TXI Chaparral Steel: The new Virginia structural mill

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TXI Chaparral Steel's new greenfield structural mill in Virginia is a unique 1.2 million ton/year facility designed to serve the markets of the eastern U.S. It is located in Dinwiddie County, approximately 30 miles south of Richmond. Built at a cost of approximately $400 million, the Virginia plant includes the latest 165-ton fingershaft electric furnace and ladle metallurgy furnace, and in-line processing units consisting of two proprietary, near net shape casters, a reheat furnace and a preheat furnace, and sophisticated rolling mills. There is also an 800,000-ton/year automotive scrap shredder.

The operation can be considered unique in so far as it represents the first time that Chaparral's patented near net shape casting technology has been married with the structural X-H rolling process of SMS Schloemann-Siemag. The patented near net shape casting technology is in commercial operation at the Chaparral plant in Midlothian; the X-H rolling mill represents a 4th generation unit that permits a complete roll change within 25 minutes.

The plant is close to two interstate routes (I-85 and I-95), is served by two railroads (Norfolk Southern and CSX), and is within easy reach of deep-water ports at Richmond and Norfolk, Virginia. The close proximity of population and manufacturers also represents a continuing supply of scrap as both a direct source of raw material for the melt-shop and automobiles for the shredder operation.

There will be approximately 400 employees when the plant is fully operational. The majority of the workforce was hired from the local area with some personnel transferred from the TXI Chaparral plant in Texas. There was an extensive classroom training program, with instruction from TXI Chaparral and vendor personnel, together with practical experience at the Texas plant.

