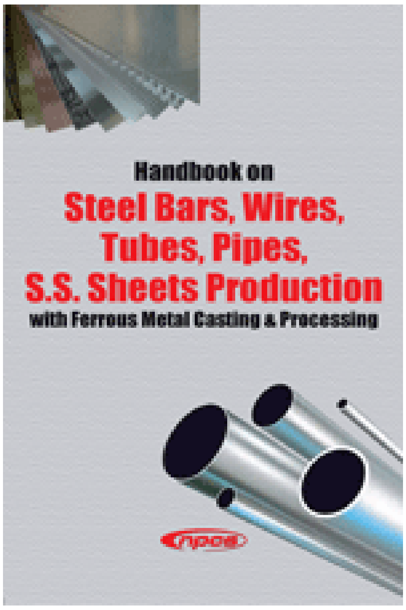
Entrepreneur India

106-E, Kamla Nagar, New Delhi-110007, India.
Tel: 91-11-23843955, 23845654, 23845886, +918800733955,
Mobile: +91-9811043595.
Email: npcs.ei@gmail.com ,info@entrepreneurindia.co

Website: www.entrepreneurIndia.co

Handbook on Steel Bars, Wires, Tubes, Pipes, S.S. Sheets Production with Ferrous Metal Casting & Processing



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Ferrous materials have made a major contribution to the development of modern technology; they span a tremendous range of properties and applications. Reflecting the industrial practices, the information provided here offers easy access to reliable processes involved in the manufacturing of Steel products like Steel Bars, Wires, Tubes, Pipes, Sheets etc that proves to be the backbone of construction and automobile industries booming worldwide.

The work closes the gap in the treatment of steel and cast iron. Each chapter takes into account the gradual transitions between the two types of ferrous materials. It demonstrates that ferrous metal and steel are versatile and customizable materials which will continue to play a key role in the future and also covers the operations performed on ferrous metals for converting them into a commodity.

The book provides a full characterization of steel, including structure, chemical composition, classifications, physical properties, production practices of different steel products, processing of ferrous metals and so on. It will prove to be a layman's guide for the entrepreneurs who are willing to invest in the ventures related to Iron and Steel Industries, as it contains information related to processing of ferrous metals and production practices followed in Steel products manufacturing units. The text discusses the importance and objectives of processes and material used for the production of disposable products. Many examples have been provided to illustrate the concepts discussed.

The topics covered in the book are: Casting of Ferrous Metals, Heat Treatment of Ferrous Metals, Stamping Process of Ferrous Metals, Forming Process of Ferrous Metals, Machining Process of Ferrous Metals, Joining Process of Ferrous Metals, Production of Stainless Steel Wire, Production and Fabrication of Steel Bars, Steel Tube & Pipe, Stainless Steel Sheet and Different Grades of Stainless Steel.

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Sample Chapter:

CASTING OF FERROUS METALS

Casting Methods

Metal casting process begins by creating a mold, which is the ‘reverse' shape of the part we need. The mold is made from a refractory material, for example, sand. The metal is heated in an oven until it melts, and the molten metal is poured into the mould cavity. The liquid takes the shape of cavity, which is the shape of the part. It is cooled until it solidifies.

Sand Casting

Sand casting uses natural or synthetic sand (lake sand) which is mostly refractory material called silica (SiO_2). The sand grains must be small enough so that it can be packed densely; however, the grains must be large enough to allow gasses formed during the metal poured to escape through the pores. Larger sized molds use green sand (mixture of sand, clay and some water).

Expendable-Pattern Casting (Lost foam Process)

The pattern used in this process is made from polystyrene (this is the light, white packaging material which is used to pack electronics inside the boxes). Polystyrene foam is 95% air bubbles, and the material itself evaporates when the liquid metal is poured on it.

The pattern itself is made by molding - the polystyrene beads and pentane are put inside an aluminum mold, and heated; it expands to fill the mold, and takes the shape of the cavity.

Plaster-Mold Casting

The mold is made by mixing plaster of paris ($CaSO_4$) with talc and silica flour; this is a fine white powder, which, when mixed with water gets a clay-like consistency and can be shaped around the pattern (it is the same material used to make casts for people if they fracture a bone). The plaster cast can be finished to yield very good surface finish and dimensional accuracy.

One advantage of vacuum casting is that by releasing the pressure a short time after the mold is filled, we can release the un-solidified metal back into the flask. This allows us to create hollow castings. Since most of the heat is conducted away from the surface between the mold and the metal, therefore the portion of the metal closest to the mold surface always solidifies first; the solid front travels inwards into the cavity. Thus, if the liquid is drained a very short time after the filling, then we get a very thin walled hollow object, etc.

Die Casting

Die casting is a very commonly used type of permanent mold casting process. It is used for producing many components of home appliances (e.g rice cookers, stoves, fans, washing and drying machines, fridges), motors, toys and hand-tools - since Pearl river delta is a largest manufacturer of such products in the world, this technology is used by many HK.-based companies. Surface finish and tolerance of die cast parts is so good that there is almost no post-processing required. Die casting molds are expensive, and require significant lead time to fabricate; they are commonly called dies.

Casting Design and Quality

Several factors affect the quality/performance of cast parts - therefore the design of parts that must be produced by casting, as well as the design of casting molds and dies, must account for these. You may think of these as design guidelines, and their scientific basis lies in the analysis - the strength and behaviour of materials.

Shrinkage

As the casting cools, the metal shrinks. For common cast metals, a 1% shrinkage allowance is designed in all linear dimensions (namely, the design is scaled p by approx 1%). Since the solidification front, i.e. the surface at the boundary of the solidified and the liquid metals, travels from the surface of the mold to the interior regions of the part, the design must ensure that shrinkage does not cause cavities.

HEAT TREATMENT OF FERROUS METALS

Successful heat treatment requires close control over all factors affecting the heating and cooling of a metal. This control is possible only when the proper equipment is available. The furnace must be of the proper size and type and controlled, so the temperatures are kept within the prescribed limits for each operation. Even the furnace atmosphere affects the condition of the metal being heat-treated.

COOLING STAGE

After a metal has been soaked, it must be returned to room temperature to complete the heat-treating process. To cool the metal, you can place it in direct contact with a COOLING MEDIUM composed of a gas, liquid, solid, or combination of these. The rate at which the metal is cooled depends on the metal and the properties desired.

The success of a heat-treating operation depends largely on your judgement and the accuracy with which you identify each color with its corresponding temperature. From a study of table 2-1, you can see that close observation is necessary. You must be able to tell the difference between faint red and blood red and between dark cherry and medium cherry. To add to the difficulty, your conception of medium cherry may differ from that of the person who prepared the table. For an actual heat-treating operation, you should get a chart showing the actual colors of steel at various temperatures.

ANNEALING

In general, annealing is the opposite of hardening, You anneal metals to relieve internal stresses, soften them, make them more ductile, and refine their grain structures. Annealing consists of heating a metal to a specific temperature, holding it at that temperature for a set length of time, and then cooling the metal to room temperature.

NORMALIZING

The purpose of normalizing is to remove the internal stresses induced by heat treating, welding, casting, forging, forming, or machining. Stress, if not controlled, leads to metal failure; therefore, before hardening steel, you should normalize it first to ensure the maximum desired results. Usually, low-carbon steels do not require normalizing; however, if these steels are normalized, no harmful effects result.

Thin pieces cool faster and are harder after normalizing than thick ones. In annealing (furnace cooling), the hardness of the two are about the same.

HARDENING

The hardening treatment for most steels consists of heating the steel to a set temperature and then cooling it rapidly by plunging it into oil, water, or brine. Most steels require rapid cooling (quenching) for hardening but a few can be air-cooled with the same results. Hardening increases the hardness and strength of the steel, but makes it less ductile. Generally, the harder the steel, the more brittle it becomes.

In plain carbon steel, the maximum hardness obtained by heat treatment depends almost entirely on the carbon content of the steel. As the carbon content increases, the hardening ability of the steel increases; however, this capability of hardening with an increase in carbon content continues only to a certain point. In practice, 0.80 percent carbon is required for maximum hardness.

