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Parametric Modelling and Optimization of Cam Mechanism Using CATIA and ANSYS

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ABSTRACT: Cam mechanisms are widely employed in numerous applications including automotive engines, robotics, and manufacturing machinery due to their ability to convert rotary motion into reciprocating or oscillating motion. The first phase of the t involves the parametric modeling of the cam mechanism using CATIA, a powerful computer-aided design (CAD) software. Parametric modeling allows for the creation of a flexible and adaptable design that can be easily modified to accommodate different specifications and requirements. Various parameters such as cam profile, follower type, and operating conditions are defined and optimized within the CATIA environment to achieve the desired performance characteristics. Once the parametric model is established, the next phase involves the analysis and optimization of the cam mechanism using Ansys, a leading finite element analysis (FEA) software. Ansys enables engineers to simulate real-world operating conditions and evaluate the performance of the cam mechanism under different loads, speeds, and environmental factors. Through advanced FEA techniques, the stress distribution, deformation, and dynamic behavior of the cam mechanism are analyzed to identify areas of improvement and optimize the design for enhanced performance and reliability. The optimization process aims to maximize the efficiency, minimize wear and tear, and optimize the overall performance of the cam mechanism while ensuring compliance with design constraints and specifications.

KEYWORDS: Parametric modelling, optimization cam mechanism, CATIA, ANSYS

I. INTRODUCTION

"Parametric Modelling and Optimization of a Cam Mechanism Using CATIA and ANSYS" represents an interdisciplinary approach that harnesses the power of advanced computer-aided design (CAD) and finite element analysis (FEA) software to address the challenges inherent in the design, simulation, and optimization of cam mechanisms. Cam mechanisms are fundamental components in numerous mechanical systems, playing pivotal roles in engines, automotive applications, robotics, and manufacturing equipment. They facilitate the conversion of rotational motion into linear motion, or vice versa, thereby enabling precise control of motion and timing within a mechanism. Given their critical functions, the optimization of cam mechanisms is paramount to enhancing efficiency, reliability, and overall performance. CATIA (Computer-Aided Three-dimensional Interactive Application) stands out as a robust CAD software solution widely embraced across industries for its comprehensive suite of tools tailored for product design and development. Through CATIA, engineers can engage in parametric modelling, which allows for the creation of intricate geometries and assemblies while preserving design intent through the establishment of parameters and relationships. This parametric approach facilitates iterative design processes and enables the exploration of various design alternatives with ease and efficiency.

Cam is a mechanical member for transmitting a desired motion to a follower by direct contact. The driver is called cam



and driven is called follower. Cam mechanism is a case of a higher pair with line contact. Camshaft is the Brain of the engine must include cam lobes, bearing journals, and a thrust face to prevent fore and after motion of the camshaft. Valve train system for an engine is vital importance in terms of performance, fuel consumption, vibration and noise etc. Due to the fact that valve train system is main control mechanism and predetermined specified motion actor for engines, all effects on parts of systems should be considered during design process.

II. LITERATURE REVIEW

Parametric Modeling: Research papers and textbooks: Look for academic papers and textbooks that delve into parametric modeling techniques, such as parameterization, feature-based modeling, and design automation.

CATIA capabilities: Explore CATIA documentation, user guides, and technical papers to understand its parametric modeling capabilities, including the use of design tables, equations, and relationships to create parametric models. **Application in mechanical design:** Seek studies or case examples where parametric modeling has been applied in mechanical design projects, particularly in optimizing designs for performance and manufacturability [1].

Optimization Techniques: Optimization algorithms: Study literature on various optimization algorithms, including genetic algorithms, particle swarm optimization, and evolutionary algorithms, focusing on their applicability to mechanical systems and design optimization

CATIA: Documentation and user manuals: Explore CATIA documentation, user manuals, and technical literature to understand its features, capabilities, and applications in parametric modeling, mechanical design, and optimization. **Research papers and case studies:** Look for academic papers and case studies that demonstrate the use of CATIA in parametric modeling, mechanical design, and optimization projects, particularly in the context of cam mechanisms or similar mechanical systems.

