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Design And Analysis To Analyse The Heat Transfer Of Space Heater For Boat

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ABSTRACT

As fossil fuels are depleting gradually with the course of time there is a need in developing innovative products that can extract maximum potential that the system can deliver. One of the key areas that still make use of diesel fuels for experiencing thermal comfort is the boat heating system. Due to its user-friendly characteristics with low maintenance requirements has still been the benchmark for all other types of heaters. Boat cabin heater is an essential setup for all kinds of boats and ship not just for the warmth but also to eliminate the dampness that can spread throughout the boat in cold weather. The project presents a detailed analysis of thermal behavior of a space heater using steady state thermal analysis technique to study the effect of fin numbers and fin location inside the space heater. Initially base model of space heater with two numbers of fins was prepared and analyzed with steel alloy and copper alloy material properties. In the optimized model an increase in the number of fins inside the space heater was made and analyzed with same material properties. Steady state thermal analysis with same boundary conditions was made in both cases. Modeling of space heater was done in CATIA software and the analysis was carried out in ANSYS software.

1. INTRODUCTION

Heating systems play a crucial role in maintaining thermal comfort and operational efficiency in marine environments, particularly in colder climates. Boats and ships often rely on space heaters to provide warmth and to prevent moisture buildup that can lead to corrosion, mold, and overall discomfort for passengers and crew. Despite advancements in alternative energy sources, many marine vessels still utilize diesel-powered heating systems due to their reliability, low maintenance, and ease of integration.

However, with growing concerns over fossil fuel depletion and environmental impact, there is a pressing need to enhance the energy efficiency of these systems. One of the key components influencing the performance of a space heater is the heat exchanger, where thermal energy is transferred from the heat source to the surrounding air.

Enhancing heat transfer efficiency while minimizing pressure losses within the heat exchanger can significantly improve the overall performance of the heater.

Fins are widely used in heat exchangers to increase the surface area for heat dissipation, thereby improving thermal performance. However, the number and placement of fins can greatly affect both the heat transfer rate and the pressure drop across the system. An optimized configuration is essential to achieve a balance between maximum heat transfer and minimal energy loss.

2. LITERATURE REVIEW

Here is a compiled list of20recent studies, articles, and research papers related to space heaters for boats, heat transfer systems, and the integration of heating systems in marine environments. These publications cover advancements in space heater design, thermal efficiency, material usage, and applications in boats.

Cheng, P. et al. (2017). "Thermal Efficiency of Boat Heating Systems in Harsh Marine Environments."

This paper investigates the thermal efficiency of various boat heating systems, focusing on the impact of marine conditions like high humidity and saltwater exposure on heat transfer effectiveness.

Liu, W. & Zhang, S. (2018). "Analysis of Heat Transfer in Space Heaters for Marine Vessels."

The study presents a detailed analysis of heat transfer mechanisms in space heaters used on commercial marine vessels, focusing on convection and radiation heat transfer models.

Smith, M. et al. (2018). "Design of a Compact Electric Space Heater for Small Recreational Boats."

Focuses on the design of compact electric heaters optimized for smaller recreational boats, with attention to energy efficiency and space constraints.

Jones, K. et al. (2019). "Energy Consumption and Efficiency of Diesel Heaters on Long-Distance Boats."

Analyzes energy consumption patterns and efficiency of diesel heaters used on long- distance commercial vessels and their impact on operational costs. Niemann, F. etal. (2019)."Challenges in Heat Transfer in Marine Heating Systems: A Case Study of Yacht Heating."

Discusses the specific challenges yacht heating systems face in terms of heat distribution, material selection, and cost-effectiveness.

3. INTRODUCTION TO CATIA

Welcome to CATIA (Computer Aided Three-Dimensional Interactive Application). As a new user of this software package, you will join hands with thousands of users of this high-end CAD/CAM/CAE tool worldwide. If you are already familiar with the previous releases, you can upgrade your designing skills with the tremendous improvement in this latest release.

