PROCEEDING BOOK

Fifteenth International Scientific Conference
of the Iraqi Mathematical Society in Cooperation
With College of Science - University of Zakho
And Al-Anwar Center for Development and Education

19 – 20 July 2025 Duhok / Zakho

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Table Content

Modeling of thermal gradients through a wall using polystyrene as thermal insulation

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Abstract

Relying on advanced technologies in the optimal use of resources and energy ensures the sustainability of building efficiency and environmental protection. Therefore, the need for modeling the evaluation of the thermal behavior of buildings has increased significantly in order to reduce energy consumption in buildings and evaluate the performance of heating systems. The importance of modeling programs is evident in classifying, analyzing and organizing data to reach highly accurate results. Therefore, they have been increasingly relied upon because they achieve maximum efficiency at the lowest cost. In this research, a layer of polystyrene was added as an insulating material to an external wall of a building. Several models were tested by changing the thickness of the insulating layer inside the studied external wall and its effect on the temperature distribution over the entire wall section using the ANSYS program with the Computational Fluid Dynamics (CFD) methodology. The researcher concluded that the best thickness for the polystyrene insulation layer is 5 cm, which led to a decrease in the thermal load to 0.57 W/m^2°C after it was 5 W/m^2°C without adding it to the wall, which constitutes an efficiency in reducing the thermal load by 88%. The temperature between the two surfaces of the wall decreased by 9 degrees Celsius. Thus, we concluded that thermal conductivity decreased by using a layer of polystyrene as an insulating material with good chemical stability and corrosion resistance to protect the structural elements of the building, reduce environmental pollution and thermal emissions, and rationalize energy consumption.

Keywords: thermal insulation, computational fluid dynamics, polystyrene, ANSYS FLUENT program, convection thermal.

1. Introduction

The use of thermal insulation is one of the most effective means of energy conservation in the real estate sector because it affects three areas in the construction sector: economic, environmental and social. Thus, the thermal resistance provided by thermal insulation increases with the thickness of the insulation layer and the decrease in its thermal conductivity. While insulation materials also play an important role in influencing other thermal properties such as corrosion factors, time delay and peak transfer loads. The types of insulation materials available vary in terms of thermal properties, and to choose the appropriate insulation according to what is locally available, the most important of which is thermal conductivity, taking into account adaptation to the construction site and durability, fire protection, smoke emission during fire, mechanical strength, durability, freeze/thaw resistance, climate and thermal losses from buildings occur through external walls, windows, roofs and floors as well as through air leakage. Where the wall thermal conductivity resistance (R) and thermal conductivity (k) are calculated such that the required thickness of insulation is equal to the wall thermal conductivity resistance multiplied by the thermal conductivity [1].

To design energy-efficient buildings and address the effects of climate change, the need for sustainable technologies is increasing, and the continued use of thermal insulation will certainly always be the optimal approach in climates where heating or cooling requirements dominate energy consumption. To achieve the design of buildings with near-zero energy consumption, new sustainable building strategies are constantly being introduced and adopted in the construction sector. Thermal insulation is a fundamental strategy, and thermal insulation is primarily conceived and implemented by simplifying heat transfer in a steady state, making its contribution easy to predict and control with high confidence. While the concept of “dynamic thermal insulation”, or variable thermal insulation, has historically been found mainly in warm regions, several recent studies show that there is a growing interest in its application in buildings to balance the few disadvantages of intensive thermal insulation or to allow buildings to adapt to changing seasonal climatic conditions. Thermal insulation can have a more beneficial contribution than the steady state assumption allows and it can offer great potential for improving the energy efficiency of a building by developing and improving the thermal insulation of the envelope according to the actual needs of the building throughout the year [2].

Thermal insulation is one of the most important factors used in wall construction. Because about 40% of the total energy consumption is related to the building area. Unsteady heat transfer in building walls depends on several variables such as thermal conductivity, density and heat capacity of the composite wall layers. These variables will lead to an increase in the heat transfer rate due to temperature differences [3].

1.1. Thermal insulation

Thermal insulation is a method in which special materials with good insulation properties are used, placed on surfaces that separate the external climate of the building from the internal climate, to prevent heat transfer from the medium with a higher temperature to the medium with a lower temperature, using materials with thermal insulation properties that have thermal conductivity resistance properties to ensure thermal comfort for residents to reduce the spread of heat, materials with higher thermal diffusion and lower solar radiation absorption have acceptable thermal responses and this makes them used as better insulation in residential buildings, as internal thermal discomfort is a major challenge and one of the reasons for this is the type of materials used in construction. Thermal insulation has been used to use energy to meet the demand for thermal recovery. The truth of thermal insulation lies in how to use appropriate insulation in the installation by choosing the appropriate material that reduces heat gain or loss, which leads to a decrease in energy costs, and finally the study focused on collecting modern thermal insulation technology in the building by choosing the best materials [4].

1.2. Principle and methods of heat transfer in materials

Heat is transferred according to physical laws by the effect of temperature differences from the higher temperature section to the lower temperature section. There are three main methods of heat transfer:

1) Conduction: It is carried out through the parts of the material by its molecules without any change or transfer of the position of the molecules from their place, as heat flows by conduction between these molecules, as in homogeneous solid materials.

2) Convection: It occurs in moving gases and liquids, where molecules are carried from a hot place to a cold place.

3) Radiation: Thermal radiation has the same physical properties as light radiation, and it is a form of electromagnetism that travels at the speed of light and can be transmitted in a vacuum [5].

1.3. Layer distribution and its relationship to thermal storage

The thermal conductivity of structural elements depends on several factors, including the properties of the material from which the elements are composed, their thickness, and the exposure of their external surfaces to weather factors. An increase in the thermal conductivity value of structural elements, i.e. a decrease in the total thermal resistance value, indicates an increase in the ability of the elements to transfer heat, which means an increase in the amount of heat lost in winter and gained in summer, and thus an increase in the energy required to heat and cool the building.

One of the main tasks of thermal insulation is to improve the thermal performance of structural elements and reduce the heat transmitted through them, as a high percentage of the energy used to heat or cool buildings is saved by thermally insulating them. However, the thermal behavior of thermally insulated elements is not only related to their thermal insulation, but also to the location of the thermal insulator in them [6].

2. Computational Fluid Dynamics (CFD)

Over the last one decade, there has been a large growth in the application of Computational Fluid Dynamics (CFD), has many advantages over modelling approaches as it is a low-cost, high-speed technique for evaluating engineering systems that are difficult to simulate in a laboratory.

CFD is a branch of fluid mechanics that uses numerical analysis and data structure to solve and analyze problems that involve fluid flows. Computers are used to perform the calculations required to simulate the interaction of liquids and gases with surfaces defined by boundary conditions. The CFD method is the complete theoretical approach to analyze heat and mass transfer in buildings. It can provide detailed information on air temperature, air velocity, and contaminant concentration once the mathematical model and its boundary conditions are solved [7].

3. Materials and Methodology

When designing buildings, reducing energy consumption is one of the most important things that designers focus on, and one of the most important solutions is the use of thermal insulation. In this research. The analysis of the work processes was carried out using a computational technique based on the equations of heat conduction, convection heat exchange and radiation heat exchange, as well as the equations describing the movement of gas and liquid and their phase changes, given in the ANSYS Fluent package with CFD methodology.

The lower indoor ambient temperatures lead to lower energy consumption. The effectiveness of the proposed method was verified using computational analytical modeling through CFD analysis. The proposed methodology can be effectively used for both existing and future buildings.

This analysis is the result of computational modeling after taking data in existing rooms where the boundary conditions are taken as the outdoor ambient temperatures and thus the thermal modeling using computational fluid dynamics analysis by applying insulators and determining the reduction in the transfer of heat current through the structural elements.
The heat current rate is used to calculate the amount of heat lost and gained through structural elements needed to determine the heating and air conditioning loads of the building.

Polystyrene has been adopted as a thermal insulation material to achieve several factors, the most important of which are: low thermal conductivity, does not expand, rust or fade, has excellent resistance to high strong pressures, has water resistance, moisture resistance, light weight, ease of use, excellent stability and corrosion resistance, good environmental performance, sound insulation and reasonable prices, and therefore it can be used, which will save a lot of energy as a result of reducing the use of high-capacity cooling devices and provide comfortable conditions for building occupants, and reduces the environmental impact and reduces material costs due to high energy consumption.

The materials used in the wall are mainly bricks, which are covered from the outside with cement and from the inside with cement and gypsum, in addition to the thermal insulation used in the study, which is polystyrene, which is a good insulator for sound and heat. Polystyrene insulation is very durable and has a significant impact on energy consumption and reduces the impact on the environment, providing comfortable conditions inside buildings.

4. Steps of numerical modeling using the Computational Fluid Dynamics methodology

4.1. Building a mathematical model which is a set of mathematical relationships that achieve the physical properties of a particular system that we want to simulate using the CFD methodology. This set of mathematical relationships is called the term Solvers, which determine the physical properties of an issue, and the term Boundary Conditions to understand the mathematical model system and the surrounding conditions (such as the type of fluid: compressible / incompressible) and (the type of flow: turbulent or laminar).

4.2. The process of converting a mathematical model into a language or form that a computer can understand and work on. The Discretization Method that is, converting differential equations into a set of algebraic equations that the computer can calculate using specific algebraic operations.

To accomplish this step, there are several methods, including the following methods:

- Finite Difference Method (FDM): It is a mathematical method for converting differential equations into finite differences at the center of the cell to obtain a series of equations for the values of the variable at points in space or time.
- Finite Volume Method (FVM): The basic idea of the finite volume method is to divide the integral shape into many control volumes that cover the area of interest. The shape of the control volume depends on the nature of the geometric shape of the studied problem.
- Finite Element Method (FEM): This method is considered relatively modern and has crystallized in the field of structural engineering and has been circulated to many other fields until it has become the most important method for numerical analysis using computers in all physical and mathematical applications. It is considered one of the most important methods through which we can transform mathematical equations that describe a specific physical state and are subject to terminal conditions. The appropriate elementary equations are divided into a set of algebraic equations that the computer can calculate. This method divides the model into a mesh/grid that connects a group of points, and we obtain the solution at each point of the grid [8].

4.3. Analyze the Numerical Scheme a term to verify the validity of the method used to convert a mathematical model to a numerical one in order to fulfill the following conditions (Consistency, Stability, Convergence, and Accuracy).

4.4. Solve the computer takes this step after determining all the terminal conditions, and the solution method (permanent flow or variable with time).

4.5. Post – Processing shows the solution results in different ways with contour colors, arrows, or lines, depending on the design goal.

5. Thermal performance simulation analysis

This research aims to use the computational fluid dynamics method to reduce energy consumption by numerically simulating the thermal performance of the composite exterior wall using ANSYS software to improve and reduce the heat loss of the surrounding wall panels, improve the thermal energy utilization rate of the building, and enhance the thermal insulation effect [9].

5.1. Basic Structure of Building Walls

There are diverse ways to classify walls in the building. According to their position in the building, they are divided into internal and external walls; according to the layout direction, they are divided into horizontal and longitudinal walls; according to whether they are stressed or not, they are divided into load-bearing and non-load-bearing walls; according to building materials and pouring methods, they are divided into solid, hollow, and composite walls. The research object reported here is the building’s exterior non-bearing thermal insulation wall [10].

Table 1 shows the thermal conductivity and density coefficient from the Syrian Code of Thermal Insulation tables according to the materials composing the external wall under study.

Table 1 Thermal conductivity and density coefficient from the tables of the Syrian Code for Thermal Insulation according to the materials composing the wall under study.

