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Design and Fabrication of Solar Powered IOT-Based Water Surface Cleaning System

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ABSTRACT:Water pollution caused by floating waste is a significant environmental concern, necessitating innovative and sustainable solutions. This project presents the design and development of a solar-powered, real-time IoT based-controlled, 3D-printed robotic boat for efficient scrap collection in water bodies. The boat integrates renewable energy, automation, and additive manufacturing to create an eco-friendly, cost-effective solution for cleaning lakes, rivers, and coastal areas. The robotic boat is powered by solar panels, ensuring continuous operation with minimal reliance on external power sources. A real-time control system is implemented through an IoTbased application, allowing users to maneuver the boat remotely via Bluetooth or Wi-Fi communication. The boat's structure is 3D-printed, making it lightweight, customizable, and easy to manufacture. The Scrap Collecting Conveyor Belt is an automated system designed to efficiently gather and transport waste materials using IoT-based technology. This project incorporates a Kiwi-IoT board for remote monitoring and control, ensuring smart operation. The conveyor belt mechanism is powered by BO motors and driven by a 12V battery, providing reliable and continuous functionality. The structural framework is fabricated using 3D-printed materials, optimizing weight and durability. The system is mobilized using tiers, enabling smooth movement across different surfaces. The integration of the conveyor belt ensures systematic collection and transportation of scrap materials, making the process more efficient and reducing manual effort. With IoT-enabled features, the system can be monitored and controlled remotely, enhancing operational efficiency and adaptability in various industrial and environmental applications.

INTRODUCTION

While the world has progressed immensely, the issue of water pollution still persists. In earlier times, the garbage floating on water surfaces was cleaned by small boats or human beings who would risk their lives for environmental protection. However, such approaches not only involved high risks but also took a considerable amount of time. Moreover, the collected waste was often thrown on the river or lake banks, further polluting the environment. In such a scenario, it becomes crucial to find innovative solutions to clean the water and maintain its quality, benefiting not only people but also the surrounding flora and fauna. Marine and freshwater pollution pose serious environmental hazards, affecting aquatic life and water quality. Traditional manual waste collection methods are inefficient, labour-intensive, and unsafe. The proposed scrap collecting boat aims to automate waste removal, reducing human effort while improving efficiency.

1.1HISTORY OF RADIO-CONTROLLED SURFACE CLEANING BOATS:

The Early Concepts and Innovations The concept of RC (radio-controlled) surface cleaning boats emerged alongside the development of remote-controlled vehicles in the mid-20th century. Early RC boats were primarily built for recreational use, but hobbyists and engineers soon saw potential for practical applications. These initial designs were often simple, using nets or scoops to collect floating debris. Operated remotely, they proved useful in cleaning small bodies of water like garden ponds or swimming pools. While these early models lacked sophisticated systems, they marked the beginning of RC boats being adapted for environmental and maintenance purposes.

Technological Advancements in the 1980s and 1990s During the 1980s and 1990s, RC technology improved significantly, enhancing the capabilities of RC cleaning boats. Advances in battery technology, motor efficiency, and radio communication increased the range and control of these devices. As a result, RC boats became more practical for tasks beyond recreation. Many designs included larger collection baskets, better manoeuvrability, and improved water resistance. These improvements enabled RC boats to operate for extended periods, making them more effective for cleaning pools, ponds, and other confined spaces. While commercial availability remained limited, hobbyists continued experimenting with innovative cleaning mechanisms.

Rise of Environmental Awareness in the Early 2000s In the early 2000s, rising environmental concerns created a demand for better water-cleaning solutions. RC surface cleaning boats gained attention for their ability to manage floating waste in public parks, lakes, and canals. Environmental organizations and community groups began incorporating RC boats in small-scale cleanup efforts. These boats were often equipped with larger collection bins and stronger motors, allowing them to clear larger amounts of debris. Their compact design and remote-control capabilities made them ideal for navigating areas that were difficult for larger cleanup vessels to access.

Introduction of Specialized Cleaning Mechanisms By the mid-2000s, RC surface cleaning boats began incorporating more advanced cleaning mechanisms. Conveyor belts became a popular addition, allowing boats to continuously lift debris onto onboard storage trays. Some models introduced suction-based systems designed to collect smaller particles, such as algae or oil residue. Additionally, RC boats with robotic arms or claws emerged, enabling operators to retrieve larger waste objects. These developments improved the boats' efficiency, allowing them to handle a wider range of debris types in various water environments.

