Design and Development of an Oil Slinger for an Automobile Engine

Yasin Baba[1], Kuldeep Kora[2]

[1]MTech Tool Engineering Scholar, Government Tool Room and Training Centre, GTTC, Mysuru.
[2]Tool Design Engineer, Government Tool Room and Training Centre, GTTC, Mysuru

---***---

Abstract - The design and development of press tools in sheet metal operations are crucial for enhancing functionality and durability in automobile manufacturing. This review compares various tool designs, particularly press and combination tools, and assesses their efficiency and quality improvements. The focus is on developing a new combination tool for manufacturing oil slingers, integrating piercing and forming operations into a single tool. This innovation aims to reduce process time, minimize operator fatigue, and lower tool costs, thereby streamlining production and maintaining high-quality standards in automotive manufacturing. The study contributes to improving the efficiency and effectiveness of sheet metal operations through advanced tool design and development of oil slingers using sheet metal.

1. INTRODUCTION

Through this paper, an attempt is made to explore sheet metal shaping procedures, which are vital in modern industry for producing high-quality, complex components efficiently and cost-effectively, thereby boosting productivity and precision. The focus is on the design and development of oil slingers for internal combustion engines, which are crucial for lubrication. The study encompasses intricate processes such as blanking, trimming, piercing, and forming, with a strong emphasis on theoretical analysis, CAD, and advanced manufacturing techniques to enhance both efficiency and durability in automotive engines.

2. METHODOLOGY

Methodology serves as the structured framework that outlines the systematic approach to achieving the objectives of the project, while aligning with its scope and requirements.

(a) Problem Identification and Scope Definition: Define the project scope, and objectives, and constraints based on automotive industry standards. Establish the clear goals focusing on cost-effectiveness, and dimensional accuracy, component quality, and production efficiency

(b) Literature Survey: Conduct the review of an academic literature and industry publications related to oil slinger components, sheet metal operations, and press tool design. Identify theoretical foundations, best practices, and case studies relevant to the project.

(c) Conceptual Design: Brainstorm initial concepts for the oil slinger component using sketches and basic CAD such as solid works software. Evaluate each concept based on technical feasibility, and manufacturability, and alignment with project objectives.

(d) Detailed Design: Select the most promising concept and develop the detailed design using Solid works software. Specify dimensions, and material properties of oil slinger, and design features required for sheet metal operations (blanking, trimming, forming, and piercing).

(e) Press Tool Design and Calculation: Design the press tool required for manufacturing the oil slinger component, focusing on Die layout, punch and die design, and material selection based on theoretical knowledge from the literature review.

(f) Simulation of press tools: Utilize Solid works software for virtual simulations to analyze the manufacturing process of the oil slinger. Perform stress analysis and simulate the forming process to validate the press tool design and ensure dimensional accuracy.

(g) Optimization and Refinement: Evaluate simulation results, calculation outcomes, and cost analysis to optimize the design and manufacturing process. Implement design refinements to improve component quality, production efficiency, and cost-effectiveness.

(h) Documentation and Reporting: Document the entire design process, including sketches, CAD models, calculation reports, and optimization findings. Prepare a comprehensive report summarizing the methodology, design rationale, results, and conclusions.

3. STUDY OF COMPONENT AND 3D MODELING OF OIL SLINGER AND PRESS TOOL

An oil slinger is a mechanical component used in rotating machinery like engines to distribute lubricating oil to key components such as bearings or gears. Designed as a disc or ring mounted on a rotating shaft, it utilizes centrifugal force to pick up oil from a reservoir and fling it towards these parts, ensuring continuous lubrication. This process reduces friction, dissipates heat, and prevents wear, maintaining the efficiency and longevity of the machinery. Regular maintenance is required to ensure the oil slinger's effectiveness in keeping the machinery running smoothly.

