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DESIGN AND TOPOLOGICAL OPTIMIZATION OF AN INTERNAL COMBUSTION ENGINE PISTON

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Abstract
This project focuses on the stress distribution of the piston four stroke engines by using FEM. The main objective is to investigate and analyze the stress and maximum or minimum principal stresses distribution on engine piston at the real engine condition during combustion process. In this project, the wok is carried out to measure the stress on the top surface of the piston. In I.C. Engine piston is most complex and important part therefore for smooth running of vehicle piston should be in proper working condition. Pistons fail mainly due to mechanical stresses and thermal stresses. Analysis of piston is done with boundary conditions, which includes pressure on piston head during working condition the stress concentration on the piston head are reduces by optimization with using computer aided design; Solid work software the structural model of a piston will be developed. Furthermore, the FEM analysis is done using ANSYS workbench 21. A piston of 4 wheeler was analyzed and optimized for weight reduction in this study. The project describes the optimization techniques with using finite element analysis technique (FEM) to predict the higher stress and critical region on that component.
Keyword: Piston, FEM, honeycomb structure, Topology optimization.

1. INTRODUCTION

Internal combustion engine is a heat engine in which air & fuel mixture is burned inside the engine, due to which high amount of heat released during combustion process & is the part of thermodynamic cycle of the engine. For example, petrol engine, diesel engine, gas-turbine engine & rocket-propulsion engine etc. The hot pressurized gases that are produced due to combustion process, act on moving surfaces of the ENGINE, such as piston and produce useful work. The piston is the moving disk enclosed in engine cylinder and is main components of IC engine that reciprocate in the engine cylinder. The piston transfers the high-pressure heat energy that produced during combustion process, to the crankshaft through connecting rod, due to which momentum occur in fly-wheel and engine works. A cyclic process is followed by piston for continuous conversion of heat energy into work. As the piston is the heart of an engine, so we must calculate the heat propagation on the piston, so we calculate the deformation & thermal stresses of piston due to
periodic load effect. The periodic load effect is often produced due to high-speed reciprocation motion and high pressure of gas the produce during combustion process. Thermal deformation and thermal stresses are produced in piston due to lateral force caused by high pressure gas. The piston cracks due to thermal & mechanical deformation so in orders to decrease the stresses at various load on piston, it is crucial to investigate the stress & temperature distribution, heat transfer and mechanical load on piston. The crucial component of an IC engine that reciprocate in the Engine cylinder is called piston. The piston transfers the energy of expanding gases to the crank shaft with the help of connecting rod.

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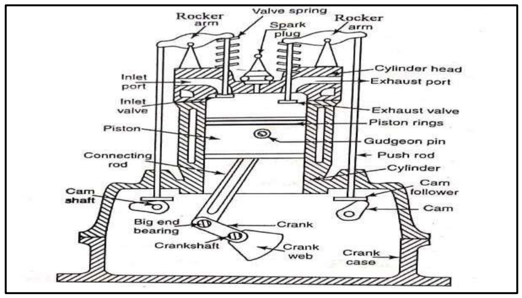

1.1 HONEYCOMB STRUCTURE

Honeycomb structures square measure natural or man-made structures that have the pure mathematics of a honeycomb to permit the reduction of the quantity of used material to reach minimal weight and lowest material price. The geometry of honeycomb structures will vary wide however the common feature of all such structures is an array of hollow cells formed between skinny vertical walls. Sub section 2 Sub section 2 Sub section 2 Sub section 2 Sub section 2 Sub section 2 Sub section 2 Sub section 2 Sub section 2 Sub section 2 Sub section 2 Sub section 2 Sub section 2 Sub section 2.

2. METHOD

The Methods sections should be brief, but they should include sufficient technical information to allow the experiments to be repeated by a qualified reader. Only new methods should be described in detail. Cite previously published procedures in References.
Tables and Figures are presented center, as shown below and cited in the manuscript.

