The Manufacturing of A Ball Bearing

Ball bearings are at the heart of almost every product with a rotating shaft.

Most bearing specifications and manufacturing tolerances are quantified in one-ten thousandths of an inch (1/10,000) by ABMA; every manufacturing process is 100% checked and feedback provided to ensure the integrity of the process and product.

Note: A ***micron*** (an abbreviation for ***micrometers***) is one-millionth of a meter, or, 25,400 microns equals one (1) inch.

Repeatability in the Manufacturing Process

Predictable uniformity, or repeatability, in the manufacturing process is crucial to ensuring consistent bearing performance. If variations occur in the manufacturing process from part to part, the production line may make bearings that fall within the complete spectrum of the allowable tolerance standards. That inconsistency-- producing parts that go from one end of the range to the other--can lead in turn to variations in the performance of each bearing, either individually or from lot to lot. The narrower the variation in each step of the manufacturing process, the greater the consistency of each bearing's performance.

Inner/Outer Ring Manufacturing Process

Manufacturing Flow Chart

Forged Rings (De-scaled) as Raw Material.
(SAE 52100 steel)

Turning Operation

↓

Center Less Grinding

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Heat Treatment

↓

Hardness testing

↓

Rough Grinding

↓

Finish Grinding

↓

Honing & Super Finishing

↓

Washing

↓

Application of rust preventive

↓

Ready for dispatch to assembly

Ball Bearing Materials

Ball bearings are generally made of high carbon steels, such as *AISI 52100 (fifty-two, one hundred)*. One of the factors that determine the life of the bearing steel (thus the bearing itself) is the purity or cleanliness of the steel. The 52100 steel are subjected to a rigorous purification process with stringent controls in order to meet the ever-increasing standards for cleanliness—eliminating nonmetallic inclusions or impurities. These impurities are removed through various processes such as *vacuum degassing* and *consumable-electrode vacuum melting (CEVM),* to name just two of the processes referred to when discussing the merits and cleanliness of bearing steel.

The hardening of the steel is achieved by a *heat treating* process in which the steel microstructure is manipulated by cycles of heating and quick cooling to obtain the optimum hardness range for the steel—usually on the order of 60 to 64 on the *Rockwell C Hardness* scale. Penetration hardness tests (such as Rockwell or Brinell) provide the means to estimate the actual hardness of metals.

Raw Material for bearings Races:

For Outer and inners the suggested raw material is SAE 52100 conforming to following chemical compositions:

Element	**C**	**Si**	**Mn**	**S**	**P**	**Cr.**
Minimum	.98	.15	.25	--	--	1.30
Maximum	1.10	.35	.45	0.025	0.025	1.60

Oxygen content; Not More than 15 ppm

Micro Inclusions

Inclusion type	**Series**	
	Thin	**Thick**
(A) Sulphides	2.5	1.5
(B) Alumina	2.0	1.0
(C) Silicate	0.5	0.5
(D) Globular Oxide	1.0	1.0