Specific features/modules: Identify any specific CATIA features or modules relevant to cam mechanism design and optimization, such as the Part Design, Assembly Design, and Generative Shape Design workbenches.

ANSYS: FEA and simulation techniques: Review literature on finite element analysis (FEA) and simulation techniques, focusing on ANSYS software and its applications in structural analysis, motion simulation, and optimization of mechanical systems. **Research papers and case studies:** Study academic papers and case studies that demonstrate the use of ANSYS in analyzing and optimizing mechanical components or systems, including examples of cam mechanism analysis and optimization. **Integration with CATIA:** Explore literature discussing the integration of CATIA and ANSYS for collaborative design and analysis tasks, including seamless data transfer between the two software platforms.

Integration of CATIA and ANSYS: CAD and FEA integration: Search for literature discussing best practices, methodologies, and challenges associated with integrating CAD and FEA software tools for parametric modeling and optimization projects, with a focus on CATIA and ANSYS integration. **Research papers and case studies:** Look for academic papers and case studies that demonstrate the seamless transfer of geometry, parameters, and simulation data between CATIA and ANSYS, particularly in the context of cam mechanism design and optimization. **Recent Advances and Trends: Emerging trends and advancements:** Seek recent publications, conference papers, and journal articles that discuss emerging trends and advancements in parametric modeling, optimization techniques, and software tools relevant to cam mechanism design and optimization. **Innovative approaches:** Identify any innovative approaches or methodologies that could be applied to enhance the parametric modeling and optimization of cam mechanisms using CATIA and ANSYS, such as machine learning-based optimization algorithms or advanced simulation techniques.[4].

Fig 2.1. The parametric table

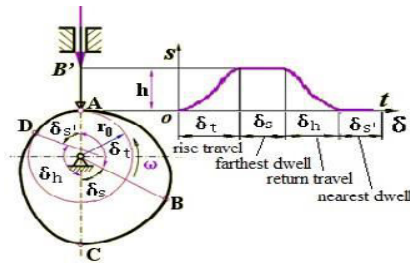
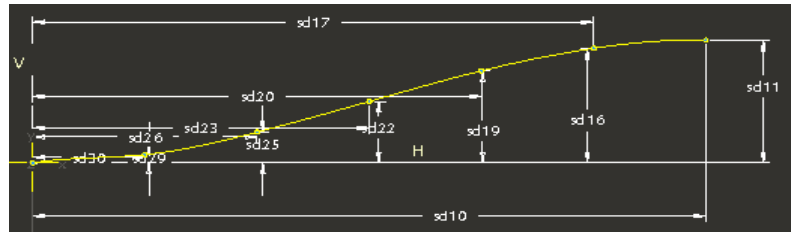
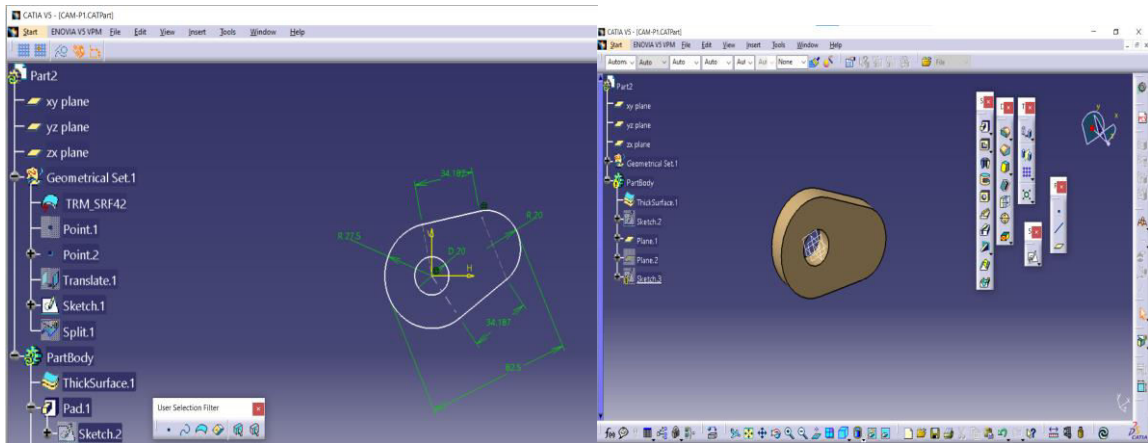


