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MOISTURE RESISTANT AIR FILTER FOR AUTOMOBILE

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Abstract - *Humidity infiltration into air pollutants poses a significant challenge, negatively impacting combustion effectiveness, energy frugality, and overall machine continuity. Our proposed result employs state- of- the- art accoutrements and a unique design to repel humidity, icing sustained filtration effectiveness indeed in sticky conditions. The sludge's composition includes hydrophobic accoutrements and strategic walls, precluding water intrusion into critical filtration rudiments. Laboratory testing and real- world simulations confirm the superior performance of our humidity- resistant air sludge, showcasing its capability to outperform conventional pollutants under different environmental conditions. Beyond securing against humidity- related issues, our result contributes to bettered air quality within the combustion chamber. By enhancing machine effectiveness and reducing conservation costs, this invention holds the implicit to revise automotive air filtration technology, offering a more dependable and durable result for the challenges posed by humidity in the vehicular terrain. The perpetration of similar advanced pollutants stands to significantly elevate vehicle performance, life, and environmental sustainability in the automotive assiduity.*

***Key Words*: Humidity infiltration, air pollutants, combustion effectiveness, energy frugality, machine continuity**

1.INTRODUCTION

In the realm of automotive engineering, the effective functioning of internal combustion machines is vital to vehicle performance, energy frugality, and overall continuity. Still, one patient challenge that has garnered adding attention is the mischievous impact of humidity infiltration into air pollutants. The intrusion of moisture into these pivotal factors poses a significant trouble to combustion effectiveness, energy economy, and the sustained durability of common machine operations. Feting the urgency of addressing this issue, our exploration delves into the development and evaluation of a humidity-Resistant Air Filter expressly designed for motorcars. This paper explores a pioneering result that leverages slice- edge accoutrements and a technical design to repel humidity, icing sustained filtration effectiveness indeed in adverse and sticky conditions. Through comprehensive laboratory testing and real- world simulations, we check the performance of our proposed moisture- resistant air sludge, comparing its capabilities with conventional pollutants under different environmental circumstances. Beyond securing against moisture- related goods, the envisaged result contributes to bettered air quality within the combustion chamber. This exploration marks a vital stride toward advancing automotive air filtration technology, offering a more reliable and durable result to the challenges posed by moisture in the vehicular terrain. The counteraccusations extend beyond bare technological invention, holding the eventuality to elevate machine interpretation, extend functional life, and foster enhanced environmental sustainability within the automotive assiduity.

Packaging involves optimum operation of space in machine. But this isn't always compatible with the asked performance. To sustain high performance from machines, clean air inflow plays a vital part, which is necessary for combustion in machine. This is handed by Air sludge system. The air supplied to combustion chamber thru air induction system contains colorful substances of atmosphere. This may damage the machine corridor similar as piston or cylinder. The part of air sludge is to filter out the air containing foreign substances and to reduce the air inflow rate in the air sludge, so that the noise generated by input system can be reduced. The air induction system consists of following:

1) An air input conduit, where dirty air enters.

2) Case pre sludge, where dirt gets accumulated

3) Air sludge, where dirty air gets filtered

4) Case post sludge, which accumulates the filtered air

5) Resonator, it helps in making machine paradoxically quieter and important.

6) Air outlet conduit, which supplies clean air to machine

The air introduced into the air induction system is smelled into the case through the sludge and also transferred to the machine. It's important that the air that passes thru the sludge should be slightly distributed. Optimum operation of sludge element can reduce the cost of sludge relief constantly and thus keep the sludge in operation for longer time. The Air induction system figure plays a huge part in understanding the quality of air inflow. When the diffuser smells air in, the shape of the diffuser and the inflow around it affects the machine's performance. This is due to the large quantum of air gathering characteristics. Reduction in energy consumption results in reducing the pressure losses in the air induction system. The asked air induction system should have high airflows while keeping the minimal pressure losses. To optimize air induction system, thorough understanding of overflows and pressure drop through the system is essential. To prognosticate the inflow as well as trials performed in inflow equipages are prognosticated with the help of numerous tools. One of the significant tools to prognosticate the same is CFD (computational inflow dynamics) analysis. CFD is the most effective result for inflow analysis of complete air induction system. Then we're fastening on the review of air sludge performances criteria for its optimum operation in the motorcycle operation

