INNOVATIVE SOLUTIONS ON RECYCLING OF OXIDE FINES AND WASTE MATERIALS TO OPTIMIZE PRODUCTION COSTS[1]

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Abstract

Waste becomes a resource, where recycling is a profitable activity within a plant. Due to increasing raw material and land filling costs and also the decreasing availability of dumping area, recycling of waste material from an integrated steel plant is getting more and more important. An integrated steel plant produces about 36 to 96 kg waste material per produced ton steel with an iron content of approx. 50%. Furthermore, DRI plants are also facing problem with oxide fines generation during material handling. These Oxide Fines are until now not used inside the DRI Plant. SVAI has developed several recycling technologies for treating waste materials and oxide fines, which are discussed in this paper. Agglomeration of recyclable material is necessary before reused in the reduction shaft (DR), blast oxygen furnace (BOF) or electrical arc furnace (EAF). Briquetting of various dusts and sludges allows integrated recycling within existing primary production units. Depending on the application area of the briquettes different curing time is necessary. Therefore various degrees of hardness can be achieved. Concerning the binding agent the process is very flexible. You have the possibility to use binding agents based on sugar, cellulose or minerals. Dependent on the recycling material different combinations of binding agents can be used as well. In particular plant concepts for briquetting of iron oxides as well as waste materials generated within integrated Steel Plants and the different ways of recycling are described in detail.

Key words: Briquetting Plant, Recycling, Oxide Fines, Waste Materials, Innovative Solution

[1] *Technical contribution to the 43rd Ironmaking and Raw Materials Seminar, 12h Brazilian Symposium on Iron Ore and 1st Brazilian Symposium on Agglomeration of Iron Ore, September 1st to 4th, 2013, Belo Horizonte, MG, Brazil.*

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1 INTRODUCTION

Waste becomes a resource, where recycling is a profitable activity within a plant. Due to increasing raw material and land-filling costs and also the decreasing availability of dumping area, recycling of waste material is getting more and more important. Up to 10wt% of by-product material (sludge, dust, scale) occur within an integrated steel plant per produced ton steel with an iron content of approx. 50% in average. Furthermore, DRI plants are also facing problems with oxide fines generation during material handling. These oxide fines are not reutilized in the DRI process up to now.
Agglomeration of the fine by product material is required before reusing it in the reduction shaft (DR), basic oxygen furnace (BOF) or electrical arc furnace (EAF). Briquetting of various dusts and sludge is a proper way of recycling within existing primary production units. Depending on the reutilization route of the briquettes different recipes can be applied to achieve the required properties of the briquettes. Various systems like molasses, cellulose, cement, water glass, bentonite or other minerals as well as combinations therefore are commonly known.
In particular plant concepts for briquetting of iron oxides as well as waste materials generated within integrated steel plants and the different recycling routes are described in detail.

2 SOURCES OF PARTICULATE BY-PRODUCTS IN STEEL MILLS AND DRI PLANTS

In Figure 1 the points of dust formation in integrated steel mills are shown with their minimum and maximum dust amount.