Name of the material	Thickness h (cm)	Thermal conductivity factor μ (W/m ·°C)	Density (kg/m^3)
cement	1	1.4	1850
brick	10	1.163	1800
polystyrene	5	0.036	30-180
brick	10	1.163	1800
cement	1	1.4	1850
gypsum	1	0.814	1680

Fig (1) shows the study of the wall using an insulating material fixed in the middle of the wall, where the wall consists of 10 cm wide bricks, 5 cm insulator, and 10 cm bricks, and from the outside it is covered with 1cm wide cement, and from the inside it is covered with 1cm cement and 1cm gypsum.

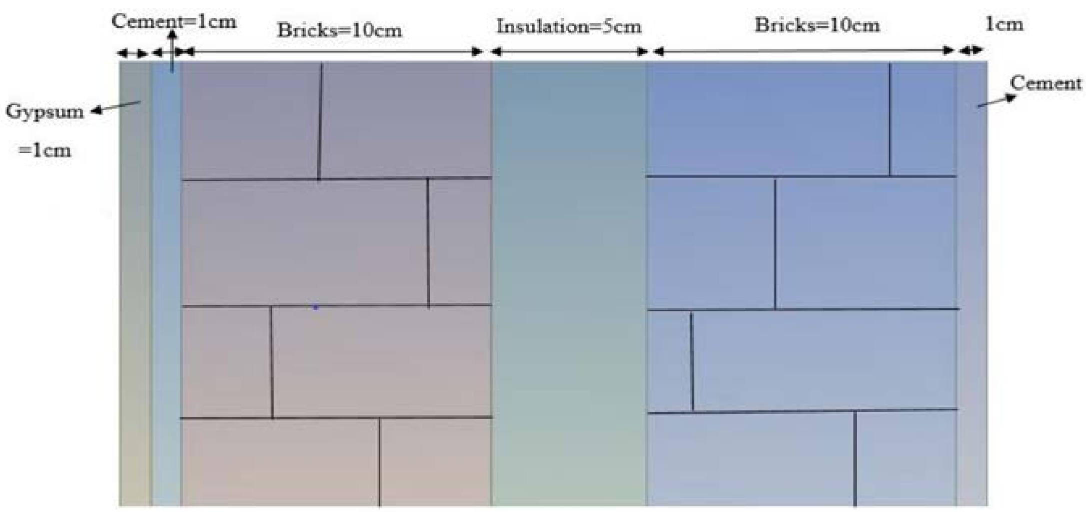

Fig. 1. The structure of the studied composite wall.

Table 2 Maximum permissible values for the total heat transfer coefficient of building elements in Syria [11].

Structural element	Maximum overall heat transfer coefficient (W/m^2 ·°C)
The last ceiling	0.5
Exterior walls without openings	0.8
External facades including all openings	1.5
Soil contact floors	1
Exposed floors	0.5

In the case of compound walls, they may contain a number of materials connected in series or parallel. The compound wall shown in Fig (1), the thermal resistance for each layer of the composite wall is determined with the equation (1):

$R_1 = h_1 / k_1 \cdot A,\ _2 = h_2 / k_2 \cdot A,\ R_3 = h_3 / k_3 \cdot A$ [m^2 ºC /W] (1) [12]

Where: R_1, R_2, R_3: are the thermal resistance of each material of the composite wall, [m^2 ºC/W]

h: is the thickness of each component layer, [m]

k: is the total heat transfer coefficient, [W/m^2 ºC]
the rate of heat transfer is as follows determined with the equation (2):

$$q_x = \frac{T_{\infty_1} - T_{\infty_4}}{R_{tot}} \quad (2) \quad [12]$$

Where:

$(T_{\infty_1} - T_{\infty_4})$: Total temperature difference.

R_{tot}: Total resistance to heat transfer.

The total resistance to heat transfer is calculated from the equation (3):

$$R_{tot} = \frac{1}{\mu_1 A} + \frac{L_A}{k_A \cdot A} + \frac{L_B}{k_B \cdot A} + \frac{L_C}{k_C \cdot A} + \frac{1}{\mu_4 A} \quad (3) \quad [12]$$

Where: R_{tot}: Total resistance to heat transfer, [m^2 ºC/W];
A: is the surface, [m^2]. The thermal conductivities of these layers are k_A, k_B, k_c respectively.

Using the temperature difference between the surfaces of a composite wall element as well as the thermal resistance of that element, the heat transfer rate (q_x) can be found from the equation (4):

$$qx = \frac{T_1 - T_2}{\left(\frac{1}{\mu_1 A}\right)} + \frac{T_2 - T_3}{\left(\frac{L_A}{k_A A}\right)} + \frac{T_3 - T_4}{\left(\frac{L_B}{k_B A}\right)} \quad (4) \quad [12]$$

The total heat transfer coefficient can be defined using the equation (5) where U : Reciprocal of total thermal resistance, i.e. ($1/R_{tot}$)

$$U = \frac{1}{R_{tot}} = \frac{1}{[(1/\mu1) + (L_A/k_A) + (L_B/k_B) + (L_c/k_c) + (1/\mu_4)]A} \quad (5) \quad [12]$$

Overall heat transfer coefficient $U = \frac{1}{Rtot}$

We find the internal and external surface thermal conductivity coefficient from the tables of the Syrian Code for Thermal for Insulation µ1 = 8.4 (m^2.°C/W), µ4= 23.26 (m^2.°C/W).

$$R_{tot} = \frac{1}{8.4} + \frac{0.01}{1.4} + \frac{0.1}{1.163} + \frac{0.05}{0.036} + \frac{0.1}{1.163} + \frac{0.01}{1.4} + \frac{0.01}{0.814} + \frac{1}{23.26}$$

$R_{tot} = 1.75$ m^2 ·°C / W

heat transfer coefficient: $U = \frac{1}{1.75} = 0.57\ W/m^2 \cdot °C < 0.8\ W/m^2 \cdot °C$

We note that the value is acceptable and does not exceed the maximum value in the table 2.

6. Analysis and Results with ANSYS 2019 R3

The heat flow model of the wall was designed by Ansys program to study the temperature distribution between the inside and outside of the wall by changing the thickness of the polystyrene layer as an insulating material in the middle. After determining the approved units, the wall under study is designed with geometric dimensions and then the wall is modeled with a square grid and each node of the grid expresses a differential equation that is converted into an algebraic equation that is easy to solve in the next stage and the smoother the grid is, the more accurate the solution is as shown in (Fig 2).

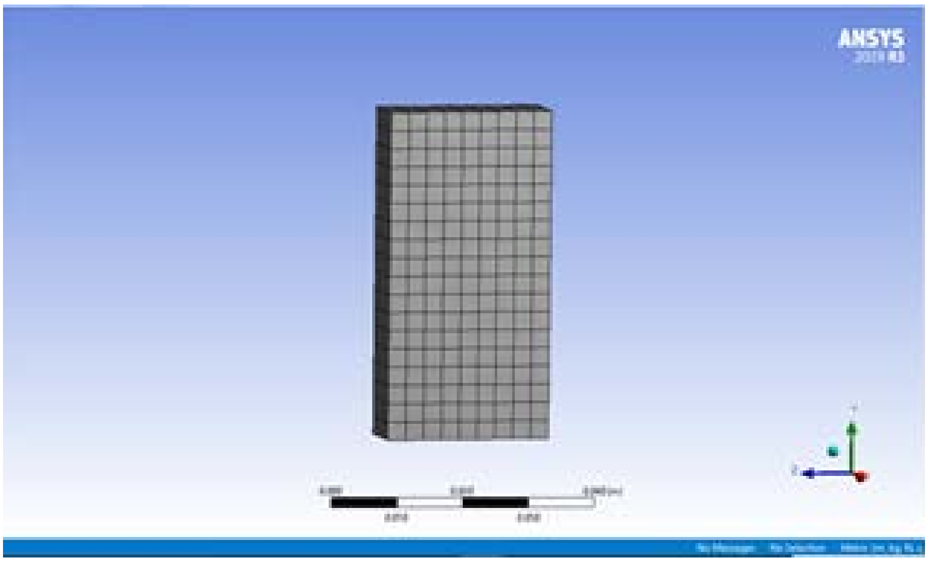

Fig. 2. Modeling the wall with a square mesh.

After determining the boundary conditions and defining the internal and external surfaces of the wall, the type of materials used is "determined from the database attached to the program in the materials list" as shown in the (Fig 3)

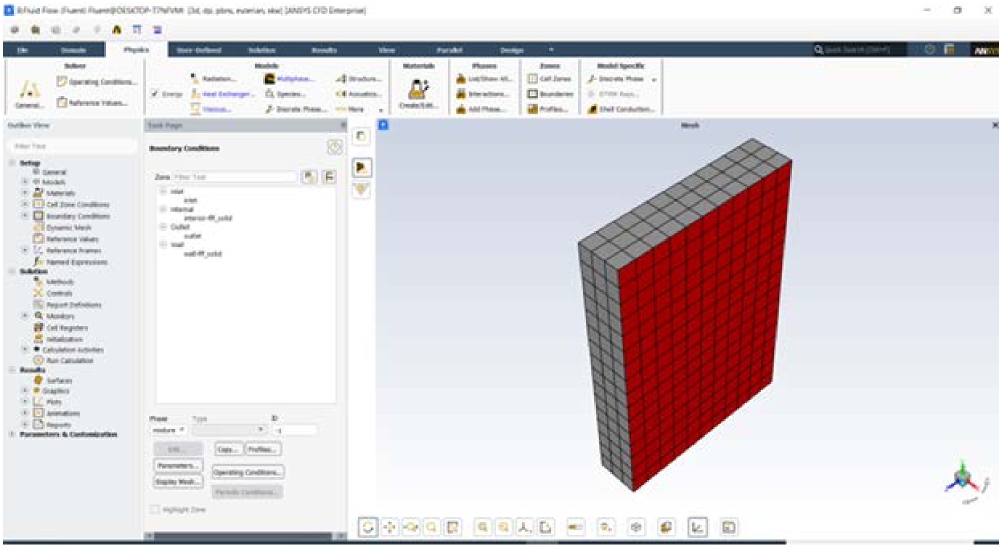

Fig. 3. Definition of materials and boundary conditions.

After solving by successive approximation and adopting the finite element method, the modeling results are displayed from (Fig 4) to (Fig 6) for the temperature distribution across the wall through a special window showing the colored lines from the minimum in blue to the maximum in red and the values of the thermal gradient between the inner and outer surfaces of the wall. Assuming that the temperature of the outer surface of the wall is 40 degrees Celsius, and assuming that h is the thickness of the polystyrene layer inside the wall, the modeling is done by changing the thickness of the insulating material layer and comparing the best values for the decrease in the convection thermal coefficient and the temperature of the inner surface of the wall as shown in (Table 3).

