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letters to the editor

Furnace Dust Recycling Process Raises Concerns

Dear Editor,

I note that the July 2014 issue of *JOM* published an article on a new method of recycling electric arc furnace (EAF) dust, the "2sDR" process.[1] My earlier comments on the many past difficulties and failures in commercializing new EAF dust processes were published in the December 2014 issue of *JOM*.[2] These arose out of my review of the CR[3] EAF dust process, recently published in *JOM*, so I won't repeat them here. A perusal of those, however, might be a good introduction to my comments here. My references there are applicable here.

However, I have four additional concerns about this new process. Firstly, the waelz kiln is inherently efficient partly because it has to heat the bulk of the material, that containing the iron, only once. A follow-up rotary calciner to fume lead and the halides is much smaller and can take the WZO of 4 or 5 waelz kilns. A previous example of the calciner first route was the Cardiff process, which fumed zinc in a follow-up waelz kiln. It was uneconomical because both kilns were nearly the same size, plus it had other economic, operational, reliability, and productivity issues.

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Secondly, an iron product from EAF dust has many negative attributes in the costs for high iron recovery, from the residual metals and from the relatively small amounts involved. On residual metals, not only some of the chromium, for example, but also copper and several other focus metals would end up in the steel product. These make recovering iron of minimal interest to steel plants. Both Horsehead, with their QuickIron process, and the PIZO process (induction furnace for zinc fuming and making pig iron) had difficulties developing a market for their iron products. QuickIron also reduced the zinc fuming capacity of the kiln, and the sponge iron product was not fully reduced. With PIZO, the pig iron had the residual metals issue. The iron can probably be marketed to the appropriate types of foundries. Duisburger Kupferhutte does this. However, in the EAF dust case, marketing irony residues (for example by PIZO, ScanArc, QuickIron, and ZincOx) has not been successful. There are plenty of iron sources around, and of higher purities, so why should the steel mills bother?

Thirdly, and most importantly, the slag in the fuming step ends up containing iron oxides. That is where the reactions occur. Such slags are almost impossible to contain at iron melting conditions—the oxide wants to consume the mag carbon refractory lining. Every process that has tried to reduce or fume irony slag has either failed in this regard (in processing EAF dust) or has greatly increased operating and refractory repair costs (iron reduction or ferroalloy plants). The following processes have had this problem: Elkem at Laclede Steel, PIZO, the IMS-Tetronics processes at Florida Steel and Nucor, the submerged arc furnace at Inmetco, the ScanArc process, the SAF (submerged arc furnace) at Iron Dynamics, and probably the electric furnace following the Primus process. Three of these had serious breakouts and fires: PIZO, IDI and Elkem, and all have high refractory costs.

Ferroalloy plants can operate with these refractory issues, but their primary products contain nickel, chromium, titanium, or vanadium, which pay for the operating problems and special equipment control designs. Carbon steel plants cannot do so. One way to avoid the breakout problem is to add sufficient carbon to that unit to convert all of the oxides to CO. Not some, but all. This is what IDI now does. That is expensive to do and requires a downstream CO boiler to burn the flammable CO and recover the heat. Also not cheap on energy consumption.

Fourthly, there are at least two versions of this iron bath process, an older one called RecoDust and the newer 2sDR. I suppose the earlier work is discussed in references 20, 21, and 25 in the original article by

Suetens et al.[1] The earlier process used a zinc condenser to recover zinc fumed from the iron bath, the 2sDR oxidizing the fumed zinc. Those articles are difficult to access and the experiences with the condenser route are not readily known. It has been well demonstrated that condensers are not reliable with zinc fumes containing oxides (or halides). For example, see L.M. Southwick, "Fumes, Fogs, and Mists," *Zinc and Lead Processing* (Montreal, Canada: MetSoc of CIM, 1998), pp. 277–297, and subsequent papers.

The point here is to compare the two processes and thereby better understand how 2sDR came about. It is difficult to understand why the condenser was even tried in the first place, and particularly if one understands that industrially the iron bath furnace would have to be run at a slight vacuum to keep fumes contained. This would bring air (oxygen) into the system, which would be consumed by the zinc, producing zinc oxide. Condensing zinc fume with zinc oxide leads to the formation of accretions and is an operational (and expensive) nightmare. With halides present operability is a virtually insoluble issue, and normal zinc condensers do not try to run even with only oxides present. The condensers also have small amounts of iron present, cleaning of which eventually destroys the condenser shell.