Case Hardening

Case hardening produces a hard, wear-resistant surface or case over a strong, tough core. The principal forms of casehardening are carburizing, cyaniding, and nitriding. Only ferrous metals are case-hardened. Case hardening is ideal for parts that require a wear-resistant surface and must be tough enough internally to withstand heavy loading. The steels best suited for case hardening are the low-carbon and low-alloy series. When high-carbon steels are case-hardened, the hardness penetrates the core and causes brittleness. In case hardening, you change the surface of the metal chemically by introducing a high carbide or nitride content. The core remains chemically unaffected. When heat-treated, the high-carbon surface responds to hardening, and the core toughens.

Flame Hardening

Flame hardening is another procedure that is used to harden the surface of metal parts. When you use an oxyacetylene flame, a thin layer at the surface of the part is rapidly heated to its critical temperature and then immediately quenched by a combination of a water spray and the cold base metal. This process produces a thin, hardened surface, and at the same time, the internal parts retain their original properties. Whether the process is manual or mechanical, a close watch must be maintained, since the torches heat the metal rapidly and the temperatures are usually determined visually.

Flame hardening may be either manual or automatic. Automatic equipment produces uniform results and is more desirable. Most automatic machines have variable travel speeds and can be adapted to parts of various sizes and shapes. The size and shape of the torch depends on the part.

When the cutting end has cooled, remove the chisel from the bath and quickly polish the cutting end with a buff stick (emery). Watch the polished surface, as the heat from the opposite end feeds back into the quenched end. As the temperature of the hardened end increases, oxide colors appear. These oxide colors progress from pale yellow, to a straw color, and end in blue colors. As soon as the correct shade of blue appears, quench the entire chisel to prevent further softening of the cutting edge.

Caustic Soda

A solution of water and caustic soda, containing 10 percent caustic soda by weight, has a higher cooling rate than water. Caustic soda is used only for those types of steel that require extremely rapid cooling and is NEVER used as a quench for nonferrous metals.

DRY QUENCHING

This type of quenching uses materials other than liquids. Inmost cases, this method is used only to slow the rate of cooling to prevent warping or cracking.

Air

Air quenching is used for cooling some highly alloyed steels. When you use still air, each tool or part should be placed on a suitable rack so the air can reach all sections of the piece. Parts cooled with circulated air are placed in the same manner and arranged for uniform cooling. Compressed air is used to concentrate the cooling on specific areas of a part. The airlines must be free of moisture to prevent cracking of the metal.

STAMPING PROCESS OF FERROUS METALS

Compound Die

A compound die blanks and perforates a part at the same time in the same station. In most cases this operation perforates a hole or holes down, while the part blanks up. This allows slugs from those holes to fall through the die. This method leaves the part in the die, requiring some means of part removal.

Compound dies commonly run as single-hit dies. They can run continuously with a feeder, provided you can remove the part in a timely manner. Open Back Inclinable (OBI) presses - in the inclined position along with an air blow-off - aid in part removal.

A disadvantage of a compound blank die is its limited space that tends to leave die components thin and weak. This concentrates the load and shock on punches and matrixes, resulting in tooling failures.

Progressive Die

Progressive dies provide an effective way to convert raw coil stock into a finished product with minimal handling. As material feeds from station to station in the die, it progressively works into a completed part.

Progressive dies usually run from right to left. The part material feeds one progression for each press cycle.

Early stations typically perforate holes that serve as pilots to locate the stock strip in later stations.

There are many variations of progressive die designs. The design shown here illustrates some common operations and terminology associated with progressive dies.

Fixed strippers have several drawbacks. They do not hold the stock strip flat and are unable to absorb impact and snap-thru shock. The result is poor part flatness and premature punch failure.
We generally do not recommend fixed strippers for high-volume or high-precision jobs. A typical clearance under the stripper is 1½ times the material thickness - 1/16" to 1/8" is common clearance on the sides of the stock strip.
Clearance under a fixed stripper is commonly 1½ times the part material. This allows for variations in part material thickness and for stock strip deformation.
This deformation allowance under the punch point results in punch point chipping. That deformation can also cause lateral movement of both part and punches, resulting in punch point breakage and poor part quality.
At snap-thru there is a sudden unloading of pressure on the punches and part material. This generates shock, which can lead to punch head breakage.
Note the buckling of the part material throughout the press cycle, as seen in. This can lead to dimensional and functional problems in the finished part.
The buckling effect binds the part on the ends of the punches, which increases stripping pressure and potentially chips the punch face.
Urethane Stripper
Urethane strippers are inexpensive and simple to use. They slide over the end of a punch with a slight press fit, which prevents the stripper from falling into the die during operation.
Through use, urethane strippers fatigue and become loose on the punches. You must continually monitor them to prevent them from falling into and damaging the die. Some urethane strippers are molded with a head designed to fit a standard urethane retainer. This greatly enhances urethane stripper life and reliability.
Deformation and movement of the urethane strippers can move the stock strip or part laterally, creating punch-to-matrix alignment problems.
A urethane stripper strips the part off the ends of the punches as it returns to its original shape. Due to the urethane's pliable nature, the part material may distort during the perforating and stripping process.
Some urethane strippers have a steel washer attached to the end to minimize part distortion. Exercise caution when using this type of urethane stripper on shaped punches or applications where large amounts of pre-load are required. Catastrophic punch failure can occur if the punch face catches the steel face prior to hitting the part material.
The optimum urethane stripper should have a combination of two different grades of urethane: a high hardness grade of urethane for the face and a medium hardness grade for the body. This helps maintain part flatness without sacrificing durability and elasticity.
Spring Stripper
Spring strippers offer superior performance.
Their main advantage is that as the die closes, they hold the stock strip or part flat and in place during perforating. A spring stripper prevents the part material from lifting or hanging up on the punches at withdrawal.
Continuous pressure throughout the working portion of each press cycle provides superior performance in tool reliability, part quality and press life.
Over-entry or closing a die below its recommended shut height can have catastrophic consequences.
To calculate tonnage requirements for perforating, multiply the part material thickness times the length of the cut, or perimeter of the hole, times the material shear strength. Determine the perimeter of a round hole by multiplying pi times the hole diameter.
It is important to include the stripper pressure when calculating die tonnage requirements. Stripper pressure

should be at least 8% of the perforating force. Some die manufacturers require stripper pressure as high as 25% of the perforating pressure.

Punch Stagger

Stagger punch lengths to minimize impact and snap-thru shock. You can split punch lengths into two or three groups, reducing impact and snap-thru shock by half or third.

Common practice is to stagger the different groups of punches by an amount equaling stock thickness. Although this reduces the initial shock, it does not reduce the total shock. Each punch, or group of punches, is exposed to both impact and snap-thru shock.

Making stagger equal to or slightly less than burnish length in the hole being perforated greatly reduces impact and snap-thru shock. This amount of stagger allows the next group of punches to contact the material before the first group snaps through. The snap-thru energy from the first group of punches is absorbed and used to drive the next group of punches through the part material.

Using burnish length instead of material thickness as the amount of stagger is extremely important in high-speed stamping applications. It reduces punch entry to minimize punch wear and slug pulling. Because the punches withdraw from the stock strip sooner, you also gain more feed time.

Piercing

Piercing makes a hole without removing a slug. A sharp or pointed punch tears open a hole, leaving a ragged edge that has been formed down.

A food grater is a good example of what pierced holes look like in a finished product.

Perforate and Shave

Shaving achieves a high percentage of burnish or shear in a hole. Shaving occurs in a two-station operation.

The first station resembles most perforating operations using optimum engineered die clearance. This optimizes tool life while minimizing work hardening of the part material.

The second station cuts the hole to size using tight die clearance.

Determining punch and matrix sizes starts in the shave station. The shave punch point size equals the desired finished hole size. The shave station matrix hole has 1% to 1½% of the material thickness clearance per side (2% to 3% of the material thickness total clearance). Too much clearance in a shave station results in a shear and rebreaking of the hole.