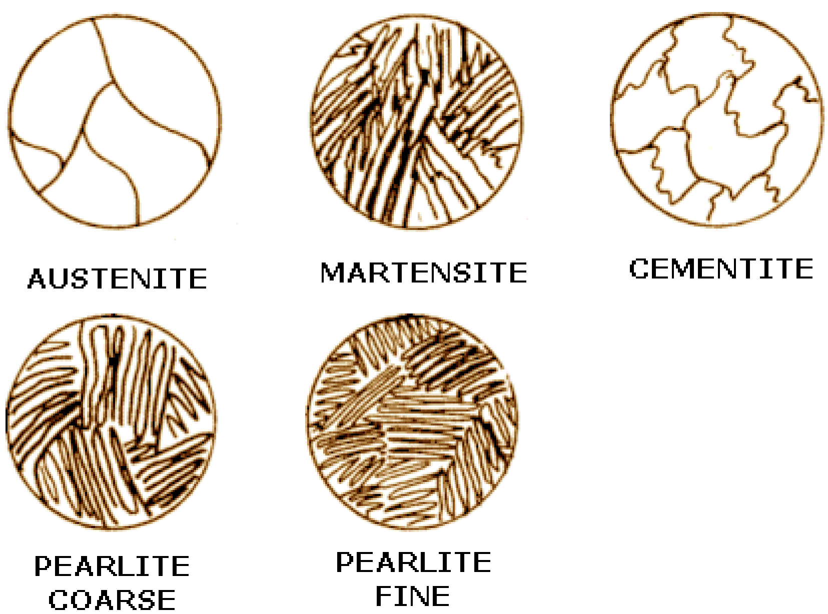
TURNING SECTION

Both the inner and outer rings are usually machined from the outer and Inner races are manufactured from SAE 52100 steel, the raw material used in the section has been considered as forged rings.

The turning operations are divided into various lathe operations, viz. O.D., face, track and Bore. All these operations are done on production lathe machines. These lathe machines offered in the project are production machines wherein individual job/ process sequence has to be set before every new batch is taken up.

HEAT TREATMENT

Hardness is a function of and brittle structure. When slowly quenched it would form Austenite and Pearlite which is a partly hard and partly soft structure. When the cooling rate is the Carbon content of the steel. Hardening of steel requires a change in structure from the body-centered cubic structure found at room temperature to the face-centered cubic structure found in the Austenitic region. The steel is heated to Austenitic region. When suddenly quenched, the Martensite is formed. This is a very strong extremely slow then it would be mostly Pearlite, which is extremely soft.



Harden ability, which is a measure of the depth of full hardness achieved, is related to the type and amount of alloying elements. Different alloys, which have the same amount of Carbon content, will achieve the same amount of maximum hardness; however, the depth of full hardness will vary with the different alloys. The reason to alloy steels is not to increase their strength, but increase their harden ability — the ease with which full hardness can be achieved throughout the material.

Usually when hot steel is quenched, most of the cooling happens at the surface, as does the hardening. This propagates into the depth of the material. Alloying helps in the hardening and by determining the right alloys one can achieve the desired properties for the particular application.

Such alloying also helps in reducing the need for a rapid quench cooling — thereby eliminate distortions and potential cracking. In addition, thick sections can be hardened fully.

Quench Media

Quenching is the act of rapidly cooling the hot steel to harden the steel.

Oil:

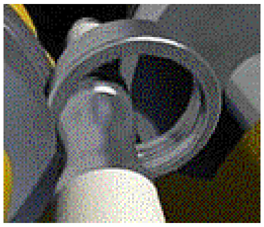
Oil is used when a slower cooling rate is desired. Since oil has a very high boiling point, the transition from start of Martensite formation to the finish is slow and this reduces the likelihood of cracking. Oil quenching results in fumes, spills, and sometimes a fire hazard.

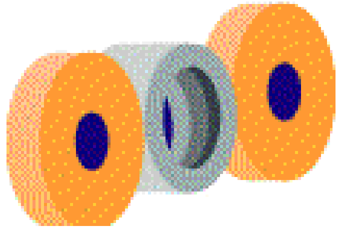
Quenches are usually done to room temperature. Most medium carbon steels and low alloy steels undergo transformation to 100% Martensite at room temperature. However, high carbon and high alloy steels have retained Austenite at room temperature. To eliminate retained Austenite, the quench temperature has to be lowered. This is the reason to use cryogenic quenching.

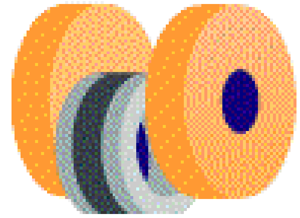
NITROGEN METHANOL SYSTEM

The above system comprise of Methanol Tank 200 liters SS 2.5 mm corrugated, Methanol Flow Meter 0.50 to 5.2 per hour, Solenoid Valve, Needle Valves, all interconnected by copper piping duly mounted on a stand with Nitrogen Pressure Regulator and Flow meter to read 2 to 5 m3/hr**.**

GRINDING SECTION







Track Grinding
Finish Grinding

Grinding the Outer Diameter of the Ring Faces

The next stage is grinding, in order to give the rings the right form and dimensions. The first operation on inner and outer rings is face grinding. Both faces are ground simultaneously to give the final width.

