E-Waste Management By Mean of Semi-Automatic PCB Dismantling Machine Using PLC And SCADA of Indigenous Nature

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Abstract- *Almost half the e-wastes of India are dumped as landfills while the rest are exported to Asia and Africa. Out of total E-Waste volume in India, Television - 68% , Desktop, Server -27%, Imports -2% and Mobile -15%. There are 10 states that contribute to 70% of the total E-Waste generated in the country. 65 cities generate more than 60% of the total E-Waste in India. To overcome this, we design an efficient-waste management by means of Semi automatic PCB dismantling Machine using PLC and SCADA of indigenous nature. Mechanical Recycling (Dismantling of Metals and non-metals)is used to recycle the e-waste in a proper manner if the metal disposal is segregated separately. This metal segregation can be done by detecting the metals in the waste that is coming in through any source (PCB). The conveyor based system which separates the metal from non-metals. This system will separate the metal using the Programmable Logic Controllers (PLC) and a simple conveyor system will helps to segregate the metals and the real time data monitoring and controlling is done with the help of SCADA.*

Keywords- PLC, SCADA, PCB, Metal Sensor.

I. INTRODUCTION

1.1 E-WASTE MANAGEMENT

Automatic PCB Dismantling Machine can remove the Tin and circuit components from the scrap motherboards automatically.The perfect separation of lots of electronic components and printed circuit board (copper clad laminate), which all can be reused separately. The circuit board after processing can be recycled by physical methods PCB recycling machine to get copper, fibre, resin powder. Electronic components can be recycled by chemical methods through the gold recovery equipment to get pure gold and other precious metals. Electronic components automatic dismantling machines apply to all circuit board: Scrap motherboard, circuit board, scrap circuit boards, TV motherboard, computer motherboard, cell phone mother board….etc

1.1.1 E-waste Management In China

China is one of the largest manufacturers and consumers of electronic products, thus consequently generating a large amount of e-wastes, while the processes of treatment and recycling of e-wastes has resulted in severe adverse environmental and human health impacts in China. Hence, e-waste management in China has aroused widespread concern around the world. In recent years, central and local governments have made great efforts to improve e-waste management in China. New regulations and enterprise cooperation have been encouraged. Considering these developments, an overview is necessary to analyze the current state as well as new possible solutions andchallenges regarding e-waste management in China. This study shows that the amount of e-wastes collected and dismantled and the growth rate of five major electronic equipment types from 2000 to 2012 increased sharply. Barriers and suggested solutions related to China’s e-wastes are identified and discussed, followed by policy implications towards improving the overall eco-efficiency of e-wastes.

1.1.2E-waste Management In Europe

Some European countries implemented laws prohibiting the disposal of electronic waste in landfills in the 1990s. The European Union has implemented several directives and regulations that place the responsibility for "recovery, reuse and recycling" on the manufacturer. The Waste Electrical and Electronic Equipment Directive (WEEE Directive), as it is often referred to, has now been transposed in national laws in all member countries of the European Union. It was designed to make equipment manufacturers financially or physically responsible for their equipment at the end of its life, under a policy known as Extended producer responsibility (EPR). "Users of electrical and electronic equipment from private households should have the possibility of returning WEEE at least free of charge", and manufacturers must dispose of it in an environmentally friendly manner, by ecological disposal, reuse, or refurbishment. EPR is seen as a useful policy as it internalizes the end-of-life costs and provided a competitive incentive for companies to design equipment with fewer costs and liabilities when it reached its end of life. However, the application of the WEEE Directive has been criticized for implementing the EPR concept in a collective manner, and thereby losing the competitive incentive of individual manufacturers to be rewarded for their green design. Since August 13, 2005, electronics manufacturers have become financially responsible for compliance to the WEEE Directive. Under the directive, each country recycles at least 4 kg of electronic waste per capita per year. Furthermore, the Directive should "decrease e-waste and e-waste exports". In December 2008 a draft revision to the Directive proposed a market-based goal of 65%, which is 22 kg per capita in the case of the United Kingdom. A decision on the proposed revisions could result in a new WEEE Directive by 2012.

Fig: 1E-waste In Worldwide

1.2 Problem :

It is the toxic design of electronic equipment, since most electronics contain toxins such as arsenic, mercury and lead. The designs of today's electronics often fail to take recycling and protecting the environment.