Commercial and Industrial Applications By the late 2010s, RC surface cleaning boats found increasing use in commercial and industrial sectors. Ports, marinas, and water treatment facilities began using these boats to manage floating debris efficiently. Equipped with larger storage compartments and improved navigation systems, these RC boats helped maintain clean waterways in busy areas. Their ability to operate in confined or hard-to-reach spaces made them ideal for locations where larger cleanup vessels could not manoeuvre easily. Commercial RC cleaning boats became valuable tools for reducing labour costs while improving water cleanliness.

Role in Environmental Cleanups RC surface cleaning boats have increasingly been used in organized environmental cleanup projects. Their compact size, manoeuvrability, and remote-control features make them ideal for navigating tight spaces like docks, marinas, and canals. Environmental groups have used RC boats to clear plastic waste, floating leaves, and other debris from water surfaces. While larger boats remain essential for major cleanup operations, RC cleaning boats offer a practical solution for maintaining smaller bodies of water efficiently. Their contribution to environmental conservation efforts continues to grow as organizations look for cost-effective and efficient cleanup methods.

1.2 SOLID WORKS SOFTWARE:

SolidWorks is a powerful computer-aided design (CAD) software developed by Dassault Systems. It is widely used by engineers, designers, and manufacturers for 3D modelling, simulation, and product development across various industries, including mechanical engineering, aerospace, automotive, and consumer products.

SolidWorks offers a parametric design approach, allowing users to create precise 3D models by defining dimensions and relationships between components. It also includes advanced tools for simulation, rendering, and manufacturing, making it a comprehensive solution for designing complex mechanical systems.

SolidWorks is an excellent choice for designing and modelling components for your project, especially for mechanical and engineering applications like CNC machines. Here's how you can use SolidWorks for your project

1. Modelling Components: You can use SolidWorks to create 3D models of the various components of your CNC machine, including the frame, rollers, motors, lead screws, limit switches, and other mechanical parts. SolidWorks offers powerful modelling tools that allow you to accurately represent the geometry and dimensions of each component.

2. Assembly Design: SolidWorks enables you to assemble the individual components into a complete 3D assembly of your CNC machine. You can use mate features to define relationships between parts, such as coincident, concentric, parallel, or tangent relationships, ensuring proper alignment and fitment of components within the assembly.

3. Motion Simulation: SolidWorks provides motion simulation capabilities that allow you to analyse the dynamic behaviour of your CNC machine's moving parts. You can simulate the motion of motors, actuators, and other components to evaluate their performance, detect interferences, and optimize design parameters for smoother operation.

4. Finite Element Analysis (FEA): If desired, SolidWorks offers FEA tools that enable you to analyse the structural integrity and mechanical performance of your CNC machine's components under various loading conditions. You can assess factors such as stress, deformation, and safety factors to ensure that the design meets performance requirements and safety standards.

5. Documentation and Drawings: SolidWorks allows you to create detailed engineering drawings and documentation for your CNC machine design. You can generate 2D drawings with dimensions, annotations, and other specifications necessary for manufacturing, assembly, and quality control purposes.

6. Integration with Other Software: SolidWorks offers compatibility with other software tools commonly used in engineering and manufacturing, such as CAM (Computer-Aided Manufacturing) software for generating toolpaths, CNC controller software for programming machine operations, and PLM (Product Lifecycle Management) systems for managing design data and revisions.

7. Collaboration and Communication: SolidWorks facilitates collaboration among team members by providing tools for sharing and reviewing designs, exchanging feedback, and tracking design changes. You can use features like 36 drawings to share 3D models with stakeholders who may not have access to SolidWorks.

1.3 CREALITY PRINT (SLICER) SOFTWARE:

CREALITY Print (Slicer) is a slicing tool for 3D printers. With this app, you can transform any 3D file into one that can be printed by a 3D printer. To do this, each model is transformed into a series of layers and instructions so that the printer can print the design layer by layer.

Although the most popular option on the market is Ulti maker Cura, CREALITY Print (Slicer) is very similar in functionality and appearance. In fact, if you have used either one, you'll be able to use the other without any difficulty. The advantage of using CREALITY Print (Slicer) over Cura is that Creality's program includes profiles for all of its printers, including those for the latest models being launched by the company. As for Ultimaker Cura, profiles take longer to arrive and need to be created by hand. With CREALITY Print (Slicer), you can get detailed information about your printer, and simply take it to Cura to use it.