Fig 2.1 Time of ascent of cam profile



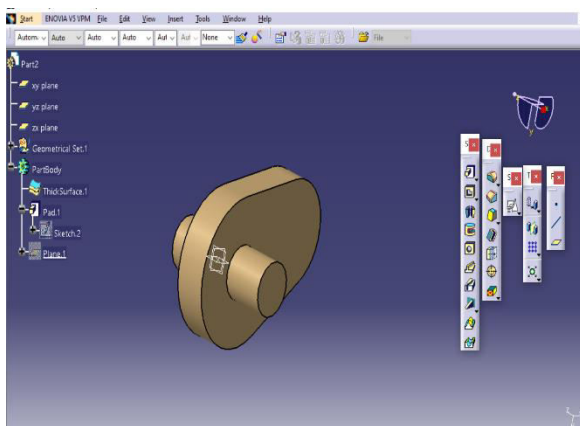
III. MODELLING

Design of cam shaft in CATIA V5R21 :

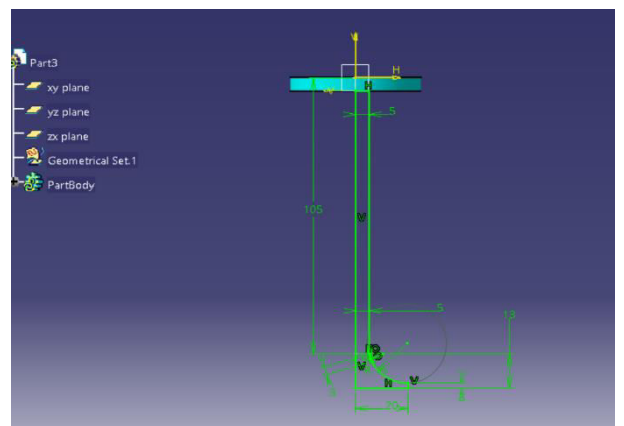


2D Diagram of cam

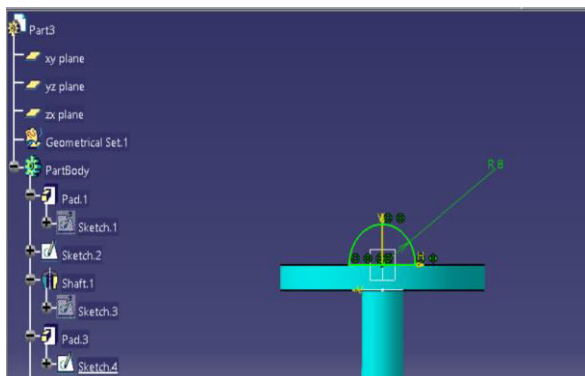
GENERATED CAM USING PAD FEATURE



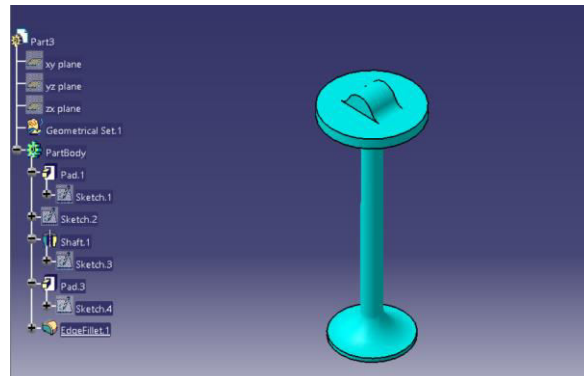
GENERATED CAM PIN USING PAD FEATURE



2D of follower diagram



2D OF FOLLOWER TYPE



GENERATED FOLLOWER SHAFT FEATURE

Cam mechanism's motion process is made up of four stages as rise travel, farthest dwell travel, return travel and nearest dwell travel, as shown in Fig. 1. In rise travel or return travel, there are some typical kinds of motion laws as constant velocity, constant acceleration and constant deceleration, cosine acceleration and sine acceleration, so cam mechanism products 16 kinds of motion combination. This paper took rise-travel and return-travel as design parameters, and gave 1, 2, 3 and 4 as their values to correspond respectively the four kinds of motion laws. So that only 8 corresponding motion curves were needed to create for program calling according to different parameters. Furthermore, cam profile can generate automatically for 16 kinds of typical combination motion law.[5]

