Fire Incident Modeling of the 2022 Sitakunda Fire Event using Fire Dynamics Simulator

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ABSTRACT: The occurrence of fire accidents in Bangladesh has resulted in not only vast economic impacts but has unfortunately inflicted a lot of damage in the form of loss of life as well. The prevalence and severity of fire incidents within urban regions have been on the rise indicating a dire need for adequate fire management. This study centers around the Sitakunda Fire Event of June 4, 2022, and seeks to explore the event by developing two simulation models using Fire Dynamic Simulator (FDS). One simulation models the real scenario of the event and the other captures a "what if" scenario in which the hydrogen peroxide (H_2O_2) container was either not present or properly stored. The simulations produced time-series graphs illustrating the fire's dynamics. The results from the actual event scenario showed significantly higher levels of heat (energy) release, increased temperatures, and a drop in oxygen levels, which in turn resulted in poor visibility due to smoke. These metrics were tracked over time and showed a much more subdued fire intensity and lower damage in the second simulation. This comparison indicates a specific action to improve the level of fire risk. The correct storage or better control of hazardous materials like H_2O_2 could have significantly limited the overall damage. To achieve sustainable fire risk management and effective emergency response, this study highlights the need to incorporate simulation modeling and implement better fire management appropriate to high-risk areas. This approach is essential for understanding fire behavior and assisting in the preparation and mitigation of future fires in locations like the container depot.

Keywords: Fire Dynamic Simulator; Fire Hazard; Fire Simulation; Risk Management; Risk Reduction

INTRODUCTION

Overview of Fire Hazards and the Sitakunda Fire Event

According to the Bangladesh Fire Service and Civil Defense (BFSCD) official report (UNB, 2021), it was found that from January 1999 to December 2020, there were approximately 285,000 fire incidents across the country, resulting in economic damages of nearly Tk 6,900 crore and the loss of 2,308 lives between 2004 and 2020. In another report published by the BFSCD, in the year 2022, 21,402 fire cases were reported in the country which led to the loss of over 908 lives and injuring more than 407, which includes 13 firefighters. Furthermore, out of the 5,896 safety audits performed, 617 buildings were classified as "very risky" and more than 1,606 were marked as "risky" in compliance with fire safety rules and regulations. This data indicates that urban areas with a high risk of fires need a more proactive and effective approach to fire safety regulations and urban risk management.

On the evening of June 4, 2022, a fire broke out at the BM Container Depot, a Dutch-Bangladeshi private venture is situated in Sitakunda, employing more than 600 people handling import and export goods, including materials for the RMG sector and hazardous chemicals (Oltermann, 2022). Around 9 p.m. (BST, GMT +6), the fire started, and then there were several explosions, the first of which happened at midnight. These explosions resulted from the fire spreading quickly between containers, one of which held barrels of hydrogen peroxide (H_2O_2), an oxidizing agent that fueled the flames (BBC, 2022). It is still unclear what caused the fire in the first place, and depot officials failed to warn firefighters about the dangerous chemicals present, which prevented them from taking the appropriate precautions (Tayeb, 2022). Five firefighters were among the five people killed and twenty-one injured in the incident, which resulted in at least 47 fatalities and

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roughly 450 injuries (BBC, 2022). The fire spread over a minimum of seven acres and took approximately four days to fully extinguish. The initial explosion associated with this incident, which occurred approximately thirty to forty kilometers away, could be heard from a distance of thirty to forty kilometers. The explosion was powerful enough to shatter windowpanes in nearby houses (Tobias, 2022). Abrar et al. (2025) reported that the adjoining households in the neighborhood, where the fire broke out, also suffered significant destruction in the range of TK 82.8 lacs in damages and TK 107.2 lacs in losses. This incident highlights the increasing severity of the danger associated with fire, especially in the context of rapid urban growth in overpopulated cities like Dhaka and Chittagong. Urban areas consisting of concentrated residence, infrastructure, and economic activities are far more vulnerable to fire outbreaks than rural areas (Abrar et al., 2024; Maniruzzaman and Haque, 2007).

In Bangladesh, limited studies have utilized fire modeling methods resulting in a scarcity of knowledge and understanding of fire incidents in the country. The absence of dedicated modeling techniques has created a knowledge gap regarding fire incidents in the country. As such techniques are not commonly used in Bangladesh, fire dynamics simulator modeling could be beneficial in understanding fire behavior and predicting fire outcomes. Historically, formal investigations of fire incidents typically concentrate on visual and physical examinations of the fire scenes, eyewitness narratives, and other superficial analyses. Those methods are usually far too simplistic to capture the complexities of the event. Fire modeling methods help to study the intricate interplay of fire, smoke, heat, and the constructed setting and assist in fire causation and spread prediction. A forensic fire analysis was conducted by Mahmud and Rahman (2019) provided a detailed analysis of a fatal fire incident that occurred in a high-rise residential building in Bangladesh in 2010 which resulted in the deaths of 156 people while injuring many others. This research used fire modeling techniques to determine the cause of the specific fire in question to prevent the same type of incident in the future. Another study carried out by Sakib et. al. (2021) sought to study fire growth behavior in a residential apartment in Bangladesh using Fire Dynamics Simulator. FDS made it possible to assess the effectiveness of various fire safety measures in evaluating fire growth behavior. Considering these examples, fire modeling and simulation are indispensable tools for fire incident investigations in Bangladesh, and their urgency cannot be understated.

The 2022 Sitakunda fire incident represents one of the most devastating fires in Bangladesh and illustrates the need for fire modeling in the country. This incident led to enormous damage to property, pollution, and resulted in the loss of lives. The use of fire modeling and simulation in such investigations can not only explain the incident, but also determine the causes of the fire, its spread, and possible mitigation strategies. Furthermore, fire modeling can determine critical data such as the consequences of fire events to the ecosystem and the surrounding communities. Fire modeling and simulation outcomes, such as smoke movement, heat release, and fire spread patterns, can also be applied to future fire management in urban areas and the garments sector, which is one of the most important industries in Bangladesh, contributing significantly to the national economy and employment. Specifically, these results can inform risk assessments by identifying high-risk zones, guide emergency response planning including evacuation routes and firefighting strategies, and support the development of fire safety regulations and staff training programs.

This research has created two different simulations of the Sitakunda fire event showing the fire spread and its intricate features with time series graphs showing the differences between the two scenario conditions. The purpose of the study was to design a model of fire and simulations in Bangladesh to establish a basis for in depth inquiries, separating the country's susceptibility to fire into components and devising integrated strategies for preparedness and risk reduction. Additionally, insights from the simulation can aid in preventive measures, such as optimizing building design, material storage, and fireproofing practices, thereby enhancing preparedness and reducing potential losses from urban and industrial fires. This incident underscores the importance of fire modeling and simulation in Bangladesh for establishing a comprehensive standard procedure. Such modeling can provide essential cognizance to support disaster risk reduction and promote sustainable development through strategic planning.

