Remote Monitoring and Sorting System for Waste Material Management Using RFID

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Abstract— **Plastics and electronic materials are widely used non-biodegradable materials which have to be recycled economically and efficiently. For efficient recycling of plastics and electronic different types of polymer and electronic materials have to be identified and segregated. Economic aspects mandate that the plastic be identified and sorted instantaneously. In this work the radio frequency identification (RFID) has been used for the instantaneous and on-line identification of consumer plastics and electronic wastes. This system enables identification of the waste material. To realize the above, a low cost embedded system, capable of automating the process of plastic and E-waste sorting method has been developed. Further, a wireless interface, capable of controlling the RFID reader remotely has been implemented to safeguard personnel from the unhygienic environments prevalent in plastic recycling plants. Though many methods are available for sorting the plastic and electronic waste materials they are very costly and expensive. Here the system is implemented by using the RFID tags which are low expensive can store vital information about the waste material. The quantity of plastic and electronic waste material found is transferred to the remote monitoring personal computer by using wireless zigbee interface.**

Index terms—**RFID, Electronic waste, Recycling, Waste management, RFID Tags.**

I. INTRODUCTION

Plastics are organic polymers[1] made from synthetic or semi-synthetic materials that can be molded and reshaped under pressure or heat, While in case of electronic waste material it is made up of ferrous, steel, semiconductors, aluminum and so on. They have found applicability in a wide and an ever expanding range of products, from common consumables like textiles, bottles, carry-bags, electronic enclosures, electronic equipments to special items like aerospace moldings, computer hardware, mobile hardware because of their durability, low cost and ease of production. In a 2011 report, "Ghana e-waste country assessment". Found that of 215,000 tons of electronics imported to Ghana, 30% were brand new and 70% were used. Of the used product, the study concluded that 15% was not reused and was scrapped or discarded. This claims that 80% of the imports into Ghana were being burned in primitive conditions.

Waste sorting methods:-

Separation technologies waste disposal companies dealing with the sorting of materials will commonly use one or more of these five methods trammel separators/drum screens, eddy current ,electromagnetic way of dividing ferrous and non-ferrous metals in relation to these traditional methods[2], the RFID based approach developed in this innovation offers multitude of advantages. The system has been demonstrated to be robust, accurate, can handle vast quantities of plastic (about 4 tones of plastic per instrument per shift) and sort them quickly (up to 4 plastic items per second) and electronic waste [3].while traditional plastic sorting are apart from manual sorting several separation technologies, like gravity methods, electrostatic separation, froth floatation have been tried and tested without much success.

II.LITERATURE SURVEY

- ✓ Electronic components such as CRT have lead and cadmium which are highly toxic in nature and should be identified and separated.
- ✓ Survey conducted in April 2013 found that 40 million metric tons of electronic wastes are produced globally each year which is extremely dangerous if not processed. About 9 million of this waste remains unprocessed.
- ✓ Combustion from burning e-waste creates fine particulate matter, which is linked to pulmonary and cardiovascular disease.
- ✓ Some plastic materials release harmful chemicals into the surrounding environment which can mix with underground water causing dangerous problems that drink this polluted water.
- ✓ Plastic and electronic waste material is also buried in the land which can make land useless.
- ✓ Nurdle is also poured into the ocean which is also hazardous to habitat in ocean because nurdle contains the toxic chemicals like bisphenol and polystyrene. It also put the ocean mammal life in danger.

II.DESCRIPTION OF THE SYSTEM

A. System Overview

An independent, wireless, embedded hardware[4] based interface for classifying any varieties of plastic and e-waste with the help of RFID reader and RFID tags [5]attached to each material to be sorted by an automatic sorting system has been developed. The RFID is considered to be attached to each type of material during manufacturing only to resolve the problem of sorting during the disposal stage of the product. Computational modules [6] ported on the embedded system successfully interpret and processes the information obtained from the RFID reader and determine the chemical nature of the plastic [7]. Based on the command signal, electro-pneumatic actuators [8] are activated to eject classified plastics into their respective bins. The important point here is that waste material is having the RFID tag which contents the all information about the product to be coded during manufacturing in the passive tag placed as there are a variety of the tags available to be attached with the material.

