



Research Paper

Comparative Finite Element Analysis of Structural Steel and Magnesium Alloys in a Five-Cylinder Radial Engine

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ABSTRACT

Radial engines are widely recognized for their balanced configuration, compact design, and ability to deliver smooth power output in aeronautical and industrial applications. However, the performance and reliability of such engines are highly dependent on material selection and effective thermal management. In conventional systems, radial engines are typically designed using standard materials with limited analytical optimization, where weight reduction is often prioritized without fully addressing the resulting structural deformation, vibrational stresses, and thermal inconsistencies. These limitations can lead to reduced component life and decreased operational efficiency, particularly under high-load conditions. To overcome these challenges, the present research focuses on a systematic evaluation of material performance using advanced computational tools. A five-cylinder radial engine model was developed in SolidWorks, and detailed simulations were conducted in ANSYS Workbench, incorporating static structural, modal, and thermal analyses. The proposed approach compares Structural Steel with lightweight magnesium alloys such as Mg-8Al-0.5Zn and ZK60 to identify the optimal balance between strength, stiffness, and heat dissipation. The results demonstrate that Structural Steel significantly reduces total deformation and elastic strain while maintaining stable thermal behavior, thereby ensuring higher durability and reliability. Although magnesium alloys contribute to weight reduction, their lower stiffness limits their performance in high-vibration environments. This research is successfully completed by integrating multi-physics simulation techniques to validate material behavior, ultimately recommending steel as the most suitable material for enhancing power output, structural integrity, and long-term performance of the radial engine.

Keywords: Radial Engine, Five-Cylinder Engine, ANSYS Workbench, SolidWorks Modeling, Magnesium Alloys (Mg-8Al-0.5Zn, ZK60).

1. INTRODUCTION

The very first design of internal combustion aero engine made was that of Charles Manly, who built a five-cylinder radial engine in 1901 for use with Langley's aerodrome, as the latter inventor decided to call what has since become known as the aero-plane. Manly made a number of experiments, and finally decided on radial design, in which the cylinders are so rayed round a central crank-pin that the pistons act successively upon it. By this arrangement a very short and compact engine is obtained, with a minimum of weight, and a regular crankshaft rotation and perfect balance of inertia forces.

When manly designed his radial engine, high speed internal combustion engines were in their infancy, and the difficulties in construction can be partly realized when the lack of manufacturing methods for this high-class engine work, and the lack of experimental data on the various materials, are taken into account. During its tests, Manly's engine developed 52.4 brake horsepower at a speed of 950 revolutions per minute, with the remarkably low weight of only 1.09 kg per horsepower, this latter was increased to 1.64 kg when the engine was completed by the addition of ignition system, radiator, petrol tank, and all

accessories, together with the cooling water for the cylinders.

In Manley's engine, the cylinders were of steel, machined outside and inside to 1.625 of a mm thickness. On the side of the cylinder, at the top end, the valve chamber was brazed, being machined from a solid forging. The casing which formed the water-jacket was of sheet steel, 0.52 of a mm in thickness, and this also was brazed on the cylinder and to the valve chamber. Automatic inlet valves were fitted, and the exhaust 8 valves were operated by a cam which had two points, 180 degrees apart. The cam was rotated in the opposite direction to the engine at one -quarter engine speed.

Ignition was obtained by using a one-spark coil and vibrator for all cylinders, with a distributor to select the right cylinder for each spark –this was before the days of the high-tension magneto and the almost perfect ignition systems that makers now employ. The scheme of ignition for this engine was originated by Manly himself, and he also designed the sparking plugs fitted in the tops of the cylinders. Through fear of trouble resulting if the steel pistons worked on the steel cylinders, cast iron liners were introduced in the latter 1.625 of a mm thick.

The connecting rods of this engine were of virtually the same type as is employed on nearly all modern radial engines. The rod for one cylinder had a bearing along the whole of the crank pin, and its end enclosed the pin. The other four rods had bearings upon the end of the first rod, and did not touch the crank pin. The bearings of these rods did not receive any of the rubbing effect due to the rotation of the crank pin, the rubbing on them being only that of the small angular displacement of the rods during each revolution, thus there was no difficulty experienced with the lubrication.

