

Granshot® iron granulation technology

In an integrated steel plant, blast furnace production is reduced when the BOF plant is unable to accept the full hot metal supply. A BF operates more efficiently on a constant blast volume and so it can be operated at a lower coke rate and produces iron of more consistent quality without having these fluctuations. The Granshot granulation process is a cost-effective method of handling excess iron at high capacity, low cost and producing prime product material for re-use.

Authors: Kristina Beskow, Per-Åke Lundström and Erik Dupon
Uvån Hagfors Teknologi AB and Danieli Corus BV

Integrated steel plants operate with little buffer capacity. Normally the buffer between the blast furnace and the steel plant is a fleet of torpedoes, which may have a buffer volume corresponding to a few hours of iron production.

At any unexpected disturbance in the steel plant or during planned maintenance which lasts for a period exceeding the buffer capacity, the excess iron has to be taken care of. The most common way of handling this is to send the torpedoes to a dry pit casting area and to reduce the BF production rate. Longer steel plant down periods always causes the BF to turn down completely, often due to the undesirable side-effects that the casting method creates. Dry pit casting generates fumes and dust, solidification is slow and the solidified product, which normally contains a lot of sand, has to be broken up into pieces at considerable cost. Due to the high environmental load (dust generation) during sand pit casting many licensing authorities decline to allow use of this method on a regular basis, which makes alternative solutions even more important for the integrated steelmaker.

GRANSHOT IRON GRANULATION

Several options are available for processing excess hot metal in cases of overcapacity or downstream disturbances. Granshot® iron granulation, developed in the 1970s and proven in pig iron production and ferro-alloy industries, is the optimum choice.

The process is straightforward. Granules are liquid iron droplets cooled in air and water. The product, known as Granulated Pig Iron (GPI®) has excellent chemical and physical properties and is used as a prime raw material in steelmaking operations. GPI can replace scrap in the BOF or, alternatively, be fed back into the BF to increase hot metal production when required. It can also be sold on the world market. Further processing of the granules is easy (ie, no crushing required) and the Granshot units are flexible with very short start-up times.

Granshot is a more environmental friendly method of solidifying the excess hot metal, which has several advantages as a parallel route for the iron as soon as the

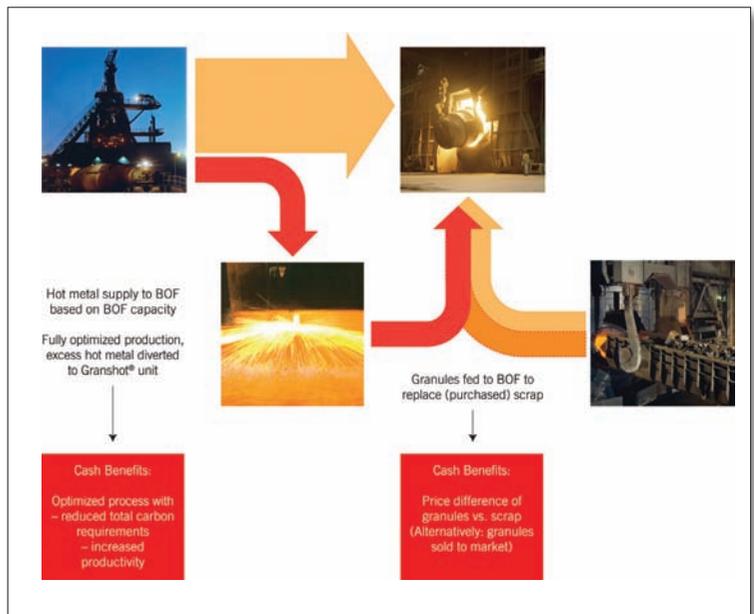


Fig 1 Schematic view of metal flow in integrated steelmaking with granulation as a backup system

liquid buffer is full. The granulation unit allows the BF to maintain a constant production rate regardless of any downstream problems, while the excess iron is sent to the Granshot unit (see Figure 1).

