Environmental Nanotechnology, Monitoring & Management 1–2 (2014) 50–56

Contents lists available at ScienceDirect

Environmental Nanotechnology, Monitoring & Management

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

Case Study

Waste management in a typical Chinese gravure plate-making industry

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ARTICLE INFO

Article history:
Received 22 March 2014
Received in revised form 30 July 2014
Accepted 31 July 2014
Verlicchi Paola

Keywords:
Waste management
Gravure plate-making industry
Technical progress

ABSTRACT

Both waste management and cleaner production (CP) are playing a crucial role in reducing consumption of energy, water and raw materials, in addition to avoiding waste generation. Through investigating one typical gravure plate-making industry in Tianjin, PR China, waste management and cleaner production audit (CPA) have been used to find important opportunities for cleaner production. In this waste management process, three major technical innovations have been proposed and applied in this company. Through the first-round cleaner production audit, 0.68 million USD can be saved during one year. By the way, cost-effectiveness of the suggested programs is increased obviously compared with traditional production technology, which is important and conductive to the promotion of these novel technical progresses for other gravure plate-making industry in China.

1. Introduction

As we all know, the main objective of cleaner production is to minimize the usage of raw materials or energy, and reduce generated pollutants, by replacing older techniques with modern ones currently used by others in a more environmental friendly manner (Dong et al., 2012; Duan et al., 2011). Through carrying out novel cleaner production methods, huge economic benefits can be obtained (Dong et al., 2010). So, cleaner production becomes popular in China; especially, three type of industries (electroplating, beer, paper-making) were forced to carry out cleaner production audit (CPA) by Ministry of Environment Protection in China (MEPC) in 2004 (Liu et al., 2012).

Until now, there are more than 7000 gravure plate-making companies in China. Among of several processing methods, the electroplating process is most commonly used. However, there are a lot of defects that need to be overcome due to complicated subsequent waste treatment process, which result in 6–7% defected (Vogtländer et al., 2002) {CE: Please raise Clarity Query}. It is difficult for a common small company to store so huge volume of waste rollers, because there are about 12,000,000 waste rollers leftover annually in China. In light of the fact, there is an urgent need to develop and apply advanced techniques to overcome these problems (Fresner et al., 2007).

The gravure plate-making industry usually causes a lot of pollutions, and plenty of hazardous waste water containing heavy metal ions was left out largely (Revathi et al., 2012). Generally, one gravure roller can be obtained by employing the following production process: pipe polishing, nickel plating, copper plating, carving, chromium plating, and laser engraving. As long as the external diameter of used pipe does not change obviously, they can be recycled as raw materials. However, the present recovery rate in China is still very low, which is due to technical difficulties, a recycling policy poorly developed and a shortage of qualified staff (Shi et al., 2008; Xie et al., 2009; Erol and Thöming, 2005; Giannetti et al., 2008) for gravure plate-making industry. In addition, the toxic and hazardous raw materials would be reduced or replaced (Sainger et al., 2011; Kapustenko et al., 2009; Xu et al., 2006).

In this article, a typical gravure plate-making industry (Tianjin Jinggong-huahui Plate Making Technology Development CO., Ltd) in Tianjin Economic Development Area (TEDA), China was chosen as a model company for CPA, whose production process has also been totally investigated in order to find new chance to reduce energy and raw materials cost, with the final goal of more economic

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http://dx.doi.org/10.1016/j.enmm.2014.07.002

