GRANSHOT® IRON GRANULATION FOR OPTIMIZED PLANT LOGISTICS[1]

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Abstract

This article discusses the principal layout of the Granshot plant, operational experience and the usability of the end product in steelmaking operations. The Granshot granulation process converts liquid metal into granules by rapid solidification in water. The simplicity of casting directly from liquid metal to ready-to-use bulk material, without any intermediate crushing and sieving steps, makes it a very attractive process. In addition, the granules have a rounded, dense shape and contain a minimum of fines and oxides and/or slag. A Granshot plant decouples the iron-making and steelmaking operations when required, and can be designed to process the entire output of the blast furnace. Due to the rapid solidification, elements like carbon remain in the metal's matrix. For granulated pig iron, the high concentration of carbon reduces the energy usage of Electric Arc Furnaces (EAFs), The equipment is more robust than comparable size pig casters due to its simplicity and lack of moving components.

Keywords: Iron-making; Blast furnace; Integrated steel-plant; Pig iron; Iron granulation.

GRANSHOT® GRANULAÇÃO DE FERRO PARA LOGÍSTICA OTIMIZADA DE PLANTA

Resumo

Este artigo discute o layout principal de uma planta Granshot, experiência operacional e de uso do produto final em operações siderúrgicas. O processo de granulação Granshot converte metal líquido em grânulos por solidificação rápida na água. A simplicidade da moldagem de metal líquido diretamente em um material pronto-para-uso, sem qualquer etapa intermediária de britagem e peneiramento, torna a tecnologia muito atraente. Além disso, os grânulos têm uma forma arredondada e densa e contém um mínimo de finos e óxidos/escórias. Uma planta Granshot desassocia as operações de redução e aciaria quando necessário, e pode ser projetada para processar toda a produção do alto-forno. Devido à rápida solidificação, elementos como carbono permanecem na matriz metálica. Para gusa granulado, a alta concentração de carbono reduz o consumo de energia nos fornos elétricos. O equipamento é mais robusto do que máquinas de lingotamento de gusa de capacidade similar devido à sua simplicidade e falta de componentes móveis.

Palavras-chave: Redução; Alto-forno; Plantas siderúrgicas integradas; Ferro gusa; Granulação de ferro.

[1] *Technical contribution to the 39th International Meeting on Ironmaking and 10th International Symposium on Iron Ore, November 22 – 26, 2009, Ouro Preto, MG, Brazil.*
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INTRODUCTION

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

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

Voestalpine Stahl in Donawitz, Austria, Mittal Saldanha Steel[1], Saldanha Bay, South Africa and SSAB Oxelösund , Sweden have installed Granshot plants for granulation of hot metal during periods of disturbances and maintenance of downstream equipment. A fourth Granshot plant for iron granulation will be in operation at Essar Steel, Hazira, India later this year.

The installations replace the traditional dry pit casting (known as ponding, pooling, plating or beaching) of excess iron, which causes severe environmental dust as well as excavation and reclamation problems and cost.

GRANSHOT IN INTEGRATED STEELMAKING

Liquid Iron Logistics

Integrated steel plants operate with little buffer capacity. Normally the buffer between the Blast Furnaces (BFs) and the steel plant consists of a fleet of torpedo-cars, which may have a buffer volume corresponding to a few hours of the BF-production.

At any unexpected disturbance in the steel plant or at 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 torpedo-cars to a dry pit casting area and to reduce the BF production rate. Longer steel plant down periods require a complete turn down of the BFs. The reason for turning down the BF is often due to the undesirable side effects that the casting method creates. Dry pit casting generates fumes, dust, solidification is slow, and the solidified product, which normally contains a lot of sand, has to be broken up in pieces at a considerable cost. Due to the high environmental load (dust generation) during sand pit casting many authorities decline sand pit casting on a regular basis, which makes alternative solutions even more important for the integrated steel maker.

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 liquid buffer is full. The Granshot granulation unit allows the BF operator to keep a constant production rate regardless of any downstream problems, while the excess iron is sent to the Granshot unit. The produced product is ready-to use and requires no tedious work of breaking up the metal compared to dry pit casting. The end-product properties are excellent for automatic handling and usage as prime iron units in-house or for external sales.