With CREALITY Print (Slicer), you can rotate, resize or position one or more parts when 3D printing. You can choose the size of each layer, the printing speed, the use (or not) of supports, and make very precise adjustments to get the best possible prints. So if you're going to 3D print a design with a CREALITY Ender printer, downloading CREALITY Print (Slicer) is one of the best options to do so.

1.4 UTILIZATION OF 3D PRINTING TECHNOLOGIES:

3D printing, also known as additive manufacturing, is a process that creates three-dimensional objects from digital designs by adding material layer by layer. These machines, or 3D printers, use various technologies to deposit materials like plastics or metals, enabling the creation of complex shapes and prototypes.

Additive manufacturing creates a model by combining the layers of digital materials in a controlled manner. 3D printing devices are conceptual models due to limitations of AM technologies. However, material selection, surface quality and dimensional accuracy are compromised in such devices. For example, stereolithography (SLA) provides high accuracy and excellent surface quality. Furthermore, this technology has low mechanical strength, may be exposed to UV rays and provides curable thermoplastic materials. Additive manufacturing is becoming increasingly functional with the adoption of 3D printers. Technical improvements are being made in terms of efficiency and quality in 3D printers. However, there is a concern that education and skill development delay these technical improvement, and that technology cannot reach broader skills. 3D printers enable researchers to produce parts and concept models in a low cost, fast way.

The idea of using 3D printing technology for scrap-collecting boats emerged in the 2010s as advancements in additive manufacturing made it possible to create durable, lightweight, and customizable watercraft. Initially, most waste-collecting boats were conventionally built using metal and fiberglass, but researchers and environmentalists began exploring 3D printing as a cost-effective and sustainable alternative. Early experiments involved small-scale, remotely operated prototypes designed for collecting floating debris in lakes, rivers, and harbours.

One of the notable milestones came in 2018 when engineers started designing fully 3D-printed autonomous boats capable of waste collection. These boats, often made from recycled plastic, demonstrated the potential of closed-loop recycling—where waste plastic collected from waterways could be repurposed into new boat components. Universities and startups began experimenting with modular designs, allowing for easier repairs and upgrades. In 2019, MIT researchers introduced the Robot, an autonomous 3D-printed boat capable of self-navigating and collecting trash, marking a breakthrough in the field.

1.4.1 3D PRINTING TECHNIQUES:

• Here are some of the main types of 3D printing techniques:

1. Fused Deposition Modelling (FDM)

2. Stereolithography (SLA)

3. Selective Laser Sintering (SLS)

4. Binder Jetting

5. Directed Energy Deposition (DED)

6. Laminated Object Manufacturing (LOM)

7. Powder Bed Fusion (PBF)

8. Material Jetting

9. Digital Light Processing (DLP)

10. Continuous Liquid Interface Production (CLIP)

1.4.2 FUSED DEPOSITION MODELLING:

Fused deposition modelling (FDM) is one of the methods used in 3D printing. This technique is one of the manufacturing methods under the additive manufacturing engineering class, gaining popularity among researchers and industry to study and develop.

The basic concept of the FDM manufacturing process is simply melting the raw material and forming it to build new shapes. The material is a filament placed in a roll, pulled by a drive wheel, and then put into a temperature-controlled nozzle head and heated to semi liquid. The nozzle precisely extrudes and guides materials in an ultrathin layer after layer to produce layer-by-layer structural elements. This follows the contours of the layer specified by the program, usually CAD, which has been inserted into the FDM work system.

1.5 COMPONENTS USED

1.5.1 HARDWARE DETAILS:

1. KIWI-IOT V1 BOARD
2. BO MOTORS
3. 12V BATTERY
4. L293D MODULE
5. 3D PRINTED MATERIAL
6. ROCKER SWITCH
7. TIERS
8. CONVEYOR BELT
9. SOLAR PANEL

2.1 EXISTING SYSTEM:

Scrap collection and waste management in industries, construction sites, and recycling plants rely on manual labour and conventional conveyor systems. The existing systems have several limitations in terms of efficiency, automation, and adaptability.

Below are some key observations about the existing systems:

Manual Scrap Collection:

In most industries, scrap materials are collected manually, which is labour-intensive, time-consuming, and inefficient.
Workers are required to sort, lift, and transport waste materials, leading to increased physical effort and health risks.
The lack of automation results in inconsistent waste collection and improper segregation.

