IRON MAKING:
FROM BLOOMERY TO BLAST

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Early History

Evidence shows that man has worked iron for many centuries but the first recorded example of iron making appeared in a region of Germany in A.D. 1311. At that time, iron making was done in great secrecy but the men who worked the little forges slowly spread their knowledge throughout the European continent and forty years later cast iron items were being made in southeastern England. The first recorded English example of cast iron was a gravestone dated 1450.

Early forges were primitive and consisted of a hearth, a tuyere and a short stack. Each forge produced a lump of iron that was hammered and reheated to achieve a bar of iron. These forges were located in forested areas because charcoal was the fuel used in smelting and trees were needed to make charcoal. A type of bellows, powered by man or animal, was used to produce the blast of air.

In England, the forges were called bloomeries. As they grew in size, larger bellows were required. Water soon became a better source of power. As a result, bloomeries began to emerge from forests into more open areas near streams and rivers.

Colonists migrating to America brought the art of making iron with them. Not many records of forges in colonial times exist. The Pilgrims discovered bog ore in marshy areas and formed the Company of Undertakers of the Iron Works of New England. Their first attempt at iron making in Massachusetts failed but the second attempt, in Saugus, was very successful. The furnace was fired in 1648 and operated off and on until 1675. The Saugus Ironworks was hailed as the birthplace of the American iron and steel industry and is now a National Historic Park with a reconstructed blast furnace, a forge, a refinery, a rolling mill and worker housing.

The Bloomery Forge

Early American iron makers used one of two very difference processes to smelt iron—bloomery or blast furnace. Wrought iron was made in a bloomery forge. It was a soft, carbon-free iron easily hammered into nails, wheel rims and horseshoes.

The bloomery forge was very popular. With a small investment of time and money, one was easily set up. A bloomery was 6 to 8 feet square, had a 3 to 4 foot high hearth, a bellows and in many cases, a water wheel. Charcoal and bog iron ore (called the charge) were loaded into the bloomery and heated. As the charge melted, a bloomer used long iron tools to constantly turn and fold the charge. He worked out pieces of stone and other non-iron material, called slag. When all the slag was removed from the charge, a bloom remained. The bloomer removed this from the hearth with long tongs. It was hammered to squeeze out the remaining non-iron particles, reheated and hammered again. The process was repeated until the bloom was shaped into a long, thick bar of iron that was cut into pieces or rolled into smaller bars. Waste material left in the hearth was removed and discarded. The hearth was recharged with charcoal and bog ore and the process was repeated.

The bloomery process was inefficient and wasted a lot of good iron. The blooms were small and produced a few pounds of iron at a time. The British were not willing to share the latest iron making techniques employed in Europe and American bloomers were sorely lacking in technology.

In spite of its inefficiency, the bloomery forge remained popular for a number of reasons: the bloomery cycle ended with the removal of the bloom from the hearth, it consumed less fuel than the blast furnace and it was able to meet the immediate needs of area blacksmiths. Bloomeries made a significant contribution to the iron market and they thrived in remote areas of the U.S. into the late 1800's.

The Blast Furnace

Cast iron, also known as pig iron when molded into ingots, was made in a blast furnace. The large carbon content in cast iron made it too hard to hammer. It had to be molded, or cast into ingots, tools, cannonballs, cooking utensils, pipes and other desired items.

The blast furnace was a major development in the making of iron. Significantly larger than the bloomery, the early 19th century stack was 25 to 30 feet square at the base and rose 30 to 40 feet high. Built of stone (and sometimes brick) masonry, the stack sloped slightly inward as it rose so that the top area was smaller than the base area. The large bellows that supplied the draft or blast of air was powered by a water wheel. The "blast of air" is how the blast furnace got its name.

