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Development of a new Dust and Slag Treatment Technology

Toshiki Watanabe[1]

1. Metallurgical Engineer of the Daido Steel, JaponMelting Sect., Chita Plant, Daido Steel Co., Ltd., Japan, Email: toshiki.cibrasil@hotmail.co.jp

Abstracts

Daido Steel has developed a new dust and slag treatment process called "DSM" (Daido Special Method of Dust Slag Melting). DSM is a process in which EAF dust is melted together with reduced slag with the specially designed fuel-oxygen burner to get oxidized slag and secondary dust. The oxidized slag obtained in the above process is perfectly harmless, thanks to the high temperature treatment and is used as road construction materials. The secondary dust,collected in a dust collector of DSM process, has a high content of Zinc(Zn) concentrated from EAF dust. It is utilized as raw materials of Zn smelting.
Thus, DSM is realized to recycle EAF dust and to reduce slag perfectly, with the features of a simple equipment and easy operation. Daido Steel constructed DSM furnace at Chita Plant and started its operation in 1996.

Key words:steelmaking wastes, EAF dust, Reduced slag, burner melt, DSM process

Resumen

Daido Steel ha desarrollado un nuevo tratamiento de polvo y escoria proceso llamado "DSM" (Daido Especial Método de polvo Escorias de fusión). DSM es un proceso en el que el polvo se funde EAF junto con la reducción de la escoria con el especialmente diseñado quemador de combustible y oxígeno para llegar a la escoria oxidada y secundaria de polvo. La oxidada escoria obtenida en el proceso antes descrito es perfectamente inofensiva, gracias a la alta temperatura de tratamiento y se utiliza como material de construcción de carreteras. El polvo de secundaria, se recogen en un colector de polvo de DSM proceso, tiene un alto contenido de Zinc (Zn) concentrado de EAF polvo. Se utiliza como materia prima de fundición de Zn.
Así, DSM proceso realizado para reciclar EAF polvo y la reducción de la escoria perfectamente, con las características de equipo sencillo y de fácil operación. Daido Steel DSM horno construido en Chita y Planta comenzó a funcionar en 1996.

Palabras Claves: Residuos de la fabricación de acero, EAF polvo, Reducción de la escoria, quemador derretir, DSM proceso

1. Introduction

Nowadays, environmental issues become a matter of urgent concern. In the steelmaking process, dust, slag and used refractories are discharged as wastes. Several technologies to minimize and recycle steelmaking wastes have been developed by steelmaking companies. In particular, utilization of slag and used refractories has been tackled from the early stage, and the recycle ratio of them becomes higher. Reduced slag is utilized to improve soft clayey soil[1] and used refractories are recycled as reformed brick, flux in refining and so on[2].

As to dust, on the other hand, it is mostly brought to the reclaiming land after stabilized treatment or to the metal smelting company. Both ways have a cost $100-200 each ton, including transportation. As the cost is presumed to be more expensive because of the lack of land for reclaim and the strict regulation in transportation in the near future, a new dust treatment technology is strongly desired. Daido Steel developed a new dust and slag treatment process called "DSM" (DSM : Daido Special Method of Dust Slag Melting) and constructed DSM furnace which started its operation at Chita Plant in 1996.

In this paper, the outline of DSM process is described, and some operational results are also reported herein.

2. Basic concept of DSM process

Table 1 shows the typical compositions of EAF dust and reduced slag in Chita Plant, Daido Steel. The basic concept of DSM process is: (1) the mixture of dust and slag is melted to change into oxidized slag which is used as road construction materials (since EAF dust and reduced slag are composed mainly by Fe oxide and Zn oxide, CaO and SiO2 respectively), and (2) at the same time Zn is concentrated into the secondary dust, which is utilized in Zn smelting. As a result, it is possible to utilize EAF dust completely.

Table 1: Chemical compositions of EAF dust and reduced slag (wt%)

	T-Fe	CaO	SiO_2	Al_2O_3	Pb	Zn	Others
EAF Dust	36.3	4.8	4.2	1.7	2.4	18.1	32.5
Reduced slag	0.9	47.8	21.8	11.2	0.01	0.02	18.3

Since removal of both, dust and slag are powdery, they can be melted with burner of high temperature flame. Then the mixture can be injected into the flame continuously and be completely melted thanks to the high temperature. This process is available without any cost-up for pretreatment of dust and slag such as pelletizing or packing into the flexible-conveyer. Melting through the burner flame made it possible to achieve higher thermal efficiency. The exclusive burner was developed for special use to melt dust and slag mixture conforming to this concept.

