Introduction to ArcelorMittal South Africa Newcastle Works

1. History

ArcelorMittal's Newcastle Works, located in the northern part of South Africa's KwaZulu Natal Province, is the country's foremost supplier of profile products.

This highly efficient and low cost operation, rated among the lowest billet cash-cost producer's in the world by a leading commodities research institute, bears testimony to the success of the intensive re-engineering programmes undertaken at ArcelorMittal South Africa.

The plant employs ±1896 staff. Yearly, Newcastle Works produces 1.6 million tonnes of final product of which 45% is exported to international markets.

The profile products produced include low and medium-carbon commercial grades, low-carbon rimming steel substitutes, sulphur containing free-cutting steels, micro-alloyed steels, high-carbon wire-rod steels and low, medium and high-alloy steels.

Sizeable capital expenditure has been invested for the extensive refurbishment of the plant and to introduce sophisticated information systems. This has optimised operations and sustained global competitiveness at all levels.

Newcastle Work's strategic priorities revolve around expanding its strong position in the domestic arena and focusing on niche, high profit international markets.

Growth of its present market share is being realised by providing customised attention to client requirements, enhanced delivery reliability and product quality.

Internationally, the focus of the operation has been to identify specific global locations where it can maximise export volume and price, and concomitantly reduce the risk of exposure to volatile markets abroad.

Successful implementation of re-engineering and continuous improvement programmes at the steel plant has honed the business into a modern, internationally aligned operation.

The ISO 9002 and ISO 14001 listed plant is an integrated operation that produces rolled steel from iron ore via a blast furnace route. The plant has one blast furnace, two basic oxygen furnaces and four rolling mills.

2. Processes

2.1 Brief description of processes

Iron Making Process

Coke Ovens

ArcelorMittal Newcastle Works has four 6,2 m DR Otto twin flue under jet type batteries of which three are in operation.

Construction of the coke ovens started in 1972, and the first coke was pushed in January 1974. Each oven can produce 19 tons of coke per day. Currently, 90 ovens are pushed daily with plans to increase. The Coke Plant is designed for 2,200 ton/day (t/d) of coke and current operations are 945,00 tpy. There are four batteries of coke ovens, with 50 ovens in each battery. The oven chambers are 6.2m high with an average width of 0.45 m and 13.85 m long. Each oven has a charging capacity of 35.1m3 of coal.

A battery repair project consisting of two phases has commenced. This will be completed over a four year period. The first phase began in April 2002 and includes refractory and steel bracing system repair for 100 ovens. This project is to result in a cleaner operating environment and improved coke quality.

Coal is railed into the plant and off-loaded by one of three tipplers, weighed, and stored in coal blend silos. The coal is then transferred to the Schenck constant weigh feeders, crushed, screened and transferred to one of the four, 4000 ton service bunkers, which are located on top of each battery pair. Coal from the service bunkers is top charges via gravity into the ovens. The hot coke is discharged into the quench cars via pusher beam.

A coal blend, consisting of 20% imported coal and 80% local coal, is charged at an average of 150 ovens per day. The Dr Otto gas purification and by-product plant produces crude tar, crude benzole, ammonium sulphate and sulphuric acid. The benzole is transported off-site monthly and the ammonium sulfate is transported daily to Mittal Steel South Africa Coke and Chemicals.

Sinter Making

Sinter is fine iron ore and fine waste material that has been melted together into lumpy material. Sintering allows fine iron ore and fine waste materials to be used in the blast furnace process. Sinter contains most of the furnace fluxes and is beneficial for the blast furnace.

Sinter for use in Blast Furnace N5 is produced in a single sinter plant. The sinter machine was built by Delattre-Levivier and was commissioned in 1976. The Sinter Plant also incorporates their on-strand cooling system. Due to the elimination of the sinter handling and the dedusting of cooling air, the plant is cleaner and less polluting. Conveyers to the Sinter Plant consist of one conveyer for lime and coke, and one for ore and other fluxes.

The sintering strand has a total surface area of 400 m2 . Sintering is achieved on the first 220 m2 of sinter strand by suction delivered by two 4,5 MW sintering fans, and cooling is achieved on the remaining 180 m2 by two 3,3 MW cooling fans. The sinter product is crushed and screened and the 5 mm - 40 mm fraction is used in the N5 Blast Furnace. An eight day buffer stock is maintained.