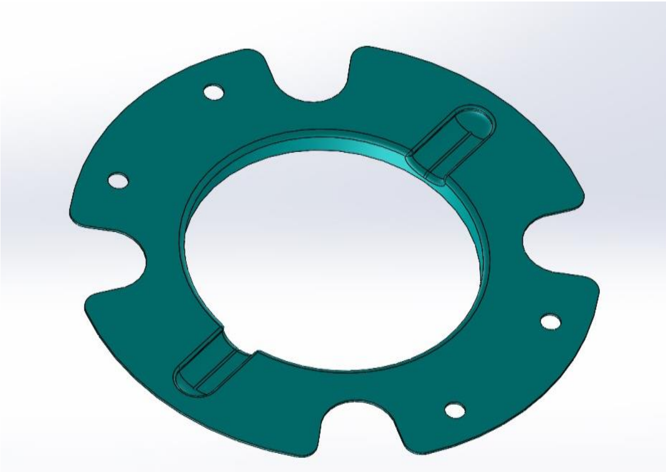

Fig -1: Oil Slinger

3.1. DESIGN CALCULATION OF OIL SLINGER

1) Blanking Operations of oil slinger
   - **Perimeter (P):** 429.23 mm
   - **Shear Force (one cut):** 103.03 kN
   - **Total Shear Force (2 cuts):** 206.06 kN
   - **Stripping Force:** 41.21 kN
   - **Press Force:** 247.27 kN
   - **Press Tonnage/Capacity:** 35.32 tons

2) Trimming Operations of oil slinger
   - **Shear Force (one cut):** 151.92 kN
   - **Total Shear Force (4 cuts):** 607.68 kN
   - **Stripping Force:** 121.54 kN
   - **Press Force:** 729.22 kN
   - **Press Tonnage/Capacity:** 106.06 tons

3) Piercing Operations of oil slinger
   - **Shear Force (one cut):** 5.277 kN
   - **Total Shear Force (4 cuts):** 21.108 kN
   - **Stripping Force:** 4.2216 kN
   - **Press Force:** 25.33 kN
   - **Press Tonnage/Capacity:** 36.18 kN (3.6887 tons)

4) Forming Operations of oil slinger
   - **Shear Force (one form):** 77.35 kN
   - **Total Shear Force (2 forms):** 154.71 kN
   - **Stripping Force:** 30.94 kN
   - **Press Force:** 185.65 kN
   - **Press Tonnage/Capacity:** 265.21 kN (27.03 tons)

5) Combined Piercing & Forming of slinger
   - **Total Combined Force:** 175.818 kN
   - **Average Force:** 29.303 kN (2.992 tons)

3.2 INTRODUCTION TO PRESS TOOLS

Most industrial products are mass-produced to meet consumer demands, ensure consistent quality, and achieve cost-effectiveness. Press tools are devices specifically designed to fulfill these requirements across a wide range of products such as televisions, tape recorders, radios, refrigerators, cars, and watches, which typically incorporate numerous components made from plastic or sheet metal. These tools are primarily utilized for manufacturing sheet metal components.

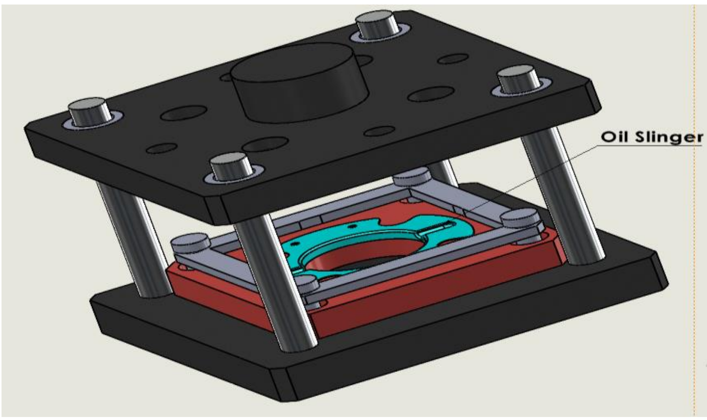

Fig -5: 3D Modeling of Press Tool

PRESS TOOL OPERATIONS

1. **Blanking**
   - **Definition:** Blanking is a manufacturing process where a piece of raw material, typically sheet metal, is cut out to create a blank with a specific shape and size.
   - **Operation:** In blanking, a blanking die and punch are used in a press to cut the desired shape from a larger sheet of material. The material surrounding the blank is removed as scrap.