3. Small scale test

3.1. Outline of dust and slag melting with exclusive burner

Fig. 1 shows the schematic illustration of test equipment with exclusive burner and Fig. 2 shows the outline of burner. Fuel-oxygen burner is selected for the high temperature flame and is designed to achieve the stable combustion even when the powder mixture is injected into the flame. EAF dust and reduced slag are fed in the ratio of one to one in weight and carried into the burner by air to be melted in the high-temperature flame. The produced slag is discharged in the slag pot after staying in the vessel where the weight of molten slag is 700 kg. Gas bubbling (0~100Nl/min) is available from the bottom of vessel to make the molten slag homogeneous.

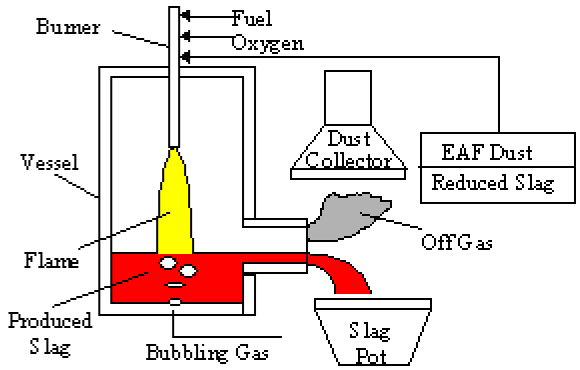

Figura 1: Schematic illustration of test equipment with exclusive burner

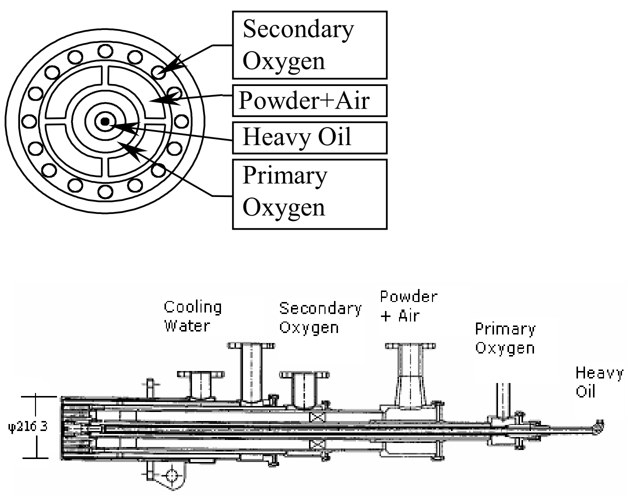

Figura 2: The outline of burner

3.2. Result of small scale test

Fig. 3 showthe effect of gas bubbling on (%Pb) in the produced slag. It is obvious that the gas bubbling is quite effective to promote the vaporization of lead (Pb). Zinc(Zn)the behavio of zinc is similar to that of lead. The volatile elements of Pb and Zn are concentrated and collected in the dust collector as secondary dust. Table 2 shows the typical chemical composition of the produced slag with gas bubbling. Table 3 shows the composition of Pb and Zn in the secondary dust. These results are enough to conform to the basic concept of DSM process mentioned above.

Concerning energy consumption, it would be attainable less than 3,400MJ/powder-ton, with a thermal efficiency is calculated to be about 55% even in the small scale test.

From these results, it is confirmed that this burner melting process is sufficient to the dust and slag treatment.

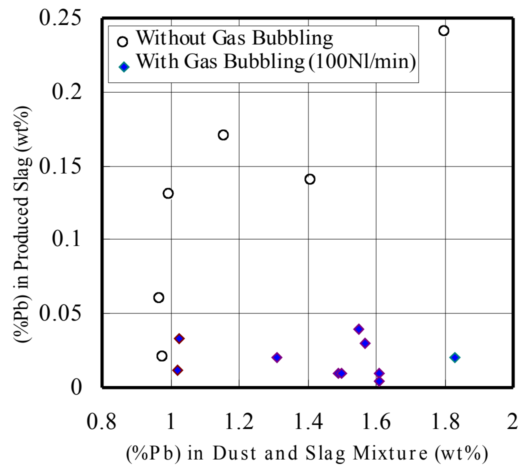

Figura 3: Effect of gas bubbling on (%Pb) in the produced slag at test equipment.

T-Fe	CaO	SiO_2	Zn	Pb
20.2	30.5	11.6	0.8	0.02

Table 2: Chemical composition of the produced slag at test (wt%)

Zn	Pb
28.6	5.8

Table 3: (%Pb) and (%Zn) in secondary dust (wt%)

4. Construction and operation of demonstration plant

4.1. Specification of demonstration plant

Demonstration plant of DSM process, which is based on the small scale test, was constructed at Chita Plant and started its operation in March 1996. Fig. 4 shows the schematic illustration of DSM at Chita Plant. The specification of DSM at Chita Plant is shown in Table 4. The demonstration plant at Chita Plant is designed to treat all of the EAF dust. One of its feature is that the mixing ratio of dust and slag is easily controlled intentionally.