1.3 Solution :

One of the solutions is for electronics manufacturers to stop using dangerous, hazardous materials when constructing electronics. Another helpful solution is for manufacturers to start taking responsibility for the full life cycle of their electronics, taking back electronics for safe recycling, disposal or re-use after they reach the end of the life cycle.

II. CONCEPTS

2.1 RECYCLING TECHNIQUES

Printed circuit boards (PCBs) is one of the most important component of electronic equipment. These PCBs encompass majority of the valuable metals and also most of the toxic components in the e-waste. PCB waste recycling includes three processes namely, pretreatment, physical recycling and chemical recycling. Starting with pretreatment stage, it includes disassembling of the reusable and toxic parts using shredding or separation and followed by physical recycling process. Finally material is recovered by chemical recycling process that includes gasification and pyrolysis. There are various traditional and some modern methods to recover the valuable metallic and non-metallic fractions from printed circuit boards (PCBs). The following section will consist of various physical and chemical recycling processes for recycling of metallic and nonmetallic fractions from waste PCBs. For establishment of E-waste Recycling & Treatment Facility shall be in line with the existing Guidelines/best practices/requirements in India for establishing and operating "Recycling and Treatment and Disposal Facilities" for hazardous wastes. This would enable to bring the non-formal sector in the main stream of the activity and facilitate to ensure environmental compliances. The proposed mechanism for the e-waste facility is an illustrative model and to develop such facilities.

2.2 E-WASTE

This word has caught up in the recent past only when someone studying the subject noted that our environment will be 3x more congested with e-waste by 2017. I did not save that tweet else I could have given you some reference. Even if it is not to be tripled, e-waste is growing in huge volumes. The reason why e-waste is increasing, is that technology is growing fast and in an attempt to get better devices, we casually get rid of old electronics – the best examples being that of smartphones. One may ask the relationship between old electronics and e-waste. I would say, e-waste is actually the old electronic goods that people simply give away to garbage trucks that are then dumped into landfill or similar sites. Electronics have a number of harmful elements that react with air and water to create problems of e-waste such as water, air and soil pollution as well as problems that affect human beings in the form of diseases. In the above example, we used old cells and batteries as an example. Most of the cheaper batteries are lead based and easily react with water (rain or moisture) to seep and mix with underground water along with polluting the soil and air where it was disposed by the garbage department. Thus, everything that falls into electronics' category, that you intend to throw away, is e-waste (electronic waste). This includes computers, laptops, tablets, smartphones and so on. There are proper methods to dispose off electronic items. They should be handled differently, but unfortunately, even the developed countries do not have strong policies to take care of such harmful, toxic garbage.

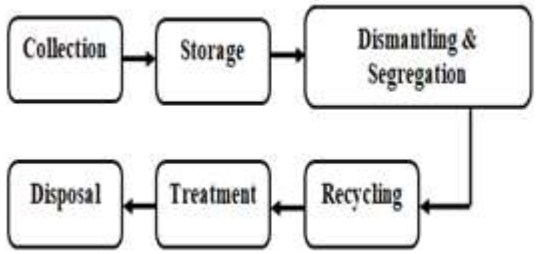

Fig: 2 Facility Operation Requirements

III. METHODOLOGY

3.1 PROPOSED SYSTEM

The proposed design consists of two sections :

- Manual Section
- Automatic Section

3.1.1 Manual Section

In this section, three processes like

1) Removal of cable
2) Removal of cable assemblies and wiring
3) Dismantling of Rear & Front panel done Manually

3.1.2 Automatic Section

In this proposed Section,the three processes like

1) Chemical recycling Separation of E-Components
2) Mech. Recycling (Acid bath)(Dismantling of Metals and non-metals)
3) Physical recycling(Separation of magnetic materials)