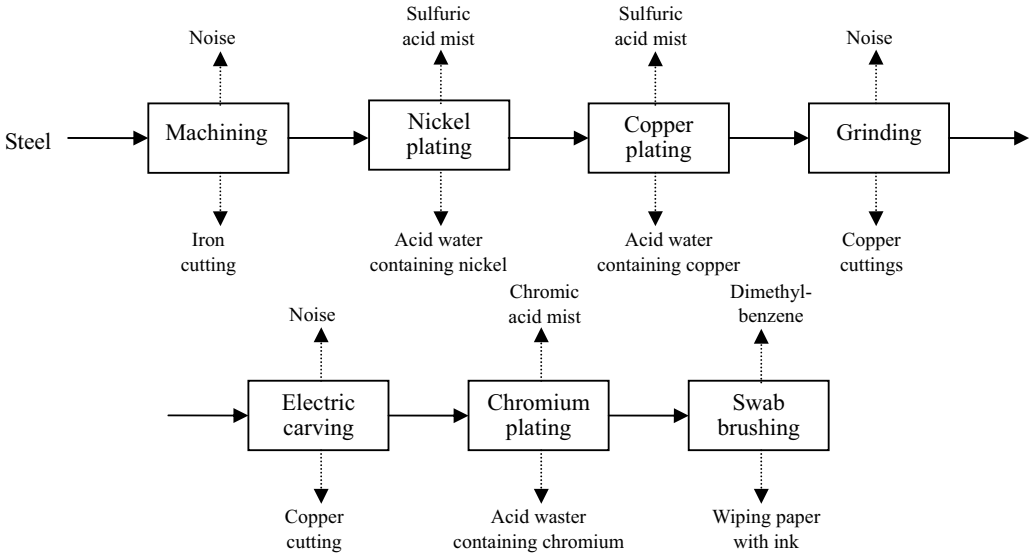

Fig. 1. Flow diagram of the gravure plate-making process.

benefits. Through this round of CP investigation, three important techniques have been proposed and applied in this company. Moreover, detailed economic benefits have also been calculated (Cagno and Trucco, 2008) and the corresponding model has also been proposed.

2. Materials and methods

2.1. Materials

Titanium baskets were purchased from Suzhou Xingao metal equipment Co. Ltd., China (SZXG-TA/0452). Phosphorus copper balls with diameter of 25 and 28 mm were purchased from Shanxi Yimeng Co. Ltd. Analytical pure sodium hydroxide (NaOH) was purchased from Tianjin Kemao chemical reagent Co. Ltd.

2.2. The production process of gravure plate-making industry

From the production flow chart of Tianjin Jinggong-huahui Plate Making Technology Development CO., Ltd shown in Fig. 1, the raw roller is grinded carefully and accurately to make its surface much smoother and uniform, which then needs extra surface treatments, such as nickel plating, copper plating, electric carving, swab brushing, and chromium plating, subsequently. However, in the production process, several serious environmental pollutions are brought out, such as noise, metal scraps and waste water containing heavy metal ions, together with huge energy consumption, more copper loss, and so on. For example, there are about 30,000 gravure rollers and 8 t copper scraps are produced in one year in this company. However, the waste copper scraps are usually thrown away as garbage or sold out at a very cheap price.

2.3. Technical demands

Since 2010, Tianjin Jinggong-huahui company was very initiative to invite experts of Cleaner Production Center in Nankai University to find significant opportunities for energy saving, because of its increased water pollution, high consumption of electrical energy and copper resources (Hwang et al., 2012). In order to obtain uniform diameter of roller, a lot of high purity of copper cuttings must be done, which were usually thrown away later. Through life circle analysis of copper element, it is amazing that only half of the copper and 60% electric energy can be really used. What is more, the hazardous metal slurry containing of nickel and chromium has been sold at a very low price instead of utilization and recycle. It is obvious that resource consumption, low resource utilization and environmental pollution are serious until now. For increasing technology innovation ability, new technical progress and new technologies must be investigated and applied as soon as possible.

3. Results and discussion

In order to realize the purpose of 3R principle (reduce, reuse and recycle), it is very much necessary to develop new technologies to recycle and reuse waste products in the electroplating process. Through CPA process, three advanced technical progresses have been proposed and applied in this company, which has brought about great economic and environmental benefits.

3.1. Increase surface evenness of electroplated gravure roller

The surface of electroplated copper coating on gravure roller is not uniform, specifically at the ends of the roller, the extra thicker part should be removed before next metal electroplating step. However, a large number of copper cuttings have to be cut down, which results in severe waste of copper resources and electric energy. In order to avoid this shocking waste, obtaining a most uniform thickness of electroplated metal membrane is one of the ultimate goal. Based on our previous work, there are two methods to improve the uniformity of the copper-plating coating. One is the addition of external anode board; another method is to change the position of titanium basket. In addition, after the implementation of these two methods, the excellent uniform thickness can be reached and the usage of copper ball is greatly reduced.

3.1.1. Impact factors of electroplated surface uniformity

As we all know, the thickness and uniformity of electroplated copper coating depend on performance of the electrolyte itself and electroplating process parameters. According to Faraday's law, the thickness uniformity of copper coating mainly depends on power line distribution near the cathode. Generally, when the electric power line distributed on cathode surface is more uniform, the electroplated coating will also be uniform. However, in actual electroplating process, several parameters play a role in uneven electric current distribution on gravure roller surface and uneven copper