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Industrial Internet of Things (IIOT) for Fire Risk Assessment Based on Electronic Sensor

Rishi Dewan[1,*], Prince Mishra[2,†], Ranjeet Brajpuriya[1,‡]

[1] *University of Petroleum & Energy Studies, Via Prem Nagar, Dehradun 248001, Uttrakhand, India*
[2] *HSE Specialist – Momentum India Pvt. Ltd, Noida, U.P. India*

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Industry 4.0 means that devices are controlled with embedded computing. This cyber physical system enables us to utilize the Internet of things (IoT) infrastructure for human and industrial plant safety. The implementation of these automatic fire fighting systems is focused on the findings conducted during Fire Risk Assessment (FRA) for clients and vendors. The major contributor for deaths in a fire accident is due to excessive smoke inhalation. So, an early detection of fire is crucial in fire detection systems. The conventional fire detection system is unable to tell the exact location of the fire. In the proposed work, an IoT based fire safety system has been developed to overcome problems found during fire risk assessment. The implemented system consists of three major parts: a processing unit, surveillance, and a detector. The detector unit is an integration of carbon monoxide sensor, humidity sensor, buzzer, temperature sensor, ionization smoke detector with ESP32. In case of a fire breakout, the system will immediately sound the alarm, and the Global Positioning System (GPS) with the coordinates and floor plan of the accommodation will be send to the firefighting team and the authorities. The floor plan is developed in such a way that it tracks the exact location of the fire. A qualitative method has been used to determine the desired features integrated in the system and determine the level of usability for the improvement, if any, such as focused group discussions, safety audits and standards implementation. This work has mitigated fire risks on this kind of catastrophic event.

Keywords: FRA, GPS, Industry 4.0, Sensors.

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1. INTRODUCTION

An audit is a technique designed to ensure that the standards achieved in any workplace and other places affected by work activities conform closely as possible to objectives specified by the management of the factory to control the risk of injury and ill health, damage to property, plant, equipment and their environment, and to provide information to management to justify continuation of the same strategy or a change of course. The site has the facilities to cast and machine cylinder blocks and heads as per customers' requirements. Vendor manufactures engines body, head and other parts-castings – Foundry-Ferrous Foundry and machining work, using LPG/Biogas for oven, paint thinner for painting, foundry chemicals, molten metal for pouring, [1], so it is necessary to find out gap/facts in storage, foundry and machine operations and dispatch to avoid incidents, accidents and become a safer workplace.

This safety audit exercise is carried out to fulfil the statutory requirements prescribed under the section 7(A) of the factories Act 1948. and Maharashtra Factories (Safety Audit) Rules, 2014. As such it is essential, on the part of the Factory Management to carry out "Safety Audit" to identify and assess the potential hazards in different sections of the plant and processes and take appropriate control measures. The fire was discovered by mankind numerous years prior. Until now, it is yet critical to humans in their everyday livings. Fire is valuable when it is leveled out. In any case, it might prompt annihilation if it is uncontrolled. Flames can be classified into two gatherings [2]: flaring fire and seething fire. A flaring fire creates a huge volume of blazes and yet more modest volume of smoke. Generally, a flaring fire is caused by ignition of materials like combustible materials or fluids. A seething fire is a kind of fire that is delayed in spreading, low in temperature, and flameless. It is a condition wherein the material is being singed gradually with smoke, yet without fire. The smoke produced by such a fire may contain toxic chemicals, for example, water-based paints, thinners, acetone, methanol carbon monoxide [3]. The quantity of detailed fire cases over five years remains high at the level of 5,000 cases. Types of structures can be additionally separated into a couple of classes, for example, private, retail, plant, foundation, office, public spot, and others. Among these classes, private premises are added to the most noteworthy structure fire episodes every year. Alluding to the National Building Codes (NBC 2016) [4], most fire losses are because of the inward breath of smoke instead of consumes. Indeed, even before the casualties can reach the exit of the structure, they were at that point inebriated by the actual smoke. One reason is that most of the oxygen was devoured by the actual fire during consuming, Today, sensors are modest and exceptionally little in size [5]. The study was conducted to analyze random statistics of different cities. Star geography was used to organize the sensors and correspondence between them and principal home sink [6]. The ZigBee convention was also utilized to give correspondence between the sensors and the sink. GSM correspondence to alert the client in the early stages if the sensor reports a fire. The framework

* rishidewan@rediffmail.com
† er.pm.ece@gmail.com
‡ ranjeetbjp@yahoo.co.in

makes the fire ID after checking from two sources. These sources are:

a) Response of the client to the GSM alert, i.e., if the client's reaction is fire, at that point our framework straightforwardly produces the caution.
b) When at least two sensors report fire, at that point the framework straightforwardly produces an alarm without waiting for the client's reaction.

