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Review

Yttrium recovery from primary and secondary sources: A review of main hydrometallurgical processes

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ABSTRACT

Yttrium is important rare earths (REs) used in numerous fields, mainly in the phosphor powders for low-energy lighting. The uses of these elements, especially for high-tech products are increased in recent years and combined with the scarcity of the resources and the environmental impact of the technologies to extract them from ores make the recycling waste, that contain Y and other RE, a priority.

The present review summarized the main hydrometallurgical technologies to extract Y from ores, contaminated solutions, WEEE and generic wastes. Before to discuss the works about the treatment of wastes, the processes to retrieval Y from ores are discussed, since the processes are similar and derived from those already developed for the extraction from primary sources.

Particular attention was given to the recovery of Y from WEEE because the recycle of them is important not only for economical point of view, considering its value, but also for environmental impact that this could be generated if not properly disposal.

Contents

1. Introduction

Yttrium (Y) is a silvery-metallic dark grey lustrous metal that is relatively stable in air. Y has an atomic number of 88.91 and it has hexagonal crystal structure. It occurs in the periodic table in group 3, following strontium and coming before zirconium and niobium. Y has +3 has oxidization state and its oxide is Y_2O_3 http://www.reehandbook.com/yttrium.html. This metal is mined from a different of ore minerals (such as gadolinite, xenotime, and monazite).

The applications of this metal are numerous, for example as phosphors in fluorescent lamps, it is also used to create cubic zirconia jewels, in fighter jet engines, as laser in industrial, medical, graphic technologies, in electronic components for missile defense systems, and others.

The market of yttrium, like for other rare earths (REs), is very dynamic because these elements are strategic materials for various technological fields, and the fluctuation of supply and demand in recent years has caused a consequential wide price fluctuations in the market.

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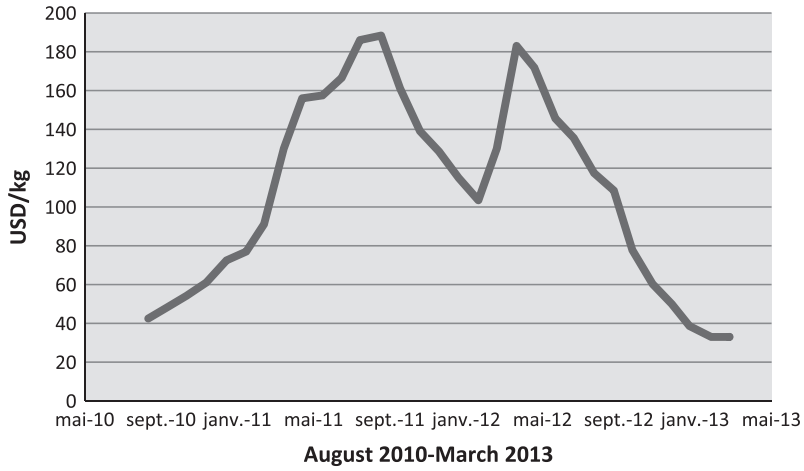

Fig. 1. Trend of the prices of Y oxide.

RE prices grow since 2003 with a very strong increase in 2011; referring to the most current data the rare earth market is still dominated by China and there was a significant fall in prices during 2012 and the first months of 2013. This reduction was the natural consequence of the attempt of importing countries to extract RE from secondary sources or old mines http://unmig.sviluppoeconomico.gov.it/unmig/miniere/terrerare/terrerare.asp.

Fig. 1 shows the price trend for yttrium oxide from August 2010 to March 2013. The economical values decreased in June and July, actually the prices are increasing. In August 2013 the prices for yttrium (99.9%) and yttrium oxide (99.999%) were around 60 USD/kg (min FOB Chi) and 30 USD/kg (CIF Europe), respectively www.metal-pages.com.

The recovery of yttrium from various types of waste is very attractive and this manuscript offers an overview of most recent literature works that describe the retrieval of yttrium. The aim of this present review is summarized the results of relevant articles that described the recovery of yttrium from ores, solutions and wastewater; generic waste and ewaste with particular attention to CRT and fluorescent lamps.

2. Yttrium recovery from ores

The first technologies for the recovery of rare earths were adopted to extract them from the minerals and considering the goals of this manuscript below some recent scientific works, about this subject, are listed.

Coltrinary and Kindig (1972) in their patent described a method to recover phosphates, yttrium and rare earth metal values from solid materials, phosphate ores or commercial concentrates and especially apatites, in a two-stage leaching process comprising: a first extraction with an aqueous acid solution to remove part of

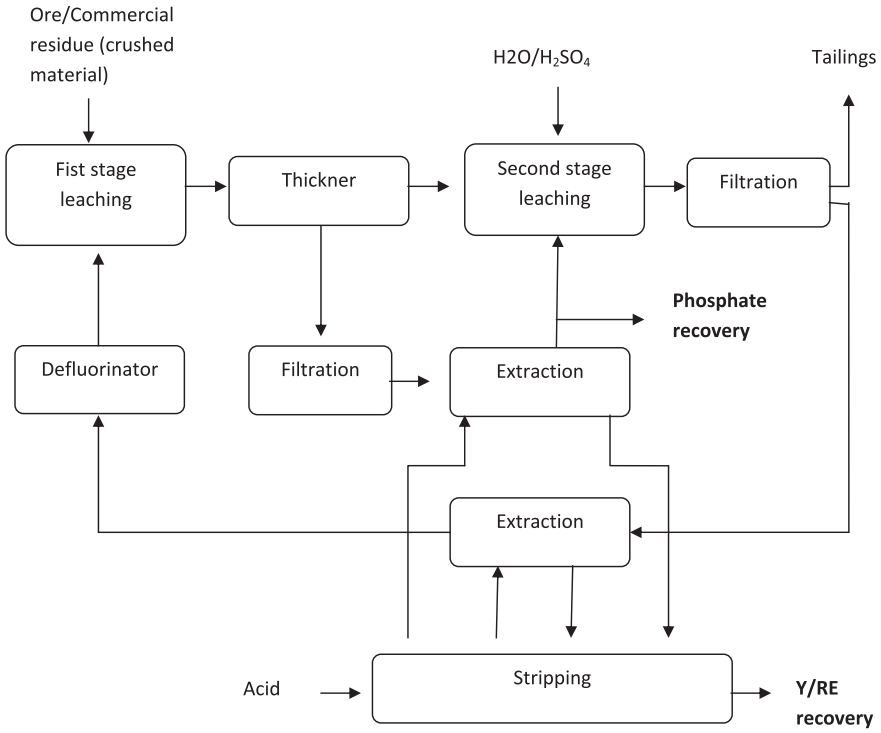

Fig. 2. Block diagram for Coltinari and kinding's process.