A TECHNICAL METHOD OF EXTRACTION OF GOLD FROM E-WASTE: A MULTI-SENSOR BASED METHOD USING MICROCONTROLLER

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Abstract

The disposal of e-wastes into the environment is hazardous as they contain chemicals. The conventional methods of disposing these e-wastes are irrelevant and have adverse effect on the environmental conditions which is a threat to life. The objective of this paper is to describe the recycling of e-wastes and extraction of valuable metals like gold and silver from it. The aquaregia solution based method of extraction is the oldest and conventional method. The steps and procedures that are followed and practiced are to be done manually which seems to be quite risky as it is a chemical process. But the aquaregia solution method of extraction can be easily automated for precise and faster extraction. The intension of our paper is to propose an idea of an automation system for the recovery of gold from E-waste. This system for gold recovery is solely controlled by the microcontroller. There is use of several types of sensors, which are in turn act as input providers to the microcontroller, in order to control the whole process. There is great advantage if it is implemented practically. It can create a sort of industrial solution as e-waste is global problem. A new trend in the recycling industry will be created which will be a revolutionary step. The only thing is that the initial investment will be quite more. But once implemented it can be used for long terms and for cost effectiveness.

Keywords: *E- waste, Aquaregia, microcontroller, signal conditioning, solenoid valve, end point.*

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1. INTRODUCTION

The advancement of technology and the industrial revolution changed the world's life-style rapidly. The improvements and advances in the field of electronics was so rigorous that a common man has became able to have more number of electronic gadgets increased, later the greatest disadvantage of e-toys was its waste disposal and its management which is challenge during these decades. Now the days of conventional PCs are gone. These are the days of tablets and laptops. And particularly in the electronics domain a device validates to a maximum of two years from the day it has released to the market. Hence the e-waste generated is found to be enormous that poses a problem to the life and environment [1],[2]. E-waste refers to the waste materials borne out of the electronic-gadgets. The disposal of e-wastes into the environment is hazardous as they contain chemicals. The conventional methods of disposing these e-wastes are irrelevant and have adverse effect on the environmental conditions which is a threat to life. The objective of this paper is to describe the recycling of e-wastes like PCBs [3], [4], batteries, SIM cards, mother boards etc and extraction of valuable metals like gold and silver from it [5]. Nowadays the management of e-waste is a biggest headache in developed and developing countries like Japan, Germany, and America and even in India too. So, in this context proper management and recycling of e-waste is necessary.

The methods that are known: Lime Sulphur Synthetic Solution (LSSS) [6], Electrolytic process, aquaregia solution [7] method and metallurgical recovery processes [8], [9]. Among these methods the aquaregia solution method of extraction is the oldest and conventional method which is widely practiced everywhere to extract scrap gold, the chemicals used here are easily available and are of reasonable cost.

The microcontroller [10] based extraction of gold from e-waste system consists of a microcontroller, various sensors for end point detection, efficient signal conditioning, actuators and many final control elements.

The process is divided into three stages and each stage is microcontroller controlled for the efficient and automated mechanism. This system can be further improvised and other precious metals like platinum and silver can be extracted with necessary modifications in detection and control.

2. THE PROCESS

The treatment and management of e-waste can be broadly in to three levels.

1. Level: Involves dismantling.
2. Level: Electrostatic separation.
3. Level: Recovery of precious metals and disposal of e-waste.

It is necessary that the e-waste must have to undergo the first two level treatments before extracting the precious metals from the crushed e-waste. The waste materials should be cut to get the metallic parts and it must be crushed. The process presented here mainly discusses the third level. At the third level treatment of e-waste, the metallic parts are extracted and cut. Then they are crushed such that it is soluble in a suitable solvent.