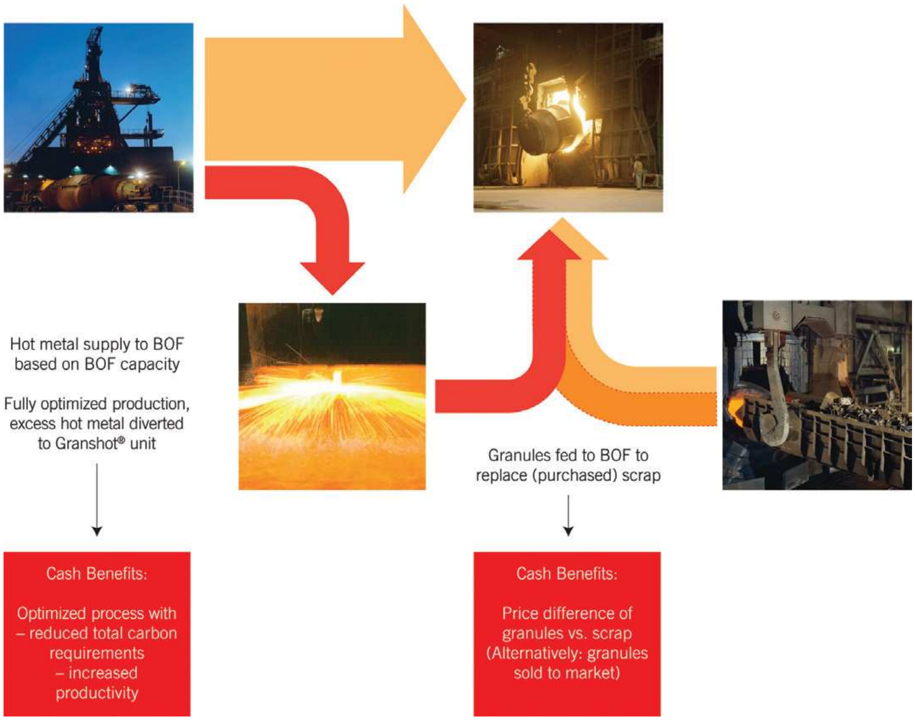

Figure 1 - Schematic view of metal flow in integrated steelmaking with granulation as a back-up system.

GRANSHOT GRANULATION PROCESS

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

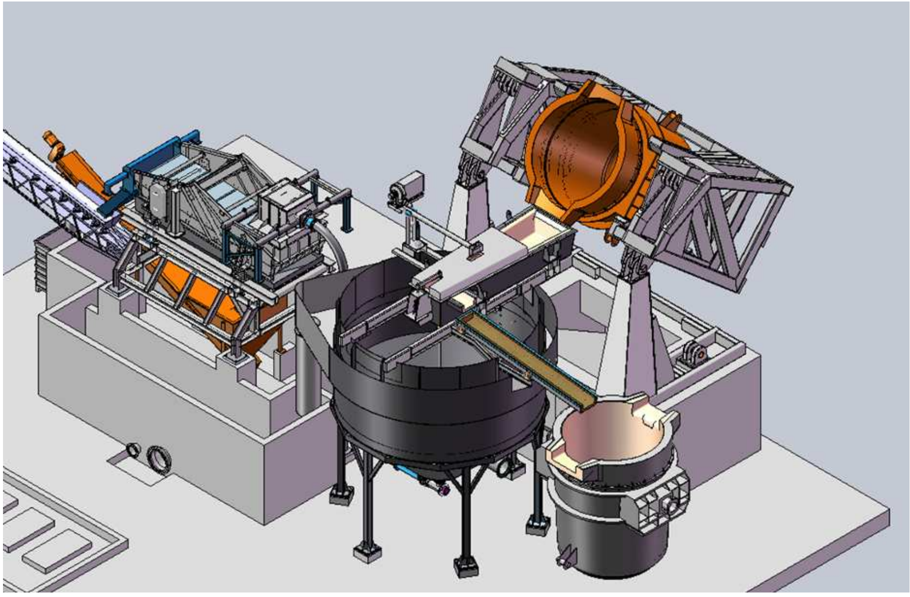

Figure 2 - A typical Granshot setup.

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, Figure 3. The liquid metal forms droplets of which the outer part solidifies in-flight before 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 it travel downwards in the water volume.