Another early example of the radial type of engine was French Anzani, of which type one was fitted to the machine with which Bleriot first crossed the English Channel—this was of 25 horse- powers. The earliest Anzani engines were of three-cylinder fan type, one cylinder being vertical, and the other two placed at an

angle of 72 degrees on each side, as the possibility of over lubrication of the bottom cylinders was feared if a regular radial construction were adopted. In order to overcome the unequal dial Engine.

2. LITERATURE REVIEW

Zhang et al. [1] proposed a quasi-isothermal expander model for compressed air engines where water droplets are injected into the expansion cylinder to improve thermal efficiency. Through numerical modeling of reciprocating adiabatic expanders, the authors demonstrate that this approach increases output work by approximately 15.7% while simultaneously decreasing the physical cylinder height. The research highlights the critical role of heat exchange optimization in maximizing the energy recovery of radial air-powered systems. Anonymous [2] focused on the geometric modeling and structural assembly of a multi-cylinder radial engine using CATIA V5. The study explored the complex mechanical linkages of the master-and-articulated rod assembly, which is a hallmark of radial configurations used in aviation. This work provided a foundational methodology for determining proper component dimensions and material selection, primarily aluminum, to ensure compact sizing without compromising power-to-weight ratios. Arvind et al. [3] presented a comprehensive review of the transition from fossil-fuel-based internal combustion to eco-friendly compressed air propulsion. The paper detailed the design challenges of single-cylinder air engines, specifically focusing on the elimination of toxic emissions and the control of exhaust temperatures. Their findings suggest that air-powered technology can achieve near-nil emissions, making it a viable alternative for sustainable mechanical power.

Lal [4] investigated the kinematic and dynamic behavior of a single-stroke engine powered by compressed air. The study utilized computational tools to analyze the force distribution on the piston and connecting rod during the high-pressure expansion phase. By modeling the engine's response to varying inlet

pressures, the author identified the mechanical constraints necessary to improve the stability and energy conversion efficiency of pneumatic prime movers. Huang [5] examined the correlation between cylinder pressure profiles and the resulting torque output in air-powered engines. Through experimental and numerical analyses, the author mapped how pressure drops during the expansion stroke affect the overall power performance. The research emphasized that maintaining high-pressure integrity is essential for achieving the efficiency levels required for modern transportation applications. Patel et al. [6] analyzed the operational dynamics of internal engine components, specifically the interaction between the piston, rings, and cylinder walls. The study focused on reducing exergy destruction during the work extraction phase by optimizing the motion of reciprocating parts. The paper provided a technical framework for understanding how internal components must be synchronized to minimize friction and maximize effective work output. Singh and Singh [7] conducted an experimental study exploring the development of a vane-type air turbine designed to serve as a high-efficiency prime mover. The authors tested the turbine at various inlet pressures, achieving efficiencies ranging from 72% to 97%. The research concluded that optimizing vane geometry and reducing internal leakage can significantly enhance the starting torque and operational longevity of air-powered rotating machinery. Asikul Islam et al. [8] evaluated the feasibility of utilizing compressed air as a primary energy carrier to replace conventional Spark Ignition (SI) engines. The paper provided a cost-benefit analysis and a theoretical explanation of the thermodynamic cycles involved in pneumatic power. The study highlighted the simplicity and low maintenance costs of air engines, positioning them as a key solution for reducing the carbon footprint of small-scale industrial vehicles. Yu et al. [9] investigated the thermal characteristics of a compressed air engine by analyzing the heat transfer between the air and the cylinder walls during the expansion process.