The concentrated hydrochloric acid (HCl) and nitric acid (HNO_3), sodium bisulphite, urea, aqueous ammonia and water are some of the chemicals that are required for the extraction of gold. Figure1 shows the conceptual arrangement of the complete process. The total process can be put into three stages for the convenience of understanding the operation and all the stages are explained below:

2.1 Stage1

The crushed e-waste is mixed with the two chemicals in the mixing chamber at the very first stage of this automated process. The stage 1 consists of two chambers for this purpose. The first chamber is for the crushed e-waste which is regulated by the solenoid valve V_1 and another for the preparation of fresh aquaregia solution from HCl and HNO_3 sub chambers. HCL and HNO_3 are to be mixed thoroughly at a ratio of 3:1. The flow rates of these two acids are controlled for this purpose by solenoid valves V_2 and V_3 that allow calculated amount of acids for the calculated amount of crushed raw material.

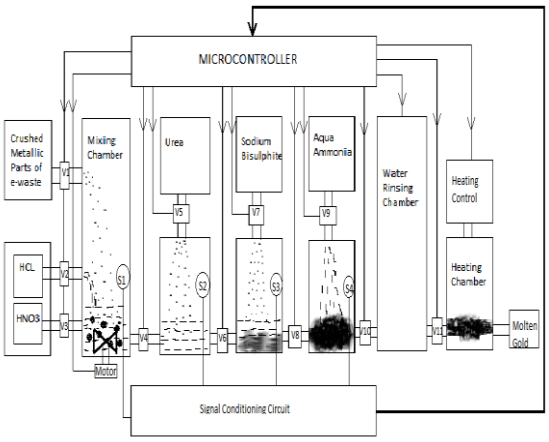


Fig 1: The complete process block diagram

The uniform mixing of these two acids is achieved with the motor assisted stirrer. Now valve V_1 is opened to allow crushed e-waste into the mixing chamber. The stirrer rotates so that waste gets mixed with aquaregia. The mixing extent is continued unless fizzing sound stops and the mixture turns to dark green coloured compound. A sensitive microphone and a colour sensor are used to detect this end point. Once these two end points are reached, the microcontroller stops the stirrer motor and opens valve V_4. At the same time solenoid valve V_5 is opened for a finite and predetermined time to add definite quantity of urea. The next three chambers are considered as stage2.

2.2 Stage2

Upon adding urea, fizzing sound starts and the end point is reached when this sound ceases and foam starts developing. One more sensitive microphone is used to detect the end point. After the reaching of the expected end point, at this point of time microcontroller opens V_6 to displace the compound into the next chamber which adds calculated amount of sodium bisulphate through microcontroller operated valve V_7. A colour sensor or time based detection is enough to make the reaction complete, resulting into brown precipitation. Next chamber is for mixing of aqueous ammonia through valve V_8. In this chamber the compound is mixed with ammonia still a muddy brown precipitation occurs with white vapour. This is monitored by a sensor S_4.

2.3 Stage3

Valve V_{10} makes the precipitate available for water rinsing. A rinsing mechanism is used to wash the muddy brown precipitate for a finite period to remove the acid in the compound. Finally microcontroller opens valve V_{11} for heating purpose. Heater is turned on for a time period up to which molten gold is obtained.

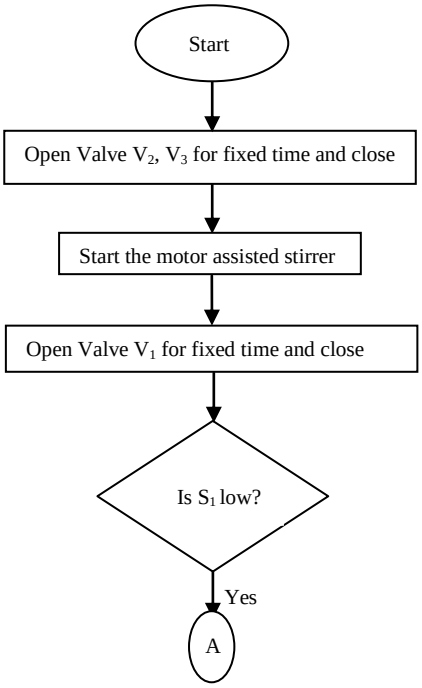
Thus, the whole process is sequential in nature. A programmed microcontroller [10] with number of sensors, their signal conditioner and actuator can effectively control the process. IC 8051 or any other microcontroller can effectively monitor and control the whole process. The output of all the sensors are signal conditioned. Since each sensor monitors only one point or value, comparators are used to give a high or low signal depending on the status of each chamber. This eliminates the use of an ADC. A 4:1 digital multiplexer is used to sequentially select the respective sensor and corresponding parameter of process by an 8 bit microcontroller. The microcontroller is programmed and the algorithm for this program is explained in the proceeding section.