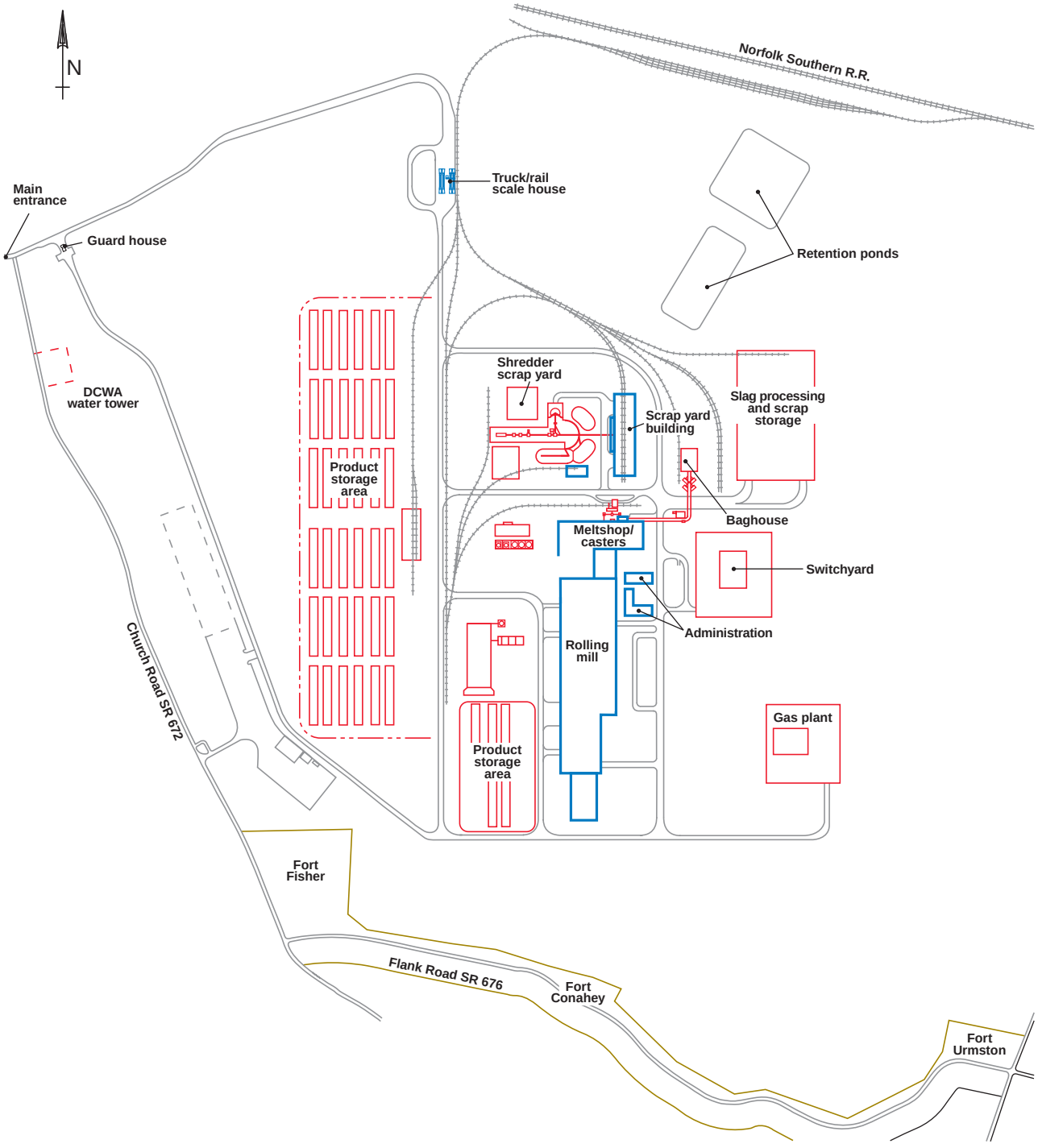
Background

TXI Chaparral Steel consists of two market mills: one mill located in Midlothian, Texas, approximately 30 miles south of the Dallas/Fort Worth Metroplex; and the new mill located in Dinwiddie County, Va.

Originally, Chaparral Steel was established in 1975 as a 50/50 joint venture between Co-Steel International Ltd. of Whitby, Ont., Canada, and Texas Industries (TXI) of Dallas, Texas. In 1986, TXI acquired Co-Steel's interest in the joint venture and Chaparral became a wholly owned subsidiary of TXI, becoming TXI Chaparral Steel.

TXI was formed in the 1950s as a Texas aggregate and concrete operation. In the early 1960s, it became the first U.S. company to integrate with the cement business. With the 1980 addition of a plant in central Texas, TXI become the largest cement producer in the state.

The first steelmaking facility was the greenfield mini mill built in Midlothian in 1975 with an annual capacity of 220,000 tons. It has, subsequently, grown into a 1.6 million ton/year operation that supplies a wide range of bar and structural sections throughout North America and overseas.[1] This plant currently includes: two electric arc furnaces and two ladle furnaces; three continuous casters



Layout of TXI Chaparral Steel, Virginia.

(4-strand billet, 5-strand bloom/beam blank and 2-strand near net shape beam blank), and rolling and finishing facilities (15-stand bar mill, 16-stand medium section mill and 11-stand large section mill). There is also an 800,000-ton/year automotive shredding facility that is one of the largest in North America.

In 1997, a decision was made to build a second steel mill, in Virginia. Construction began April 1998, with start-up in June 1999. It has a capacity of 1.2 million tons/year of structural beams from 6 to 36 in. wide as well as sheet pile and H-pile sections used in construction. As mentioned previously, the plant is based on the combination of the company's patented near net shape casting technology, developed at the Midlothian plant, the proprietary Chaparral-Schloemann designed rolling mill and state of the art Fuchs fingershaft electric arc furnace melting technology.

Products and markets

The plant will produce a wide range of H-beams, Bantam beams, sheet piling, H-piling and channels.

Customers include fabricators, service centers and construction materials suppliers. A marketing and distribution agreement is in place with L. B. Foster for sheet pile and H-pile products.

It is estimated that approximately 65% of the products will be shipped by truck and 35% by rail (Norfolk Southern and CSX). Raw materials are received by truck (70%) and rail (30%).

Plant description

The plant site consists of close to 725 acres within a few miles of I-85. Approximately 80 acres of the site are dedicated to wetlands that are incorporated into the plant's design for a community buffer and green space.

The site is historically significant. It is bounded on the south by land that is now part of the Petersburg National Battlefield that contains Fort Fisher, Fort Conahey and Fort Urmston, constructed during the Civil War by Union troops. Prior to building the plant, Chaparral commissioned an archeological mapping of the entire property with detailed site investigations performed at several locations. Significant historical features such as small earthen forts, rifle pits and trenches remain on the property.

The property is bounded on the west and east by state routes 672 and 818, respectively, and to the north by the Norfolk Southern railroad.

Approximately 650,000 sq ft of the plant are under roof. There are more than five miles of internal rail and five miles of roads. Internal transportation is by rubber-tired mobile equipment and rail cars.

