The apparatus is enabled with at least one smart diode testing device that checks the functionality of the diodes.
before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))
"AUTOMATIC COMPONENT SEGREGATOR ENABLED WITH SMART DIODE TESTING KITS"

FIELD OF THE INVENTION

The present invention relates to an apparatus and a method for automatic segregation of recyclable and reusable parts from electronic wastes. More particularly, it relates to an apparatus and a method for automatic separation of the working and non-working parts of a waste printed circuit boards.

BACKGROUND OF THE INVENTION

E-waste management is an important requirement for ecologically sustainable development in many countries. Efficient sorting of waste is a major issue in today's society and is becoming a burgeoning problem for the waste management industries to ensure effective and sustainable management of waste. The economic value of waste is best realized when it is segregated.

The trend of making the manually controlled things automatic has become a common practice these days. Making things automatic reduces burden on the humans. Also, the cost and effort used in manually operated products is much higher than that of the automated systems.

The main problem of manually operated waste management systems is checking and segregating components based upon their recovery, reuse potential. The usual method either involves a manual approach wherein either a person has to wander through the different spots, checking the places for waste collection or a team is required for identification and segregation of the components. This is somewhat complex and time consuming process. Hence, the present day waste management system is not as efficient as it should have been taking into consideration the advancements in the technologies that arose in the recent years. Hence, there is no safeguard regarding effective utilization of the e-waste by the proper identification, segregation and applying waste management approaches for the underlying components of the e-wastes.
Moreover, there’s another problem wherein recyclers need to identify values or reuse capability of underlying components of the e-wastes to determine or plan the appropriate waste management strategy. PCB’s are the important components of electrical equipments that owns a precious composition of metals, non-metals, the parts like diodes, semiconductors, inductors, removable board ports etc. Hence, recycling becomes a more complex task. The complexity of recovery process is not merely due to the disparity of precious composition; rather it is due to the existence of such removable parts that have tendency of reuse, recycle, or recovery depending on the functional state of the components.

Re-using functional components like diodes, inductors, semiconductors etc. could be a better option and cost effective approach in an effective waste management procedure.

CN101444784A discloses a method and a device for high-efficiency recovery of waste circuit boards in vacuum. As per the disclosed methodology, the waste circuit board is arranged in a vacuum vessel and heated for pyrolysis, wherein, most of pyrolysis volatile matter is cooled and liquefied into liquid oil, and the rest is taken into a gas collector; a centrifuge device separates soldering tin from the circuit board during the pyrolysis; substrates and electronic components of the pyrolyzed circuit board are assorted and collected to be further separated and recovered. The main disadvantage of this method is that the heating involved in the pyrolysis process might affect the functionality of working components even pyrolysis take place under vacuum condition.

US6234317 discloses device for sorting raw, pretreated or recycled bulk material. The device is of lesser utility in recycling purpose as the main function of component removal from PCB has to be performed separately.

In order to overcome limitations of the state of the art, one way is to come up with an approach that can ensure an effective waste management procedure irrespective of the nature, functional status, and abundance of valuable materials like metals, non-metals etc. Such approach should focus on the ease of operation, low dependence on man power and tendency to implement one or more waste management techniques at the same time without interrupting the parallel ongoing process(s).
Therefore, an approach is needed that can automatically segregate the components and determine the functional state of the components which may help the recyclers to set the flow and objectives of waste management process which either may be the re-use, recycling, and recovery of the components.

OBJECT OF THE INVENTION

The main object of the present invention is to provide an automatic component segregator comprising a component segregation section and a functionality check section equipped with at least one diode testing kit or device, said section is contiguously connected to segregate functional and non-functional diodes in the various stages depending upon their functionality, nature and reusability.

Yet another object of the present invention is to provide a Programmable Logic Controller (PLC) controlled apparatus that through a series of input/output modules, sensor modules and communication processors operates the segregation process in an automatic mode.

Yet another object of the present invention is to provide an approach for segregating components present in the waste printed circuit boards or e-waste.