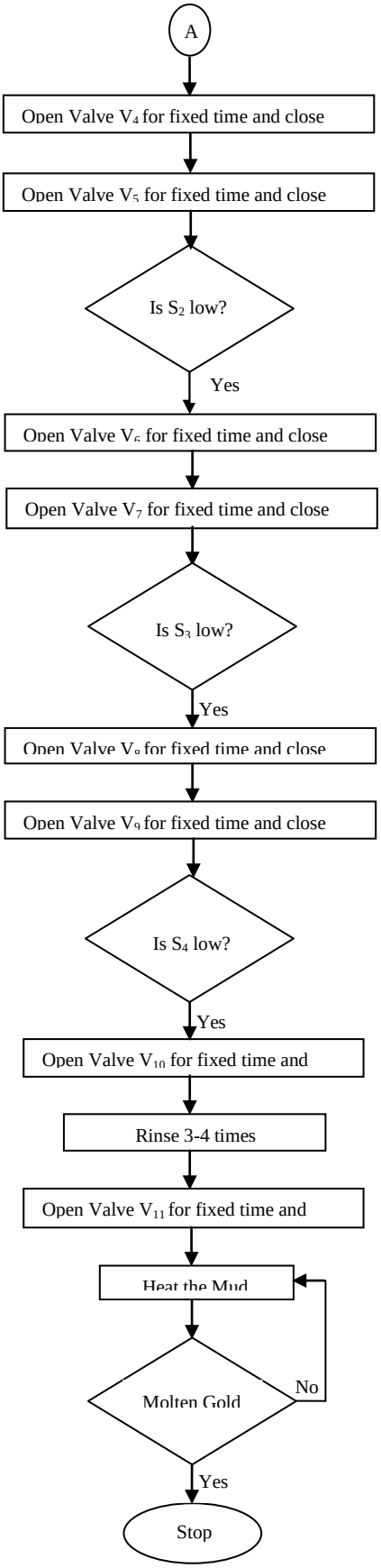
3. ALGORITHM

The complete process of separation can be put into sequential steps and are

1. Start the process
2. Open valves V_2, V_3, allow HCl and HNO_3 at 3:1 ratio for a fixed time interval and then close
3. Mix the solution with stirrer by actuating the motor
4. Open valve V_1, allow finite quantity of e-waste and then close
5. Mix the solution and e-waste with stirrer by actuating the motor
6. Switch on S_1 and monitor for no fizzing sound and dark green liquid.
7. When S_1 is low switch-off stirrer motor
8. Open valve V_4 for a fixed time interval and then close
9. Open valve V_5 for a fixed time interval and then close
10. Monitor S_2 for no fizzing sound
11. When S_2 goes low, open valve V_6 a fixed time interval and then close
12. Open valve V_7 for a fixed time interval and then close
13. Monitor S_3 for brown precipitate
14. When S_3 goes low, open valve V_8 for a fixed time interval and then close
15. Open valve V_9 a fixed time interval and then close
16. Monitor S_4 for muddy brown precipitate
17. When S_4 goes low, open valve V_{10} to transfer the compound to next chamber and then close
18. Rinse the mud 3-4 times using water shower
19. Open valve V_{11} to allow heating and then close
20. Switch on the heater to heat the mud
21. Heat until Molten Gold is obtained

4. FLOWCHART





5. CONCLUSIONS

The aquaregia solution method of extraction can be easily automated for precise and faster extraction. The steps and procedures that are followed and practiced are sequential in nature and hence a microcontroller based automatic extraction method is feasible and possible.

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