Once you know the shave station component dimensions, you can determine the perforating station component sizes. The perforating matrix equals or is slightly larger than the shave station matrix size. Perforating clearance is as much as possible without generating an excessive burr. This clearance is achieved by reducing the punch point size.

Piloting

Pilots locate the stock strip or part. The pilot working length extends beyond the perforating punches and a fully extended stripper.

The pilot nose picks up an existing hole and moves the stock strip or part into proper location before the stripper makes contact.

Pilot point diameters are commonly dimensioned .001" smaller than the punch point diameter used to perforate the locating hole. This prevents the stock strip or part from sticking.

Proper die clearance for pilots is subject to debate. Many designers maintain a very tight clearance of .0005" or less, incorporating the matrix as a guide below the part material. This offers additional lateral support that results in better part location when forming or working with thick material.

The drawback with tight clearance around a pilot is when a misfeed causes a pilot to perforate a hole. The extreme stripping force created by the tight clearance galls the pilot, possibly pulling it from the retainer. Ball lock pilots are particularly vulnerable to pulling due to misfeeds.

Another practice employed by designers is to use material thickness as the clearance per side around pilots. The intent is to allow enough room around the pilot for the part material to extrude down into the matrix without grabbing the pilot. The problem is that when the material pierces and extrudes down, it tends to spring back resulting in excessive stripping force.

Coining

Coining leaves an impression in the part surface. You can apply this process to one or both sides of the part. In many cases coining is used to thin or displace material. No slug is removed in coining operations.

Embossing

Embossing deforms a shape within the part, but without intentional thinning of the part material.

A punch is used to form material into a blind hole. The punch bottoms out to produce a flat surface at the bottom of the form.

FORMING PROCESS OF FERROUS METALS

Rolling

In metalworking, rolling is a metal forming process in which metal stock is passed through a pair of rolls. Rolling is classified according to the temperature of the metal rolled. If the temperature of the metal is above its recrystallization temperature, then the process is termed as hot rolling. If the temperature of the metal is below its recrystallization temperature, the process is termed as cold rolling. In terms of usage, hot rolling processes more tonnage than any other manufacturing process and cold rolling processes the most tonnage out of all cold working processes.

Hot and Cold Rolling

In smaller operations the material starts at room temperature and must be heated. This is done in a gas- or oil-fired soaking pit for larger workpieces and for smaller workpieces induction heating is used. As the material is worked the temperature must be monitored to make sure it remains above the recrystallization temperature. To maintain a safety factor a finishing temperature is defined above the recrystallization temperature: this is usually 50 to 100°C (122 to 212°F) above the recrystallization temperature.

If the temperature does drop below this temperature the material must be re-heated before more hot rolling. Hot rolled metals generally have little directionality in their mechanical properties and deformation induced residual stresses. However, in certain instances non-metallic inclusions will impart some directionality and workpieces less than 20 mm (0.79 in) thick often have some directional properties. Also, non-uniformed cooling will induce a lot of residual stresses, which usually occurs in shapes that have a non-uniform cross-section, such as I-beams and H-beams. While the finished product is of good quality, the surface is covered in mill scale, which is an oxide that forms at high-temperatures. It is usually removed via pickling or the smooth clean surface process, which reveals a smooth surface. Dimensional tolerances are usually 2 to 5% of the overall dimension.

Flat Rolling

Flat rolling is the most basic form of rolling with the starting and ending material having a rectangular cross-section. The material is fed in between two rollers, called working rolls, that rotate in opposite directions. The gap between the two rolls is less than the thickness of the starting material, which causes it to deform. The decrease in material thickness causes the material to elongate. The friction at the interface between the material and the rolls causes the material to be pushed through.

Ring Rolling

Ring rolling is a specialized type of hot rolling that increases the diameter of a ring. The starting material is a thick-walled ring. This workpiece is placed on an idler roll, while another roll, called the driven roll, presses the ring from the outside. As the rolling occurs the wall thickness decreases as the diameter increases. The rolls may be shaped to form various cross-sectional shapes. The resulting grain structure is circumferential, which gives better mechanical properties. Diameters can be as large as 8 m (26 ft) and face heights as tall as 2 m (79 in). Common applications include rockets, turbines, airplanes, pipes, and pressure vessels. Structural shape rolling Cross-sections of continuously rolled structural shapes, showing the change induced by each rolling mill.

Shape

The term shape is used to describe the flatness and the profile of the workpiece. The profile consists of the how the thickness of the workpiece varies across the width of the workpiece and can be measured in units of length. The flatness of the workpiece is based on how the fiber elongation varies across the width of the workpiece and it typically measured in I-Units.

Another way to overcome defection issues is by decreasing the load on the rolls, which can be done by applying an longitudinal force: this is essentially drawing. Other method of decreasing roll defection include increasing the elastic modulus of the roll material and adding back-up supports to the rolls.

Equipment

A horizontal hydraulic press for hot aluminum extrusion (loose dies and scrap visible in foreground).

Indirect Extrusion

In indirect extrusion, also known as backwards extrusion, the billet and container move together while the die is stationary. The die is held in place by a "stem" which has to be longer than the container length. The maximum length of the extrusion is ultimately dictated by the column strength of the stem. Because the billet moves with the container the frictional forces are eliminated.

Drives

Accumulator water drives are more expensive and larger than direct-drive oil presses, and they lose about 10% of their pressure over the stroke, but they are much faster, up to 380 mm/s (15 psi). Because of this they are used when extruding steel. They are also used on materials that must be heated to very hot temperatures for safety reasons.

Hydrostatic extrusion presses usually use castor oil at pressure up to 1400 MPa (200 ksi). Castor oil is used because it has good lubricity and high pressure properties.

Production forging involves significant capital expenditure for machinery, tooling, facilities and personnel. In the case of hot forging, a high temperature furnace (sometimes referred to as the forge) will be required to heat ingots or billets. Owing to the massiveness of large forging hammers and presses and the parts they can produce, as well as the dangers inherent in working with hot metal, a special building is frequently required to house the operation. In the case of drop forging operations, provisions must be made to absorb the shock and vibration generated by the hammer. Most forging operations will require the use of metal-forming dies, which must be precisely machined and carefully heat treated to correctly shape the workpiece, as well as to withstand the tremendous forces involved.

Press Forging

We specifically know what kind of strain can be put on the part, because the compression rate of the press forging operation is controlled. There are a few disadvantages to this process, most stemming from the workpiece being in contact with the dies for such an extended period of time. The operation is a time consuming process due to the amount of steps and how long each of them take. The workpiece will cool faster because the dies are in contact with workpiece; the dies facilitate drastically more heat transfer than the surrounding atmosphere. As the workpiece cools it becomes stronger and less ductile, which may induce cracking if deformation continues. Therefore heated dies are usually used to reduce heat loss, promote surface flow, and enable the production of finer details and closer tolerances.

Roll Forging

The work piece is then transferred to the next set of grooves or turned around and reinserted into the same grooves. This continues until the desired shape and size is achieved. The advantage of this process is there is no flash and it imparts a favorable grain structure into the workpiece.

Bottoming

In bottoming, the sheet is forced against the V opening in the bottom tool. U-shaped openings cannot be used. Space is left between the sheet and the bottom of the V opening. The optimum width of the V opening is 6 T (T stands for material thickness) for sheets about 3 mm thick, up to about 12 T for 12 mm thick sheets. The bending radius must be at least 0.8 T to 2 T for sheet steel. Larger bend radius require about the same force as larger radii in air bending, however, smaller radii require greater force-up to five times as much-than air bending. Advantages of bottoming include greater accuracy and less springback. A disadvantage is that a different tool set is needed for each bend angle, sheet thickness, and material. In general, air bending is the preferred technique.