Both automobiles and trucks enter and exit the plant through the main entrance located in the northwest corner of the property: automobiles travel south through a guard house into the plant to the employee, customer and visitor parking area; truck traffic travels east to a scale house that services both truck and rail shipments.

The main plant facilities are:

- Scrap handling and shredding operation.
- Steelmaking: electric arc furnace (EAF) and ladle metallurgy furnace (LMF).
- Continuous casters, A and B.
- Reheat furnace and buffer/preheat furnace.
- Multi-Purpose Section (MPS) rolling mill with in-line finishing units.
- Storage and shipping.

Scrap handling and shredding operation

Scrap is received in two forms: prepared scrap and obsolete automobile scrap for shredding. Inbound (and outbound) shipments enter (and leave) the plant through the truck and rail scale house that consists of four weigh stations. The scale house can be operated to meet the particular flow of materials into and out of the plant. For example, it can be operated with one inbound and one outbound station for scrap, and one inbound and one outbound station for trucks delivering consumable materials.

Prepared-scrap shipments are delivered by truck or rail either to a remote storage area or to the scrap yard building.

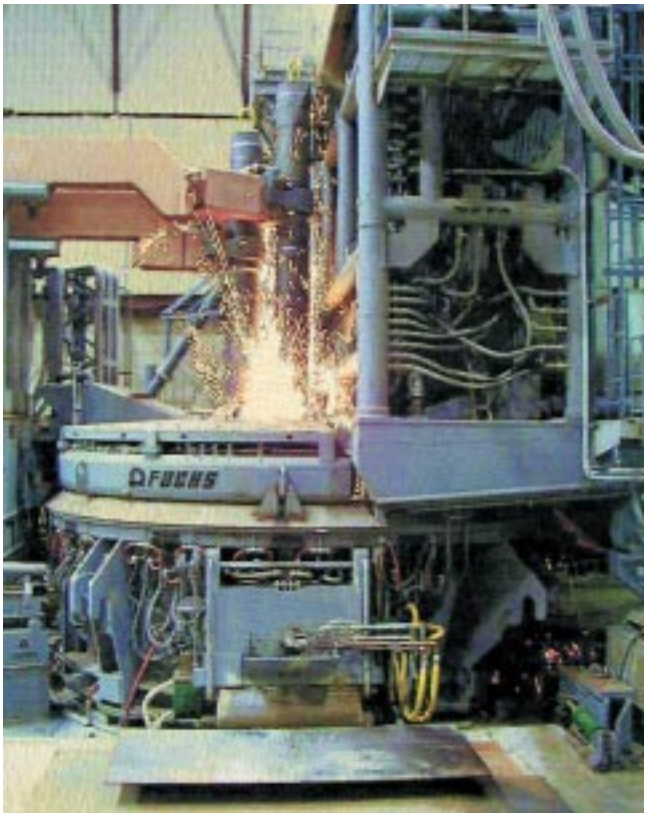
The shredder, manufactured by Sunbelt Technologies, has a capacity of 150 tons/hour for an annual capacity of 800,000 tons—one of the largest in North America. (Approximately 8% of the cars and light trucks scrapped in the U.S. each year will be recycled by the shredders at the Chaparral plants in Texas and Virginia.) The overall length of the shredder, including the conveyor system to the scrap yard building, is approximately 700 ft.

Steelmaking

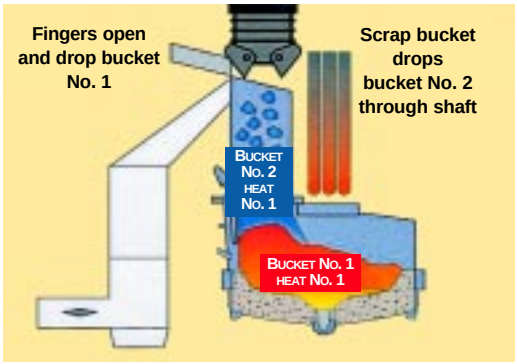
Electric arc furnace — The fingershaft a-c furnace has a capacity of 165 tons and operates with a 45-ton hot heel to produce a 120-ton heat size. Projected operating rate is 160 tons/hour with a 40-min tap to tap time and a 30-min power-on time, equivalent to approximately 36 heats/day.

