IJCRT.ORG ISSN : 2320-2882
INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)
An International Open Access, Peer-reviewed, Refereed Journal

APPLICATION OF SMART TECHNOLOGIES FOR AUTO COLLISION PREVENTION OF ELECTRIC HOISTS IN AUTOMOBILE INDUSTRY

Gopi D [1] & Srinivasan PSS [2]

[1] PG Scholar, Department of Industrial Safety Engineering, Knowledge Institute ofTechnology, Kakapalayam,Salem-635704, Tamilnadu

[2] Professor, Department of Mechanical Engineering, Knowledge Institute of Technology, Salem, Kakapalayam,Salem-635704,Tamilnadu

ABSTRACT

Smart technologies are been extensively used in manufacturing processes in order to increase overall performance, an increasing focus is outlined also for supporting occupational and industrial safety. Applying smart technologies in the safety domain could contribute to increase the work place safety. This project aims to evaluate potentialities of adopting these technologies in a specific critical process in Automobile industry to prevent Electric hoist and Electric Monorail System (EMS) collision. The collision happen in the overhead equipment leads to electrical short circuits, Fire and property damages beyond the repair. Collision prevention in this kind of critical process is much needed to increase the work place safety. An automated collision prevention system based on smart technologies in supporting an efficient collision prevention process based on the literature review analysis.

By using the statistical tool, Binary DOE (Design of Experiment) three critical factors like Speed of the EMS system, Distance to be maintained between hoist and EMS system during automatic operation, Types of sensors to be used for the collision prevention has been arrived. This auto collision prevention system detects the Electric hoist and Electric Mono rail System movement and its position in the bus bar system by monitoring its movements continuously through Sensors and Programmable Logic Controllers. If operator mistakenly operates any one of the both collision contributors (Electric Hoist or EMS) in the track change over area, the track change system interlock will show error indication in the operator panel.

The Interlock system implemented with the usage of smart technologies which can prevent the collision and alerts to the operators while they do any errors via visual indicators. Thus, this auto collision prevention system helps to maintain the safety at the work place with the usage of smart technologies. Automatic forward or reverse operation of the EMS system at the track changer area will begin once the manual electric hoist clearance in the travel path of EMS and the track changer feedback. By implementation of this auto collision prevention system Lifting tackle collision between EMS system and manual Electric hoist has been reduced to zero.

Keywords: ***Smart Technologies, Auto Collision Prevention, Electric Monorail, Design of Experiment***.

1. INTRODUCTION

The automobile sector in India is the fourth-largest by production in the globe as per 2021 statistics, as of 2022 India is the 3rd largest automobile market in the world, surpassing Japan and Germany in relation to sales. Currently India's auto industry is worth greater than US$100 billion and contributes 8% of the country's total export and accounts for 2.3% of India's GDP. India enjoys a strong position in the global heavy vehicles market, being the biggest tractor producer, second-largest bus manufacturer, and third-largest heavy trucks producer in the world. India's annual making of automobiles in FY22 was 22.93 million vehicles. India's major automobile manufacturing companies includes Tata Motors, Maruti Suzuki and Ashok Leyland, Mahindra & Mahindra.

1.1 About the Project Area

In the company various equipment are used for producing the vehicles, In Ashok Leyland Unit-2 have 1679 equipment, like Electric hoists (652), Spot Weld Guns (454), Electric mono rail system (167), Other equipment (154), Conveyors (60), Cranes (54), Scissor Lifter (48), Hydraulic press (21), to produce the Light, Medium and Heavy Commercial vehicles

Accident occurs due to the equipment failure or malfunction results in injury to the workers and also impact on the environment. Seventy Percentage (70%) of the accidents happens in Electric hoists and Electric Mono rail systems (EMS), which are used for lifting the materials based on its process nature. Electric hoists and EMS collision during material handling causes more property damages and injuries to the operators. Although fully automated industry is the target of industry 4.0 [1], there still a need for human supervision and expert guidance [4]. Even if most of the industries have various safety standards that must be maintained for the safety of the workers and properties, which can be improved further using smart technologies.

This project focus on eliminating the collision of EMS (Electric Monorail System) with Electric hoist which results in accidents, this can be eliminated by providing the innovative framework with the help of smart technologies. "The tasks are conducted with the utilization of deep learning with intelligent detection capabilities".