Study Area

Sitakunda hosts the world's largest shipbreaking industry (TSJ, 2004), alongside a variety of other industrial sectors such as cement factories, jute mills, textile mills, re-rolling mills, and brick kilns. However, these industries are currently experiencing a downturn in demand, primarily due to growing concerns over environmental impact, workplace safety, and ongoing allegations of smuggling activities (CBS, 2006). Additionally, the workers are paid low wages and often have little access to medical treatment, while the ecology is reportedly damaged, with heavy metals polluting the soil and depleting fish populations. Safety standards in the industry are low with the main causes of death being fire or explosion, suffocation, and inhaling CO_2.

The fire took place at BM Container Depot, a privately operated facility situated in Sitakunda Upazila, Chattogram District, with geographic coordinates of 22.4550°N latitude and 91.7375°E longitude. The depot covers a total area of approximately 30 acres and is situated 40km from the southeastern port of Chattogram city. Sitakunda Upazila covers an administrative area of 273.47 km² (BBS, 2011) and has a total population of 335,178, resulting in a population density of 1,200 inhabitants per km². The location of the depot relative to Chattogram district is displayed in Fig. 1.

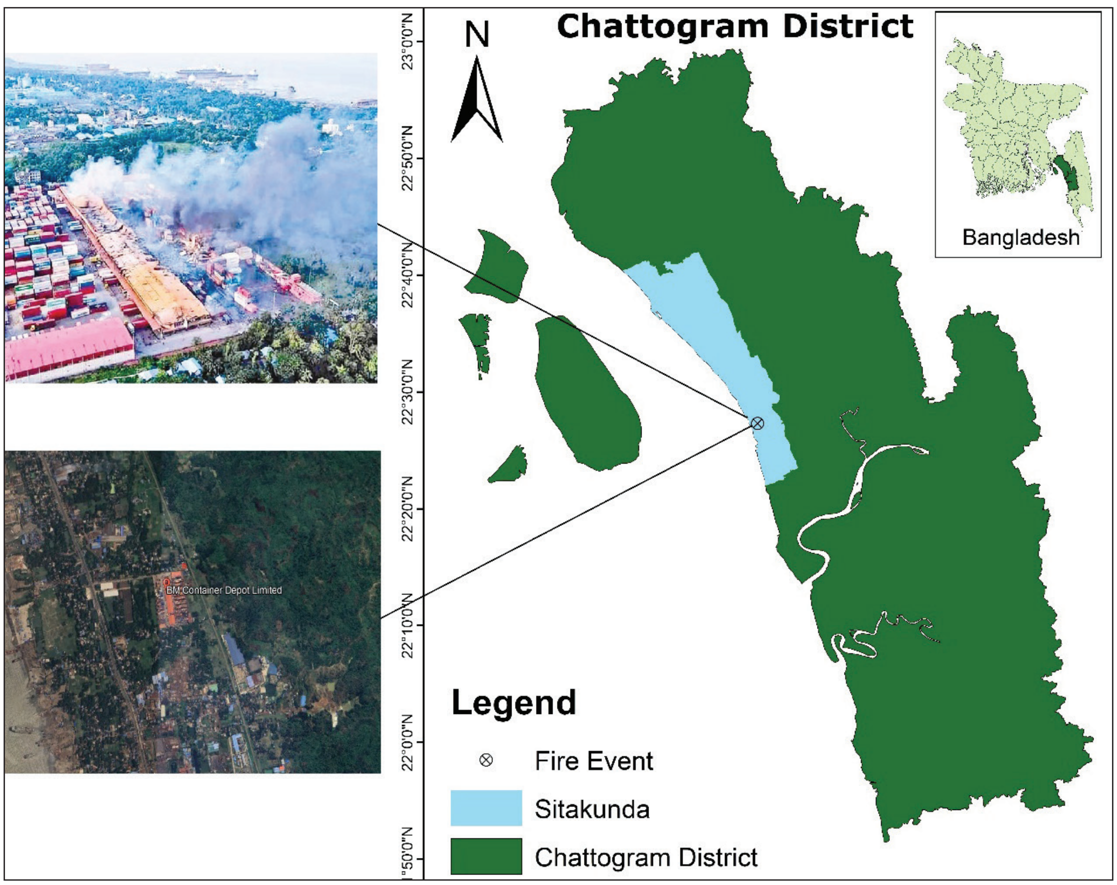

Figure 1: Map of Sitakunda. Source: Daily Observer and Google Earth (Amin, 2022)

METHODS

Fire Dynamics Simulator

Fire modeling tools such as Computational Fluid Dynamics (CFD) enable in-depth fire analysis while conducting comprehensive risk assessments regarding incidents and their environmental impacts, financial implications, as well as human casualties. CFD modeling replicates real-world fire scenarios with great accuracy. With CFD models, fire safety experts and engineers can analyze with adequate detail the movement of smoke, the spreading of toxic gases and the mechanical behavior of fire in complicated geometries (Yeoh and Kwok Kit, 2009). Such models can also help to figure out the gaps in the knowledge and action undertaken by stakeholders to enable better tailored solutions.

The simulation of the fire event was carried out using a software called Fire Dynamics Simulator (FDS) developed by the National Institute of Standards and Technology (NIST), a non-regulatory research laboratory within the United States Department of Commerce that focuses on physical sciences. Typical fire incidents investigations make use of physical fire testing through laboratories as well as software models which stem from computational fluid dynamics. FDS is an example of such CFD computer model which simulates fire spreading through structures and analyzes various fire scenario outcomes and how they interact with the environment around them (Tuhuț et al., 2022). Using scientific fire protection engineering along with fire and evacuation simulations often yields the most effective results. A study conducted by Packer Engineering Inc. has shown FDS to be effective in constructing models to assess the potential risk of an explosion and subsequent failure of fire safety systems in buildings (Ryder et al., 2004). For visualization of the FDS output results, a secondary program, SmokeView (SMV) has been used. NIST has created another software called PyroSim, which serves as a graphical interface tool for FDS, streamlining the fire modeling process (Long et al., 2017). FDS was created to solve real fire protection engineering challenges, as well as to study and investigate fires and combustion phenomena (Shen et al., 2008). FDS models a physical domain using grids of cells, each of which represents a small volume of the physical domain, simulating the smoke and hot gas emission movement caused by fires by solving the Navier–Stokes equations . To customize and analyze simulations, FDS provides a number of additional input and output files. Input files for FDS contain domain geometry, material properties, and simulation boundaries and initial conditions. The output files detail the simulation's status at every timestamp which includes temperature, velocity, and concentration of various species (McGrattan, 2006).

