrosion.