

# The OPTIDUST project: Optimised recycling of steel plant dusts

Hannu Makkonen

University of Oulu, Laboratory of Process Metallurgy  
FIN-90014 University of Oulu, P.O.Box 4300

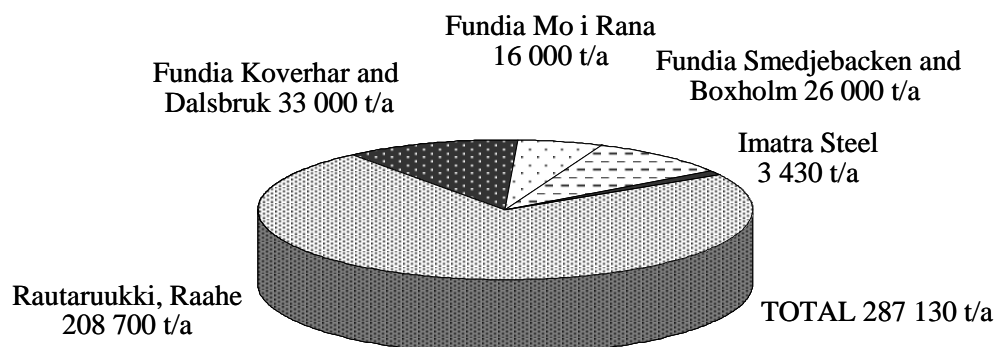
## *Abstract*

In addition to metals, iron and steel making processes also generate dusts, sludge and other fine-grained residues. If these materials are discarded, their iron content is wasted. However, utilization of these residues provides a challenge. Therefore, the OPTIDUST and OPTIDUST II projects investigate optimal recycling of these fine-grained residues.

## The OPTIDUST project

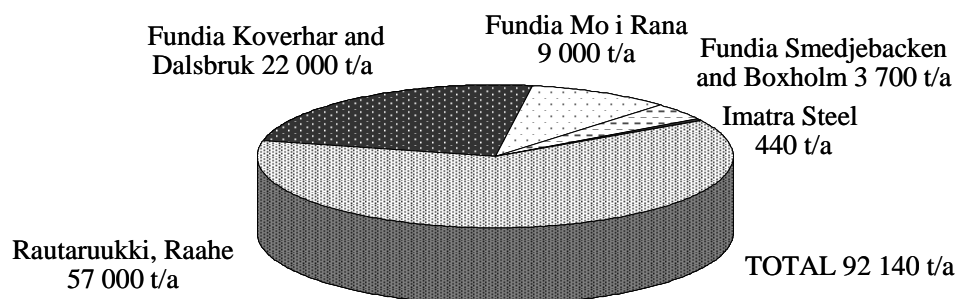
The OPTIDUST project was carried out during the period of March 1<sup>st</sup> 1999 to February 28<sup>th</sup> 2001, in partnership with the National Technology Agency of Finland, Rautaruukki Group, SKJ Companies, Imatra Steel and the University of Oulu. The objective of the project was to find an economically and environmentally beneficial recycling method for steel plant dusts, scales, sludge and scrap fines.

The quantities of the fine-grained residues (dusts, scales, sludge and scrap fines) arising in the steel plants of Rautaruukki Group (two in Finland, one in Sweden and one in Norway) and Imatra Steel (in Finland) were determined. A noteworthy portion of these materials is already recycled. The sintering plant is the most significant route to recycle these materials, though other utilization methods are also used, e.g. via the basic oxygen furnace and the electric arc furnace. However, not all of these residues can be recycled, as they may contain harmful components such as Na, K, Zn, Pb, Cd, S, oil, and humus. The residue may also be excessively fine-grained, and their low iron content may prevent utilization, or it may be too difficult to process the sludge. The total amount of the non-utilized material fraction is 92 140 t/a, which is about 32 % of all fine-grained residues. Currently, non-utilized residues are stored.



**Figure 1** Total amounts of dusts, scales, sludge and scrap fines (0 – 10 mm) arising in the steel plants of Rautaruukki Steel in Raahе, Fundia Koverhar (and Dalsbruk), Fundia Mo i Rana, Fundia Smedjebacken (and Boxholm) and Imatra Steel.

The total amounts of the fine-grained residues arising in the investigated steel plants are presented in Figure 1, and the amounts of the non-utilized residues in Figure 2. The quantities of the stored materials are small in scrap-based plants (Moi Rana, Smedjebacken and Imatra), which resulted that the subsequent OPTIDUST II project concerned integrated steel plants that are using ores as the main raw materials (Raahe and Koverhar).



**Figure 2** Amounts of non-utilized dusts, scales, sludge and scrap fines (0 – 10 mm) arising in the steel plants of Rautaruukki Steel in Raahe, Fundia Koverhar (and Dalsbruk), Fundia Mo i Rana, Fundia Smedjebacken (and Boxholm) and Imatra Steel.