These days, sensors are modest, so we utilized multi-sensors for each basic district to deliver issues connected to single sensor discovery. The problems and difficulties identified with the current methodologies are distinguished. The current strategies use one sensor for each target area [7].

The objectives of the study are as follows:

i) Safety audit is an important tool for identifying falling standards, areas of risks or vulnerability hazards and accident potential in the proposed and existing plants and processes for determining the actions necessary to remove hazards before personal injuries or damage occur.
ii) The loss potential in the industry is always high and is not restricted only to large-scale incidences like accidents, fires etc., but minor issues like failure or damage of instrumentation or equipment may lead to lengthy down time of the plant, resulting in heavy financial loss. Also, loss potential is not concerned with the production.
iii) Identify and recommend mitigations for all possible fire hazards in casting machine cylinder blocks and heads in automotive industry and implement a fire alarm system based on latest technologies with the help of GPS based system.

2. LITERATURE REVIEW

The study for this work is initiated by different Indian standards, state rules and acts. The questions for this fire risk assessment are based on ISO 45001 guidelines, and points not implemented at the time of evaluation were found as a way to accomplish compliance and in an advanced way with the help of Industry 4.0. The research work is not limited to codes and standards only, instead it was derived in more than eighty journals to find the extent of applications and implementation of IIoT [8]. To find the root cause of failure and accidents occurring due to the failure of fire safety systems, research was done, and studies showed that in nearly thirty two percent of cases a fatality or a serious injury occur because of inaccurate, insufficient and delayed response of fire safety system, the same was shown in the section one of this paper for Maharashtra state. The interfacing and requirement for the sensors became clear after studying different kinds of research papers, journals, articles and blogs. A few comparative studies have also been done in order to find a better and reliable energy efficient system to ensure the cost efficiency of the system [9]. Filtering out the sensor was a bit of challenge in the ocean of technologies of internet of things (IoT), but this was made possible by industrial internet of things (IIoT) to look into an industrial approach.

The findings during the fire risk assessment for metal pouring industries have given an approach towards the automotive industry fire risks and understanding of existing fire safety systems with the help of national building code 2016 and other Indian standards such as IS 2190,2192,2189, etc. The advantage of this study is that it shows that the implementation of cloud computing can be diversified with an example of implementing the same by detectors. The implementation of Industry 4.0 has become very popular and is considered the key to the future of technology. Safety has been found a core pillar with this industrial revolution as the automation is gaining popularity day by day in every sector [10]. With the varying sectors various risks came and automation is one of them. In order to mitigate those risks, safety needs to be implemented and automation is the answer for that with the help of industrial internet of technologies.

3. METHODOLOGY

3.1 Safety Assessment

Hazard appraisal is a significant piece of owner wellbeing and security (OSH) executive plan. At the time of an appropriate assessment, one uncovers dangers and hazards, distinguishes individuals who might be in danger, and finds which control measures are expected for forestall ailment and injury. Even though numerous businesses need to meet administrative prerequisites, the basic reason for hazard evaluation is likewise to zero in on furnishing owner laborers with a protected, solid climate. Improving wellbeing of the owner group additionally reduces the potential obligation issues faced by the owner organization. Assessment of open fire sources to guarantee that the working environment has adequate fire avoidance and relief frameworks is set up. As one is setting up the extent of this appraisal, they should approach the particular assets required: data sources, industry guidelines, and a group of prepared people to finish the evaluation.

Frequently, individuals included are those affected by the result of the appraisal: directors, chiefs, agents, hazard reviewers, and that is just the beginning. Utilizing parties, who do not have a stake in the evaluation discoveries, leads the appraisal can help guarantee that it is levelheaded and precise. This interaction incorporates a careful investigation of the workplace [11], hardware, and frameworks to decide expected dangers and carry out security frameworks to forestall injury. Since every working environment is one of a kind, one wellbeing group ought to consistently modify the danger appraisal dependent on novel conditions nearby.