The construction of the stack was critical. It was usually built next to a hill or an embankment to keep the length and slant of the charging ramp to a minimum. Pairs of horizontal iron rods or flat iron straps called binders were embedded in the walls of the masonry. These served to hold the masonry together as well as to prevent shifting caused by expansion and contraction during the charging process. The outer wall was tapered inward to reduce the size of the opening at the top. The inner wall was tapered inward to allow for the shape of the bosh, the cavity in the furnace. The top part of the bosh was called the shaft. There was a foot of space between the bosh lining and the inner wall. The crucible and hearth were located directly below the bosh. The molten iron and slag collected in the crucible.

Arches were an important characteristic of the blast furnace. The number of arches varied from two to four. The largest was called the work arch and was spacious enough to allow ironworkers to work the hearth. The other arches housed the bellows and provided additional work areas. A wooden structure with a sand floor was built against the work arch. Called the casting house, it protected casting operations from the weather.

Iron ore, charcoal and limestone were the three ingredients used to make iron. They were prepared for smelting and then put into the furnace in the proper ratios needed to obtain the best possible quality of iron. Charging carts were used to bring each load of materials to the top of the charging ramp. Once there, bridge men dumped the materials into the charge hole. The limestone, called flux, chemically united with the impurities in the bog ore as the two were heated to produce a waste product known as slag. Charcoal was the fuel. The furnace was lit and the temperature brought to about 3000° F to liquefy the ingredients.

It took about twelve hours for the ingredients to melt. At the end of that time, the taphole was opened and the molten iron was allowed to run out. Just prior to the pour, channels were cut in the sand floor of the casting house. The main channels had numerous side channels branching off at right angles. The configuration resembled a sow nursing piglets, hence the term pig iron. The molten iron flowed into the channels and was allowed to cool and harden before being handled for shipment to a manufacturing site.

As the charge liquefied, the slag, which weighed less than the molten iron, was poured through the slag taphole onto sand and was hauled away from the work area. The slag remaining in the crucible was skimmed from the molten iron as it was poured.

Cold blast furnaces used unheated outside air and required great quantities of fuel to smelt the ore. The efficiency of the furnace was especially affected during the colder months of the year. Most blast furnaces did not operate during the winter season because streams and rivers, the source of power, froze and the water wheel was inoperable.

The efficiency of the blast furnace was determined by the amount of charcoal needed to make a ton of iron. The design of the stack played an important role in the amount used. The best stack height was about 35 feet.

The most significant change in iron making was the development of the hot blast. Iron makers had tried a number of ways to preheat the blast but were unsuccessful until 1828, when James Nielson introduced the technique in England. The preheated blast not only kept the temperature in the stack uniform but it reduced the amount of fuel needed to smelt the ore. The blast could be preheated in one of several ways. Some iron makers warmed it by pumping air through circulating pipes heated over a fire or “stove” not attached to the furnace. Others opted to run the circulating pipes through a “stove” that was built at the top of the stack. The latter method caught on quickly. It utilized the hot, waste gases being expelled through the top of the furnace and required no extra fuel. It proved to be a very efficient method of preheating.

Sometimes large pieces of ore or charcoal slipped into the furnace unnoticed by the bridge men working near the charge hole. These large pieces expanded when they neared the hotter end of the bosh and sometimes caused a blockage. The charge above the blockage stopped moving and became “frozen.” It was necessary to loosen the blockage quickly because as pressure built up inside the bosh, the stack was in danger of collapsing. If the bosh ruptured, molten iron and slag spewed into the casting shed causing severe, and many times, fatal injuries.

The bridge men watched the charge carefully and were quick to notice when it stopped moving through the bosh. When a blockage occurred, they first turned the blast off and on several times in rapid succession. If that didn’t dislodge the blockage, a bridge man ran a long iron rod inside the furnace from the top to try to “unstick” the charge. If neither procedure worked, the tapholes were opened to let the iron and slag run out of the hearth and iron rods were run up the bosh from the hearth to dislodge the blockage. A few ironworks kept a small cannon on hand to remove the “frozen” charge. The cannon was loaded with small shot and fired upward to dislodge the blockage.