2. **Trimming**
   - **Definition:** Trimming involves cutting away excess material from a formed part to achieve its final shape and dimensions.
   - **Operation:** A trimming die and punch are employed to remove unwanted edges or features from the part. This step ensures the part conforms to precise dimensional and aesthetic standards.

3. **Combined Operations of Piercing & Forming for Oil Slinger**
   - **Definition and Operation:**
     - **Piercing:** This process involves creating precise holes or patterns in the material, which is crucial for oil circulation in the oil

slinger. A piercing die and punch are used to ensure accurate hole placement and sizing.
  - **Forming:** This shapes the material into the necessary configuration, such as bending or deep drawing, to create the final oil slinger shape. The oil slinger is designed to effectively fling oil away from critical machinery components to ensure optimal lubrication.
- **Integrated Approach:** Combining piercing and forming in one process streamlines production and enhances efficiency. It ensures that the oil slingers meet both functional requirements and high-quality standards, crucial for maintaining machinery performance.

DESIGN CALCULATION OF PRESS TOOL

1. **Blanking Tool**

- **Thickness of Die Block (TD):** 35 mm
- **Width of Die Block:** 250 mm
- **Length of Die Block:** 250 mm
- **Die Block Dimensions:** 35mm×250mm×250mm

2. **Trimming Tool**

- **Thickness of Die Block (TD):** 35 mm
- **Width of Die Block:** 250 mm
- **Length of Die Block:** 250 mm
- **Die Block Dimensions:** 35mm×250mm×250mm

3. **Combined Piercing and Forming Tool**

- **Thickness of Die Block (TD):** 35 mm
- **Width of Die Block:** 250 mm
- **Length of Die Block:** 250 mm
- **Die Block Dimensions:** 35mm×250mm×250mm

4. ANALYSIS OF OIL SLINGER

4.1 STRESS, STRAIN, & DEFORMATION ANALYSIS

a) ANALYSIS OF BLANKING WORKPIECE

1. STRESS:- The analysis shows minimum principal stress in the oil slinger, with stress levels from 9.48e-5 to 9.577e-9, highlighting potential high-stress areas. The stress is within acceptable limits, confirming the component's reliability and performance.

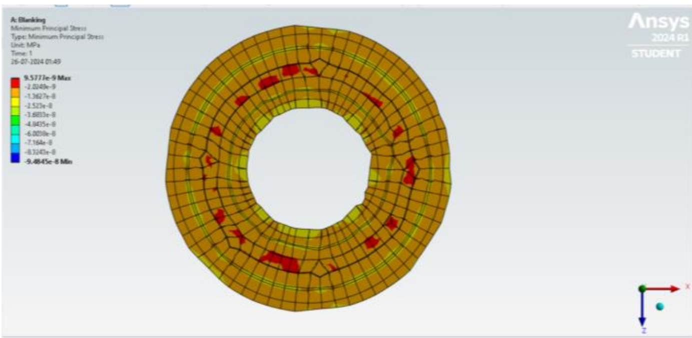

Fig -9: Analysis of stress

2. STRAIN:- The strain analysis shows the maximum principal elastic strain in the oil slinger, with higher concentrations near the inner and outer edges. The maximum strain of 4.760e-13 is within allowable limits, confirming the component's suitability for use in rotating machinery.

