A Comprehensive Computational Fluid Dynamics (CFD) Analysis of Brick Kiln and Brick Soils Using ANSYS

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***Abstract*—This research involves the application of Computational Fluid Dynamics (CFD) in optimizing the thermal performance of brick kiln and brick soils. In this research four popular turbulence models – SST k-ω, Realizable k–ε, Standard k-ω, and RNG k-ε – to simulate the complex, turbulent flow and heat transfer within a brick kiln. Our primary objective is to identify the most effective model for accurately predicting thermal profiles and flow patterns that can impact brick quality and thermal efficiency. The study involves developing detailed 3D CFD models of the kiln, incorporating design configurations, kiln geometry, and brick arrangements. We analyze the predicted temperature distributions, airflow patterns, and heat transfer obtained from each model. Our findings reveal that the SST k-ω model demonstrates superior accuracy in capturing the intricate interplay of turbulence, combustion, and heat transfer within the kiln. It provides the most realistic predictions of temperature profile. Compared to the other models, SST k-ω exhibits superior near-wall performance and accurately captures the complex flow dynamics, leading to a better understanding of combustion efficiency and design formation. The SST k-ω Model is applied to investigate the thermal characteristics of various brick soils, including Brown Earth Soil, Hill/Mountain Forest Soil, Degraded/Grey Brown Podzolic Soil, Mountain Meadow Soil, Red/Yellow Podzolic Soil, and Alluvial Soil. Four key thermal parameters - mean thermal dispersion, effective thermal conductivity, thermal diffusivity, and thermal boundary resistance - are determined for six different types of soils. These parameters are crucial for understanding heat transfer during bricks production. The results indicate significant variations in thermal properties among the different soils. Among these, Brown Earth Soil emerges as the most suitable soil for brick manufacturing, as it experiences consistent uniform heating and also ensure high-quality brick production. Optimized heat transfer helps to reduced fuel consumption and minimizing production costs. The findings provide valuable insights for brick kiln design and soil selection, contributing to enhanced efficiency and sustainability in brick production.**

***Index Terms*—Brick kiln, brick soils, computational fluid dynamics (CFD, heat transfer, thermal characteristics. turbulence models.**

I. INTRODUCTION

A Brick kiln

The brick kiln industry plays a pivotal role in the global construction sector, providing the essential building blocks for various infrastructural projects. The process of brick manufacturing within kilns involves complex interactions of fluid dynamics, heat transfer, and combustion, making it an area of significant interest for scientific investigation and improvement. Understanding and optimizing the operations within a brick kiln are essential for enhancing production efficiency, reducing energy consumption, minimizing environmental impacts, and ensuring the quality of bricks produced.

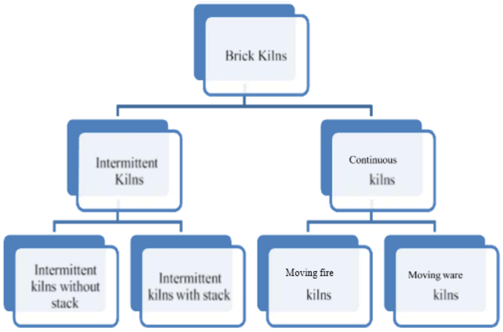

Figure 1 Brick kiln Classification

Brick kilns are traditional, yet technologically evolving, structures where raw materials, typically clay, are subjected to intense heat to transform them into durable bricks. This transformation is influenced by a myriad of factors, including temperature distribution, airflow patterns, and combustion dynamics. Achieving optimal conditions within the kiln is crucial to produce bricks with desired properties and to manage the overall energy and resource consumption efficiently