Tipplers are used to offload sinter raw materials that are transported in train trucks. Once tipped, the raw materials are transported by means of a conveyor belt to separate bunkers at the sinter plant, or to the fine material mixing bed. Usually there will also be a stockyard where lime, dolomite, fine iron ore, scrap material, etc. are stored.

Because of the number of different materials used, their different compositions and sizes they are first mixed together using a mixbed. All the raw sinter materials, fine iron ore, lime, dolomite and waste materials (scrap, slag, millscale and dust) are stacked onto the mixbed. This forms a mixture of material with constant chemical composition and size distribution. The sinter plant has 2 mixbeds with a combined mass of 80 000 to 100 000 tons of material. While one mixbed is built, the second mixbed is reclaimed to the sintering process.

The mixbed material is reclaimed from the mixbed with a drum reclaimer to the sinter mixbunkers. There are also bunkers for lime, dolomite, coke and fine sinter. Table feeders (conveyors belts with weighing equipment) at the bottom of these bunkers ensure that the ingredients for the final sinter mixture are drawn in the correct ratio according to the sinter specifications.

Just before the sinter machine, the supply of material enters a mixing drum. The mixing drum ensures that the materials are very well mixed. Water is added to the raw mixture in the mixing drum. The water and mixing of material in the mixing drum causes the fine dust particles in the raw mix to stick to the bigger particles.

From the mixing drum, the mixture is placed on the sinter strand by means of a feeder. A 50 mm layer pre-sintered material, hearth layer, is loaded first onto the strand before the second layer of final mixis added. This layer of pre-sintered material protects the sinter strand against the high temperatures of burn through and prevents material sticking to the sinter strand.

The coke in the top layer of the raw sinter mixis ignited with the ignition hood. Coke oven gas is burned inside the ignition hood.

The sinter strand consists of a recirculation chain of pallet cars running on a closed track. The strand is driven by a sprocket wheel.

Two high-powered fans suck air through the sinter bed into wind boxes below the bed. A lot of dust and fine material is sucked from the raw material. This fine dust is removed from the air with two electrostatic precipitators. The raw materials are sintered together on the first half of the strand. On the second half, cooling of the already sintered material occurs.

At the discharge end of the sinter strand, the large sinter cakes fall on to the sinter breaker. The sinter is broken up to a maximum size of 45 mm. The sinter is conveyed to the sinter screens where it is screened.

The fine sinter, -5 mm, is returned to the sinter raw mix to be recycled. The +5mm sinter is used by the blast furnace.

The average production rate is 300 tons/hour, or 7,150 tons/day. The daily and monthly production records are 8,188 t/day and 202,625 t/month respectively.

Blast Furnace

Basically, a blast furnace is no more than a vertical steel cylinder lined on the inside with refractory material. The blast furnace process has been the most important way of producing liquid iron from iron ore for the past six hundred years. The liquid iron is supplied to the steel plant were, with the basic oxygen furnace, it is turned into steel.

The blast furnace produces liquid hot metal from iron ore. The hot metal is cast at a temperature of ±1450℃. To melt the iron ore, and to separate it from the unwanted material (slag), the iron ore is heated to this high temperature.

A single iron making unit, Blast Furnace N5, provides +-5,000 tons of hot metal for the steel plant.
The blast furnace process consists of weighing of the burden, charging of the blast furnace, hot product dispersal from the blast furnace and off gas cleaning.

Constructed in 1974, this GMBH-designed unit has a 10, 14 m diameter hearth and a 2,017 m3 working volume after the last reline in 1994. Refractories used are SiC in the stack and super-micropore carbon in the hearth.

A conveyor-fed Paul Wurth bell-less top is used for charging. Three Krupp-Koppers external combustion chamber stoves preheat the blast air, which is enriched by up to 3,5% oxygen. A 55 kg/thm pitch injection practice is used and casts are rotated continuously over the three tapholes.

Hot air is blown in to the furnace to burn the coke. An increase in air blown into the furnace will increase the burning of coke and will increase hot metal production.

The coke burns to provide the heat to melt the iron ore mixture. The blast air is preheated. This preheating of air lowers the coke consumption as the heat from the air replaces some of the heat supplied from the burning coke.