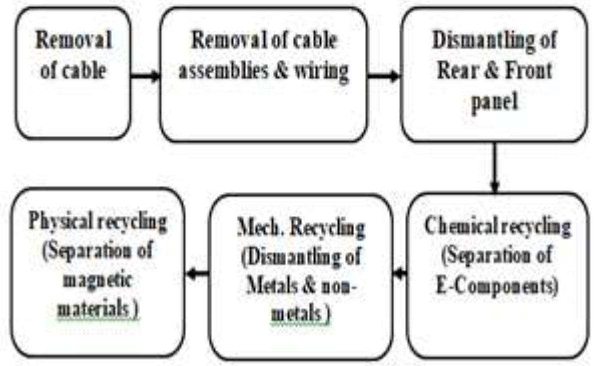

Fig: 3 Simple design of Proposed model

3.2 Flowdiagram for the proposed design:

The flow diagram of proposeddesign is shown in **Fig: 4**

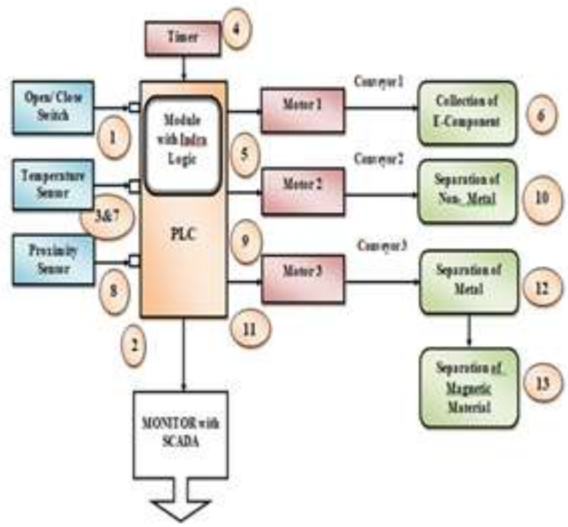

Fig: 4 Flow diagram of proposed design

3.3 PROPOSED PLC & SCADA BASED PCB DISMANTLING SECTION

3.3.1 Chemical recycling : Separation of E-Components

Dimethyl sulfoxide (DMSO) is a non-aqueous solvent that act both as a soft base (sulfoxide sulfur) as well as a hard base (sulfoxide oxygen). Various organic and inorganic chemicals are soluble in DMSO also it does not corrode metal. It has a high thermal stability at low temperatures and hence can be recycled many times. The waste PCBs are composed of glass fiber, bromine epoxy resins and metals. The separation process of waste PCB involved its treatment with DMSO in presence of nitrogen environment. The bromine epoxy resin concentration in DMSO was determined by measuring the amount of bisphenol-A, which is a component of bromine epoxy resin. Fig 3 shows the schematic diagram of the reactor for treating waste PCBs in DMSO solvent. The used DMSO was continuously stirred and vapored under the decompression. Further the regenerated DMSO and residues can be obtained by cooling down the vaporing substance to room temperature, from which the bromine epoxy resin in DMSO is separated out.

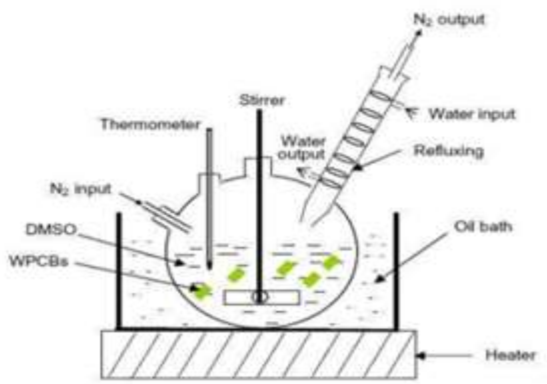

Fig: 5 Schematic diagram of the reactor for treating waste PCBs in DMSO solvent

3.3.2 Mech. Recycling : Dismantling of Metals and non-metals

It is a physical recycling method. In this method, the disassembled samples are first cut into specific sizes depending upon the milling needs. Then the pieces are put through a milling process resulting into fine pulverized PCB powder. This powder is subjected to eddy current separators that separates the metal by their eddy current characteristics. Finally the pulverized samples are subjected to density separation process. Depending upon the density and particle size, stratification can be seen in the liquid column