2. LITERATURE SURVEY

Valerio Elia, Maria Grazia Gnoni and Fabiana Tornese on their paper titled **Applications of smart technologies for automatic near miss detection in the industrial safety**, Describes that Applying smart technologies in the safety domain could contribute to increase performance of several processes starting from workers tracing, environmental monitoring and dynamic risk analysis, also focusing on further developments will be oriented to define also an economic analysis to evaluate life cycle costs of applying smart technologies for near miss automatic detection.

Zhongxian Zhu, Yong Yin, Hongguang Lyu on their paper titled **Automatic collision avoidance algorithm based on route-plan-guided synthetic potential field technique, This** study provided a stable and reliable technical program for automatic ship navigation. First, an improved route-plan-guided artificial potential field (APF) method was presented by balancing the attractive and repulsive forces, resolving the irrationality and swaying of the collision prevention (CP) strategy. Second, a fast local path planning (FLPP) method was proposed according to the high-precision ship motion model to obtain the expected CA results in advance, and to promote its acceptance and application by the navigators. Third, a dynamic goal-guided APF method was proposed to navigate a ship to return to its route plan upon completing the CA procedure.

Ecem Eroglu Turhanlar, Banu Y. Ekren & Tone Lerher on their paper titled **independent mobile robot travel under deadlock and collision prevention algorithms by agent based modelling in warehouses,** discuss about flexible travel of independent mobile robot (IMRs) in warehouses by developing smart deadlock and collision prevention algorithms on agent-based modelling. By that, IMR Agents can communicate with one another and environment, so that they can choose wisely maximizing their goals. They contrasting the results of the developed flexible travel system with non-flexible designs where there is a single IMR dedicated to a specific zone so that no deadlock or collision possibility takes place. The findings indicate that IMRs may provide up to 39% improvement in the flexible system compared to its non-flexible design.

Pranav S Wazarkar, Neel S Bhurkunde, Nitin S Yadav and Sajal S Patil on their paper titled **IoT Based Intelligent Low-Cost Anti-Collision Cum Monitoring System for Fishing Vessel,** Describes about The collision of fishing vessels is the problem many fishermen face. Due to the lack of a proper system, this problem persists and inevitable danger needs to be solved. Even after detecting the potential collisions between the ships, the captain may not be able to manoeuvre it to safety. The system proposed here would be able to overtake the control of the motor and the propeller, to reduce the speed of ship. In this journal, an use of an ultrasonic sensor for detection of objects and the system alerts the crew of the danger ahead.

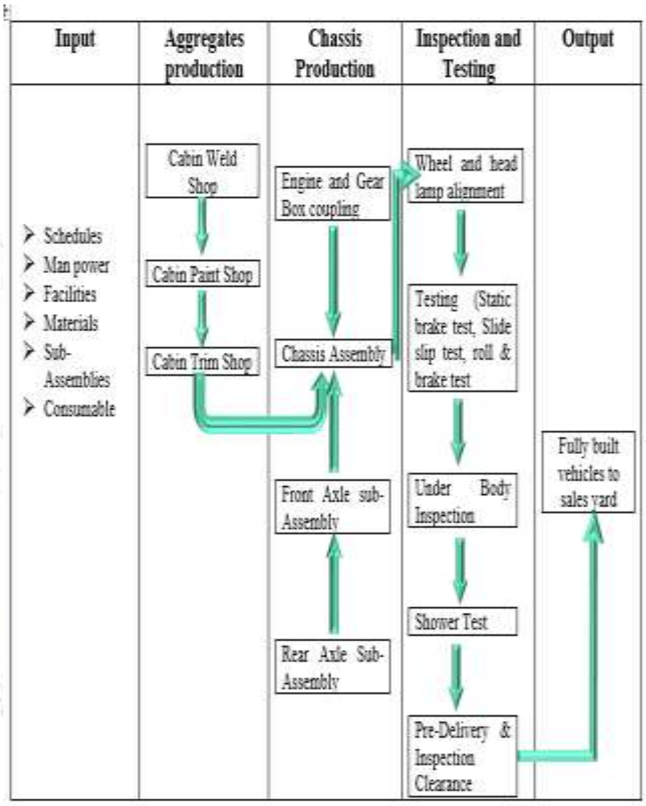
Kazi Ahmed Asif Fuad and Tasneem Sanjana and Habib Mehrab Masayeed on their paper titled **Automated Automobile Anti-Collision System** describes that vehicle safety system that automatically prevents collisions between vehicles and objects is known as an automated vehicle anti-collision system. They the prototype of a designed microcontroller-based automated car anti-collision system was discussed for implementation. This The system is skilled at spotting obstacles using a precise distance sensor, alerting the driver when a collision is imminent and then automatically applying the brakes without the driver's assistance when necessary. This system continuously monitors the condition of the vehicle and will automatically stop the vehicle if the driver somehow fails to avoid the collision.