Yet another object of the present invention is to provide an apparatus wherein specific parameters like temperature, speed, time can be customized as per the requirement of the segregation process.

Yet another object of the present invention is to provide a sensing mechanism enabled apparatus to sense presence of waste on the conveyor belt and initiating the belt movement.

Yet another object of the present invention is to provide a method of segregation involving automatic operations like size sorting, metal sorting and diode sorting from printed circuit boards or any electronic waste products having components with scope of reuse, recovery and recycling.

Yet another object of the present invention is to provide an approach to scrutinize and segregate working or reusable diodes from electronic wastes.
Yet another aspect of the present invention is to provide an apparatus with a safety mechanism to protect damage of embedded parts present in the e-waste.

**SUMMARY OF THE INVENTION**

Accordingly, the present invention relates to an apparatus for automatic segregation of working and non-working parts from waste printed circuit boards or electronic waste with minimal or no manual efforts. The apparatus comprises a component segregation section and a functionality check section equipped with at least one diode testing device to segregate functional and non-functional diodes in the various stages depending upon their functionality, nature and reusability.

The apparatus automatically takes in the bulk waste product as feed; the entry of the same is then sensed by the sensors provided on the conveyor belt and initiates the segregation process. The components from the waste product are then undergo a number of stages wherein all necessary steps are taken like shredding, size sorting, metal sorting, reusable parts sorting viz. chips, diodes, resistors etc.

The removed components, particularly the diodes are then tested by kits/devices for reusability. If tested negative, they are directed towards recycling procedures. On functionality check section, the segregated diodes are checked for physical integrity and further go through various component specific tests; if the diodes pass said tests, it is qualified for reuse. If not, it is sent for mechanical recycling.

In another embodiment of the proposed invention, the apparatus is enabled with at least one smart diode testing kit(s) that checks the functionality of the diode(s). The smart diode testing kit(s) are capable to check conductivity of the diodes to assess the reusability of the same.

The diodes are checked by these smart kits in order to determine whether they should go for mechanical recycling or for reuse. On testing bench, the removed diodes are checked for physical integrity and go through the conductivity test; if the diode passes the physical integrity and conductivity tests, it is qualified for reuse. If not, the diode is sent for mechanical recycling.
BRIEF DESCRIPTION OF DRAWINGS

The various features, advantages and other uses of the present e-waste recycling method and apparatus will become more apparent by referring to the following detailed description and drawings in which:

FIG. 1 is an isometric view of the component segregator apparatus contiguously attached with a functionality check section according to an embodiment of the present invention.

FIG. 2a is a process flow diagram elucidating the component removal procedure according to an embodiment of the present invention.

FIG. 2b is a schematic flow diagram for the processing of remaining material obtained is explained.

FIG. 3 is a process diagram depicting the various stages like size sorting, metal sorting and chips sorting according to an embodiment of the present invention.

FIG. 4 is a perspective view of the main component segregator along with a functionality check section for segregated diodes, according to an embodiment of the present invention.

FIG. 5 is a layout of a PLC controlled system controlling various component removal machines equipped in the apparatus.

FIG. 6 is a flow chart to explain diode reuse mechanism is elucidated.

FIG. 7 is the front view of the diode testing kit assembly is provided according to an embodiment of the present invention.

FIG. 8 is the side view of the diode testing kit assembly according to an embodiment of the present invention.

FIG. 9 is the top view of the diode testing kit according to an embodiment of the present invention.
DETAILED DESCRIPTION OF THE INVENTION

The present invention now will be described hereinafter with reference to the accompanying drawings, in which some, but not all embodiments of the invention are shown. Indeed, the invention may be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will satisfy applicable legal requirements.

Many modifications and other embodiments of the invention set forth herein will readily occur to one skilled in the art to which the invention pertain having the benefit of the teachings presented in the foregoing descriptions and the associated drawings. Therefore, it is to be understood that the invention is not to be limited to the specific embodiments disclosed and that modifications and other embodiments are intended to be included within the scope of the appended drawings. Although specific terms are employed herein, they are used in a generic and descriptive sense only and not for purposes of limitation.