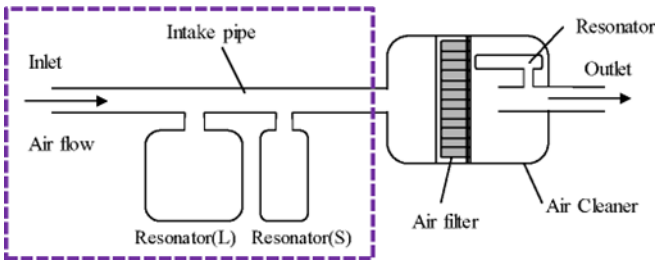


Fig -1: Simple Structural diagram of an intake system

1.1 Type of filter

Air filters are mainly classified on basic of following 2 categories:

1.2 Based on geometric Shape:

1.Rectangular

2.Circular

3.Polygon

1.3 Based on Material Used:

i. Foam Air filter.

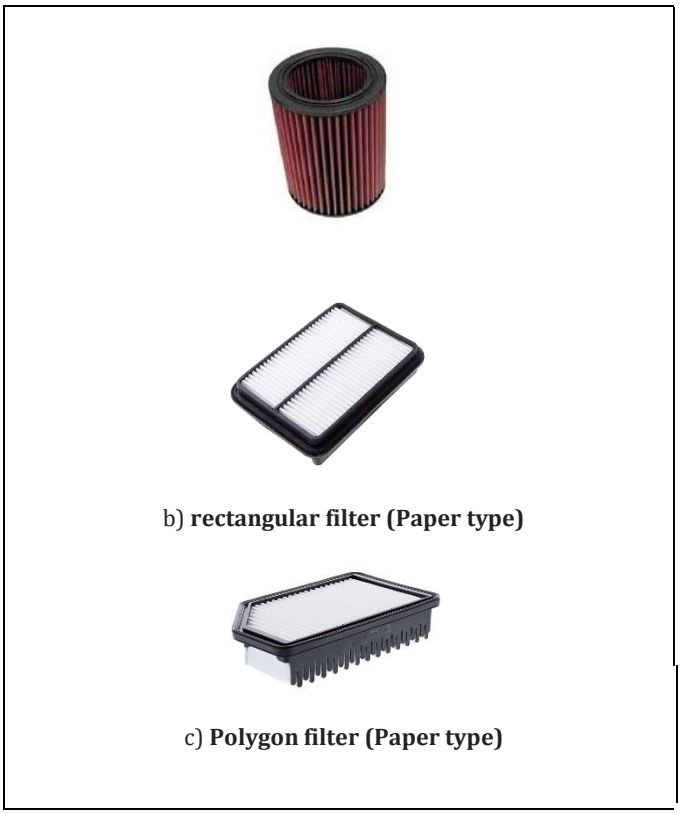
In the dusty dawn of automotive history, before paper dared to breathe, reigned the mighty foam filter. Dense and defiant, it stood guard against the cavalry of grit and grime, a silent shield for the engine's delicate heart. Today, it still whispers its valiant ballad in the throaty roar of dirt bikes, their tires churning battlefields of clay and gravel. Costlier than its papery kin, yes, but a loyal squire, ever ready for a bath and another round. And for those who dance with the dustiest devils, oiled variants stand, sticky knights armed against the finest, most nefarious particles. So, when the wind whips sand across your face and your engine purrs a song of gratitude, remember the unsung hero, the foam filter, forever etched in the annals of automotive grit.

ii. Paper Air filter

Paper filters, the Robin Hoods of air filtration. They snatch dust from the rich (engine air intakes) and give it to the poor (garbage can), all while keeping your wallet fatter than Robin's quiver. These simple heroes are the go-to for single-cylinder workhorses, chugging happily along highways and city streets. A mere breath of pressurized air is their elixir, reviving them for another dusty duel. Sure, they're not Lancelot when mud monsters attack, but for everyday knights on commuter steeds, paper filters are a trusty squire. So, when you zip past on your trusty two-wheeler, remember the quiet guardian whispering "breathe easy" – the paper filter, champion of clean lungs and fat wallets.

iii. Cotton Air filter

Cotton air filters rule the high-performance roost. Crafted from the whisper of angels' wings (okay, cotton plants), these bad boys don't just block crud, they choreograph the air's waltz into your engine's soul. Dust dances aside, a mere fly before the tornado these filters unleash. Cotton's the maestro, conducting every microsecond of air into a symphony of untamed horsepower.