THE GRANULATION PROCESS

The equipment is designed for granulation of large batches of liquid metal at a rate of up to 250t/hr per production line. The principle is based on heat exchange between the liquid metal and the cooling media. Heat released from the metal cooling and solidification is transferred to the cooling water, which carries the heat out of the system. A typical setup is shown in Figure 2.

The liquid metal stream emerging from the tundish strikes a refractory spray-head, placed in the centre of the tank and the metal, and is distributed over the granulation tank water surface (see Figure 3). The liquid metal forms droplets of which the outer part solidifies in-flight before ▶

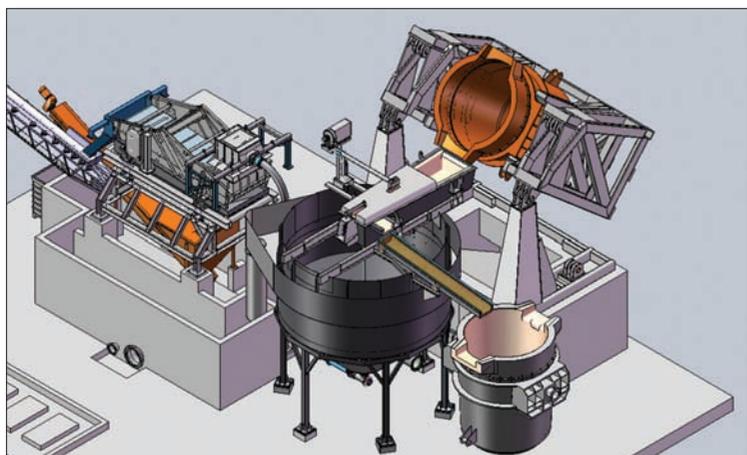


Fig 2 A typical Granshot setup

penetrating the water surface. The remaining inner part of the semi-liquid droplet, now a granule, is quenched as it strikes the water surface and starts its journey downwards in the water volume.

Further cooling of the granules takes place as the granules sink downwards in the granulation tank and heat is exchanged with the counter-flowing cooling water. When approaching the granulation tank lower end, the granules are forced towards the tank centre due to the conical shape, which ends in the discharge system inlet.

The solidified granules are discharged from the lower end of the granulation tank by a specially designed air/water ejector onto a de-watering screen. After de-watering the granules are transported via conveyor belts to the storage area or fed into a rotary dryer (a common route for ferroalloy granulated products).

BLAST FURNACE OPERATION STABILITY

Fluctuations and changes in BF set points are detrimental for its process stability and general performance. Apart from reducing the crude iron output, a BF turndown strongly influences pig iron quality and furnace fuel consumption. As the BF operating conditions are altered there are two significant iron properties that vary: the Si content and the temperature. These have adverse effects on raw material costs and slag volumes in the BOF, which can result in lower yields and increased energy consumption. Temperature variations in the BF will also induce stresses in the refractory lining, which results in higher refractory wear.

As a granulation plant decouples the pacing of the ironmaking and steelmaking facilities this eliminates BF shutdowns due to steel plant interference and allows for a more stable BF operation. A decreased number of BF down periods will give a higher utilisation of available equipment. This will in turn lower the capital element of the total cost per tonne of iron produced. In addition, the variable cost per tonne of produced metal will decrease



Fig 3 Granshot granulation on spray-head – typical metal umbrella formation

since many of these, eg personnel and consumables, are in practice, also totally or partly tied to the BF operation during shorter production stops.

PLANT CONFIGURATION CHOICES

There are no fundamental variations in the process whatever the type of metal to be cast. Consequently, steel as well as iron may be cast in the same production unit. If both iron and steel are to be granulated, the Granshot system should preferably be placed inside the steel plant. If only iron is to be granulated, it can be placed anywhere downstream of the BF.