However, as with all simulation tools, FDS has some shortcomings. FDS, for example, can only simulate the combustion of a single gaseous fuel, which, as expected, results in poor performance in multi-fuel scenarios. Regarding the validity of numerical simulation results, Jahn et al. (Jahn et al., 2008) studied the sensitivity of FDS fire growth simulations to different model parameters like convection and radiation, combustion parameters, fire size and location. They concluded that simulations of fire growth are very sensitive to both the location and heat release rate. Rein et al. (2009) performed a round-robin study on the predictive FDS modeling of the Dalmarnock Fire One Test. Their comparison showed considerable variability and discrepancies both among the predictions and between the predictions and experimental measurements. Research conducted afterwards in Edinburgh (Rein et al., 2007) showed that the FDS model has little predictive capability for fires in small spaces with limited ventilation. Thus, it can be concluded that for the highest level of accuracy, modeling realistic enclosure fires requires experimental measurements from fire tests that are directly related to the specific scenario being studied.

Simulation Scenarios

To replicate the study area, the fire's point of origin, the type of fuel, the obstructions to fire flow and smoke movement, possible fire fuel sources, and the dimensions of the study area all had to be mapped and coded. Based on these features, the software created a graphical illustration of how the fire spread and calculated smoke concentration, visibility, heat release rate per unit volume (HRRPUV), heat flux (radiative and convective), burn rate, temperature, and soot density. The results were then depicted in time series plots so that the firefighting response could be compared to the actual response. Such simulation can assist in evaluation of responsive strategies and preparedness measures concerning firefighting for anticipated fire scenarios.

Two separate simulations have been created based on two separate scenarios. The simulation parameters aimed to replicate the incident scene at the time of the fire. A mapping of the incident area has been conducted during field surveying and data collection with the help of the authorities of BM Depot. Due to the limited data provided by depot officials, particularly the lack of detailed structural layouts, material specifications, and information on other stored substances, the simulation parameters were simplified to represent the overall depot environment rather than localized variations.

The first scenario is of the actual event, a container filled with smaller H_2O_2 containers near the point of the fire and the second scenario is of a hypothetical situation, the same parameters being used but with an empty container instead of one with H_2O_2 used in the first scenarios. The two scenarios were run for a total of 8400-time steps, total intervals of the data processing, analysis, and result formulation. The 8400-time steps constructed into a total simulation time of 120 seconds.

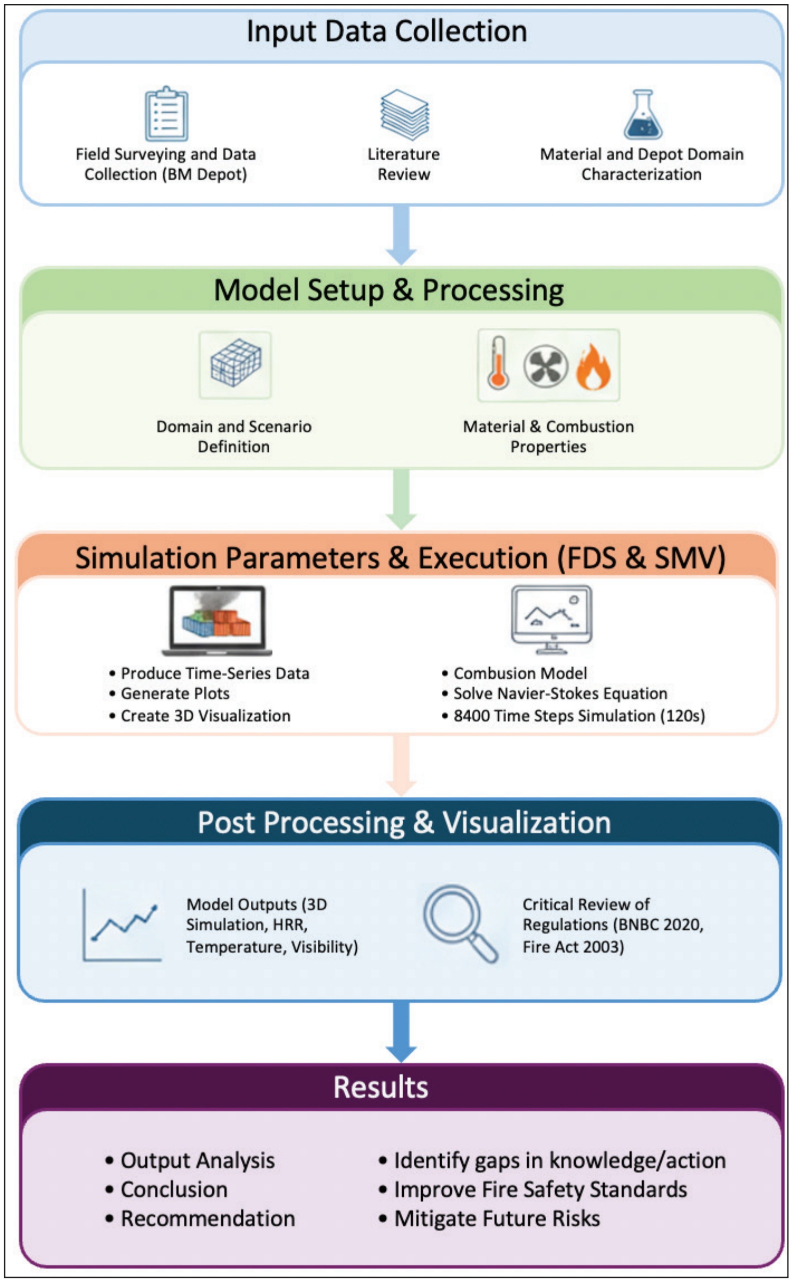

Figure 2: A Methodological Framework for Simulating and Analyzing the 2022 Sitakunda Depot Fire

Figure 2 illustrates the methodological framework of this study comprising of four sequential stages: Input Data Collection, Model Setup & Processing, Simulation Parameters & Execution (FDS & SMV), and Post-Processing & Visualization. The initial stage, Input Data Collection, involved comprehensive field surveying and data collection at the BM Depot site, complemented by a thorough review of relevant literature, Sitakunda reports, and applicable regulations. The subsequent Model Setup & Processing phase focused on translating the collected data into the FDS environment. This involved defining the computational domain geometry and mesh based on the depot layout. Material and combustion properties were assigned, and initial and boundary conditions (such as ambient temperature and ventilation) were carefully defined to replicate the incident scene as closely as possible, given the available data. FDS was then utilized to run each simulation for 8400-time steps, totaling 120 seconds of simulated time. Concurrently, SmokeView was also integrated to extract time-series data and generate 3D visualizations from the FDS output. Finally, the Post-Processing & Visualization stage involved analyzing the extracted data. Time-series plots were generated for key fire parameters including heat release rate, temperature, visibility, and soot density, allowing for a detailed comparison between the actual and hypothetical scenarios. The insights derived from these stages informed the conclusions and recommendations for improving fire safety standards and mitigating future risks.