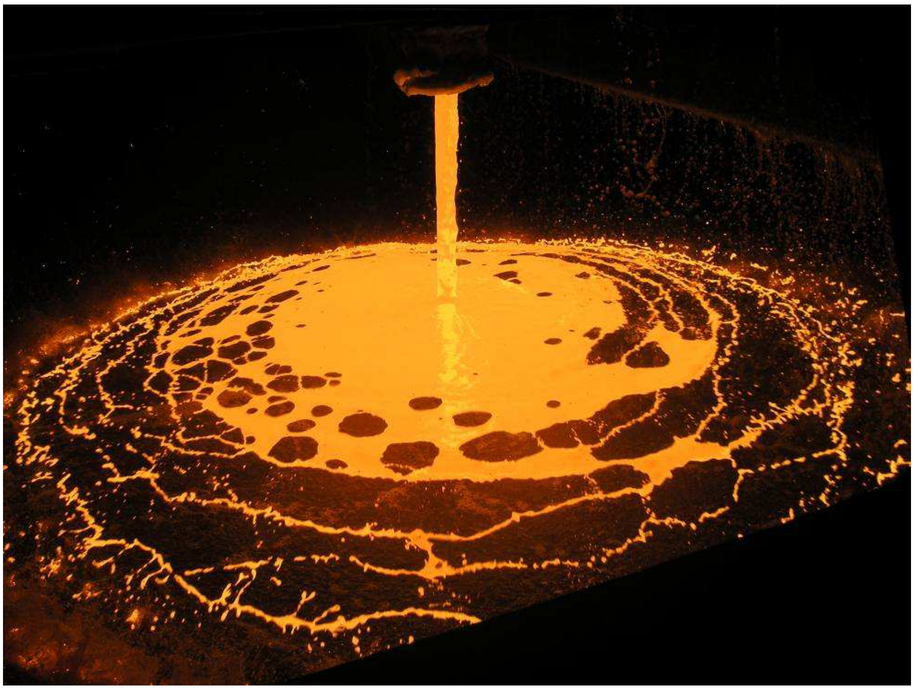

Figure 3 - Granshot granulation on sprayhead - typical metal umbrella formation.

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 tank wall 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 on to a dewatering screen. After dewatering, the granules are transported via conveyor belts to the storage area, or fed into a rotary dryer (common route for ferro alloy granulated products).

BLAST FURNACE OPERATION STABILITY

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

The Granshot 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 since many of these, e.g. personnel and consumable are, in practice, also totally or partly tied to the BF operation during shorter production stops.

Multiple choices for plant configuration

In integrated steelmaking, the Granshot process is used as a back-up facility whenever downstream facilities are down as a producer of GPI or granulated steel. There are no fundamental variations in the process whatever the type of metal to be cast. Consequently, iron as well as steel may be cast in the same production unit. If iron and steel are to be granulated, the Granshot system should preferably be placed inside the steelplant. 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 and prerequisites, as no plant is identical to another. 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 the existing preconditions at site in order to achieve the best logistical solution for each production case.

IRON GRANULATION PLANTS

Voestalpine, Donawitz, Austria installed a Granshot plant 2002, see Figure . The unit is located inside the steel plant premises. The major task is for iron granulation but its location also opens the opportunity 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. Excess iron produced in the Corex® iron making unit is transferred to the granulation facility in ladles. The produced granulated iron is used as raw material in the down stream Conarc® electric steelmaking furnace, partly substituting merchant scrap and internally produced DRI.

The latest Granshot plant for iron granulation was installed at SSAB, Oxelösund in Sweden. The plant was commissioned in the spring of 2007. The plant is the first high-capacity plant designed to granulate 100 % of the Blast Furnaces’ production output during periods of steel plant maintenance, at a granulation rate of 240 tonnes per hour continuously. The Granshot plant is located in the steel plant casting bay in order to easily allow for granulation of steel as a backup during caster problems or maintenance.

