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Design and Development of Smart Scrap Management System for a Manufacturing Organisation

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Abstract: *Scrap management is handled through manual processes in many manufacturing organizations leading to poor efficiencies. This paper discusses design, development, and deployment of a suitable scrap management system leveraging Industry 4.0 in a lean manner with traceability using ANPR technology and digital weighbridge setup aided by logistics trucks, digital handshake, and virtual stores in SAP. The complete processes are digitally photographed leaving behind a digital thread for future forensics.*

Keywords: Scrap management

I. INTRODUCTION

Manufacturing industries get to deal with scrap as an outcome of process daily and needs to be managed through Scrap management systems. They are essential in any manufacturing setup for managing scrap generated from manufacturing processes such as Production & Non-production materials, Obsolete and Non-moving materials, warranty scrap, hazardous waste, E-Waste, and Worn-out & damaged machinery parts.

In many industries, the data for scrap are handled manually through a manual process of collection, weighment& reconciliation leaving behind a trail of paperwork. Manual process has their inherent inefficiencies and scrap management is no exception.

Also, scrap accounting for both material rejections and process areas does not have visibility in total. Possibility of leakages in scrap sales and accounting are a few practical challenges encountered. Industry 4.0,integration of IOT devices are now more widely discussed at Enterprise levels and are also gainingpriority. They claim to ensure processes followed at every functional area and audit accounting made seamless across the chain of operations. Streamlining offline accounting processes and bring about common method of accounting which is manipulationproofed (right from generation of stock till revenue creation) are also observed.

Reconciliation of process scrap supposed to be generated and what is actually generated based on the norms and there by fine tune norms and work on the gaps identified are a potential area needing further study. Periodic audit of each step gets necessitated due to the challenges in the manual system.

Through this project, we have attempted to delve deeper into scrap management, and we redefine the same to turning waste into wealth and building a greener, more prosperous future for all.

II. METHODOLOGY

This study aims to digitalise scrap management as a process in manufacturing industries. Further research into this specialised area were conducted through a detailed review of literature:

III. LITERATURE REVIEW

[1] AbdKadir et. alpresents an autonomous alphabet and number inspection method based on optical character recognition (OCR) and digital image processing for Malaysian vehicle plate numbers. Utilizing LabVIEW software, an intelligent OCR Training Interface was designed as a library for the system. Subsequently, employed to evaluate

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various scenarios to verify that the suggested system is suitable for actual deployment. The suggested approach performs well for inspection and can identify the letters and numbers on car license plates, according to the results.

[2] Amar et. aldiscusses how Automatic Number Plate Recognition has become a necessary aspect of daily life. Due to the swift growth of automobiles and transportation networks, which renders human management and oversight impractical. Also explains how ANPR will shape industry in the future and how it might benefit society.

[5] Chenet. alexplains the distinctions between SAP's assembly, component, and operation scraps are first described in the study. After that, it looks at several approaches to managing these kinds of scrap, such as automated data collecting, human data entry, and interaction with production scheduling and inventory management. The advantages and disadvantages of each technique discussed, including enhanced production planning, lower inventory costs, and higher data accuracy.

[6] Bhavinet. alexplains the increased focus on significant research and development of algorithms in the field of intelligent transportation. Traffic control and traffic law enforcement now require a reliable, fast, accurate, and automated car plate recognition system with focus on ANPR. Further enhancing with developing neural network-trained collection of object attributes for enhanced OCR-based license plate recognition.

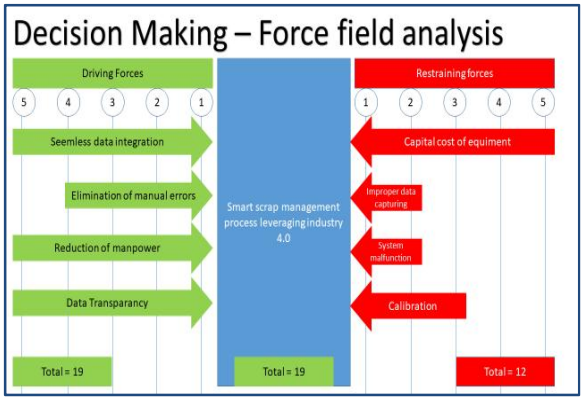
[7]Moustafa et.aldiscusses aspects of a number plate identification technique via segmentation, picture preprocessing and number recognition. With the use of this technology, license plates may be efficiently recognized from both day and night photographs. Because of its many useful applications, automatic number plate recognition (ANPR) systems are a component of intelligent transportation systems.