MACHINING PROCESS OF FERROUS METALS

Chucking the Workpiece

We will be working with a piece of 3/4" diameter 6061 aluminum about 2 inches long. A workpiece such as this which is relatively short compared to its diameter is stiff enough that we can safely turn it in the three jaw chuck without supporting the free end of the work.

For longer workpieces we would need to face and center drill the free end and use a dead or live center in the tailstock to support it. Without such support, the force of the tool on the workpiece would cause it to bend away from the tool, producing a strangely shaped result. There is also the potential that the work could be forced to loosen in the chuck jaws and fly out as a dangerous projectile.

Turning with Power Feed

One of the great features of the 7x10 is that it has a power lead screw driven by an adjustable gear train. The leadscrew can be engaged to move the carriage under power for turning and threading operations. Turning with power feed will produce a much smoother and more even finish than is generally achievable by hand feeding. Power feed is also a lot more convenient than hand cranking when you are making multiple passes along a relatively long workpiece.

The power feed is engaged by the knurled tumbler gear lever on the back of the headstock. To change the lever setting you must pull back on the knurled sleeve with considerable force. With the sleeve pulled back you can move the lever up and down to engage its locking pin in one of three positions. In the center position the lead screw is not engaged and does not turn. In the upper position the lead screw rotates to move the carriage towards the headstock and in the lower position the lead screw moves the carriage away from the headstock. For turning, you will generally want to cut towards the headstock, so move the lever to the upper position and release the sleeve to engage the locking pin.

Grinding is a subset of cutting, as grinding is a true metal-cutting process. Each grain of abrasive functions as a microscopic single-point cutting edge (although of high negative rake angle), and shears a tiny chip that is analogous to what would conventionally be called a "cut" chip (turning, milling, drilling, tapping, etc.).

Cylindrical Grinding

Cylindrical grinding (also called center-type grinding) is used in the removing the cylindrical surfaces and shoulders of the workpiece. The workpiece is mounted and rotated by a workpiece holder, also known as a grinding dog or center driver.

Effects on Workpiece Materials

Mechanical properties will change due to stresses put on the part during finishing. High grinding temperatures may cause a thin martensitic layer to form on the part, which will lead to reduced material strength from microcracks.

Threading

Threading is the process of creating a screw thread. More screw threads are produced each year than any other machine element.

Single-Point Threading

Single-point threading, also colloquially called single-pointing (or just thread cutting when the context is implicit), is an operation that uses a single-point tool to produce a thread form on a cylinder or cone. The tool moves linearly while the precise rotation of the workpiece determines the lead of the thread.

The cutter geometry reflects the thread pitch but not its lead; the lead (thread helix angle) is determined by the tool path. Tapered threads can be cut either with a tapered multiple-form cutter that completes the thread in one revolution using helical interpolation, or with a straight or tapered cutter (of single- or multiple-form) whose tool path is one or more revolutions but cannot use helical interpolation and must use CAD/CAM software to generate a contour-like simulation of helical interpolation.

Thread Grinding

Then the blank is slowly rotated through approximately 1.5 turns while axially advancing through one pitch per revolution. Finally, the centerless thread grinding process is used to make head-less set screws in a similar method as centerless grinding. The blanks are hopper-fed to the grinding wheels, where the thread is fully formed. Common centerless thread grinding production rates are 60 to 70 pieces per minute for a 0.5 in (13 mm) long set screw.

Additive Methods

Many, perhaps most, threaded parts have potential to be generated via additive manufacturing, of which there are many variants, including fused deposition modeling, direct metal laser sintering, 3D printing, solid free form fabrication, layered object manufacturing, and stereolithography. Most additive technologies are still on the laboratory end of their historical development, but further commercialization is picking up speed.

Uses

For instance, a 15-inch drilling machine can center-drill a 30-inch-diameter piece of stock. Other ways to determine the size of the drill press are by the largest hole that can be drilled, the distance between the spindle and column, and the vertical distance between the worktable and spindle

Care of Drilling Machines

Lubrication

Lubrication is important because of the heat and friction generated by the moving parts. Follow the manufacturer's manual for proper lubrication methods. Clean each machine after use. Clean T-slots, grooves, and dirt from belts and pulleys. Remove chips to avoid damage to moving parts. Wipe all spindles and sleeves free of grit to avoid damaging the precision fit. Put a light coat of oil on all unpainted surfaces to prevent rust. Operate all machines with care to avoid overworking the electric motor.

Power-Feed

The power-feed drilling machines are usually larger and heavier than the hand-feed. They are equipped with the ability to feed the cutting tool into the work automatically, at a preset depth of cut per revolution of the spindle, usually in thousandths of an inch per revolution.

Common twist drill sizes range from 0.0135 (wire gage size No. 80) to 3.500 inches in diameter. Larger holes are cut by special drills that are not considered as twist drills. The standard sizes used in the United States are the wire gage numbered drills, letter drills, fractional drills, and metric drills. Twist drills can also be classified by the diameter and length of the shank and by the length of the fluted portion of the twist drill.

The margin is the narrow surface along the flutes that determines the size of the drill and keeps the drill aligned.

The portion of the drill body that is relieved behind the margin is known as the body clearance. The diameter of this part is less than that of the margin and provides clearance so that all of the body does not rub against the side of the hole and cause friction. The body clearance also permits passage of lubricants around the drill.

Drill Point

When grinding the lip angle, use the drill point gage and grind one lip perfectly straight and at the required angle (usually 590). Then flip the drill over and grind the other lip. Once the angle is established, then the lip clearance angle and lip length can be ground. If both lips are not straight and of the same angle, then the chisel edge will not be established. It is it important to have a sharp and centered chisel edge or the drill will not rotate exactly on its center and the hole will be oversized. If the drill point is too flat, it will not center properly on the workpiece.

Drill Drifts

Drill drifts are flat, tapered keys with one rounded edge that are designed to fit into a spindle chuck's slot to force a tapered shank drill loose. The rounded top of the small end of the drill drift is designed to face upward while inserting the drift into the slot. There are two types of drill drifts, the standard type and the safety type. The standard drift must be inserted into the chuck's slot and then struck with a soft hammer to jar the taper shank drill loose. The drill will fall quickly if not held by the hand and could break or cause injury. The safety drill drift has a sliding hammer weight on the drift itself to allow for a free hand to stay constantly on the drill as it comes loose.

Table or Base Mounting

When a workpiece is table or base mounted, the strap clamps must be as parallel to the table or base as possible. All bolts and strap clamps should be as short as possible for rigidity and to provide for drilling clearance.

Parallel bars should be set close together to keep from bending the work. Washers and nuts should be in excellent condition. The slots and ways of the table, base, or vise must be free of all dirt and chips. All work holding devices should be free of burrs and wiped clean of oil and grease. Work holding devices should be the right size for the job. Devices that are too big or too small for the job are dangerous and must be avoided.

Drilling Round Stock

When drilling shafts, rods, pipes, dowels, or other round stock, it is important to have the center punch mark aligned with the drill point. Use V-blocks to hold the round stock for center punching and drilling. Align the center of the round stock with a square or by lining the workpiece up with the twist drill point. Another method to drill round stock is to use a V-block drill jig that automatically centers the work for drilling.

JOINING PROCESS OF FERROUS METALS

Until relatively recently, structural steel connections were either welded or riveted. High-strength bolts have completely replaced structural steel rivets. Indeed, the latest steel construction specifications published by AISC (the 13th Edition) no longer covers their installation. The reason for the change is primarily due to the expense of skilled workers required to install high Strength structural steel rivets. Whereas two relatively unskilled workers can install and tighten high strength bolts, it took a minimum of four highly skilled riveters to install rivets in one joint at a time.

Blind rivets, also known as pop rivets, are tubular and are supplied with a mandrel through the center. The rivet assembly is inserted into a hole drilled through the parts to be joined and a specially designed tool is used to draw the mandrel into the rivet. This expands the blind end of the rivet and then the mandrel snaps off. These types of blind rivets have non-locking mandrels and are avoided for critical structural joints because the mandrels may fall out, due to vibration or other reasons, leaving a hollow rivet that will have a significantly lower load carrying capability than solid rivets. Furthermore, because of the mandrel they are more prone to failure from corrosion and vibration. Unlike solid rivets, blind rivets can be inserted and fully installed in a joint from only one side of a part or structure, "blind" to the opposite side.