FIG. 1 is an isometric view of component segregator depicting complete system for executing the segregation process. In the first step, the e-waste components from component removal machine(s) 400 are received by the primary sieving unit 110 for sorting. Component removal machines provide two types of fractions, i.e. fine and coarse, other than the blank boards. Primary sieving unit 110 conducts screening of fraction containing Solder balls, dust, diodes, capacitors, pins and fine particles, which further goes for separate sorting system 300. Furthermore, the diodes are sorted and separated by any suitable method preferably, a roller separation method. Thereafter, the diodes are selectively sent towards the functionality check section 200 for the functionality determination of diodes in terms of conductivity measurement. The functionality check section 200 is equipped with at least one diode testing kit 215 to assess functionality of the segregated diodes. For functionality assessment of diodes, a scrutiny area 210 is provided on at least one side of the section 200. In yet another embodiment, the functionality check section comprises of at least oneveyor system to convey diodes towards the scrutiny area 210.

FIG. 2a is a process flow diagram elucidating the component removal procedure wherein the waste material is fed into the component removal machine/apparatus. The
Component removal machine (CRM) performs preparatory steps like primary sorting of electronic waste, and removal of the components of the e-waste, particularly waste printed circuit boards. After component removal, the blank boards are sent for shredding and further recycling procedures. Whereas, the removed components are sent for segregation process of present invention. Precisely, the component removal machine connected prior to the segregator apparatus removes all of the working and non-working components from the printed circuit boards and conveys said components for various checks to ensure proper waste management approach depending on the type and status of each component. For example, if printed circuit board is entered as feed then the apparatus would remove all the embedded components of the printed circuit boards convey all such parts for functionality check with the help of various sensing modules and smart testing kits equipped in the apparatus. If components are found in good working condition, then they are sent for reuse purpose. Similarly, if components are found defective, then other approaches of waste management could be opted based on recovery, recycle potential of such defective part(s). The blank boards after component removal are sent for metal recovery process.

Referring to FIG. 2b, a schematic flow diagram for the processing of remaining material obtained is explained. The removed components are sent for size sorting, sieving, metal sorting, and chips sorting. Size sorting of the removed components is done by the rolling separation method. Whereas, metal present in the removed components are sorted through magnetic sorter.

Referring to FIG. 3, a process diagram depicting the various stages like size sorting, metal sorting and chips sorting according to an embodiment of the present invention. Size sorting is done in stages further by passing the components through rollers and segregating connectors/ports, processor jack/Iron, diodes/Tra nsistors where diodes/tra nsistors are send for functionality checks to assess whether they need to be introduced to mechanical recycling or reuse.

FIG. 4 is a perspective view of the main component segregator along with a functionality check section for segregated diodes, according to an embodiment of the present invention. In this embodiment, the segregator comprises a frame 145 to support the
conveyor system 120 and other sub-assemblies. There are two types of PCB material fractions received from CRM processing other than Blank board namely fine and coarse. Primary sieving unit 110 does the screening of Fine fraction which contains Solder balls, dust, diodes, pins and fine particles, which further goes for separate sorting system. The primary sieving unit 110 forms with screen, cam mechanism for back and forth vibration. It is same as vibratory feeder. The primary sieving unit 110 receives the components from the component removal machine (CRM) wherein, the coarse and fine components are separated. The coarser components includes the components like heat sink, sockets, connectors, copper coils, diodes, coils, connector bases, transistors, inductors, chips, etc. The coarse components are then transferred to feeder 115 which receives all sized / coarse fraction of mixed components. It works on cam mechanism for back and forth vibration. It is same as vibratory feeder. The feeder 115 is contiguously connected to the conveyor system 120. The conveyor system 120 comprises a motor driven conveyor belt that longitudinally runs along the main frame 145 and conveys the coarse fraction of mixed components which passes through various separation stages. The conveyor system further comprises cameras and proximity sensors to sense the components on the conveyor belt and triggering the motor thus moving the conveyor belt in desired direction. A plurality of roller separators 125, 130, & 140 is provided at a suitable location at an adjustable height above the conveyor belt, such that the belt runs just beneath the separators. Each roller separator unit is provided with at least one hopper 155 to receive and collect the components from the roller separator unit. Each roller separator unit segregates the components depending upon their size and transfers the remaining components towards another roller separator unit where, the components are segregated based on the same principle (size based). As discussed above, the segregated components are collected in the respective hoppers 155. Hoppers acts as guide to segregated materials and help in transfer thereof to the functionality check section 200. For segregation of magnetic components, a magnetic separator/sorter 160 is provided. The magnetic separator/sorter is attached subsequently next to the roller separators to initiate the magnetic separation process with the components left after roller separation process and guides segregated iron material to collection bins.
In another embodiment, the functionality check section 200 comprises a conveyor system, a scrutiny area 210, at least one diode testing kit 215. The conveyor system conveys the segregated diodes towards the scrutiny area wherein, the functionality assessment takes place.

