RECYCLING OF FERROUS BY-PRODUCTS IN IRON AND STEEL PLANTS

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SUMMARY

Due to rising energy prices and stringent environmental regulations, energy efficiency, resource saving and climate protection are becoming more important than ever. Primetals Technologies ECO Solutions offers a wide range of services and technologies to increase energy efficiency, reduce the environmental impact of steel production plants and to ensure efficient water and by-product management

Primetals Technologies ECO Solutions provides processes and solutions along the entire iron and steel production chains, which meet the strictest emission regulations and also help producers achieve substantial cost savings. In response to these ecological and economic challenges, Primetals Technologies offers energy-efficient solutions and services along the entire process chain, with a clear objective: saving resources, creating value.

The optimized consumption of energy and raw materials, the application of advanced technological processes and the maximum application of recycling solutions lead to major energy savings, reduced emissions, improved water and by-prooduct management. Saving resources • Minimized emissions • Minimized use of raw materials • Minimized energy consumption • Optimized by-product recycling Creating value • Reduction of conversion costs • Increase performance • Improve quality

1. INTRODUCTION

Significant amounts of by-product fines are produced and collected in steel plants at all steps of iron & steelmaking. It can be assumed that per ton of steel produced around 60 -150 kg of particulate by-product is generated. Considering that these by-products have an average iron content of >50%, this is 3 up to 7,5% of the total steel production.

Primetals Technologies has developed several recycling technologies for treating particulate by-products. Cold briquetting is one of the favorable solutions to transform fine material into recyclable agglomerates.

2. RECYCLING OF FINES – COLD BRIQUETTING

Recycling of only a part of the by-product stream to the sinter plant is very common. In many cases the addition of mainly unconditioned by-products may be possible, in some cases with a negative impact on the plant operation, such as increase generation of fines and reduction of productivity, and leaving still a large amount of by-products unused.

In order to include most or all of the generated by-products, cold briquetting of various dusts and sludges allows integrated recycling within existing primary production units. After pre-treatment of the residues, including drying, screening and mixing, binders are added and following the mixture is briquetted using roller-type presses. The selection of the binder system is dependent on desired metallurgical route for the respective recycling.

In Figure 2 a block diagram of a cold briquetting process including pre-treatment of the waste material is shown.

In the first step of the cold briquetting process the wet by-products are dried. Then the dried materials as well as other dusts are mixed while adding the binders. Afterwards the material is directly fed to a briquetting press. In a final step the product briquettes are screened and then conveyed to the curing and storage yard.

Approximately 10% fines are internally recycled after the screening. Final product screening is done just before loading to the trucks.