The hot metal is transported to the steel plant via rail tracks and torpedo ladles. The high temperature also stops the metal from freezing while it is been transported to the steel plant. Hot metal torpedoes are specially designed train trucks, which transports the liquid iron to the steel plant. A torpedo can carry up to 200 tons of hot metal.

The torpedo is lined inside with refractory material, to protect the torpedo shell and to stop the hot metal from losing heat. At Newcastle the torpedo mouth is covered with a refractory lined lid. This prevents heat loss from the hot metal.

The current average production rate is 5 000 thm/24h with and a 96% availability. At the end of the 1984 campaign, with a large working volume, a production record of 6 141 thm/24h was set. The new campaign maximum is 5 600 thm/24h.

Steel Making

The products of this industry can be utilized as the final application, or else they can be processed further in the manufacturing industry. In this process the liquid iron is converted into steel. Impurities are removed from the hot metal to manufacture steel. Steel is a processed form of iron to which certain additions are made to impart special qualities.

Steels are generally classified on the basis of both carbon content and alloy content. Numerous types of alloying elements are added to plain carbon steel when in liquid form so that the mechanical and other properties are of those required for the application.

The most important additions are, Carbon, Manganese, Silica, Chrome, Nickel, Copper and Aluminium. There are also a large number of other elements (additions) that can be made to ensure more specialised properties (example Boron for hardness) but most of these additions are made in smaller amounts. The most important impurities in steel are Hydrogen, Nitrogen, Sulphur and Phosphorus as well as fluxes such as alkali metal oxides.

Basic Oxygen Furnace (BOF)

There are three Nippon Steel BOF's which operate on a 2 out of 3 system to accommodate maintenance and inspection schedules. All furnaces were refurbished between 1997 and 1998. These furnaces operate at approximately 165 tons per heat, and produce an estimated 1.9 million tons/year of steel. Current operations utilize approximately 10% - 15% scrap, with the balance of charge being hot metal (from the blast furnaces). Every load of scrap is scanned for radioactive content.

The sulphur content of hot metal received from the blast furnace is first reduced by using soda ash. A deslagging process follows and then the clean, purified metal is charged into a 1 500 ton capacity induction furnace. This furnace can heat the metal at a rate of 15 MW. Its function is to superheat the metal, melt additional scrap and homogenise the metal both chemically and thermally. In this way, a supply of hot metal with a relatively consistent analysis and temperature is assured.

Approximately 160 t of the hot metal (together with about 12% scrap) is charged into the Basic Oxygen Furnace (BOF). Here the injection of oxygen and the addition of lime initiate oxidation reactions that raise the temperature from 1 300° C to 1 600° C in a process typically lasting 20 minutes. During subsequent tapping into a ladle, alloying elements (e.g. carbon, manganese, silicon) are added to achieve the specific properties of the required end-product. This liquid can then be further processed in the secondary metallurgical units or delivered direct to the casting plant.

The average monthly production rate is approximately 165 000 tons, but a record of 192 000 tons has been achieved.

Ladle Furnace (Secondary Metallurgy)

The two units involved in the secondary treatment of steel are a ladle furnace and a vacuum degasser. All Melt Shop production passes through these furnaces. These furnaces receive power from two ladle metallurgy transformers rated at 25 MVA, which step down power from 33kV to 340V (AC).

The ladle furnace, designed and built by Nippon Steel Corporation, Japan, was commissioned in 1989. It has three electrodes of 450 mm diameter arranged in a pitch circle of 1,2 m. One 25 MVA transformer provides a heating rate of 3,5° C/min, which allows tap temperatures at the BOF to be reduced significantly.

The ladle furnace is fitted with a water-cooled hood. Flux and alloy additions are made from specially designed bunkers by a conveyor feed system. A wire feeder allows certain alloying elements (e.g. Ca, Ti, C, Al) to be injected directly into the steel. Precise slag compositions are designed to give low sulphur and phosphorous concentrations and cleaner steel. The furnace normally processes about 30% of the total liquid steel production and has treated up to 24 heats/day.

Vacuum Degasser

Vacuum degassing treats hydrogen sensitive and ultra low carbon grades. This operation is currently utilized at a very low capacity, and handles a maximum of 25% of product from the BOF's.