The Granshot equipment is tailor-made for each application as plants are not identical. Several different configurations are possible:

- Granulation from ladle in ladle tilter via tundish
- Granulation from ladle in turret via tundish
- Granulation from torpedo via runners and tundish
- Granulation from ladle hanging in crane via tundish
- Granulation directly from furnace via runners and tundish

The different configurations make it possible to design the plant based on existing preconditions at site to achieve the best logistical solution for each production case.

IRON GRANULATION PLANTS

voestalpine, Donawitz, Austria installed a Granshot plant in 2002 inside the steel plant premises (see Figure 4). The main task is iron granulation but its location also allows for steel granulation. The material produced is used as an additive in the converters or is sold as feedstock to other steel plants.

At ArcelorMittal, Saldanha Steel, in South Africa the Granshot plant is located in a stand-alone building.



Fig 4 Granshot plant at voestalpine, Donawitz

Excess iron produced in the Corex® ironmaking unit is transferred to the granulation facility in ladles and the granulated iron is used as raw material in the downstream Conarc® electric steelmaking furnace, partly substituting merchant scrap and internally produced DRI.

The most recent plant was installed at SSAB, Oxelösund, Sweden in 2007 (see *Figure 5*). The plant is the first high-capacity one designed to granulate 100% of BF production output during periods of steel plant maintenance, at a granulation rate of 240 t/hr continuously. The plant is located in the steel plant casting bay to allow for granulation of steel as a backup during caster problems or maintenance.

Desulphurised liquid iron is tapped from torpedoes into 200t transfer ladles equipped with a sliding gate arrangement for bottom pouring. The transfer ladles are placed in a turret in a similar manner to continuous casters and the metal is granulated via a tundish. The turret in combination with the tundish provides for a smooth sequence granulation without any operational shutdown between ladles.

For a granulation rate of 240 t/hr the generated power that is transferred from metal to water is about 80MW. With this magnitude of power in a water system, the power has to be distributed to the water in such a way that the power concentration (power/volume unit) is safely below the critical concentration for vapour explosions. The Granshot metal distribution system (spray-head) in combination with the specially designed water inlet nozzle distribution system in the granulation tank reduces the power concentration in the water basin and hence allows for granulation at high metal flow rates.

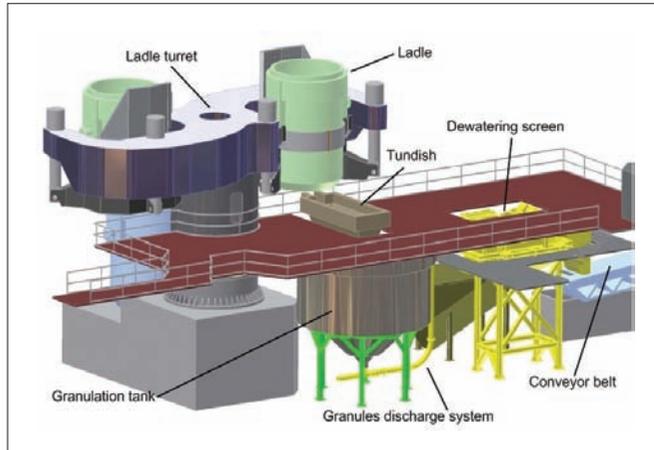


Fig 5 The Granshot plant at SSAB, Oxelösund, Sweden

Since the plant at Oxelösund was commissioned the number of granulated sequences performed is around 450 (~145,000t). All of these instances would otherwise have caused the BF to shutdown if the Granshot system were not available due to new, tougher restrictions on dry pit casting.

A fourth Granshot plant will be in operation at Essar Steel, Hazira, India in 2009. It is designed for a granulation rate of 150t/hr and will accommodate excess iron from the Corex ironmaking unit.

