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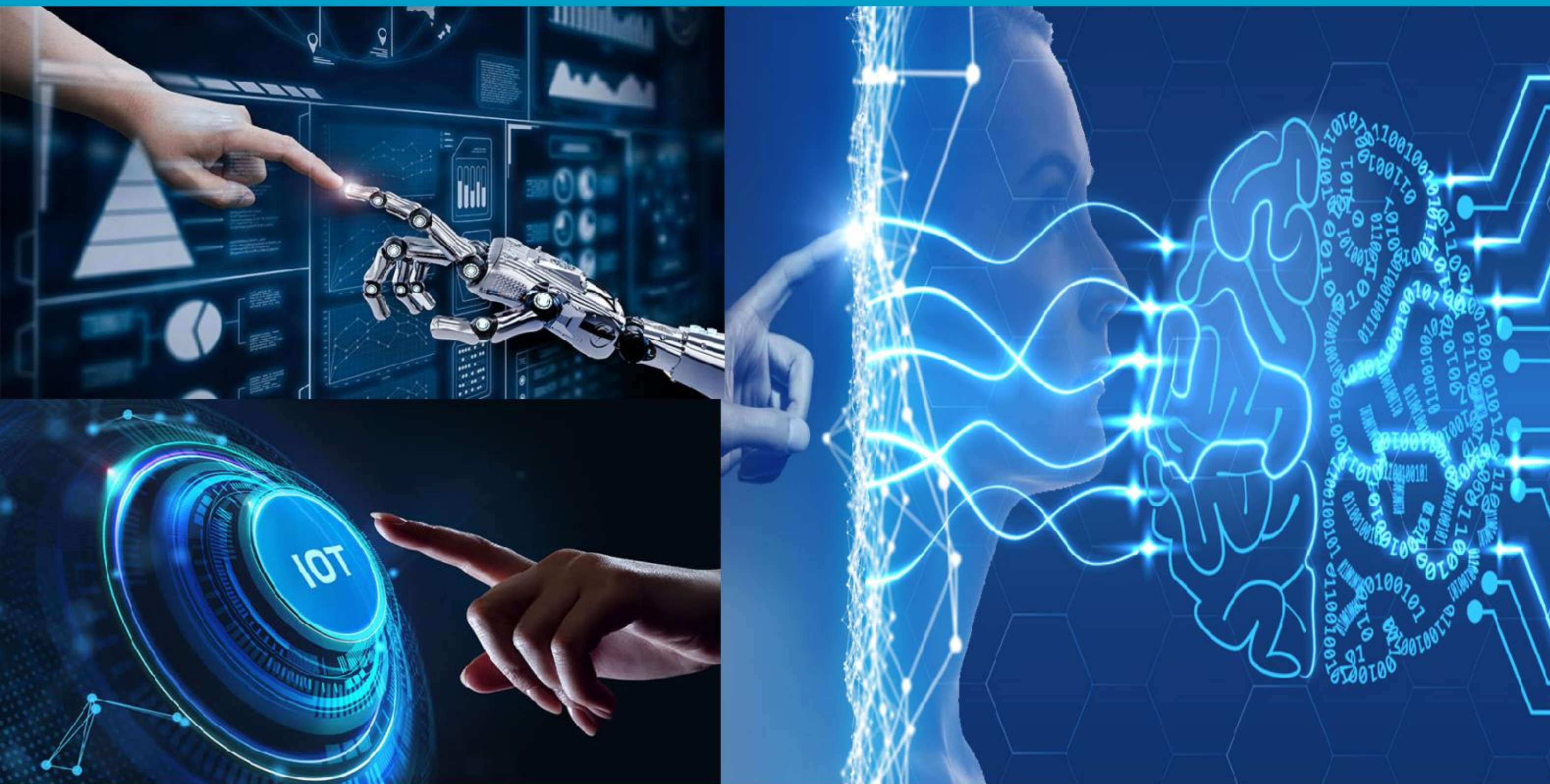

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Experimental Investigation in Heat Stress Index with Various Thermal Coatings