A piece of iron that hardened early inside the furnace was called a salamander. Often shaped like a salamander, it formed a large obstruction and caused the charge to freeze. Very large pieces of prematurely solidified iron were referred to as bears.

The Nassawango Iron Furnace

The blast furnace on the Nassawango site, now known as Furnace Town, was constructed in 1830 by Maryland Iron Company on a 4800-acre tract of woodland and was the only one in the state to use bog ore exclusively. It was in operation until about 1850 and produced as much as 700 tons of pig iron per year. Erected west of the Nassawango Creek, a dam, millrace, canal and water wheel were also built to provide the waterpower necessary to operate a bellows. Originally a cold blast furnace it went into operation in 1832 with a work force of sixty men. It proved to be a shaky adventure for the first several years. By 1837 it had been sold and “let out” several times.

In December of 1837, Thomas Spence took over as Ironmaster. Spence was a lawyer who very much wanted his business venture to succeed. His first major innovation was the placement of a brick enclosed cast iron “pipe stove” over the opening at the top of the brick stack. Nine cast iron pipes were placed within the stove. The blast air was circulated through the pipes and heated by the hot gasses spewing from the furnace. The heated air was channeled to the tuyere (bellows opening) and ultimately pumped into the furnace. By adding the pipes, Spence changed the furnace from cold blast to hot blast and was able to increase its efficiency.

The bog iron ore used in the smelting process was found in the swamp behind the furnace. Sometimes called swamp ore or meadow ore, it was easy to harvest and store in long warehouses on the site. Shells, used instead of limestone, were found in abundance in the Crisfield area. They were collected, loaded onto schooners, sailing vessels with two masts, and brought to the Nassawango site via the Pocomoke River, the Nassawango Creek and the mile long canal. They, too, were stored in warehouses until needed.

At the time the Nassawango Furnace was in operation, charcoal, made by burning wood slowly with little or no oxygen, was the preferred fuel. Wood in its natural state contained too much moisture to provide a fire intense enough to melt bog ore. Slow burning removed the moisture and left a fuel that, when fed a blast of air, would reach temperatures hot enough to liquefy iron ore.

Woodcutters and/or colliers set to work felling the trees on the site. The best trees for charcoal making were hardwoods, such as chestnut, maple and oak. The trees were cut during the winter months when the sap wasn't running. As a result, the wood dried better and the charcoal produced was hard and heavy. The wood was cut to 4-foot lengths and stacked in billets 2 to 6 inches square.

Coaling began in May and continued through the early fall. Charcoal hearths were built on a level spot. The area selected for the hearth was large enough to contain a pile of wood 30 to 50 feet in diameter and was protected from the wind. The men who worked the charcoal pits were called colliers.

A pole or "fagan" was placed in the center of the hearth. At least 10 feet or more in height, the fagan was green wood and didn't burn easily. Lapwood, short, small pieces of wood, was used to build a three-cornered chimney around the fagan. Billets were then placed snugly against the chimney. The first section or tier, called the "foot" was about 4 feet high. The second tier, called the "waist" was also 4 feet high. It was placed upon the first tier. The collier carefully built the mound around the chimney, alternately adding billets to the foot and then to the waist to prevent reeling and twisting. As the mound grew in height, the top of the billets sloped toward the chimney. Lapwood was used to fill the cracks and spaces. The tier above the waist was called the "shoulders" and the top tier was known as the "head." Billets smaller in diameter were used for those tiers. They were placed horizontally around the chimney. A foot wide hole was left over the chimney and small vent holes about 1 foot from the ground were opened around the sides. It took about 30 cords of wood to construct a charcoal pit, equivalent to a 1- acre woodlot. The huge mound was covered with thin layers of leaves, earth and charcoal dust. The covering was necessary to control the burn.

The collier filled the chimney with wood chips and dropped in burning tinder and ashes to start a fire. He opened and closed the side vents as needed to provide a sufficient draft. When the chimney was thoroughly heated, he added dust to the mound and closed the top. It was the collier's job to make sure the fire didn't burn too hot. When that happened, he was in danger of losing the entire mound as well as his life.