Designating CAD DATA

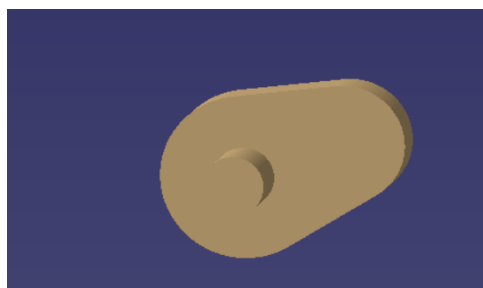


fig 3.1 : CAM

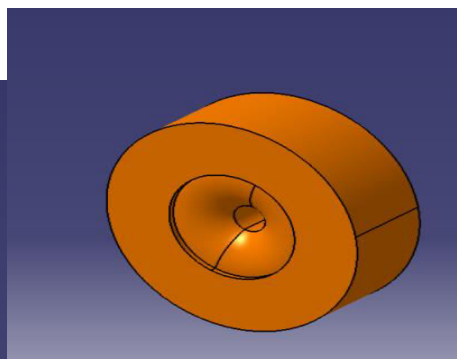


fig 3.2 : BASE SUPPORT

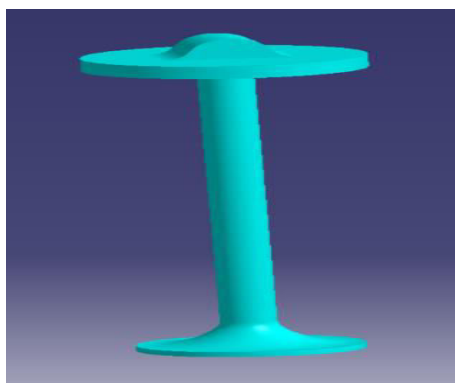


Fig 3.3 : FOLLOWER

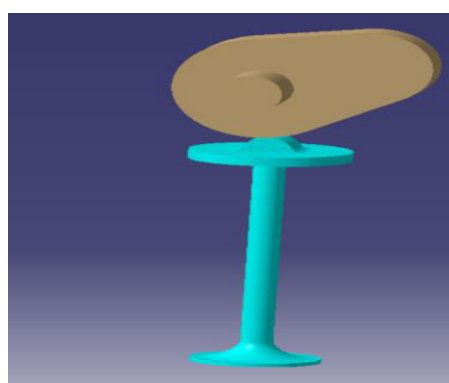


fig 3.4 : CAM AND FOLLOWER

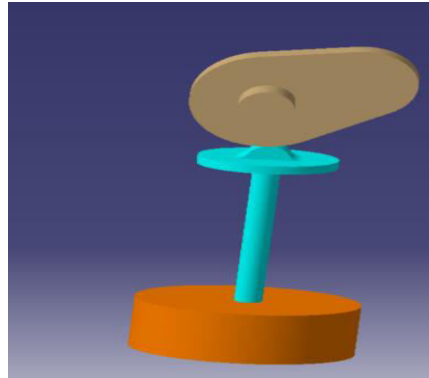


fig 3.5 : FIANL ASSEMBLY

IV. METHODOLOGY

ANSYS INTRODUCTION

Dr. John Swanson founded ANSYS, Inc. in 1970 with vision found to commercialize the concept of computer-simulated engineering, establishing himself as one of the pioneers of finite element analysis (FEA). ANSYS Inc. The ANSYS program is a flexible, robust design analysis and optimization package. The software operates on major computers and operating systems, from PCs to workstations to super computers. ANSYS features file computability throughout the family of products and across all platforms. ANSYS design data access enables user to import computer-aided design models into ANSYS, eliminating repeat work. This ensures enterprise-wide, flexible engineering solution for all ANSYS user.