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Abstract: This study explores the use of ceramic coatings on asbestos sheeting to improve its durability and thermal insulation properties. Asbestos sheeting is widely used in construction, but its susceptibility to corrosion in high-temperature environments limits its lifespan and contributes to energy waste and heat pollution. Ceramic coatings can mitigate these issues by providing a higher thermal barrier and resistance to corrosion. In this study, various ceramic powders, including aluminum dioxide, zirconium dioxide, and titanium dioxide, were used to coat asbestos sheets. The coated sheets were analyzed in ANSYS software to determine their performance compared to uncoated sheets. The results showed that ceramic coatings improved the surface quality and thermal insulation properties of the asbestos sheeting, with aluminum dioxide and zirconium dioxide coatings providing the best results. The study suggests that ceramic coatings on asbestos sheeting can be effective in reducing heat radiation to the environment and maximizing the efficiency of asbestos metal sheets in power plants, industrial, and construction areas.To mitigate the health issues associated with steel metal roof sheets during heat transfer processes.

1. INTRODUCTION

Asbestos sheeting has been widely used in construction for decades due to its numerous advantages, including high tensile strength, flexibility, and resistance to fire and chemicals. However, the use of asbestos in construction has been linked to health hazards, including mesothelioma and lung cancer, leading to its ban in many countries [1]. In India, where asbestos is still widely used in construction, environmental health and safety concerns have led to increased scrutiny and the search for safer alternatives.

One issue with asbestos sheeting is its susceptibility to corrosion in high-temperature environments, which can contribute to energy waste and heat pollution. To address this issue, various thermal coatings have been investigated as a potential solution. Ceramic coatings, in particular, have shown promise due to their high thermal barrier and resistance to corrosion [2].

Previous studies have evaluated the effectiveness of ceramic coatings on asbestos sheeting in mitigating heat radiation and improving thermal insulation properties. For example, a study by Gouda et al. analyzed various ceramic (including aluminum dioxide, zirconium dioxide, and titanium dioxide) to determine their performance as coatings on asbestos sheeting in ANSYS software [3]. The study found that ceramic coatings improved the surface quality and thermal insulation properties of the asbestos sheeting, with aluminum dioxide and zirconium dioxide coatings providing the best results.

Similarly, in a study by Rajasekaran et al., the effectiveness of various thermal coatings on reducing heat stress index was evaluated in high-temperature environments using devices such as the WBGT meter and TWL meter [4]. The study found that thermal coatings can significantly reduce heat stress index and improve thermal comfort in such environments.

Overall, the use of thermal coatings on asbestos sheeting has significant implications for the construction industry, particularly in India, where environmental health and safety concerns are paramount. By reducing energy waste, heat pollution, and heat stress index, thermal coatings have the potential to improve the efficiency and sustainability of construction practices.

II. MATERIALS AND METHODS

The materials used in this study include a metal roof sheet, aluminum dioxide,zirconium dioxide, and titanium dioxide. The metal roof sheet serves as the base material onto which the ceramic coatings are applied, while the aluminum dioxide, zirconium dioxide, and titanium dioxide are used to create the ceramic coatings.

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2.1 Metal roof sheet:
A metal roof sheet is a type of roofing material used in construction. It is made of metal, typically aluminum or steel, and is designed to provide a durable and weather-resistant barrier for buildings. Metal roof sheets are commonly used in industrial, commercial, and residential construction due to their durability, ease of installation, and low maintenance requirements.

2.2 Aluminum dioxide:
Aluminum dioxide is a ceramic material composed of aluminum oxide (Al_2O_3). It is a white or off-white powder that is commonly used in thermal coatings due to its high thermal resistance and excellent insulating properties. Aluminum dioxide can withstand high temperatures, resist corrosion, and provide a high level of thermal insulation, making it ideal for use in high-temperature environments such as power plants and industrial settings.

2.3 Zirconium dioxide:
Zirconium dioxide is a ceramic material composed of zirconium dioxide (ZrO_2). It is a white or off-white powder that is known for its high strength, toughness, and thermal resistance. Zirconium dioxide is commonly used in thermal coatings for its ability to provide excellent thermal insulation and wear resistance. It is often used in industrial and manufacturing settings, such as in furnaces and kilns, where high temperatures and wear are a concern.

