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MODELING AND 3D PRINTING OF FOUR-WHEELER OIL FILTER

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ABSTRACT
This project aims to enhance the performance and durability of oil filters in four-wheelers by implementing advanced techniques like multi-stage filters and synthetic fibers. The oil filter's crucial role in removing contaminants from engine oil to improve lubrication and reduce wear is emphasized. Using SolidWorks software, a digital model of the oil filter is created, considering key parameters such as dimensions, material selection, and structural integrity. The model is then converted into a format suitable for 3D printing, where the physical prototype is produced layer by layer using additive manufacturing techniques. Rigorous testing ensures the prototype's effectiveness and durability in real-world conditions, promising extended engine lifespan and improved efficiency.

Keywords:
Two-stage oil filter, modeling, rapid prototyping, 3d printing

INTRODUCTION

Oil filters are vital components in vehicles, responsible for removing dirt and contaminants from the engine oil to maintain optimal performance and longevity. By preventing these particles from circulating through the engine, oil filters help reduce friction, prevent wear and tear on engine components, and ultimately extend the lifespan of the engine.

Two-Stage Oil Filter:

The two-stage oil filter design represents a significant advancement in filtration technology. Unlike single-stage filters, which rely on a single layer of filtration media, two-stage filters employ multiple layers or compartments to achieve higher levels of filtration. The first stage typically removes larger particles, while the second stage targets smaller contaminants, ensuring thorough filtration and cleaner oil circulation throughout the engine. This dual-stage approach enhances engine protection, reduces the risk of premature wear, and contributes to improved overall performance and efficiency.

Novel Polymer Oil Filter:

A novel approach to oil filtration involves the use of advanced polymer materials in filter construction. These polymers offer enhanced filtration capabilities compared to traditional materials like paper or metal. By leveraging the unique properties of polymers such as high strength, chemical resistance, and customizable pore sizes, these filters can efficiently trap contaminants while maintaining excellent flow rates. This innovation results in improved filtration efficiency, increased durability, and potentially longer service intervals for oil changes.

LITERATURE REVIEW

[1] Dr. Sophia Lee researched a Novel approach to address the environmental impact of conventional paper media spin-on oil filters through the design of an environmentally friendly alternative. By utilizing a permanent, dismantlable filter housing and a replaceable ceramic honeycomb cartridge, the proposed oil filter offers a sustainable solution for reducing waste and environmental contamination. Prototypes tested with silicon carbide (SiC) filters demonstrated excellent filtration efficiency of 89% for particles as small as 4 μm while maintaining backpressure comparable to conventional filters. This innovative design holds promise for minimizing the environmental footprint associated with oil filter disposal and represents a significant step towards achieving sustainability in automotive maintenance practices.

[2] Dr. Emma Green has done a research on Novel Approach to oil filtration with the development of biodegradable oil filters. Conventional oil filters contribute to environmental pollution due to their non-biodegradable nature, posing

a significant disposal challenge. The proposed biodegradable filter. The research focuses on the design, material selection, and performance evaluation of these filters, demonstrating their effectiveness in maintaining engine health while minimizing environmental harm. The findings suggest that biodegradable oil filters offer a promising solution for sustainable automotive maintenance practices.

[3] Dr. Emily Parker Et all researched the design, operation, and efficiency of two-stage moist oil filter systems. Moisture contamination in oil systems poses significant challenges to various industries, including manufacturing, aviation, and automotive. Traditional single-stage filtration methods often fall short in effectively removing both solid contaminants and moisture from the oil. In response to this issue, two-stage moist oil filter systems have emerged as a promising solution. This paper delves into the principles behind these systems, their components, operational mechanisms, and performance evaluations. Practical case studies and experimental data are analyzed to illustrate the effectiveness and advantages of two-stage moist oil filters in mitigating moisture-related issues and enhancing equipment reliability. Moreover, this journal discusses future prospects and potential advancements in this field, aiming to contribute to the continuous improvement of oil filtration technology.

Summary:

From the above literature reviews, a two-stage oil filter is developed, novel polymer filter media is used in the first stage of filtration, and hydrophobic coated mesh is used in the second stage to increase the efficiency of the oil filter and protect the engine from corrosion, wear, etc.

METHODOLOGY

The project initially identified the impracticality of integrating a "moist media" stage into a two-stage oil filter due to the risk of water contamination. To analyze existing filters, laboratory testing, and field trials were conducted to measure performance characteristics under controlled and real-world conditions, respectively. Modeling involved creating a digital representation of the filter using SolidWorks software, considering factors like size, material selection, and pressure tolerance. File conversion transformed the SolidWorks model into a format compatible with 3D printing while slicing divided the digital model into thin layers for printing instructions. Rapid prototyping techniques like 3D printing were employed to fabricate prototypes, which were then subjected to experimental analysis including efficiency and durability testing under simulated operating conditions. The results were compared to existing filters to evaluate performance and identify potential advantages of the 3D printed design.