The RH vacuum degasser was designed by Vacmetal, Germany, and erected by Dorbyl Structural Engineering. It has a rocker arm mounted one-piece vacuum vessel which allows the nozzles to be immersed 1,5 m into the steel. The electrical preheating capacity for the vessel is 1,4 MVA. Four steam ejectors, operating in three stages, produce a vacuum of 0,07 kPa. Full vacuum is obtained in 4 minutes and steam consumption is 11 t/h. Argon injection at 1 500 l/min creates a steel circulation rate of 85 t/min. A vacuum alloy feed system allows micro-alloy adjustments to give narrow chemical analysis, while the circulation results in thermal and chemical homogenisation.

The vacuum degasser was commissioned in 1991 to produce low hydrogen (< 1,5 ppm) and ultra low carbon steels (< 50 ppm). About 15 000 tons of liquid steel is treated each month.

Continuous Casting

Continuous casting describes the continuous or uninterrupted casting of steel. It was originally used for non-ferrous metals such as copper and aluminium.

The continuous casting plant comprises three similar machines, each designed to convert liquid steel into solid blooms at the rate of 175 tons per hour. The cross section of the bloom differs from machine to machine, but is either 315 x315 or 315 x210mm.

When a machine is in operation, six strands are cast simultaneously from which blooms with lengths of between 5 m and 14 m are cut, each weighing typically between 4 and 10 tons.

Bloom lengths are infinitely variable between these limits, the exact lengths being determined to maximise the bloom into the customers' products. Through the process of continuous improvement the casters have been equipped to cast a wide range of materials which include low carbon alloys, rope wire rod and aluminium killed nut and bolt steels.

The capacity of the caster is matched to that of the BOF vessels and it consequently typically processes 165 000 tons of liquid steel per month.

Rolling Operations

Billet Mill

The billet mill can be regarded as a primary mill that processes cast blooms received from the continuous caster into blooms and billets for the secondary mills (medium, bar and rod mill). Round bar of various sizes is also produced for the local and export markets, as well as blooms.

Two 150 ton/hour pusher furnaces reheat the blooms to rolling temperature. The fuel used in these furnaces is mainly coke-oven gas or a combination of coke-oven gas and heavy fuel oil.

A breakdown or reversing mill is used to form the cast blooms into blooms for dispatch, or for the continuous mill, where two vertical and two horizontal stands are used for further rolling into billets or round bar, after which a flying shear cuts the products to ordered lengths.

Magnaflux inspection, with surface grinding facilities on billets, is available for special steel grades.

Medium Mill

The medium mill comprises three areas -- the mill area, finishing area and the roll preparation area. The products rolled on this mill include rounds, billets, flats, rails, beams, channels, equal leg angles, unequal leg angles and several special profiles. Various sizes of each profile are rolled and in total nearly five hundred products can be produced by this plant. Production varies between 30 000 and 50 000 tons per month depending on the product mix.

The mill consists of a walking beam reheating furnace, two reversing breakdown mill stands, a hot saw for cropping, six horizontal and three vertical/horizontal mills. The material from the mill is cut into cooling bed lengths with a shear. The cooling bed is 130 metres long.

From the cooling bed the material goes through the straighteners into the finishing area where the material is cut to the ordered lengths by five cold saws and then piled and bundled on two piling machines. There the material is weighed and marked for dispatch to various customers.

Bar Mill

The bar mill is referred to as a multi-line hot profile mill as different mill set-ups or paths are used to roll reheated intermediate billets into finished profile products.

Final products are produced from billets that are reheated in the furnace and passed through the eight-stand roughing train, where the billet cross-section is reduced. Further reduction and profiling takes place through the five-stand intermediate trains and the four-stand finishing train.

The final products are angles, flat bars, squares, round bars and some special sections. The round bars can be rolled to very fine tolerances in the order of 0,12 mm through a precision sizing block.

The final product is then either coiled or run out onto the cooling beds as straight bar. These are cut into lengths (as per customer order) and bundled before being loaded for transport, either by rail or by road. The finishing complexhas four 500 ton cold shears connected to four semi-automatic bundling units.

Rod Mill

This mill produces rod in sizes from 5,5 mm up to 14 mm in various steel grades ranging from low carbon steel to high carbon and alloy steel.