2.4 Titanium dioxide:
Titanium dioxide is a white pigment that is commonly used in paints, coatings, and plastics. It is known for its ability to reflect light and provide opacity, making it useful for creating bright white colors. In this study, titanium dioxide is used as a ceramic material for its thermal insulation properties. It can reflect heat and provide a barrier against thermal radiation, helping to reduce heat transfer and improve the energy efficiency of the coated Metal roof sheet.

3. Health Issues by existing Metal roof Sheet
Existing steel metal roof sheets can pose several health issues, especially during the heat transfer process. When exposed to high temperatures, steel can release toxic fumes and chemicals such as zinc oxide, cadmium oxide, and lead oxide. These fumes can cause respiratory problems, irritation of the eyes, nose, and throat, and can also lead to long-term health issues such as lung cancer, kidney damage, and neurological problems.
Moreover, steel roof sheets can also contribute to heat pollution and increase the overall temperature in the surrounding environment. This can lead to discomfort, heat exhaustion, and dehydration for people working or living in the affected area. The increased temperature can also have adverse effects on the ecosystem, wildlife, and vegetation.
Therefore, it is essential to take appropriate measures to address the health issues associated with existing steel metal roof sheets, such as applying ceramic coatings to improve their thermal insulation properties and prevent the release of toxic fumes. This can help to reduce the health risks associated with heat transfer and ensure a safer and healthier environment for workers and residents.

4. Necessity of ceramic coating
The necessity of ceramic coating with titanium dioxide, zirconium dioxide, and aluminum dioxide on metal roof sheets arises from the need to improve their performance and increase their durability, thermal insulation properties, and resistance to corrosion.
Firstly, the use of ceramic coatings can improve the energy efficiency of buildings by reducing heat transfer through metal roof sheets. This reduces the amount of heat that is radiated into the environment, which can help to reduce energy consumption and improve indoor comfort. Ceramic coatings can reflect a significant portion of solar radiation, preventing heat buildup in the building and reducing the need for air conditioning.
Secondly, ceramic coatings can increase the durability of metal roof sheets by protecting them from corrosion. Metal roof sheets are vulnerable to corrosion caused by exposure to weather elements such as rain, wind, and UV radiation. Ceramic coatings can provide a protective layer that prevents corrosion, thereby extending the lifespan of metal roof sheets and reducing maintenance costs.
Thirdly, ceramic coatings can improve the thermal insulation properties of metal roof sheets. This reduces heat loss from the building, which can help to maintain a comfortable indoor temperature and reduce energy consumption. Ceramic coatings can also improve the fire resistance of metal roof sheets, providing an added layer of protection in the event of a fire.
Finally, ceramic coatings are environmentally friendly and do not release harmful chemicals during installation or use. This makes them a safer and more sustainable option for construction.