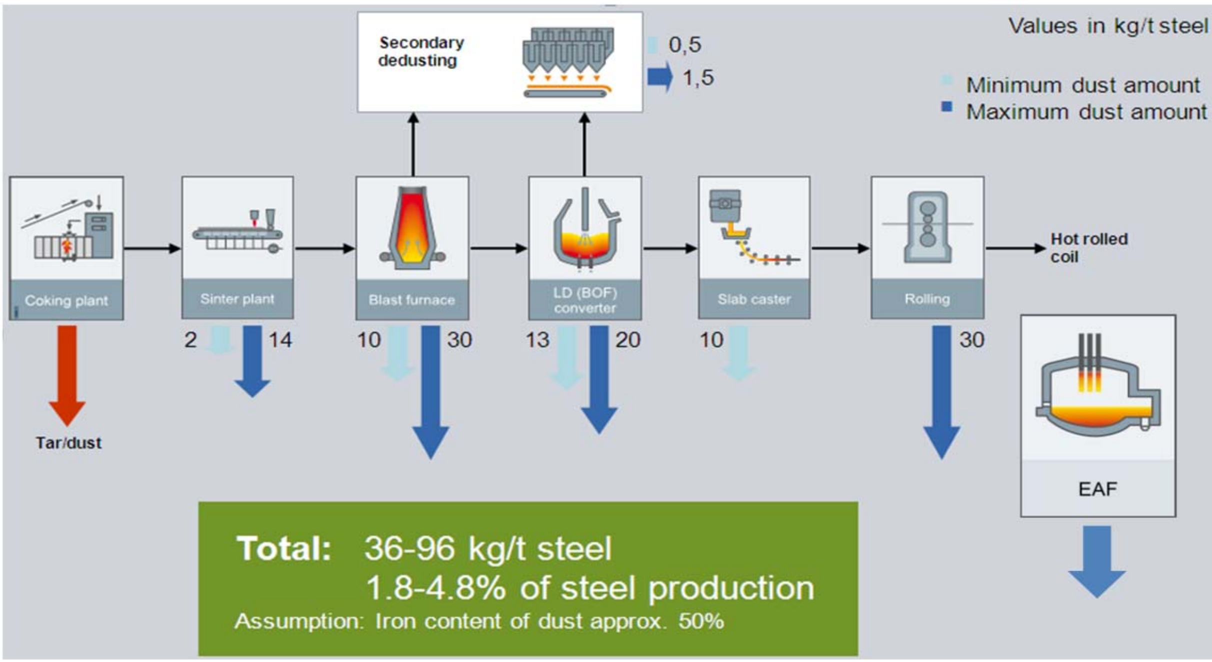

Figure 1. Points of dust formation in integrated steel mills.

Significant amounts of dust and waste material are produced and collected in an integrated steel plant at all steps of iron & steelmaking. It can be assumed that per ton of steel produced around 40 – 100 kg of particulate by-product is generated. Considering that these by-products have an average iron content of 50%, this is 1.8 up to 4.8% of world steel productions.

As productivity and high raw material prices of by-products are the driving factors today recycling becomes an essential issue.
Siemens VAI Metals 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.

3 COLD BRIQUETTING – PROCESS AND PLANT DESCRIPTION

Cold briquetting of various dusts and sludge 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.

3.1 Briquettes Used in Converter or Blast Furnace

Briquettes with a high iron content and high basicity can be charged directly into LD (BOF), converter replacing cooling scrap or ore. Briquettes rich in carbon but with limited alkali and zinc contents can be charged into the blast furnace.
In Figure 2 a block diagram of a cold briquetting process including pre-treatment of the waste material is shown.

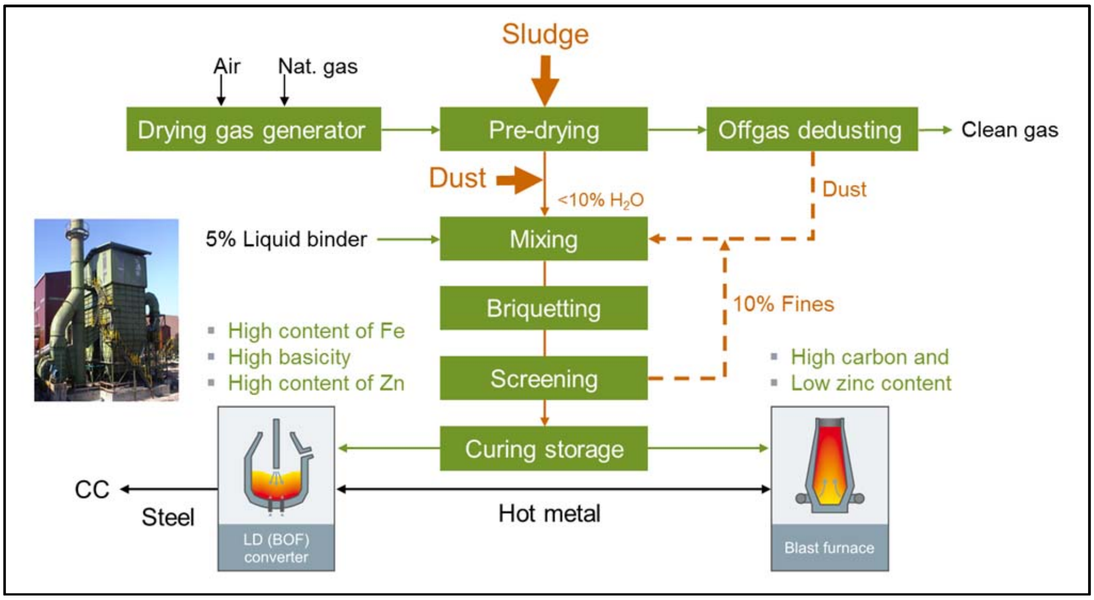

Figure 2. Cold briquetting process – Reference ILVA Taranto .