B. Computational Fluid Dynamics (CFD)

Computational fluid dynamics (CFD) is a specialized field within fluid mechanics that employs numerical techniques and data structures to study and address fluid flow problems. Computers are harnessed to make the necessary computations to simulate fluid movement and its interactions with defined boundary surfaces. The capabilities of high-performance supercomputers enable more precise solutions, especially for highly intricate challenges like transonic or turbulent flows. As this field evolves, new software emerges that enhances both the precision and efficiency of these simulations. In a CFD software analysis, fluid flow and its associated physical properties, such as velocity, pressure, viscosity, density, and temperature, are calculated based on defined operating conditions. In order to arrive at an accurate, physical solution, these quantities are calculated simultaneously. Every CFD tool, both commercial and/or open source, uses a mathematical model and numerical method to predict the desired flow physics. The most common CFD tools are based on the Navier- Stokes (N-S) equations. While the bulk of the terms in the Navier-Stokes equations remains constant, more terms can be added or removed based on the physics.In recent years, Computational Fluid Dynamics (CFD) has emerged as a powerful tool to simulate and analyze the fluid flow, heat transfer, and combustion processes within brick kilns. CFD enables researchers and industry professionals to gain insights into the kiln's internal dynamics, aiding in the design and optimization of kiln configurations and operating parameters. Moreover, utilizing advanced turbulence models and numerical simulations allows for a detailed examination of the airflow patterns, temperature profiles, and energy transfer mechanisms within the kiln, providing valuable information for process improvements and environmental sustainability.

This paper aims to delve into a comprehensive study of the fluid dynamics and heat transfer phenomena within brick kilns using CFD analysis. The utilization of advanced turbulence models will enable a detailed investigation into the complexities of airflow and heat distribution, enhancing our understanding of the kiln's behaviour and its interplay with brick stacks. The findings from this study hold potential to revolutionize the brick manufacturing industry, leading to increased efficiency, reduced environmental impact, and advancements in sustainable brick production.

