ARTICLE IN PRESS

Waste Management xxx (2017) xxx–xxx

Contents lists available at ScienceDirect

Waste Management

journal homepage: www.elsevier.com/locate/wasman

Recycling potential for low voltage and high voltage high rupturing capacity fuse links

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A R T I C L E I N F O

Article history:
Received 14 May 2017
Revised 6 September 2017
Accepted 14 September 2017
Available online xxxx

Keywords:
Low voltage fuse links recycling
High voltage fuse links recycling
WEEE Directive
Materials recovery
Industrial wastes reduction

A B S T R A C T

Low voltage and high voltage high-rupturing-capacity fuse links are used in LV and HV installations respectively, protecting mainly the LV and HV electricity distribution and transportation networks. The Waste Electrical and Electronic Equipment Directive (2002/96/EC) for "Waste of electrical and electronic equipment" is the main related legislation and as it concerns electrical and electronic equipment, it includes electric fuses. Although, the fuse links consist of recyclable materials, only small scale actions have been implemented for their recycling around Europe. This work presents the possibilities for material recovery from this specialized industrial waste for which there are only limited volume data. Furthermore, in order to present the huge possibilities and environmental benefits, it presents the potential for recycling of HRC fuses used by the Public Power Corporation of Greece, which is the major consumer for the country, but one of the smallest ones in Europe and globally, emphasizing in this way in the issue. According to the obtained results, fuse recycling could contribute to the effort for minimize the impacts on the environment through materials recovery and reduction of the wastes' volume disposed of in landfills.

1. Introduction

In electrical installations of low and medium voltage distribution networks, fuses have been in use for over 100 years. Low voltage (LV) high-rupturing-capacity fuse links (commonly NH) are used in LV installations protecting mainly the LV electricity distribution networks (230/400 V in Greece and most EU Member States) public and private ones, as well as a significant amount of LV electrical equipment used in industrial, commercial and residential facilities and infrastructures. High voltage (HV) high rupturing capacity fuses (commonly HH) are used in order to provide protection against thermal and dynamic damages that would occur in case of a short-circuit or overloading more than the minimum rupturing capacity. For many applications, fuse links represent a relatively cheap and safe way of providing protection for electrical systems and equipment (Bessei, 2007; Newberry & Wright, 1995; Rüdenberg, 1970; Schneider Electric, 2016; http://www.profuseinternational.com/, 2017).

The WEEE Directive (2002/96/EC) for "Waste of electrical and electronic equipment" is the main related legislation and as it concerns electrical and electronic equipment it includes electric fuses. Although, the fuse links consists of metals, silica and ceramics, only small scale actions for their recycling have been implemented around Europe, mainly from Non-Profit Associations created from manufactures, where NH/HH – Recycling in Germany has collected and recycled over 208 tonnes of LV and MV fuses only in 2016. Up to now and except these activities from some Non-Profit Associations, no other actual action, regarding the disposal of waste fuse links, have been taken, and the usual method is the inclusion among the common non – hazardous municipal and commercial waste streams, as these are not considered hazardous. Thus, the waste fuse links finally are disposed on landfills although the European Union (EU) Landfill Directive (1999/31 EC) promotes more environmental friendly waste management options, by reducing the amount of wastes disposed of in landfills (Bessei, 2007; EU Directive 1999/31/EC; EU Directive 2002/96/EC; E.E.A, 2007; Fink and Grote, 2007; Rüdenberg, 1970; http://www.nh-hh-recycling.de/, 2017; http://www.profuseinternational.com/, 2017).

In this paper, the current actions on fuses recycling in Europe are presented and the possibilities for recycling of LV HRC fuses in Greece (Public Power Corporation of Greece is the major consumer) are investigated. The quantities of waste fuses which could be recycled, instead of landfilled, are evaluated as well as the

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https://doi.org/10.1016/j.wasman.2017.09.018
0956-053X/

Please cite this article in press as: Psomopoulos, C.S., et al. Recycling potential for low voltage and high voltage high rupturing capacity fuse links. Waste Management (2017), https://doi.org/10.1016/j.wasman.2017.09.018

potential materials recovery. The work is also trying to bring in front the problem arising from the lack of concrete approaches in the recycling of fuses, an electrical equipment that can be almost 100% recycled. Through their recycling significant by-products and valuable metals can be recovered in order to reduce the waste pressure and the environmental impact, as even for a small country as Greece, the quantities are very high, to be neglected.

2. Low voltage high rupturing capacity fuse links

Low voltage (LV) high-rupturing-capacity (HRC or most commonly NH) fuse links are used to protect mainly the LV electrical installations of the LV electricity distribution networks, public and private. LV fuses are also used for the protection of a significant amount of LV electrical equipment used in industrial, commercial and residential facilities and infrastructures. Fig. 1 illustrates a typical LV HRC fuse.