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Fig. 1 Block Diagram of the system

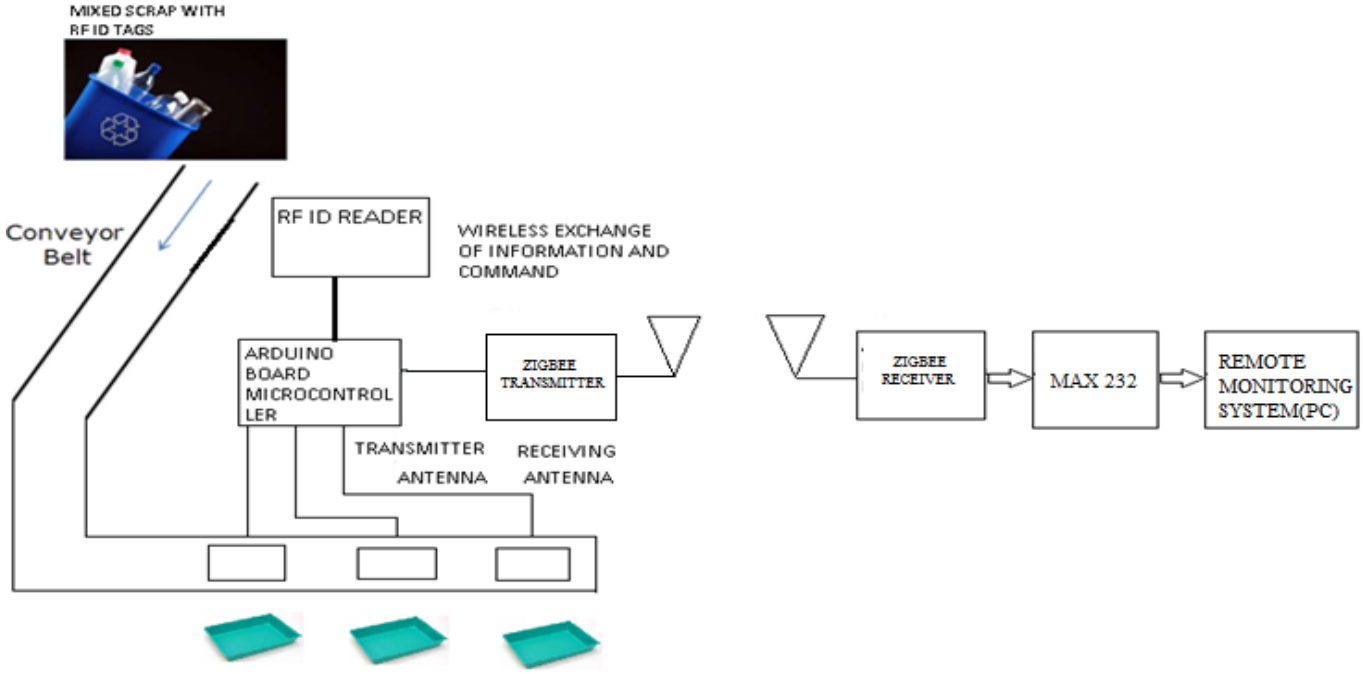

Fig .1 system block diagram

Commands are exchanged wirelessly between the RFID tags and RFID reader as shown in Fig.1.Whenever the objects moves by the motion of conveyer belt it comes in electromagnetic energy[9] emitted by the RFID reader which is in stationary with respect to the RFID tag. First of all RFID gains energy by using charge coupled devices which provide power to the RFID tag. Once charged or energized by the RFID reader it sends the information to the reader. Reader collects the information from the each waste material and sends this information to the arduino board used for processing. Zigbee receiver receives the data from transmitter wirelessly this will be transmitted to the remote monitoring system using the serial communication terminal [10].Later this data is saved in the Microsoft excel for storage and processing.