Their research indicated that the temperature drop caused by rapid expansion significantly impacts power output, suggesting that external heat sources or multi-stage expansion could mitigate these losses. Dimitrova and Maréchal [10] proposed a methodology for the systematic design and optimization of compressed air energy storage (CAES) integrated with small-scale pneumatic engines. Their study demonstrated that by utilizing waste heat from other industrial processes, the round-trip efficiency of the compressed air system could be improved by over 20%. Chen et al. [11] analyzed the performance of a multi-stage expansion pneumatic engine, focusing on the pressure regulation between stages. Their findings showed that a three-stage expansion system provides a more stable torque delivery compared to single-stage models, making it more suitable for automotive applications requiring variable load capacities. Schechter [12] explored the potential of using variable valve timing (VVT) in air engines to optimize the intake and exhaust cycles. The research proved that electronically controlled valves could precisely manage the air mass flow, resulting in a 12% improvement in overall air consumption efficiency during urban driving cycles. Zeng et al. [13] conducted a study on the lubrication requirements of high-speed air engines, noting that traditional oil-based lubrication often leads to exhaust contamination. They proposed the use of self-lubricating composite materials for the piston rings and cylinder liners to maintain the "zero-emission" status of the engine while reducing mechanical friction. Xu et al. [14] developed a mathematical model to simulate the transient response of a radial air engine under sudden load changes. Their work highlighted that radial configurations, due to their balanced inertia forces, offer superior stability and quicker response times compared to in-line pneumatic engine designs.

3. PROPOSED METHODOLOGY

The system architecture follows a sequential engineering workflow that integrates geometric modeling in SolidWorks with multi-physics

simulation in ANSYS Workbench to evaluate engine performance. It begins with the precise assembly of radial components such as the master rod and piston pins before subjecting them to comparative material testing between Structural Steel and lightweight Magnesium alloys (Mg-8Al-0.5Zn and ZK60). The core of the architecture involves a tripartite analytical approach: static structural analysis for deformation and strain, thermal analysis for heat flux and distribution, and modal analysis to assess vibration resistance. This data-driven pipeline concludes with a comparative evaluation, identifying Steel as the optimal material for balancing structural rigidity with thermal stability in high-vibration aeronautical or industrial compressed air applications as demonstrate in Fig. 1.

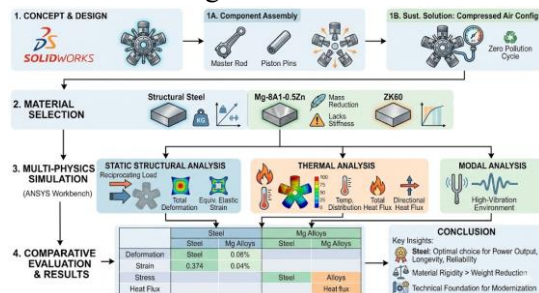


Fig. 1: Proposed system architecture.

Operations performed in radial engine are shown Fig .2; in Most radial engines use overhead poppet valves driven by pushrods and lifters on a cam plate which is concentric with the crankshaft, with a few smaller radials. A few engines utilize sleeve valves instead. At least five companies build radials today. Vedeneyev engines produces the M-14P model, 360 Hp (270kW) (up to 450 Hp(340kW) radial used on Yakovlevs and Suk hoi, Su-26 and Su-29aerobic aircraft.

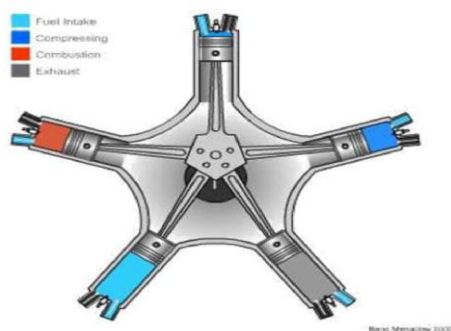


Fig. 2: Operations performed in radial engine

The M-14P has also found great favor among builders of experimental aircrafts, such as the Culp's Special and Culp's Sop with Pup, Pitts S12 "Monster" and the Murphy "Moose". Engines with 110 Hp (82kW) 7-cylinders and 150 Hp (110 kW) 9-cylinders are available from Australia's Rotec Engineering. HCIA aviation offers the R180 5-cylinders (75 H (56kW)) and R220 7-cylinders (110 Hp (82kW)), available "ready to fly" and as a "build it yourself" kit. Verner Motor from the Czech Republic now builds several radial engines. Models range in power form 71 Hp (53 kW) to 172 Hp (128 kW).