2.1. Structure of low voltage high rupturing capacity fuse links

A typical industrial LV HRC fuse link consists of a conducting metal strip element (most commonly silver or copper) surrounded by granular filler (silica) all of which is enclosed within a cartridge (usually ceramic). Fig. 2 shows the internal of a LV HRC fuse. Fig. 3 represents the main structure of a LV HRC fuse. In Fig. 4, the mean composition of typical LV HRC fuses (Deuβer, 2003) is presented. Differences may exist on these mean values depending on the construction year (fuses have 15–20 years life if they do not operate, thus melting of the fusible element) and the type.

2.2. Operation of low voltage high rupturing capacity fuse links

The operation of a fuse link is mainly determined by the construction of the fuse element, and therefore a fuse with specific characteristics can be designed for a particular application. Each fuse link must possess electrical resistance, depending on the configuration and the materials used and produce Joule heating whenever current passes through it. The fuse element determines whether a slower or faster interruption occurs. During overload, the temperature of the fuse element is so high that the deposited solder (or solder composite) reacts with the fuse element. This reaction results in the diffusion of the deposited solder into the fuse element. This causes the fuse element to become locally more resistive, which itself results in an accelerated diffusion. This phenomenon will continue until the fuse element melts (Bessei, 2007; Newberry & Wright, 1995; Rüdenberg, 1970; Schneider Electric, 2016; http://www.profuseinternational.com/, 2017)

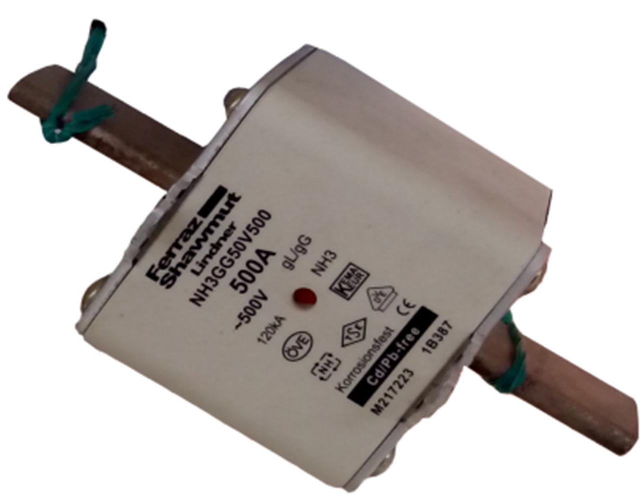

Fig. 1. Typical LV HRC fuse.

Fig. 2. LV HRC fuse Internal.

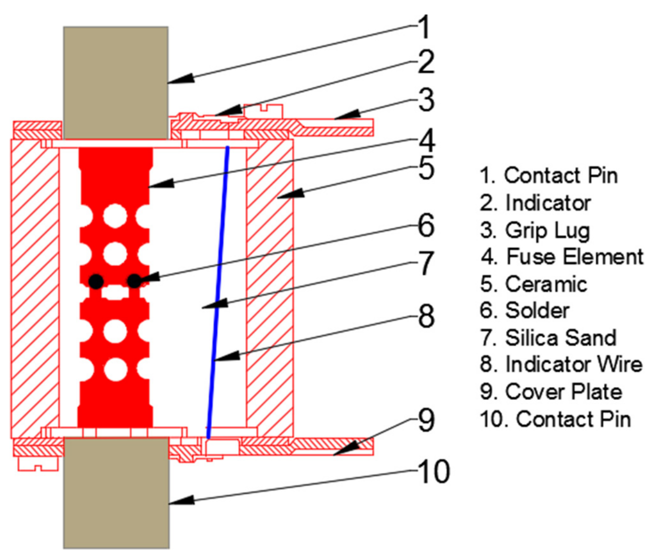

Fig. 3. LV HRC typical structure.

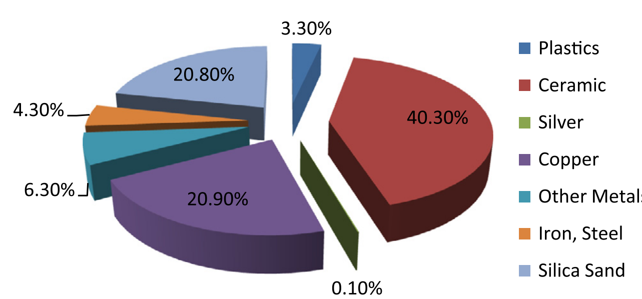

Fig. 4. LV HRC mean composition (as given by Deuβer, 2003).

Generally, fuses operate either under a minus value of their nominal current or momentarily under excess or short-circuit currents. During the operation under nominal or less current, the current passing through a fuse link changes from its initial value, depending on the network load variation and the Joule heating produced on fuse element and it is uniformly distributed to the surrounding area of the element. After a time period, thermal equi-