5. Design and Analysis

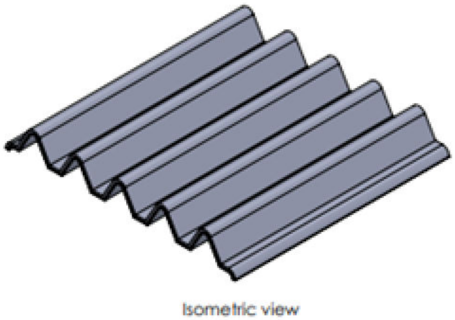

Fig 5.1 Design

5.2 Analysis

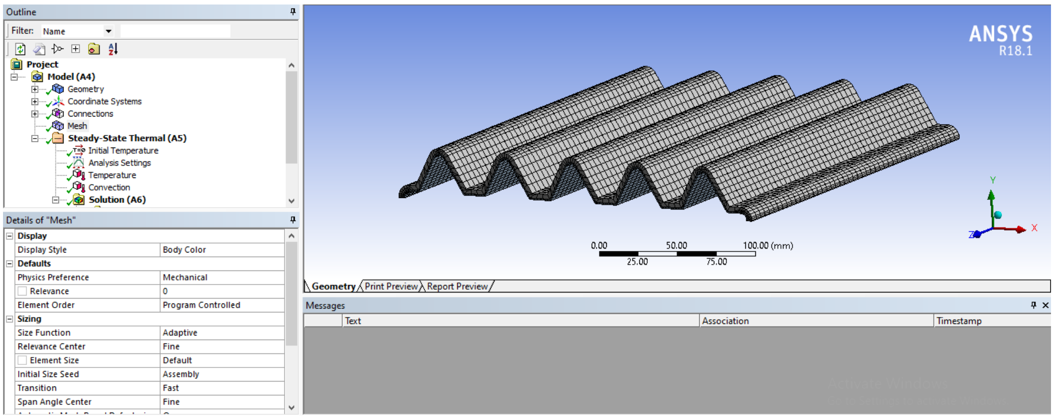

Fig 5.2.1 Mesh

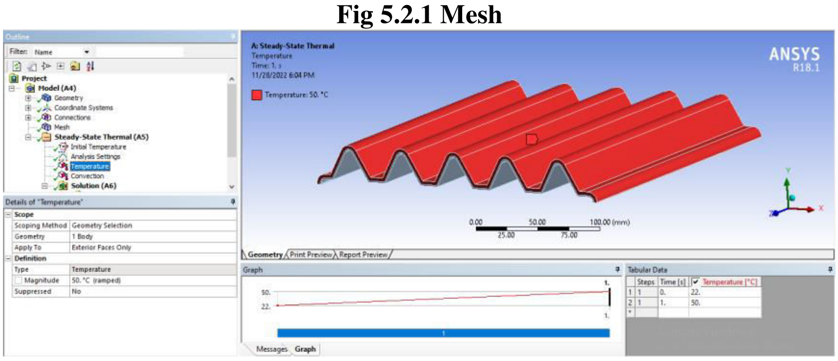

Fig 5.2.2 Temperature

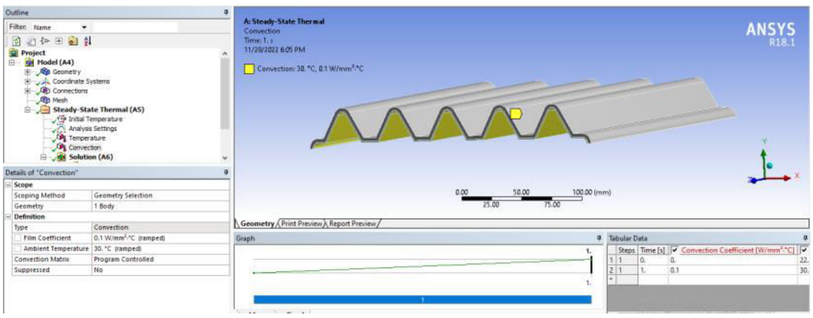

Fig 5.2.3 Convection

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5.3 Resultsfor Aluminum dioxide