II. LITERAUTRE REVIEW

This literature review delves into the integration and application of Ansys Fluent, a cutting-edge CFD software, in the domain of brick kiln simulations. It explores the growing significance of CFD in simulating and analysing the intricate processes occurring within brick kilns. The focus lies on understanding temperature distributions, fluid flow patterns, and energy transfer phenomena, all of which profoundly influence the quality and efficiency of brick production. Through an in-depth analysis of existing studies and research endeavour, this review aims to unveil the diverse applications, methodologies, and outcomes obtained through the utilization of Ansys Fluent in the context of brick kiln simulations. Furthermore, it highlights the potential of CFD to revolutionize the brick manufacturing industry by fostering advancements in kiln design, energy efficiency, and environmental sustainability. The integration of the simulations with Ansys Fluent signifies a significant leap towards enhancing the efficiency and sustainability of brick kiln operations, contributing to a greener and more sustainable future for the construction sector. Refaey and Specht [1998), studied the burning process of sanitary ware in tunnel kilns is a complex process involving heat transfer, mass transfer, and combustion. Understanding the flow patterns within the kiln is crucial for optimizing the burning process and ensuring the quality of the final product.S. Prasertsan [1998] aimed to optimize the kiln design and operation, with a particular emphasis on improving energy efficiency and enhancing the overall quality of the produced bricks. By incorporating separate chambers for each process and integrating a heat recovery system, the new downdraft brick kiln design holds significant potential for more efficient and sustainable brick manufacturing. Abou-Ziyan [2004] study on the optimization of design parameters for a tunnel kiln using computational fluid dynamics (CFD). The author developed a three-dimensional model of the kiln and used it to simulate the flow of air and combustion gases, the heat transfer within the kiln, and the drying and firing of the bricks. The model investigates the effects of various design parameters, such as the kiln dimensions, the burner configuration, and the brick arrangement, on the performance of the kiln. Naccache et al. [2005] presents a novel multi-scale approach for the numerical simulation of a tunnel kiln used for brick production. This approach combines a macroscopic model for the fluid flow and heat transfer within the kiln with a microscopic model for the drying and firing of individual bricks. The macroscopic finite volume method and accounts for the combustion process, radiation heat transfer, and porous media effects. The microscopic model describes the coupled heat and mass transfer processes within the bricks using a homogenization technique. Refaey [2013],In this a comprehensive approach to the mathematical modeling and optimization of tunnel kilns used for brick production. The author developed a mathematical model that considers the coupled heat and mass transfer processes within the kiln, including combustion, radiation, and diffusion. The model is capable of predicting the temperature distribution, flow patterns, and drying and firing behavior of the bricks. The author then applied optimization techniques to the model to identify the optimal operating conditions for the kiln, minimizing energy consumption while maintaining desired product quality. The study investigated the impact of various operating parameters, such as firing temperature, air-fuel ratio, and burner configuration, on the kiln's performance .S Pariyar and Ferdous [2013] used a combination of primary and secondary data collection methods. Primary data were collected through household environmental health surveys and school health examinations conducted near brick kilns. Secondary data on air pollutant concentrations and brick kiln production were obtained from relevant government agencies and research reports.Auvi Tehzeeb[2013] stated that in order to get a uniform distribution of heated gases, positions of the brick stacks are such that on each occasion of its changed position it would be just directly below the inlet jets. Gaps between two consecutive brick stacks should also be reduced to 200 mm instead of the initially assumed 400 mm spacing. Hence additional number of bricks could be accommodated inside the kiln at a time which will result higher production of bricks with the same amount of fuel. Dar et al. [2014] Brick kilns are a vital industry in the Kashmir Valley, providing essential building materials. However, their operation raises concerns about their environmental impact. This study investigates the environmental consequences of brick kiln emissions in the region. The authors employed a combination of field measurements and laboratory analyses to assess the air and water quality near brick kilns. They measured ambient air concentrations of particulate matter (PM), sulfur dioxide (SO2), and nitrogen oxides (NOx). Additionally, they collected water samples from nearby sources to analyze their contamination levels. Mezquita et al. [2014] deeply investigates the performance heat recovery system in a ceramic tile kiln. The study specifically focuses on the effectiveness of the system in recovering waste heat from the cooling zone of the kiln and utilizing it to preheat the combustion air. Tehzeeb et al. [2014] stated that traditional brick kilns are notorious for their high energy consumption and significant air pollution emissions. This study investigated the potential of using computational fluid dynamics (CFD) to model the behavior of a brick kiln and identify opportunities for emission reduction. Ratanathavorn[2015] aimed at simplifying model and redesigning the clay brick kiln using three- dimensional computational fluid dynamics (CFD). The studied parameters for 23 factorial designs were as follows: kiln height (200 – 225 cm), horizontal holes width(7.5 – 15 cm) and height (45 – 60 cm). The total volume of brick stack, averaged steady- state temperature and time to reach a steady-state temperature were selected as the response parameters. Alrahmani et al. [2022][Tunnel kilns are widely used for brick production, but their efficiency and sustainability can be improved. This study investigates the combined effect of brick surface roughness and lattice setting density on the firing process in tunnel kilns, aiming to optimize both energy consumption and product quality.The authors employed a three-dimensional computational fluid dynamics (CFD) model to simulate the firing process within a tunnel kiln. Bilal Hussain[2022] gave the theory of planned behavior to examine the individual’s intentions and zig-zag kiln technology adoption attitude in responding to carbon emissions. Partial least squares structural equation modeling technique was used for the analysis. Results depicted that environmental concern and self-efficacy have a significant influence on attitude toward sustainable technology while subjective norms have a significant effect on intentions toward zig-zag kiln technology. HÀ Refaey[2023] investigation presents the flow characteristics through four different lattice brick settings (e.g., velocity vectors, velocity contours and streamlines) that could not be measured experimentally. The investigation also looks at the flow zones of the vortex formation upstream, downstream and through the brick column.