RESULTS

Simulation Output

Relative to the primary source of the fire event, there were also several other containers in the surrounding area, represented by blue blocks in the simulation. These included 16 containers on the south, two sets of 8 containers of 4-high height (4 vertically stacked containers) on the southwest and southeast sides, 6 containers of varying heights on the east, and 6 containers in two stacks of 3-high height on the north. The brown block at the east in the simulation represents a warehouse that was completely burned down in the actual event. Each container in the simulation was set to have dimensions of 3m × 6m × 3m. Fig. 3 illustrates the set of the BM depot environment modelled along with the input parameters provided to the model to generate domain setup as well as the simulation.

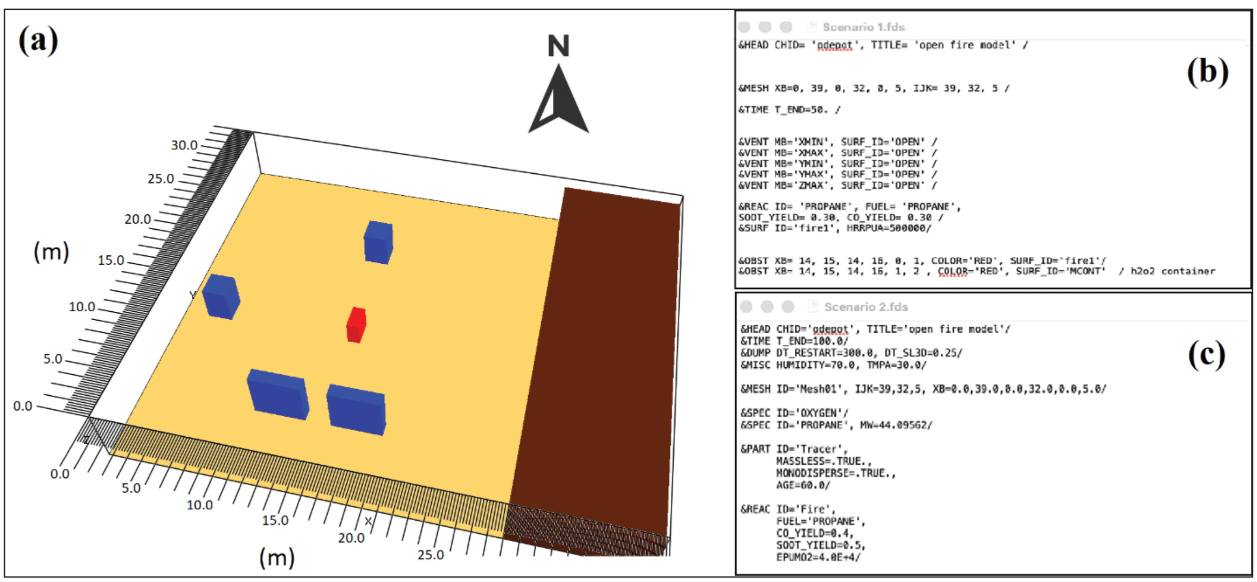

Figure 3: Visualization of the BM Container Depot Model (a) and Corresponding FDS Input Configuration used for Fire Simulation for Scenario 1 (b) and Scenario 2 (c)

Hydrogen Peroxide is a pale blue liquid that is an oxidizing agent (Housecroft and Sharpe, 2012) that can enhance combustion of other substances. H_2O_2 has a boiling point of 150°C and undergoes explosive thermal decomposition if heated to this temperature (Brauer, 1963). H_2O_2 is not a combustible material itself, but it can cause intense fires due to the large amounts of O_2 it releases. Fires involving H_2O_2 should be flooded with water, and dry chemical extinguishing agents should be avoided (New Jersey Department of Health, 2016). Due to the large amounts of O_2 released from the chemical H_2O_2, the fire behavior was much more intense in scenario 1 compared to scenario 2.