The plant was upgraded in November 1995 with the addition of a four-stand reducing/sizing block per strand allowing rolling speeds up to 100 m/s on the smaller diameter rod. The finished product is coiled, compacted and tied with four steel straps before dispatch to the customer.

The rod is used in the manufacture of steel ropes, bolts and nuts, welding wire, fencing wire, steel wool, etc.

2.2 Process flow chart

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Vereeniging Works: Process Configuration

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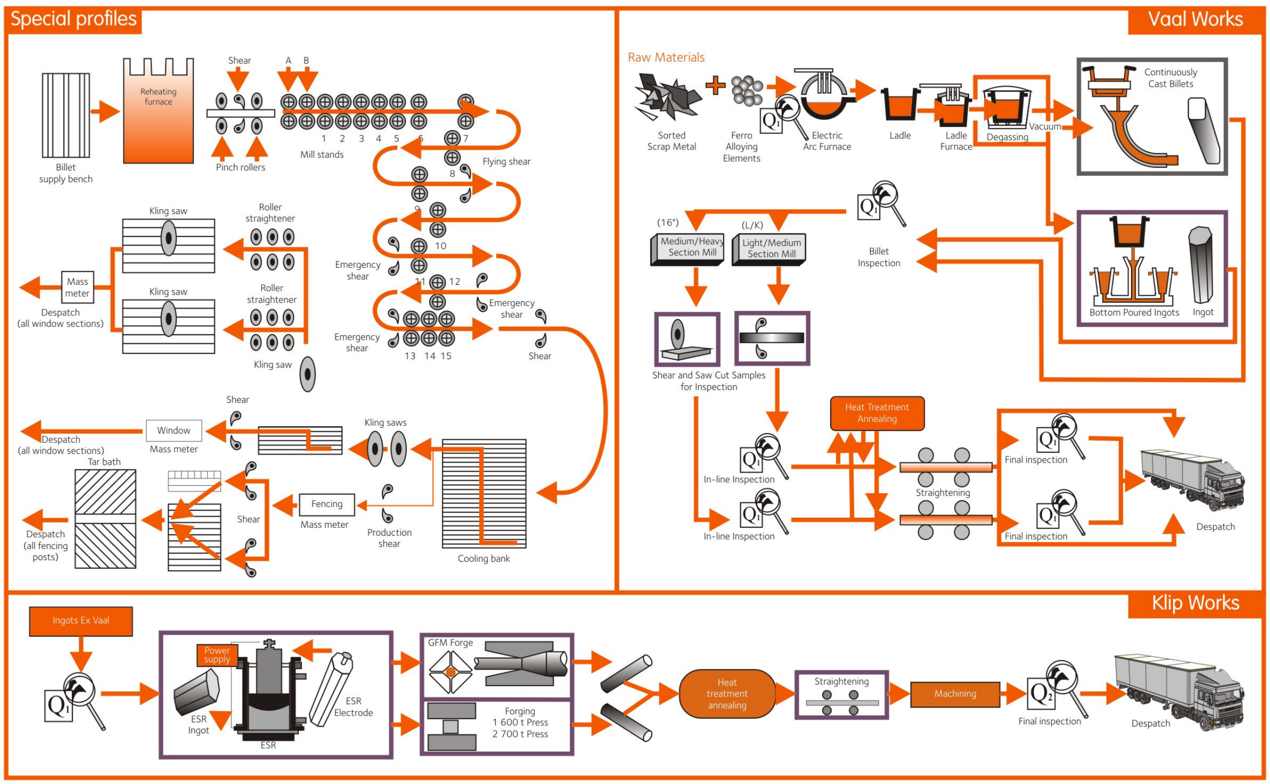

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General information about Newcastle

Newcastle, at the junction of three provinces, is the largest town in northern KwaZulu-Natal and was named after the Earl of Newcastle who was, in 1864, the Colonial Secretary in Queen Victoria's Government. The township was set out by Dr Sutherland who later became the Surveyor General of Natal.

Originally known as Post Halt Two on the journey between Port Natal-Durban and the Zuid-Afrikaansche Republiek (Transvaal), the town was referred to as Viljoensdorp by the Boers during their brief occupation in 1899.

In 1864, a Natal government proclamation advertised certain lots of land for sale in the township of Newcastle. The first property was purchased for £5.30.