III. OBJECTIVES

1. *Improved Brick Kiln Designs*:
   The tunnel kiln is one of the advanced and efficient kiln types used mainly for continuous, large-scale brick production. It consists of a long, horizontal tunnel in which bricks move on cars from the entrance (cold end) to the exit (hot end).
2. *Uniformity and Quality*:
   The controlled environment within the tunnel ensures that bricks are uniformly heated and fired. This leads to a consistent quality, with minimal defects like warping or cracking.
3. *Effective Design Principle*:
   The tunnel kiln operates on a counter-current principle where raw bricks enter the cold end and are pre-heated using the outgoing hot air from the firing zone. As the bricks progress through the tunnel, they reach the central firing zone, where they're fired at peak temperatures. Post firing, they move towards the exit, undergoing gradual cooling.
4. *Energy Efficiency*:
   The counter-current heat exchange principle ensures optimal use of heat, reducing energy wastage. The continuous process eliminates the need to heat and cool the kiln for each batch, saving energy compared to intermittent kilns.
5. *Flexibility:*
   While traditionally used for brick-making, the design of tunnel kilns allows for modifications to accommodate different products like tiles, ceramics, or evencertain metals.
6. *Economic Benefits*:
   The high throughput and efficiency of tunnel kilns often translate to lower per-unit production costs, making them economically favourable for large-scale production setups.

IV. METHODOLOGY

The ANSYS Design Modeler serves as a tool for creating the geometric representation of the fluid domain, providing a versatile platform for conducting analyses. While it's possible to generate geometries in alternative CAD software and subsequently import them into ANSYS, there are certain considerations to bear in mind. Geometries fashioned in other CAD software may encompass intricate details that may not seamlessly translate into the CFD simulation context, potentially necessitating adjustments or corrections. As a result, opting for the integrated drawing software, known as 'Design Modeler' within ANSYS, is often the preferred approach for modelling the geometry.

In geometric modeling using ANSYS, a sustain approach was employed. Specifically,we opted for the Fluid Flow Fluent analysis system. This choice was driven by the need to undertake a thorough Computational Fluid Dynamics (CFD) analysis focused on thedynamics within the brick kiln. It is preferred to deeply understand the fluid dynamics, heat distribution, and various related aspects within the intricate structure of the kiln. The flow characteristics around brick settings in the manufacturing process is crucial for assessing energy consumption and improving process efficiency. By achievinghigher efficiency, fuel consumption can be reduced, leading to lower carbon emissionsand a reduced environmental impact. The complexity of this setup necessitates a comprehensive understanding of the flow behavior. Therefore, the primary objective of this research is to investigate the flow field in various lattice brick configurations.

1. Geometry

In the process of designing the brick kiln, the software tool Space Claim withinthe Geometry section proved instrumental. This platform facilitated the accurate modeling of the brick kiln, meticulously incorporating the specified dimensions of 6000mm in length, 2200mm in breadth, and 1000mm in height. Regarding the arrangement of bricks within the kiln, a total of 300 bricks were strategically introduced. They were methodically stacked, each stack containing precisely 10 bricks. The dimensions of each brick stack were meticulously maintained at 200mm in length, 100mm in breadth, and 100mm in height, ensuring a systematic and structured setup as shown in figure 2.

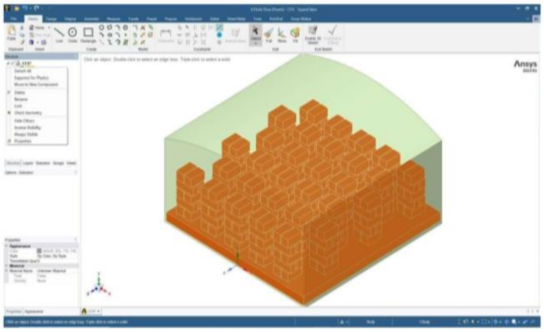

Figure 2: Geometrical Model of Brick kiln with brick stacks

In the modular design phase of the Fluid Flow Fluent software, the Boolean expressionemerged as a pivotal tool, wielding substantial influence over the geometry of both the brickkiln and its associated brick stacks. This computational method allowed for the creation of complex shapes and structures by integrating and manipulating various geometrical elements. Specifically, the Boolean operation known as “Intersect” played a paramount role. This operation allowed for the formation of a cohesive body by extracting the shared or intersecting components from two or more initial bodies. In the context of this project, the Intersect operation was applied to the geometrical representations of the brick kiln and brick stacks. By skillfully employing Boolean operations, particularly Intersect, the design process achieved a high level of precision and accuracy. It enabled the creation of a coherent unified body that encapsulated the essential features arising from the intersection of the respective geometries. This meticulous use of Boolean operations profoundly impacted the subsequent analysis and simulation of the brick kiln and its stacks within the Fluid Flow Fluent module, enhancing the robustness and reliability of the computational model shown in figure 3