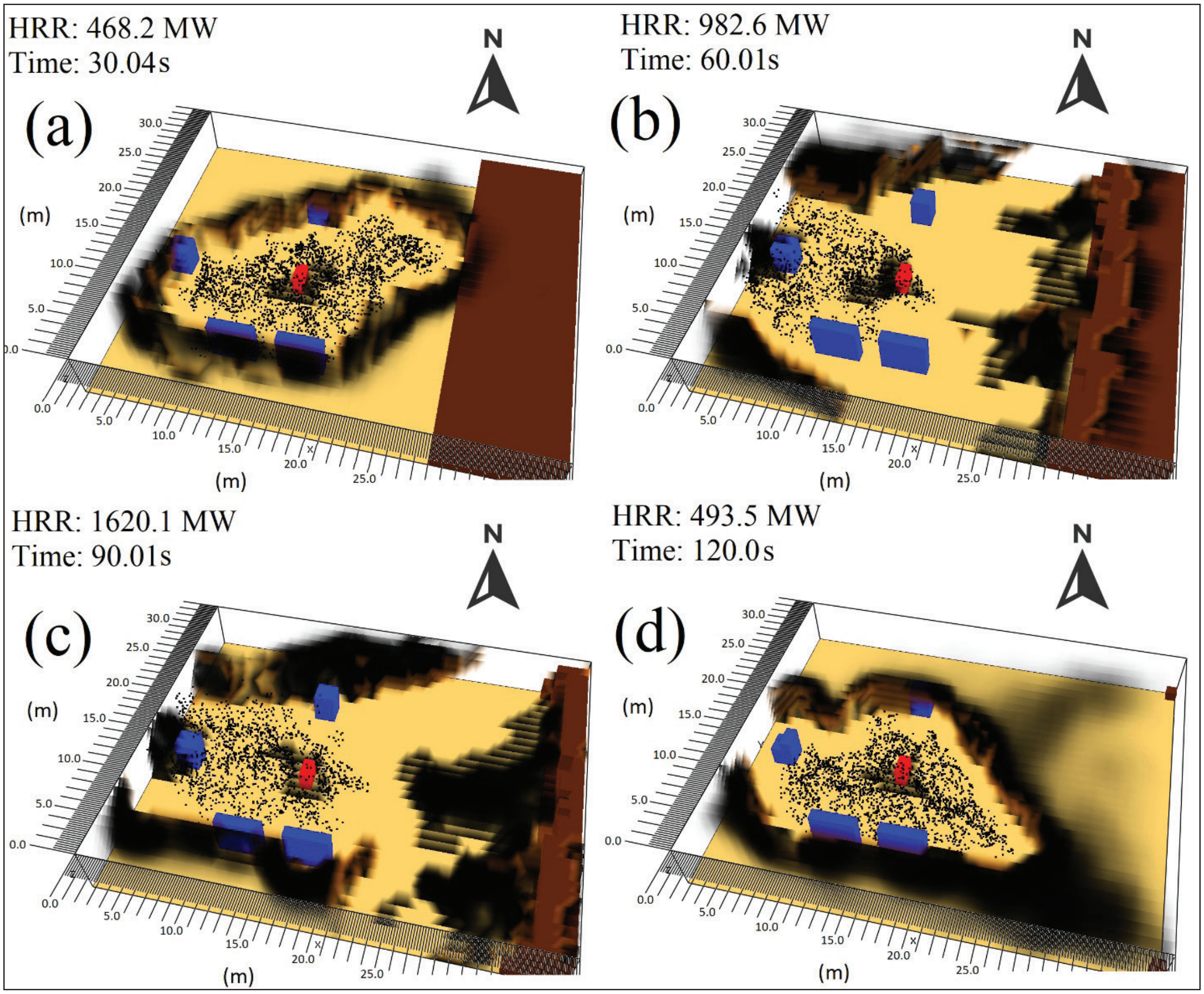

Figure 4: Progression of Fire and Smoke Movement of Scenario 1 Model at Intervals of T = 30s (a), T = 60s (b), T = 90s (c), and T = 120s (d)

Figure 4 shows the fire behavior of scenario 1 at 30-second intervals. The origin of the fire was in the lower container, with H_2O_2 in the upper container in the center. The fire spread quickly to the warehouse and burned it down completely by the end of the simulation at T=120s. The fire's intensity was accelerated by the release of oxygen from the chemical breakdown of H_2O_2, resulting in a large amount of dense soot.

Figure 5 illustrates the behavior of a fire in scenario 2, with a time interval of 30 seconds. The red block represents two stacked containers, the lower one as the origin of the fire and the upper one as an empty container. Unlike scenario 1, the excess oxygen release did not occur, and therefore the fire behavior was less vigorous. The fire did not spread as far as the warehouse, and the soot generated was less spread out and less dense.

As displayed in Figure 6, in scenario 1, the HRR (heat release rate) reached a peak of 5.1×10^5 KW at T=10s, remained stable until T=43s, and then sharply rose to 1.4×10^6 KW. The HRR then fluctuated between 1×10^6 KW and 2.92×10^6 KW until approximately T=115s, after which it dropped back to a steady value of 5×10^5 KW. In contrast, scenario 2 showed a steady increase in HRR, starting from 2.5×10^5 KW at T=0s and fluctuating between 1.5×10^5 KW and 2.85×10^5 KW until the simulation ended at T=120s.

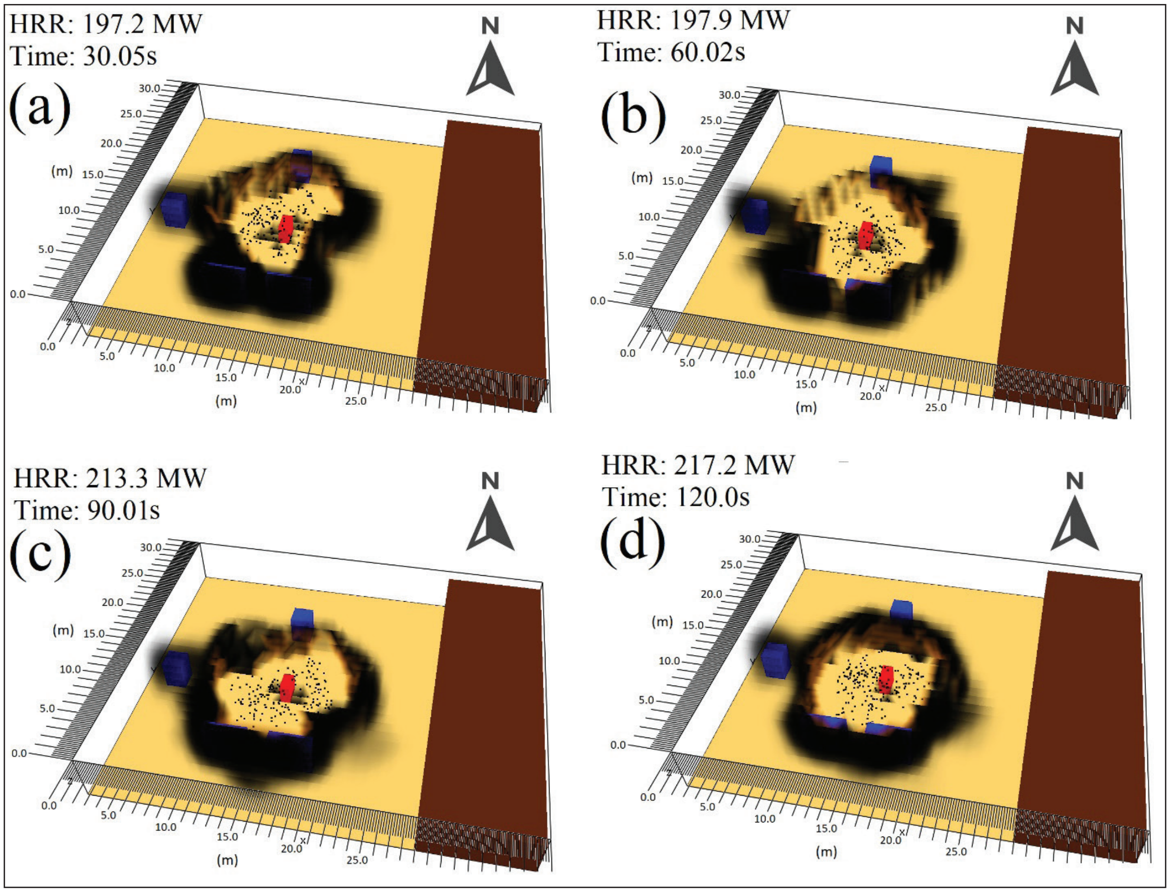

Figure 5: Progression of Fire and Smoke Movement of Scenario 2 Model at Intervals of T = 30s (a), T = 60s (b), T = 90s (c), and T = 120s (d)