The DSM operation is Batch-type. The discharged slag is 7 ton a heat with hot heal.. while the slag remaining in the vessel is 3 ton.

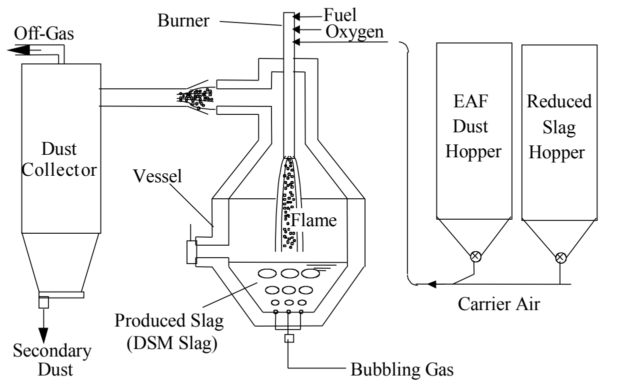

Figura 4: Schematic illustration of DSM in Chita Plant

DSM Furnace	Productive Capacity	3,000t/month
	Melting Rate	Max 9t/H
	Operation Temp.	1,400～1,500℃
	Bubbling Gas	200Nm^3/H
Burner	Fuel Oil	Max 1,000 l/H
	Oxygen	Max 2,000Nm^3/H
	Thermal Capacity	Max 37,800MJ/H
	Flame Temp.	2,800℃
Dust Collector Capacity		2,270m^3/min (at 180℃)

Table 4: Specification of DSM at Chita Plant

4.2. The properties of DSM slag

As the DSM slag is aimed to be used for road construction materials, its properties fulfill the regulation of leaching test in notice 13 by Environmental Protection Agency (EPA) Japan.

However, it was necessary to clear notice 46 by EPA Japan additionally, in order to correspond to the environmental restriction reinforcement in the near future. Table 5 shows the leaching test results of heavy metal in notice 46 by EPA Japan.

Table 5: Leaching test result of DSM slag (Notice 46 by EPA Japan) (mg/l)

	Pb	Cd	Cr^{+6}	As	Se	T-Hg
Notice 46 by EPA, Japan	< 0.01	< 0.01	< 0.05	< 0.01	< 0.01	< 0.0005
DSM Slag	**0.03**	< 0.001	< 0.005	< 0.005	< 0.006	< 0.0005

As a result, only Pb is over the regulation, and some improvements are required in DSM operation. Fig. 5 shows the relation between (Pb%) in DSM slag and value of leaching test of Pb. It is obvious that the lower of (Pb%)in DSM slag, the lower the value of leaching test of Pb. Accordingly, the operation is intended to reduce the Pb content in DSM slag by means of promotional gas bubbling. CO bubbling is assumed to be effective on the reduction of Pb particularly, and the coke grain is blown in with the mixture of dust and slag. The value of leaching test of Pb decreases in proportion as the carbon consumption increases, and over 40kg dust-ton of carbon consumption makes possible to clear the regulation.

Fig. 6 shows the relation between the carbon consumption and the value of leaching test of Pb in notice 46 under the several conditions of mixing ratio. According to these results, the DSM operation is modified to adopt carbon blowing into the burner with dust and slag during melting period.

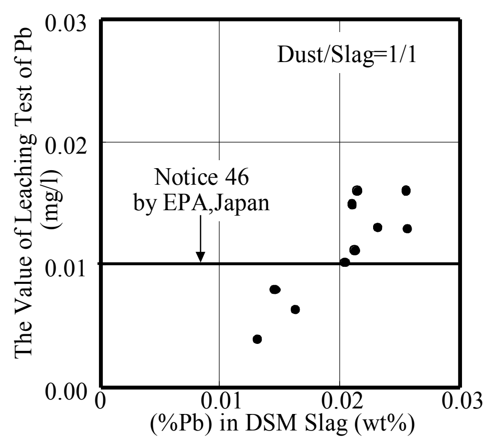

Figura 5: Relation between the carbon consumption and the value of leaching test of Pb

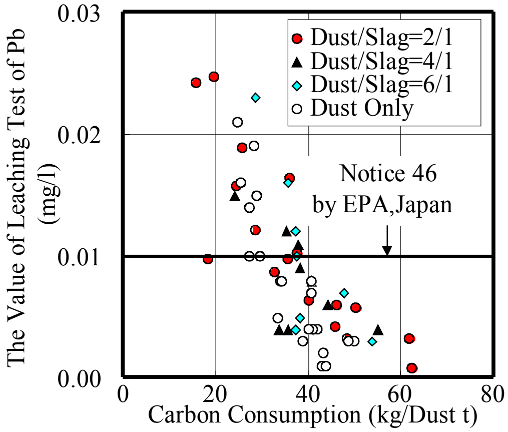

Figura 6: Relation between the carbon consumptionand the value of leaching test of Pb