Table 3 Internal temperature values with changing Polystyrene layer thickness

Outside temperature (c°)	**Internal temperature (c°)**	**temperature difference (c°)**	**h: Polystyrene layer thickness (cm)**
40	35	5	3
40	33	7	4
40	31	9	5

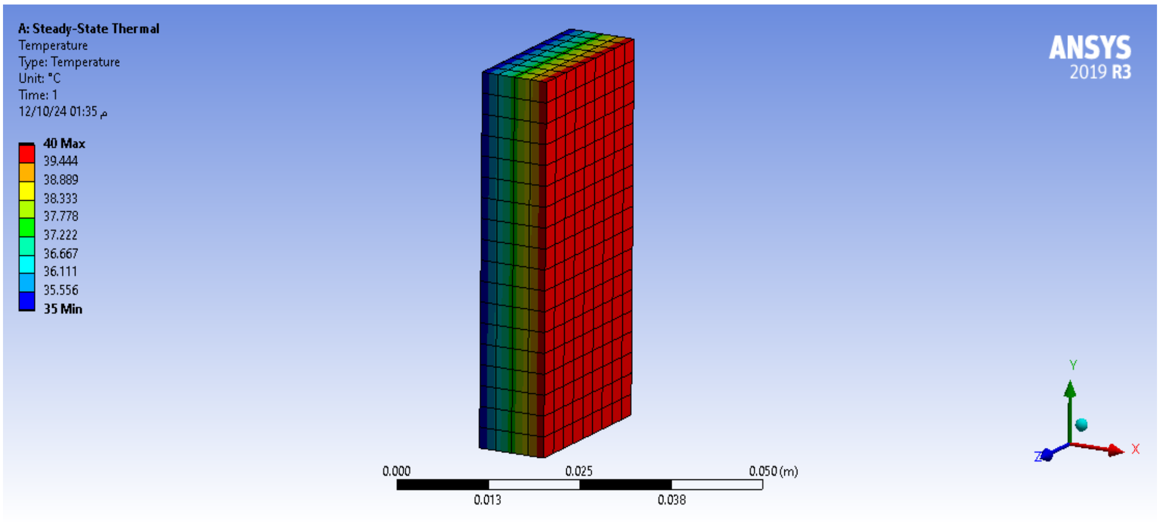

Fig. 4. Modeling the heat distribution across the wall when h = 3 cm.

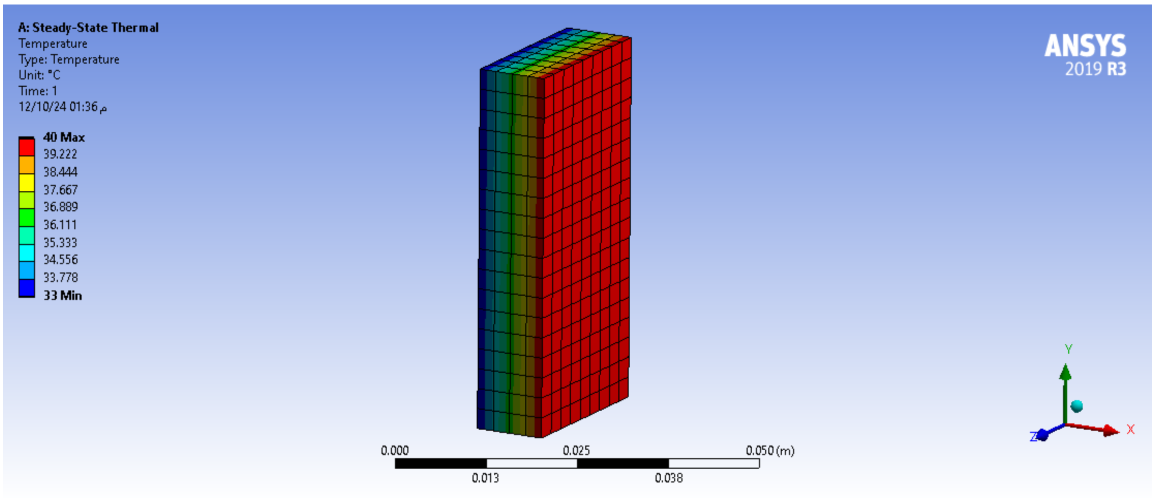

Fig. 5. Modeling the heat distribution across the wall when h = 4 cm.

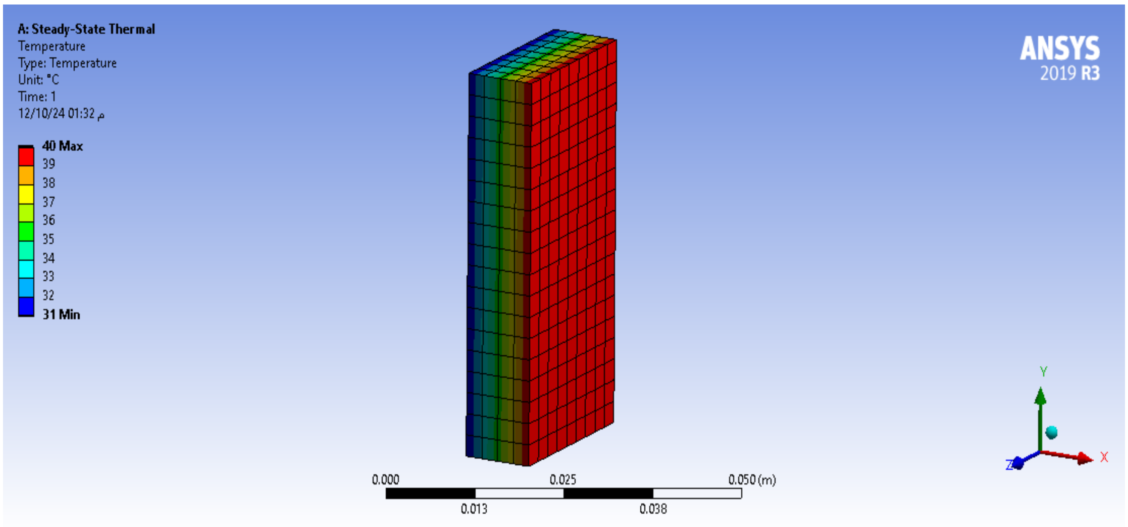

Fig. 6. Modeling the heat distribution across the wall when h = 5 cm.

7. Discussion of results

The above results prove that the presence of a 5 cm thick insulation layer can maintain the best thermal insulation effect and the temperature difference between the inner and outer walls is 9 °C.

The modeling was tested by changing the external temperature of the wall and stability was observed in the temperature difference between the two surfaces of the wall. For example, when studying "the temperature distribution across the wall, such that the external temperature was 45° C instead of 40° C, the internal temperature was 36 ° C", as shown in (Fig 7). Thus, the difference of 9 ° C is constant across the dimensions of the wall under study.

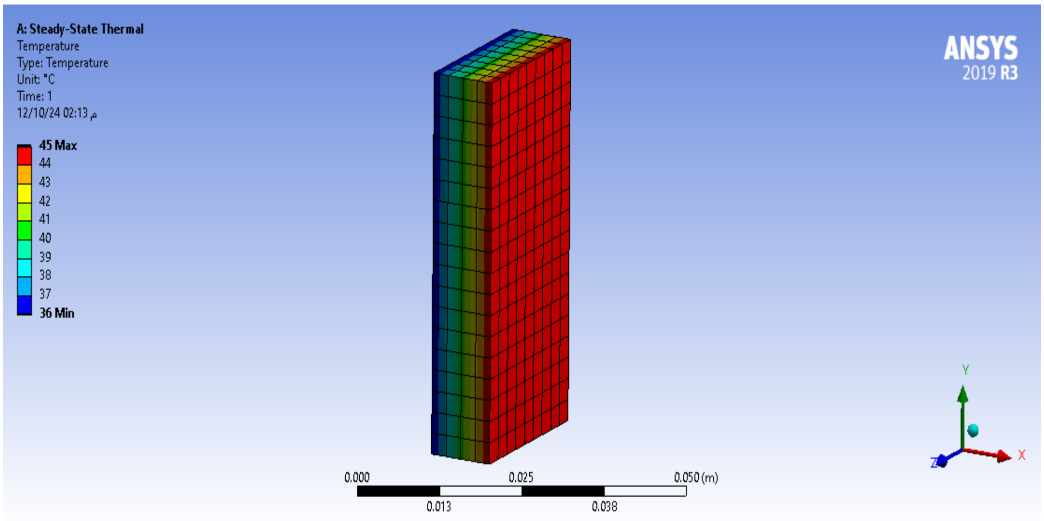

Fig. 7. Modeling the heat distribution across the wall when h = 5 cm, Outside temperature 45 ° C.

The thermal convection coefficient was queried from the ANSYS program in the absence of the insulating layer inside the wall" as shown in (Fig 8), where the value was 5 W/m^2. °C

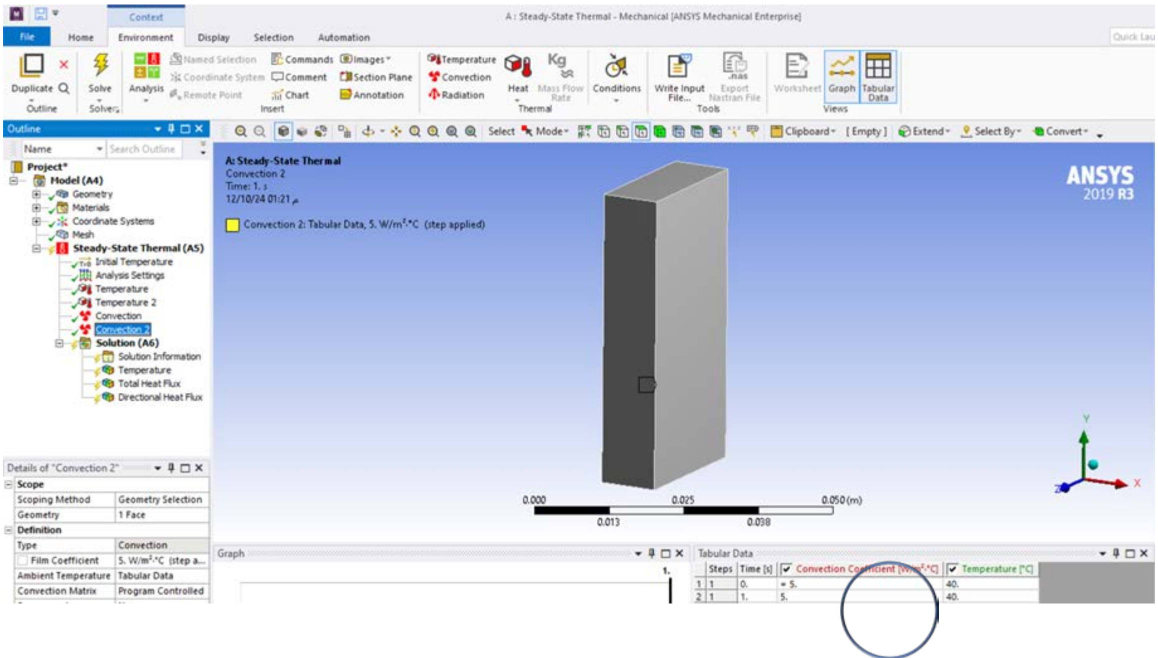

Fig. 8. Thermal convection coefficient without insulation layer.

The thermal convection coefficient value was also analyzed and determined as shown in (Fig 9) in the event that the wall was provided with a layer of insulating material with a thickness of 5 cm, where the value was 0.57 W/m^2. °C which achieves the Syrian Arab Code for Thermal Insulation, because it is < 0.8 W/m^2 ·°C, and thus the thermal convection coefficient decreased by 88%.

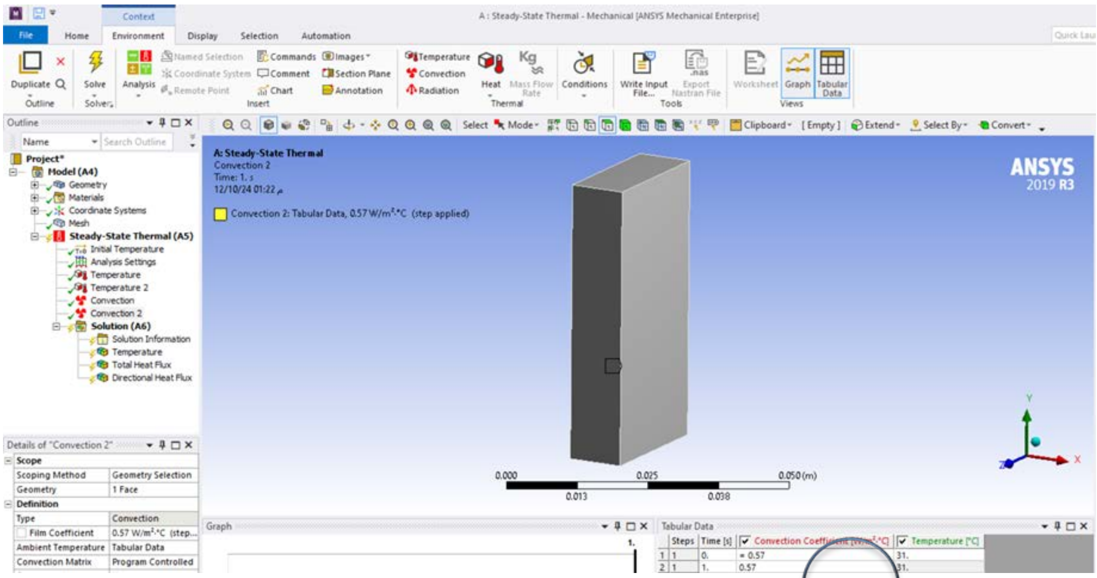

Fig. 9. Thermal convection coefficient with insulation layer.