Fixed Conveyor Belt Systems:

Traditional conveyor belts are stationary and primarily used in factories, warehouses, and production lines.
These systems require permanent installation and cannot be easily relocated to different areas for scrap collection.
The absence of mobility makes it difficult to collect scrap from different locations.

Lack of IoT and Smart Monitoring:

Most conventional conveyor systems do not incorporate IoT-based technology, making remote monitoring and control impossible.
Maintenance and breakdown detection are performed manually, which can lead to unexpected failures and production downtime.
The absence of real-time data limits the efficiency of the system and increases operational costs.

Power and Energy Consumption Issues:

Many conveyor systems rely on grid power or large industrial motors, leading to high energy consumption.
Lack of battery-powered or energy-efficient alternatives makes them unsuitable for portable or remote applications.

Limited Use of Lightweight and Advanced Materials:

Traditional conveyor belts are constructed using heavy metallic structures, making them difficult to transport and modify.
3D-printed materials are not commonly used, which could otherwise reduce cost and weight while maintaining durability.

2.2 PROBLEM STATEMENT:

In many industries, scrap collection and waste management remain labour-intensive, inefficient, and costly due to the lack of automation and mobility in existing conveyor systems. Traditional scrap collection methods rely on manual labour or fixed conveyor belts, which are time-consuming, physically demanding, and prone to inconsistencies. Additionally, most conventional systems lack IoT-based monitoring and control, making them inefficient in tracking, managing, and optimizing waste collection processes.

2.3 PROPOSED SYSTEM:

The proposed system aims to provide a smart, efficient, and automated solution for scrap collection in industries such as manufacturing, recycling, and construction. By integrating IoT technology, automation, and mobility, this system enhances waste management efficiency, reduces operational costs, and promotes sustainability.

The conveyor belt is driven by BO motors, reducing the need for manual labour.
Kiwi-IoT board enables real-time monitoring and remote control of the system.
Unlike fixed conveyor belts, this system uses tiers (wheels) to move across different locations.
3D-printed materials ensure a strong yet lightweight design, making the system cost-effective and easy to transport.
Reduces industrial waste collection time, promotes sustainability, and improves workplace hygiene.

3.1 Block Diagram And Circuit Diagram :

3.1.1 Block Diagram:

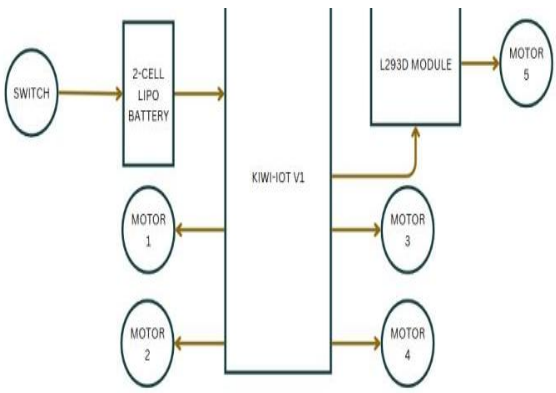

Figure 3.1 Block Diagram

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3.1.2 Working:

The diagram represents a Scrap Collecting Conveyor Belt system controlled by the KIWI-IOT V1, an IoT-based microcontroller. The system is powered by a 2-cell LiPo battery, which is activated through a switch. Once turned on, the battery supplies power to the KIWI-IOT V1, which serves as the central control unit for the motors. It directly controls Motors 1, 2, 3, and 4, which likely contribute to the movement of the conveyor belt.

Additionally, the system includes an L293D motor driver module, which is used to control Motor 5. The KIWI-IOT V1 sends signals to the L293D module, which then regulates the power and movement of Motor 5. This additional motor might be responsible for specific actions such as adjusting the conveyor mechanism or handling scrap collection more efficiently.

3.2Circuit Diagram:

3.2.1 Working:

The scrap collecting conveyor belt is designed to automate the collection, transportation, and disposal of scrap materials in industrial and waste management settings. It integrates key components such as the KIWI-IoT board, BO motors, a 12V battery, 3D-printed materials, tiers (wheels), and a conveyor belt to ensure efficient operation.