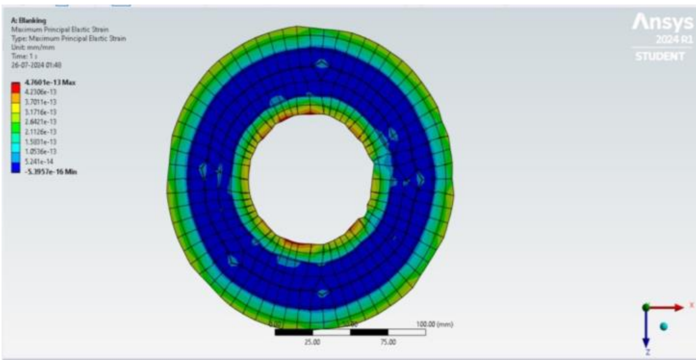

Fig -10: Analysis of strain

3. DEFORMATION:- The total deformation analysis of the oil slinger shows minimal deformation, with red indicating the maximum and blue the minimum. Slight variations occur near specific areas, but overall, the oil slinger maintains its structural integrity under applied loads, ensuring reliable performance. Understanding these deformation characteristics is essential for assessing the component's durability and functionality in real-world conditions.

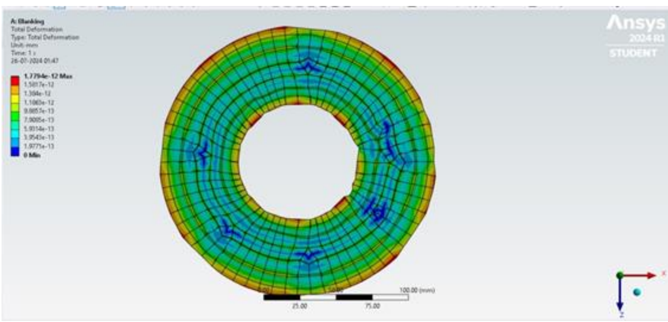

Fig -11: Analysis of deformation

b) ANALYSIS OF TRIMMING WORKPIECE

1. STRESS: The analysis shows "Maximum Principal Stress" in the oil slinger. A color gradient highlights stress distribution, with red indicating the highest stress at 6.4204e-7 MPa and blue the lowest at -5.0495e-8 MPa.

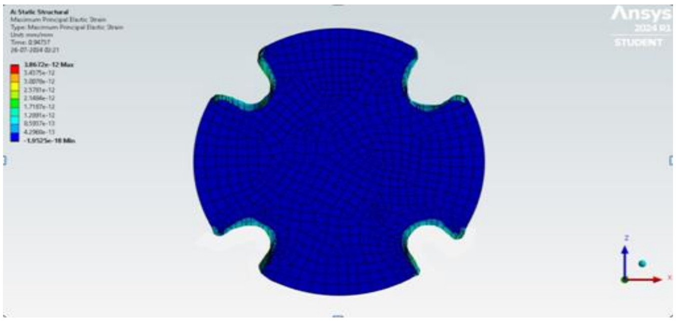

Fig -12: Analysis of stress

2. STRAIN: The analysis shows the "Maximum Principal Elastic Strain," representing the highest recoverable strain along the major principal axis. The contour plot uses colors to indicate strain levels, with red showing the highest strain (3.8672e-12) and blue the lowest (-1.9525e-18), illustrating strain variation across the oil slinger.

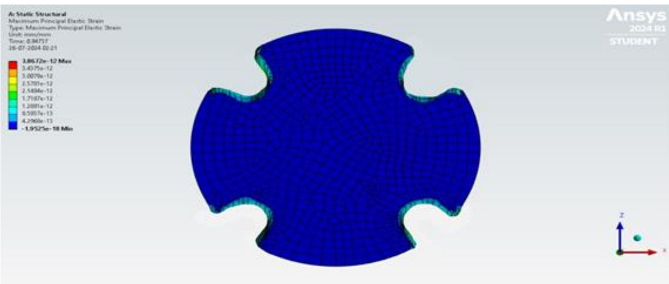

Fig -13: Analysis of strain

3. DEFORMATION: This figure shows the total deformation of the oil slinger under load. The color contour plot visualizes deformation, with red indicating maximum deformation (4.7094e-12) and blue showing minimal deformation (5.2372e-13), highlighting the variation across the slinger.