[9]Shreyas et.alargues Image processing technology serves as the foundation for the projected Automatic Number Plate Recognition (ANPR) System. The primary functions of the proposed system include monitoring traffic-related events on the road, such as identifying vehicles involved in infractions, such as speeding, and spotting lane violations at traffic signals. This makes it possible to track down any vehicle that violates a traffic law and provide the information to the appropriate authorities so they can take appropriate action. This helps to maintain a smooth flow of traffic and reduces the likelihood of accidents at traffic signals. The authorities can also utilize this technique to help identify any stolen vehicle.

Identification of Key factors:

Key factors influencing scrap management in production planning processes were identified from the literature review. These factors include yield uncertainty, demand uncertainty, rework, and machine breakdowns. Other factors, such as supplier selection and inventory management, were also considered.

Force field analysis is applied as a decision-making tool in evaluating the automation needed for scrap management.



From the force field analysis, we can conclude that the advantages outweigh the disadvantages. Therefore, the implementation of ANPR will not significantly impact the system. This conclusion is based on a careful evaluation of benefits such as seamless data integration, reduction of manpower, and enhanced data transparency, which outweigh potential concerns like privacy issues and initial costs. Additionally, ANPR has been successfully integrated into various systems worldwide, indicating its feasibility and positive outcomes in similar contexts.

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Technology Selection:

Pugh matrix was used for the identification of ANPR among the other available technologies like RFID, QR code/Bar code, LPR, CCTV Camera, and Biometric.

Criteria	Alternatives: Automatic Number Plate Recognition	RFID	Barcode/QR Code	License Plate Recognition	CCTV Camera	Biometric	Totals	Rank
Recognition Accuracy	+	+	+	0	–	+	2	5
Performance in Low Light Conditions	0	+	+	0	0	0	2	3
Robustness to Environmental Factors	+	–	–	–	0	0	-2	8
Sensitivity to Interference	+	–	–	+	0	0	0	6
Real-time Processing	+	+	+	0	+	–	4	1
Resistance to Spoofing/Manipulation	+	–	–	–	0	+	-2	8
Integration Complexity	–	–	+	0	0	–	-1	7
Scalability	+	+	+	–	+	0	3	2
Cost	0	0	+	0	+	–	2	3
Totals	5	0	3	-2	2	-1		
Rank	1	4	2	6	3	5		

The Pugh matrix analysis reveals that ANPR provides significantly more benefits compared to other available technologies. Its ability to perform in low light conditions and recognition accuracy makes ANPR the most suitable choice for our scenario. Implementing ANPR promises to streamline operations and thereby align perfectly.

Data Collection:

Data on scrap generation and management were collected from a manufacturing company. The data includes all kinds of scrap that is generated in the company, and it also consists of the root cause of the scrap.

In a manufacturing setting, diverse processes give rise to various forms of waste. The principal manufacturing processes encompass material abrasion and material aggregation.

Within manufacturing, three primary types of material removal processes exist:

1. Machining Processes:

This category encompasses traditional procedures such as turning, milling, and drilling, where a cutting tool is utilized to extract material from a workpiece.

-Turning involves the rotation of the workpiece while a cutting tool shapes it into cylindrical forms.

- Milling employs multiple rotating cutting edges to Mold the workpiece.

- Drilling creates holes in a workpiece utilizing a rotating drill bit.

Waste generated in machining processes includes chips, burrs, and dust.

2. Assembly Processes:

Assembly process involves assembly of multiple components into sub assemblies and sub assemblies into final assembly. During this transformation various input material which are received through safe logistics processes generate scrap material as below:

- Packaging material like carton boxes, plastic wraps
- Logistics aids like wooden pallets, bins
- Defective material supplied
- Assembly defects due to assembly process

Waste produced require to be disposed.

3. Non-Traditional Processes:

This category encompasses processes achieving material removal without conventional cutting tools.

- Electrochemical Machining (ECM) removes material through an electrochemical reaction.

-Electrical Discharge Machining (EDM) eliminates material through electrical discharges.

- Laser Cuttingdeploys a focused laser beam for cutting or engraving materials.

These broad classifications encompass specific techniques tailored to diverse manufacturing needs. The selection of a material removal process depends on factors such as material properties, desired tolerances, surface finish requirements, and overall production goals.