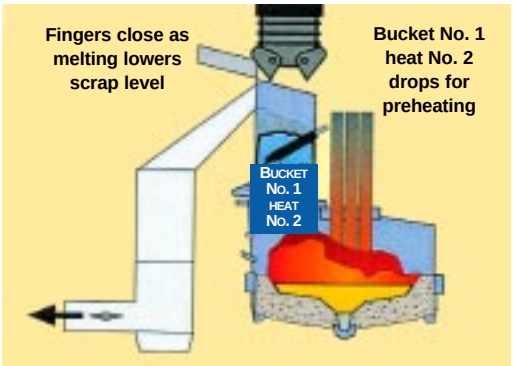
The scrap buckets, delivered to the east end of the meltshop building by mobile carriers, are transferred and placed over the furnace shaft by a 230-ton overhead crane at an appropriate time during progress of the heat.

The charging sequence begins with scrap from the first bucket being deposited, for preheating, into the furnace

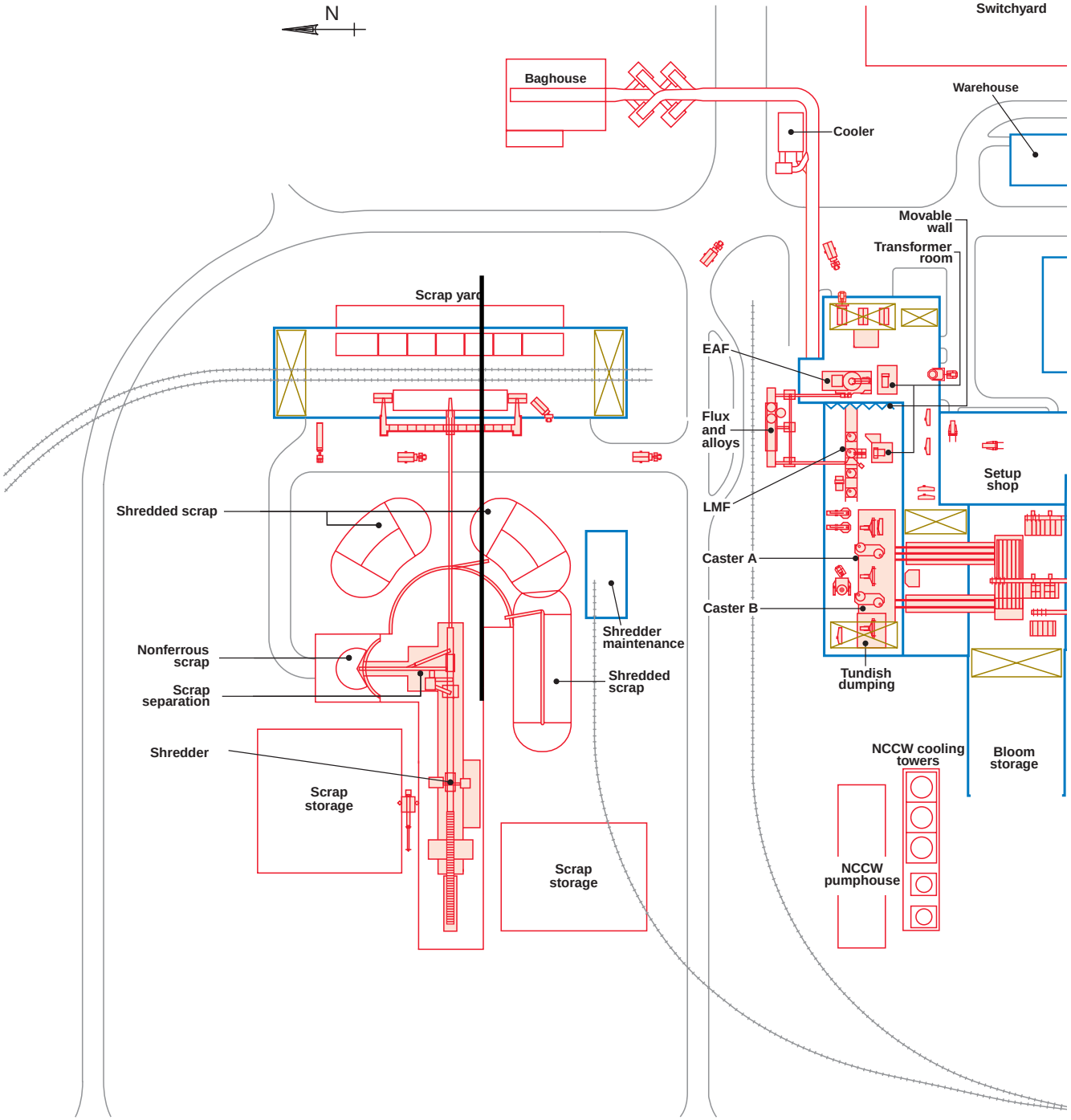


Fingershaft electric arc furnace.