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.
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 (BOF) converter and blast furnace (BF) up to certain defined amount.

LD approx. 4 t per heat
BF approx. 1% of burden
A combination of molasses and hydrated lime is used as binding agent.
Input example (ILVA Taranto):

- 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%

Figure 3 shows the briquette product on the way to the curing yard. Due to the ceramic reaction of molasses, lime and air-CO_2 the mechanical properties (spot pressure resistance, shatter index, tumbler index) are excellent and withstand the handling and charging procedure with very limited fines generation.

Figure 3. Product briquettes.

Figure 4. Cold briquetting plant, ILVA Taranto, Italy.

The main benefits of this system are:

- Less raw materials utilization due to recycling of by-products (ore, scrap, coke);
- Short payback period;
- Minimization of landfilling costs and volume;
- CO_2 reduction;
- Sinter saving up to 5% (BF).

3.2 Briquettes Used in Direct Reduction (DR) Plants

The recycled by-products in this concept are fine dusts like iron ore fines or EAF dust (0-3 mm) and HBI fines (0-6 mm), pre-dried slurry fines (max. humidity 20wt% H_2O) and mill scale processed with an inorganic binder system. The produced briquettes are directly fed into the reduction zones of a direct reduction plant (e.g. MIDREX) and replace ferrous materials like iron ore or pellets up to 30% in the reduction shaft.
The following example shows a briquetting plant designed for a total capacity of approx. 250,000 tons per year for fine dusts, coarse dust, pre-dried slurry fines and mill scale. This results in a total mass flow of approx. 60 t/h for the briquetting plant since additional water, inorganic binding agent and recirculation of briquette chips has to be considered. A detailed mass balance is shown in Figure 6 in the block diagram of such a briquetting plant.

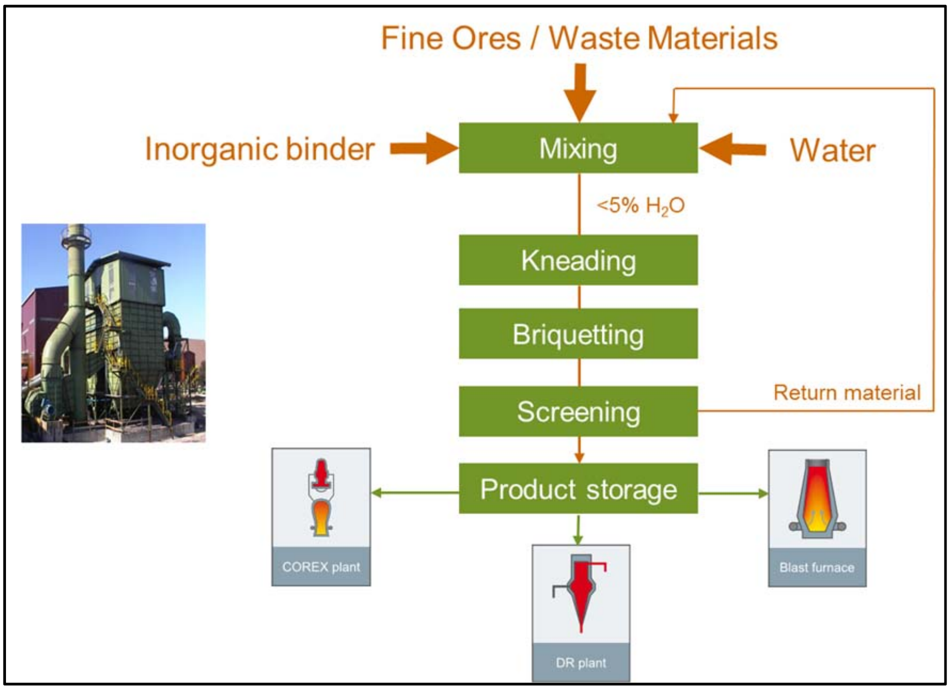

Figure 5. Cold briquetting process for reutilization in DR plants.