B.RFID tag and reader

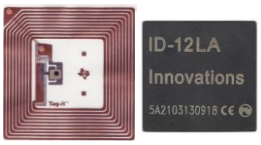

Fig.2 (a)RFID tag Fig. 2 (b) RFID reader IC

Radio-frequency identification system uses tags, or labels attached to the objects to be identified. Two-way radio transmitter-receivers called interrogators or readers send a signal to the tag and read its response as shown in Fig. 2(a) and 2(b). RFID tags can be passive, active or battery-assisted passive. An active tag has an on-board battery and periodically transmits its id signal. A battery-assisted passive (bap) has a small battery onboard and is activated when in the presence of an RFID reader. A passive tag is cheaper and smaller because it has no battery. However, to start operation of passive tags, they must be illuminated with a power level roughly three magnitudes stronger than for signal transmission. That makes a difference in interference and in exposure to radiation. Tags may either be read-only, having a factory-assigned serial number that is used as a key into a database, or may be read/write, where object-specific data can be written into the tag by the system user.

C. Principle involved

Each waste material will have a identical types of RFID tags that stores the information about the object along with which travels on conveyer belt. So whenever waste comes near the RFID reader it sends the vital information to the RFID reader. Commands and information are exchanged between the RFID reader and RFID tags. This information is used to drop the each waste material in their respective beans. Later this information is conveyed to the arduino microcontroller for further processing. After interpreting the data received from the RFID reader it will be forwarded to remote master embedded system wirelessly. The zigbee receiver [11] is interfaced with the personal computer which stores the information.

D. Components of the system

- ✓ RFID tags to store the information about individual abject
- ✓ RFID reader for collecting the information from all RFID tags,
- ✓ An embedded system to collect digital data from the arduino[12] board and perform necessary mathematical computations to identify nature of polymer,
- ✓ A wireless interface for remote monitoring, data collection, information management and data storage.
- ✓ A conveyor belt assembly for on-line capture of spectral signature of plastic materials that are to be sorted,

E. Operation of the system

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- ✓ The consumer/domestic waste polymer and e-waste samples move on a fixed speed conveyor.
- ✓ The samples are identified by using the RFID tags.
- ✓ RFID reader collects the information for sorting from tags.
- ✓ The embedded system collects the reader data and performs pattern recognition of the plastic material and e-waste.
- ✓ Uses decision supporting system for classification jet nozzles are activated based on the command signal to eject classified plastics into their respective bins.
- ✓ Through a wireless interface the information is relayed to a remote monitoring system.
- ✓ The data base is updated for all the classified consumer polymers and e-waste.

F. Computing system

i) Arduino board

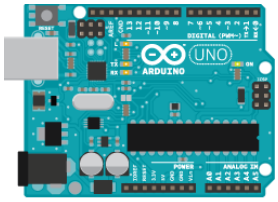

Fig.3Arduino microcontroller board

Features of Arduino Yun

- ✓ Microcontroller - atmega328
- ✓ Digital i/o pins-14
- ✓ Analog input pins -6
- ✓ Flash memory-32 kb (atmega328) of which 0.5 kb used by boot loader
- ✓ Sram-2 kb (atmega328)
- ✓ Eeprom-1 kb (atmega328)
- ✓ Clock speed-16 MHz

Computational modules that acquire the data from RFID reader and successfully interpret and processes the information to determine the type of the plastic and e-waste have been ported on an arduino atmega based embedded system has been shown in Fig.3. Arduino is an open-source single-board microcontroller and a successor to the open-source wiring platform. The hardware consists of a simple open hardware design for the arduino Yun board with an Atmel atmega328 microcontroller and on-board input/output support. The software consists of a standard programming language compiler and a boot loader that runs on the board. Arduino hardware is programmed using a wiring-based language (syntax and libraries), similar to c++ with a few simplifications and modifications, and a processing-based integrated development environment.