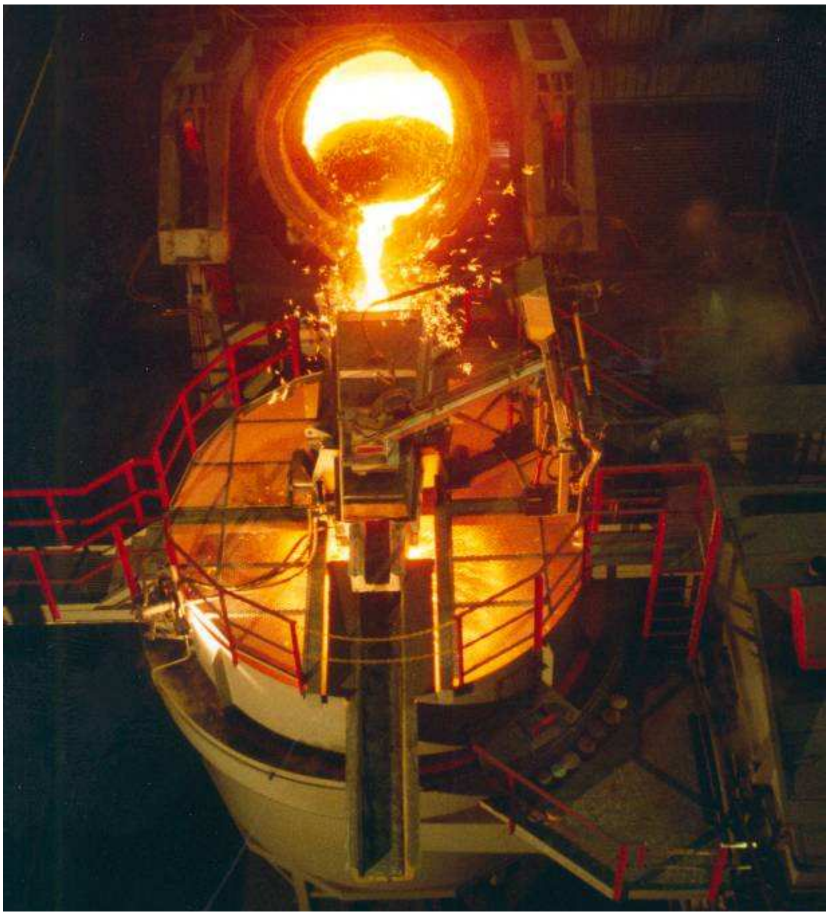

Figure 4 - Granshot plant at Voestalpine, Donawitz.

Desulphurised liquid iron is tapped from torpedo-cars to 200 tonnes transfer ladles equipped with sliding gate arrangement for bottom pouring. The transfer ladles are placed in a turret and the metal is granulated via a tundish in a similar manner as in continuous casters. 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 tonnes/h the generated power that is transferred from metal to water is about 80 MW. With this magnitude of power in a water system, the power has to be distributed to the water in a way securing that the power concentration (power/volume unit) is safely below the critical concentration for vapor 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.

Since the Granshot plant at SSAB Oxelösund was commissioned the number of granulated sequences performed is around 450 (approx. 145 000 tonnes). All of these instances would otherwise have caused the BF to shutdown if the Granshot system were not available due to the new firmer restrictions on dry pit casting. A schematic overview of the Granshot plant at SSAB-Oxelösund is shown in Figure 5.