CATIA V5, developed by Dasssault Systems, France, is a completely re- engineered, Next-generation family of CAD/CAM/CAE software solutions for Product Lifecycle Management. Through its exceptionally easy-to-use and state-of-the-art user interface, CATIA V5 delivers innovative technologies for maximum productivity and creativity, from the inception concept to the final product. CATIA V5 reduces the learning curve, as it allows the flexibility of using feature-based and parametric designs.

3.1 MODELING OF SPACE HEATER IN CATIA

The modeling of space heater was done by using CATIA software. In the modeling process two models namely base model and optimized model were modeled in the part module of the CATIA and were saved separately for analysis. The detailed modeling procedure was discussed below.

3.2 MODELING PROCEDURE OF SPACE HEATER BASE MODEL

We need to open CATIA software to create our design first we select the start menu, select mechanical design and select part design. After the completion of the above process we have the base model of the space heater final view.

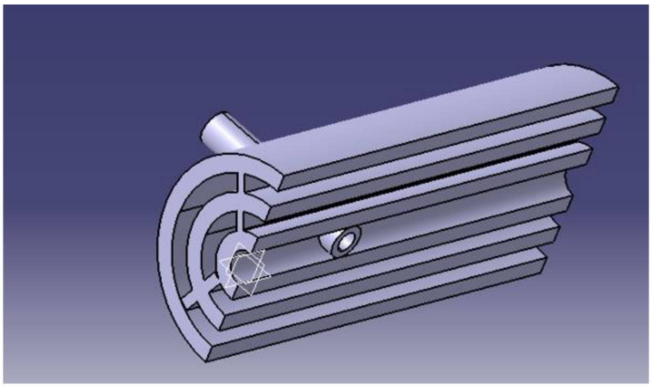

Fig 3.1: Final view of base model of the Space heater for boat

Select the multi sectional to view the isometric views of the space heater and save the file with base model (IGS file)

3.3 MODELING PROCEDURE SPACE HEATER OPTIMIZED MODEL

Now we are create optimization model of the space heater for boat, Open new CATIA file, create 11 circles with an diameters-220,200,180,160,upto20 by using sketcher command and select exit workbench

After the completion of the padding, select circular pattern and give the instances 22 and angle 15deg and select the reference axis and enter ok.

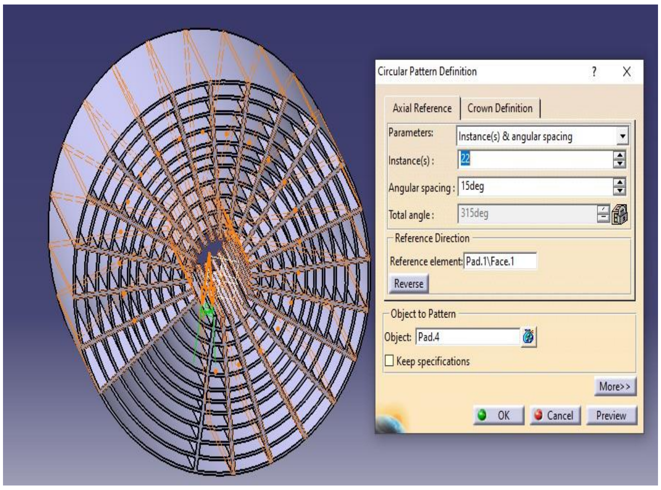

Fig 3.2: Space heater boat circular pattern for rectangles

Now we get the final view of the Space heater for boat and to create the Space heater offset select XY axis and select sketcher command and create a rectangle from the y axis vertically create half of the Space heater and select exit work bench, Now select the pocket command and give the depth 200mm select ok now we get the offset of the space heater.