Arduino Yun can sense the environment by receiving input from a variety of sensors and can affect its surroundings by controlling lights, motors, and other actuators. The microcontroller on the board is programmed using the arduino programming language and the arduino development environment. The development environment here used is Arduino 1.5.3 supported on windows platform. The developed program can be compiled, tested and can be uploaded to the microcontroller board by universal bus (USB). The arduino integrated development environment (IDE)[13] is a cross-platform application written in java. It includes a code editor with features such as syntax highlighting, brace matching, and automatic indentation, and is also capable of compiling and uploading programs to the board with a single click.

ii) Wireless module

Fig.4 Zigbee module

In order to control and monitor the system remotely, Zigbee RF modules which follow the IEEE 802.15.4 protocol [14] , have been used . Zigbee RF modules are embedded solutions providing wireless end-point connectivity to devices. These modules use the IEEE 802.15.4 networking protocol for fast point-to-multipoint or peer-to-peer networking is shown in Fig.4. They are designed for high-throughput applications requiring low latency and predictable communication timing. Zigbee modules are ideal for low-power, low-cost applications. These modules are easy-to-use, share a common footprint, and are fully interoperable with other Zigbee products utilizing the same technology. Industrial, scientific and medical physical range10 to 20 meters (approx.) Zigbee specification for a suite of high-level communication protocols used to create personal area networks built from small, low-power digital radios. Zigbee is based on an IEEE 802.15 standard.

III. REMOTE MONITORING SYSTEM

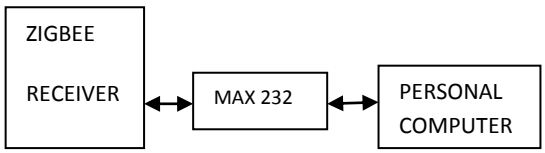

Fig.5 Remote system

As shown in Fig.5 the remote monitoring system consists of Zigbee receiver which receives the data from the transmitting side Zigbee module. This data from Zigbee receiver is further sent to the personal computer which is located at the remote location by using a interfacing hardware that is MAX 232. The remote personal computer is capable of receiving the data from the transmitting embedded system as well as to control over by using Zigbee modules.

A. Arduino 1.5.3 Development Software Program Screenshots

Arduino 1.5.3 software development package available for programming using Microsoft windows7.arduino 1.5.3 has various features like serial monitor, which can be used to observe the data being sent to the arduino Yun board while downloading into the microcontroller board. It also has vast libraries like EPROM, USB Host, Wi-Fi, and Wire which eases the communication to other hardware devices. Various screenshots are taken and shown in following figures Fig. 6, Fig. 7, Fig. 8.

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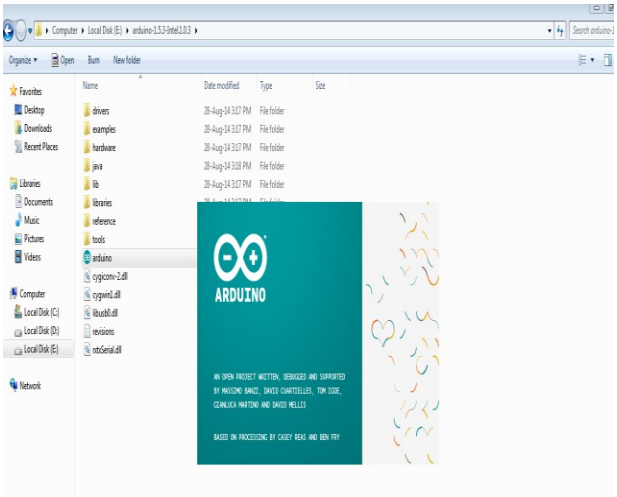