Miniature radial engines for model air plane use are also available from Seidel in Germany, OS and Saito Seisakusho of Japan, and Techno power in the USA. The Saito firm is known for making 3 different sizes of 3-cylinder engines, as well as a 5- cylinder example, as the Saito firm is the specialist in making a large line.



Fig 3: Radial engine in vehicles

- They can produce a lot of power. A typical radial engine in a B-17 has nine cylinders, displaces 1,800 cubic inches (29.5 liters) and produces 1,200 horsepower.
 - Radial engines have a relatively low maximum rpm (rotations per minute) rate, so they can often drive propellers without any sort of reduction gearing.
 - Because all of the pistons are in the same plane, they all get even cooling and normally can be air-cooled. That saves the weight of water-cooling.
- Radial engines reached their zenith during WWII. There are some radial engines around today, but they are not that common. Most

propeller-driven planes today use more traditional engine configurations (like a flat four-cylinder) or modern gas turbine engines. Gas turbines are much lighter than radial engines for the power they produce.

In present work thermal analysis of radial engine has been performed on three parts of engine such as piston, connecting rod and master rod by applying temperature and finding heat temperature by analysis. The main objective of this work is to investigate the temperature variation between different materials through thermal by using solid works simulation. In order to maintain the temperature normal with other materials are Al 1060 alloy, grey cast iron and cast carbon steel. The radial engine started its life decades ago, and was the most common option before turbine engines were introduced. They've been found on everything from crop dusting planes to bombers, and continue to be used to this day. Radial engines have a relatively low maximum rpm (rotations per minute) rate, so they can often drive propellers without any sort of reduction gearing.

- Uses air energy for small movement of machine to reduce human effort.
- Small and light weight.
- With balance structure contained, smooth working with little vibration available.
- high efficiency, less engine cost.
- Grass cutter, surface cleaning, etc...
- Small capacity automobile vehicles.
- All type of application where air energy is used.
- Vehicular transportation using a compressed air vehicle.
- Pneumatic screwdrivers.

PROJECT DESIGN

In this research, we are going to design a five-cylinder radial engine. We are going to design its parts and do the assembly as well as we take temperature in thermal analysis which will help us in deciding the feasibility and practicality of our design. We also going to learn about the

problems faced during assembly and material selection for the three-cylinder engine. Also, the reason for selection of various points during our design process. In three-cylinder radial engine the reciprocating motion of piston is converted to the rotating motion of flywheel which is done by connecting a shaft to flywheel at one end and piston holder at other. The cylinder radial engine not only have application as an automobile engine but it can also use in industries for carrying loads or may be used as a belt mover in the conveyor. This may also be used in production of electricity for small scale use like mobile charging etc. we have chosen this design because it has variety of application and abundant positive points for society and as well as environment was done in solid works. Solid Works is mechanical design automation software that takes advantage of the familiar Microsoft Windows graphical user interface. A Solid Works model consists of parts, assemblies, and drawings.

Typically, we begin with a sketch,

- create a base feature, and then add more features to the model. (One can also begin with an imported surface or solid geometry).
- We are free to refine our design by adding, changing, or reordering features.
- Associatively between parts, assemblies, and drawings assures that changes made to one view are automatically made to all other views.
- We can generate drawings or assemblies at any time in the design process.
- The Solid works software lets us customize functionality to suit our needs.
- Solid works mechanical design automation software is a feature-based, parametric solid modelling design tool which advantage of the easy to learn windows TM graphical user interface.
- We can create fully associate 3-D solid models with or without while utilizing

automatic or user defined relations to capture design intent.

- Parameters refer to constraints whose values determine the shape or geometry of the model or assembly. Parameters can be either numeric parameters, such as line lengths or circle diameters, or geometric parameters, such as tangent, parallel, concentric, horizontal or vertical, etc. Numeric parameters can be associated with each other through the use of relations, which allow them to capture design intent.