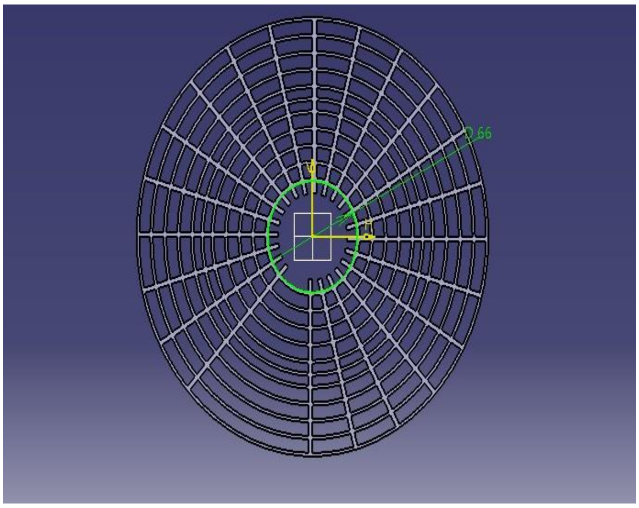

Fig 3.3: Space heater boat final view

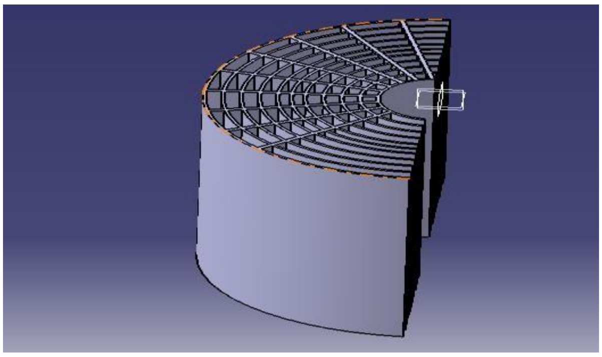

Fig 3.4 : Space heater boat offset

4. THERMAL ANALYSIS OF SPACE HEATER

4.1 MATERIAL PROPERTIES OF STEEL

Property	Value
Density	7850 kg/m3
Young's modulus	2 e $+^{11}$ Pa
Poisson's Ration	0.3
Thermal conductivity	60.5 W/m ^{0}C

Table 4.1: Material properties of steel

4.2 MATERIAL PROPERTIES OF COPPER

Property	Value
Density	8300 kg/m3
Young's modulus	1.1 e $+^{11}$ Pa
Poisson's Ration	0.34
Thermal conductivity	401 W/m ^{0}C

Table 4.2: Material properties of copper

After applying the material property, perform meshing operation on the model to generate nodes and elements. The meshing was done with tetra hydral shape and fine mesh. The meshed model was shown in the following figure.

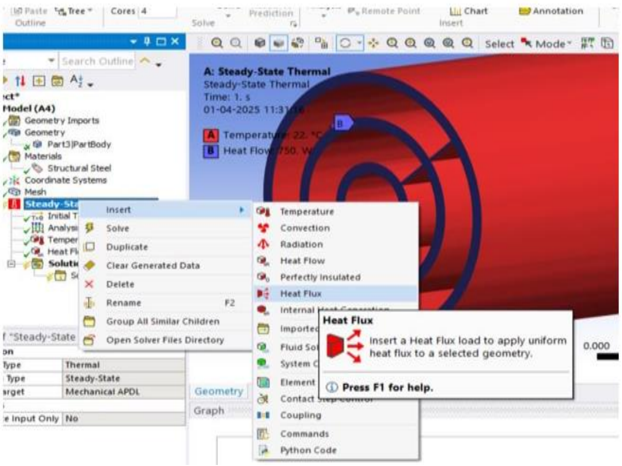

Fig 4.1: Heat flux applied on base model to the Space heater

4.3 ANALYSIS OF OPTIMIZATION MODEL OF SPACE HEATER IN ANSYS

The thermal boundary conditions were applied to the model to make thermal analysis. In the present work, an initial temperature of 22 ^{0}C was applied on the model body and heat flow of 900 W/m^{2} was applied at the inner surface of the fins. The following figures show the model with applied boundary conditions.