ANSYS finite element analysis software enables engineers to perform the following tasks:

- 1) Build computer models or transfer CAD models of structures, products, and components systems.
- 2) Apply operating loads or other design performance conditions.
- 3) Study physical responses such as, stress levels and temperature distributions or the impact of electromagnetic fields.
- 4) Optimize a design early in the development process to reduce production costs.
- 5) Do prototype testing in environments where it otherwise would be undesirable or impossible.[8]

PROCEDURE FOR ANSYS ANALYSIS:

Analysis in ANSYS can be either linear or non-linear. The procedure for any analysis consists of these main steps.

- 1) Pre-Processor Phase (Build the model)
- 2) Solution Phase (Obtain the solution)
- 3) Post-Processor Phase (Review the results)

PRE-PROCESSOR PHASE:

In this step, we specify job name and analysis title and then use PREP 7 to define the element types, element real constants, material properties and the model geometry element types—both linear and nonlinear structural elements are allowed. The ANSYS element library contains over 80 different element types. A unique number and pre-fix identify each element type(3).

SOLUTION PHASE:

The solution phase deals with the solution of the problem according to the problem definitions. All the tedious work of formulating and assembling of matrices are done by the computer and finally displacements and stresses are given as output

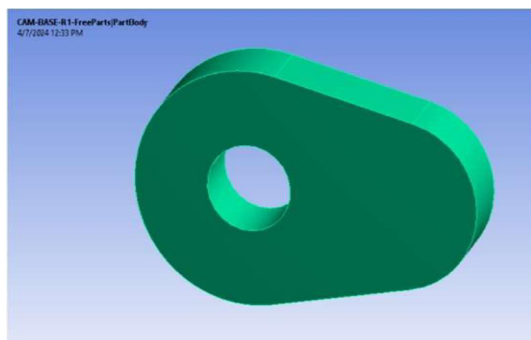
POST-PROCESSOR PHASE:

The post-processing phase of the ANSYS program follows the preprocessing and solution phases. With this portion of the program, the user may easily obtain and operate on the results calculated in the solution phase through a very

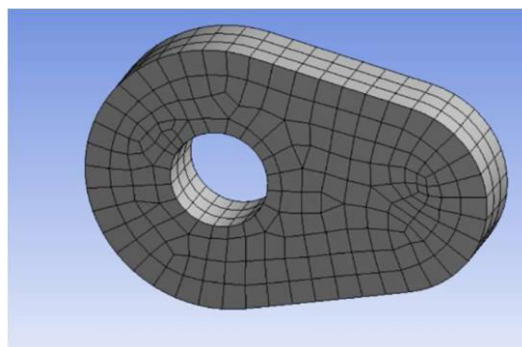
complete set of user-friendly post-processing features. These results may include displacements, temperatures, strains, and stresses, velocities and heat flows. The output from the postprocessing phase of the program is in display and/or tabular report form. Because the post-processing phase is fully integrated with the ANSYS preprocessing and solution phases, the user can examine results immediately.