Table 1. Experimental input parameters for EDM

EDM TOOL	VOLTAGE (v)	PULSE ON(μs)
Aluminum	11	12
Copper	22	44
Graphite	33	10
Composite	45	66
Aluminum	11	12
Copper	22	44
Graphite	33	10
Composite	45	66
Aluminum	11	12
Copper	22	44
Graphite	33	10
Composite	45	66

2.1. Tables

Tables should be typewritten separately from the main text and preferably in an appropriate font size to fit each table on a separate page. Each table must be numbered with Arabic numerals (e.g., Table 1, Table 2) and include a title. Place footnotes to tables below the table body and indicate them with superscript lowercase letters (a, b, c, etc.), not symbols. Do not use vertical rulings in the tables. Each column in a table must have a heading, and abbreviations, when necessary, should be defined in the footnotes.

2.2. Figures

Figures should be provided separately from the main text. Use Arabic numerals to number all figures

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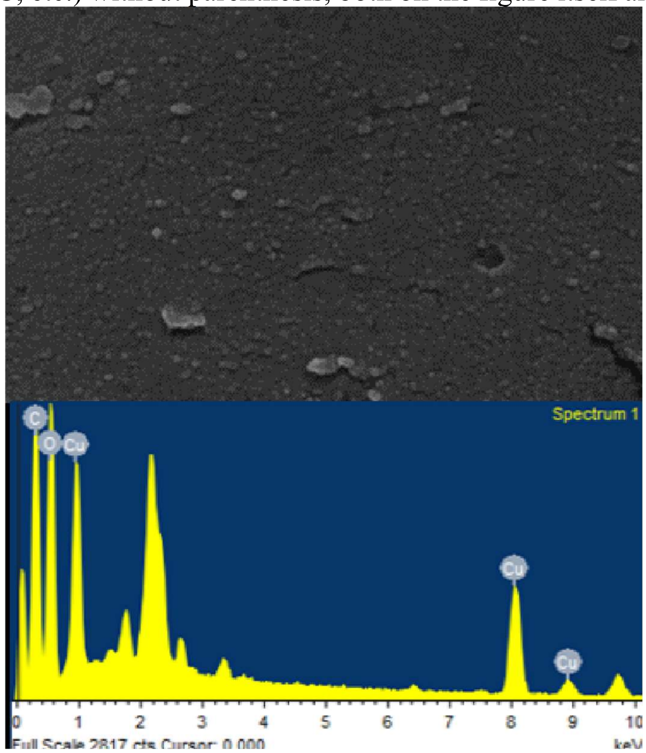

FIGURE 1. SEM and EDX visualization of the synthesized copper nanoparticles [2]