3.2 Audit Methodology

The Indian Standard IS 14489:2018 is used as basis for this audit. Guidelines given under ISO 45001:2018 safety audit subject each area of a company's activity to a critical appraisal of all potential hazards. Every component of the total system is included e.g., policy attitudes, training, features of the process and design, layout of the plant, operations, emergency plans, personnel protection, accident records etc.

The following activities are carried out in conducting safety audit. A preliminary review is carried out of company's description and specified requirement of SAFETY

system as a basis for planning the safety audit [12]. The opening of this project took the review for adequacy of the company's specified requirements and recorded description of the methods for meeting the OS and H system requirements such as the safety manual or equivalent.

3.3 Internet of Things (IoT)

The Internet of Things, or IoT, alludes to the billions of actual gadgets all throughout the earth that are presently related to the online, all gathering and sharing information. Due to the looks of super-modest central processors and therefore the universality of remote organizations, it is feasible to show anything, from something as little as a pill to something as large as a plane, into a bit of IoT [13]. Interfacing up all those various articles and adding sensors to them adds a degree of computerized knowledge to gadgets that might be generally idiotic, empowering them to impart ongoing information without including a private.

The web of things is making the feel of our general surroundings more astute and more responsive, consolidating the computerized and actual universes. Pretty much any object is often transformed into an IoT device if it is often connected to the web to be controlled or transmit information [14]. A lightbulb which will be switched on employing a smartphone app is an IoT device, as may be a motion sensor or a sensible thermostat in one office or a connected streetlight. An IoT device can be a child's toy or as serious as a driverless truck. Some objects may be crammed with smaller IoT components, like a reaction-propulsion engine that is now crammed with thousands of sensors collecting and transmitting data back to make sure it is operating efficiently [15]. At a bigger scale, city projects are filling regions with sensors to assist us understand and control the environment. Fig. 1 represents the block diagram of the implemented fire alarming system. IIoT or the fourth modern unrest or Industry 4.0 are largely names given to the utilization of IoT innovation in a business setting. The idea is similar to buying IoT gadgets at home, however for this situation the point is to utilize a blend of sensors [16], remote organizations, large information, AI and investigation to quantify and improve mechanical cycles.

4. INDUSTRY 4.0

Industry 4.0 is utilized reciprocally with the fourth mechanical insurgency and addresses another stage in the association and control of the modern worth chain. Digital actual framework structures are the premise of Industry 4.0. They utilize current control frameworks, have implanted programming frameworks and discard Internet address to be associated and accessed via IoT [20]. Thus, the items and methods for creation are organized and can 'impart', empowering better approaches for creation, esteem creation, and continuous enhancement. Digital actual frameworks make the abilities required for smart industrial facilities.

These are similar capacities we know from IIoT like distant observing, or track and follow, to name a few. Industry 4.0 is frequently utilized conversely with the idea of the fourth mechanical set [21]. This manifests itself, among other things, in a much greater mechanization than in the third mechanical insurgency, the spanning of the physical and computerized world through digital actual frameworks, empowered by IIoT, a shift from a focal modern control framework to one, where brilliant items characterize the stages of creating and closing information models information models and control frameworks [23] as well as personalization/ customization of items.

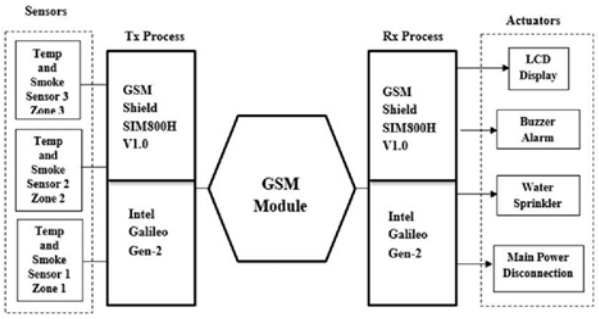

Fig. 1 – Block diagram of implemented fire alarming system

5. SYSTEM DESIGN

The traditional alarm and observing framework contains three significant subsystems.