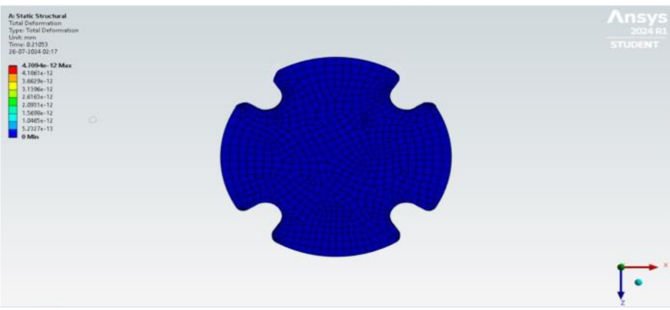

Fig -14: Analysis of deformation

c) COMBINED OF FORMING & PIERCING WORKPIECE ANALYSIS

1. STRESS: The maximum principal stress, observed at -5.049e-8 MPa, occurs in specific regions of the oil slinger, highlighted in red to orange, indicating high tensile stress near geometric discontinuities. The minimum principal stress, 6.420e-7 MPa, shows areas under compressive stress, represented in blue. This stress distribution is crucial for assessing the oil slinger's durability

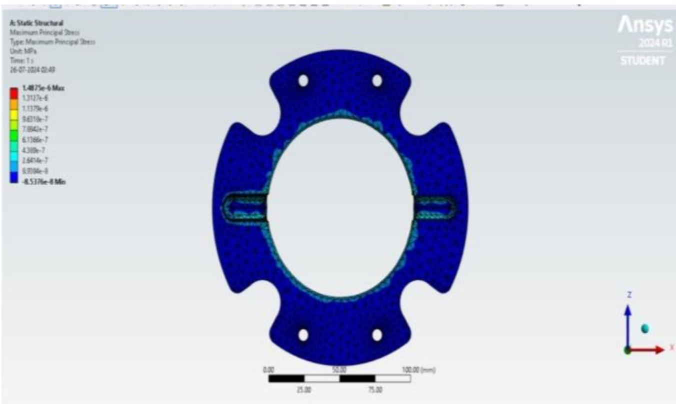

Fig -15: Analysis of stress

2. STRAIN:- The maximum principal strain in the oil slinger, ranging from -1.952e-18 to 3.867e-12, occurs near areas like sharp corners and holes. These minimal strain values indicate the material is within its elastic limit, suggesting the design is robust and can withstand operational stresses without failure.

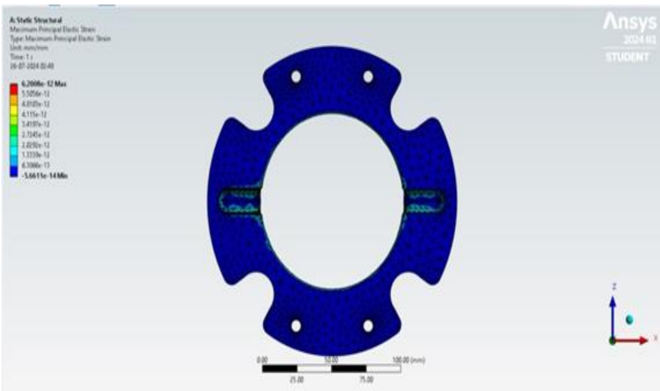

Fig -16: Analysis of strain

3. DEFORMATION:- Deformation: - The maximum total deformation observed is 4.709e-12 mm. This value represents the highest displacement experienced by any point on the oil slinger, which occurs in areas subjected to the greatest load or stress concentration. The distribution of total deformation across the oil slinger is relatively uniform, with slight variations occurring near geometric discontinuities such as holes or edges

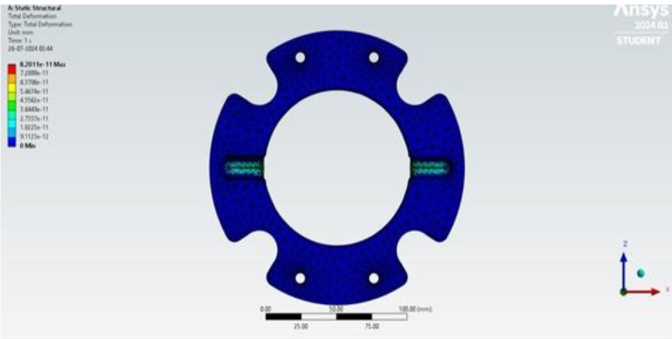

Fig -17: Analysis of deformation

5. TOLL DESIGN CONSIDERATIONS

- The study emphasizes the critical role of tool design in enhancing the efficiency and durability of sheet metal operations, specifically in the automotive industry.
- It presents a combination tool design that integrates piercing and forming operations into a single process, potentially reducing process time and operator fatigue while lowering tool costs.