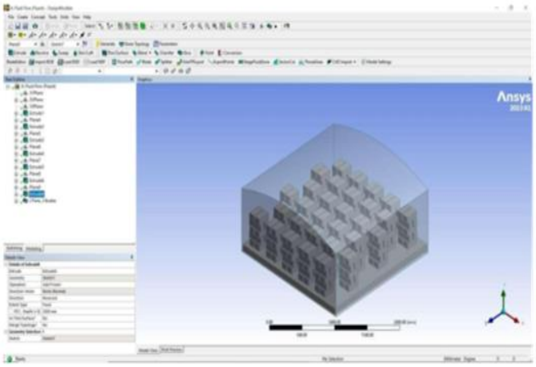

Figure 3: Boolean Operation

2.Meshing

In the process of creating a mesh for the simulation, careful considerations were made regarding the physics and solver preferences. The mesh was specifically generated with a focus on Computational Fluid Dynamics (CFD), aligning with the nature of the analysis. The solver preference leaned towards utilizing Fluent, a choice that harmonized well with the intended simulation requirements. To ensure an optimal mesh structure, a linear element order was employed..In terms of element size, a meticulous approach was adopted, especially concerning the intricacies of brick kiln and stack geometries. The element size for meshing relevant to the machining features was set at 0.1 m. This choice was well-thought-out, factoring in the intricacies of the bricks and their arrangements within the kiln. It aimed to strike a balance between computational efficiency and capturing the essential details crucial for the accuracy of the simulation. This finely-tuned element size was particularly chosen to optimize the representation of the brick kiln and stacks, ensuring that the subsequent simulation is both precise and computationally feasible.

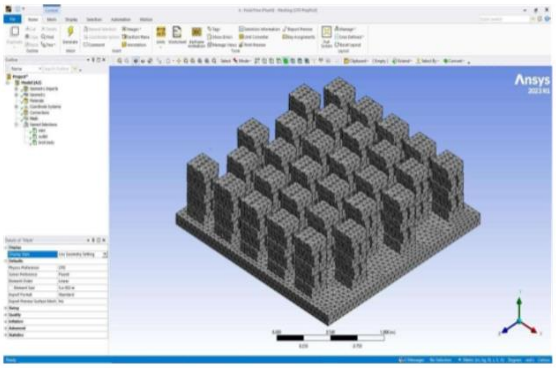

Figure 4: Meshing of Brick Stacks

3.Solution Set up

To initiate this critical stage, the k-epsilon (k-ε) turbulence model with the realizable formulation is judiciously selected. This model holds particular significance in the domain of fluid dynamics simulations due to its proven efficiency and accuracy in capturing turbulent flow behaviors. The essence of the k-ε turbulence model lies in its capability to handle turbulence with realism and reliability. It involves the estimation and computation of two essential variables, namely, turbulence kinetic energy (k) and turbulence dissipation rate (ε). These parameters, coupled with the realizable formulation, allow for a more realistic representation of turbulence in the system. Furthermore, in pursuit of precision and relevance, incorporated into the turbulence model. These wall functions are meticulously chosen to ensure the accurate representation of boundary layer behavior, an integral aspect when analyzing the airflow and heat transfer within the brick kiln. Distinctive model constants are attributed to these wall functions, tailored to suit the specific conditions and intricacies of the brick kiln system. The careful selection of these constants further fine-tunes the turbulence model, enhancing its predictive accuracy and enabling a more refined simulation of the fluid dynamics within the brick kiln.