Joint Analysis

The stress and shear in a rivet is analyzed like a bolted joint. However, it is not wise to combine rivets with bolts and screws in the same joint. Rivets fill the hole where they are installed to establish a very tight fit (often called interference fit). It is difficult or impossible to obtain such a tight fit with other fasteners. The result is that rivets in the same joint with loose fasteners will carry more of the load-they are effectively more stiff. The rivet can then fail before it can redistribute load to the other loose fit fasteners like bolts and screws.

The welding processes covered in this chapter are gas welding, arc welding which includes manual metal arc welding (MMA), tungsten inert gas shielded arc welding (TIG), gas metal arc welding (MIG, MIG/CO2), submerged arc welding is (SAW), etc. High energy density processes like electron beam welding, laser beam welding, plasma welding are also dealt with. Pressure welding and some special welding techniques like electro-slag welding etc. are also discussed in detail. The broad classification of the welding processes.

Submerged arc welding (SAW)

Submerged arc welding is a method in which the heat required to fuse the metal is generated by an electric current passing through between the welding wire and the work piece. The tip of the welding wire, the arc and the weld area are covered by a layer of granular flux. A hopper and a feeding mechanism are used to provide a flow of flux over the joint being welded.

MIG welding (gas metal arc welding)

Gas metal arc welding is a gas shielded process that can be effectively used in all positions. The shielding gas can be both inert gas like argon and active gases like argon-oxygen mixture and argon-carbon-di-oxide which are chemically reactive. It can be used on nearly all metals including carbon steel, stainless steel, alloy steel and aluminium. Arc travel speed is typically 30-38 cm minute and weld metal deposition rate varies from 1.25 kg/hr when welding out of position to 5.5 kg/hr in flat position.

Plasma Welding

Since too powerful a jet would cause a turbulence in the molten puddle, the jet effect on the work piece is softened by limiting gas flow rates through the nozzle. Since this flow alone may not be adequate to protect the molten puddle from atmospheric contamination, auxiliary shielding gas is provided through an outer gas cup on the torch.

The molten metal flowing around the keyhole forms a reinforced weld bead. Square butt joints upto 6 mm thick can be welded in a single pass by this method.

For heavier plates which require multi-pass welding partial beveling is done and the root pass of the largest size is deposited with the key hole technique without using filler wire. The rest of the passes are then carried out with normal melt-in technique with filler wire addition. PAW process is limited to around 25 mm thick plates.

PRODUCTION OF STAINLESS STEEL WIRE

Melting Process

The involved process of manufacturing precision stainless steel wire begins at the melt shop. The initial melt is composed of controlled scrap, processed ores and virgin pure metallic elements. When charged into a furnace, melting is accomplished by high-power electric arcs transferred from graphite electrodes. Once molten, the entire batch or heat is given a unique alphanumeric identity and tapped into a waiting preheated ladle for transfer to a secondary refining operation.

Once cooled into a straight billet, each length of the billet is identified to maintain necessary trace-ability from melt all the way through to finished wire. Each billet is often times visually inspected for surface consistency to ensure that no abnormal surface irregularities were formed during the continuous-casting process. Depending on the condition found, billets may be spot surface ground to blend or remove irregularities that could otherwise contribute to rolling defects.

Production of Spring Wire

A majority of spring wire products begins with hot-rolled and solution-annealed wire rod that has been de-scaled and acid cleaned. The resultant consistent white pickled finish is now ready for conversion into high-

quality drawn wire.
Spring manufacturing is also a demanding process. It requires a wire starting stock that is manufactured with the utmost consistency in size, and mechanical and physical properties, as specified as part of an order or specification.
By keeping variations to a minimum, the springmaker can realize a much greater degree of consistency in the coil winding operation, where free length and coil OD are held in close control.
Spring wire can be produced in a wide variety of specialty alloys. Applications for these special grades may include springs for high heat resistance, corrosion resistance and other high-performance attributes needed in the automotive, aerospace, chemical and process industries.
In addition to common stainless steel types 302/304, 316 and 17-7PH, other exotic stainless grades can bring added benefits. Duplex stainless steel UNS S32205 or 2205 alloy is a grade that combines the properties of austenitic and ferritic stainless steels.
Wire Drawing
Drawing is usually performed at room temperature, thus classified as a cold working process, but it may be performed at elevated temperatures for large wires to reduce forces. More recently drawing has been used with molten glass to produce high quality optical fibers.
Process
The American wire gauge scale is based on this. This can be done on a small scale with a draw plate, or on a large commercial scale using automated machinery. The process of wire drawing improves material properties due to cold working.
The areal reduction of small wires is 15-25% and larger wires are 20-45%. Very fine wires are usually drawn in bundles. In a bundle, the wires are separated by a metal with similar properties, but with lower chemical resistance so that it can be removed after drawing. If the reduction in diameter is greater than 50%, the process may require annealing between the process of drawing the wire through the dies.
Commercial wire drawing usually starts with a coil of hot rolled 9 mm (0.35 in) diameter wire. The surface is first treated to remove scales. It is then fed into either a single block or continuous wire drawing machine.
The block is also tapered, so that the coil of wire may be easily slipped off upwards when finished. Before the wire can be attached to the block, a sufficient length of it must be pulled through the die; this is effected by a pair of gripping pincers on the end of a chain which is wound around a revolving drum, so drawing the wire until enough can be coiled two or three times on the block, where the end is secured by a small screw clamp or vice. When the wire is on the block, it is set in motion and the wire is drawn steadily through the die; it is very important that the block rotates evenly and that it runs true and pulls the wire at a constant velocity, otherwise "snatching" occurs which will weaken or even break the wire. The speeds at which wire is drawn vary greatly, according to the material and the amount of reduction.
Often intermediate anneals are required to counter the effects of cold working, and to allow further drawing. A final anneal may also be used on the finished product to maximize ductility and electrical conductivity.
An example of product produced in a continuous wire drawing machine is telephone wire. It is drawn 20 to 30 times from hot rolled rod stock.
While round cross-sections dominate most drawing processes, non-circular cross-sections are drawn. They are usually drawn when the cross-section is small and quantities are too low to justify rolling. In these processes, a block or Turk's-head machine are used.
Lubrication in the drawing process is essential for maintaining good surface finish and long die life.
Mechanical Properties
The strength-enhancing effect of wire drawing can be substantial. The highest gruel strengths available on any steel have been recorded on small-diameter cold-drawn austenitic stainless wire. Tensile strength can be as high as 400 ksi (3760 MPa).)

Drawing dies are typically made of tool steel, tungsten carbide, or diamond, with tungsten carbide and manufactured diamond being the most common. For drawing very fine wire a single crystal diamond die is used. For hot drawing, cast-steel dies are used. For steel wire drawing, a tungsten carbide die is used. The dies are placed in a steel casing, which backs the die and allow for easy die changes. Die angles usually range from 6-15º and each die has at least 2 different angles: the entering angle and approach angle. Wire dies usually are used with power as to pull the wire through them. There are coils of wire on either end of the die which pull and roll up the wire with a reduced diamet.

PRODUCTION OF STEEL BARS

Steel is a metal alloy containing iron, carbon and other metals. Steel bars, which are used to reinforce concrete work, come in different shapes, strengths and sizes. They are built through different methods. Steel is non-combustible, but it starts to lose strength when temperatures reach 750 degrees Fahrenheit. Common types of steel bars include hot rolled bars, cold twisted deformed bars and TMT bars.

Hot Rolled Bars

Hot rolled bars are round, have a smooth surface and are made by a method called hot rolling, which consists of transforming a piece of steel into a cylindrical bar by rolling it when still hot. Hot rolled bars can also have ribbed surfaces, which increases the bond strength of the pieces.