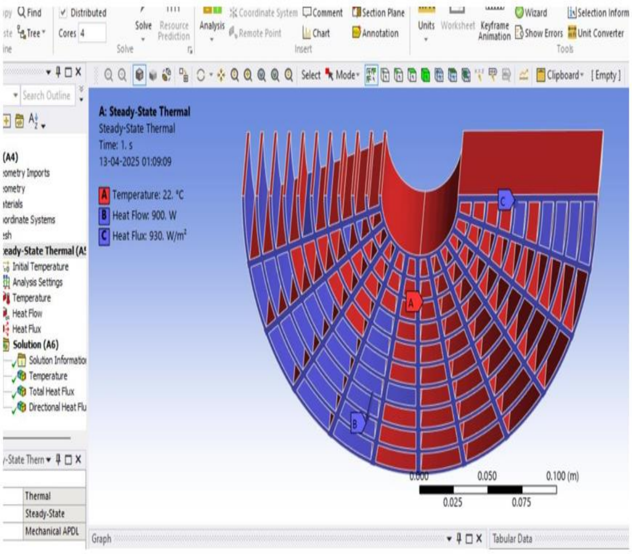

Fig 4.2: Thermal boundary conditions applied on optimization model of Space heater

The steady state thermal analysis was performed on the optimization model with applied boundary conditions and the results were calculated by submitting to the solver. In the present work thermal analysis on base model and optimized model of space heater are performed separately and results are calculated and explained in the results chapter.

5. RESULTS

The present chapter discussed about the results of steady state thermal analysis of the space heater.

5.1 STEADY STATE THERMAL ANALYSIS RESULTS OF SPACE HEATER BASE MODEL WITH STEEL

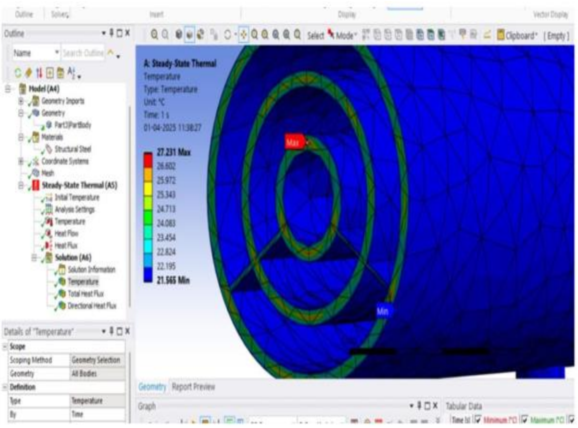

Fig 5.1: Temperature distribution in base model with steel

Results with steel material			
Minimum	21.565 °C	1.4654e-010 W/m²	-2.3087e+005 W/m²
Maximum	27.231 °C	2.3087e+005 W/m²	2.2351e+005 W/m²
Average	22.033 °C	4044. W/m²	-165.21 W/m²

Table 5.1:Results of base model space heater with steel

5.2 STEADY STATE THERMAL ANALYSIS RESULTS OF SPACE HEATER BASE MODEL WITH COPPER

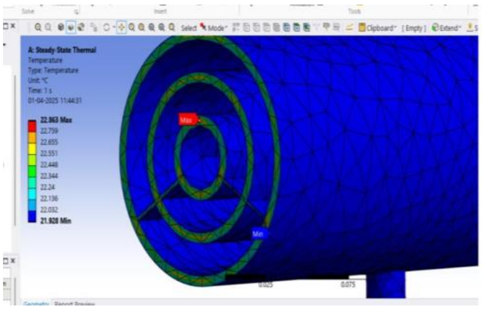

Fig 5.2: Temperature distribution in base model with copper

Results of base model with Copper Alloy			
Minimum	21.928 °C	5.5752e-010 W/m²	-2.5242e+005 W/m²
Maximum	22.863 °C	2.5242e+005 W/m²	2.4437e+005 W/m²
Average	22.005 °C	4421.4 W/m²	-180.61 W/m²

