THE STUDY FOR RECYCLING OF NORM – CONTAMINATED STEEL SCRAPS FROM STEEL INDUSTRY

Kwang-Fu Tsai, Ying-Sheng Le e, Hsuan-Erh Chao
Institute of Nuclear Energy Research, AEC, ROC
P.O. BOX 3-7, Lung-Tan, Taiwan ROC 325
Tel: 886-3-471-1400 ext. 5839
FAX: 886-3-4711983
E-mail: kftsai@iner.gov.tw

ABSTRACT

Since 1994, most of the major steel industries in Taiwan have installed portal monitor to detect the abnormal radiation in metal scrap feed. As a result, the discovery of NORM (Naturally Occurring Radioactive Material) has increased in recent years. In order to save the natural resources and promote radiation protection, an experimental melting process for the NORM contaminated steel scraps was carried out by the Institute of Nuclear Energy Research (INER) Taiwan, ROC.

The experimental melting process has a pretreatment step that includes a series of cutting and removal of scales, sludge, as well as combustible and volatile materials on/in the steel scraps. After pretreatment the surface of the steel scraps are relatively clean. Then the scraps are melted by a pilot-type induction furnace. This experiment finally produced seven ingots with a total weight of 2,849 kg and 96.8% recovery. All of the surface dose rates are of the background values. The activity concentrations of these ingots are also below the regulatory criteria. Thus, these NORM-bearing steel scraps are ready for recycling. This study has been granted by the regulatory authority.

INTRODUCTION

In order to protect the occurrence of radioactively contaminated rebar, the main steelworks in Taiwan were encouraged by supervisory authority to install portal monitor to detect the abnormal radiation in shipments of metal scraps feed in 1993. Since the portal monitor operation started in 1995, the government has temporarily received about 7500 kg of NORM. The radioactive nuclides in the NORM contained ^{226}Ra, ^{228}Ra, ^{232}Th, ^{238}U etc.
The discoveries of NORM have increased in recent years due to more monitors installed and improved detection technology. The steelworks usually store the contaminated scraps temporarily or return scraps to the supplier. This was quite costly and manpower consuming. Also, the radioactive scraps could threaten the health of the public (1,2,3)
The reuse or free release of metal scraps for NORM has been regulated or executed in Germany and U.S.A., and by the organizations such as ICRP and IAEA (4,5,6). In order to save natural resources and promote radiation protection, an experiment melting for the

NORM-contaminated steel scraps was carried out at INER under the direction of supervisory authority.

The experimental melting procedures were to pretreat the steel scraps, then melt the scraps with an induction furnace. This melting procedure will produce ingots and slag. The dose rates of the surface and activity concentrations from samples of the ingots were all below regulatory standard in Taiwan, which is similar to that of Germany, U.S.A, ICRP and IAEA. Finally, the ingots were mixed with other steel scraps originated from non-nuclear activities for recycling.

EXPERIMENTS

In order to meet the waste metal scraps reception criteria for the melting facility in INER, the NORM-contaminated steel scraps from steelworks were pretreated first by a series of cutting and cleaning processes to remove scales, sludge as well as combustible and volatile materials on/in the waste steel pipes and plates, then melted in an induction furnace. The melting will produce ingots and slag. The dose rates at the ingots surfaces are measured using dosimeter for taking samples of the hot spots. The activity concentrations of ^{226}Ra (or ^{238}U) and ^{228}Ra (or ^{232}Th) in ingots were measured at their progeny of ^{214}Bi (609.3Kev) and ^{228}Ac (911.1KeV), respectively, by gamma spectrometer equipped with HpGe detector and multi-channel analyzer under secular equilibrium condition. The radiation impact to workers and environment for the whole processes (pretreatment, melting, sampling) is also monitored and evaluated.

RESULTS AND DISCUSSION

Pretreatment of Steel Scraps

The steel scraps are segmented by thermal methods (oxygen/acetylene) and cleaned by the mechanical decontamination method (corundum blasting). The pretreated scraps were inspected visually and radiologically to prevent liquids or paints from being fed into the furnaces, and to verify that the material conforms to the melting specification. The pretreated steel scraps surfaces are relatively clean (Fig. 1).