Fingershaft electric arc furnace: charging sequence following the tapping of a heat.



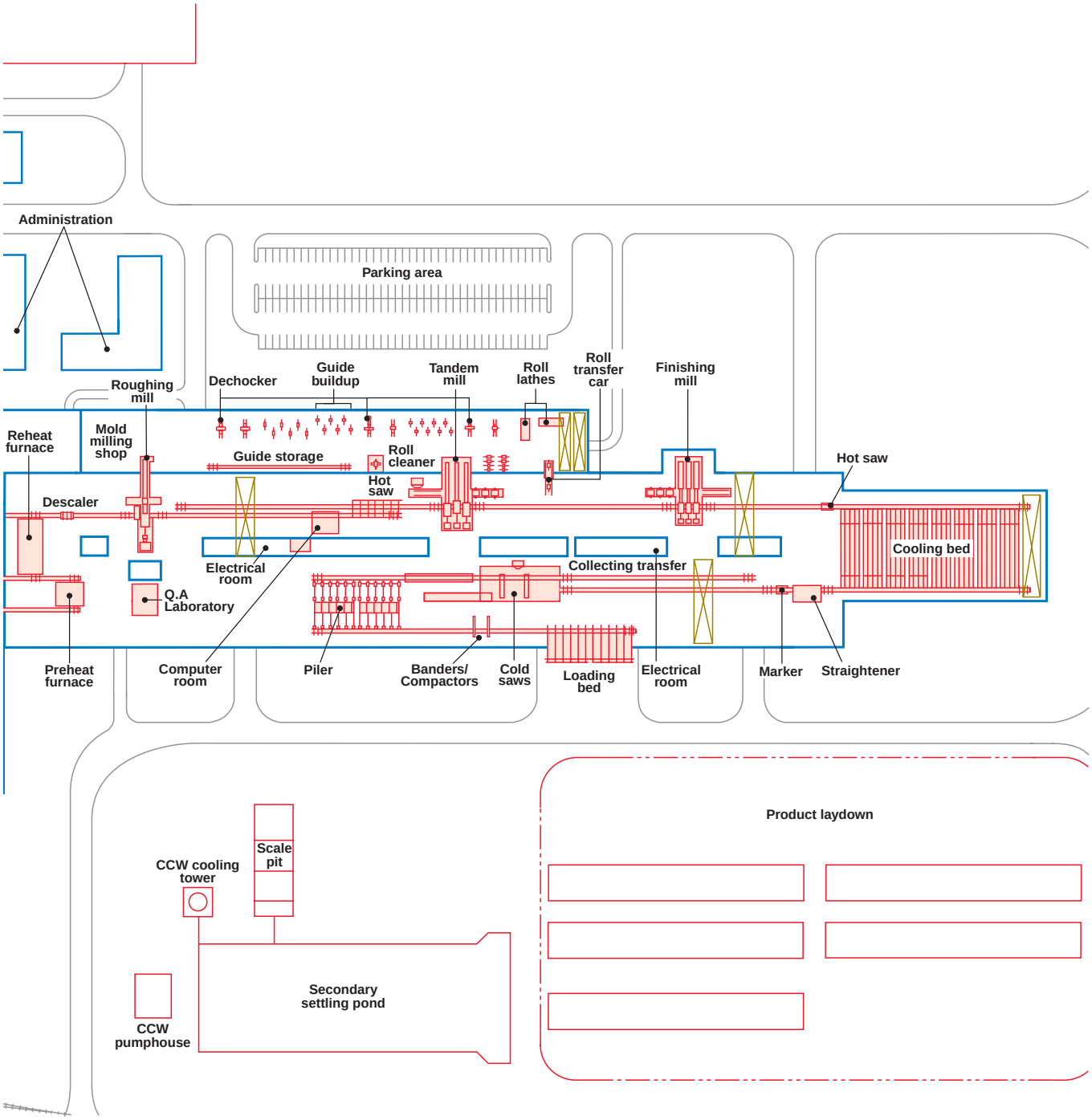
Plant facilities.

shaft with the fingers at the bottom of the shaft closed. This is accomplished while the refining of the preceding heat is in progress.