Then the outside diameter of the inner rings is ground to the final dimension in centreless grinding machines.

The final machining operations are carried out on parallel lines of grinding and finishing machines - one for inner and one for outer rings. Inner rings have the bores and raceways ground, while outer rings have only the raceways ground. This is carried out with form dressed grinding wheels using plunge-grinding techniques.

After honing, the rings are thoroughly washed with a water-based cleaning medium so that they are perfectly clean before assembly.

In-process measurement is common to all grinding machines. Automatic process control, by means of post-processors, and random checks in specially equipped measuring rooms are also used for additional monitoring of quality.

1. Rough O.D. grinding on centre less
2. Face grinding on Rotary table/duplex
3. Bore grinding
4. External track grinding
5. Internal track grinding
6. Finish O.D. grinding

Manufacturing Process

Flow Chart

Input Wire Rod as Raw Material.
(SAE 52100 Steel)

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Shearing & Heading operation
On Ball Header Machine

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Deburring on Vibro Benz Machine

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Flushing of excess material after the
Ball forged in cold header

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Heat treatment of ball

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Grinding of ball in rotary
Grinding machine (Flashing m/c)

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Lapping in Ball Lapping machine

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Inspection for checking
Hairline cracks

↓

Lapping of balls in
Tumbling barrel

↓

Magnetic Crack Testing

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Washing

↓

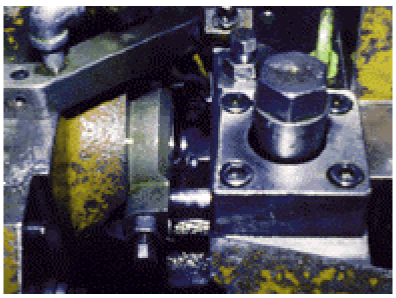
Application of rust preventive

↓

Packing

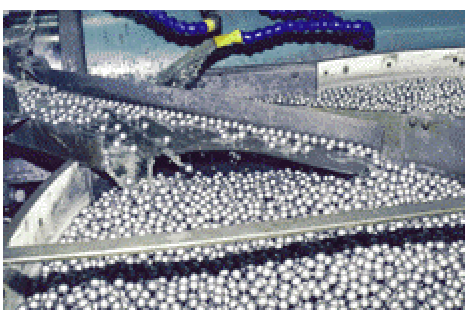
The raw material used in the manufacture of balls is a specially formulated grade of steel wire.
The raw material is supplied from either wire or rod. It is then cut to length and the width is a small percentage larger than the width of the finished ball.

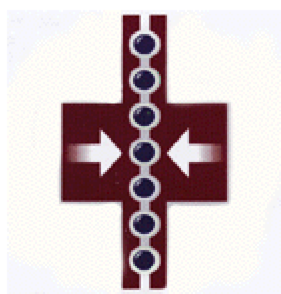
The wire or rod is then fed through a header. This cold forged process produces "slugs" at an incredibly high speed.
Wire is fed from decoilers into cold heading machines where it is cut into blanks, and then pressed into balls between hemispherical dies.



Heat Treating Balls

Ball Flashing Operation

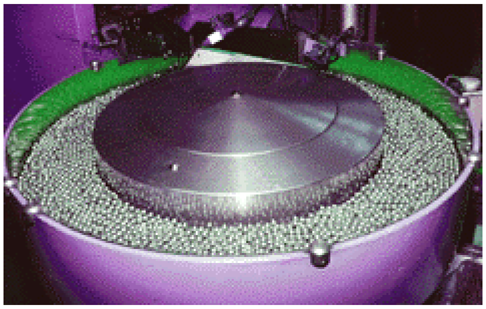




The flash around the balls produced during pressing is removed by filing plates in deburring machines.

These rough shaped balls have a ring around the middle. The next process is to remove this ring.