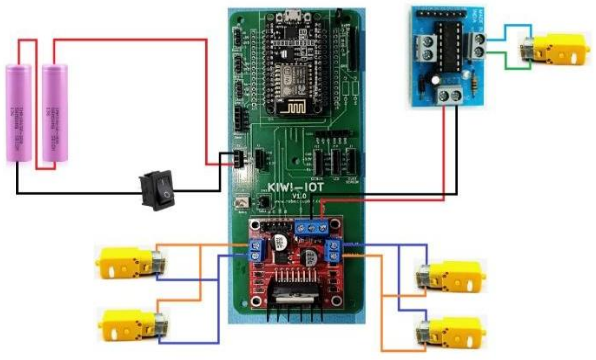

Figure 3.2 Circuit Diagram

1. Power Supply & Initialization:

The system is powered by a 12V battery, which supplies energy to the BO motors and KIWI-IoT board.

The KIWI-IoT board acts as the control unit, receiving inputs and sending commands to operate the conveyor belt

2. Mobility & Positioning:

The tiers (wheels) allow the conveyor belt to be moved to different locations where scrap materials are collected. If the system is automated, it can be remotely controlled or programmed to follow a specific path.

3. Scrap Collection Process:

The BO motors drive the conveyor belt, causing it to move continuously.
Scrap materials are loaded onto the belt manually or through automated means (such as robotic arms or hoppers).
The moving belt transports the scrap toward the collection bin or disposal area.

4. Smart Automation & Monitoring:

The KIWI-IoT board can be used for monitoring belt speed, motor performance, and scrap load detection.
If connected to an IoT system, the conveyor belt can send alerts about operational status, overload conditions, or maintenance needs.

5. Scrap Disposal or Segregation:

The scrap is transferred to a collection bin for further processing, such as sorting, recycling, or disposal.
If an automated sorting mechanism is integrated, the system can segregate different types of materials (e.g., metal, plastic, paper).

6. Stopping & Resetting:

The conveyor system automatically stops when the collection bin is full or when no more scrap is detected.The system can be reset to a new location for further scrap collection.