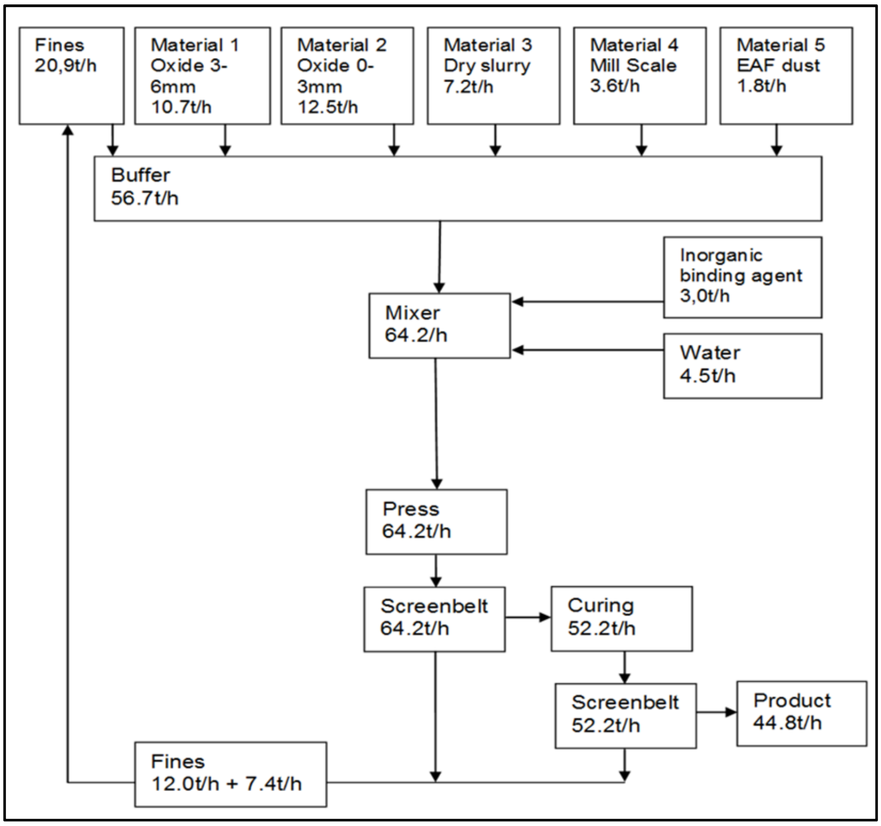

Figure 6. Block diagram of cold briquetting process of different dusts, mill scale and dry sludge.

In case also zinc rich dust, mainly coming from EAF is used, zinc concentration has to be limited to less than 15wt%. With an on-line measurement based on laser or x-ray analysis the zinc concentration can be online detected on the conveyor and separated by a switch. In Figure 7 a block diagram of processing raw material containing zinc is shown.