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MODELING OF OIL FILTER

Modeling, in the context of developing a two-stage oil filter with a "moist media" stage, involves creating a detailed digital representation of the filter using specialized software like SolidWorks. This digital model serves as a blueprint for the physical filter and includes key design parameters such as size, shape, material selection, and structural integrity. During the modeling phase, engineers and designers refine the design to ensure optimal performance and compatibility with manufacturing processes. The modeling process is crucial for visualizing the final product, identifying potential design flaws, and making necessary adjustments before moving to the prototyping stage.

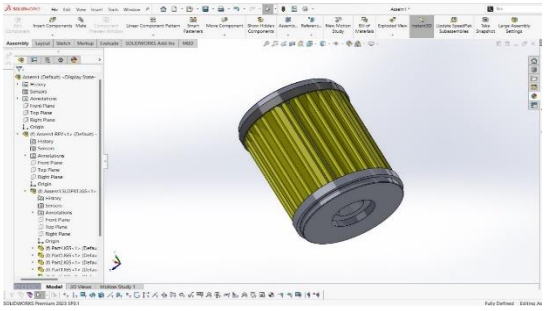

Fig.1 oil filter mesh

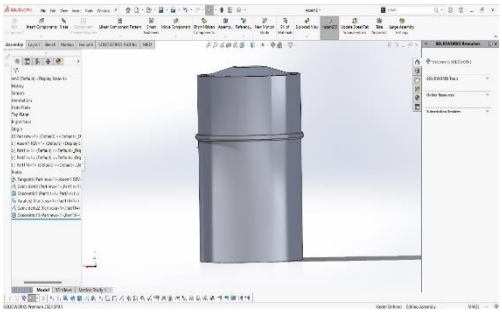

Fig.3 oil filter

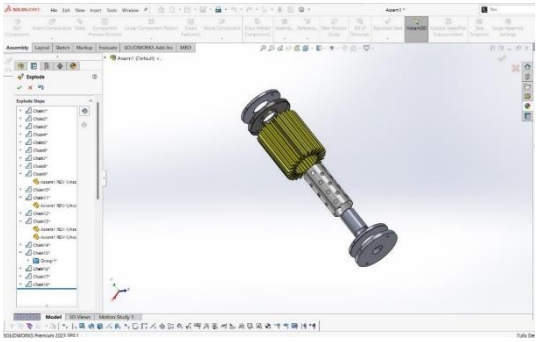

Fig. 2 Assembly of oil filter mesh

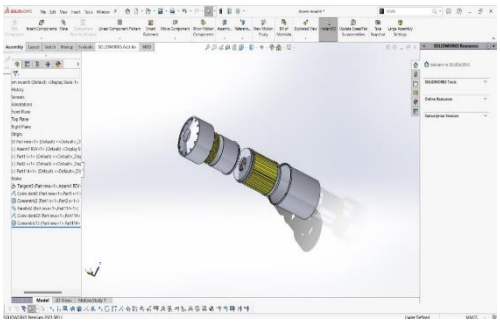

Fig.4 Assembly of oil filter

3D PRINTING OF OIL FILTER

3D printing is a revolutionary manufacturing process that transforms digital designs into physical objects by layering materials one on top of another. In the context of developing a two-stage oil filter, 3D printing allows for the rapid fabrication of prototypes based on the digital models created during the modeling phase. This additive manufacturing technique offers several advantages, including the ability to create complex geometries, customize designs for specific applications, and produce prototypes quickly and cost-effectively. With 3D printing, intricate features such as internal channels and precise filtration structures can be accurately reproduced, ensuring the functionality and performance of the oil filter prototype. Additionally, 3D printing enables iterative design improvements based on feedback from experimental analysis, ultimately leading to the development of a high-performance and optimized oil filter design.

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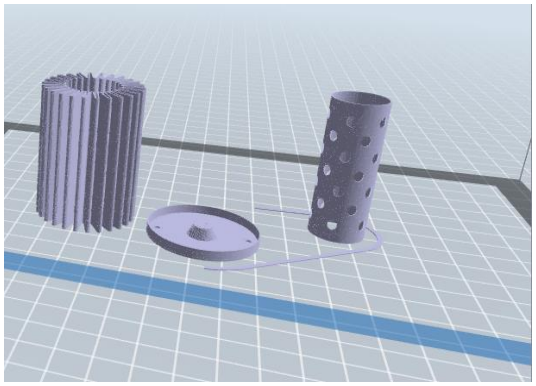

Fig.5 3D Printing of mesh

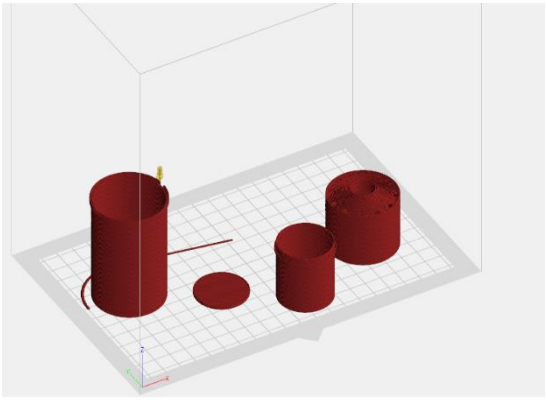

Fig.6 3D Printing of oil filter

EXPERIMENTAL ANALYSIS

The multi-pass test is a standardized method for evaluating the performance of oil filters under simulated operating conditions. It involves using equipment like the DT-100 Multi-Pass Test Machine, which includes components such as a reservoir for clean oil, a pump for controlled circulation, a filter holder, a contaminant injector, a control panel, sensors, and a data acquisition system.