Cold Twisted Deformed Bars

These bars are first hot rolled with three or more parallel ribs or indentations. When cooled, the bars are twisted, thus straining the steel's elastic limit this helps to make the bar stronger. However, cold twisted deformed bars corrode much more quickly than other bars because of the hot-cold method by which they are produced.

As deformed bars are rods of steels provided with lugs, ribs or deformation on the surface of bar, these bars minimize slippage in concrete and increases the bond between the two materials. Deformed bars have more tensile stresses than that of mild steel plain bars. These bars can be used without end hooks. The deformation should be spaced along the bar at substantially uniform distances.

To limit cracks that may develop in reinforced concrete around mild steel bars due to stretching of bars and some lose of bond under load it is common to use deformed bars that have projecting ribs or are twisted to improve the bond with concrete. These bars are produced in sections from 6 mm to 50 mm dia. In addition the strength of bonds of deformed bars calculated should be 40 to 80% higher than that of plain round bars of same nominal size. And it has more tensile stress than that of plain round bars of same nominal size. Cold twisted deformed (Ribbed or Tor Steel Bars) bars are recommended as best quality steel bars for construction work by structural Engineer.

Various Grades of Mild Steel Bars

Some of manufacturers stamped MS bars grade with their make/name and also give certification of test and grade. On the basis of the above information you can store mild steel bars grade-wise at the site of work.

Steel Bars for RCC Work

All finished steel bars for reinforced work should be neatly rolled to the dimension and weights as specified. They should be sound, free from cracks, surface flaws, laminations, rough, jagged and imperfect edges and other defects. It should be finished in a work manlike manner.

Weight of Different Steel Bars

When we want to purchase Mild steel members from the market, the shopkeeper quotes the price of steel members in weight. When any type of steel members for use in house construction is required, we calculate the length of steel member in feet or meter but we are ignorant about the weight of steel.

Here are details of weight per meter for various types of steel members :

Types of Cold Finished Bars

Cold drawn bars are widely used in mass production of parts due to their excellent mechanical and dimensional properties, with machining characteristics in excess of the hot rolled bar condition. Round, hexagonal and square bars can be produced by cold drawing.

Turned and polished round bars have similar mechanical properties to those of equivalent hot rolled bar, but exhibit a smooth, bright surface finish and improved dimensional accuracy. They are widely used where a surface free of decarburisation is required, for example in induction hardening and when the surface must be free from surface defects, such as for use in cold forming.

Production Flow

To meet the diversified end-use requirements, cold-rolled coil is designed to provide specific attributes such as high formability, deep drawability and good paintability. How those good attributes come will be explained by the following steps.

Pickling

Continuous Pickling Line

The cold reduction operation induces very high strains into the sheet, thus, the sheet not only becomes thinner, but also becomes much harder, less ductile. However, after the cold-reduced product is annealed, it becomes very soft and formable. In fact, the combination of cold reduction and annealing lead to a refinement of the steel that provides very desirable and unique forming properties for subsequent use by the customers.

The pickling operation must be well-controlled to assure that all the oxides formed during hot rolling are removed. The thickness of the hot-rolled strip is important in that the properties of the final cold rolled and annealed product is influenced by the cold reduction. This means that the thickness of each hot-rolled coil is carefully controlled to provide the mill with a specific thickness to achieve the proper cold reduction. Among other things, cold reduction affects the forming behavior of the product after annealing.

After the steel is batch annealed, the specific properties of the steel sheet depends on the steel chemistry, the temperatures used during hot rolling, the amount of cold reduction, and the annealing cycle.

In the method of annealing, the steel is maintained under a protective (non-oxidizing) atmosphere using hydrogen and nitrogen to prevent oxidizing the steel while it is at high temperature. In addition to preventing oxidation, the protective atmosphere is designed to clean the steel breaking down the oils that are present after cold rolling and entraining the oil vapors in the hydrogen/nitrogen gases that are passed through the furnace.

Skin Pass

After annealed, the steel coil is most often processed by passing it through a set of rolls that appear similar to the rolls used during cold rolling, in fact, skin pass does impart a small amount of cold reduction, typically between 0.25 and 1.0 percent.

Warehousing

After those processes are finished, the following work will involve packing steel coils after being done in skin pass mill. Those coils are moved into the warehouse waiting for loading.

PRODUCTION OF STEEL TUBE AND PIPE

In the case of seamless tube and also in the case of the Fretz-Moon welding process, the production stage invariably involves a heating operation, in which case the product may also be referred to as hot-formed tube or pipe. Downstream facilities for hot drawing or hot expanding occur relatively rarely; on the other hand, hot-formed tubes are extensively used as starting products for a downstream cold forming process. The latter is used in order to extend the product mix of a plant toward smaller diameters and wall thicknesses (DIN 2391), to reduce wall thickness and diameter tolerances, and to achieve special surface finishes or mechanical/thermo-mechanical properties in the tube.

As the requirements imposed on tubular products continued to increase, not only were the associated manufacturing processes constantly improved, but also appropriate systems for effective production control

and quality assurance were introduced. Nowadays, tube and pipe manufacturers of renown all have a system in place enabling the production process from the steelworks to the finished tube to be continuously monitored and documented for total traceability, and effectively controlled on the basis of quality criteria.
The mechanical and nondestructive tests stipulated in the relevant technical specifications are carried out by personnel operating independently from the production control department so as to guarantee product of a constantly high quality.
Another possibility for the production of seamless tube was invented by H. Ehrhardt. By piercing a solid square ingot in a round die, he was able to produce a thick-walled hollow shell with a closed bottom. This shell was subsequently stretched on a mandrel bar through tandem-arranged ring dies to produce the final tube dimensions. This so-called push bench process in its modified form has remained viable to this very day.
Pierce and Pilger Rolling Process
The pierce and pilger method for the production of seamless pipe is also referred to as the Mannesmann process after its inventors, the Mannesmann brothers. Pipe diameters above the rolling range indicated can also be produced by expansion. To this end, the largest rolled pipes are reheated and then expanded either by pulling through a plug - a process often performed in several passes to gradually increase the outside diameter - or by rolling on a becking mill. Whichever of the two processes is employed, the wall thickness is, of course, also reduced.
With small pilger mills for manufacturing the lower size range, the two-stage rolling process is still employed today. The starting material takes the form of round rolled steel blooms, although round ingots are still frequently used. Round conticast billets measuring between 100 to approx. 300 mm in diameter are also being increasingly employed.
The piercing mill features two specially contoured work rolls which are driven in the same direction of rotation. Their axes are inclined by approx. 3 to 6° in relation to the horizontal stock plane. Generally, the roll gap is closed by a non-driven support roll at the top and a support shoe at the bottom. Located at the centre of the roll gap is a piercing point which functions as an internal tool and is held in position by an external thrust block via a mandrel.
Push Bench Process
This process is also known as the rotary forge process, and - in Germany - after the name of its inventor, as the Ehrhardt process. It is employed for the manufacture of tube in the diameter range from approx. 50 to 170 mm with wall thicknesses from 3 to 18 mm and lengths up to 18 m. Modern push bench plants usually only produce one (large) hollow bloom size, leaving a downstream stretch-reducing mill to convert this into all the usual tube dimensions down to a smallest outside diameter of approx. 20 mm.
Arranged in the foundation bed of the push bench are up to 15 roll stands. The roll stands usually comprise three (sometimes four) circumferentially distributed, non-driven grooved rollers. The gradually decreasing cross sections of the roller passes produce reductions which, in the main work passes, can amount to up to 25%. During this process, between 6 and 7 roll stands are simultaneously in operation at any one time. The push force is applied to the mandrel bar by a rack-and-pinion arrangement, and operating speeds can be up to 6 m/s.
Pierce and Draw Process
This process, also developed by H. Ehrhardt, is similar to the push bench variant but, unlike the technologies described so far, is not suitable for mass production. Consequently, therefore, the number of plants employing this process is quite small. These, however, are specially designed for the manufacture of seamless hollow components combining large diameters with large wall thicknesses.
The production range of such facilities lies between approx. 200 and 1450 mm in outside diameter, with wall thicknesses ranging from approx. 20 to 270 mm. This therefore provides an effective complement to

the product mix available in large pilger mills. With a maximum length of around 10 m, tube blanks and hollow sections can be manufactured (in all steel grades), by this process for items such as power plant components, hydraulic cylinders, high-pressure gas cylinders and pressure vessels, as can products such as thick-walled square section tubes.