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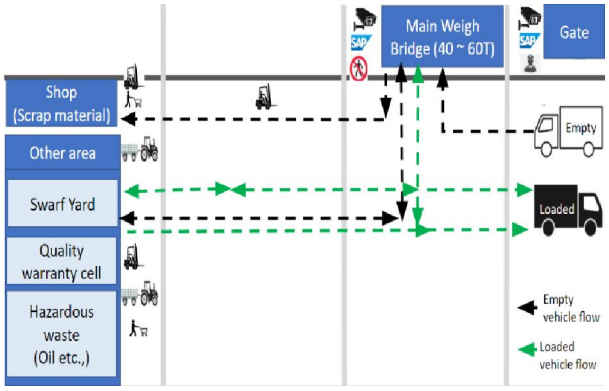
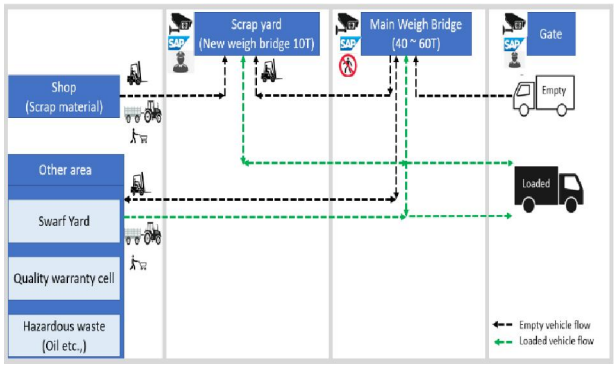
Development of Optimization of Existing Process:

Based on the data analysis, an optimization model was developed to minimize scrap generation and optimize production planning processes.



Existing Process

All the steps in the existing workflow are manual and require much human interaction. This may lead to several mistakes, improper processing of the data, and possible manipulation.



Modified Process

Scrap management team raises a request with vehicle registration number. After the vendor gets the information on this request, driver will report to plant gate with same vehicle number. Vehicle gets validated using ANPR camera and security can print gate pass only if it is valid vehicle. Boom barrier opens with digital display giving instruction to driver to GO. If any error, it will be notified to driver in the display.

Vehicle reports to weigh bridge for tare weight capturing and gets validated with ANPR camera and only if it is valid vehicle & driver gets down the vehicle, weight gets captured to SAP. Digital display gives the instructions to driver to get / get in / go based on the activity completion of each step.

Vehicle reports to scrap yard for picking material, gets validated using ANPR and allows vehicle inside scrap yard. Scrap material gets loaded and comes to exit gate of scrap yard for validation and image will be taken from top with loaded truck. After validation it allows vehicle to go out for next step. Vehicle will then report to weigh bridge for gross weight capturing with validation by ANPR camera and very -focal camera verification to identify human presence. After successful validation vehicle will be weight gets updated to SAP.

Weights captured in previous steps will be used for automated documentation in SAP. After final validation by finance, printed invoice & E Way will be handed over to Driver to proceed to next step. Driver will carry the documents and report vehicle to gate exit. At gate exit stage security will validate all the images and look at the total turnaround time and confirms for exit of vehicle. If the vehicle is valid and documentation completed, digital display will instruct driver

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to Go and vehicle will exit the plant. This cycle ensures controls at each stage and also requires very minimal physical printing. Traceability of every vehicle for its stage and images ensured at every step.

The components used in the solution as below:

Digital controllers for Weigh bridges – For Weight integration

ANPR (Automatic Number Plate Recognition) Cameras – Number plate validation

Veri focal cameras - Human identification

Boom barriers – Allowing valid vehicles

Central server - for API management

SAP - to store data and accounting

Weightec APIs – For data exchange between SAP & Devices

Internal APIs – For Storing and retrieving images

Implementation of Modified Process:

The modified smart processeswere implemented, new weighbridges that are required in the new process wereinstalled andscrap management system was implemented.

Evaluation of Result:

The scrap management system was evaluated based on its effectiveness in handling and disposition of scrap. The poke yoke of digital data transfers directly from the weighbridge to the SAP system based on ANPR confirmation was checked and found ok. Digital forensics of various photographs taken during the various process stages were checked and found satisfactory with time stamps. The weighment data posted in the virtual store were also validated for consistency and were found satisfactory.

Its seamless integration of digital data transfer and robust digital forensics capabilities ensure accurate recording and management of scrap throughout its lifecycle, enhancing efficiency and reliability in scrap handling and disposition.

It is concluded that it has more advantages as compared to the conventional processes.