Fig:6Dismantling of PCBs

3.3.3 Physical recycling(Separation of magnetic materials)

The material composing of PCB is complicated and diverse.It contains many kinds of metal and nonmetal materials, including precious metal, heavy metal, alloy, resin, glass-fiber and halide flame retardant. The recycling process of waste PCB is complicated. There are three traditional recycling processes: hydrometallurgy, pyrometallurgy and physical process. Hydrometallurgy process is aiming at recycle precious metals in PCB, but it generates large quantity of waste acid liquid which needs to be carefully disposed, so the cost of hydrometallurgy is very high. For pyrometallurgy, a waste and poisonous gas produced during the recycling process is a big problem. Both hydrometallurgy and pyrometallurgy could not recovery all materials in PCBs. In this content, physical recycling process of waste PCBs has been conducted in an attempt to recovery all the materials in PCB in a high efficient and environment friendly way. With the steadily-decreasing contents of the precious metals used in electronics, the precious-metal-oriented recovery techniques, such as hydrometallurgy and pyrometallurgy, are facing great challenges. On the other hand, physical recycling process for waste PCBs is getting more and more attentions for its better environmental property and easier operability. When compared with hydrometallurgy and pyrometallurgy, besides precious metal, physical process could recover nonmetal materials in PCBs. Physical recycling process usually includes four stages: pretreatment, crushing, separation and ultimate refinement/reusing. The pretreatment stage includes classifying PCBs and dismantling reusable and toxic components of PCBs.

The PCBs samples we used in the recycling experiments are provided by ShenZhen ZhiZhuo Corp. and all the components on PCBs have been disassembled previously. The crushing stage is a key step of the physical process. The separation process and separation effect are subjected to crushing result, the granularity. In order to get better crushing result, the crushing stage usually falls into two sub-stages: coarse crushing and fine crushing (powder-making). The objective of separation stage is to separate the metal particles from nonmetal particles in PCB powders. The ultimate recycling efficiency is determined by separation process. After been separated, the metal particles could be sent to refining factory for further refinement and the nonmetal particles could be used as main or accessorial materials to make other new products.

Fig: 7 Physical recycling of PCBs

IV. SYSTEM DESCRIPTION

The system is represented by Implementation using PLC and Simulation using SCADA. For each recycling process, the constant time for four steps in mechanical recycling (I0 Switch is ON, Door Open (Q0= 0-20Seconds), After that, machine starts rotate (Q1=0-20 Seconds), Door open in downwards components are dropped into the conveyor (Q2= 0-20 Seconds), Metal sensor separate the metals (Q3=0-10 Seconds) with each steps as per our design and all the processes are visually viewed by SCADA

4.1 FLOW CHART

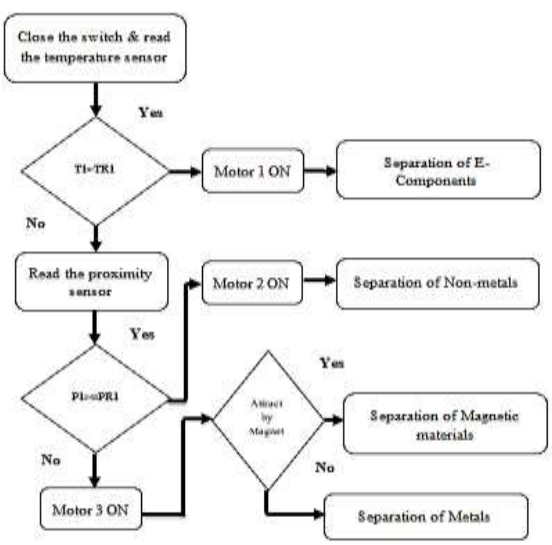

Fig: 8Flow Chart of E-waste management

4.2 SOFTWARE DESCRIPTION

4.2.1 PLC

A Programmable Logic Controller (PLC) is an industrial computerized control system that continuously monitors the state of input devices and makes decisions based upon a custom program to control the state of output devices. Almost any production line, machine function, or process can be greatly enhanced using this type of control system. However, the biggest benefit in using a PLC is the ability to change and replicate the operation or process while collecting and communicating vital information. Another advantage of a PLC system is that it is modular. That is, you can mix and match the types of Input and Output devices to best suit your application.