b) **rectangular filter (Paper type)**

c) **Polygon filter (Paper type)**

Fig -2: Type of filter

2.Literature Review

K.L. Srinivasulu outlines a study focused on enhancing the design and performance of an air filter through the utilization of Computational Fluid Dynamics (CFD) analysis. To optimize the flow characteristics within the Air Intake System (AIS), a strategic decision was made to implement a rectangular type of filter. Additionally, modifications were introduced to the placement of baffles within the inlet plenum of the filter. The outcomes of the analysis clearly indicated a substantial pressure drop in conjunction with a prominent recirculation zone. Recognizing the need to mitigate the high pressure drop inherent in the existing filter design, the introduction of baffle plates in various positions was proposed. These modifications aimed to achieve a notable reduction in pressure drop, with the analysis indicating an improvement of up to 14%. [1]

In his paper, Hoseop Song delves into the optimization of diffuser shape for improved engine efficiency. The investigation involved assessing the flow characteristics, flow noise, and pressure drop of a standard air cleaner without any alterations to its shape. Finite Element Analysis was employed for this purpose. The analysis revealed that the air introduced through the inlet follows a rotational path along the wall of the upper box, passing through the filter and displaying a specific shape as it is drawn through the diffuser. The study assumed the flow within the air cleaner to be an incompressible perfect turbulent flow. The analysis utilized the widely adopted k-ε realizable model for simulating turbulent flow, ensuring stability and accuracy in the results. [2]

In his research paper, M. R. Chopade details the efforts to enhance the performance of an air filter through the optimization of the Air Intake System (AIS) design. The focus of the study revolves around reducing the pressure drop across the filter by implementing an eccentric design for the housing. Here, the casing, serving as a cylindrical element, safeguards the filter and the housing while creating an annular space to facilitate the movement of air. [3]

Chang Ming Tsang conducted a thorough investigation in his thesis, examining the various factors that impact pressure drop and flow patterns across pleated air filters through a numerical study. Utilizing FLUENT and numerical analysis, the research delved into the influences of air velocity, geometry, and the shape of filter pleats on the filter's pressure drop. The study provided insights into the intricate relationship between these factors, contributing to a comprehensive understanding of pleated air filter performance. [4]

3. Description and Main function of AIS

Following are the functions of AIS: -

1. The system starts by drawing air from outside the vehicle, usually through an opening in the front grille or bumper. This ensures access to fresh, unheated air.
2. Before entering the engine, the air passes through an air filter to remove dust, debris, and other contaminants that could damage the engine.
3. Depending on the engine, the air intake system may have sensors that measure the volume and temperature of the incoming air. This information is used by the engine computer to optimize the fuel mixture for efficient combustion.
4. The amount of air entering the engine is controlled by a throttle body or butterfly valve. This valve opens and closes in response to the driver's accelerator pedal, regulating the speed and power output of the engine.
5. The filtered and measured air is delivered to the engine's intake manifold, where it is mixed with fuel and then sent to the cylinders for combustion.

To induce the power to crankshaft; the combustion chamber of machine needs air as well as energy. The air is guided by AIS to the combustion chamber. Depends upon the type of vehicle; the position of AIS is defined. The quantum of air demanded in the combustion chamber depends on numerous factors but substantially it depends on the speed and acceleration of the machine. When the vehicle accelerates from low to high rpm; the energy consumption is high. And thus, the quantum of air (or

oxygen) demanded inside the combustion chamber is also high. The quantum of air is substantially controlled by ECU in the machines. The alternate purpose of AIS is drawing of the incoming air from patches like beach, leaves etc. This is done by using air sludge inside the sludge box. The standard demand of air sludge filtration is approximately. 99.8 of the incoming air. Air sludge also helps in reducing the noise from the machine. A conception image of AIS is shown below for understanding point of view where air haste is denoted by U_{∞}. In factual operation, the design and layout may differ.