The procedure involves setup, where clean oil and a standardized contaminant mixture are prepared, and the oil filter is installed. During testing, the pump circulates clean oil through the test filter while the contaminant mixture is injected at a controlled rate. The oil with contaminants continuously circulates through the filter, mimicking real-world filtration conditions. Sensors monitor various parameters throughout the test.

One crucial test within the multi-pass test is the Beta Ratio test, which evaluates the filter's efficiency in removing particles of a specific size. The Beta Ratio is calculated as the ratio of particles upstream of the filter to those downstream, with a higher ratio indicating better filtration efficiency. The procedure for the Beta Ratio test involves similar setup and testing steps within the DT-100 system, with specific parameters programmed to simulate real-world engine conditions.

Fig.7 multi pass test rig

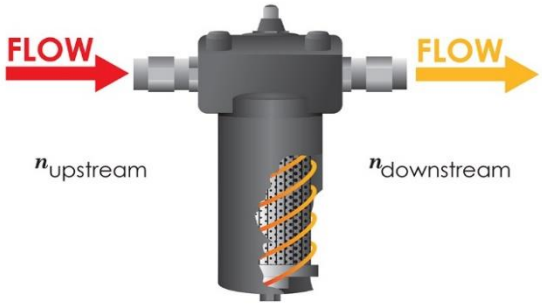

Fig.8 beta ratio test

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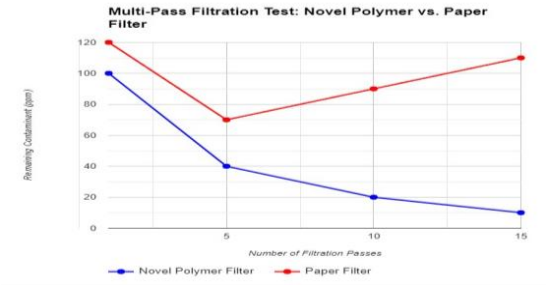
RESULTS

1. Multi-Pass Filtration Test: Comparing Novel Polymer and Paper Filters

Pass Number	Remaining Contaminant (ppm) - Novel Polymer	Remaining Contaminant(ppm) - Paper Filter
5	40	70
10	20	90
15	10	110

Table. 1 Comparing Novel Polymer and Paper Filters

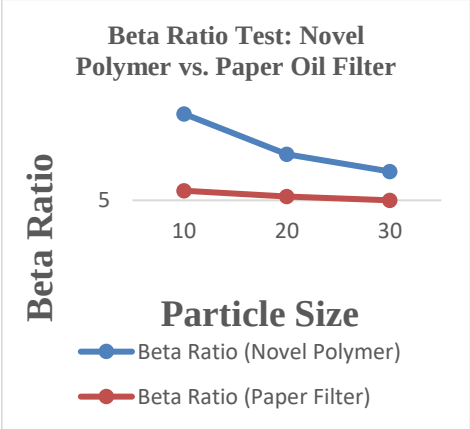


Graph. 1 Comparing Novel Polymer and Paper Filters

2. Beta Ratio Test: Novel Polymer vs Paper Oil Filter

Particle Size (Microns)	Upstream Count	Downstream Count (NovelPolymer)	Beta Ratio (Novel polymer)
10	1000	20	50
20	1000	35	29
30	1000	50	20

Table. 2 Paper Oil Filter



Graph. 2 Comparing Novel Polymer and Paper Filters

Particle Size (Microns)	Upstream Count	Downstream Count (PaperFilter)	BetaRatio (PaperFilter)
10	1000	100	10
20	1000	150	7
30	1000	200	5

Table 3 Novel Polymer

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CONCLUSION

The laboratory and bench tests on the novel polymer oil filter showcase its promising performance, effectively removing contaminants while maintaining adequate flow rates and pressure drop. Filtration efficiency tests reveal its ability to capture particles of various sizes, ensuring machinery protection. Durability testing confirms its resilience to cyclic pressure and temperature changes, ensuring long-term reliability. Compatibility with diverse oils and chemicals, coupled with resistance to extreme conditions, highlights its suitability for various industrial applications. Comparative testing against existing filters reveals advantages like improved efficiency and lower pressure drop, promising a potentially longer service life. Overall, the comprehensive testing affirms the efficacy and reliability of the novel polymer oil filter, making it a compelling choice for industries in need of superior oil filtration solutions.

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