Fig.6 Arduino software development package

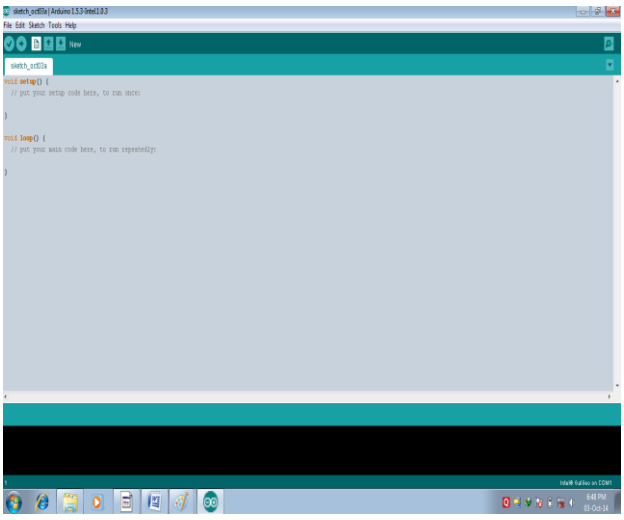

Fig.7 Arduino 1.5.3 software programming

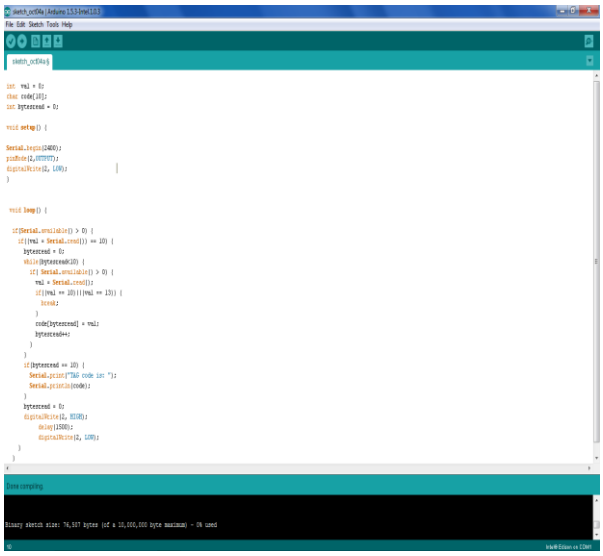

Fig.8 Arduino developed program

B. Data Received On Remote Monitoring System Using Zigbee Module

The data is received from zigbee via max 232 interface available for serial communication to personal computer. Whatever the data received is either printed on paper or it can be copied to text file by using commands available in hyper terminal in Windows XP or earlier. The later operating systems can use the free software program available like hyper terminal from internet. The information management is done using Microsoft excel is shown in Table1.

TYPE OF PLASTIC WASTE FOUND	QUANTITY
PVC	955
Polythene	1000
Polypropylene	857
Polycarbonate	954
Bakelite	5852
Epoxy resin	9595
Melamine	2264

TYPE OF E- WASTE FOUND	QUANTITY
Cathode ray tubes	885
video cameras	995
TVs	7744
Chips	8884
keyboards	9911
printers	7418
Computer wires	3361

Table. 1

C. Key Features And Benefits of The System

- ✓ Automated, low cost device which can sort any kind of material which has RFID tag through identification.
- ✓ Smart and fast system capable of sorting up to 4 materials per second.
- ✓ System can handle bulk input (target specification is 4 tons of material per shift).
- ✓ Classification of plastics and electronic waste material is done to a high degree of accuracy.
- ✓ Robust and indigenously integrated system capable of handling the varieties of Indian environmental conditions.
- ✓ Sorting of plastics and e-waste through non-destructive methods for efficient recycling (wealth from waste).
- ✓ Provision of wireless interface for remote, safe handling and monitoring of the system.

IV. CONCLUSION

In this paper we presented our work on developing an affordable and efficient method that can sort different categories of plastics and e-waste quickly and accurately. The innovation which applies radio frequency identification for on-line sorting of consumer waste groups can satisfy a very important requirement of an efficient waste management system. Not only is the system robust, it is also accurate , can handle vast quantities of plastic and e-waste (about 4 tons of waste per instrument per shift) and sort them quickly).Further, a wireless interface has been provided to control the system remotely and keep the operating personnel away from unhygienic and hazardous environments.

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