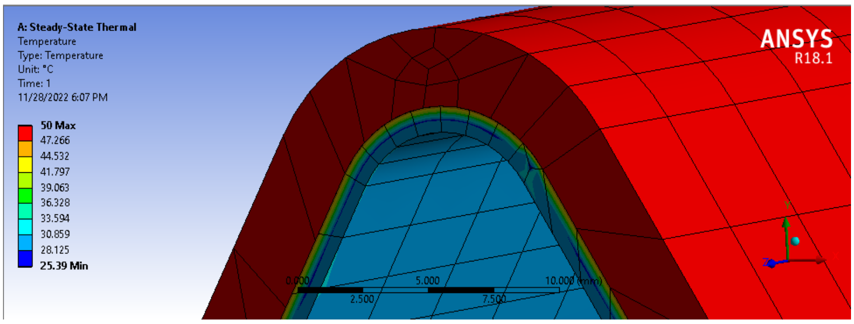

Fig 5.3.1 Temperature

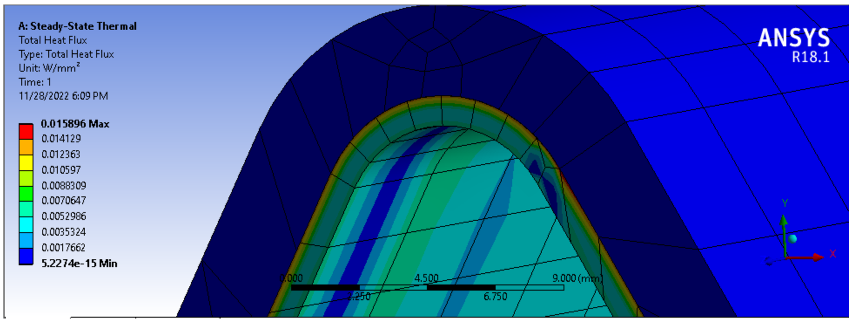

Fig 5.3.2 Total heat flux

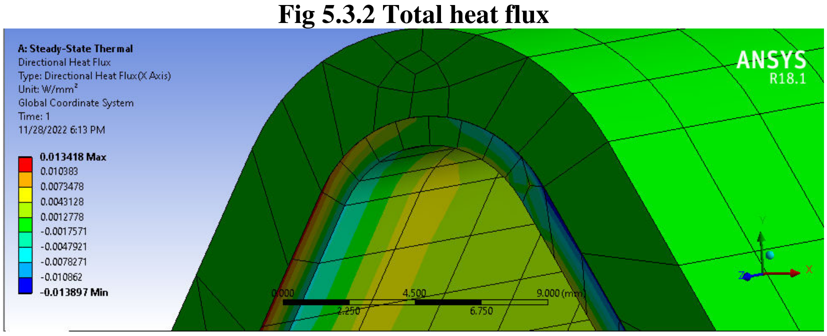

Fig 5.3.3 Directional heat flux

5.4 Results for Titania

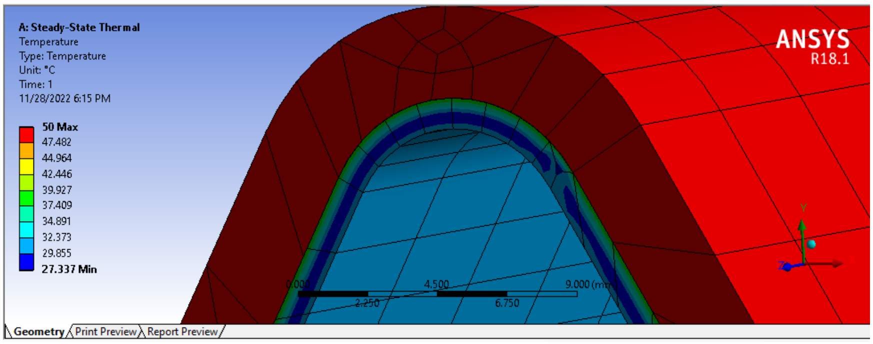

Fig 5.4.1 Temperature

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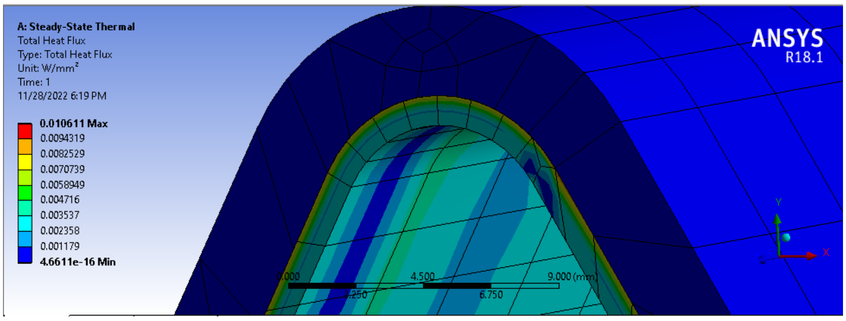