Design intent is how the creator of the part wants it to respond to changes and updates. For example, you would want the hole at the top of a beverage can to stay at the top surface, regardless of the height or size of the can. Solid Works allows you to specify that the hole is a feature on the top surface, and will then honour your design intent no matter what the height you later gave to the can. Several factors contribute to how we capture design intent are Automatic relations, Equations, added relations and dimensioning. Features refer to the building blocks of the part. They are the shapes and operations that construct the part. Shape-based features typically begin with a 2D or 3D sketch of shapes such as bosses, holes, slots, etc. This shape is then extruded or cut to add or remove material from the part. Operation-based features are not sketch-based, and include features such as fillets, chamfers, shells, applying draft to the faces of a part, etc.

Building a model in Solid Works usually starts with a 2D sketch (although 3D sketches are available for power users). The sketch consists of geometry such as points, lines, arcs, conics (except the hyperbola), and spines. Dimensions are added to the sketch to define the size and location of the geometry. Relations are used to define attributes such as tangency, parallelism, perpendicularity, and concentricity. The parametric nature of Solid Works means that the dimensions and relations drive the geometry, not the other way around. The dimensions in the sketch can be controlled

independently, or by relationships to other parameters inside or outside of the sketch.

5. RESULTS ANALYSIS:

The load effects can be calculated on a structure by ignoring the damping and inertia effects, such as those caused by time varying loads can be calculated by structural static analysis. Steady equivalent loads like steady inertia loads and time varying loads are included in Static analysis. Static analysis is utilized to decide the removals, burdens, strains and powers in structures or segments brought about by burdens that don't instigate noteworthy dormancy and damping impacts. Enduring stacking and reaction conditions are accepted, i.e. the stress and the structure's reactions are expected to differ gradually as for time. The kinds of load can be applied in static analysis include:

- Force and pressure application on body.
- Steady state inertial forces.
- Displacement.
- Thermal behavior.

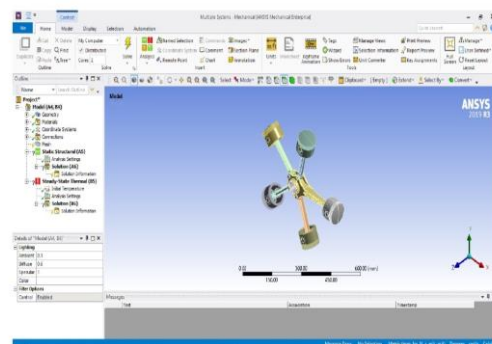


Fig. 4: Inserted .igs file in ansys

The steps needed to perform an analysis depend on the study type. You complete a study by performing the following steps:

Create a study defining its analysis type and options.

If needed, define parameters of your study. A parameter can be a model dimension, material property, force value, or any other input.

- Define material properties.
- Specify restraints and loads.
- The program automatically creates a mixed mesh when different geometries

(solid, shell, structural members etc.) exist in the model.

- Define component contact and contact sets.
- Mesh the model to divide the model into many small pieces called elements. Fatigue and optimization studies use the meshes in referenced studies.
- Run the study.

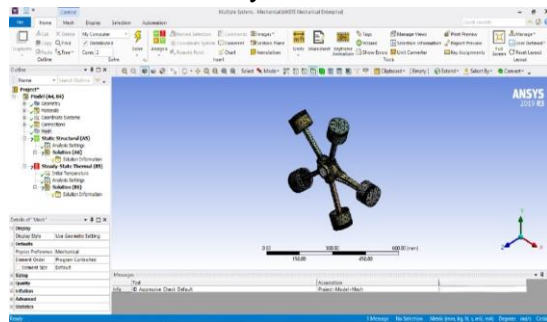


Fig. 5: mesh file

The Fig. 5 illustrates the finite element mesh generated for the five-cylinder radial engine model in ANSYS. A refined mesh is applied across critical regions such as the crank and piston interfaces to capture stress concentration accurately. The discretization ensures improved solution accuracy while maintaining computational efficiency. This mesh serves as the foundation for both structural and thermal simulations.