Lime and charge carbon additions are made through the furnace roof during the early stages of the heat. Bulk alloys and aluminum additions for deoxidation are made into the ladle during tapping through a hopper/chute system. After tapping, the ladle is moved on the same transfer car into the LMF area for composition and temperature adjustment. Thus, normal operation will not require crane movements for steel ladles.

The material handling system is located adjacent to the north side of the meltshop. It includes equipment for both the EAF and LMF. There are three silos, two for lime (13% MgO) and one for charge carbon, and alloy bins for SiMn (four), FeSi (two), FeCu (one) and a spare. The system also includes conveyor belts and a weigh and holding hopper. Materials can be received by truck and rail car and transferred by conveyors to the various silos and bins.

Slag handling facilities are provided by Olympic Mill Services. These include processing, disposal and metal reclamation. The slag processing area is located in the



northeast corner of the plant. All slag processing operations are under roof and emissions are controlled.

Ancillary facilities in the meltshop area include two horizontal and one vertical natural-gas fired ladle preheat stations that operate at 1800°F. There is a complement of eight 120-ton capacity ladles having a high-alumina spinel working lining with 18% C magnesite layer at the slag line. The ladles are also equipped with a porous plug for gas stirring that automatically connects with a pipe system when the ladles are set at the furnace for stirring during the tapping operation and transfer to the LMF.

Ladle metallurgy furnace — There is an in-line 2-ladle car transfer system between the EAF and the LMF. Following tapping, the ladle is moved by the transfer car to the LMF station where it is raised hydraulically and connected to the roof of the unit. The ladle car then returns to the EAF shop to receive a ladle for preheating in preparation for the next heat. Following treatment at the LMF, the ladle is lowered onto the second ladle car and moved into the continuous casting area where it is raised by a 230-ton crane and transferred to a specific caster.

Continuous casting

The two near net shape casting machines are designed and arranged to achieve a high overall plant production level by maximizing both meltshop and rolling mill productivity, and reducing the effects of potential bottlenecks to a minimum. This is accomplished by a highly flexible operation obtained from the ability to cast seven different beam blank sizes, two casters that feed into a common roller transfer system, and two heating furnaces (a reheat and a preheat furnace).

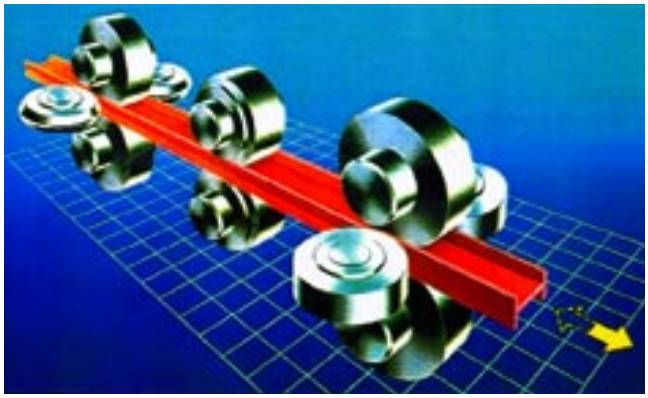
Typically, beam blanks from one caster are transferred directly into the reheat furnace. The availability of two casters permits the second machine to be set up for casting a different section size while the first caster is in operation.

Caster A is a 3-strand machine that produces four sizes of beam blanks. Caster B is a 2-strand machine that produces three sizes of beam blanks. Both machines have similar design features: both have curved-type molds with multipoint bending and unbending to the horizontal before the strands are torch-cut to length.

Rolling

Rolling facilities include the reheat and preheat furnaces, three rolling mills (a 2-stand roughing mill, a 3-stand tandem X-H reversing mill and a 3-stand finishing mill) and a cooling bed. The 3-stand finishing mill is used when sheet piling sections are produced.