3. INTRODUCTION ABOUT COMPANY

The Company is the second largest producer of commercial vehicles and the fourth-largest producer of buses in the world, and the 19th largest truck manufacturers. With its headquarters in Chennai, the company has nine manufacturing facilities, including seven in India, one in Leeds, United Kingdom, one in Ras Al Khaimah (UAE), and a joint venture for the production of high-press die-casting extruded aluminum components for the automotive and telecommunications industries with the AL Teams Group..

3.1 Products manufactured and its application with process flow

The following are the various products manufactured in the organization.



- Heavy Commercial vehicles
- Light Commercial vehicles
- Medium Commercial vehicles
- Diesel Generators

Products include trucks, 9 to 80 seater buses, vehicles for defense and special applications, industrial diesel engines, and vehicles ranging in gross vehicle weight from 1T to 55T. 2016 saw the introduction of the first electric bus and truck in India.Over 70 million passengers use

Fig No:3 Process Over view

Every day, this business uses buses to transport employees to their destinations, and our trucks keep the economy's cogs turning. With the Indian Army's largest deployed fleet of logistics vehicles and significant partnerships with armed forces around the world.

3.2 Manufacturing Process flow

Being an assembly unit, it depends on other units like Engines from Hosur-1 and Gear box from Bhandara and Several other things are being procured on BOF basis from the approved vendors except frame side member which is manufactured by punching & forming in 5000T press.

State of art manufacturing facility at Hosur-2 includes,

- Automated conveyors.
- Integrated Cab Weld shop.
- Paint Shop.
- Side member press shop (5000T capacity SPS press, Germany).

Vehicle test shop and other resources and Infrastructures like, Sanctioned power 3500 KVA, internal power generation capability 6250 KVA, water availability around 400 KL per day, Employee’s strength is 906 and Compressed air generation capacity 6000 CFM @ 7 kg/cm^2 pressure.

4. PROBLEM IDENTIFICATION

Profound study is practiced in the sector to identify the associated lagging indicators that plays a crucial part in deteriorating safety culture.

Found Electric hoist and EMS (Electric Monorail System) used for transferring the components from one place to another place on the same track are getting collide on the track change over area, where the electric hoist and EMS path decided manually by the operator by pressing the track position change.