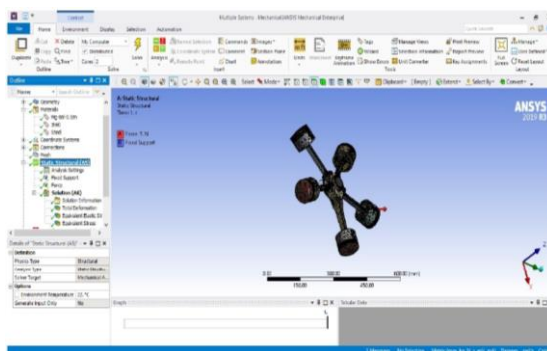


Fig. 6: Static structural Boundary conditions.

This Fig 6 presents the applied boundary conditions for the static structural analysis of the radial engine. A fixed support is defined at the central hub to restrict all degrees of freedom, simulating real mounting conditions. External forces are applied at specific piston locations to represent operational loading. These conditions enable evaluation of

deformation, stress, and strain under realistic mechanical loads.

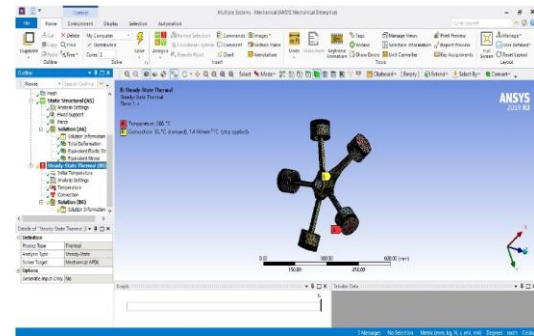


Fig. 7: thermal Boundary conditions.

The Fig 7 shows the setup for steady-state thermal analysis in ANSYS. A temperature load is applied to simulate heat generation within the engine components, while convection boundary conditions are defined to represent heat dissipation to the surroundings. Critical regions such as cylinder heads are monitored for temperature distribution. This setup helps in analyzing heat flux and thermal stability of the selected materials.

MATERIAL: Steel

This Fig 8 presents the fundamental mechanical properties of structural steel as defined in the ANSYS engineering data library. Key parameters such as Young's modulus, Poisson's ratio, bulk modulus, and shear modulus are specified, which govern the material's elastic behavior under load. The high Young's modulus indicates strong resistance to deformation, making steel suitable for high-stress applications. These properties are essential inputs for accurate structural analysis of the radial engine.

Steel	
Fatigue Data at zero mean stress comes from 1998 ASME BPV Code, Section 8, Div 2, Table 5-110.1	
Density	7.85e-06 kg/mm ³
Structural	
▼ Isotropic Elasticity	
Derive from	Young's Modulus and Poisson's Ratio
Young's Modulus	2e+05 MPa
Poisson's Ratio	0.3
Bulk Modulus	1.6667e+05 MPa
Shear Modulus	76923 MPa
Isotropic Secant Coefficient of Thermal Expansion	1.2e-05 1/°C
Compressive Ultimate Strength	0 MPa
Compressive Yield Strength	250 MPa

Fig. 8: Material Properties – Structural Steel (Mechanical Properties)

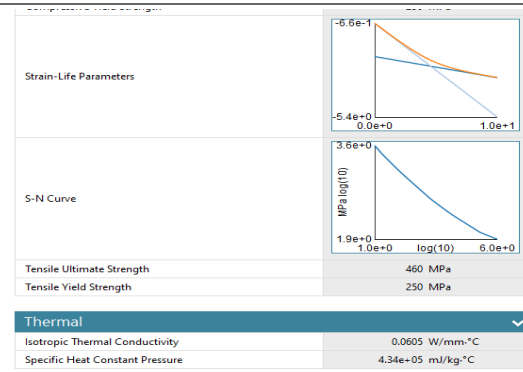


Fig. 10: Material Properties – Thermal Characteristics

This Fig 10 shows the thermal properties of structural steel used in the simulation, including thermal conductivity and specific heat capacity. These parameters determine how the material conducts and stores heat during engine operation. Proper definition of these properties is crucial for evaluating temperature distribution and heat flux. The data enables accurate thermal analysis to ensure safe operating conditions of engine components.