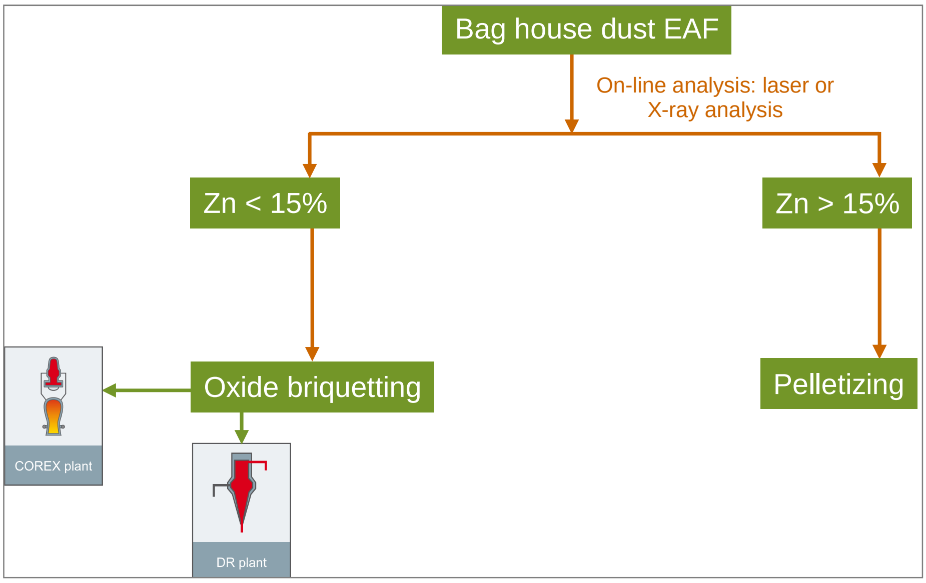

Figure 7. Block diagram for sorting Zn rich dust.

Fine and coarse dust are delivered to the plant by tank trucks. The trucks unload the dust by pneumatic conveying into the storage silos. From the storage silos the dusts are then conveyed to the briquetting plant by mechanical conveyors.

Slurry fines and mill scale are delivered to the plant by front loader or truck.
The inorganic binding agent is delivered to the plant by tank trucks and stored in solid binder storage silo situated within the plant. From the solid binder storage silo the agent is conveyed into the briquetting plant pneumatically.
In Figure 8 a typical layout of a cold briquetting plant is shown.

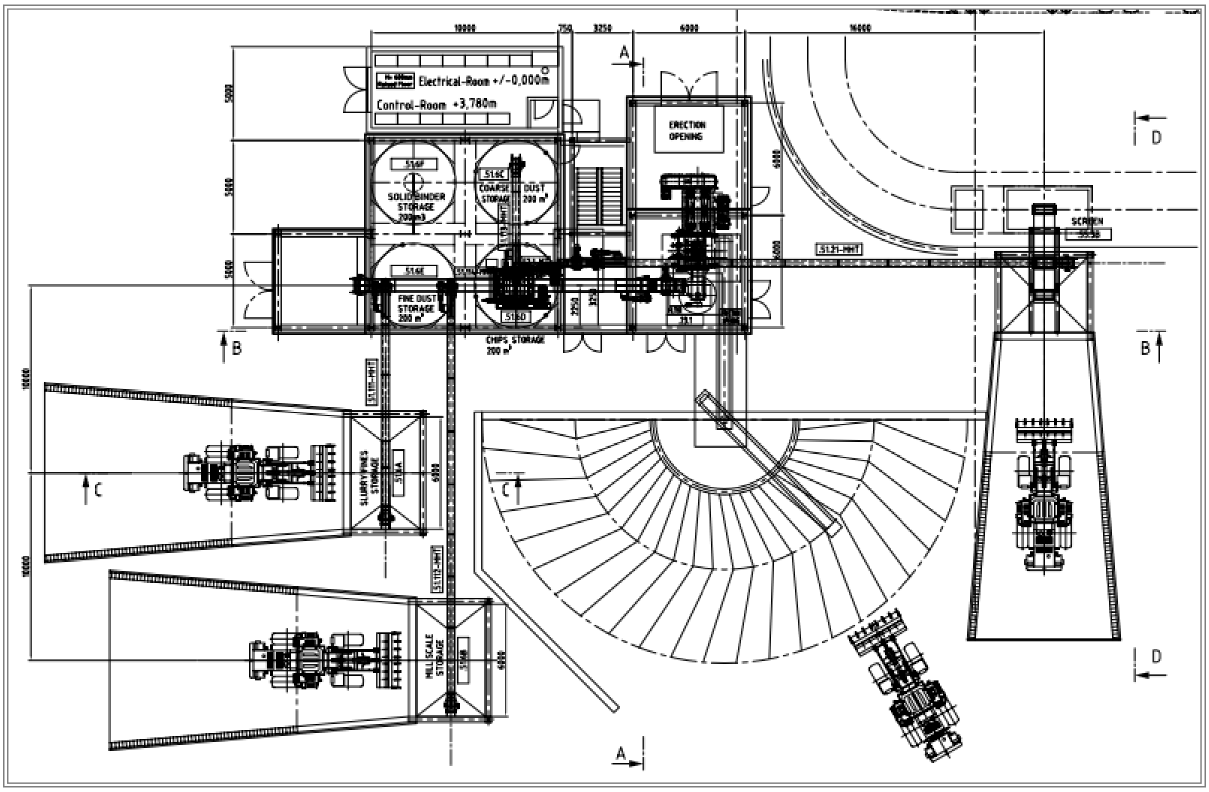

Figure 8. Typical plant layout of a 250,000 tons per year cold briquetting plant.