Fig.1. The cleaning surfaces of the pretreated steel scraps

Melting

The pretreated steel scraps are fed into a 1-ton induction furnace using an overhead crane for each batch. During melting, the slag is removed from the surface of the melt. The melt is poured into steel moulds to produce ingots. Normally, Two ingots are produced for each melting practice. The weight of each ingot is about 450 kg. Seven ingots with total weight of 2,849 kg are produced for 4 batches (Fig. 2). The recovery of steels is about 96.8%. The surface dose rates for all the ingots are of the background values.

Fig. 2. The ingots of the melting process

Analysis of Samples

The samples for radiological measurement, which are about 50 g, are geometrically adapted from the ingots. The activity concentrations of ^{208}Tl, ^{212}Bi, ^{212}Pb, ^{214}Bi, ^{214}Pb, ^{228}Ac of the ingot from 4 batches are all below 0.3Bq/g, which is the regulatory criterion in Taiwan. The activity concentrations of the slag from 4 batches are between 0.08~9.21 Bq/g.

Table 1 summarized the analytical results of the ingots and the slag; the activity concentrations of the slag are 2 orders higher than that of the ingots. It can be seen from Table I that most of nuclides left in the slag for the melting of NORM-contaminated steel scraps.

Table I Analytical results of samples taken from the melting products

Batch number	Melting Product	Nuclide activity concentration Bq/kg					
		^{208}Tl	^{212}Bi	^{212}Pb	^{214}Bi	^{214}Pb	^{228}Ac
1	Ingot	＜LLD[a]	＜LLD	23.2±2.8	＜LLD	25.1±3.1	＜LLD
	Slag	106±15	＜LLD	294±22	6160±301	9210±681	143±30
2	Ingot	9.6±3.0	＜LLD	17.3±3.4	91.5±7.2	79.3±5.4	＜LLD
	Slag	239±18	687±75	724±48	4110±164	5620±243	568±35
3	Ingot	11.5±3.3	＜LLD	19.6±3.4	50.9±5.1	56.6±4.1	＜LLD
	Slag	109±9	83.5±17.6	339±19	6550±184	7380±215	258±26
4	Ingot	＜LLD	＜LLD	20.7±2.7	20.1±3.4	10.9±2.4	＜LLD
	Slag	203±20	545±69	615±43	3770±190	6120±454	465±32

[a] LLD : Low Limit of Detection

Table II summarized the analytical results the air sample s for pretreatment and melting practices, which are below MDC(Minimum Detect Concentration). It can be seen from Table II that the melting of NORM-contaminated steel scraps has no significant radiological concern. The radiation exposure of the operators at the experimental melting process is very low, shown in Table III.

Table II The NORM analytical results of the pretreated and melting for air sampling

Treatment method	Batch number	Air sampling		
		Operating area	Emitters	Counting after 24hr
Pretreated	1	Pretreated room	α	＜MDC [a]
			β 、 γ	＜MDC
	2	Pretreated room	α	＜MDC
			β 、 γ	＜MDC
Melting	2	Melting cell entrance	α	＜MDC
			β 、 γ	＜MDC
	3	Melting cell entrance	α	＜MDC
			β 、 γ	＜MDC

[a] MDC α ：$\leqq 7.0\times10^{-2}$ Bq/m^3， β ：$\leqq 4.6\times10^{-1}$ Bq/m^3

Table III The radiation exposure of the operators at the experimental melting process

Treatment method	Operation time (hr)	Receive dose (μ Sv)
Pretreated	14	1.49
Melting	32	0.84
Sampling	1	0
Total	47	2.33

CONCLUSION

The study for recycling of NORM-contaminated steel scraps was a first trial in Taiwan. The air concentrations of the working area were below MDC and the radiation exposure for operators is very low (negligible) during the pretreatment and melting processes. All of the surface dose rates of the ingots are of the background level. The activity concentrations of the ingots are below the regulatory criteria. Considering unjustified anxiety and ignorance concerning radioactive and radiological risks among the public and to further improve the radiation safety, the ingots were mixed with other steel scraps originated from non-nuclear activities for reuse. The study has been granted by the regulatory authority, and the ingots have been remelted for recycling.

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