This research was compared with the reference [13] which includes two aspects: the first aspect is measuring the thermophysical properties of polystyrene concrete and cement mortar and the second aspect is studying the thermal behavior of these materials where numerical and experimental methods were used for both approaches, the ambient conditions have a direct effect on the behavior of walls. Therefore, studies are conducted in different climatic conditions in parallel with the experimental approach, and the results were consistent between this research and the reference study and it was reached to develop a model that represents the heat and mass transfer in materials in order to predict the thermal behavior of the wall. A numerical simulation of the thermal behavior of a multi-layer wall was also conducted.

8. Conclusions

The total energy resources in the world are limited. With the increasing demand for conventional energy in modern society, energy conservation and emission reduction have become an inevitable trend of social and environmental development.

Based on the principles of computational fluid mechanics and modern modeling software ANSYS, the thermal performance of an external wall was studied by analyzing the simulation of temperature distribution across the wall from the outer surface to the inner surface and finding out the heat load value.

The results showed that the 5cm thick polystyrene insulation layer can maintain the best thermal insulation effect and the temperature difference between the inner and outer walls is 9

°C, which reduced the heat load value to 0.57 W/m^2. °C where it was 5 W/m^2. °C without adding the wall insulation material, the heat load value decreased by 88%.

To improve future studies on measuring the dynamic hygrothermal response of the thermal conductivity of the insulation and its impact on building energy performance, it is worth employing a more appropriate model that takes into account the combined effect of temperature and moisture change. Moreover, this study should also be extended to other insulation materials, including fiberglass, mineral wool, cellulose, and polyurethane foam, which could be more sensitive to the variations in the combined effect of temperature and humidity.

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Text Steganography Enhanced by Using RNN Algorithm Secure Communication in IoT Devices with Block chain

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Abstract

IoT is a crucial component of contemporary technology since it allows linked objects to communicate with one another. However, data integrity and privacy are seriously threatened by security flaws in IoT networks. This research combines RNN-enhanced text steganography with blockchain technology to present a breakthrough approach to IoT communication security. The suggested method will use RNN-based linguistic steganography to conceal messages in cover text. Blockchain technology decentralizes and immutably saves encrypted data. According to performance assessment, the improved system performs better than regular steganography in terms of embedding capacity, security, and communication efficiency. It exhibits robust defense against brute-force and steganalysis assaults. For the scale-up strategy for data security and integrity on the Internet of Things, in this paper safe IoT communication protocols.

Keywords: *Communication Protocols, Steganalysis Assaults, IoT data Transmission, Utilizing RNN algorithms*

1. Introduction

IoT has brought unprecedented levels of connection due to its explosive expansion, revolutionizing how devices communicate. IoT systems have become vital in many industries, from manufacturing and smart cities to healthcare and agriculture. However, the growth in IoT devices has also created serious security issues, primarily about privacy and data transfer. Secure communication among IoT devices is the most critical preventive strategy against data breaches and cyberattacks, as these devices deal with sensitive data more often.Text steganography, a technique of making private communications in regular text, has turned out to be one of the most feasible methods to enhance the secrecy of communications. Steganography ensures that sensitive material will be hard to find by unauthorized parties through its enclosure in apparently innocent language. Conventional text steganography methods, including statistical and linguistic methods, have been well researched and applied. However, these methods usually face difficulties with embedding capability, assault resistance, and handling large-scale communication effectively [1].

Recent advances in machine learning, especially RNNs, may boost the performance of text steganography. Since RNNs are appropriate for sequential data, their use in improving the embedding process is plausible to increase security among steganographic approaches. One can develop more effective, safer methods for hiding data with the help of capabilities that RNNs will allow [2].

Due to its decentralized and unchangeable nature, blockchain technology has improved IoT security. Blockchain can safeguard communication links, verify data integrity, and make conveyed messages impregnable. Blockchain and Internet of Things platforms may provide secure, open, and reliable communication frameworks [3].

Blockchain and RNN-based IoT communication network text steganography provides a whole new perspective regarding data security and privacy. Technology can solve IoT data transmission problems by advancing the steganographic technologies with the latest machine learning algorithms and securing the communication through blockchain.

1. 1 Problem Statement

Despite the development of IoT security, transferring sensitive data safely remains an issue. Bad actors seek IoT networks because of their openness and infiltration potential. Traditional encryption techniques and other security methods include problems such as high computational cost, weak resistance to attack, and key exposure in decentralized situations [4].

Despite going a long way to cover up communications, text steganography has its shortcomings. Various conventional steganographic techniques are vulnerable to detection tools of steganalysis for identifying hidden signals and most often fail on the embedding capacity factor. Besides this fact, many steganographic algorithms are unsuitable for dynamic and resource-constrained IoT applications due to bounded computational power and bandwidth [5].

Moreover, integrating blockchain with IoT security presents unique challenges. Even though blockchain offers a decentralized, impenetrable solution for data security, it also has challenges, such as scalability, energy consumption, and latency. These issues must be resolved to ensure blockchain can be effectively used in IoT systems without hindering their functionality.

Therefore, there is a need for more efficient and secure methods that integrate strengths from text steganography, RNNs, and blockchain. This research covers these gaps by proposing a framework that will enhance text steganography with RNNs for secure communication in IoT devices, using blockchain to add an extra layer of security and integrity.

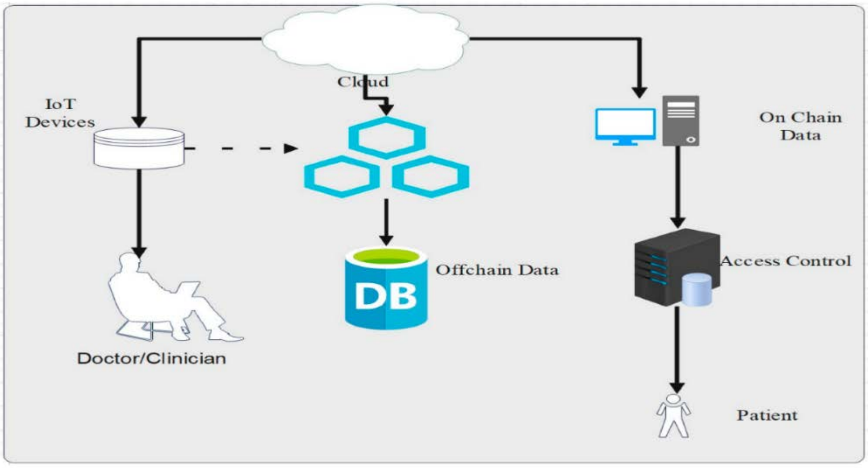

Figure 1 proposed smart contract integration with cloud.

1.2 Objectives

This project basically focuses on proposing a unique framework for secure communication in Internet of Things devices using blockchain technology combined with RNN-based text steganography. The research aims to find:

- Enhancement in embedding capacity, security, and robustness against steganalysis; the text steganography performance by utilizing RNN algorithms.
- Look into how blockchain could be utilized for securing the IoT communication routes, while keeping data sent secret and integral.
- Develop a functional implementation of the proposed framework and evaluate its scalability, security, and efficiency.
- Check the feasibility of integrating the proposed approach into practical IoT applications such as smart cities, healthcare systems, and industrial IoT.

1.3 Scope of the Study

In this paper we integrates text steganography, RNN algorithms, and blockchain for IoT communication. The areas that the research will dwell on are:

- IoT Devices and Communication: The study will evaluate IoT device communication, security threats, and secure transmission mechanisms.
- Text Steganography: it will employ RNNs to enhance the security and efficiency of text steganography.
- Blockchain Integration: The research will cover how blockchain technology can secure the lines of communication and keep data unalterable.

1.4 Research Significance

Some reasons that make this study important include solving one of the urgent needs for secure communication in IoT networks, where data integrity and privacy are paramount. The suggested approach has provided a reliable way of protecting sensitive data by integrating blockchain for extra security and improving text steganography using RNN algorithms.

Second, this study contributes to the growing body of work in the areas of blockchain, steganography, and machine learning by making new contributions regarding how the combination of these technologies may be used to solve some real-world security challenges.

An innovative method that can enhance the effectiveness and performance of data-hiding techniques includes the application of RNNs to text steganography.

2. Literature Review

- The IoT connects various devices through the Internet, allowing them to communicate and share data online. Security in the communication of IoT has become the most crucial concern for researchers nowadays because IoT devices are being installed in very important sectors: healthcare, agriculture, and transport.
- With the vast number of networked devices, openness in communication protocols, and limitations in resources.
- most IoT devices are usually vulnerable to all threats. Due to their vulnerabilities, IoT systems may be exploited for DoS, unauthorized access, and data leakage authentication, encryption.
- integrity checks are some of the security techniques that have been proposed to prevent tampering in transit. However, most of the standard techniques are problematic due to the substantial processing cost, scalability, and resource limits of IoT devices [6].

Recent research shows that integrating encryption with steganography might improve IoT security [7].

2.1 Text Steganography

Embed confidential information in a seemingly harmless cover letter by using text steganography. This method of hiding sensitive data is important in the Internet of Things, where privacy plays a major role. Text steganography uses linguistic-based methods and LSB encoding. LSB encoding embeds the secret data in the least significant letters, while linguistic steganography changes everyday language to hide information via punctuation, sentence structure, or word choice [8].

Although text steganography effectively conceals data, it has limitations. The first significant barrier is that the use of steganalysis to uncover hidden information might compromise the security of clandestine communications. Embedding capacity, or the amount of material that can be added without impairing cover text reading, is another important limitation. Embedding should be safe and effective in resource-constrained scenarios, such as IoT networks, when computing power and bandwidth are restricted [9].

Recent studies have focused on machine learning-based linguistic steganography techniques to enhance their effectiveness and robustness. The VAE technique in [8] was effective for the security of IoT communication, showing an increased capacity and robustness against detection.

2.2 Recurrent Neural Networks (RNN) in Security

Recent studies have focused on machine learning-based linguistic steganography techniques to enhance their effectiveness and robustness. The VAE technique in [8] was effective for the security of IoT communication, showing an increased capacity and robustness against detection [17].

RNNs improve text steganography data concealing. According to several researchers, RNN models that have been trained on very large datasets can safely and efficiently embed messages in text. These approaches reduce adversarial detection, adapting to natural language structure [10]. The RNN-based model could improve the security of communication by hiding information in ways that standard steganalysis techniques cannot discover [11].

RNNs also allow for more sophisticated encoding methods, which enhances embedding capacity. In the applications of the Internet of Things, data hiding in the connection stream may increase bandwidth and privacy [16].

2.3 Blockchain Technology in IoT Security

Blockchain technology secures communication in decentralized networks like IoT systems. A blockchain, a distributed ledger, ensures data transparency and integrity by recording transactions immutably. Blockchain for IoT communication can secure and decentralize data transmission verification, device authentication, and data modification [12].