4.Problem caused in engine due to moisture in air

The major problem to engine due to moisture in engine via air which the decreases performance and efficiency of engine are:

a. Corrosion: Exposure to moisture can lead to the development of rust on crucial metal surfaces within the engine, including the engine block, cylinder walls, pistons, and other internal components. This corrosion has the potential to compromise the structural integrity of these parts, impacting their proper functioning.
b. Fuel System Challenges: The presence of moisture in the fuel system can result in issues related to fuel quality and combustion. Water entering the fuel can cause poor engine performance, misfires, and difficulties in starting the engine. In severe cases, it may even cause damage to fuel injectors and other components in the fuel delivery system.
c. Electrical Complications: Moisture and electricity are a problematic combination. When moisture infiltrates electrical components such as sensors, spark plugs, and ignition coils, it can lead to malfunctions. This, in turn, can result in suboptimal engine performance, reduced fuel efficiency, and the potential for engine misfires.
d. Air Intake Challenges: If moisture manages to enter the air intake system, it can disrupt the air-fuel mixture and the combustion process. This disruption may manifest as reduced engine power, hesitation during operation, and poor fuel efficiency.
e. Oil Contamination: Moisture present in the engine can mix with the oil, diminishing its effectiveness in lubricating and safeguarding engine components. This situation can escalate friction, accelerate wear and tear, and pose a risk of damage to internal parts.
f. Exhaust System Issues: Moisture within the exhaust system can initiate rust and corrosion, particularly in components like the muffler and exhaust pipes. This corrosion can lead to exhaust leaks and undermine the efficiency of the catalytic converter.

5. Performance and Efficiency of engine due to moisture

A. Performance Downgrade:

Powerless Punch: Imagine replacing oxygen, the combustion cheerleader, with moisture, the party pooper. That's what happens when humidity rises. The air-fuel mixture becomes leaner, resulting in incomplete combustion and a noticeable decrease in power. You might feel that sluggish, "won't-get-out-of-its-own-way" feeling as your engine struggles to muster its usual muscle.

Ignition Hiccups: Think of moisture as a wet blanket smothering the spark plugs. It takes much more effort to ignite the air-fuel mixture, leading to hesitation, stuttering, and even stalling, especially during cold starts.

Efficiency Impasse: Incomplete combustion doesn't just sap your engine's strength; it also guzzles more fuel to achieve the same output. Imagine pushing that stalled car – energy wasted! This translates to a noticeable drop in fuel efficiency, making your wallet lighter faster.

Fuel Inefficiency: Picture a scenario where oxygen, the crucial partner in fuel combustion, is replaced by moisture, the efficiency dampener. As humidity levels rise, the air-fuel mixture becomes leaner, compelling the engine to exert more effort to achieve the same power output. This results in elevated fuel consumption, reducing your travel range and leaving your wallet lighter.

Challenges of Incomplete Combustion: Envision moisture as a dampening cover smothering the flames of combustion. Incomplete burning, caused by water vapor, leads to the wastage of energy potential. The energy that could have propelled your vehicle forward is lost as unburnt hydrocarbons, causing the engine to work harder for meager gains in mileage.

Sensor Confusion: Moisture not only disrupts the fuel combustion process but also throws the sensor system into confusion. Intake air sensors, acting as the engine's eyes and ears, become befuddled by the increased water vapor. This confusion leads to miscalculations and improper adjustments by the engine control unit, further compromising efficiency as the engine operates under suboptimal conditions.

Icy Challenges: In colder climates, moisture transforms into another adversary of efficiency – ice. It can accumulate inside the intake system, restricting airflow and compelling the engine to exert more effort to draw in air. This extra effort burns additional fuel, leaving you with a colder engine and a heftier fuel bill.

The Complexity of Efficiency Impact: The effect of moisture on efficiency is a multifaceted equation with several factors at play. While a slight increase in humidity

may have minimal effects, elevated humidity levels can significantly reduce fuel economy by 5-10%. This impact may be even more pronounced in older engines or those with poorly maintained air filters.

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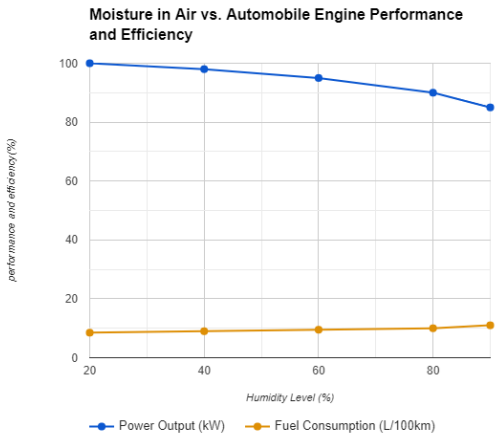

Chart -1: Moisture in air V/S performance and efficiency.