4.3. Operation result

The mixing ratio of dust and slag in the recent DSM operation is mainly 6/1. The ratio of dust is rather high because of the development of slag utilization in various fields. Table 6 shows the chemical composition of DSM slag and secondary dust when the mixing ratio of dust and slag is 6/1. Zn content in secondary dust is more than 50 wt%, which is enough to the raw materials of Zn smelting.

Table 6: Chemical composition of DSM slag and secondary dust at dust/slag=6/1 (wt%)

	T-Fe	CaO	SiO_2	Zn	Pb	Cl	F	Other
DSM Slag	40.1	17.8	10.2	2.1	< 0.02	0.4	0.4	29.0
Secondary Dust	6.5	2.5	0.9	52.3	8.5	7.7	1.8	19.8

Fig. 7 shows the mass balance of DSM process. About 72% of melting quantity changes to the DSM slag and about 24% of that changes to the secondary dust. As to Pb and Zn, more than 90% of Pb and more than 80% of Zn is collected in the secondary dust. There is still a room of improvement to collect Zn and Pb into the secondary dust.

Fig. 8 shows the relation between melting rate and the energy consumption in DSM. The energy consumption is influenced with the melting rate drastically, and the thermal efficiency reaches 50% under the accommodative condition.

The treatment cost becomes less than that of disposal to reclaim land. The cost merit would be expected to increase in the future because of the reinforcement of the waste restriction.

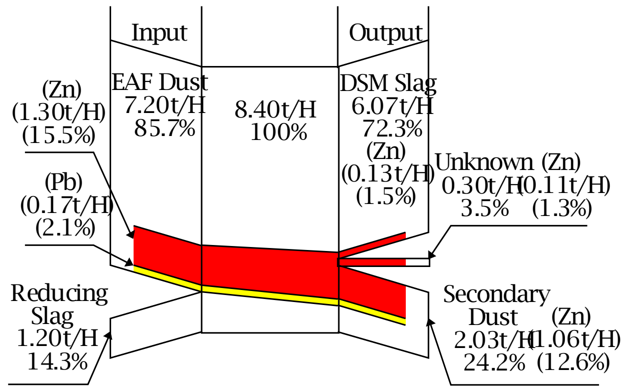

Figura 7: Mass balance of DSM process

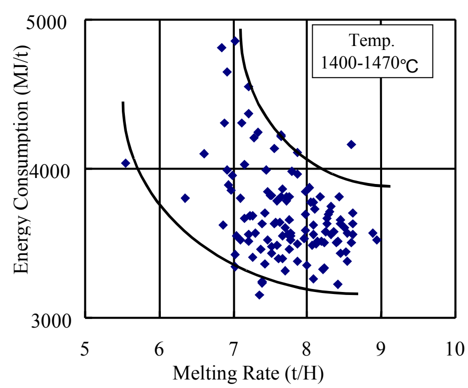

Figura 8: Relation between the melting rate and the energy consumption in DSM

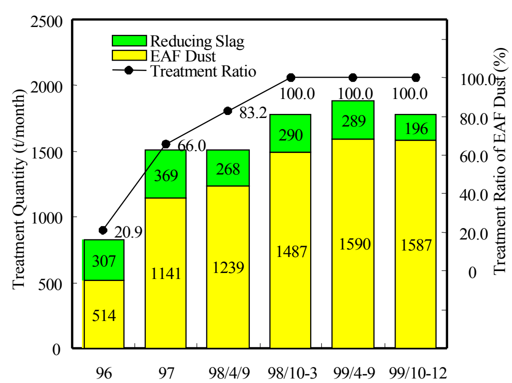

Figura 9: Change of the treatment quantity of DSM

5. Conclusion

Daido Steel developed a new EAF dust and reduced slag treatment process called DSM and constructed the demonstration plant at Chita Plant in 1996. The treatment quantity of DSM at Chita Plant is increasing satisfactorily as shown in Fig. 9, and now 100% of EAF dust discharged at Chita Plant are treated.

The characteristics of DSM process are as follows.

(1) Complete melting with exclusive burner makeit possible to stabilize EAF dust and reduced slag.

(2) Simple equipment and its easy operation are suitable for the on-site treatment.

(3) Operational cost is lower than that of the conventional one.

(4) DSM process has the possibility to treat the other industrial wastes.

(5) DSM process is quite effective to resolve dioxin.

6. Reference

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