USE OF GPI

By running the BF at peak performance at all times with a backup granulation system a prime iron product is generated with excellent properties for internal use or for sales to external consumers. The GPI has a chemical composition identical to the liquid iron. No chemical reactions have been found during granulation due to rapid quenching. Hence, the metallic yield is close to 100%.

Some typical characteristics of the GPI are listed below:

- High bulk density (4,000~4,500kg/m³) depending on size distribution. This is strongly dependent on the production plant set-up. (One plant produces 97% in the range 8-25mm)
- Excellent preheating properties and fast melting/dissolution when added to metallurgical processes
- Very low oxide content
- The granule shape is excellent for raw material handling by conveyor belt, magnet, front-end loaders, bin systems and scrap skip

GPI can be used as prime raw material in many metallurgical/steelmaking operations, some of which are listed in *Table 1*. ▶

GPI use – case	Suitability	Comment
Blast Furnace (BF)	Suitable	<ul style="list-style-type: none"> Recycling of GPI into the BF burden to boost and/or promote iron throughput. This is a special case to be considered when for instance, there is shortage of iron due to one ironmaking unit off for relining.
Electric Arc Furnace (EAF)	Very suitable	<ul style="list-style-type: none"> Virgin feedstock low in residuals Suitable to load in scrap bucket (high density, valuable for efficient charging) Possible to feed continuously through fifth hole. Charging with power on, lowering of tap-to-tap time High carbon content, promotes slag foaming and reduced power consumption High metallic content and small size reduces risk for electrode breakage
Basic Oxygen Furnace (BOF)	Very suitable	<ul style="list-style-type: none"> Excellent cooling scrap – neutral composition Suitable to load in scrap skip (high density and efficient magnet loading) Possible to feed continuously for temperature control during blow Small size ensures rapid melting and dissolution – no late carbon boils
Ladle Furnace (LF)	Limited	<ul style="list-style-type: none"> Suitable for recarburisation. Limited primarily by chemical composition (phosphorous and sulphur)
Continuous Casting (CC)	Very limited	<ul style="list-style-type: none"> Used as starter head cooling scrap

Table 1 Use of GPI in different steelmaking operations



Fig 6 Potential savings

SERVICES

Since 2008, Uvån Hagfors Teknologi (UHT) and Danieli Corus have been working together on the implementation of Granshot systems in integrated steel plants, their combined knowledge and technologies allowing them to assess plants and to create optimal solutions. The technology is proven, however the benefits to a particular plant configuration need to be defined prior to making the decision to invest in such a system.

By undertaking a techno-economic feasibility study on the BF and steelmaking capacities and logistical arrangements, the areas for savings can be clearly highlighted. In many cases, this will be where there is either inherent or temporary mismatch between the BF output and the steelmaking requirement, or indeed

between the steelmaking plant and the continuous casting machines. This mismatch can either be re-absorbed into the production stream, with the subsequent ripple effect to the whole production chain. Alternatively, it can be taken out of the production stream and dealt with by the Granshot system, allowing the production stream to continue without hindrance.

As an indication of the potential savings, Figure 6 shows the reasons for delays on a site with multiple blast furnaces. In this case a quarter of the unplanned reduction of BF output were caused by steelmaking delays. Some improvements were possible in the steelmaking plant, but significant benefits could also be realised by installing a Granshot facility to free up torpedo space and allow the BF output to continue. A techno-economic feasibility study can quantify this benefit for an individual plant and so easily demonstrate where investments will be paid back more quickly.

CONCLUSIONS

The Granshot granulation process is a cost-effective method of handling excess iron at high capacity and low cost. The granulated material shows excellent chemical and physical properties and is used as a prime raw material for internal use and for external sales. **MS**

Kristina Beskow and Per-Åke Lundström are with Uvån Hagfors Teknologi AB (UHT), Täby, Sweden. Erik Dupon is with Danieli Corus BV, IJmuiden, The Netherlands.

CONTACTS: info@uht.se info@danieli-corus.com