Result Summary

Results	Minimum	Maximum	Units	Time (s)
Total Deformation	0.	1.0547e-003	mm	1.
Equivalent Elastic Strain	3.8821e-011	1.4202e-005	mm/mm	1.
Equivalent Stress	2.9563e-006	2.807	MPa	1.

Table 1 results of steel in static structural

Mg-8Al-0.5zn	
Density	1.8e-06 kg/mm ³
Structural	
Isotropic Elasticity	
Derive from	Young's Modulus and Poisson's Ratio
Young's Modulus	45000 MPa
Poisson's Ratio	0.35
Bulk Modulus	50000 MPa
Shear Modulus	16667 MPa
Isotropic Secant Coefficient of Thermal Expansion	2.6e-05 1/°C
Compressive Ultimate Strength	0 MPa
Compressive Yield Strength	193 MPa
Tensile Ultimate Strength	255 MPa
Tensile Yield Strength	190 MPa
Thermal	
Isotropic Thermal Conductivity	0.156 W/mm·°C
Specific Heat Constant Pressure	1.024e+06 mJ/kg·°C

(a)

(b)

Fig. 11 (a), (b): mechanical properties of Mg-8Al-0.5zn.

Table 2 results of Mg-8Al-0.5zn

Result Summary

Results	Minimum	Maximum	Units	Time (s)
Temperature	-39.447	300.09	°C	1.
Total Heat Flux	2.5405e-014	17.602	W/mm ²	1.
Directional Heat Flux	-5.4275	5.3973	W/mm ²	1.

The table 1 presents the summary of static structural analysis results for steel, showing minimum and maximum values of key response parameters at a simulation time of 1 second. Total deformation ranges from 0 to 1.0547×10^{-3} mm, indicating very small displacements under the applied load. The equivalent elastic strain varies between 3.8821×10^{-11} and 1.4202×10^{-5} mm/mm, reflecting minimal material deformation within the elastic range. Similarly, the equivalent stress spans from 2.9563×10^{-6} to 2.807 MPa, suggesting that the stress levels remain relatively low compared to typical steel strength limits.

5.10.2 Mg-8Al-0.5zn

Fig 11 (a) presents the material properties of the Mg-8Al-0.5Zn alloy, highlighting its structural, thermal, electrical, and magnetic characteristics. It shows key parameters such as Young's modulus (45,000 MPa), Poisson's ratio (0.35), and tensile yield strength (190 MPa), indicating moderate stiffness and strength typical of lightweight alloys. Fig 11 (b) illustrates additional physical properties, including thermal conductivity, electrical resistivity, and magnetic permeability, which are essential for multiphysics analysis.

Electric	
Isotropic Resistivity	0.00077 ohm-mm
Magnetic	
Isotropic Relative Permeability	10000

Table 1 summarizes the thermal analysis results of the material at 1 second. The temperature ranges from -39.447 °C to 300.09 °C, indicating a wide thermal variation. The total heat flux reaches up to 17.602 W/mm², while directional heat flux varies between -5.4275 and 5.3973 W/mm², reflecting both magnitude and direction changes in heat transfer within the material.

5.10.3 Material ZK60

zk60	
Density	1.83e-06 kg/mm ³
Structural	
Isotropic Elasticity	
Derive from	Young's Modulus and Poisson's Ratio
Young's Modulus	45000 MPa
Poisson's Ratio	0.35
Bulk Modulus	50000 MPa
Shear Modulus	16667 MPa
Isotropic Secant Coefficient of Thermal Expansion	2.6e-05 1/°C
Compressive Ultimate Strength	5.65e-06 MPa
Compressive Yield Strength	250 MPa
Tensile Ultimate Strength	405 MPa
Tensile Yield Strength	365 MPa
Thermal	
Isotropic Thermal Conductivity	0.156 W/mm·°C
Specific Heat Constant Pressure	1.024e+06 mJ/kg·°C

(a)

(b)

Fig. 12 (a), (b): mechanical properties of ZK60.