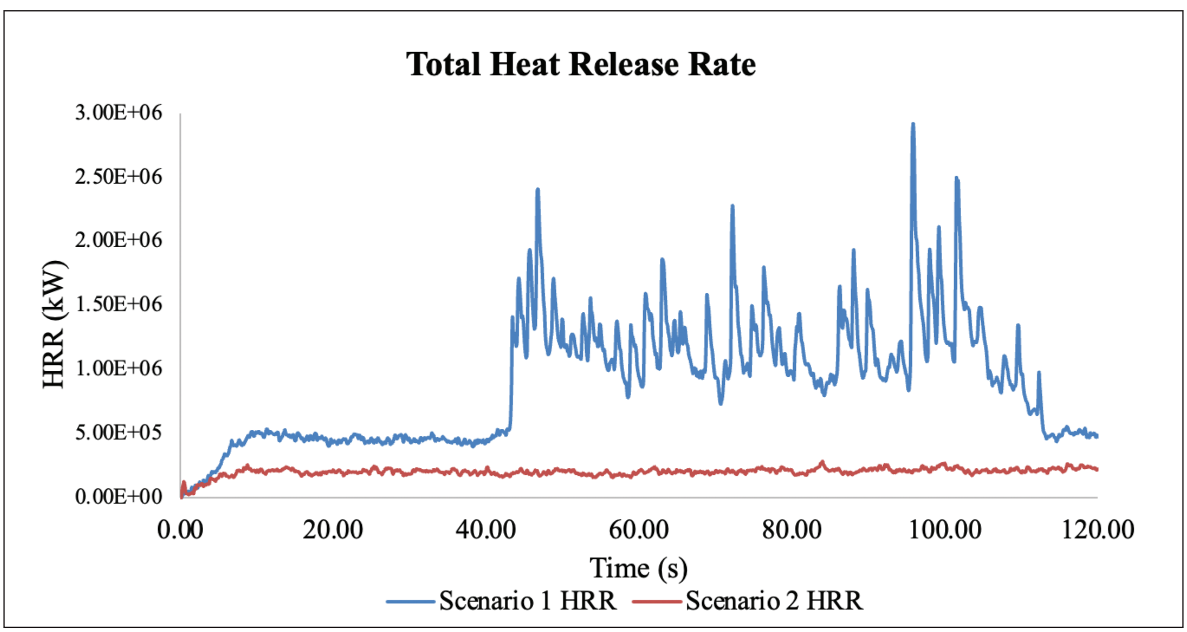

Figure 6: Total Heat Release Time Series Plot. Scenario 1 Generated Significantly more Amount of Heat Compared to Scenario 2 with a Sharp Increase and Fluctuating Levels of HRR Starting at T = 43s

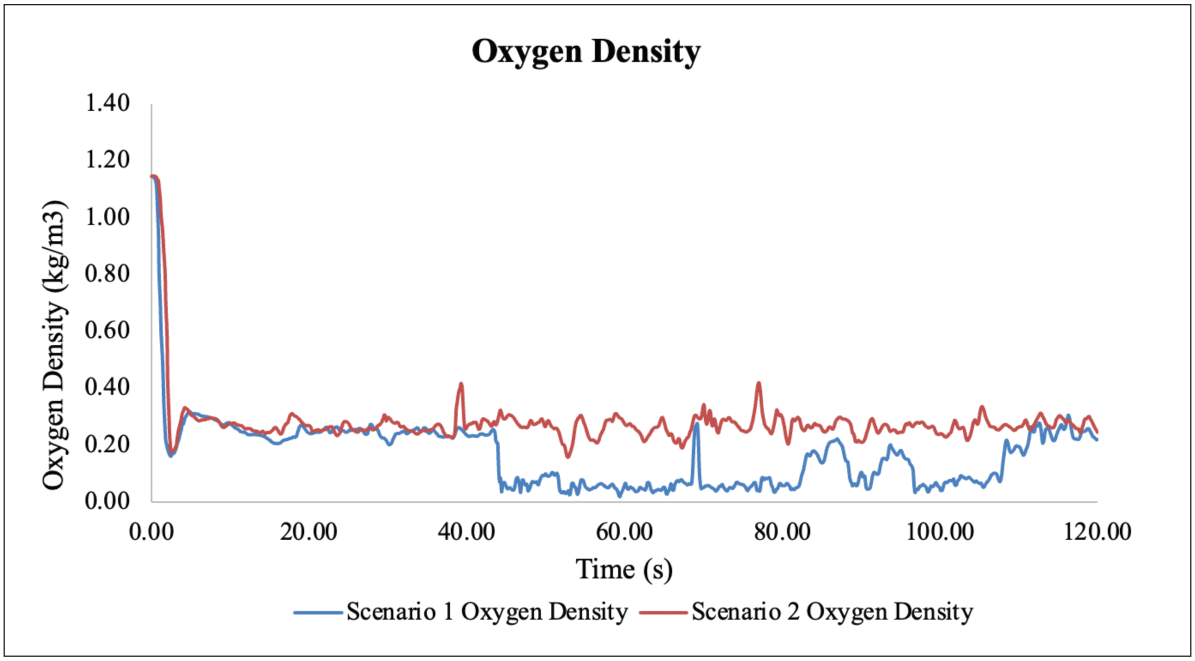

Figure 7: Oxygen Density Time Series Plot. Scenario 1 had Lower Levels of Oxygen Density Compared to Scenario 2 Indicating more Oxygen from the Environment was being used as Fuel for the Fire

In both scenarios, the differences in heat release rate (HRR) were greater than the differences in oxygen density as represented in Figure 7. In Scenario 1, the oxygen density dropped from 1.15 kg/m^3 to 0.16 kg/m^3 at 2.5s and then fluctuated between 0.018 kg/m^3 and 0.32 kg/m^3 until the end of the 120s simulation. In Scenario 2, the oxygen density dropped from 1.15 kg/m^3 to 0.17 kg/m^3 at 2.4s and then consistently fluctuated between 0.156 kg/m^3 and 0.427 kg/m^3.