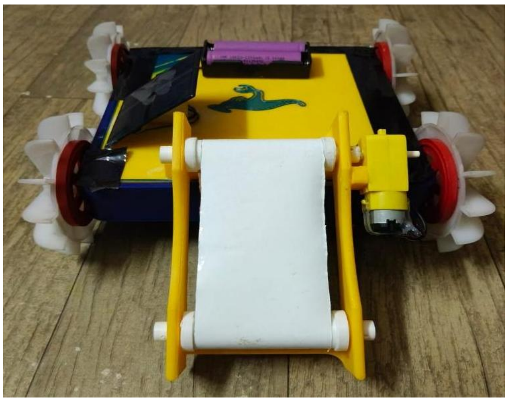

Figure 3.4 Side View Of The Project

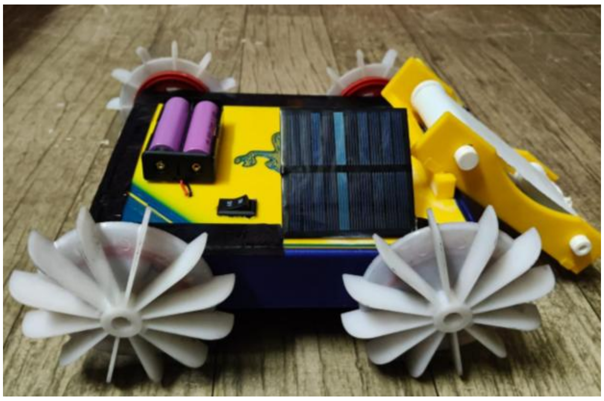

Figure 3.5 Out Look of The Project

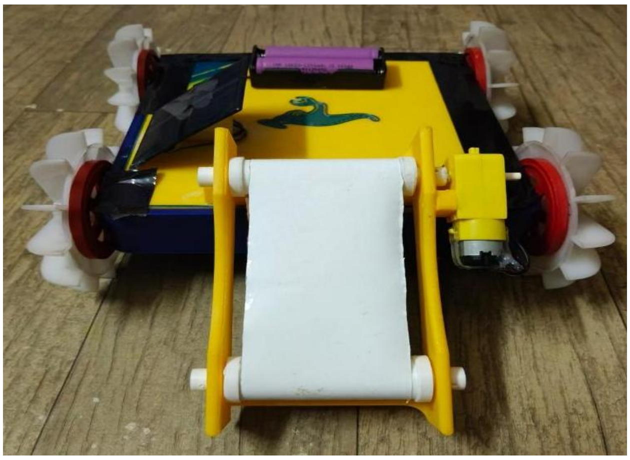

Figure 3.6 Side View Of The Project

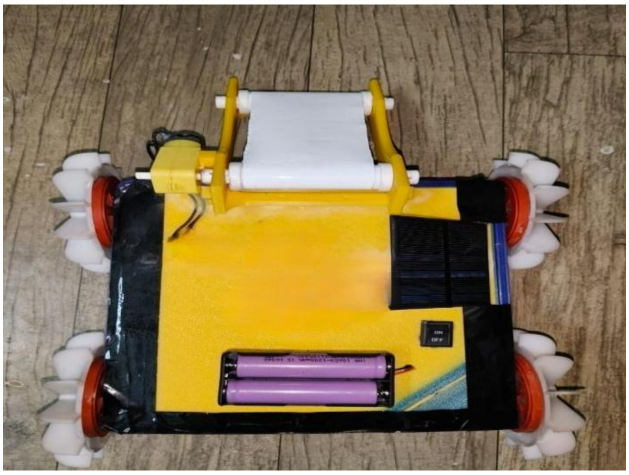

Figure 3.7 Top View Of The Project

4 RESULTS

4.1 CALCULATIONS:

Solar Panel Rated Power = 3.3V, 3.3W
BO Motor Rated Voltage = 12V, Rated Current = 0.3 AMH
DC battery Rated Voltage = 8V, Ampere hour = 1.3 AMH
Number of Batteries = 2
Solar Panel Efficiency = 18%

Dc Motor For Wheel:

BO Motor for wheel = 12V, 0.3 amp
Power of motor = 3.6 watts
Total power of Motor for 4 wheels = 4 × 3.6 = 14.4 watts

BO Motor For Conveyor Belt:

BO Motor for conveyor belt = 12V, 1.3 amp
Power required for conveyor belt = 12 × 1.3 amps = 15.6 watts

Total Power From Battery:

Total Power From Battery = Number Of Batteries × Volts × Current = 2 × 12 × 1.3 = 31.2 watts

Total Power From Motors:

Total Power From Motors = 14.4 + 15.6 = 30 watts

Total Power From Battery = Total Power From Motors:

31.2 watts ≈ 30 watts

Total Time Taken To Charge The Battery From Solar Panel:

Charge the battery from solar panel = 27 Watts × 0.18 = 4.86 watts

TOTAL POWER FROM BATTERY / 4.86 = 31.2 / 4.86 = 45 min. (approximately)

Operating hour per day = 45 min

4.2 FINAL OUTCOMES

The conveyor belt was able to move scrap materials smoothly from the collection point to the disposal unit.
The BO motors provided sufficient torque to drive the belt efficiently.
The KIWI-IoT board allowed remote monitoring, improving automation and system control.
The inclusion of tiers (wheels) enabled easy movement of the conveyor belt system to different locations.
The system was able to adjust speed and direction, making it flexible for various scrap collection environments.
The conveyor belt successfully collected and transported scrap materials such as metal, plastic, and paper waste.
The system was able to handle different material sizes and weights, proving its versatility.
Testing showed increased efficiency, reducing manual labour and improving scrap management.

5. CONCLUSION

The scrap collecting conveyor belt is an efficient and innovative solution for automating the collection, transportation, and disposal of scrap materials in industrial environments. By integrating KIWI-IoT board, BO motors, a 12V battery, 3D-printed materials, tiers (wheels), and a conveyor belt, the system successfully enhances waste management, reduces manual labour, and improves operational efficiency.

The results show that the system is portable, energy-efficient, and cost-effective, making it suitable for factories, warehouses, recycling plants, and other industrial waste management applications. The integration of IoT technology allows real-time monitoring, ensuring better control and maintenance.

In conclusion, the scrap collecting conveyor belt provides a sustainable, automated, and scalable solution for scrap collection, making industrial waste handling more efficient, safe, and environmentally friendly. With further advancements, the system can be improved by adding AI-based sorting mechanisms, solar-powered energy sources, and advanced automation features for even greater efficiency.

The Scrap Collecting Conveyor Belt is an innovative and automated solution designed to enhance industrial waste management by efficiently collecting, transporting, and disposing of scrap materials. Traditional scrap collection methods rely heavily on manual labor, which can be inefficient, costly, and hazardous. This system integrates KIWI-IoT technology, BO motors, a 12V battery, 3D-printed materials, wheels (tiers), and a conveyor belt to provide a more efficient, cost-effective, and safer alternative for waste handling in industries such as factories, warehouses, and recycling plants. By automating the process, the system minimizes human intervention, improves safety, and optimizes operational workflow.

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