Fig 5.4.2 Total heat flux

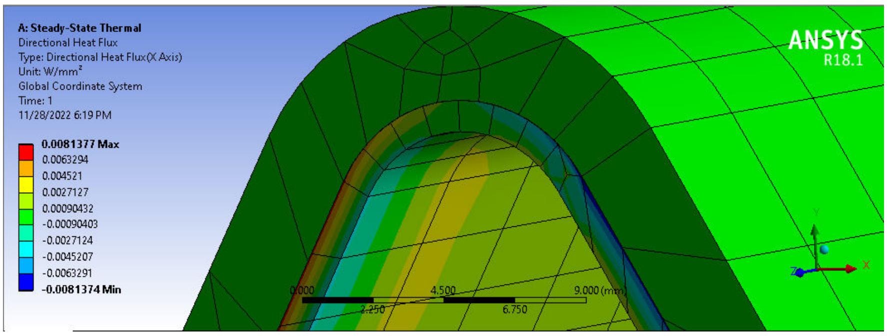

Fig 5.4.3 Directional heat flux

5.4 Results for Zirconium dioxide

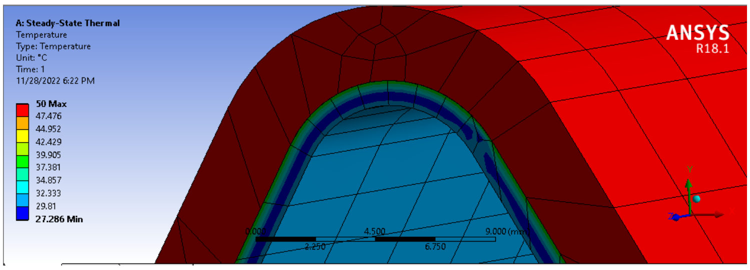

Fig 5.4.1 Temperature

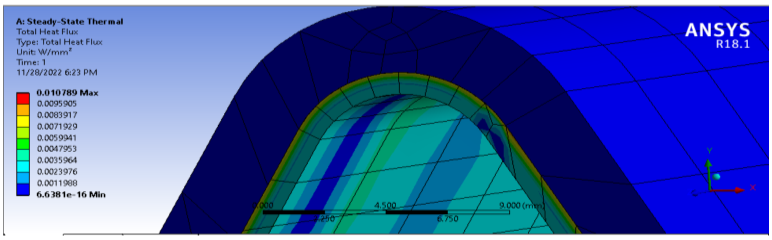

Fig 5.4.2 Total heat flux

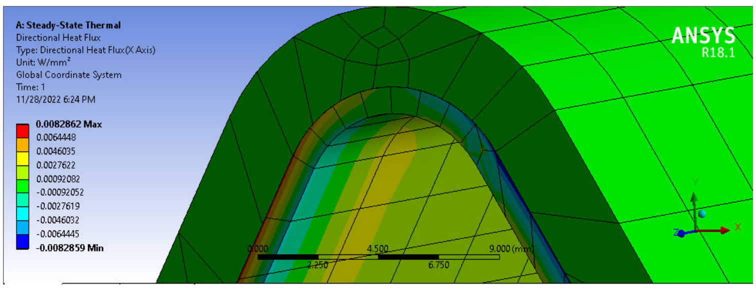

Fig 5.4.3 Directional heat flux

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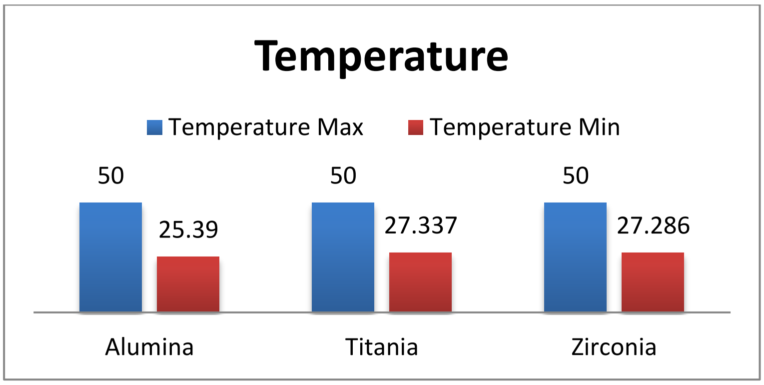
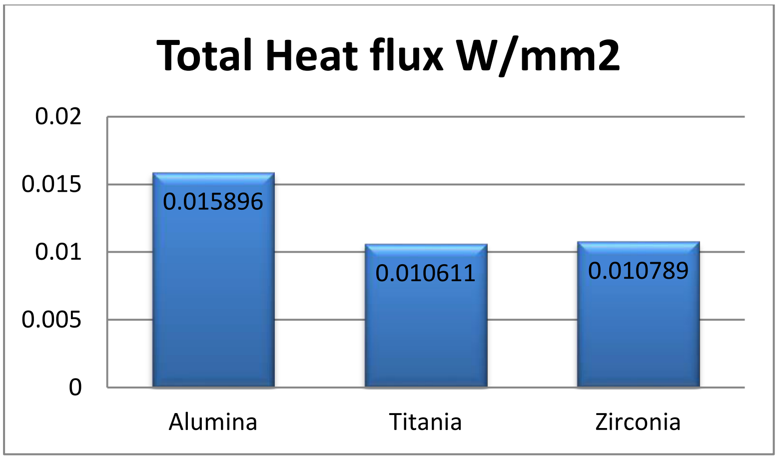
6.Comparison of the Analysis



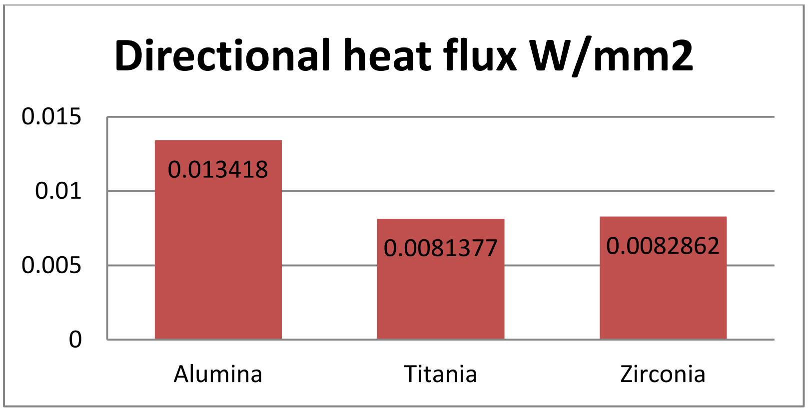
	Temperature	
	Max	**Min**
Aluminum dioxide	50	25.39
Titanium dioxide	50	27.337
Zirconium dioxide	50	27.286

Fig6.1 Comparison of Temperature



	Total Heat flux W/mm2
Aluminum dioxide	0.015896
Titanium dioxide	0.010611
Zirconium dioxide	0.010789

Fig 6.2 Comparison of Total Heat flux



	Directional heat flux W/mm2
Aluminum dioxide	0.013418
Titanium dioxide	0.0081377
Zirconium dioxide	0.0082862

Fig 6.3 Comparison of Directional heat flux

6.1. Result & Discussion

The results of the experimental investigation showed that aluminum dioxide had the strongest thermal barrier among the ceramic coatings tested, resulting in a lower temperature than the other materials. The minimum temperature that the sheet could withstand with aluminum dioxide coating was 25.39°C, while the other two materials had temperatures 2.0°C or higher compared to aluminum dioxide. Moreover, the overall heat transmission rate was lower for aluminum dioxide when compared to titanium dioxide and zirconium dioxide.

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VII. CONCLUSION

In conclusion, this study highlights the health issues associated with existing steel metal roof sheets during heat transfer and the potential use of ceramic coatings to mitigate these issues. The toxic fumes and chemicals released during high-temperature processes can lead to respiratory problems and long-term health issues for workers and residents. However, the results of this study showed that ceramic coatings, particularly aluminum dioxide, can improve the thermal insulation properties of the roof sheets and prevent the release of toxic fumes. Aluminum dioxide was found to be the most effective in reducing the overall heat transfer coefficient and lowering the temperature of the sheet, making it a viable solution for controlling the thermal environment across the surface.