6. Modification in design of Air filter

While the frame remains unchanged, a significant innovation lies within this new air filter: glass fiber. This material boasts a powerful hydrophobic property, acting as a formidable shield against moisture in the air. Think of it as an invisible raincoat for the engine, repelling any water droplets or moisture encountered as air flows through. This is crucial, as excess moisture can damage sensitive engine components and hinder performance.

The science behind its effectiveness lies in its **hydrophobicity**. Unlike traditional air filter materials, glass fiber naturally repels water, creating a barrier against moisture ingress. This ensures that the air filter maintains its primary function of capturing dust and pollutants while simultaneously keeping moisture out, ultimately delivering clean air to the engine for optimal performance. Furthermore, the durability of glass fiber extends the lifespan of the air filter, offering long-lasting protection against moisture, wear, and tear.

Beyond its moisture-repelling properties, glass fiber boasts several additional benefits relevant to air filtration:

- **High Filtration Efficiency:** While effectively repelling moisture, glass fiber retains its primary function of capturing airborne contaminants, including dust, pollen, and other particulates. This ensures clean air reaches the engine, optimizing performance and fuel efficiency.
- **Durability:** Compared to traditional materials, glass fiber exhibits superior **mechanical strength and resilience**. This translates to longer filter lifespan, reduced maintenance requirements, and cost-effectiveness.
- **Reduced Environmental Impact:** Glass fiber offers a **sustainable alternative** to traditional materials, as it is recyclable and requires less energy to produce.

Fig -3: Air filter made by using glass fibre

7. CONCLUSIONS

In conclusion, the development and implementation of a moisture-repellent air filter presents significant advantages in maintaining engine efficiency and overall vehicle performance. By incorporating hydrophobic treatments, open structure designs, and other moisture-resistant features, such air filters aim to counter the detrimental effects of moisture on the engine system.

A. levated Engine Efficiency:

The deployment of moisture-repellent air filters plays a pivotal role in advancing engine efficiency. By thwarting the adverse effects of water vapor on the combustion process, these filters ensure a consistent and optimal air-fuel mixture. This, in turn, empowers the engine to operate with enhanced efficiency, translating into an overall improvement in vehicle performance.

B. Diminished Fuel Consumption:

A noteworthy advantage of moisture-repellent air filters lies in their ability to minimize the impact of moisture on combustion and engine components, leading to reduced fuel consumption. This reduction is instrumental in maintaining fuel economy, allowing vehicles equipped with such filters to cover more distance per unit of fuel. This not only benefits the environment by lowering carbon emissions but also proves economically advantageous for vehicle owners.

C. Prolonged Engine Lifespan:

The prevention of corrosion and damage caused by moisture is a key attribute of moisture-repellent air filters.

These filters serve as a formidable defense against rust and corrosion, safeguarding critical engine components. Consequently, the extended protection contributes significantly to the longevity of the engine, mitigating the need for premature maintenance or costly replacements.

D. Optimized Sensor Functionality:

Moisture interference with the proper functioning of sensors within the engine control system is a common challenge. Moisture-repellent air filters address this issue by effectively repelling moisture, thereby preserving the accuracy of readings and calculations made by sensors. This ensures that the engine control unit can make precise adjustments, optimizing overall engine performance.

E. Versatility Across Various Climates:

The adaptability of moisture-repellent air filters shines in diverse climatic conditions. Whether facing high humidity, rain, or colder temperatures leading to ice formation, these filters offer a versatile solution. They maintain consistent airflow and engine performance, ensuring reliability and efficiency across a spectrum of environmental challenges.

In essence, the incorporation of moisture-repellent features in air filters represents a proactive and transformative strategy to counteract the adverse effects of moisture on internal combustion engines. Vehicles equipped with these advanced filters stand to gain not only in terms of immediate performance improvements but also through sustained benefits such as prolonged engine life and reduced environmental impact. The investment in such innovative filtration technology underscores a commitment to optimal vehicle functionality in diverse operating conditions. As automotive technology continues to evolve, moisture-repellent air filters emerge as a crucial component in the pursuit of efficiency, sustainability, and the prolonged health of internal combustion engines.

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