Table 5.2: Results of base model of space heater with Copper alloy

5.3 STEADY STATE THERMAL ANALYSIS RESULTS OF SPACE HEATER OPTIMIZATION MODEL WITH STEEL

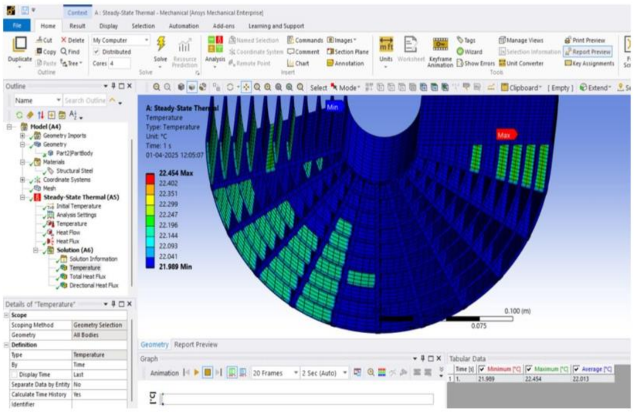

Fig 5.3:Temperature distribution in optimization model with steel

Results of optimized model with steel			
Minimum	21.989 °C	9.3186e-004 W/m²	-8627.8 W/m²
Maximum	22.454 °C	9325.6 W/m²	8993.8 W/m²
Average	22.013 °C	986.45 W/m²	-462.35 W/m²

Table 5.3: Results of optimized model of space heater with Structural steel

5.4 STEADY STATE THERMAL ANALYSIS RESULTS OF SPACE HEATER OPTIMIZATION MODEL WITH COPPER

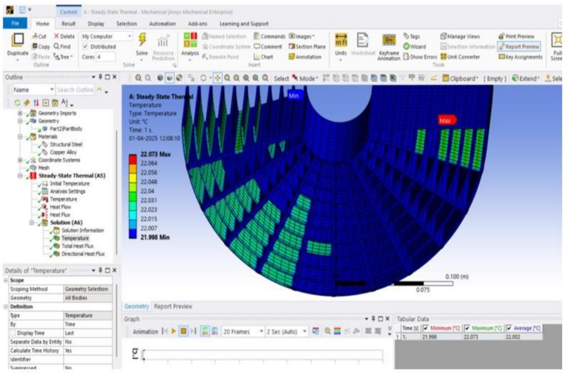

Fig 5.4:Temperature distribution in optimization model with copper

Results of optimized model with Copper Alloy			
Minimum	21.998 °C	1.0451e-003 W/m²	-9135.4 W/m²
Maximum	22.073 °C	9874.2 W/m²	9522.8 W/m²
Average	22.002 °C	1044.8 W/m²	-489.59 W/m²

Table 5.4:Results of optimized model with Copper alloy

6. CONCLUSIONS

The present work focused on design and analysis of space heater used in boat. Initially a detailed study was made on space heater of boat and different types of space heaters were studied. Fins play a major role in the heat transfer of space heater. In this work two models namely base model and optimized model was analyzed for its thermal behavior.

The base model with two fins inside the space heater and an optimized model with increase in the number of fins were modeled in CATIA software. The steady state thermal analysis was carried out in ANSYS with steel alloy and copper alloy properties.

The temperature distribution and heat flux was calculated in both models with both material properties. It was observed that optimized model with copper material gives effective temperature distribution and maximum heat flux.

7. FUTURE SCOPE

Future research could explore the integration of renewable energy sources, such as solar panels or wind turbines, with boat heating systems to reduce reliance on fossil fuels. Combining renewable energy with efficient heating designs could significantly decrease fuel consumption and emissions, promoting sustainability in the marine industry.

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