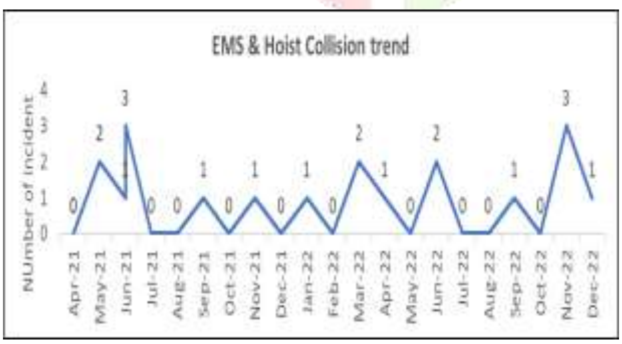


Fig.No:4 EMS & Electric hoist collision trend

4.1 Track Changeover Process

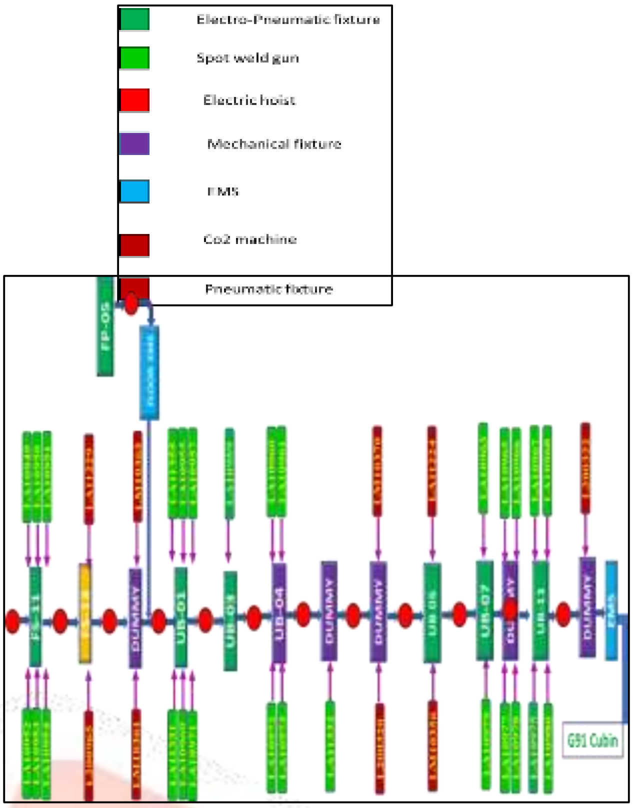


Fig.No:4.1 EMS & Electric hoist collision trend

In the above picture G91 Underbody, line EMS and Electric hoist operations are explained with utilizing the track change over system

4.1.1 Straight and Divert Position of Track Changeover System

The track changer used to transfer the Manual Electric hoist and Automated Electric monorail system on the same path on different interval times to produce the panels. There are two operating positions used, Straight and Curve operation in the track changer.

Straight operation of the track changer used for Manual Electric hoist travel between one stages to another stage.

Divert position used for automated electric monorail system travel between floor panels to underbody stage. Above picture shown that, the operator panel for the track changeover system for straight and divert operation push buttons and emergency stop switch with the indication lamps for error indication and power ON indication.

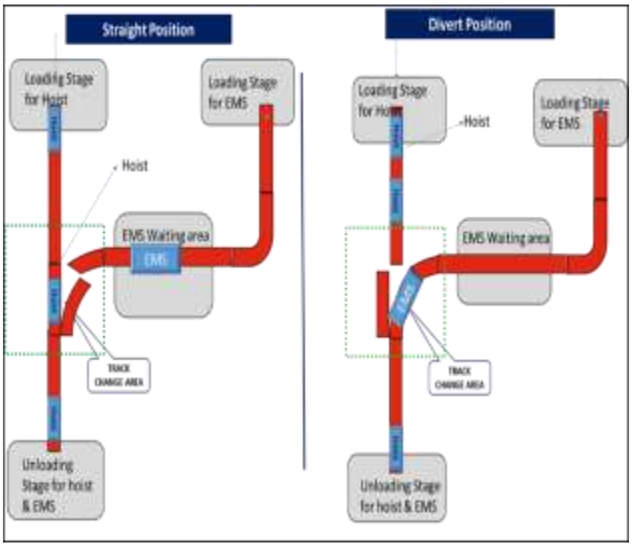


Fig.No:4.1.1 EMS & Electric hoist collision trend

Collision of Electric hoist with Track changer system due to human errors. Track change divert operation performed while moving the Manual Electric hoist. Collision of Electric Mono Rail system happened while doing straight position of track changer. This collision leads to electric sparks and fire due to electrical short circuits.

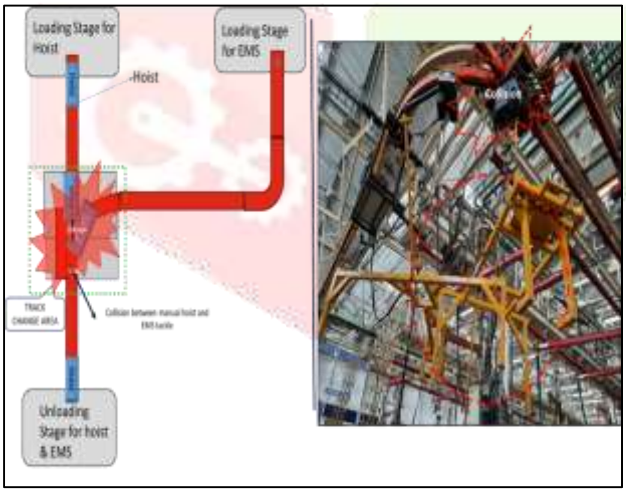


Fig.No:4.2 EMS & Electric hoist collision

4.2.1 Hazards associated with Electric Hoist and EMS Collision

The Collision happened between Electric Hoist and Electric Monorail System (EMS) leads to following hazards.

- ➢ Exposure to electrical Sparks
- ➢ Exposure to lifting tackle fall from height
- ➢ Exposure to fire caused by electrical short circuit

4.2 Electric Hoist and EMS Collision in the Track Change Area

In this section, the base structure of the cabin is being assembled in a sequential flow. The section consists of under body sub-assemblies & under body main assembly. The manufacturing processes included in this section are spot welding & drilling. Material handling done by Electric hoist and Electric Mono rail systems

4.2.2 Impacts of Electric Hoist and EMS Collision

Due to EMS and Electric hoist, collision following property damages are occurred.