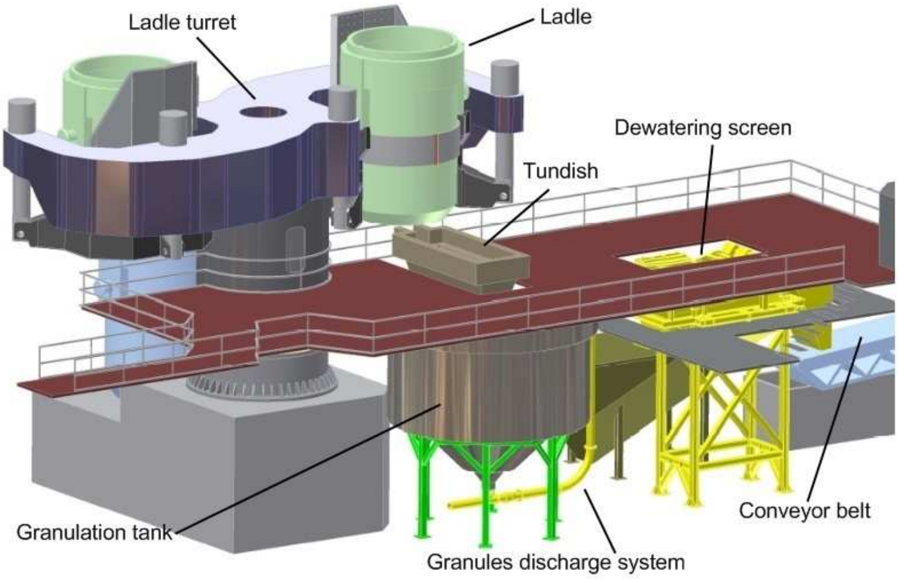

Figure 5 - The Granshot plant at SSAB-Oxelösund, Sweden.

A fourth Granshot plant for iron granulation will be in operation at Essar Steel, Hazira, India later this year. It is designed for a granulation rate of 150 tonnes per hour and will accommodate excess iron from the Corex iron-making unit.

USE OF GRANULATED PIG IRON, GPI®

By running the BF at peak performance at all times with a back up of a granulation system a prime iron product is generated, which has 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 to take place during granulation due to the rapid quenching. Hence, the metallic yield is high and close to 100%. Some typical characteristics of the GPI are listed below:

- High bulk density (~3500 kg/m^3), depending on size distribution
- Excellent preheating properties and fast melting and/or dissolution when added to metallurgical process
- 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

The GPI can be used as prime raw material in many metallurgical/steel making operations, some of which are listed in Table 1.

Table 1 - The use of GPI in different steelmaking operations

GPI use-case	Suitability	Comment
Blast Furnace (BF)	Suitable	• Recycling of GPI into the BF burden to boost and/or promote iron throughput. This is a special case to be considered when production situation at hand so requires, e.g. shortage of iron due to one ironmaking unit on hold for relining.
Electric Arc Furnace (EAF)	Very suitable	• 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	• Excellent cooling scrap – neutral composition. • Suitable to load in scrap skip (high density and efficient magnet loading). • Possible to feed continuous for temperature control during blow. • Small size ensures rapid melting and dissolution – no late carbon boils.
Ladle Furnace (LF)	Limited use	• Suitable for exact recarburization. Limited primarily by chemical composition (Phosphorous and Sulfur).
Continuous Casting (CC)	Very limited use	• Used as starter head cooling scrap.

SERVICES

Since 2008, Uvån Hagfors Teknologi (UHT) and Danieli Corus are working together on the implementation of Granshot systems in integrated steel plants. Their combined knowledge and technologies allow them to assess plants and to create optimal solutions for integrated steel plants[2]. The technology offered with the Granshot system 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 blast furnace and steelmaking capacities and logistical arrangements, the areas for savings may be clearly highlighted. In many cases, this will be in the instance where there is either inherent or temporary mismatch between the blast furnace 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, the graph shown in Figure 6 shows the reasons for delays on a site with multiple blast furnaces. In their case, a quarter of the unplanned reduction of output on the blast furnace was caused by steelmaking delays. Some improvements were possible in the steelmaking plant, but significant benefits could also be realized 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.

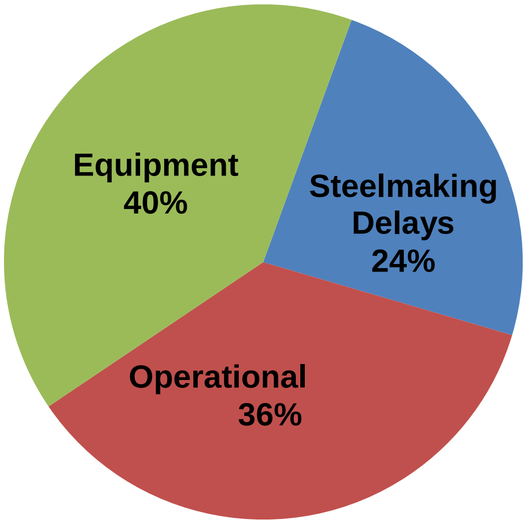

Figure 6 - Potential savings.

CONCLUSIONS

The Granshot granulation process is a cost effective method of handling excess iron, fulfilling all basic requirements such as high capacity, low cost of operation and prime product material. The granulated material shows excellent chemical and physical properties and is used as a prime raw material for internal use and for external sales.

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