3. RESULTS AND DISCUSSION

Total Deformation

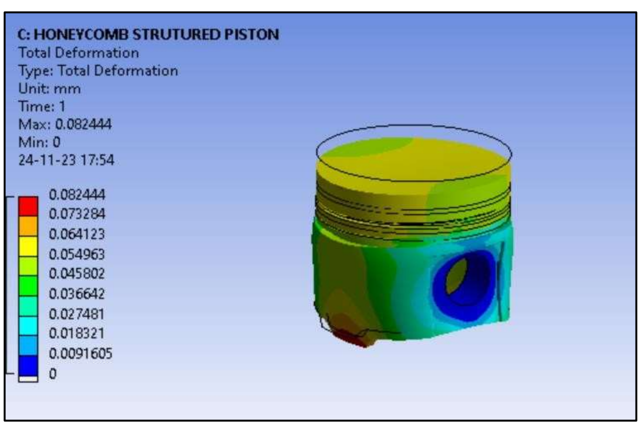

Figure 12. Total deformation of honeycomb structure piston Equivalent Stress

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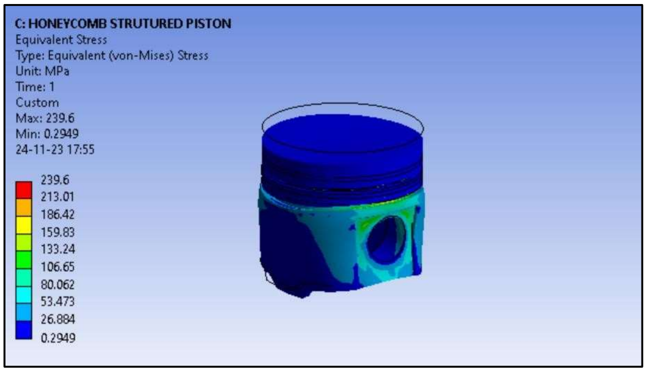
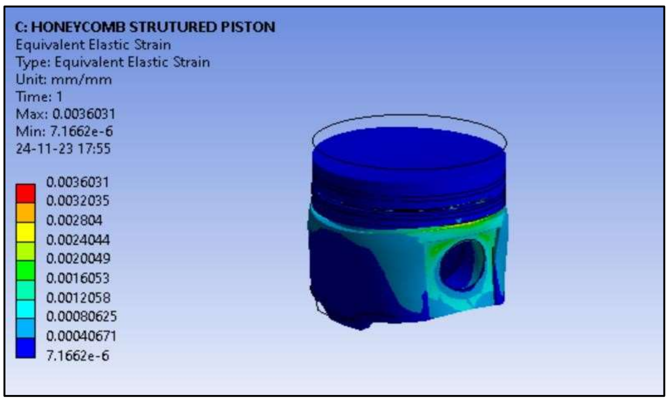
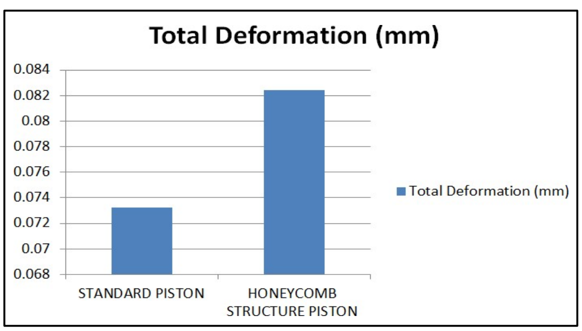


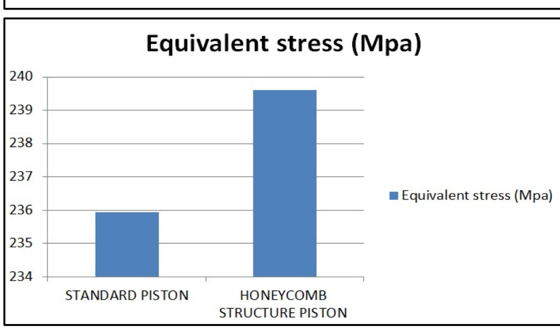
4. Figure 13. Equivalent Stress of honeycomb structure piston Equivalent Strain

5. Figure 14. Equivalent Strain of honeycomb structure piston



FEA Results





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Parameter	STANDARD PISTON	HONEYCOMB STRUCTURE PISTON
weight	0.39498 kg	0.35445 kg
Total Deformation (mm)	0.073226	0.082444
Equivalent stress (Mpa)	235.95	239.6
Equivalent strain	0.003562	0.0036031

CONCLUSION

• The design and static structural analysis of existing piston and honeycomb structure piston has been carried out. Comparison has been made between honeycomb structure piston with existing piston having same design and same load carrying capacity.
• The stress and displacements have been calculated using ANSYS 21 for existing piston and honeycomb structure piston. From the static analysis results it is found that there is a maximum displacement of 0.073226 mm in the existing piston and 0.082444 mm honeycomb structure piston. By analyzing the design, it was found that all the stresses in the existing piston were well within the allowable limits and with good factor of safety.
• The stresses in the honeycomb structure piston of design are much lower than that of the allowable stress.
• Thus a total weight reduction of 40gms was achieved. Initial weight was 394.98 g whereas final weight was 354.45 g.
So we have successfully reduced the weight of existing piston by 10 % using honeycomb structure.

ACKNOWLEDGEMENTS

I would like to express my deepest gratitude to all those who contributed to the successful completion of this project, titled "Design and Topological Optimization of an Internal Combustion Engine Piston."

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