6. SCOPE AND LIMITATION

- The scope is focused on optimizing the oil slinger's design and production process to improve engine performance. However, the study is limited to theoretical analysis and CAD simulations, without validation through physical testing.
- Limitations include the scope of materials used and the specific operational conditions simulated, which might not fully capture real-world variables.

7. DEVELOPMENT AND INNOVATION

- The study proposes a new combination tool that merges multiple operations into one, streamlining production and ensuring high-quality standards in automotive manufacturing.
- The design process involves detailed CAD modeling, stress-strain analysis, and deformation studies, which could serve as a foundation for future tool developments in the industry.

8. FURTHER STUDY

- The study recommends further research involving physical testing to validate the proposed design under real-world conditions.
- Additional studies could explore alternative materials for the oil slinger and the press tools to achieve better performance and sustainability.
- Future research could also investigate the impact of varying operational conditions on the tool's performance and longevity.

9. CONCLUSION

The project focused on optimizing the design of the oil slinger used in automobile engines through rigorous simulation and analysis. Results indicate that the proposed design modifications can significantly enhance the efficiency of oil distribution, thereby improving overall engine performance and reliability. It is recommended to proceed with implementing the optimized design, with further validation through physical testing to ensure its effectiveness under real-world operating conditions. Future research could explore additional refinements and alternative materials to achieve greater efficiency gains and sustainability in automotive engine applications.

REFERENCES

[1] In 2017, Gaurav C. R, D. N. Raut, and Samadhan A published a study and analysis of press tool design in the International Journal of Engineering Research & Technology.

[2] In 2013, Nilesh N. Patil and Wasim I. Shaikh, provided an overview of press tool design used for sheet metal processes, emphasizing design considerations, in the International Journal of Science and Research.

[3] In 2013, Aas M and Hasin Z J, explored the causes and prevention of defects (burr) in sheet metal components, as documented in the International Journal of Engineering Research and Applications.

[4] In 2017, Pritam B.B, Shubhangi A.D, Shubham R.B, Ajinkya B.P, and Shubham V.S, authored a paper titled "Design and Manufacturing of Progressive Die," published in the International Journal of New Technology and Research.

[5] In 2016, Ramegowda D., Vyshakh, and Sannamani L. G, conducted a study titled "Design and Analysis of Punch and Die for Blanking, Piercing, and Forming Tools to Produce Chain Guide Mounting Bottom Bracket," published in the International Journal for Ignited Minds.

[6] In 2018, Ram J, R. R. Alaraddi, and Santosh K. M, explored productivity enhancement through the use of press tools, as published in the International Research Journal of Engineering and Technology.

[7] In 2016, Rupali C. and Navneet P. conducted a study titled "Design, Development, and Analysis of Press Tool for an Industrial Part," published in the International Journal of Mechanical and Industrial Technology.

[8] In 2016, Subramanyam P, B. Rajashekar, and B. Damodhar detailed the process of press tool design and its manufacturing for blanking operations in the International Journal of Innovative Research in Science, Engineering, and Technology.

BIOGRAPHIES

Mr. Kuldeep Kora is a skilled tool engineering professional with strong business administration expertise. Certified as a Toastmasters Competent Leader, he has excelled in managing technical and commercial operations for organizations across India and internationally.

Mr. Yasin Baba is an MTech Scholar in Tool Engineering at Government Tool Room Training Centre, Mysuru. His research focuses on Press Tool Designing and Jigs & Fixtures, contributing to advancements in precision manufacturing.