- ➢ Current collector Unit frequently damaged
- ➢ Travels bus bar inside frequently burnt & spark from bus bar
- ➢ Current collector wire cut
- ➢ MCB frequently tripping
- ➢ Tackle Collision and damage
- ➢ Control panel Components burnt &fire

4.3 Fault tree Analysis of Electric hoist and EMS Collision

The Root cause analysis is being done with Fault tree analysis shows that following root causes for the Electric hoist and EMS system collision.

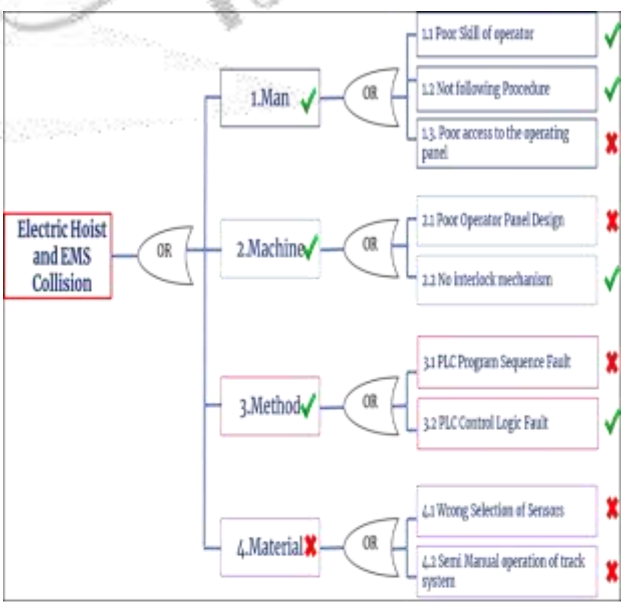


Fig.No:4.3 Fault Tree Analysis

The following root causes are identified

- ➢ Poor Skill of Production operator
- ➢ Operator not following the procedure

- No interlock system to prevent collision
- PLC program control logic faults

Based on the above Root causes we finalized that No interlock system to prevent the human errors which causing the Ems and Electric hoist system collision.

4.4 Solution Selection for Preventing Collision

Following ideas are generated for preventing the EMS & Electric hoist collision

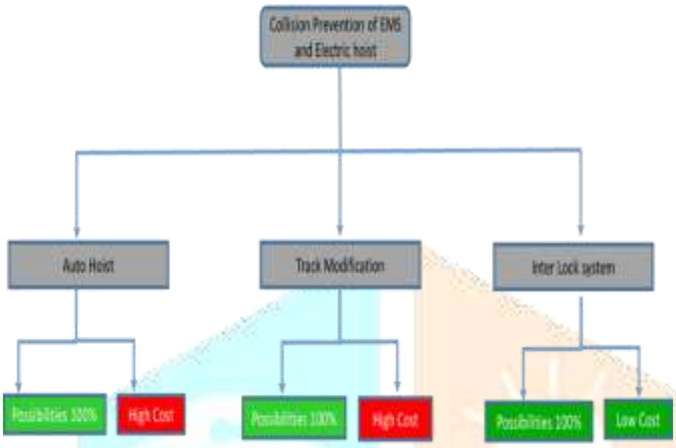


Fig.No:4.4 Solution selection for collision prevention

1. Auto hoist operation for eliminating the Manual hoist intervention in the automated EMS system operation. This will leads to high cost and implementation time is very high.

2. Track modification of the track changer system is the second idea generated, this also consumes higher cost and entire process change, which is not suitable in short time span.

3. Interlocking system for the Manual Electric hoist and EMS system with track changer is the best solution to prevent the collision with minimal cost and short time span.

5. DATA COLLECTION

Using Design of Experiments (DOE) techniques, we can determine the individual and interactive effects of various factors that may have an impact on output results of your measurements. We can also use DOE to gain knowledge and estimate the best operating conditions of a system, process or product.