Referring to FIG. 5, a layout of a PLC controlled system controlling various component removal machines equipped in the apparatus. The PLC system operates all the machines, rollers and sieving motors in an automatic mode. The status of the operation is displayed on the LCD/TFT screen provided to monitor proper functioning of the apparatus.

Referring to FIG. 6, a flow chart to explain diode reuse mechanism is elucidated wherein each type of diode is gone through an initial physical test. If the diode passes the physical test it proceeds for a further test called conductivity (or connectivity) test. If, in case, the diode fails either of the test it is sent for mechanical recycling.

Referring to FIG. 7, the front view of the diode testing kit assembly is provided. In this embodiment, the kit assembly 215 includes at least one diode testing kit. The diode testing kit comprises an ON/OFF switch 245, an enclosure 250, at least one test PCB 255, at least one mounting screw 260; at least one connecting plate, and at least one indication means 270.

FIG. 8 is the side view of the diode testing kit according to an embodiment of the present invention. In this embodiment, the diode testing kit comprises an enclosure 220, at least one test PCB 225, a positive connecting plate 230, a negative connecting plate 235, all these components are mounted on the base 240.

Referring to FIG. 9, a top view of diode testing kit is elucidated. In this embodiment, the kit comprises: an enclosure 220, at least one test PCB 225, a positive connecting plate 230, a negative connecting plate 235, all these components are mounted on the base 240.

In yet another embodiment of the present invention, the diode testing kit comprises an indication LED which blinks and shows if the diode is working and conducting, a testing PCB, a positive connecting plate, a negative connecting plate, and an enclosure. The diode testing kit further comprises an On/Off button for the kit. The test is carried out to ensure that diode is working. By connecting anode to the positive connecting plate and cathode
to the negative connecting plate, if indication LED blinks, it shows that the diode is conducting and in working condition.

In general, the diode testing kit comprises an enclosure 220, at least one test PCB 225, at least one positive connecting plate 230, at least one negative conducting plate 235, a LED means for power indication 270 and a switch 245 provided to turn the kit to ON/OFF state, and plurality of connecting Plates, i.e., a positive connecting plate 230 and a negative connecting plate 235 for connecting positive and negative terminals of the diode.

Accordingly, in the most preferred embodiment of the present invention is proposed an automatic component segregator for segregating electronic waste components comprising:

a) a frame;
b) at least one feeder to receive the components to be segregated;
c) at least one conveyor system to move the components away from the feeder, the system comprising motor driven conveyor belt, at least one proximity sensor;
d) plurality of roller separator units to segregate diodes, each of the roller separator unit comprising at least one roller separator and at least one hopper;
e) at least one magnetic sorter contiguous to the roller separator units to segregate magnetic components; and
f) at least one functionality check section contiguous to the at least one hopper of the roller separation units comprising, at least one diode testing device, at least one scrutiny area, and at least one means to move the diodes from the hopper towards the scrutiny area;

wherein, the conveyor system senses the load and starts transferring the components towards the roller separator units; the roller separator unit segregates and shifts the diodes to be checked into at least one hopper respective to the roller separator unit; and the functionality check section receives the diodes from at least one hopper to perform at least one functionality test of the components via said at least one diode testing device.
We claim:

1. An automatic component segregator for segregating electronic waste components comprising:
   a) a frame;
   b) at least one feeder to receive the components to be segregated;
   c) at least one conveyor system to move the components away from the feeder, the system comprising motor driven conveyor belt, at least one proximity sensor;
   d) plurality of roller separator units to segregate diodes, each of the roller separator unit comprising at least one roller separator and at least one hopper;
   e) at least one magnetic sorter contiguous to the roller separator units to segregate magnetic components; and
   f) at least one functionality check section contiguous to the at least one hopper of the roller separation units comprising, at least one diode testing device, at least one scrutiny area, and at least one means to move the diodes from the hopper towards the scrutiny area;

wherein,

the conveyor system is triggered on as soon as the conveyor belt receives the components from said feeder thus conveying the components towards the roller separator units;

the roller separator units are placed at an adjustable height above the conveyor belt such that the conveyor belt runs just beneath the separator;

the roller separator unit segregates and shifts the size segregated diodes to be checked into at least one hopper respective to the roller separator unit;
the functionality check section receives the diodes from at least one hopper to perform at least one functionality test of the components via said at least one diode testing device; and

the segregator is controlled by programmable logic controller.

2. The automatic component segregator as claimed in claim 1, wherein the functionality tests can be carried in either manual or automatic mode or both.

3. The automatic component segregator as claimed in claim 1, wherein the conveyor system further comprises an imaging module to detect presence of components on the conveyor belt.

4. An automatic component segregator for segregating electronic waste components comprising:
   a) a frame;
   b) at least one feeder to receive the components to be segregated;
   c) at least one conveyor system to move the components away from the feeder, the system comprising motor driven conveyor belt, at least one proximity sensor;
   d) at least one roller separator unit to segregate diodes according to their respective sizes, each of the unit comprising at least one roller separator and at least one hopper;
   e) at least one magnetic sorter contiguous to the roller separator units to segregate magnetic components; and
   f) at least one functionality check section contiguous to the at least one hopper of the roller separation units comprising, at least one diode testing device, at least one scrutiny area, and at least one means to move the diodes from the hopper towards the scrutiny area;
wherein,

the conveyor system is triggered on as soon as the conveyor belt receives the components from said feeder thus conveying the components towards the roller separator units;

the roller separator units are placed at an adjustable height above the conveyor belt such that the conveyor belt runs just beneath the separator;

the roller separator unit segregates and shifts the size segregated diodes to be checked into at least one hopper respective to the roller separator unit;

the functionality check section receives the diodes from at least one hopper to perform at least one functionality test of the components via said at least one diode testing device; and

the segregator is controlled by programmable logic controller.

5. The automatic component segregator as claimed in claim 4, wherein the functionality tests can be carried in either manual or automatic mode or both.

6. The automatic component segregator as claimed in claim 4, wherein the conveyor system further comprises an imaging module to detect presence of components on the conveyor belt.
Fig. 1
Fig. 3

Fig. 4
PLC System Controlled

1. CRM
   Roller Motor On/Off
   Time

2. Magnetic Conveyor Motor On/Off

3. Sieving Motor On/Off

HMI with Touch Control

Fig. 5
Diode

Physical Test
  No
  Yes

Connectivity Test
  No → Mechanical Recycling
  Yes → Separation

Separation
  No → Cleaning

Cleaning

Packing

Fig. 6
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
B07B13/00, B03C1/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B07C, B07B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic database consulted during the international search (name of database and, where practicable, search terms used)
Patseen, IPO Internal Database

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
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<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
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<td>US7210581 B2, MICRON TECHNOLOGY, INC., 1 May 2007</td>
<td>1-6</td>
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<td>(01/05/2007) (column 6, line 41) - (column 7, line 24), FIG. 6</td>
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<td>X</td>
<td>US6568612 B1, HITACHI, LTD., 27 May 2003</td>
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☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

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