The recycling capabilities of the sintering plant, the blast furnace (BF) and the basic oxygen furnace (BOF) were evaluated. Usually, the fine-grained residues disturb the primary production process, resulting in increased energy consumption and dust emissions, and decreased product quality. In addition, most of the non-recycled materials contain harmful components, and cannot be utilized in the sintering process or in the BF. In the BOF, it is possible to use iron oxide residues, however, the maximum tolerated amount is only about 10 000 t/a, therefore, recycling to the BOF can be only a part of the ultimate solution.

Not only it is difficult to increase recycling percentages, even present-day recycling levels cause problems. Small amounts of fine-grained materials are needed in the sinter mix, but excess dust has a negative effect on the productivity, and on the dust emissions of the sinter plant. It is possible that, in future, the sinter plant cannot utilize as much dusts as today. Likewise, in particular cases, some residues may be useful to be added in the BF or in the BOF but, as a general rule, it can be said that, overall, adding residues is disadvantageous to the process. It must be emphasized that the most important functions of the sinter plant, the BF and the BOF are to produce sinter, hot metal or steel, and not to process wastes.

Based on the previous reasons, the option to recycle more dusts, scales and sludge to the sinter plant, to the BF or to the BOF had to be abandoned. It is possible to utilize small amounts of appropriate material in these processes, but this cannot be an ultimate solution to the waste problem. The majority of the non-recycled residues must be recovered by other ways.

The elimination of the option to use iron and steel making processes for increased recycling led to the conclusion that there the residues have to be treated in a separate process. An advantage of the separate unit operation is that the primary production of the steel plant is not disturbed. In a separate process, it is possible to utilize some of the material presently treated in the sintering process. If the amount of the dusts in the sinter mix will decrease, the production capacity of the sinter plant will increase and dust emissions will decrease. Owing to the resulting increase in production efficiency, it is possible to cover part of the costs of separate processing by the

efficiency gains. The decrease of dust emissions is also environmentally preferred, assuming that the separate treatment will not cause other damaging environmental impacts.

The decision to process dusts, scales and sludge separately led to new alternatives. Several facilities and processes have been developed and modified for treating fine-grained remains, e.g. cupola furnace, PRIMUS process, rotary hearth furnace. The criteria for choosing the optimal method include:

- treatment capacity;
- productivity;
- possible pre-treatment method;
- rate of reducing harmful components;
- energy consumption;
- labour costs;
- capital costs.

A particularly important feature is the state of the product. At Rautaruukki Steel, the optimal product state would be hot metal (molten iron) that can be utilized in the smelting plant. In Rautaruukki Raahe Steel, there is lack of hot metal, thus recycling of dusts, scales and sludge could increase the productivity of the steel plant. In this regard, methods producing solid direct reduced iron can be considered as pre-treatment methods, demanding an extra smelter.

Habitually, the aim is to recycle dusts, scales and sludge, arising from iron and steel making processes, back to the process they originated from. Regularly, this is the primary goal and separate processing is considered an unfavourable solution. However, this reasoning is not justified, as separate recycling may be a better choice from an economical and an environmental point of view. If the residues disturb the primary production process, it is more favourable to treat them separately, and cover the costs of the separate process by the savings resulted in a smooth-running primary process, and the incurred profits from the potentially higher quality product. In addition, it is possible to devise a separate unit process that produces a material stream that can be fed back to the production line, at the most optimal stage, removing bottlenecks of the production. Overall, separate processing of dusts, scales and sludge may decrease emissions, and energy consumption of the steel plant.

### **The OPTIDUST II project**

Subsequent to the above outcomes of the OPTIDUST project, the OPTIDUST II project started on January 1<sup>st</sup> 2002. OPTIDUST II is ongoing, and will last until December 31<sup>st</sup> 2004. The project is performed in partnership of the National Technology Agency of Finland, Rautaruukki Group, SKJ Companies, the Technical Research Centre of Finland and the University of Oulu. The objective is to find the most feasible and environmentally favourable recycling technique for fine-grained residues of steel plants in Raahe and Koverhar. The residues will be utilized in a separate process, instead of recycling them directly to primary production. Evaluation will focus especially on the Cupola furnace and rotary hearth furnace (RHF) processes.

Currently, laboratory scale reduction trials, to evaluate the efficiency of the Cupola furnace and RHF in, e.g. zinc removal, are conducted. In addition, laboratory scale smelting tests are performed for the reduced material. Additional information on reduction and smelting reactions is gained from thermodynamic calculations, providing assistance for planning experiments and interpretation of experimental results.

It is to be hoped that, ultimately, an environmentally beneficial and cost-efficient utilization method will be found to recover fine steel residues, consistent with resources use optimization.

Article reference:

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