As the wood slowly reduced to charcoal, the mound began to sink. When holes and soft spots called "mulls" appeared in the covering the collier dug those areas out and filled them with dust. To do that, he walked on the hot, smoking covering. It was imperative that no air be allowed to enter the mound because oxygen-rich air created the risk of a major fire. Sometimes he used a long iron rod to probe inside the mound to "settle" hot coals.

Dust was continually added to the settling and shrinking mound until it stopped "smoking." When smoking ceased, the pit was allowed to cool for 4-5 days. The charcoal was then raked out carefully, a little at a time. The collier was always alert for embers and kept a barrel of water nearby to douse an unexpected blaze. Wooden rakes and carrying baskets were used to avoid damaging the fragile charcoal. The coaling process took 2 to 2 ½ weeks and yielded 30-35 bushels of charcoal per cord of wood burned.

The charcoal was stored in a cooling shed for a day or so to make sure no embers remained. It was then shoveled into a storage area. It deteriorated if left in storage too long and was generally used within a few weeks.

The collier was kept very busy during the coaling season. Pits were built 100 feet or so apart to allow him working room as well as to keep fires from spreading. The pits required supervision twenty-four hours a day. Several colliers were able to tend 8 or 9 pits at a time. Black and dirty from the charcoal dust and smoke, they lived in small huts near their mounds and scratched out a living as best they could.

The Nassawango Furnace has three arches with the work arch being the largest. One of the smaller arches housed the large bellows. Sheds attached to the outside furnace walls protected the work area surrounding each arch. Each shed had a roof and a sand floor. The sheds kept the ironworkers dry during inclement weather.

The furnace was "charged" about every twelve hours with three ingredients: bog iron ore, shells and charcoal. As the charge melted, the impurities in the ore fused with the melting shells to form slag. It was poured onto sand or skimmed from the top of the molten iron. After it cooled and hardened, the slag was hacked into small pieces, hauled into the swamp area and dumped.

When the molten iron was almost ready to pour, the pig iron mold was carved into the sand floor of the work arch. After the pour, the ingots were allowed to cool and harden before being loaded onto barges and taken down the canal to the Nassawango Creek. Schooners waited on the other side of the wooden lock located at the junction where the two bodies of water met. The lock was necessary because the creek was tidal and the water level varied with the tide. The pig iron was transferred to the schooners; they then sailed down the Nassawango Creek and out the Pocomoke River to the Chesapeake Bay. Once in the bay, the pig iron was taken to three large manufacturing cities: Baltimore, MD, Philadelphia, PA and New York City, NY.

The Nassawango Furnace operated twenty-four hours a day during three seasons of the year. Cold weather shut it down for approximately twelve weeks a year. When the temperature dropped well below freezing, the water in the canal froze and the water wheel was inoperable. Temperatures at freezing or slightly below made the operation somewhat more costly because the furnace had to "work harder" to keep the temperature up. That meant more fuel was used. It was cost effective to shut down until temperatures moderated.

By the mid-1840's the Nassawango community had swelled from sixty men to almost four hundred men, women and children. They eked out a hard-earned subsistence, relying heavily on their gardens for food. Not all the men on the site worked at the furnace. There were other job opportunities available. A gristmill and a sawmill were located on the creek just to the north of the furnace. Other businesses included a weaver, a broom maker, a blacksmith, a barrel maker, a baker and a basket maker.

The men who toiled in the furnace community were paid in credit or scrip. This could be used in the company store located on the site. The women and children labored long hours in the family gardens producing food stuffs as well as herbs used in medicines and seasonings. They relied heavily on the barter system to meet their needs. If a household needed a new basket, the basket maker was given a jar of food from the pantry shelves or a quart of milk as payment.