5.1 Optimized Setting for Lowest Probability of Ems Collision Using Binary DOE

Optimized setting based on Speed; Distance & Sensors used for preventing the EMS collision can be obtained by using the Binary DOE

Table 5.1.1 Factor Selection for Binary DOE

Following factors to be considered for optimized setting:

a. Speed of the EMS auto forward & Reverse Operation ought to be regarded

b. Safe distance to be maintained between EMS & hoist during Fast and Slow speed operation of EMS

c. Sensor selection for EMS home position and Track position based on the life & accuracy of the sensor

Fig.No:5.1.2 Binary DOE Calculations

5.2 Parameter & Component selection confirmation based on the result of DOE

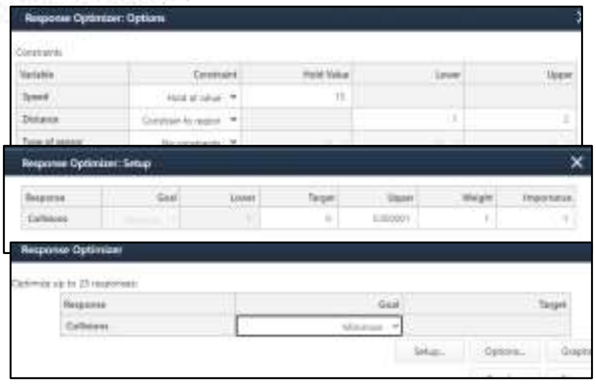


Fig.No:5.2 Binary DOE Calculations

Best setting derived for Zero probability of Collision is to maintain min distance between two at 2-meter Limit switch has been selected, as it is low cost and low maintainability, Speed for Auto track is marinated at 15 meter per minute in order to maintain cycle time

6. ANALYSIS AND IMPLEMENTATION

According to the binary DOE output, 2 meter safe distance to be maintained at all time between the Electric hoist and the EMS system. For this there are 2 limit switches installed at the manual Electric hoist travel path to sense, Hoist In and out operation at the track changer area.

6.1 Installation of Limit Switches at the Track Changer Area for Electric Hoist & EMS:

For the EMS System based on the binary DOE output, 2 limit switches are installed at the EMS parking area nearby to the track changer area in order to sense EMS position for enabling Auto forward and Auto reverse operations.

Fig.No:6.1.1 Limit switches for sensing Electric hoist position

LS1 – Hoist at Exit Stage Limit Switch at Track Change

LS2 – Hoist at Entry Stage Limit Switch at Track Change

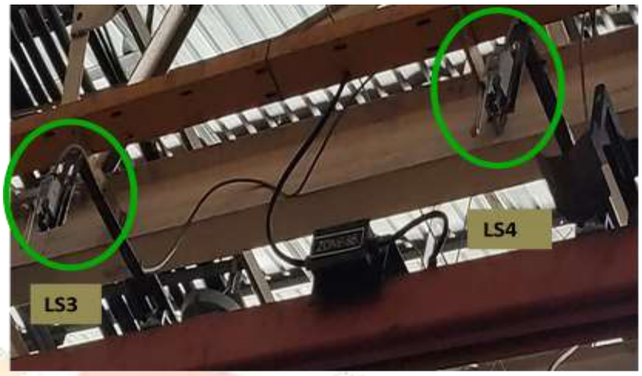


Fig.No:6.1.2 Limit switches for sensing EMS position

LS3 – EMS at Exit Stage Limit Switch at Track Change

LS4– EMS at Entry Stage Limit Switch at Track Change

6.2 Installation of Photo Electric Sensor for Sensing EMS Safety Zone

For sensing the EMS Safety zone there are two Photo electric sensors are added in the EMS system. To detect the EMS position with help of stopper plate positioned in the Track changer area, for the safe distance between the Electric hoists. Also another photo electric sensor sense any obstacle in the EMS travel path and stops the EMS system if any object presents in the path.

In the Track changer area Sensing plate with the Pneumatic cylinder installed to sense the EMS home position for the EMS forward operation at the Track changer area.

F

Fig.No:6.2.2 EMS position sensing plate with Pneumatic cylinder

In track changer area in there are two photo sensors available for sensing straight and divert position of the track changer and the feedback linked with the PLC for enabling the auto operation mode of EMS system. All the sensors and limit switches are fail safe, if any one limit switch output not came to

PLC the operation of Track changer and EMS will be stopped and error indication lamp will glow to alert the operator.