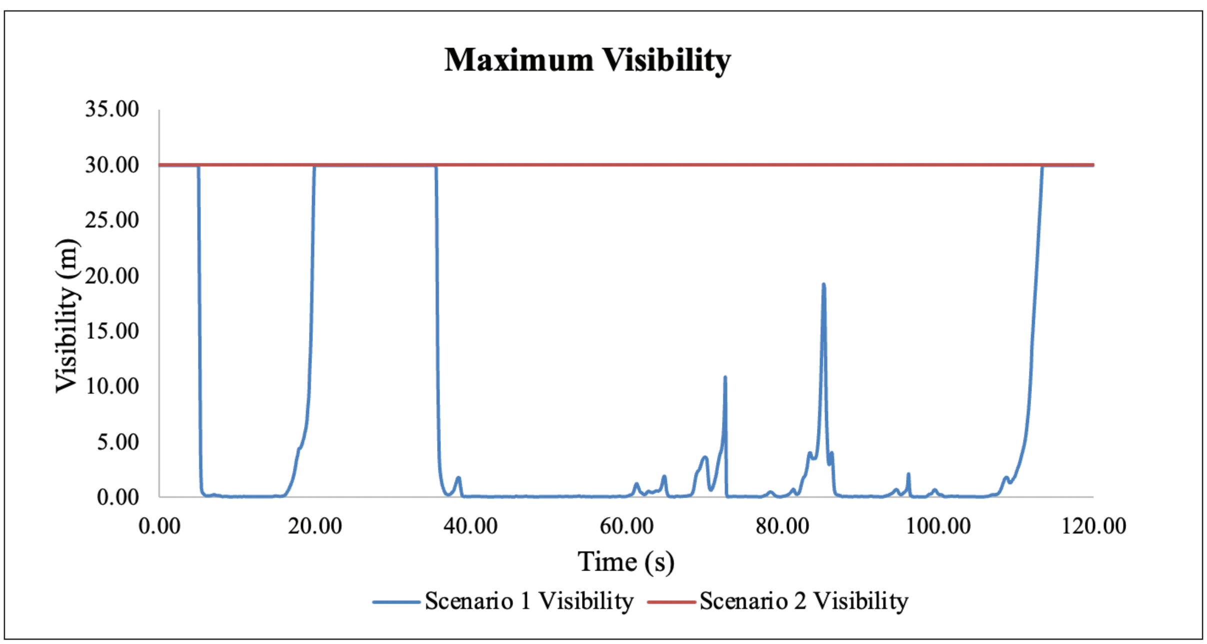

Figure 8: Visibility Time Series Plot. Scenario 2 had a Steady Visibility Indicating Lower Levels of Soot and Smoke Whereas Scenario 1 had Fluctuating Levels of Visibility Even Reaching Zero at Times

The visibility sensor was positioned 10.6 meters away from the fire source, and the two scenarios resulted in markedly different outcomes. Figure 8 showcases a time series graph of the visibility comparing both scenarios. In scenario 1, the visibility was highly variable and dropped to almost zero at T=9s due to the extreme density of smoke. The visibility continued to fluctuate, occasionally reaching high visibility, until T=106s, after which it started to improve. At T=114s, the visibility reached a maximum of 30 meters. In contrast, scenario 2 showed consistent visibility of 30 meters, indicating a relatively low amount of smoke generated at the sensor location.

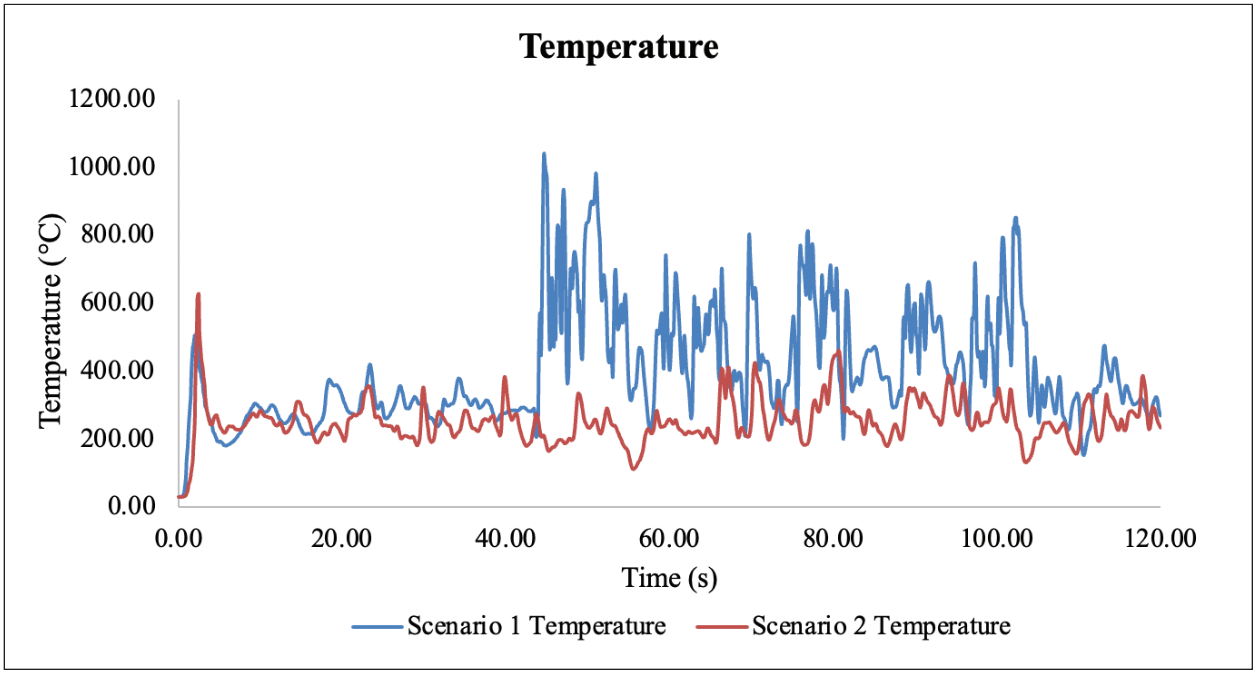

Figure 9: Scenario 1 Temperature Time Series Plot. Both Scenarios had Fluctuating Temperature Readings with Scenario 1 Showing Higher Temperature Levels Compared to Scenario 2 at All Time

As represented in Figure 9, scenario 1 exhibited a temperature increase from 30°C at T=0s to 506°C at T=2s, followed by a drop to 181°C at T=5.65s. From T=6s to T=23s, the temperature fluctuated between 181°C and 420°C. There was a sharp increase in temperature to 1040°C at T=44.6s, with rapid and sharp fluctuations between 983°C at T=45s and 152°C at T=111s until the end of the simulation. In Scenario 2, the temperature increased to 627°C at T=2.4s, dropped to 218°C at T=5.6s, and fluctuated rapidly between a lower end of 112°C at T=55.6s and a higher end of 462°C at T=80.6s.

DISCUSSION

Upon comparation of the two simulated scenarios, it is evident that the presence of excess oxygen emissions in scenario 1 led to a faster and wider spread of fire compared to scenario 2, where such emissions are absent. In fact, the warehouse located to the east is entirely burnt down in scenario 1, just like the actual fire incident, whereas it remained unaffected in scenario 2. Moreover, scenario 1 generated a significantly larger amount of soot and smoke than scenario 2. H_2O_2 decomposes into water and oxygen with rise in temperature, and the resulting oxygen may be released into the atmosphere and fuel other fires in the area, leading to a further spread of the fire (Petrucci; H, 2007). The greater intensity of the fire in scenario 1 compared to scenario 2 can hence be directly contributed to the presence of H_2O_2 which emitted large amount of oxygen after reaching the chemical's melting point. The emission of oxygen accelerated the dissemination of the fire onto the surrounding environment.