As the 1840's drew to a close, the Nassawango Furnace fell onto hard times. A better grade ore was discovered in the Lake Erie region. Mr. Spence could not compete with pig iron better in quality and cheaper to sell. By 1850, he had declared bankruptcy and the smelting ceased. The ironworkers moved away leaving only the saw and grist mills in operation. No one else was interested in continuing the smelting of iron on the site. The black smoke and cinders would belch no more from the big, red stack on the Nassawango site.

In 1991, the Nassawango Iron Furnace received distinction as a National Historic Mechanical Engineering Landmark. While typical of blast furnaces built during its day, it differs somewhat from others of the same era: it is constructed for the most part of brick (manufactured on the site) while others during the time period were built with stone and it smelted bog ore found in the swamp lying between the furnace and the Nassawango Creek. Most importantly, it is the earliest surviving American example of the hot blast mechanism and was a forerunner of that innovation which eventually swept the iron making business.

GLOSSARY

Arch: A curved masonry construction that spans an opening.
Bear: A large solid mass of furnace charge.
Bellows: A leather or leather and wood box with flexible sides that expand and contract;
air enters through a side vent and is expelled through a nozzle.
Billet: A "packet" of wood usually cut to 4 foot lengths and 2 to 6 " square.

Binder: Cross-rods inserted in blast furnace masonry to prevent reeling and twisting.
Blast: A blowing of air into the furnace.
Blast Furnace: A furnace with a tall shaft; operated by a blast of forced air.
Blockage: A large "frozen" mass that blocks the flow of charge through the stack.
Bloom: A mass of wrought iron produced in an early forge.
Bloomery: A forge that made wrought iron blooms.
Bog Ore: Iron ore found in wet, swampy areas.
Bosh: The bottom of the furnace cavity; sloped inward.
Cast Iron: An iron that contains a large amount of carbon.
Charcoal: Carbon made by burning or charring wood without air.
Charcoal Pit: An earth-covered mound used to char wood.
Charge: A specific weight of ore, shells and fuel put into the furnace.
Charge Hole: A large hole at the top of the furnace into which the charge was dumped.
Charging Ramp: A slanted bridge extending from the bottom of the furnace to the top; used to transport the charge.
Coaling: A name for making charcoal.
Cold Blast: Furnace blast at outside or air temperature.
Collier: A charcoal maker.
Crucible: Bottom part of the bosh used for melting iron.
Draft: A blast of air from the bellows that maintained burning/combustion in the furnace.
Fagan: A pole of green wood used to help form the chimney in a charcoal pit.
Flux: A material added to the charge that combined with the impurities in the melting ore to form slag.
Forge: A term that includes a furnace or a hearth where iron is heated before shaping.
Hearth: The floor of the furnace.
Hot Blast: A preheated blast of air.
Ingot: A bar of cast iron.
Lapwood: Small, short pieces of wood.
Lock: A structure placed between two bodies of water that served to raise or lower the level of one to equal that of the other.

Mound: A large, carefully stacked pile of wood to be covered and charred; a charcoal pit.
Mulls: Soft spots in the covering of a charcoal pit.
Pig Iron: A cast iron run directly from the furnace into channels cut into sand; the channels resembled a sow nursing piglets.
Salamander: A piece of hardened iron that obstructed the furnace; shape was similar to that of a salamander.
Schooner: Sailing vessel with two masts used to transport ingots of pig iron from the locks at Nassawango Creek to manufacturers bordering the Chesapeake Bay.
Slag: A covering that formed on molten iron as a result of combining flux with the impurities in the ore; a waste product poured or skimmed off.
Slag Taphole: An opening in the furnace above the level of the molten iron through

which slag was poured.

Smelting: The process of melting ore to obtain iron.

Stove: A special box used to preheat the blast; was placed at the top of the stack to utilize hot gases or was separate from the furnace.

Taphole: An opening in the furnace that allowed molten iron to pour.

Tapping or Tapped: Opening the taphole to allow molten metal or run from the furnace.

Tuyere: An iron nozzle through which blast was sent to the furnace.

Wrought Iron: An iron that contains very little carbon and is easily hammered.

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