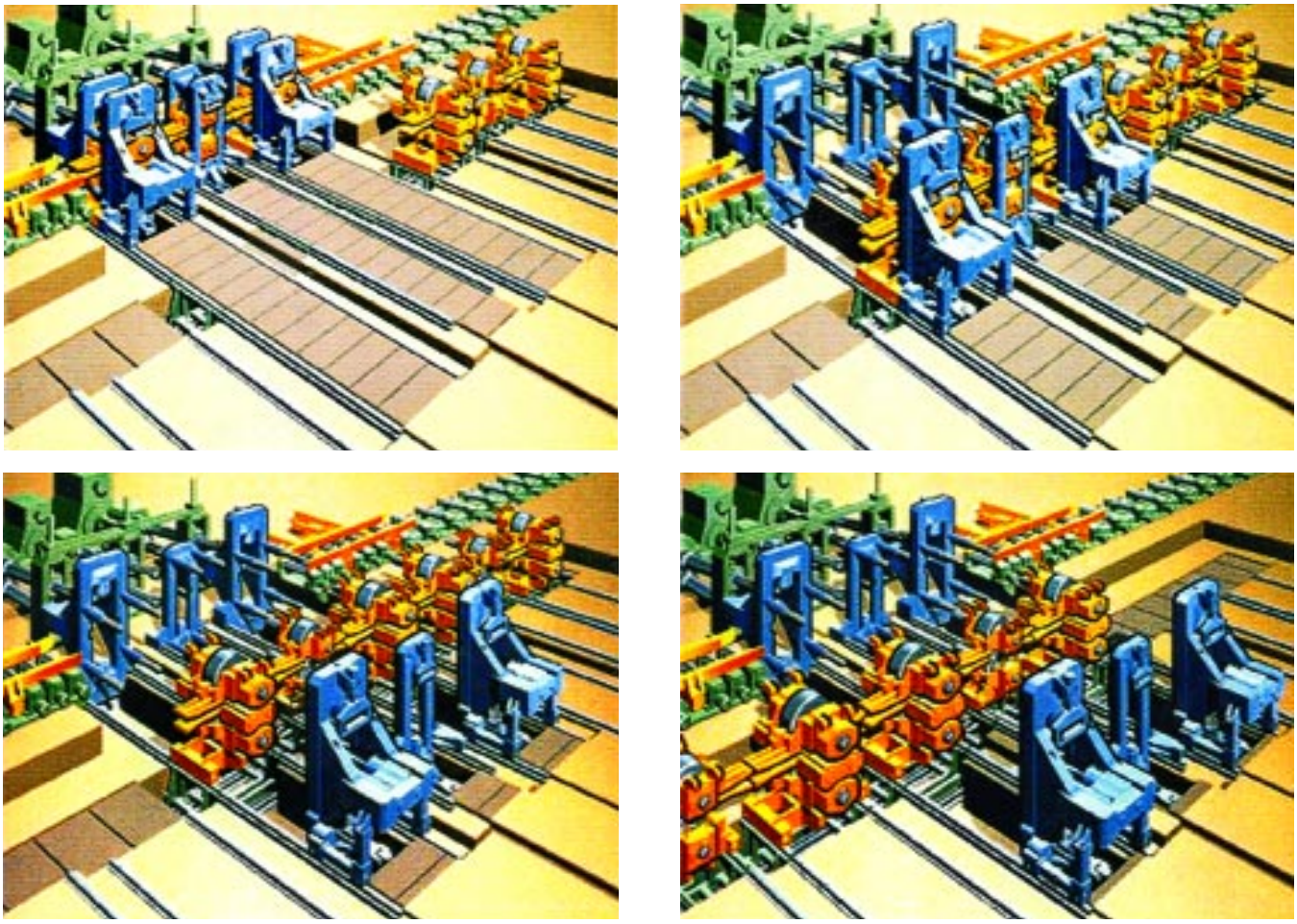
These facilities are housed in a building 1440 ft long with a width of 325 ft at its widest. The overall mill length from the exit of the reheat furnace to the end of the cooling bed is 1360 ft.



Principle of X-H rolling technology.

Both furnaces are designed as walking-beam furnaces with stationary and movable water-cooled beams, and equipped with a combustion air system and a common recuperator that heats combustion air to a preheat temperature range of 800 to 900°F. Stein Heurtey supplied the furnaces as well as the control system that incorporates parameters such as air/gas ratio, furnace pressure and waste-gas oxygen content.

Rolling mills — The rolling mills have a total design annual capacity of 1.2 million tons. Suppliers include SMS for the mechanical equipment with GE providing the electrical drives and AMI the control systems. In-line equipment includes a descaler, roughing mill, tandem mill, finishing mill, hot saws and cooling bed.