So where are we? There are still the abundantly demonstrated serious problems and virtual nil chances of making new EAF dust processes work. If they cannot confirm on a commercial scale any and all claimed economic, byproduct, productivity, metal recovery, and environmental benefits, then they will remain an intellectual curiosity only. If the new development does not address the previous fatal flaws in similar processes, then they will fail for the same reasons. If the project is not aware of what went wrong before, and thus which steps are going to be problematic in the end, and the R&D program does not address them, then it will fail. "Proving" a process on the laboratory or pilot scale is irrelevant if it does not address the fatal flaws that have already been identified. Further, it needs to look for new ones and deal with them if they exist. A zinc condenser in this service was a known fatal flaw, it did not need to be retested.

The waelz kiln has an enormous data base proving its benefits, with new examples being added yearly. As the *JOM* article notes, the waelz kiln is recognized as the standard technology by virtually all regulatory authorities. There is a reason for this—reliable compliance trumps theoretical niceties. Without all the above issues being addressed and proven in the field, it will never be otherwise.

References

1. T. Suetens, K. Van Acker, B. Blanpain, B. Mishra, and D. Apelian, *JOM* 66, 1119 (2014).
2. L.M. Southwick, *JOM* 66 (2014), DOI: 10.1007/s11837-014-1228-0.

Sincerely,
Larry M. Southwick
Cincinnati, OH

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Our first concern was the successful separation of halides.

Dear Editor,

First, it is a pleasure for us that our article seems to cause attention in a time where the waelz process is more dominant than ever before, obviously proving its status as best available technology. More than 12 years ago, our activities in this field started forming the basic idea of the two-step process as a consequence of general problems in steel mill dust recycling. While similar developments included some fatal errors, especially by not taking interaction reactions of halides and other compounds into account, our first concern was the successful separation of halides. The generated two-step concept was then investigated together with an Austrian process development company. However, this was done by making use of a high-temperature melting as a first step as well as an alternative reduction step, which, in this combination, has not shown success due to various problems mainly related to the utilized facilities (carry over, energy input, lining…). Therefore, we redeveloped the concept with a different temperature regime and more common facilities which are state of the art.

Coming back to concerns raised in the

letter by Larry M. Southwick and published here, let us summarize a little more clearly what the advantages are from our point of view and, hence, for our concept.

1. Especially in Europe, steel mills want to become more and more independent from centralized solutions asking for on-site processes flexible in treating their own dusts. We think that our process concept would fulfill some of the requirements of these small-scale units.
2. We know that the iron product quality suffers from copper and sulfur contents and for this we performed some market studies in Europe evaluating different possible outlets for such alloys.
3. Making use of a non-smelting procedure for the first step would solve the lining problem at least for this step. For the second one we know that it definitely constitutes a problem. Also, we did much investigation work on this topic, creating possible concepts together with our partner RHI (refractory producer) by also keeping the consumption as small as possible.
4. Another advantage of the 2sDR process is the high quality of the zinc oxide, hence avoiding washing steps which only make sense if companies are able to discharge the wash water to the sea or need some very special solutions, like discharge to rivers (not really possible in Europe). Also, SX seems to be a very expensive solution considering the revenues of the waelz kiln rather than proofing its own economy.
5. Another advantage is the possible utilization of the remaining slag. Here we are in permanent discussion and investigation with cement producers.
6. Concerning the used furnaces: Indeed, for the second step the TBRC (top-blown rotary converter) might not be the adequate furnace and a submerged arc furnace would probably display the better one. However, we have worked together with partners in different parts of the world where gas is available more easily and cheaply than electricity. However, here different options are available for the first step where a rotary kiln would also be possible.
7. Regarding concern about energy consumption: We try to perform our process in one heat without losing too much energy between the two steps. This is another reason why our concept should be more efficient than the RecoDust process. Depending on the utilization of the zinc oxide, clinkering is not the best solution due to agglomeration during the process.
8. A further advantage should be the already mentioned flexibility and therefore the chance for a tailor-made solution for different steel mills which are not able to bring their dust to waelz kilns due to political reasons, no adequate zinc contents, disturbing elements, etc.

Also know that there is serious interest of different steel mills and especially a process development company which is evaluating the concept at the moment by planning pilot trials on a 1 ton/batch scale in their R&D center close to our university which provides a TBRC as well as a submerged arc furnace at this scale.

Best regards,

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Corrections

In the December 2014 article “TMS Celebrates its Scholars,” an incorrect photo was published with an announcement of Alexandra Glover’s scholarship award by the Materials Processing and Manufacturing Division. The correct photo is shown on the left.

Mohsen Asle Zaeem’s name was misspelled in the October article: “TMS Volunteer Face Time: Meet the New Advisors (and Find out More about Their Topics) for 2015.” Asle Zaeem is advisor for the Solidification Committee.

JOM regrets the errors.

Alexandra Glover