IV. SUMMARY

Poor efficiency arise from the manual handling of scrap management. This article, "Design & Development of a Smart Scrap Management System," describes an all-encompassing plan that uses Industry 4.0 concepts to transform the treatment of waste resources. With the use of ANPR technology, a digital weighbridge configuration, logistics vehicles, digital handshakes, and SAP virtual shops, the system is deployed leanly and traceably.

The project entails a painstaking procedure for gathering, classifying, and arranging various waste products. All garbage produced from various sources is systematically collected, and then items are sorted using an advanced mechanism that classifies them according to their properties and planned uses. This guarantees the best possible downstream procedures for reuse, recycling, or safe disposal.

The efficient use of technology at different phases of the project is crucial. Accurate waste volume measurement is made possible by the weighbridge, which supports resource accounting and strategic decision-making. Truck entry and exit are tracked by ANPR equipment, which records important information and generates a digital trail for accountability and traceability. Decision-makers and operational managers can access this data in real time because to its integration with the SAP interface.

By combining these technologies seamlessly, the scrap management process is optimized for resource utilization and waste disposal rules are followed, making it a model of accountability and efficiency. For regulatory reporting, continuous improvement programs, and internal audits, the digital trail generated by the connection of SAP with ANPR is useful.

In the end, by lowering environmental impact and coordinating operations with worldwide sustainability initiatives, this project improves operational effectiveness and regulatory compliance and advances more general sustainability objectives.

The solution utilizes multiple technologies both hardware and software like ANPR , Veri focal Cameras, Digital Displays, Weighbridge controllers, network devices, APIs, and SAP.

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All these devices and software work in harmony to give seamless and error-proof results.

V. RESULTS

According to the study's findings, efficient scrap management is essential for streamlining production planning procedures and cutting production costs.

There are multiple steps in the suggested methodology for optimizing the scrap management system. First, by analysing the production process, the core cause of scrap is found, and the problems are fixed using corrective measures.

Second, the planning process is modified in accordance with the impact of component scraps that is produced during production process

Thirdly, in order to maximize the effectiveness of scrap management, an ideal model of the system is put forth that takes assembly scrap and other pertinent variables into account.

We can save a significant amount of labor time and manpower by using the updated new scrap management technique. Additionally, the system becomes safe as no one can alter it externally and it has a digital trail, making it even safer. This redesigned method becomes effective since it takes less time to complete in its entirety process in a short span of time.

The study's overall findings point to the substantial increase in productivity and decrease in manufacturing costs that can be achieved with an efficient scrap management system.

Implications and Limitations:

Implications:

The research on Introducing smart scrap management process in manufacturing has a few implications for practitioners and researchers. The results of this study highlight the importance of effective scrap management in reducing manufacturing costs and optimizing production planning processes.

Practitioners can use these models and techniques to develop effective scrap management strategies that optimize production planning processes and reduce manufacturing costs. The results of this study also have implications for researchers.

We have checked the aspects of process this can be used in Future research also so that futurescrap management systems will be optimized

Limitations:

The applicability of the optimization models and methodologies presented in this paper to various scrap management systems may be limited.

There could be issues with software integration and incomplete data received by the installed ANPR equipment. Conditions such as persistent rain, haze, or dust can lower the camera's recognition precision.

Transmission of data may be delayed or lost as a result of network outages or disturbances. Additionally, improper license plate recognition may result from software defects or mistakes in the ANPR image-processing algorithms.

This study provides valuable insights into the optimization of scrap management in production planning processes.

VI. CONCLUSION

Smart scrap management helps in lowering scrap disposal costs and enhancing better monitoring and close controls against leakges. The design, development, and implementation of an Industry 4.0-based optimized scrap management system are described in this project. Through the use of ANPR technology, a digital weighbridge setup, logistics vehicles, digital handshakes, and SAP virtual shops, the system assures lean and traceable procedures. All of these features are backed by comprehensive digital documentation for possible forensic study.

The method entails determining the underlying causes of scrap, putting corrective measures in place, modifying the planning procedure to take scrap impacts into account, and creating an ideal system model that takes assembly scrap and other pertinent elements into consideration.

The revised scrap management method is very effective since it drastically cuts down dependencies on manual operations, improves system security with a digital trail that stops outside interference, and shortens process times overall.

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The study's findings show that there is room for major improvements in operational effectiveness and cost savings, proving that a well-designed scrap management system may dramatically increase output while cutting expenses.

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