Compact cartridge stand changing procedure.

The 3-stand tandem mill consists of two universal stands having both vertical and horizontal rolls, arranged in an X-H type rolling configuration, and a horizontal edger. The first universal stand has an X-pass design, followed by the edger and the second universal stand having the H-pass design. The vertical rolls of the first universal stand are cut at a 6° angle to produce a section with the X-profile: the vertical rolls of the third stand (the second universal stand) have a flat face to produce the section with an H-profile. The second stand, the horizontal edger, provides an edging operation with respect to the ends (edges) of the flanges of the section being rolled. The advantages reported for the X-H rolling technique, in comparison with conventional beam rolling, include: fewer passes through the mill because there are, in effect, two universal passes at one time; higher production rate; higher temperature level; lower rolling forces and drive power; and increased roll service life. An additional advantage of the X-type pass is that the 6° profile of the vertical roll permits the resurfacing of all three faces of the roll while retaining the same geometry of the profile: the only dimensional change is the roll diameter.

The tandem mill is also equipped with a new generation mill stand, called Compact Cartridge Stand (CCS), that facilitates rapid roll changing within 25 minutes. Rolls, chocks and guides of all three stands are changed simultaneously.

Roll shop facilities include two lathes and six hydraulically powered chocking/dechocking stations. The shop is serviced by two overhead cranes.

Finishing, storage and shipping

Finishing operations include straightening, cutting to length, banding and compacting prior to shipping.

Product is collected on a transfer bed for cutting. The preform layers are then cut to ordered length by two sled-type cold saws in a tandem arrangement. There is one fixed saw with a second shiftable saw that moves with a gage carriage to make cuts of the appropriate length.

Finished product is shipped by rail or truck.

Plant services

Electrical power — The plant is serviced by Virginia Power with a 230-kv main feed to a 150-Mw main substation located on Chaparral property to the east of the meltshop. The main substation was designed and constructed with the assistance of Virginia Power. It is owned and operated by Chaparral.

The substation services all of the electrical needs of the plant with six main transformers splitting the electrical loads according to the process requirements. Each main transformer is equipped with metering and control equipment capable of providing real-time use data that is tracked and controlled from the operating pulpits via a power management system designed by Chaparral.

The EAF and LMF circuits are controlled by a Joslyn power control system and vacuum switch gear as well as being serviced by a capacitor bank. The EAF power circuit is serviced by a 120-Mva, 230-69 kv regulatory transformer. There are step-down transformers and reactors for both the EAF and LMF.

Finished product.

Water — The water is provided by the Dinwiddie County Water Authority from the Appomattox River nearly 13 miles from the facility.

Water systems at the site are capable of conveying more than 72 million gpd of process waters. The process waters are divided into Contact Cooling Water (CCW) and Noncontact Cooling Water (NCCW) systems, and are designed to operate without a process water discharge from the facility.

The facility is equipped with a stormwater management system that includes approximately 7.5 acres of retention ponds. These ponds are capable of holding nearly 30 million gallons of water and also serve as a source of makeup water to the process water system.

Gases — Oxygen, argon and nitrogen are supplied under contract by Air Products and Chemicals, Inc. An on-site cryogenic air separation unit supplies 250,000 cu ft/hr of oxygen.

Natural gas is supplied by Columbia Gas of Virginia via a 12-in. dia line. Expected usage is 16 million cu ft/day.

Summary

The concept of the new TXI Chaparral Steel 1.2 million ton/year greenfield structural mill in Virginia is innovative with respect to both its location in the eastern U.S. and plant layout and the combination of processes and technology.

The facilities include an 800,000-ton/year shredder for auto bodies, a 165-ton fingershaft a-c electric arc furnace and ladle metallurgy furnace, two near net shape casters with a total of five strands capable of producing seven beam blank sizes, a reheat and a preheat furnace, and an in-line rolling complex consisting of a 2-stand roughing mill, 3-stand reversing tandem mill that employs X-H rolling technology, and a 3-stand continuous finishing mill for producing piling sections.

The product mix includes wide-flange beams, standard beams, channels, piling sections and Bantam beams.

REFERENCE

1. Samways, N. L., "Chaparral Steel: An International Competitor," *Iron and Steel Engineer*, Vol. 69, No. 3, April, 1992, pp 59-68. ▲