Assel Rolling Process

Assel mills are used nowadays to produce stainless tube with outside diameters ranging from 60 to 250 mm and lengths of up to 12 m. The ratio of outside diameter to wall thickness tends to lie in the region 4 to 15. The smallest inside diameter of the tubes is approx. 40 mm. The tubes manufactured by this method are characterized by their excellent concentricity and are extensively employed in the production of turned components (shafts, axles) and also for medium-alloy steel roller bearing production (general product name: mechanical tube).

The starting material predominantly takes the form of round steel blooms of the appropriate length which are heated to forming temperature in a rotary hearth furnace. Following descaling and end face centering, the bloom is formed into a hollow shell in the cross roll piercing mill and then fed into the Assel mill.

Although Diescher mills have not enjoyed wide market penetration as elongating or finish-rolling facilities, modern cross roll piercing mills are nowadays being equipped more and more with Diescher discs (see continuous mandrel process and plug rolling/MPM process).

Cold Drawing

Seamless precision steel tube has been standardized in DIN 2391 for the diameter range from 4 to 120 mm and wall thicknesses from 0.5 to 10 mm. In addition, however, non-standardized intermediate sizes, and tube up to 380 mm outside diameter with wall thicknesses up to 35 mm, can also be manufactured by cold drawing.

These predominantly take the form of draw benches equipped with a continuous chain; or draw benches with reversible finite drawing and return chains attached to the drawing carriage. Other designs include rope-type draw benches, rack and pinion draw benches and also draw benches with a hydraulic drive system.

Large tube lengths are generally drawn using a floating plug on continuous-type straight-line machines in which two reciprocating sledges alternate in the performance of the drawing operation. Tube of small diameter is usually cold-drawn by the bull block process in which the stock is taken from a coil and the drawing power is applied by a capstan.

The pass design of the two rolls consists of a circular recess, corresponding to the cross section of the hollow blank, which tapers over a certain portion of the roll circumference to provide an ideal, continuous transition to the finished tube diameter. Consequently, as the rolls move forward and backward, the hollow blank is formed in the desired manner. An essential aspect of the process lies in the fact that elongation of the hollow blank to produce the finished tube is performed by simultaneous reduction of the diameter and the wall thickness. This is aided by the shape of the mandrel which tapers from the hollow blank inside diameter to the finished tube inside diameter. Following a forward and backward rolling cycle, the rolls release the blank which is then advanced by a certain, infinitely variable feed value. The corresponding material volume is then elongated with the subsequent forward and backward rolling cycle executed by the stand.

Aside from this hot pressure welding technique, in which the strip is heated in a furnace to welding temperature, several other processes were devised by the American E. Thomson between the years 1886 and 1890 enabling metals to be electrically welded. The basis for this was the property discovered by James P. Joule whereby passing an electric current through a conductor causes it to heat up due to its electrical resistance.

The starting material can be formed into its tubular shape in either the hot or cold condition. A distinction is

made in this respect between continuous tube forming and the single tube forming process.
In continuous tube forming, uncoiled strip material is taken from an accumulator, with the leading end and trailing end of the consecutive coils being welded together.
In single pipe production, the tube forming and welding process is not performed over endless lengths, but rather (as the name suggests) in single pipe lengths.
The main methods used for the production of welded tube and pipe are the Fretz-Moon, high-frequency induction, submerged-arc and combination gas-shielded submerged-arc processes, plus the various gas-shielded welding methods for the production of stainless steel tube and pipe.

Pressure Welding Processes

Fretz-Moon Process

In this process, named after its inventors, steel strip in the form of a continuous skelp is heated to welding temperature in a forming and welding line. The stock is continuously formed by rollers into an open-seam tube and then the mating edges are pressed together and welded by a process related to the forge-welding technique of old.
The hot-rolled steel strip coils used as the starting material are uncoiled at high speed and stored in loop accumulators. These serve as a buffer during the continuous production process, enabling the trailing end to be butt-welded to the leading end of the strip provided by the next coil. This continuous strip or "skelp" is taken through a tunnel furnace where it is heated to a high temperature. Laterally arranged burners increase the temperature at the skelp edges to a welding heat approx. 100 to 150°C higher than the temperature prevailing at the skelp centre.

Low-Frequency Process

In this process, welding is performed with alternating current frequencies from 50 to 400 Hz. An electrode comprising two insulated discs of a copper alloy serves not only as the power supply but also as the forming tool and the element which generates the necessary welding pressure.
The electrodes constitute the critical components of the plant, because not only must they be provided with a groove which matches the diameter of the tube being manufactured, but also this radius has to be constantly monitored for wear during production operations.
The material extruded during the pressure welding process forms an inner and outer flash along the weld zone which has to be removed inline just downstream of the welding point by internal and external trimmers.
The welding current can be introduced into the open-seam tube both by conductive means using sliding contacts and by inductive means using single or multi-wind coils. Consequently, a distinction is made in the nomenclature between high-frequency induction (HFI) welding and high-frequency conduction welding. The strip or skelp is shaped in a roll forming mill or in an adjustable roll stand (natural function forming) into the open-seam tube for the manufacture of a wide range of products. These include line pipe and structural tube in the size range from approx. 20 to 609 mm OD and 0.5 to approx. 16 mm wall thickness, and also tube blanks as the feedstock for a downstream stretch-reducing mill. The starting stock is provided in the form of coiled steel strip or hot-rolled wide strip. Depending on the tube dimensions and application, and particularly in the manufacture of precision tube, the steel strip may either undergo an upstream pickling operation, or cold-rolled strip is used. The individual coils are welded together and, at high uncoiling speeds, the strip first passes through a loop accumulator. The tube welding machine operates continuously at a speed ranging from 10 to 120 m/min by drawing the strip from the loop accumulator.
The roll forming mill is used for tube diameters up to max. 609 mm, and generally consists of 8 to 10 largely driven roll forming stands in which the strip is gradually shaped into the open-seam tube-as indicated in stages 1 to 7 in Fig. 29. The three fin pass stands - 8, 9 and 10 - guide the open-seam tube toward the welding table. The forming rolls have to be precisely matched to the final tube diameter. For the

manufacture of large-diameter pipe, the natural function forming process may also be applied. Fig. 30 shows the principles of this forming process involving a series of roll stands (roller cages).

The main features of the roller cage is that a number of non-driven internal and external forming rollers, adjustable within a wide product diameter range, are configured in a funnel-shaped forming line which gradually bends the strip into the open-seam tube shape. Only the breakdown stand at the inlet and the fin pass stands at the exit end are actually driven. The cross-sectional details A-B, C-D and E-F in Fig. 30 indicate the degree of deformation and the arrangement of the forming rollers at various sections along the line.

Before the strip enters the forming section, it is straightened and cut to a constant width by a longitudinal edge trimmer. The cut edges may be additionally bevelled for welding preparation. The strip is then formed into an open-seam tube as described above, and with the gap still relatively wide, fed via three or four fin pass stands to the welding table. The overhead fin rolls, the width of which is tapered toward the welding point, determine the gap entry angle and control its central position in the welding table. There the converging strip edges are pushed against each other by shaped squeeze rolls and then welded by means of the high-frequency electric resistance process.

The HF pressure weld can either be left in its as-welded condition or subsequently heat-treated in the normalizing range, depending on the application. Partial inductive annealing of the weld may also be performed on the continuous tube, or the individual tubes may be subjected to a separate heat treatment following cutting to length, depending on the material flow conditions within the plant.