The two major IoT security responsibilities of blockchain include the following: First, its decentralized design eliminates central authority and hence minimizes single points of failure. This is critical in IoT networks where devices are often remote or untrusted. Second, blockchain can ensure data integrity by using consensus methods that require many people to verify data before adding it to the blockchain [14].[13].

For IoT communications, there exist blockchain-based security mechanisms. Blockchain will monitor the flow of data, manage access control, and verify communications among devices in smart cities and industrial IoT applications [13]. Blockchain might be combined with steganography and cryptographic techniques to enhance the security of IoT [15].

3 Methodology

3.1 System Architecture

The proposed study proposes blockchain, RNN, communication protocols, and IoT devices for securing communication. IoT devices are the major sources and consumers of data exchange, transmitting private data via a secure protocol.

RNNs improve encoding and embedding at the communication layer, while blockchain does the job of storing and validating messages. This architecture leverages blockchain technology along with RNN-enhanced text steganography to secure end-to-end IoT device communication and assure data integrity, confidentiality, and authenticity. Figure 2 presents the whole system architecture, explaining in detail the interaction among the blockchain network, the RNN model, the IoT devices, and the communication protocols.

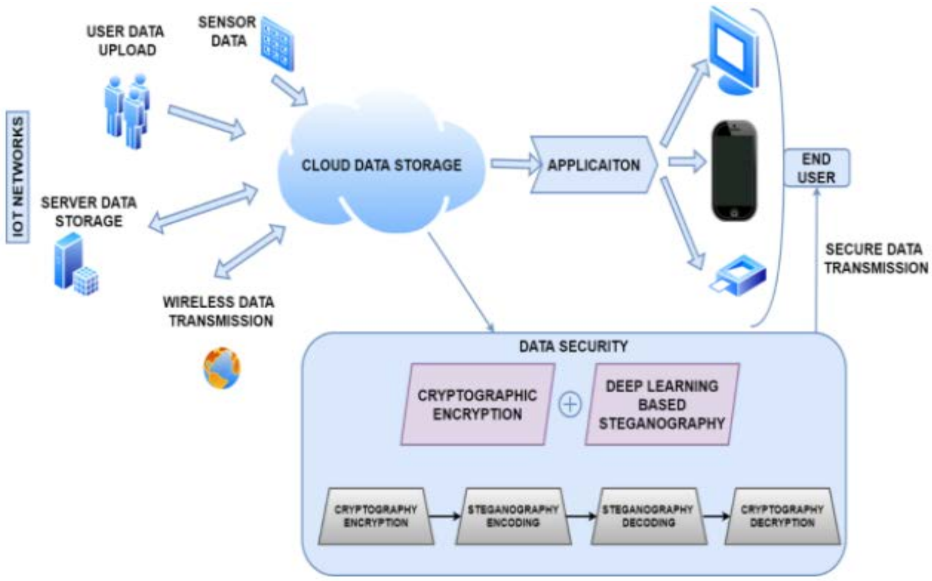

Figure -2 System Architecture of Secure.

3.2 Data Embedding Using Text Steganography

The proposed research introduced blockchain, RNN, communication protocols, and devices of the Internet of Things for securing communication. IoT devices, which are sending private information with the help of a secure protocol, are the main originators and receivers of the data exchange.

Blockchain handles message storage and validation, while RNNs enhance encoding and embedding at the communication layer. Such architecture ensures data integrity, secrecy, and authenticity, while securing end-to-end IoT device connection using blockchain technology together with RNN-enhanced text steganography.

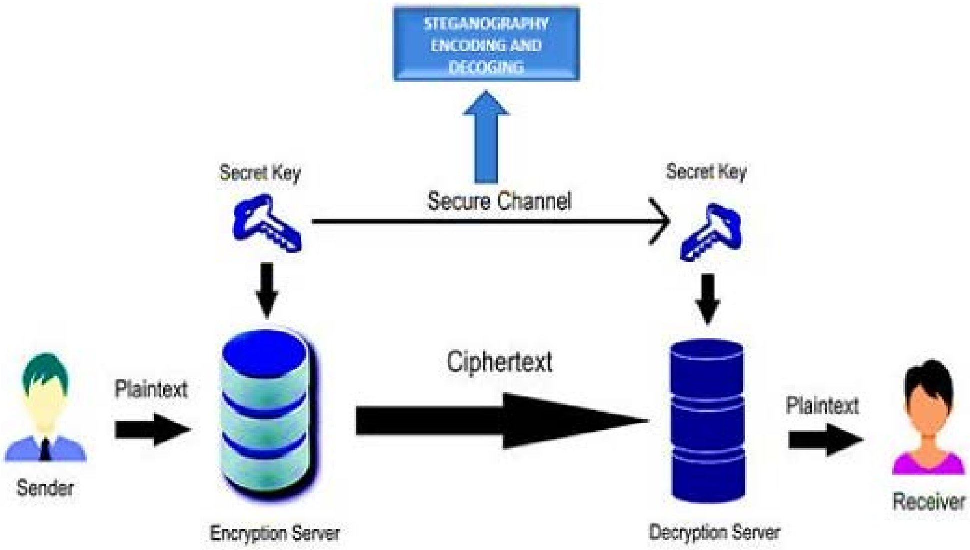

Figure 3 Data Embedding Process Using RNN-enhanced Text Steganography.

3.3 RNN Algorithm for Data Encoding

Security encoding secret messages using RNN is very important. The encoded message and its processing through an RNN-based model are summed up with the cover text. The RNN model is optimized for word dependencies and linkages, thus allowing encoded information to be steganographic ally buried without affecting the structure and meaning of the cover text.

It has several layers, which include input, hidden, and output. Model feedback loops can remember information in early stages. That is why RNN does so great in processing data sequentially, like text, where context is important. For training the machine to encode secret messages, one needs regularly to change its weights and biases to minimize the loss function that measures the difference between predicted and encoded messages. To ensure that the model encrypts secret messages without causing abnormalities, RNN performance is checked on a separate test dataset. The RNN is optimized for training using backpropagation and gradient descent to generalize well to new text input. Figure 4: RNN architecture for secret messaging.

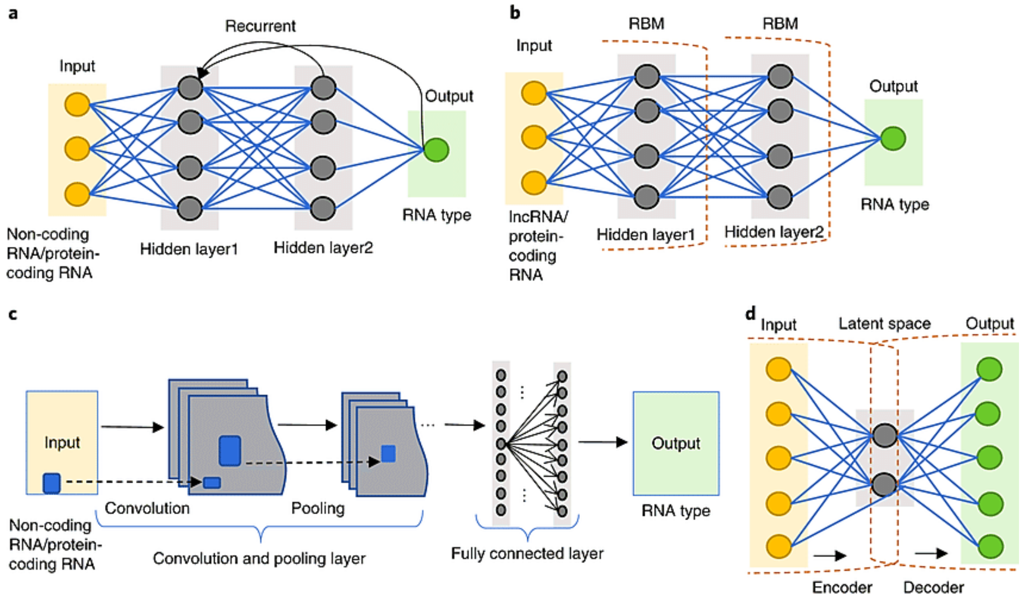

Figure 4 RNN Model Architecture for Encoding Secret Messages.

3.4 Blockchain Integration

Encryption of the communications between devices of the Internet of Things is stored and validated using Blockchain. Blockchain verifies communication reliability as a decentralized, impermeable ledger. Each encrypted communication is consensus-verified before being added to the ledger and preserved as a blockchain transaction.

Thus, this is a proof-of-work system, where nodes perform extensive computation when validating and adding new messages to the chain. Therefore, this technique ensures the integrity of new transactions on the blockchain and provides a secure foundation for establishing the source of a message. All transactions can be publicly confirmed, meaning data is irretrievable once in the ledger because of blockchain openness.

3.5 Security Measures and Protocols

The proposed methodology ensures security in IoT device connection through various protocols. The proposed architecture in security protects communication via blockchain, hashing, and encryption.

The communication between IoT devices is encrypted. The secret messages are encrypted by using the Advanced Encryption Standard prior to embedding into the cover text. This makes the secret data inaccessible even if extracted from the cover text without the decryption key.

Each message is hashed before it is sent and stored on the blockchain. Upon receipt of the message, the hash would be recalculated and checked against the blockchain hash for tamper-proofing.

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4 Results and Discussion

4.1 Performance Evaluation

The proposed secure communication system, using blockchain and RNN-enhanced text steganography, is analyzed in this section. The suggested solution has been compared against standard steganography methods based on communication efficiency, security, resilience, and concealing capacity.

- Comparison of Traditional Steganography Techniques

Language-based steganography and LSB have limited computing efficiency, detection resistance, and embedding capability. The proposed approach of RNN-based text steganography outperforms the state-of-the-art methods.

But one of the most important benefits from our approach is that in this case, the RNN learns the nuances of cover text and contextual patterns, embedding more capacity without affecting flow. This conceals the secret information extra within the steganographic cover text suspiciously or without major alterations.

The upgraded RNN model enhances steganography by making embedded data difficult to detect. Traditional approaches are prone to steganalysis since they rely on predetermined patterns of data modification. The RNN model may be adaptable to different languages, which makes the embedding of data more dynamic and difficult to detect.

- Evaluation Metrics

Embedding Capacity: The proposed system has a much larger embedding capacity as compared to the conventional methods. Since RNN can comprehend syntactic and semantic structures of languages, it may be applied to embed more hidden content without making the cover text less readable.

Robustness: Statistical analysis and pattern recognition were done to test the recommended approach for robustness. The results demonstrate that, when compared to previous methods, the RNN-enhanced steganography is more robust against various types of attacks.

Security of the System: Brute-force, steganalysis, and other assaults evaluated the security of the system. Blockchain technology to encrypt data and verify messages will make the system more resistive against brute-force assault.

The efficiency of communication has been evaluated in terms of the timeframes required for embedding, transmission, and decoding. The results show that the proposed approach enhances the effectiveness of communication with no compromise on security and embedding capability. The RNN with blockchain integration can be used for real-time IoT applications since it reduces the connection latency.