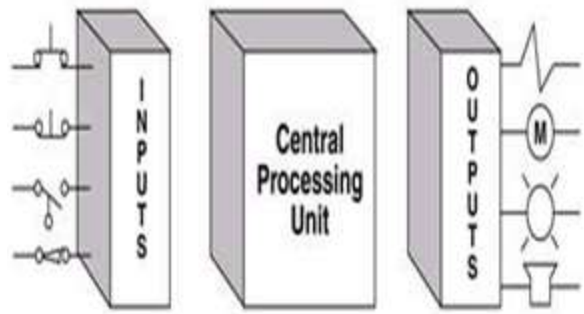

Fig: 9 Block Diagram of PLC

The Central Processing Unit, the CPU, contains an internal program that tells the PLC how to perform the following functions:

- Execute the Control Instructions contained in the User's Programs. This program is stored in "non-volatile" memory, meaning that the program will not be lost if power is removed.
- Communicate with other devices, which can include I/O Devices, Programming Devices, Networks, and even other PLCs.
- Perform Housekeeping activities such as Communications, Internal Diagnostics, etc.
- Controller (PLC) was introduced

PLC is a specialized computer used to control machines and process. It uses a programmable memory to store instructions and specific functions that include On/Off control, timing, counting, sequencing, arithmetic and data handling. Initially industries used relays to control the manufacturing processes. The relay control panels had to be regularly replaced, consumed lot of power and it was difficult to figure out the problems associated with it. To sort these issues Programmable Logic.

4.2.1.1ADVANTAGES OF PLC CONTROL SYSTEMS

- Flexible
- Faster response time
- Less and simple wiring
- Solid state no moving parts
- Modular design-easy to repair and expand
- Handles much more complicated systems
- Allows for diagnostics easy to troubleshoot

4.2.2SCADA

SCADA systems are used to monitor and control a plant or equipment in industries such as telecommunications, water and waste control, energy, oil and gas refining and transportation. It is widely used in industry for Supervisory Control and Data Acquisition of industrial processes, SCADA systems are now also penetrating the experimental physics laboratories for the controls of ancillary systems such as cooling, ventilation, power distribution, etc. More recently they were also applied for the controls of smaller size particle detectors such as the L3 muon detector and the NA48 experiment, to name just two examples at CERN. SCADA systems have made substantial progress over the recent years in terms of functionality, scalability, performance and openness such that they are an alternative to in house development even for very demanding and complex control systems as those of physics experiments. SCADA stands for Supervisory Control And Data Acquisition. As such, it is a purely software package that is positioned on top of hardware to which it is interfaced, in general via Programmable Logic Controllers (PLCs), or other commercial hardware modules.

SCADA systems are used not only in industrial processes: e.g. steel making, power generation (conventional and nuclear) and distribution, chemistry, but also in some experimental facilities such as nuclear fusion. The size of such plants range from a few 1000 to several 10 thousands input/output (I/O) channels.

However, SCADA systems evolve rapidly and are now penetrating the market of plants with a number of I/O channels of several 100 K: SCADA systems used to run on DOS, VMS and UNIX; in recent years all SCADA vendors have moved to NT and some also to Linux.

4.2.2.1 Potential benefits of SCADA

The benefits one can expect from adopting a SCADA system for the control of experimental physics facilities can be summarised as follows:

- The amount of specific development that needs to be performed by the end-user is limited, especially with suitable engineering.
- Reliability and robustness.
- Technical support and maintenance by the vendor.

V. RESULT AND DISCUSSION

The system is to separate the metals and non metals using a simple conveyor system by using the Programmable Logic Controllers (PLC).Here by separating the metal products, the waste disposal can be easily managed and also the metals from the waste can be easily separated.

SIMULATION OUTPUT

PLC:

STEP:1

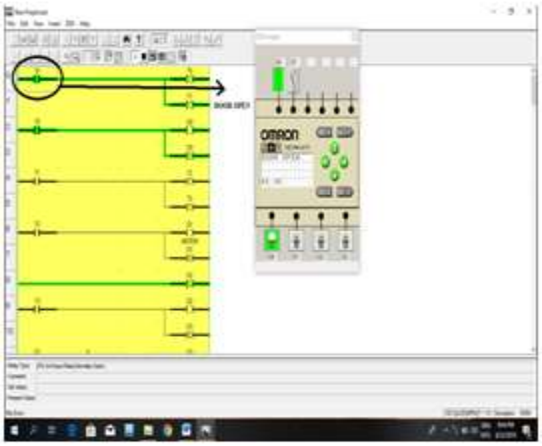

Fig:10 After door open PCB are put into the Roller in PLC

STEP:2

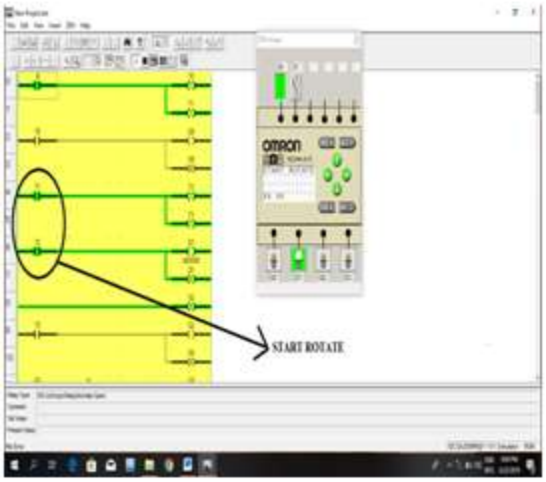

Fig:11 Roller Roating For 20seconds in PLC

STEP:3

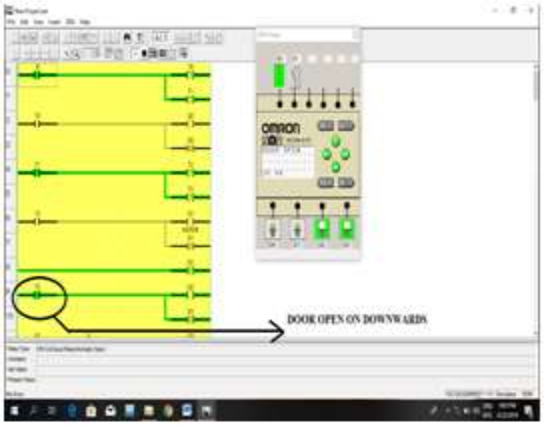

Fig:12 Door open downwards the equipments are send through theconveyor in PLC

STEP:4

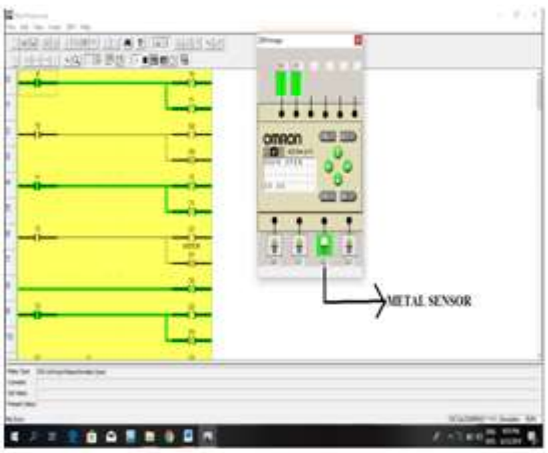

Fig:13 Metal Sensor Detects the Metal in PLC

SCADA:

STEP:1

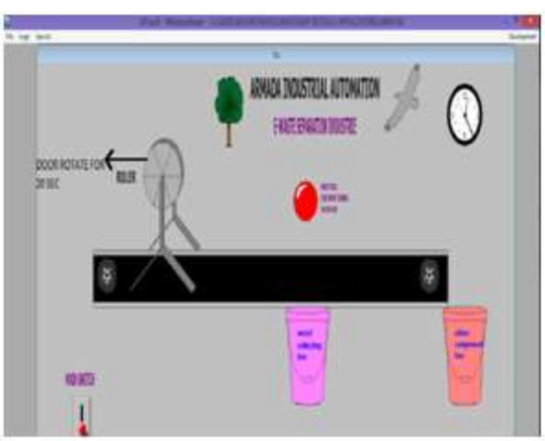

Fig:14 After door open PCB are put into the Roller in SCADA

STEP:2

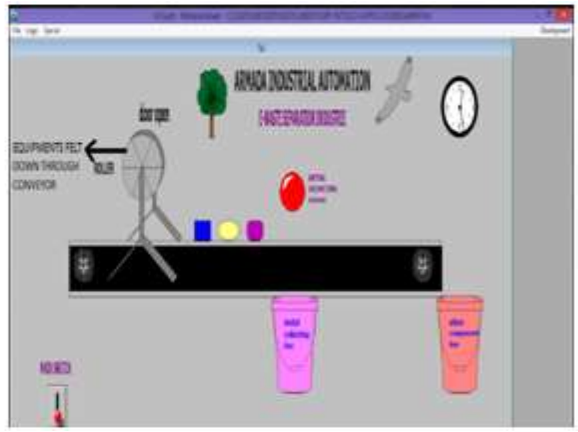

Fig:15 Roller Roating For 20seconds and Door open downwards the equipments are send through the conveyor in SCADA