V. ANALYSIS

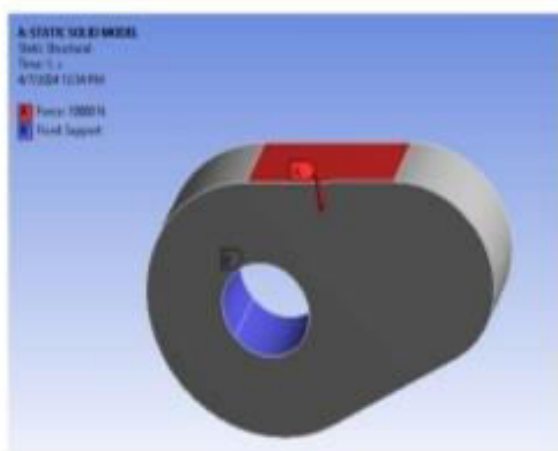
STATIC :



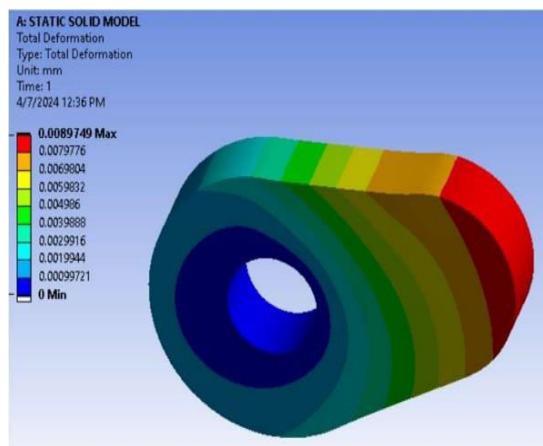
FEM MODEL



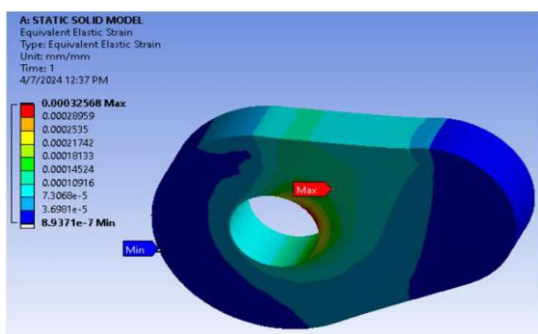
MESH MODEL



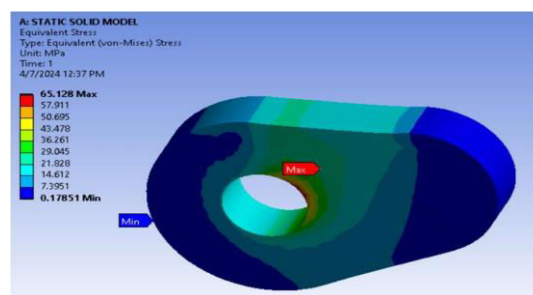
LOAD BOUNDARY CONDITIONS



DEFORMATION



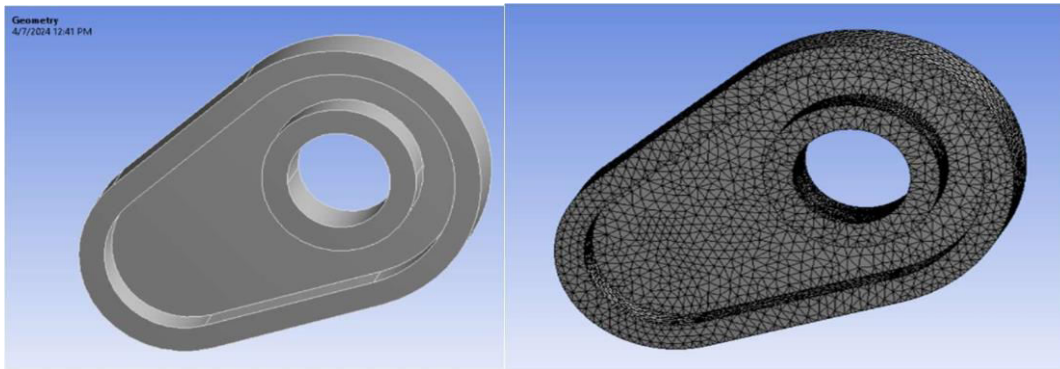
VON MISES STRESS 65.12MPA



VON MISES STRAIN 3.2E-4MMMM

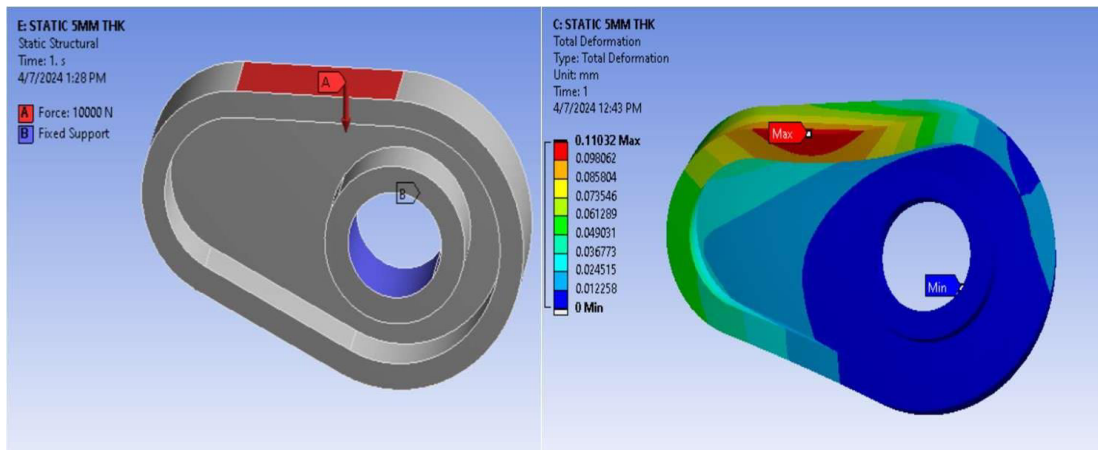
OPTIMIZED CAM PROFILE :

STATIC:



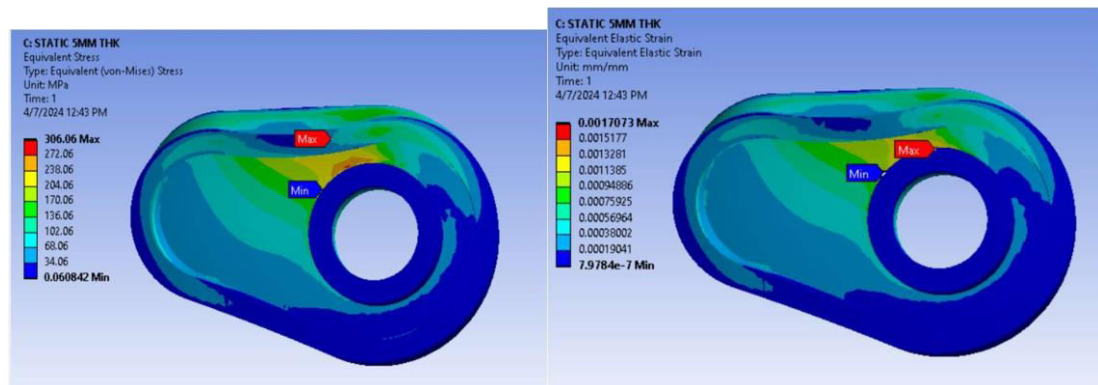
FEM MODEL

MESH MODEL



LOAD BOUNDARY CONDITIONS

DEFOMATION 0.11MM



VON MISSES STRESS 306.06MPA

VON MISSES STRAIN 1.7E-3MM



VI. CONCLUSION

parametrically designed and their motion was simulated and analyzed. Not only had it built high accuracy model but also realized and Modified Thickness of CAM profile. By solid model, thickness of 7.5 and 5-mm CAM model analysis with load of 10K N flower load. Basic design safe up to thickness of 5mm of CAM. Designs of upto 5mm thickness. By results were reduce weight upto 40%.

Solid model weight of Steel : 0.378 kgs

Weight of CAM after thick 5mm : 0.237Kgs

% of weight reduce : $0.378 - 0.237 / 0.378 * 100 = 37.3$

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