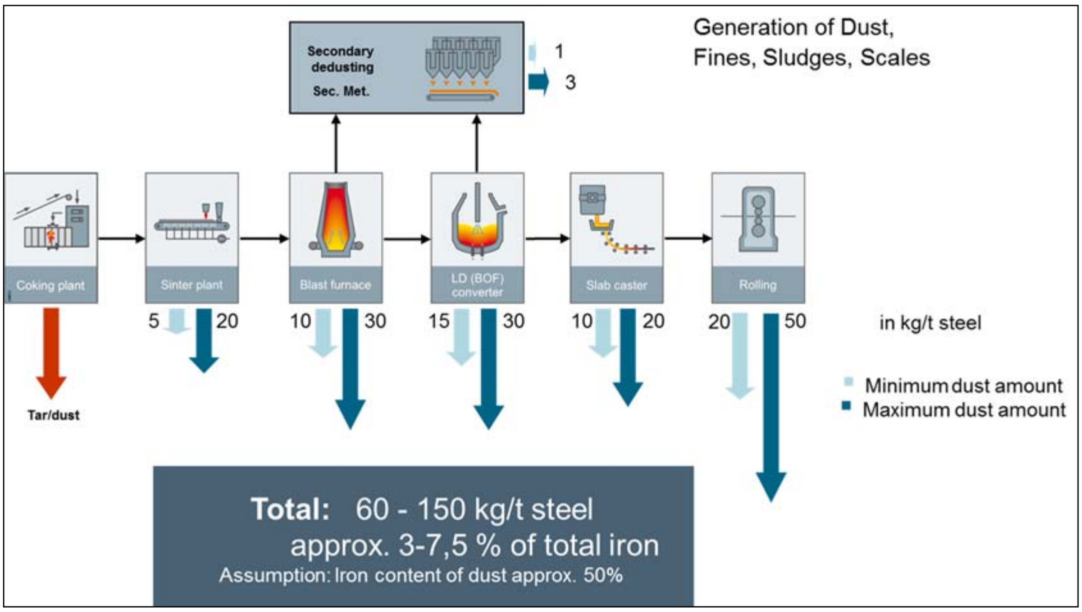

Figure 1. *Typical by-product fines generation in an integrated steel mill*

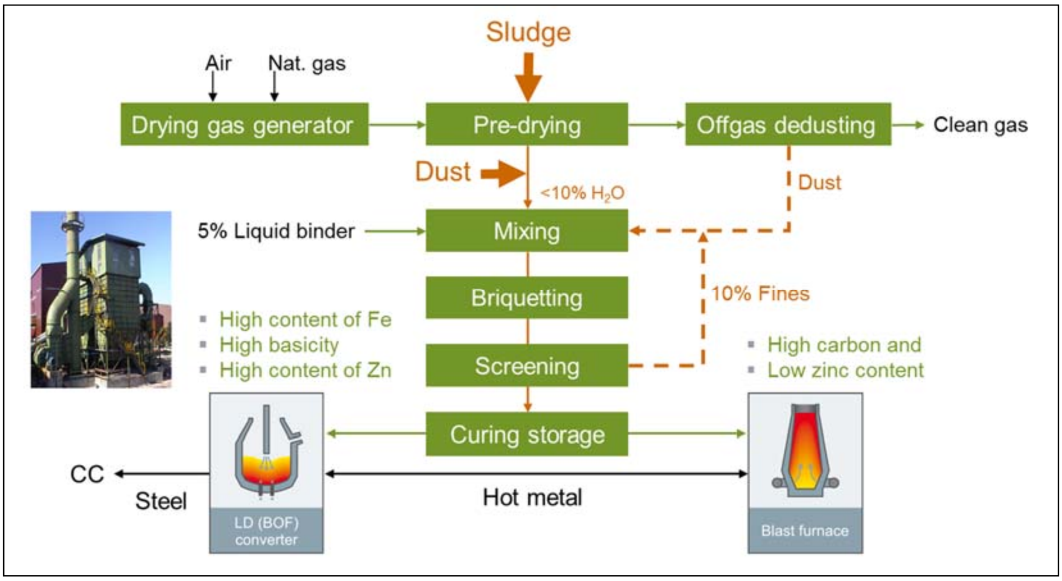

Figure 2. *Cold briquetting process – Reference ILVA Taranto*

The reference plant at ILVA Taranto was designed as 2-line briquetting arrangement for a yearly production of around 240,000 tons. The briquettes were foreseen to be recycled to the LD converter (BOF) and blast furnace (BF) up to certain defined amount.

LD approx. 4 t per heat (approx. 8 kg briquettes/t_{steel})

BF approx. 1% of burden

A combination of molasses and hydrated lime is used as binding agent. Following input materials are treated in this briquetting plant:

- Converter fine sludge 30%
- Converter coarse sludge 10%
- BF sludge 10%
- Mill scale sludge 25%
- Sec. LD-dust 5%
- Dust catcher dust (BF) 10%
- Separation iron fines 10%

Briquettes with a high iron content and high basicity can be charged directly into LD converter (BOF), replacing cooling scrap or ore. Briquettes rich in carbon but with limited alkali and zinc contents can be charged into the blast furnace.

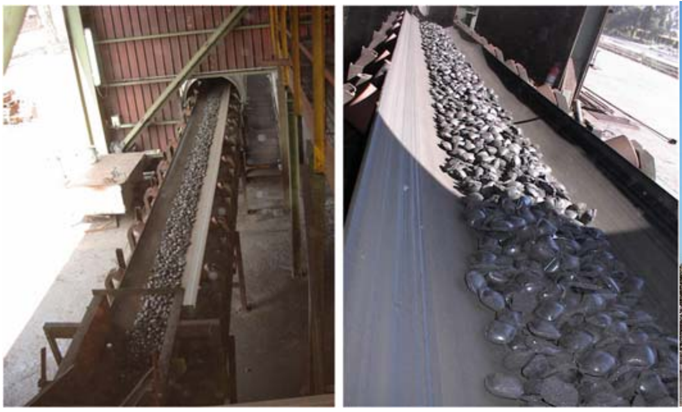

Figure 3a and 3b: *Product briquette*

Figure 4. *Briquetting plant, ILVA Italy*

The main benefits of this system are:

- Less raw materials utilization due to recycling of by-products (ore, scrap, coke) and therefore reduced operating costs
- Minimization of landfilling costs and volume
- CO2 reduction
- Sinter saving up to 5% (BF)
- Short payback period

Similar to the example of recycling of fines in an integrated plant described above, the recycling of fines in an DRI based plants can be applied using cold briquetting technology. In DRI based steel mills there is normally no agglomeration plant such as the sinter plant available which offers the possibility to recycle the generated fine by-products. In many cases it is not economical or generates little added value to sell and transport the materials to other plants for recycling. For these plants, the best recycling concept is to agglomerate the by-products, which reach approximately 10% of mass of the produced DRI capacity, such as dust from the material handling systems, oxide fines, HBI fines and DRI slurry by briquetting with an inorganic binder system.

The cold briquetting process itself is similar to the process shown in Figure 2. The produced briquettes are directly fed into the direct reduction plant (e.g. MIDREX) and may replace ferrous materials like iron ore or pellets in the reduction shaft.

New developments: The recycling concept for by-products generated in DRI plants is not yet commonly used on a large scale. The great economic value of such a project is determined by the high iron ore and pellet costs, compared to a relatively low operating cost and investment cost for such a plant.

Primetals, based on its experience from similar applications with cold briquetting plants, has invested considerably in laboratory testing to verify the briquetting properties and selection of appropriate binders and process parameters. To verify the right recipe for briquetting such materials and their combinations, several tests on laboratory scale as well as reduction tests simulating gas atmospheres of DRI plants were carried out.

In Figure 5 the oxide briquettes before and after passing the DRI shaft under reduction gas atmosphere are shown. The results fulfill the requirements of a direct reduction shaft concerning the low temperature disintegration (550°C). In Figure 6 the promising results are summarized and compared with iron ore pellets.

These results are promising in the sense that briquettes were produced that are stable under the reduction conditions. The actual basket tests results agreed well with the laboratory tests results, so that conclusion from the laboratory tests can be applied to the actual plant conditions.

a) before

b) after

Figure 5. *Soft basket tests in reduction shaft [2]*
a) before test; b) deformed soft basket after test

sample no.	test no.	briquette size [cm³]	comp. Strength [N] +0h	comp. Strength [N] +24h	shatter strength [%] +0h	shatter strength [%] +24h	basket test results: executed	basket test results: metallization [%]	basket test results: percentage "whole briquettes" [%]	$RDI_{+6,3mm}$ [%]	porosity [%]
T02	18624b	10	215	361	96,2	92,1	yes	90	90	76,0	25,3
T10	18624b	10	150	491	97,7	96,5	yes	81	100	77,4	-
T15	18624b	10	338	655	95,3	90,7	yes	87	93	77,8	25,5
T16	18624b	10	194	399	97,2	95,3	no	-	-	76,3	-
T21	18624b	5	185	517	91,5	83,3	no	-	-	80,7	25,8
T06	18665b	5	250	718	84,4	78	yes	94	89	88,0	-
T07	18665b	5	250	670	92,3	82,5	yes	95	100	86,9	27

Figure 6. *Summary of test results*

3. ADVANTAGES OF PRIMETALS COLD BRIQUETTING

- **Saving of Raw Materials,** substitution of pellets or lump ore
- **Compact plant layout,** easily integrated in integrated plant or DRI plant layout
- **Avoid Depositing of By-Products,** avoid cost of depositing, save space
- **Low overall CAPEX**, low investment cost, short payback time
- **Minimize Handling,** use of materials directly in the main process
- **Low OPEX** compared to cost of pellets or lump ore
- **Environmental compatibility:** 100% recycling of by-products, processing of in-plant waste materials
- **Fully automated** process control and plant operation

4. CONCLUSION

Many iron and steel plants already practice recycling of by-products to a certain extent, however there is still room for increasing the value creation by optimizing the recycling concept and finding new innovative applications. One of these applications is recycling of by-products in DRI plants by cold briquetting and using the briquettes as iron ore or pellet substitute. A similar concept is used in integrated plants by cold briquetting of by-product fines and recycling the briquettes in blast furnaces and BOF converter plants.

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