The presence of H_2O_2 in a fire scenario can supply additional oxygen to the combustion process, therefore increasing the rate and extent of the fire. Fire requires a combination of fuel, oxygen, and heat to sustain itself, a concept known as the fire triangle (NPS, 2016). When additional oxygen is available, as is the case with the release of oxygen from H_2O_2, the fire triangle is enhanced, leading to a more vigorous fire. The availability of additional oxygen makes the fire burn hotter and spread more rapidly (NOAA, 2022). H_2O_2 can also react with other substances in the fire to produce more heat, contributing to the increased spread of the fire.

The total heat release rate, as seen in Fig. 6, among the two scenarios was also much different. Scenario 1 not only generated more amount of heat compared to scenario 2, at T=43s there was a sudden increase in HRR seen which corresponds to the same time period in the simulation when the warehouse first started to catch fire. As the fire started, it consumed fuel and oxygen, leading to an initial surge in heat release rate. As the fire continued to burn, the heat release rate increased or decreased depending on the availability of oxygen and the fuel properties (Babrauskas and Peacock, 1992).

Scenario 2 had higher oxygen density on average throughout the simulation, as seen in Fig. 7. As fires burn, it consumes oxygen from the surrounding air and can reduce the oxygen concentration in the environment. The more intense fire in scenario 1 used up more oxygen compared to scenario 2 resulting in the difference in the two scenarios' oxygen density. This phenomenon aligns with the fundamental understanding that oxygen concentration directly impacts fire intensity (Quintiere, 2006).

The fluctuating levels of visibility, graphically represented in Fig. 8, in scenario 1 compared to the constant level of visibility in scenario 2 can be justified by the pattern of smoke movement. In the first scenario the smoke from the fire spread much further while in the second scenario it was confined within a smaller range, not reaching as far as the sensor defined in the simulations. The higher levels of temperature in scenario 1 compared to scenario 2 can also be justified as when fire burns, it releases heat that can increase the temperature of the surrounding environment. The dispersion of smoke affects visibility, and this has critical implications for firefighting efforts and evacuation procedures (Guidotti and Clough, 1992).

Similar to the time series plots of HRR, there was a sharp increase in temperature, displayed in Fig. 9, seen for scenario 1 at T=43s, the moment when the warehouse starts to burn. This initial temperature increase is typically due to the sudden release of energy as the fuel ignites, which can cause an initial surge in heat release rate (Drysdale, 2011).

In summary, the simulations and their analysis highlight the significant impact of H_2O_2 on fire behavior. The chemical's ability to release oxygen, contribute to heat generation, and alter oxygen concentration in the environment all contribute to the observed differences in fire spread, intensity, visibility, and temperature between the two scenarios.

CONCLUSIONS

This specific research intended to apply fire modeling within Bangladesh to advance its scientific regard for predictive fire behavior models that can be applied to future potential fire events and scenarios. The Sitakunda fire tragedy of 2022 highlights the countless gaps in the need for tools of advanced investigation beyond the traditional eyewitness account and evidence collection methods. Mainstreaming fire modeling within the framework of disaster risk management in Bangladesh may help the country set more effective national fire safety regulations and construct policies to minimize the devastation caused by such disasters. Understanding fire dynamics is critical not only for the protection of communities, but also for sustainable development in fire-prone areas. This research addresses both issues being beneficial for academia and policy making alike.

In addition to analyzing fire dynamics, it is important to consider measures for constructing a fire-resilient container depot and improving fire management strategies. The comparison among scenario 1 and 2 highlights the significant role of hazardous materials in fire dynamics. This underscores that fire management strategies for depots storing hazardous materials must differ from those without such substances. The use of fire-resistant or non-combustible materials for walls, roofs, and storage containers can slow fire spread and reduce structural damage, while active fire protection systems such as fire detectors, alarms, and hydrants enable early detection and rapid response. Strategic depot design, such as maintaining adequate spacing between containers, ensuring proper ventilation, and providing designated fire lanes, further limits fire propagation (Drysdale, 2011; Wang, 2002). Preparedness measures and firefighting approaches should be tailored to the type of materials stored (Nadarajah et al., 2024). For example, fires involving chemicals like H_2O_2 require specialized suppression techniques and safety protocols as they cannot be effectively or safely controlled using conventional methods like water or sand (Lee et al., 2010). Incorporating these structural and operational measures into depot planning can enhance overall fire safety, inform regulatory standards, and support staff training programs, contributing to more resilient container depot operations.

This study was not without its limitations as numerous challenges arose from gathering data to conducting analysis. The software used had computational limitations, so the containers' dimensions were adjusted to match the software's capabilities. Instead of the actual dimensions of 2.43m × 6m × 2.74m, the containers were simulated with dimensions of 3m × 6m × 3m. The grid size of the simulations was set at 3m each to prevent significantly increased computational time. Each calculation took approximately 0.5 hours using the simulation parameters, whereas using a grid size of 0.33m, which could have provided better outcomes, would have taken around 30 hours. Furthermore, the limited availability of detailed structural and material information from the depot officials constrained the ability to model localized variations in fire behavior, smoke movement, and heat release accurately. As a result, the current simulations provide a generalized representation of the depot's overall fire dynamics, and the exact placement of obstructions could not be replicated. Future studies incorporating comprehensive spatial layouts, material specifications, and storage details are essential to achieve more precise and realistic fire and smoke modeling, which would better inform disaster risk reduction and emergency planning.

In the context of providing a regulatory framework to prevent and manage fire disasters, the Fire Prevention and Extinguishing Act 2003 (GoB, 2003) and the Bangladesh National Building Code (BNBC) 2020 (MoHPW, 2021) are particularly relevant as the primary legislation in such scenarios. The Act of 2003, enacted to enhance fire safety standards and emergency response mechanisms, emphasizes the importance of fire prevention measures and effective firefighting strategies. Additionally, BNBC has undergone amendments in response to past fire incidents setting out specific provisions for fire prevention. Moreover, there exist numerous guidelines for safe storage of combustible chemicals in industrial warehouse settings incorporating regulations of specific room temperatures to maintain nearby objects, humidity conditions and much more.

Although these laws exist, fire events continue to occur regularly. Such regulations are often ignored by concerned organizations due to lack of knowledge, caution, and supervision combined with the absence of a governing body responsible for regular inspections of regulations being met. Continuous vigilance and improvement in fire safety standards are of paramount importance to mitigate the risks of similar incidents in the future.

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