Overall, the study suggests that using ceramic coatings can be an effective solution to mitigate the health issues associated with steel metal roof sheets during heat transfer processes. However, further research is needed to investigate the long-term durability and performance of these coatings in real-world settings. The findings of this study can contribute to the development of safer and healthier construction practices, promoting the well-being of workers and residents.

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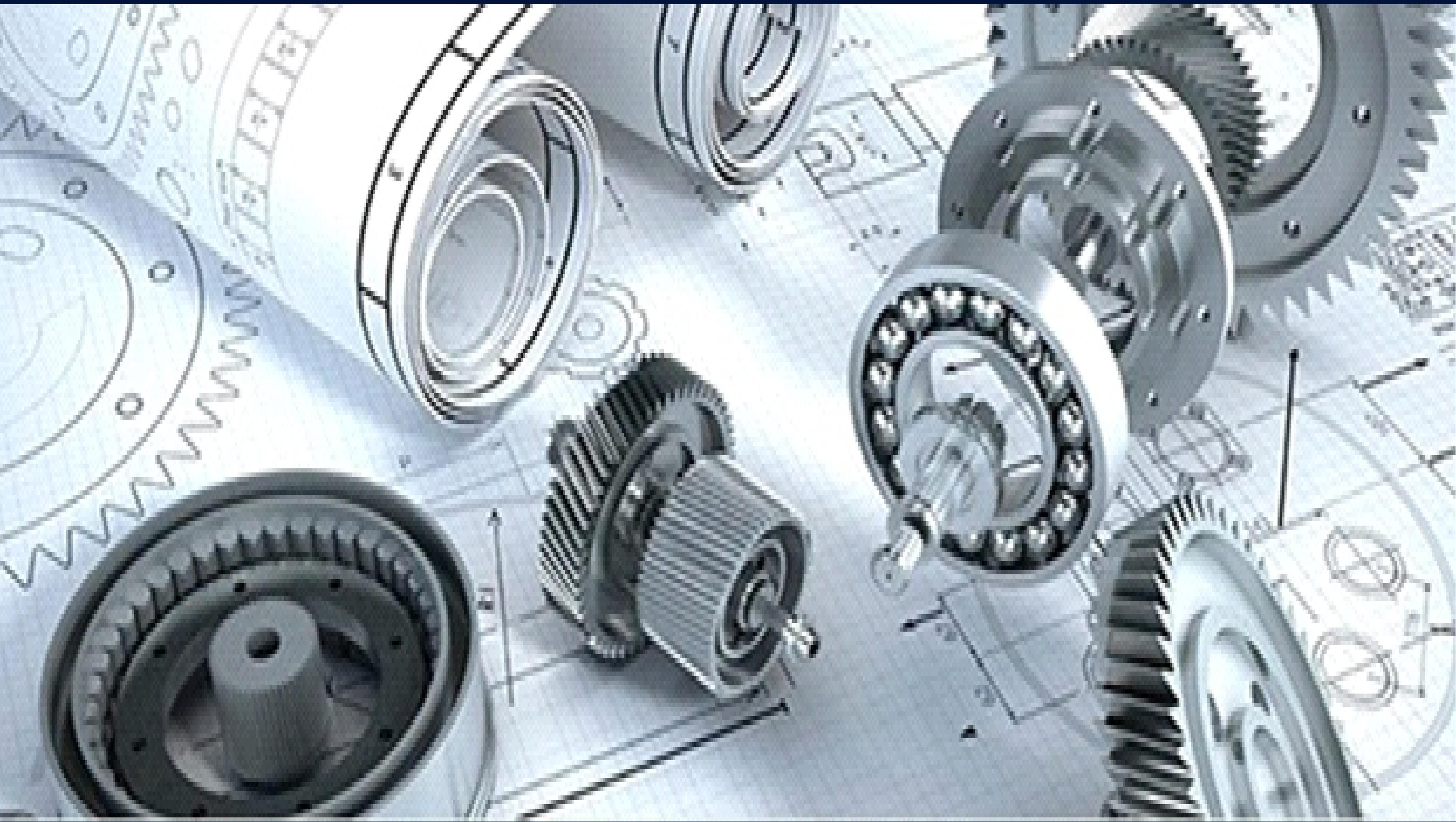

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