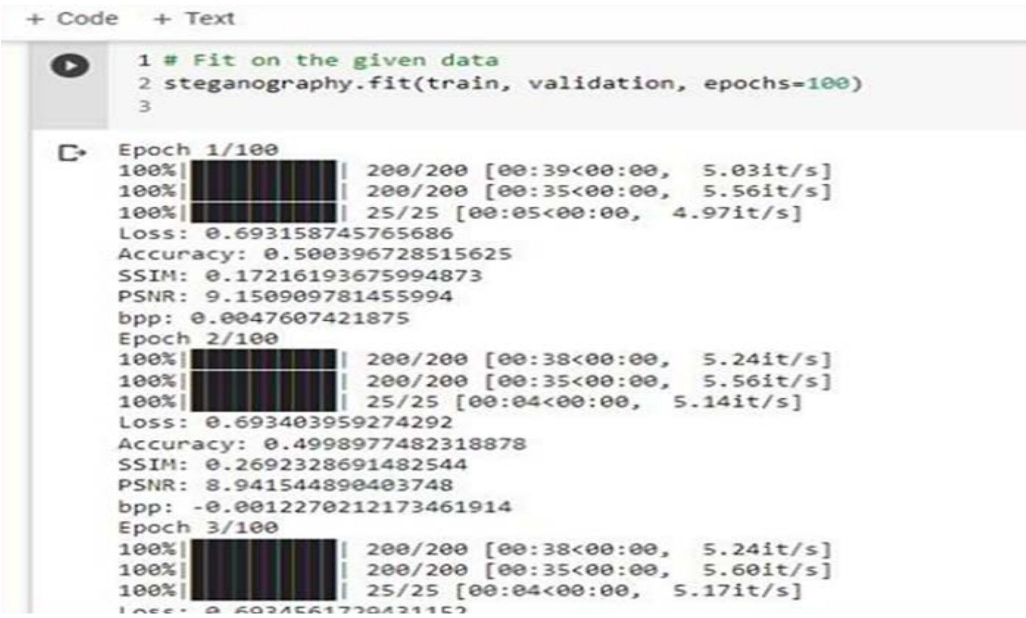

Figure 5 Deep Learning Algorithm Training.

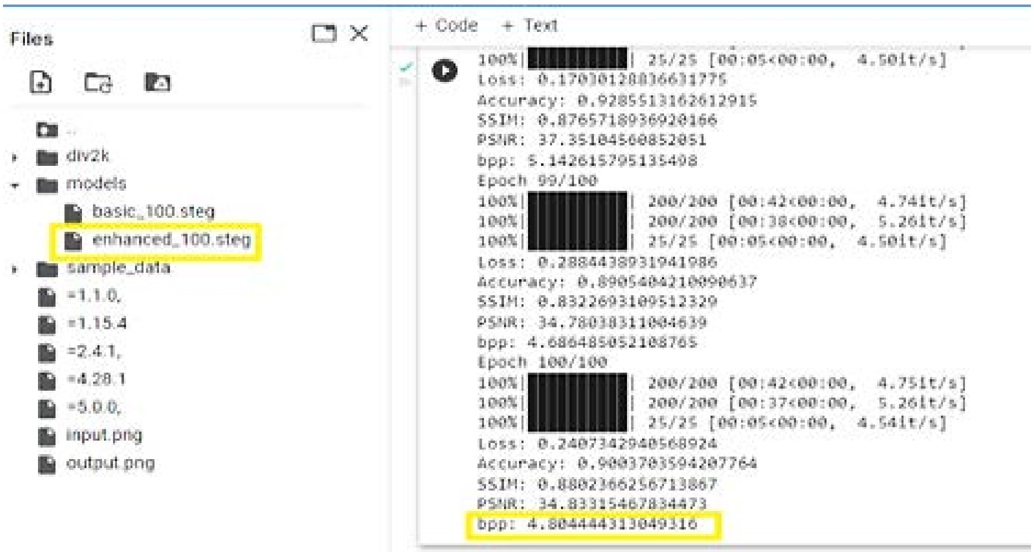

Figure 6 Model File Generation After Enhanced Algorithm Training.

A deep learning model training process was carried out to ensure the optimum performance of the RNN. After training the computer with a large collection of text samples, which would teach it all the complex patterns and relationships between words, it would then be able to perform well in encrypting and decoding secret messages.

A model file with the learned parameters and weights necessary for data encoding and decoding was generated after training the algorithm. This would later be used to extract and embed the concealed data in the cover text.

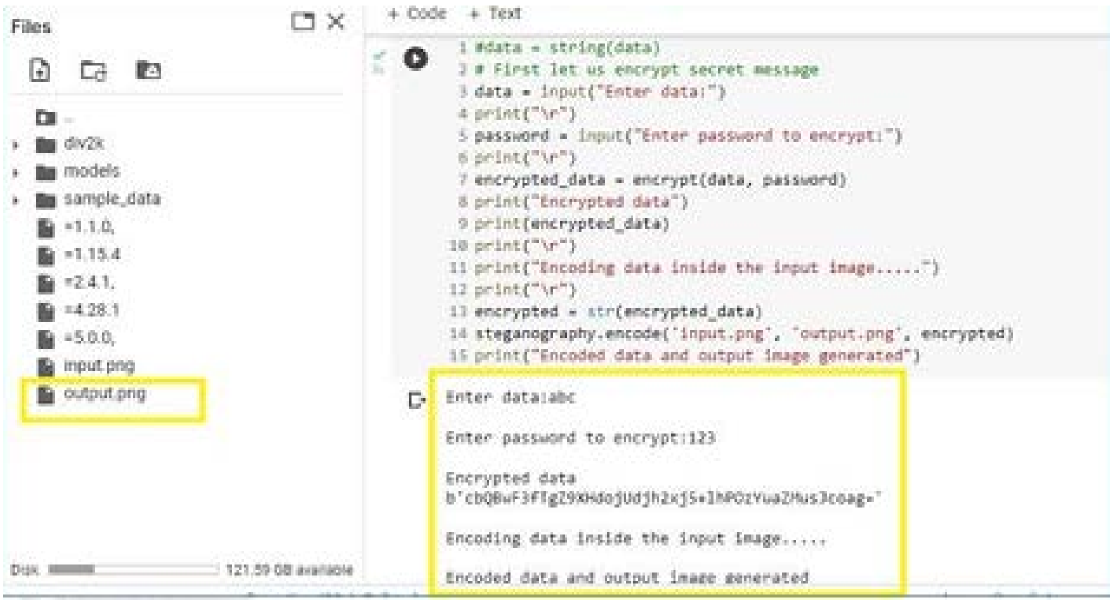

Figure 7 Encrypting and Encoding Data Using Enhanced Model.

The data, after being encoded by the model and a secret message embedded, are encrypted before sending out via the IoT communication network. In doing so, even when it gets intercepted, there's an added security layer with encryption to ensure that data kept inside remains confidential.

4.2 Security Analysis

The security characteristics of the proposed system are examined in this section, with special focus to the encryption techniques, attack resistance, and overall security posture of the communication framework.

- Strength of Encryption

One of the main factors that can ensure the secrecy of the secret message is the strength of the encryption. In our approach, the confidential data are encrypted using a strong cryptography technique, such as the Advanced Encryption Standard, prior to embedding into the cover text. AES is well regarded for its efficiency and potency in protecting sensitive information, including stringent resistance against various forms of attacks.

This, of course, assures that even when an attacker gets to successfully buried data, it will still be tough for him or her to decrypt them without the appropriate key; hence, assurance of the confidentiality of embedded data is ensured, making the system really secure against undesired access.

- Resistance to Brute Force Attacks

An extensive search strategy was employed to try and decipher the encrypted message to assess its resilience against brute-force attacks. The results show that the system is highly resistant to brute-force attacks since the encryption and dynamic nature of the RNN-enhanced steganography approach provides good resistance. The vast key space and the additional complexity of the RNN model make the challenge of effectively launching a brute-force assault much more difficult.

- Resistance to Steganalysis

Steganalysis uncovers hidden meanings in innocent-appearing cover letters. Resistance to steganalysis using statistical analysis and machine learning-based classification, state-of-the-art detection methods, is tested by the recommended method. RNN-based embedding outperformed standard text steganography in detection resistance, its findings showed. Because it can understand complicated linguitic patterns, RNN may conceal a signal from steganalysis.

Encryption of conversations, storage, and verification using blockchain add an additional layer of security. Message integrity during communication is assured by the blockchain.

Table 1 Comparison of The Existing System and Proposed System.

Metric	*Existing System*	*Proposed System*
Embedding Capacity	Low	High
Robustness	Low	High
Security Level	Moderate	High
Communication Efficiency	Moderate	High

5 Conclusion

This article discusses how blockchain technology and text steganography augmented by the recurrent neural network have been used to secure IoT device connections. The integration, therefore, allowed the research to address data security, confidentiality, and effectiveness of communication in IoT environments that are normally vulnerable to data breach attacks.

This work significantly enhances the robustness, security, and embedding of the communication systems. The RNN text steganography enhances embedding efficiency, concealing more hidden data into the cover text without harming the underlying message. This was significantly better compared to conventional steganography, who's embedding, and detection were limited in nature. Since RNNs were flexible and masked well the text data, thereby making the system impervious, it is resistant to steganalysis.

Another scientific contribution of blockchain technology provides immutability and decentralization to communication. Connections within an IoT network are secure due to blockchain's secure validation and storage of communication. Blockchain consensus has improved communication and protects them from intrusions.

Our security research shows that the updated system resists steganalysis and brute-force decryption. Conventional cryptography safeguarded secret data through AES encryption and the RNN technique. The system maintained remarkable communication efficiency despite rigorous data encoding, encryption, and blockchain verification. The solution enables real-time communication in IoT networks, where efficiency and security are critical.

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Stress Evaluation in Different Implant Crown Geometries Based on Artificial Intelligence

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Abstract:
The purpose of this study is to assess the effect of the geometry of crown on the stress distribution of the implant and surrounding tissue by investigating the effect of different crown configurations and various loading angles. The researchers aimed to evaluate how variations in crown design and load angle of inclination can influence factors such as stress distribution, occlusal forces, tissue response, and overall oral health. Finite element analysis (FEA) was used to investigate the biomechanical reactions in the crown of implant, including von Mises equivalent stress energy density (SED) and overloading factors in two models of varied different crown configurations and angles. Solid modeling software (SolidWorks) was used to create solid models of the mandible, implant, zirconia crown of left mandibular first molar and adjacent teeth.

ANSYS software program was used to carry out the reconstitution of the 3D model assembly. The analytical technique comprised pre-processing for building the finite element model as well as post-processing with SolidWorks program for representing the solutions. An area was created on the crown of implant to apply a pressure load with various angles towards the y-axis. The area before modeling using SolidWorks software was 33.01 mm^2, but after modification, it was 47.64 mm^2. The highest peak von Mises stress under loading condition of 100 N on the crown of implant approximately 6 MPa before modeling, while the maximum von Mises stress values were 5 MPa after modeling.

Keywords: Stress distribution, Dental implant, crown geometry, Implant health, Digital dentistry, artificial intelligence.

Introduction

Dental implants are the greatest alternative for replacing missing teeth since they attempt to replace lost tissue while also restoring perform, comfort, esthetics, speaking, and tissue health (1,3). The primary purpose for using dental implants to replace missing teeth is to maintain alveolar bone (4).

Several approaches based on photo elastic, strain-gauge, and finite element analysis (FEA) investigations have been utilized to study stress in the peri-implant area and in implant-supported restorative components (5,8). Fatalla et al (9) investigated the optimal form and attachment combination for supporting an overdenture with little stress and bending in the alveolar bone around any natural teeth and/or small dental implants. The distribution of stress in the bone is determined by the position and size of the implants (9,10).

Falcón-Antenucci, Rosse Mary et al. (10) concluded that the cusp inclination increased stress on the implant and implant/abutment contact while decreasing stress on the cortical bone. The prosthetic restoration's splinting of adjacent short implants in the posterior jaw has a significant impact on the amplitude and distribution of local stress peaks in peri-implant areas. According to Jassim and Ibrahim, the distribution of stress and the peak stress intensity surrounding dental implants had a relationship with the quantity of dental implants (11). One of the key elements influencing dental implant healing and successful osseointegration is implant stability (12). For many years, there has been a concern with technical difficulties with implants and restorations supported by implants. The most common consequence is loosening of the fixing screw; while rarely disastrous, this can have a negative impact on patient satisfaction and the efficacy of implant therapy if it happens frequently (13). The primary reasons for a potential fracture rely on biomechanical factors and implant-prosthetic component manufacturing procedures. It is advised to adhere to strict planning guidelines and use implant-prosthetic devices made by the same manufacturer (14). The abutment screw is the simplest, dependable, and the component that is used for connecting prosthetic to the elements of implant body. The abutment screw enables simple retention on a little scale (15,16).