In the subsequent tube finishing department, the tubes are further processed on straightening machines. The straightening operation may be preceded by a heat treatment, depending on the tube dimensions and application. Nondestructive examination facilities and the performance of a visual inspection serve to monitor the production process. Once completed, the tubes are subjected to the relevant, specified acceptance procedures irrespective of the in-process tests and inspections performed on them.

High-Frequency Induction Welding Process

In the high-frequency induction welding process (HFI or Induweld process), welding speeds of up to 120 m/min may be attained, depending on wall thickness and application.

The open-seam tube 1 to be welded is introduced in the direction of the arrow to the welding table where it is engaged by the squeeze rolls 5. These initially press together the incoming open seam edges approaching at angle 2. The high-frequency current supplied by the welding generator 4 forms an electro-magnetic field around the induction coil 3 which induces an AC voltage in the open-seam tube corresponding to a current travelling around the tube circumference.

Any increase in the rate of deposition beyond this limit requires the employment of several wire electrodes. This then allows a higher overall current to be applied for the welding work without the danger of the current carrying capacity of the flux being exceeded at any of the individual wire electrodes. In practical operations, increased performance is obtained by employing a multi-wire welding configuration with 2, 3 or 4 electrodes.

The MAG process is being increasingly used for tack-welding in the manufacture of spiral and longitudinally welded large-diameter pipe. The tack weld also serves as the weld pool backing for the subsequent submerged-arc welding process. The prerequisites for an optimum weld are a precise edge preparation (double-V butt joint with wide root faces) and a good, continuous tack weld. In large-diameter pipe production, the welding speeds for the tack weld range from approx. 5 to 12 m/min.

The Production of Longitudinally Welded Pipe (U-ing/O-ing process)

The plates employed for longitudinally welded pipe are formed on presses featuring open dies for the U-ing and closed dies for the O-ing operation. The process is also sometimes referred to as the UOE process (U-ing, O-ing, Expanding) and is applied in the manufacture of longitudinally welded large-diameter pipe in individual lengths up to 18 m. Depending on the material and diameter, the wall thicknesses range from 6 to 40 mm. The starting material invariably takes the form of steel plate as indicated above.

Spiral Pipe Production with Separate Forming and SAW Welding Lines

A special roller table rotates the pipe in precise accordance with its spiral joint, so enabling the SAW welding heads to perform first the inside and then the outside passes. Precise weld centerline alignment control of the inside and outside welding heads is required in this operation in order to minimize weld offset. The two- or three-wire method is employed for the inside and outside pass welding operations.

Aside from a few modifications, the subsequent production stages such as pipe end machining, hydrostatic testing and also the nondestructive examinations and mechanical tests, are in principle the same as those applied in the conventional spiral pipe manufacturing process.

Here again, a high standard of quality is achieved by in-process quality control activities which are performed after every stage of production. The results of these tests and inspections are immediately fed back to the individual production stage concerned in order to ensure continuous product quality optimization.

MANUFACTURING OF STAINLESS STEEL SHEET

Manufacturing Process

The manufacturing of stainless steel sheet involved a series of processes. First the raw material is melted in a electric furnace. This step usually involves 8 to 12 hours of intense heat. Next the mixture is cast into slabs. Next the slabs goes through forming operations, beginning with hot rolling, in which steel is heated and passed through huge rolls.

Heat Treatment

After the stainless steel is formed, most types must go through an annealing steps. Annealing is a heat treatments in which is steel is heated and cooled under controlled conditions to relive internal soften the metal. Some steels are heat treated for higher strength. Lower aging temperatures produce high strength with low fracture toughness, while higher-temperature aging produces a lower strength, tougher material.

Cutting

Nibbling is a process of cutting by blanking out a series of overlapping holes and is ideally suited for irregular shapes.

Stainless steel can also be cut using flame cutting, which involves a flame-fired torch using oxygen and propane in conjunction with iron powder. This method is clean and fast. Another cutting method is known as plasma jet cutting, in which an ionized gas column in conjunction with an electric arc through a small orifice makes the cut. The gas produces extremely high temperatures to melt the metal.

Finishing

A bright finish is obtained by first hot rolling and then cold rolling on polished rolls. A highly reflective finish is produced by cold rolling in combination with annealing in a controlled atmosphere furnace, by grinding with abrasives, or by buffing a finely ground surface. A mirror finish is produced by polishing with progressively finer abrasives, followed by extensive buffing. For grinding or polishing, grinding wheels or abrasive belts are normally used. Buffing uses cloth wheels in combination with cutting compounds containing very fine abrasive particles in bar or stick forms. Other finishing methods include tumbling, which forces movement of a tumbling material against surfaces of parts, dry etching (sandblasting), wet etching using acid solutions, and surface dulling. The latter uses sandblasting, wire brushing, or pickling techniques.

Manufacturing at the Fabricator or End User

After the stainless steel in its various forms are packed and shipped to the fabricator or end user, a variety of other processes are needed. Further shaping is accomplished using a variety of methods, such as roll forming, press forming, forging, press drawing, and extrusion.

There are a variety of methods for joining stainless steel, with welding being the most common. Fusion and resistance welding are the two basic methods generally used with many variations for both. In fusion welding, heat is provided by an electric arc struck between an electrode and the metal to be welded.

Bending Process of Steel Sheet

The Air Bending Process

The upper tool (or punch) is pressing down on the sheet metal at the center of the bend while the lower tool (or vee die) is pressing up on the sheet metal.

In general, the tooling only touches the sheet metal along these 3 lines. Thus the process is call "air bending".

Flat Layouts

In general, sheet metal stretches when it is bent. For example, if you were to take a piece of metal that measured exactly 2.000" in the flat and then bent it down the middle at 90°, when you measure the length of the 2 bends (from the outside of the bend), the sum of the leg lengths would be greater than 2.000" (in the case of 16 GA (.059) cold roll steel, it would be likely to add up to 2.094").

GRADES OF STAINLESS STEEL

A Brief Overview of Stainless Steel

This development was the start of a family of alloys which has enabled the advancement and growth of chemical processing and power generating systems upon which our technological society is based. Subsequently several important sub-categories of stainless steels have been developed. The sub-categories are austenitic, martensitic, ferritic, duplex, precipitation hardening and super alloys.

Austenitic Grades

Austenitic grades are those alloys which are commonly in use for stainless applications. The austenitic grades are not magnetic. The most common austenitic alloys are iron-chromium-nickel steels and are widely known as the 300 series. The austenitic stainless steels, because of their high chromium and nickel content, are the most corrosion resistant of the stainless group providing unusually fine mechanical properties. They cannot be hardened by heat treatment, but can be hardened significantly by cold-working.

"L" Grades

The "L" grades are used to provide extra corrosion resistance after welding. The letter "L" after a stainless steel type indicates low carbon (as in 304L). The carbon is kept to .03% or under to avoid carbide precipitation. Carbon in steel when heated to temperatures in what is called the critical range (800 degrees F to 1600 degrees F) precipitates out, combines with the chromium and gathers on the grain boundaries.

"H" Grades

The "H" grades contain a minimum of .04% carbon and a maximum of 10% carbon and are designated by the letter "H" after the alloy. People ask for "H" grades primarily when the material will be used at extreme temperatures as the higher carbon helps the material retain strength at extreme temperatures.

Ferritic Grades

Ferritic grades have been developed to provide a group of stainless steel to resist corrosion and oxidation, while being highly resistant to stress corrosion cracking.

Duplex Grades

Duplex grades are the newest of the stainless steels. This material is a combination of austenitic and ferritic material. This material has higher strength and superior resistance to stress corrosion cracking. An example of this material is type 2205. It is available on order from the mills.

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NIIR PROJECT CONSULTANCY SERVICES
106-E, Kamla Nagar, New Delhi-110007, India.
Tel: 91-11-23843955, 23845654, 23845886, +918800733955
Mobile: +91-9811043595
Email: npcs.ei@gmail.com ,info@entrepreneurindia.co
Website: www.entrepreneurIndia.co