a) The focal processor, which is essentially a microcontroller structure, responsible for the entire dynamic cycle.
b) The sensor subsystem that has sensors that determine the actual amount of distinguishing fire followed by comparator [22].
c) Actuators driven by transfers. The practical square graph of traditional alarm and checking framework.
d) The focal processor is fundamentally a microcontroller framework that takes the sensor yield as information and compares it with a pre-defined edge by the comparator. The comparator yields are either "1" or "0" that is being the offered contribution to the processor. After getting and investigating the data, it gives important guidance to the actuators.
e) The actuators of the framework are LCD displays, water sprinkler engines, bell alert [23] and primary force disengagement switch. Other than LCD displays, all actuators need more current to drive. Consequently, transfer circuits are being utilized as shown in Fig. 2. The initial step is to turn out more acquainted with arising advances for security and even more so in general for the various purposes that can support [24] welfare efforts. New items are being created at an unimaginable speed and wellbeing experts will discover they need either additional time, openness (gatherings and workshops, and so on), proficient assistance from the IT office or even a devoted security professional.
f) New computerized gear goes from robots and robots to wearables for laborers, vicinity sensors for vehicles and surprisingly smart PPE.

The circuit works in the following manner:

1) On detection of flame, sensor through T_x sends the packets to microcontroller.
2) The controller as per the looped program through 5 V power sends the signal to buzzer, and buzzer starts buzzing.

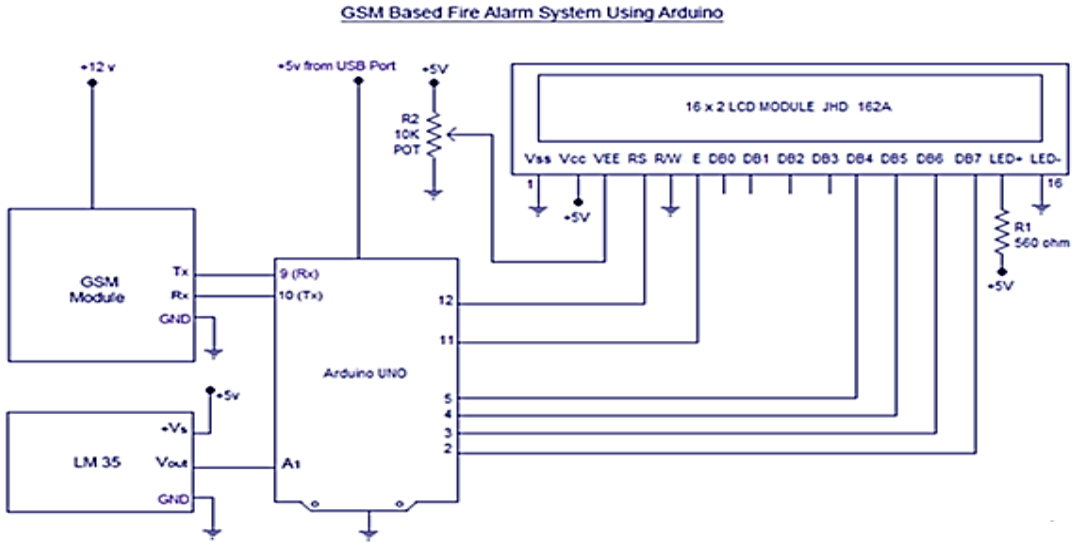

Fig. 2 – Circuit for Arduino based fire alarm system

3) The end result that should come from these endeavors is an innovation guide. Albeit such an arrangement may change because of future issues or improvements, it will give an establishment to arrange different parts of security that should up-hold the innovation. The guide will empower the development or redevelopment of the general security methodology. Assuming the association does not have such a methodology, there is an ideal opportunity to implement it right now.
4) A system is a strategy and a plan to accomplish an objective. In this situation, the system ought to be the manner in which the association will distinguish and relieve hazards inherent in the items or administrations created. The system is truly necessary in security, where generally very regularly the endeavors are a set of projects coordinated at slacking pointers.
5) In automatic wellbeing programs, significant activities are regularly reactive rather than proactive. The procedure perceives that achievement is more than keeping away from disappointment, and results are the aftereffect of cycles and execution. The technique adjusts the cycles and execution as per the essential systems.
6) The most phenomenal security methodologies start with the outlook that specialists are not an issue to be controlled, but instead are clients of wellbeing endeavors. The technique ought to be based on enhancing those clients to empower them to tackle their responsibilities even more securely. Innovation can empower the association to climb the order of controls, killing worker openness and depending less on managerial controls.
7) From pin 9 GPS 900 A is operated and the message is sent to the personnel phone number with the coordinates of location and zone. The same can be understood through Fig. 2.