In summary, the choice of the k-ε turbulence model with the realizable formulation and appropriately calibrated wall functions marks a pivotal step towards an accurate and insightful CFD analysis of the brick kiln. This decision sets the stage for in-depth exploration and comprehension of the complex airflow

4.Fluid Material

In constructing a robust setup for the Computational Fluid Dynamics (CFD)analysis of the brick kiln, a fundamental element that demands thorough consideration is the choice of the fluid material to be simulated within the system. This selection profoundly influences the accuracy and relevance of the analysis.

In this particular analysis, the designated fluid material is air—an apt choice given its real-world relevance and its common occurrence in brick kilns. Air, being the primary medium for heat transfer and airflow within the kiln, stands as a representative fluid for a host of thermal analyses. Its properties, including density, specific heat, and thermal conductivity, hold immense importance in accurately modelling the dynamic behaviors of heat and mass transfer within the kiln.

The properties of air, a crucial part of the fluid dynamics equation, play a pivotal role in shaping the simulation outcomes. These properties encompass only the thermodynamic properties but also the transport properties such as viscosity and thermal diffusivity. Understanding and accurately representing these properties allow for a faithful emulation of the complex thermal and fluid interactions happening withinthe brick kiln.

Moreover, incorporating the actual properties of air ensures a direct representation of the practical working conditions in a brick kiln, lending authenticity to the simulation.It enables an exploration of temperature distributions, airflow patterns, and the intricate interplay between the kiln structure and the air—insights that are crucial for optimizing the kiln design and its operational efficiency.

In conclusion, selecting air as the fluid material for this CFD analysis of the brickkiln isa prudent choice. It mirrors real-world conditions and allows for a precise and meaningful investigation into the thermal and fluid dynamics of the kiln. This choice sets the stage for a comprehensive understanding of the system, ultimately contributing to advancements and improvements in brick kiln design and operation.

5. Initialization Methods

"Hybrid initialization" in the context of Computational Fluid Dynamics (CFD) refers to the approach where different parts of the domain are initialized using different methods. This can help achieve a more accurate and stable initial condition for the simulation. In the case of a brick kiln with brick stacks, let's discuss a hybrid initialization approach:

1.*Initialization for the Air Inside the Kiln:*

(i) Method:

Initialize the airflow within the kiln using the given inlet boundary conditions (velocity of 0.001 m/s and temperature of 900 K). This represents the initial state of the air as it enters the kiln.

(ii) Temperature Profile:

Consider establishing a temperature profile based on the inlet geometry of the kiln to represent the temperature distribution inside the kiln at the beginning of the simulation.

1. Species Initialization: If relevant, initialize species concentrations based on the composition of the incoming air.

(a) Initialization for the Bricks and Kiln Walls:
1.Method:
Initialize the bricks and kiln walls using an isothermal or adiabatic condition, depending on the nature of the wall boundaries (e.g., adiabatic) if no heat transfer is expected through the walls).
2.Temperature Profile:
Assign a uniform or gradient-based temperature profile to the solid parts to represent their initial thermal state.
3.Hybrid Approach:
Combine the initial conditions for the air and solid parts to achieve a hybrid initialization. This could involve a stepwise initialization, where the air properties areset first, followed by the initialization of the solids. By using a hybrid initialization approach, you ensure that the airflow within the kiln and the temperature distribution in the bricks and kiln walls are appropriately set at the beginning of the simulation. This can lead to a smoother and more accurate convergence during the simulation, as the initial conditions reflect the expected behaviour of the system. It is important to carefully consider the properties and behaviour of the materials involved, and adjust the initialization method based on the specifics of the brickkiln and brick stacks being simulated. Additionally, validation and fine-tuning of the initialization approach may be necessary to ensure accurate representation of the system.

V. RESULTS

During research work, various temperature and pressure values were corresponding to six consecutive rows of bricks were taken and tabulated accordingly in the form of tables. Then from tabulated values of SST, graph was modelled in ANSYS depicting the variation of temperature (in K) and pressure (in Pa) across the different layers or rows of bricks stacked together.

For calculation purposes, minimum six consecutive rows are taken for consideration. Two Model were taken k-ω Model and k–ε Model each of standard and average type.