6.3 Layout Diagram for EMS and Electric Hoist Collision Prevention System

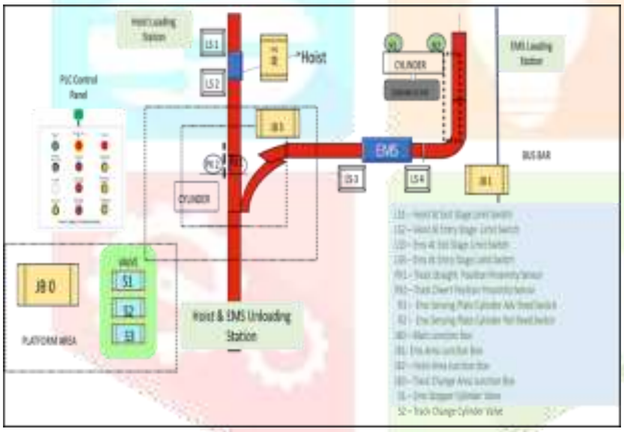
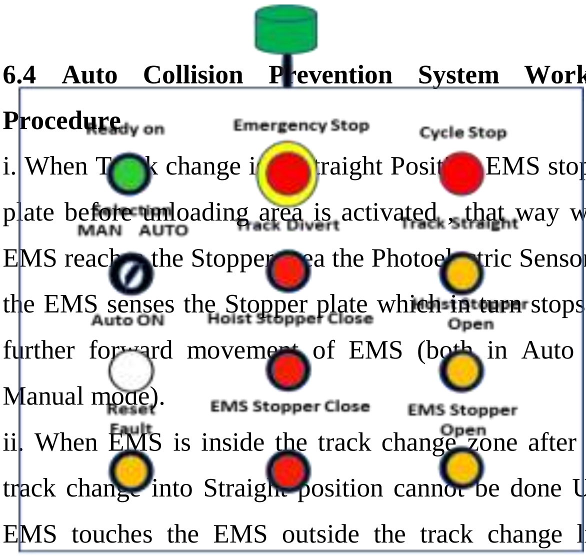


Fig.No:6.3 Layout Diagram for EMS and Electric hoist collision prevention system

6.4 Auto Collision Prevention System Working Procedure

i. When Track change is in Straight Position EMS stopper plate before unloading area is activated, that way when EMS reaches the Stopper area the Photoelectric Sensor in the EMS senses the Stopper plate which in turn stops the further forward movement of EMS (both in Auto and Manual mode).

ii. When EMS is inside the track change zone after that track change into Straight position cannot be done Until EMS touches the EMS outside the track change limit switch (EMS at exit stage).



iii. Similarly When Hoist is inside the Track change zone (hoist at entry stage) after that track change into divert position cannot be done until hoist touches the Hoist outside the track change zone limit switch (Hoist at exit stage)

iv. Due to this set of controlling method only one panel carrier will be present inside the track change area at a time so collision does not happens.

v. Proper training regarding the working of the track change function, troubleshooting and rectification methods is trained to every technicians for the wellbeing of the maintenance process.

6.4.1 Track Changer Operating Panel Operating Procedure

Track change function has two modes, Auto mode and Manual mode. Auto and Manual mode selection is done through selector switch using key. Auto mode operation is used for normal operation, Manual mode operation is used for maintenance purpose where no fault feedback for sensors is taken into consideration. So in manual mode all 3 cylinder operations can be controlled.

Green tower lamp is used at the top of the operating panel. Continuous On of tower lamp indicates track change operation is ready to work. When tower lamp off indicates any error in feedback or miss position of either hoist or EMS.

Ready on Push Button has two states continuously ON, Blinking. If the Ready on Push Button is continuously ON then the Track change operation ready to go. If Ready on Push Button is Blinking, Then the track change operation not ready. At this time Ready on Push Button should be pressed once to make the track changer ready.

Fig.No:6.4.1 Track changer Operating Panel

Emergency Stop Push Button is used to shutdown whole track change operation during any abnormal situations and after emergency stop switch reset only track change operation is ready to use. Cycle Stop indicator is ON whenever there is a fault condition or Emergency PB is activated. Track change operation wont until cycle stop indicator is OFF.

Manual / Auto selector switch is operated by using coded key. This selector switch is used to switch the track change operation into Auto mode and Manual modes, this key available only with the maintenance team to operate the track changer in manual mode during any maintenance activities.

Track Divert Push Button is used to change track to divert position. It can be operated in both Auto and manual modes, Track Straight Push Button used to change track to straight position. It can be operated in Auto as well as in Manual mode. Auto ON LED Continuously ON indicated Operation is in Auto mode. And if Auto ON LED is blinking that means Selection is in Manual Mode.