6. RESULTS AND DISCUSSION

IIoT is the future of Industry 4.0, and safety is one of the core pillars of it. On the one hand, we have accomplished to initiate the implementation of IoT in industry, and on the other hand, we have found studies which can be a concept of a smart city.

The growing interest in IIoT applications is driven by solid industrial patterns. This article inspected a portion of these patterns related to IIoT network normalization and innovation choices that can be used by different industry verticals. In any case of the utilized IIoT network arrangements, multi-facet start to finish safety efforts are needed to keep up secure activity of IIoT applications. What is more, IP-based incorporation stages are expected to conquer the fracture of the IIoT availability environment. It should be underlined that the network arrangements and stages determined in this article involve a little subset of IIoT empowering advances.

7. CONCLUSIONS

This task was set to help building proprietor overcome the difficulties associated with the spread of fire anywhere in the building where the owner is not located. The eccentric circumstance or basic circumstance continuously happens in the structure or inhabitant regions without the occupants' notification. In light of the outcomes acquired, the home ready framework is feasible and practical to the inhabitants to secure their homes. Indeed, the framework assembled is modest in esteem contrasted with another existing alert framework on the lookout and simple to apply. The capacity to identify warmth or high temperature is obvious in light of the utilization of LM35 in the framework. This gadget can be applied in shifted zones because of its adaptability and straightforwardness in taking care of; for case in houses, lodgings, inn ventures, manufacturing plants, vehicle businesses and a lot more zones, which are identified with the group, individuals or advantageous things. Clients can essentially apply the gadget in their intrigued territory to shield the region from the presence of fire. At whatever point the temperature reaches the cut-off (40 °C), the gadget will quickly alarm the clients by communicating something specific through IoT.

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Промисловий Інтернет речей (IIoT) для оцінки пожежного ризику на основі електронного датчика

Rishi Dewan[1], Prince Mishra[2], Ranjeet Brajpuriya[1]

[1] *University of Petroleum & Energy Studies, Via Prem Nagar, Dehradun 248001, Uttrakhand, India*
[2] *HSE Specialist – Momentum India Pvt. Ltd, Noida, U.P. India*

Індустрія 4.0 означає, що пристроями керують за допомогою обчислень у вбудованих системах. Ця кіберфізична система дозволяє використовувати інфраструктуру Інтернету речей для безпеки людей і промислових підприємств. Впровадження цих автоматичних систем пожежогасіння зосереджено на висновках, отриманих під час оцінки пожежного ризику для клієнтів і постачальників. Основною причиною смертей унаслідок пожежі є надмірне вдихання диму. Отже, раннє виявлення пожежі має вирішальне значення в системах її виявлення та не може визначити точне місцезнаходження пожежі. У роботі розроблена система пожежної безпеки на основі IIoT для подолання проблем, виявлених під час оцінки пожежного ризику. Впроваджена система складається з трьох основних частин: блоку обробки, спостереження та сповіщувача. Блок сповіщувача являє собою інтеграцію датчика чадного газу, датчика вологості, зумера, датчика температури, іонізаційного детектора диму з ESP32. У разі виникнення пожежі система негайно подасть сигнал тривоги, а глобальна система позиціонування (GPS) з координатами та планом поверху приміщення буде надіслана до пожежної команди та органів влади. План поверху розроблений таким чином, щоб відстежувати точне місцезнаходження пожежі. Якісний метод був використаний для визначення бажаних функцій, інтегрованих в систему, та визначення рівня зручності для покращення, якщо таке є, наприклад, зосереджені групові обговорення, аудит безпеки та впровадження стандартів. Ця робота знизила ризики виникнення пожежі при таких катастрофічних подіях.

Ключові слова: FRA, GPS, Індустрія 4.0, Датчики.