Any occlusal imbalance, inadequate casting adaptation, or uneven pressures can produce crown vibration during operation, leading to loosening or rupture of a screw (when the applied load is great or the metal dimensions are tiny) (17). A high degree of stress can cause bone microcracks, which could result in resorption of bone or failure of implant or suprastracture elements such ceramic rupture, loosening and fracture of abutment screw (18). Demirkol and Demirkol (19) investigated the diameter and length characteristics of individual dental implants positioned posteriorly on the maxilla and mandible. It is suggested to replace each lost tooth with an implant whenever bone supply and cost allow (20). Dental implant surface enhancement is significantly aided by the science of nanotechnology. Nonetheless, at the nanoscale level, the various methods employed to cover these implants with nanostructured materials may have distinct effects on biomolecules, cells, and even ions (21). In the oral cavity, implantology offers a dependable and significantly safer alternative for tooth replacement (22).

The association between implant stability quotient (ISQ) values and insertion torque (IT) was investigated by Noaman A.T. and Bede S.Y.(23). The "gold standard" material for endosseous dental implants is titanium and its alloys. They stand out from the other dental implant materials on the market because of their many advantageous qualities and multiple decades of long-term clinical survival rates (24).One of the best computational tools for determining the stress on implant-supported restorations is probably the finite element method (FEM)(25).

The objective of the present study was to evaluate the influence of crown dimensions on distribution of stress in the crown during application of load utilizing 3D of FEM.

Materials and methods

The modeling method is summarized in the following steps: import the 3D model of the crown and supporting dental implant into the SolidWorks program, changing the geometry of the crown according to mathematical modelling, based on the primary data, correct the crown surface in SolidWorks, load the resulting files into a program for mathematical modeling (for example, Ansys) and calculate the stress- state of the model. To correct the surface of the crown, it is necessary to use distribution of stresses on the crown surface .

For simulation of implant crowns, two 3D FEM models were created with five millimeters diameter implant to support a single molar crown. The first model had 439736 nodes and 238531 elements. The second model, after modeling by using SolidWorks program, consisting of 472542 nodes and 256341 elements. The crown dimensions of the first model were x= 8, y = 7.5 and z= 9.4 (figure 1), while the crown dimensions of the second model were x= 8.3 , y = 7.5 and z= 10 (figure 2) .

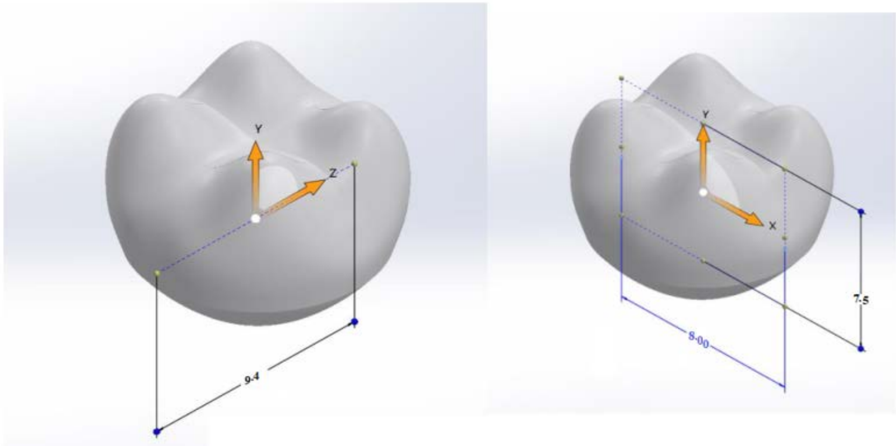

Figure1: The crown dimensions of the first model (before modeling).

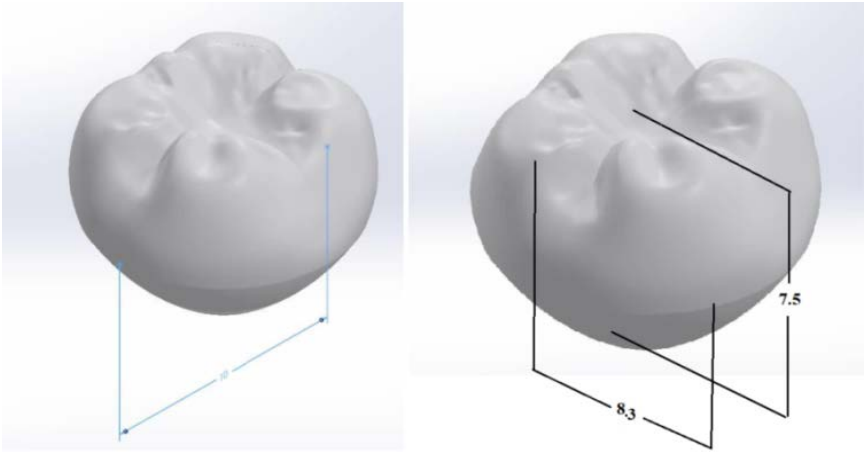

Figure 2: The crown dimensions of the second model (after modeling).

Tetrahedral and octahedral components were used to mesh 3D objects and molded by determining the exact placement of nodes following a mathematical procedure that took thread inclination into account. Modeling by SolidWorks program include that the crown was modeled by changing the geometry of the cusps, distribute stresses better on the occlusal surfaces of tooth by creating additional area .The cusps are contoured, rounded and less sharp (figure 2). Dental implants, zirconia crowns, and bone segments were among the models used in the study. The models were designed to therapeutically mimic the properties of implant prosthetic materials. Titanium alloys were used to create the implant components. The models of the implants were 12 mm in length and 5 mm in diameter. The materials' characteristics were determined using their modulus of elasticity, Poisson's ratio, and density (table 1).

Table 1: Materials properties assigned to the implants models

Component	*Modulus of elasticity, GPa*	*Poisson's ratio, v*	*Density, Kg/m^3*
Cortical bone	*13*	*0.30*	*1180*
Cancellous bone	*1.3*	*0.30*	*500*
Titanium alloy	*113.8*	*0.342*	*4500*
Zirconia	*200*	*0.31*	*6090*
Enamel	*91*	*0.3*	*3000*

ANSYS was used to carry out the reconstruction of the 3D model assembly (figure 3).

a) b)

Figure 3: Three dimensional models with different geometrical features of occlusal surfaces of crown of implants. a) before modeling, b) after modeling

Because of bone anisotropy, the destructive impact of offsetting or slanted stresses on bone is increased. Anisotropy refers to the property of bone in which its mechanical characteristics, particularly ultimate strength, vary depending on the angle of loading and the type of force applied. Any occlusal force exerted at an angle to the implant components can be classified as normal (compressive and tensile) or shear. As the angle of load to an implant crown increases, the amount of compression and tensile forces changes due to the cosine of the angle. As a result, the force is somewhat lessened. The component of angled force is shear force, which is equal to the amount of force multiplied by the load's sign. The load on the bone is the amount of compressive, tensile, and shear forces. In the article, a 100-N force is applied at 15, 30, and 45 degrees on the y-axis (figure 4 & 5).

Figure 4: An applied vertical occlusal load of the implant.

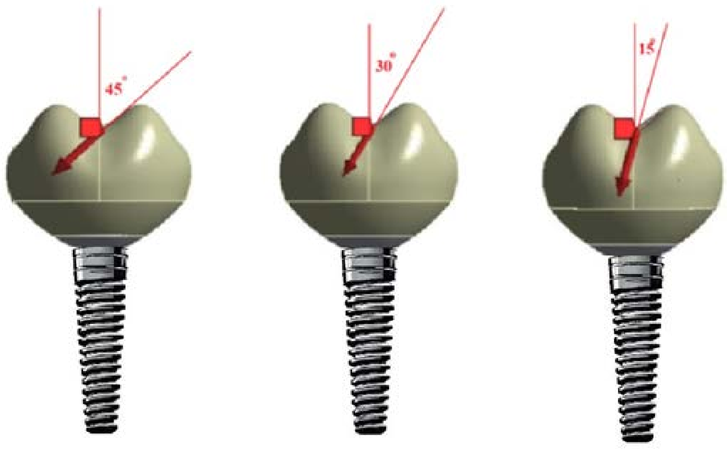

Figure 5: An applied occlusal load of the implant with various angles towards the y-axis.

Results

The tensile and shear stresses increase as the angle of load to the implant long axis increases. The forces to the bone by 100 N × cosine 15° = 96.59 N and 100 N × Sine 15° = 25.8 N, 100 N × cosine 30° = 86.6 N and 100 N × Sine 30° = 50 N and 100 N × cosine 45° = 70.7 N and 100 N × Sine 45° = 70.7 N (figure 6).

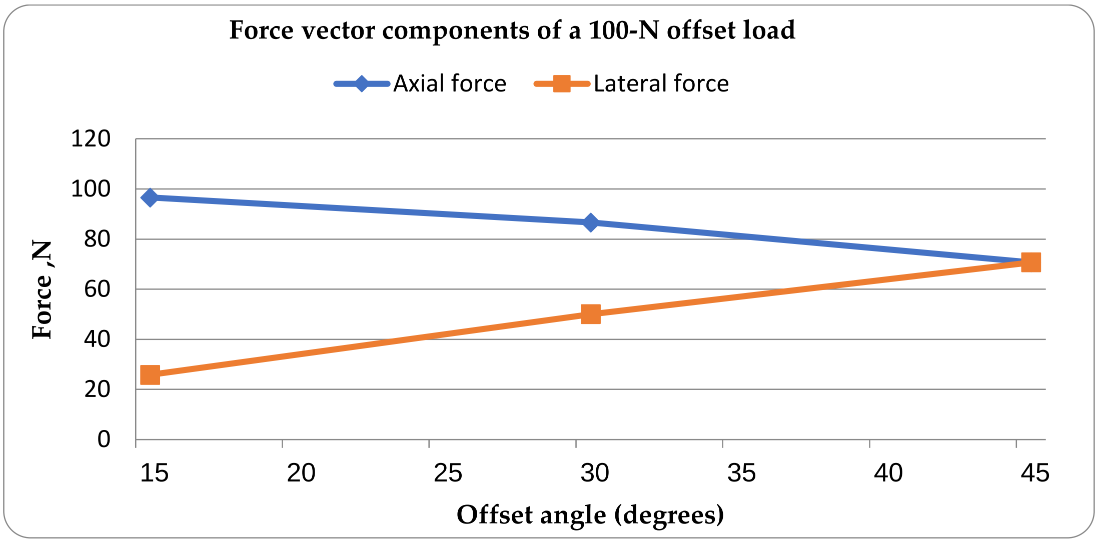

Figure 6: Increasing of force with the offset angle of the load.

In the Fig. 6 shown that the compressive stress decrease as the angularity of force to the y- axis of implant increases, while the tensile, and shear stresses increase. The quantity of compressive and tensile forces is varied by using the cosine of the inclination as the angle of load to the crown surface of implant. As a result, a force is somewhat lessened. The angled component of force, on the other hand, is a shear force, and the shear force is the amount of force multiplied by the sign of the load, that significantly increases the load.