1.*SST (Shear Stress Transport) k-ω Model:*

1. It is of two types viz. average and standard types.

Table 1: SST (Shear Stress Transport) k-ω Model showing average temperature and pressure distribution of Brick Kiln with Brick Stacks

Row	Brick Kiln (Temperature)[K]	Brick Stacks (Temperature)[K]	Brick Kiln (Pressure)[Pa]
1	1264.22	1275.17	0.53
2	1231.37	1242.32	0.42
3	1198.53	1209.48	0.32
4	1165.69	1176.64	0.21
5	1132.84	1143.79	0.10
6	1107.45	1110.95	0.03

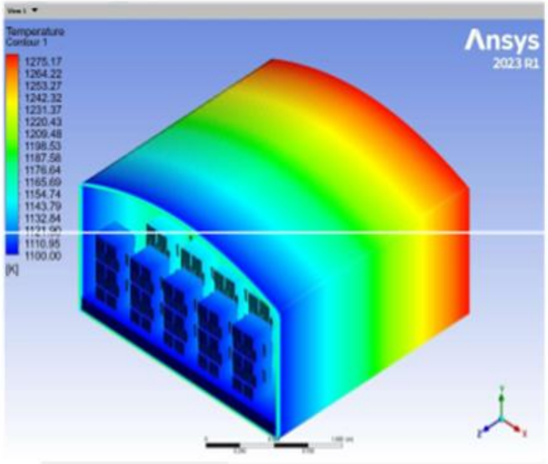

Figure 5: SST (Shear Stress Transport) k-ω model Brick Kiln temperature distribution

Table 2: SST (Shear Stress Transport) k-ω Model showing standard temperature and pressure distribution of Brick Kiln with Brick Stacks

Row	Brick Kiln (Temperature)[K]	Brick Stacks (Temperature)[K]	Brick Kiln (Pressure)[Pa]
1	1547.64	1584.15	0.57
2	1438.11	1474.62	0.46
3	1328.58	1365.09	0.35
4	1219.05	1255.56	0.25
5	1109.53	1146.04	0.14
6	1018.26	1036.51	0.03

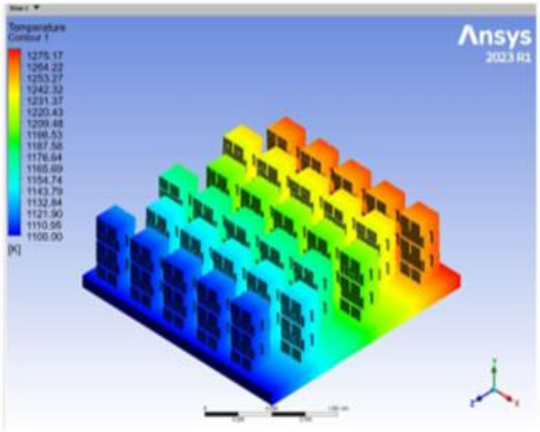

Figure 6: SST (Shear Stress Transport) k-ω model standard Brick Stacks temperature distribution

2.*SST (Shear Stress Transport) k- ε Model:*

It is of two types viz. average and standard types and temperature and pressure distribution is tabulated as under

Table 3: Realizable k–ε Model, Average Temperature and Pressure Distribution of Brick Kiln with Brick Stacks

Row	Brick Kiln (Temperature)[K]	Brick Stacks (Temperature)[K]	Brick Kiln (Pressure)[Pa]
1	1509.09	1569.70	0.55
2	1327.27	1387.88	0.45
3	1145.45	1206.06	0.32
4	963.64	1024.24	0.23
5	781.82	842.42	0.14
6	630.35	660.61	0.05

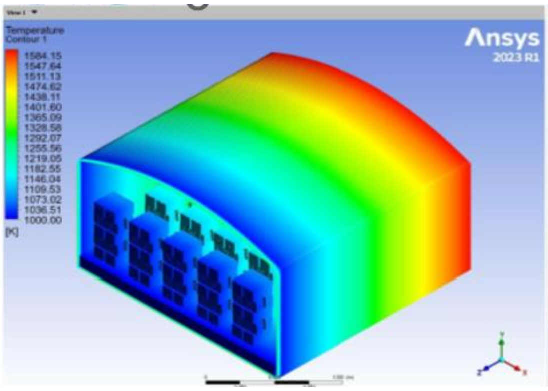

Figure 7: Standard k-ω model Brick Kiln temperature distribution.