Fig. 12 (a) illustrates the mechanical properties of the Mg–8Al–0.5Zn alloy, including Young's modulus, Poisson's ratio, and tensile yield strength, indicating that the material has moderate stiffness and strength suitable for lightweight structural applications. Fig 12 (b) presents the thermal, electrical, and magnetic properties, such as thermal conductivity, electrical resistivity, and relative permeability, which are important for evaluating Multiphysics behaviour.

Table 3 results of ZK60.

Result Summary

Results	Minimum	Maximum	Units	Time (s)
Total Deformation	0.	4.6697e-003	mm	1.
Equivalent Elastic Strain	1.8162e-010	6.2411e-005	mm/mm	1.
Equivalent Stress	4.3025e-006	2.7746	MPa	1.

Table 3 summarizes the analysis results, showing variations in temperature and heat flux within the material. The temperature ranges widely from negative to high positive values, indicating significant thermal gradients. Additionally, both total and directional heat flux values demonstrate the intensity and direction of heat transfer, reflecting the material's thermal response under applied conditions.

Electric	
Isotropic Resistivity	0.00077 ohm-mm
Magnetic	
Isotropic Relative Permeability	10000

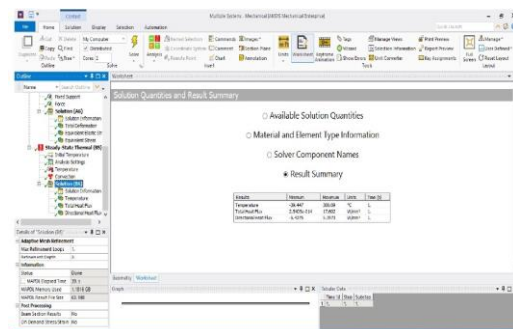


Fig. 13: results of z60 thermal

Fig. 13 shows the ANSYS Mechanical interface displaying the solution quantities and result summary for the thermal analysis. It highlights key outputs such as temperature and heat flux values, along with their minimum and maximum ranges at a specified simulation time. The interface also indicates the completed solution status and provides access to different result components within the analysis tree.

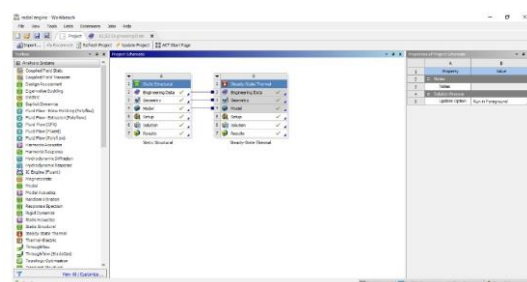


Fig. 14: Final results of radial Engine

Fig 14 presents the ANSYS Workbench project schematic, illustrating the coupled simulation setup involving static structural and steady-state thermal systems. It shows the workflow from engineering data to solution stages, with connections between systems indicating data transfer for multiphysics analysis. Together, these figures demonstrate the overall simulation process and how results are

generated and organized within the software environment.

5. CONCLUSION

The study concludes that material selection plays a critical role in the performance of a five-cylinder radial engine, with Structural Steel emerging as the most reliable option. Compared to magnesium alloys (Mg-8Al-0.5Zn and ZK60), Steel demonstrated significantly lower deformation and elastic strain, ensuring better resistance to vibration and fatigue. Thermal analysis further confirmed Steel's superior heat management and stable temperature distribution under operating conditions. Although magnesium alloys offer weight reduction, they lack the stiffness required for high-load applications. Overall, Steel provides the best balance of strength, durability, and thermal stability. Therefore, it is recommended as the optimal material for maximizing engine performance and longevity in this design.

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