Using artificial intelligence and computer software, stresses resulting from loads on implants can be extracted. One of the tools used to analyze the stresses resulting from loads on the implant is the ANSYS program. After running the models using ANSYS tool, the values and distribution of the maximum von Mises stresses at the implant surface were investigated. For the quantitative analysis, the stress gradients were displayed as color-coded maps, with red representing the highest stress and blue representing the lowest. (figure 7).

Before modeling After modeling

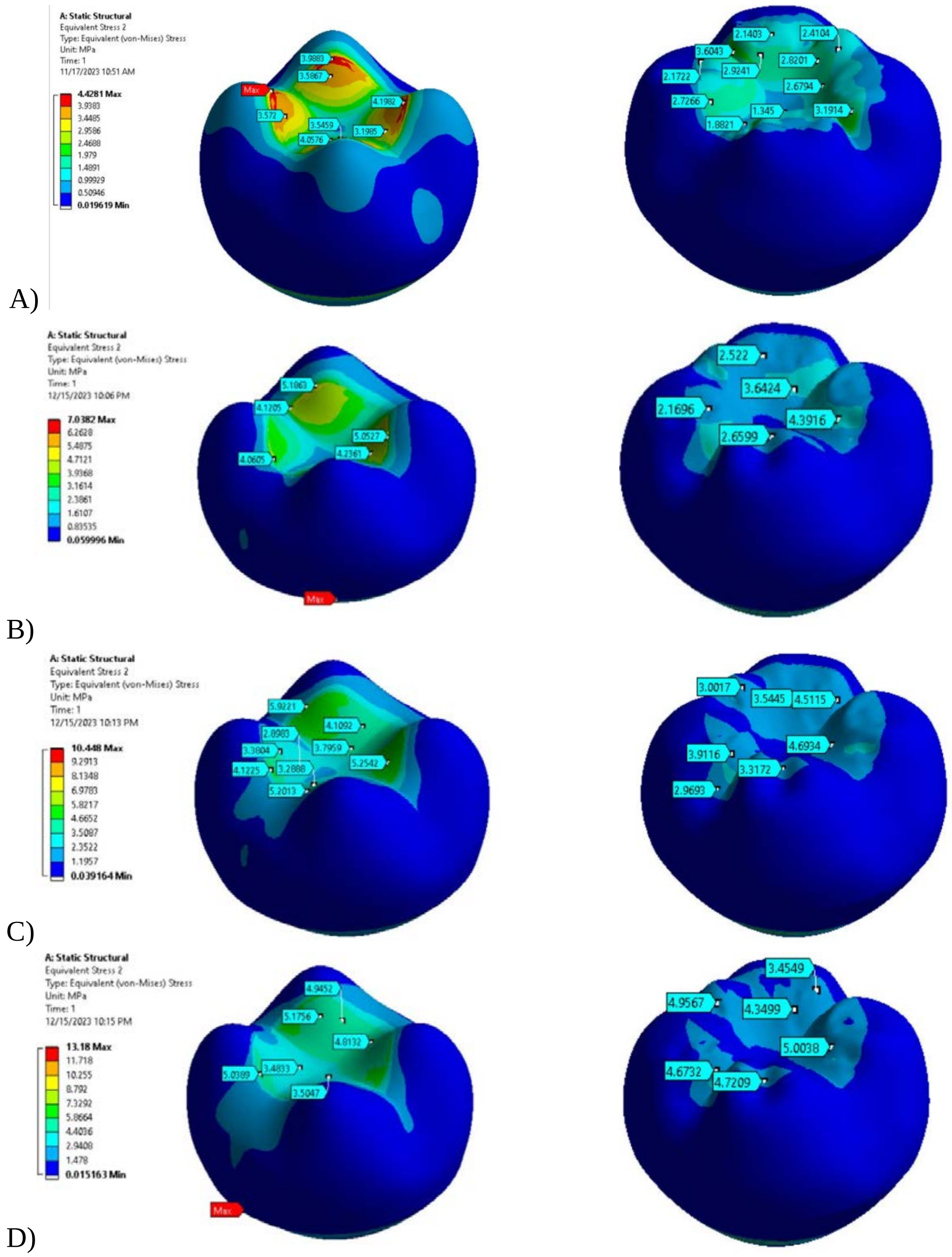

Figure 7: Von Mises stresses distribution of the crown of implant .A) model under axial load, B) model under oblique load 15º; C) model under oblique load 30º; D) model under oblique load 45º.

The loading process creates variable stress for each implant model. Table 2 summarizes the results of this investigation.

Table 2 : Comparison of parameters in implant assembly.

Parameters	Before modeling				After modeling			
	axial load	15°	30°	45°	axial load	15°	30°	45°
Max. Von Mises stress values , MPa	4,4	5.2	6	5.2	2,4	4.4	4.7	5
Min. Von Mises stress values , MPa	3	4	2.8	3.4	1,3	2.1	2.9	3.4
Loaded Area , mm^2	33,01				47,64			
Dimensions of crown, mm	X= 8, Z=9,4 ,Y= 7,5				X= 8,3, Z=10 ,Y= 7,5			
Geometry of the cusp	Prominent				Rounded			

Under loading circumstances, image analysis indicated that the maximum von Mises stress values in the crown surface were greater than 5.5 MPa prior to modeling using SolidWorks program. After modeling the highest von Mises stress value was 4 MPa. In the present study, it can be noted a change in the distribution of stresses on the occulsal surface of both cases will cause that the distribution of stresses after modeling is less severe compared to the stress on the crown of implant before modeling. So, in general, the average value of stresses decreased when the surface contoured and optimized and the stress value after modification decreased by about 30%.

The previous figures show a change in the distribution of stresses on the occulsal surface of both implants with various angles towards the y-axis, as the distribution of stresses on the crown of the implant after modeling is less severe than the distribution of stresses on the crown of the implant before modeling (see the areas colored in red and their gradations in the implant before modeling, where stress prevails). After modeling, it requires an average value of 4.1 MPa for the implant to be dominated by less severe stress areas (the areas with green hue and its gradations) in which the stress approaches the value 2.4 MPa.

Discussion

In the analysis of the present study observed that, after changing the geometry of the crown, it is necessary to calculate the stress condition of the model and make sure that the absolute stress values have decreased and are evenly distributed. According to the finite element method, the results showed the maximum and minimum Von Mises stress values that calculated under loading condition of 100 N before and after modifications of the crown of implant. As well as the area adopted in the analysis and dimensions of the model. The obtained results show that the stress on the crown increased for the models as the load's angle of inclination increased. Before adjustment, the maximum stress value under axial loading was 4.4 MPa. After loading the model at angles of 15, 30, and 45, the stress increased by 18%, 36%, and 18%, respectively. After modeling, it can be noted that the stress value in vertical loading has decreased by 45% compared to the models before modeling. This scenario does not differ in the case of loading at angles 15, 30 and 45, as the stresses decreased by %22 ,%15 and 4%. The cusp inclination of the restoration and occlusal contact may have an impact on the stress on the implants. The relationship between axial and lateral forces is determined by the cusp inclination when contact is permitted during jaw excursive movements.

One restriction of the study is that the materials were deemed to be homogeneous and isotropic. Combined, horizontal, and axial loads should all be taken into account when applying FEA to the prosthesis. Although several implant designs have been created, patients and clinicians continue to be concerned about implant failure and bone loss. Stress from functional loads causes the bone surrounding implants to restructure. Consequently, appropriate biomechanical considerations are essential for the long-term viability of dental implants.

Within the limits of the present investigation, we concluded that implant therapy should always be prosthodontically driven and the success of therapy with implants depends not only on surgical part of implant, but it depend on the prosthetic part of implant biomechanical aspects, geometry of implant assembly and good distribution of occlusal forces. The cusp geometry has a significant impact on stress distribution, and therefore the implant's success. It follows that the occlusal geometry of the implant crown, which includes adequate contact areas and occlusal force vectors, can improve the predictability of final restorations.

Artificial intelligence algorithms have garnered significant interest from researchers and have been effectively utilized to address medical challenges. However, because of the stochastic nature of search methodologies, Artificial intelligence algorithms take a long time to compute for large and complex problems. In order to find answers in real-world applications with limited resources, time, and money, it may be necessary to build efficient algorithms.

Even while finite element models have limitations due to the inability to precisely anticipate the mechanical characteristics and nonlinear behavior of biological tissues, the use of 3D FEA in this study permits depiction of a more complex and detailed geometry. Conversely, finite element models offer the benefit of providing comprehensive stress distributions and enabling the evaluation of particular parameters independently of other variables.

In a conclusion, this study was conducted to perform a procedure for design of implant crown based on artificial intelligence to obtain implant crowns with better stress distribution. This was a preliminary investigation, however, and further study is planned using a larger sample size with different cusp inclinations, different load and different materials.

Finely it can be said considering the parameters of the current study that, the amount of stress on the crown increased for the models as the load angle of inclination increases. Dental implant crown with shallower occlusal morphology lead to better stress redistribution and therefore less occlusal force.

Expectations for the topic's future development

Research may be conducted to use artificial intelligence in the treatment of dental implants failure by using software programs.

Acknowledgements

I would like to extend my thanks to the College of Dentistry, University of Baghdad for providing the necessary support and giving me the opportunity to complete the research work.

Conflict of interest

The authors haven't any conflict of interest to declare.

Informed consent

Informed consent was obtained from all authors in this research.

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تأثير هندسة تاج الزرعة على توزيع الاجهادات بالاعتماد على الذكاء الاصطناعي

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الخلاصة:

الغرض من هذه الدراسة هو تقييم تأثير هندسة التاج على توزيع الضغط للزرعة والأنسجة المحيطة بها. من خلال دراسة تأثير تكوينات التاج المختلفة وزوايا التحميل المختلفة، يهدف الباحثون إلى تقييم كيف يمكن للتغيرات في تصميم التاج وزاوية ميل الحمل أن تؤثر على عوامل مثل توزيع الضغط، وقوى الإطباق، واستجابة الأنسجة، وصحة الفم بشكل عام. تم استخدام تحليل العناصر المحدودة (FEA) لدراسة التفاعلات الميكانيكية الحيوية في تاج الزرعة، بما في ذلك كثافة طاقة الإجهاد المكافئة لفون ميزس ، وعوامل التحميل الزائد، في نموذجين لتكوينات وزوايا تاج مختلفة ومتنوعة. تم استخدام برنامج النمذجة الصلبة (SolidWorks) لإنشاء نماذج صلبة للفك السفلي والزرع وتاج الزركونيا للرحى الأولى للفك السفلي الأيسر والأسنان المجاورة. تم استخدام برنامج ANSYS لتنفيذ عملية إعادة بناء مجموعة النماذج ثلاثية الأبعاد. تشتمل التقنية التحليلية على المعالجة المسبقة لبناء نموذج العناصر المحدودة بالإضافة إلى المعالجة اللاحقة باستخدام SolidWorks. برنامج ثلاثي الأبعاد لتمثيل الحلول. تم إنشاء منطقة على تاج الغرسة لتطبيق حمل ضغط بزوايا مختلفة باتجاه المحور الصادي حيث كانت المساحة قبل النمذجة ببرنامج أفانتيس 33.01 مم2 ولكن بعد التعديل كانت المساحة 47.64 مم2. أعلى ذروة إجهاد فون ميزس تحت حالة التحميل 100 نيوتن على تاج الغرسة حوالي 6 ميجا باسكال قبل النمذجة، في حين كانت قيم الحد الأقصى لإجهاد فون ميزس 5 ميكا باسكال بعد النمذجة. يجب أن يكون العلاج بالزرع دائمًا مدفوعًا بالتعويضات السنية، ولا تعتمد فعاليته فقط على الجانب الجراحي للزرع، ولكن أيضًا على الجانب الاصطناعي للزرع، وهندسة مجموعة الزرع، والتوزيع الصحيح لضغوط الإطباق.