By-products and binding agent are dosed according the recipe. This mixture is intermediately stored in a buffer vessel to ensure a continuous feeding to the downstream mixer. In the mixer the water content is adjusted to meet the requirements. The mixture is then fed to a briquetting press. Following the product briquettes are screened and the fines are recirculated again.
After briquette curing (1-2 days), the product (briquettes) is again screened to remove fines, which will also be recirculated in the process.
The product briquettes are fed into a briquette chute to be recycled in the DR plant.
Testing the right mixture:
To verify the right receipt several tests in laboratory scale as well as shaft test under reduction gas atmosphere were carried out in the past.
In Figure 9 the resistivity of oxide briquettes under reduction gas atmosphere is shown. The results fulfill the requirements of a direct reduction shaft concerning the low temperature disintegration (550°C). The results are similar or even better compared with lump ore.

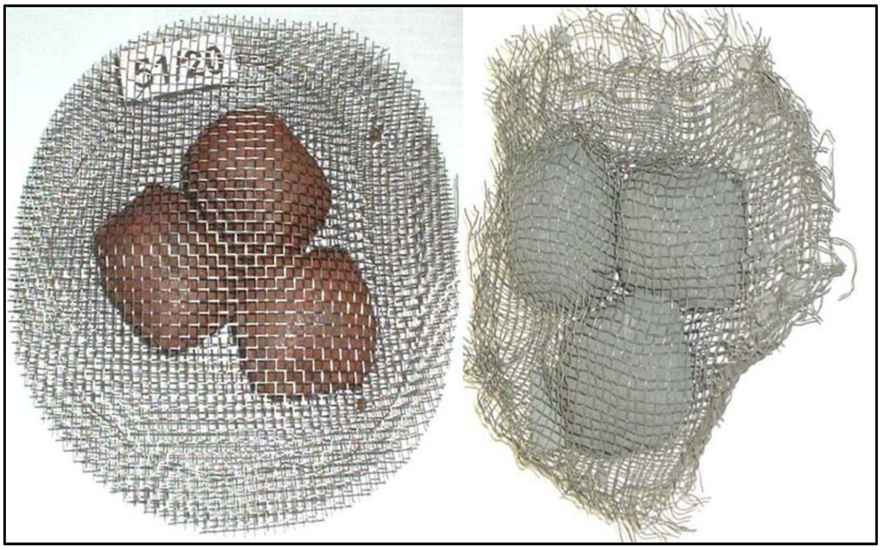

Figure 9. Soft basket tests in reduction shaft. (a) before test; (b) deformed soft basket after test.

Technical concepts are focused on the following aspects:

- Minimum investment;
- Maximum productivity;
- Minimum specific consumption of utilities;
- Compliance with environmental regulations and local safety regulations.

The design of the briquetting plant is flexible and can be designed for various by-products, binder systems and required properties of the product briquette as well as 1 to 3 shift operations.
Similar Plants for recycling and briquetting of oxide fines and waste materials were supplied by Siemens VAI in the past for different customers worldwide.

4 CONCLUSION

As productivity and high raw material prices of by-products are the driving factors today recycling becomes an essential issue.
Up to 10wt% of by-product material (sludge, dust, scale) occur within an integrated steel plant per produced ton steel. Considering that these by-products have an average iron content of 50%, this is 1.8 up to 4.8% of world steel productions. Furthermore, DRI plants are also facing problems with oxide fines generation during material handling. These oxide fines are not reutilized in the DRI process up to now.
Siemens VAI Metals 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 before reusing it in the reduction shaft (DR), basic oxygen furnace (BOF) or electrical arc furnace (EAF).

Acknowledgement

The authors gratefully acknowledge for the support of the “COMET K1 Competence Center for Excellent Technologies in Advanced Metallurgical and Environmental Process Development” of the Austrian Federal Ministry of Economy, Family and Youth (BMWFJ).