The balls are then machined in rill-filing machines, equipped with one fixed and one rotating cast iron rill-plate. Concentric grooves in the plates ensure that the whole ball surface is machined to the same extent and thus a spherical form is achieved.



Final inspection for size, form and surface finish is carried out on a sample basis by means of microscopes and other precision equipment. The balls are then cleaned and packed ready for bearing assembly operations.

The tiniest deviation in the roundness of bearing elements can have an impact on bearing quality. Periodic form deviations in the range of 1 angstrom 10^{-10} m may influence bearing quality.

CAGE MANUFACTURING

Flow chart

Raw material
(Narrow width CR sheet)

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Blanking & Punching

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Forming (Pocketing)

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Inspection and batch checking

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Shot Blasting/ Virbro

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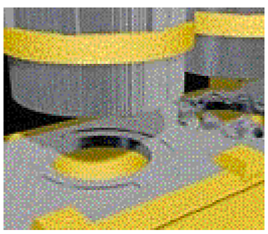
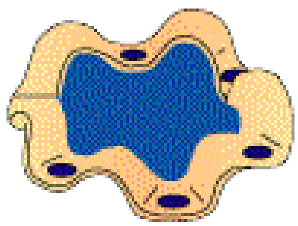
Assembly in Assy. shop

The cages for various bearings sizes are manufactured from Cold Rolled narrow width sheets IS 4397 cold rolled, cold annealed sheets, and The CR sheet is converted in the cage in Press machines in successive press operations:

Blanking, Punching, forming (pocketing) rivet holes and visual inspection is carried for any deformity.

Cages are manufactured from cold rolled steel strip. Presses with progressive or, alternatively, transfer tools are used to produce cages halves from the strip. The operational sequence consists of piercing and blanking, forming the ball pockets and piercing the rivet holes. After surface treatment and cleaning, the cage halves are coated with preservative and packed for transport to the assembly plant.





Rivet manufacturing

Flow Chart

Raw material (Wire EN 8)

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Heading in Ball Header

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Deburring in vibro benz machine

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Rust Preventive Oiling

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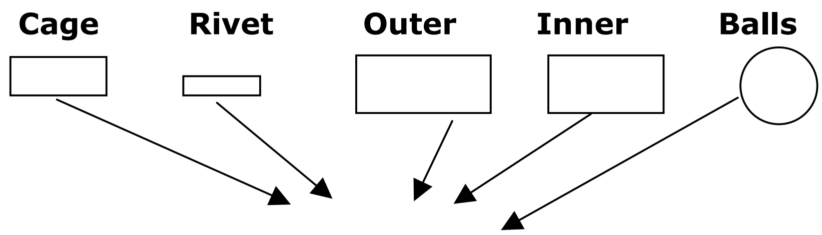
Ready for Assembly

The rivets are manufactured from wire rods, the wires is cut in required size in rivet header machines, then in the vibro machines it is super finished. There is no grinding operation involved.

Raw Material EN 8 or EN9 Round Bars dia/3 mm to 6 mm

Assembly Section

<u>Flow chart</u>



Put Inner in Outer

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Insert Balls

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Put retainers

↓

Put under riveting machine

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Riveting

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Washing of bearing

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De Magnetizing

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Clearance testing

↓

Application of Anti rust

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Packaging of Bearing
In pillow wrapping machine

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Ready for Dispatch

Finally the rings, balls and cage - which have been manufactured in different locations - come together for automatic assembly.

Raceway diameters of inner and outer rings are measured separately. By selecting suitable combinations of ring and ball sizes, the required internal clearance is obtained. Balls are fed between the rings and spaced equally before the two cage halves are fitted and then riveted together. Prior to automatic assembly the rings are optically inspected.

After washing, the final inspection sequence starts. This consists of a number of automated stations, which check running accuracy, vibration level, and outside and bore diameters, as well as radial clearance of the bearings.

The bearings are then automatically washed, coated with preservative, greased and fitted with seals or shields, before being packed according to customer requirements.