Hoist Stopper Close Push Button is used to operate hoist stopper cylinder to Advance mode. This can done only in Manual mode. Hoist Stopper Open Push Button is used to operate hoist stopper cylinder to Retract mode. This can done only in Manual mode.

Reset Fault Push Button is used to clear fault, EMS Stopper Close Push Button is used to operate EMS stopper cylinder to Advance mode. This can done only in Manual mode. EMS Stopper Open Push Button is used to operate EMS stopper cylinder to Retract mode. This can done only in Manual mode.

6.5 Electrical and PLC Circuit Diagram for the Auto Collision Prevention System

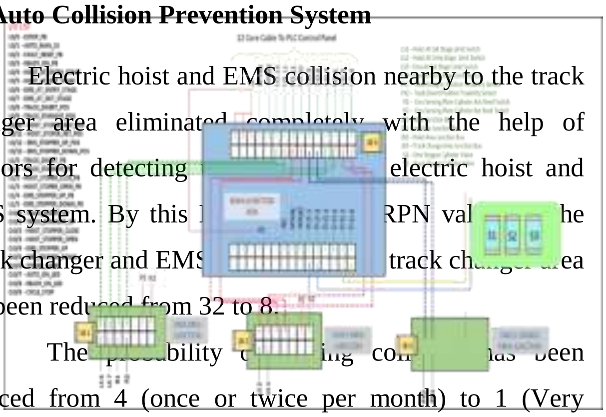


Fig.No:6.5 Electrical and PLC wiring Diagram for auto collision prevention system

7. RESULT AND DISCUSSION

7.1 Accident Reduction after Implementation of Auto Collision Prevention System

Electric hoist and EMS collision nearby to the track changer area eliminated completely with the help of Sensors for detecting the positions of electric hoist and EMS system. The sensors which was provided on the EMS parking area and the Manual hoist track system, will detect the EMS and Electric hoist position respectively at all time.

Alert the operator if the manual hoist not moved to the safe distance, Operator identifies his fault through the fault indication lamp and will move the Electric hoist to the safe distance.

EMS system will activate in auto mode once all the logics are true in the track changer area. By this we have achieved the elimination of Electric hoist and EMS collision and also lifting tackle damage, Bus bar burnt, Electrical components failure due to the collision was completely eliminated.

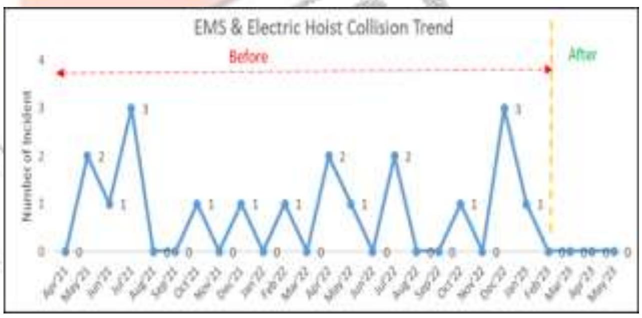


Fig.No:7.1 EMS & Electric Hoist Collision Trend after implementation of auto collision prevention system

7.2 HIRA RPN Reduction after Implementation of Auto Collision Prevention System

Electric hoist and EMS collision nearby to the track changer area eliminat[illegible] with the help of Sensors for detecting [illegible] electric hoist and EMS system. By this [illegible] RPN val[illegible] the Track changer and EMS [illegible] track ch[illegible] area has been red[illegible] from 32 to 8.

The p[illegible]bility [illegible] co[illegible] been reduced from 4 (once or twice per month) to 1 (Very unlikely occurrence). As this is fail safe structure, any one of the sensor or the limit switch feedback was not came the auto operation of the track changer and EMS will not work.

8. CONCLUSION

Auto collision prevention of Electric hoist system in Automobile industry has been carried out. From the Literature survey, Speed, Distance and Type of Sensor to be used are identified as key parameters. Experiments have been carried out by using the Binary DOE (Design of Experiment) method. From the Design of Experiment, Travel Speed of the Electric Monorail System set to fifteen meters per minute and safe distance to be maintained between Electric hoist and Electric Monorail System at the track change over area set two meters, Proximity sensors and limit switches and wireless communication systems are installed to prevent the collision.

Based on this study the following major conclusions are arrived at:

(i) The collision between manual electric hoist and EMS system has been completely eliminated

(ii)Visual fault identification indicators are provided for operator friendly operation of track changer and EMS

(iii)Safe work environment provided to the workers to meet the legal requirements.

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