STEP:3

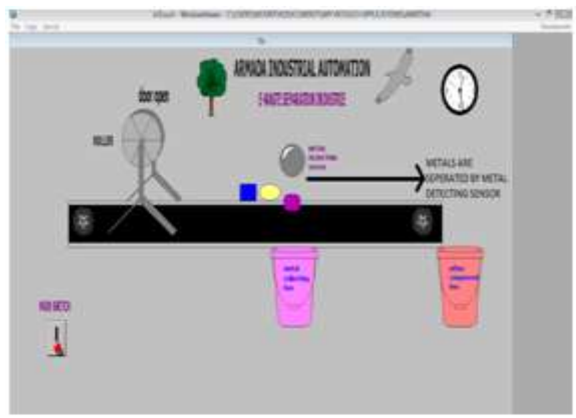

Fig:16Metal Sensor Detects the Metal in SCADA

STEP:4

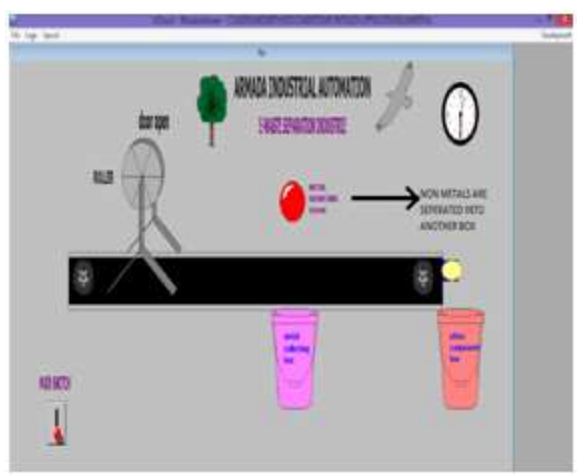

Fig:17 Non Metals are separated into another conveyor in SCADA

HARDWARE OUTPUT

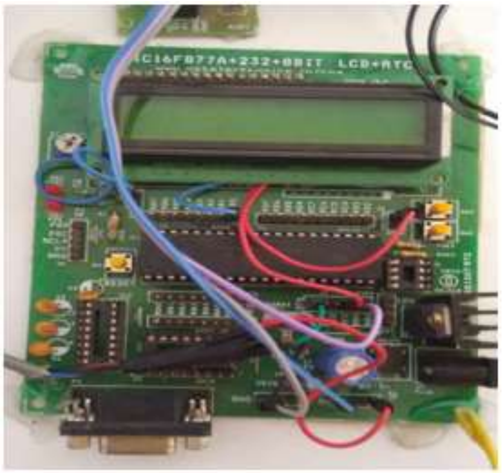

Fig:18 Hardware Kit

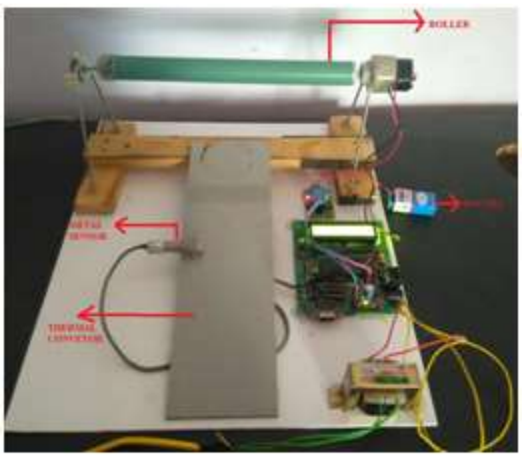

Fig:19 Hardware Module

VI. CONCLUSION AND FUTURE ENHANCEMENT

6.1 CONCLUSION

We designed and developed an E-waste management by means of Semi automatic PCB dismantling Machine Using PLC and SCADA of indigenous nature. Metal sensing and separation is one of the most important things in the waste management process.

6.2 FUTURE ENHANCEMENT

We can also do this for the non-metallic product like plastics, rubber, or any other products based on the requirements. This will be used to protect environment and human health

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