Table 4: Realizable k–ε Model showing average temperature and pressure distribution of Brick Kiln with Brick Stacks

Row	Brick Kiln (Temperature)[K]	Brick Stacks (Temperature)[K]	Brick Kiln (Pressure)[Pa]
1	1509.09	1569.70	0.55
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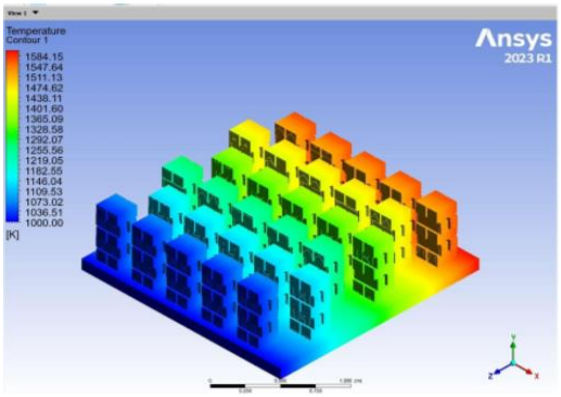

Figure 8: Standard k-ω model Brick Stacks temperature distribution

VII. CONCLUSION

In conclusion, our research endeavour was dedicated to a thorough analysis of the intricacies surrounding Brick Kiln and Brick Stacks. We sought to unravel the most effective model capable of providing an accurate representation of temperature and pressure distributions within the complex framework of the kiln and stacks. After a rigorous evaluation process, the SST k-omega model emerged as the unequivocal frontrunner, not only demonstrating a remarkable proficiency in precisely representing temperature and pressure distributions within the brick kiln and stacks but also showcasing a remarkable alignment with real-world observations. This level of precision is crucial for developing a comprehensive understanding of the nuanced thermal and pressure behaviors inherent in the system.

The SST k-omega model's superiority became evident not only in its capacity to capture intricate nuances in temperature and pressure variations but also in its ability to portray these distributions in a manner that closely mirrors real-world scenarios. This high degree of accuracy forms a robust foundation for informed decision-making related to temperature and pressure control, ultimately leading to the optimization of the efficiency of the kiln and stack system.

Moreover, the SST k-omega model's exceptional balance between computational efficiency and accuracy enhances its standing as a pivotal tool for future Computational Fluid Dynamics (CFD) analyses in similar industrial contexts. This equilibrium positions it as a reliable instrument for advancing research and engineering efforts, ensuring a judicious use of computational resources without compromising the precision required for insightful analyses. Transitioning to the thermal behaviors of soils in the specific context of Jammu and Kashmir, our investigation uncovered a nuanced landscape. Brown Earth Soils and Hill or Mountain Forest Soils emerged as particularly advantageous, boasting high thermal conductivity and diffusivity, facilitating only efficient heat transfer but also expediting the drying process. Conversely, Degraded or Grey Brown Podzolic Soils, Mountain Meadow Soils, Red and Yellow Podzolic Soils, and Alluvial Soils presented a spectrum of thermal properties, influencing factors such as drying times, energy consumption, and drying uniformity. The integration of these findings provides a nuanced understanding of distinct thermal behaviors, empowering brick manufacturers to tailor their processes with precision. This optimization not only enhances the production of high-quality bricks but also contributes significantly to sustainable practices in the brick manufacturing industry within the unique environmental context of Jammu and Kashmir. Thus, our comprehensive insights into both turbulence models and soil-specific thermal characteristics collectively lay a robust foundation for advancing the brick manufacturing industry in the region, promoting a harmonious blend of quality production and environmental sustainability

VIII. ACKNOWLEDGMENT

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