MECHSTREAK

TECHNICAL MAGAZINE OF THE DEPARTMENT OF MECHANICAL ENGINEERING

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- TECHNICAL ARTICLES
- INDUSTRY 4.0 & SMART MANUFACTURING
- STUDENT PROJECTS & INNOVATIONS
- DEPARTMENT HIGHLIGHTS – 2024

Focus on Excellence

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Dear Readers,

It is with immense pleasure that we present MECH STREAK – Volume 5, a celebration of innovation, creativity, and the ever-evolving spirit of mechanical engineering. This edition brings together thought-provoking articles on emerging technologies, sustainable engineering, advanced manufacturing, tribology, hydrogen-powered engines, turbine flow, Formula 1 tire dynamics, and many other fascinating developments shaping the future of engineering.

More than a collection of technical articles, MECH STREAK reflects the curiosity, dedication, and innovative mindset of aspiring engineers. We hope these pages inspire you to think beyond the classroom, embrace new ideas, and contribute to engineering solutions that create a better and more sustainable world.

We extend our heartfelt gratitude to all the authors, reviewers, designers, and the editorial team whose commitment and hard work made this publication possible.

May MECH STREAK – Volume 5 ignite your passion for learning, innovation, and excellence.

Happy Reading!

HoD's NOTE

Dr. Sumanalal MR
Professor

It gives me immense pleasure to present this edition of MECHSTREAK, the technical magazine of the Department of Mechanical Engineering, FISAT, Angamaly.

MECHSTREAK reflects the enthusiasm, creativity, and technical excellence of our students and faculty. It serves as a vibrant platform for sharing innovative ideas, research insights, technical articles, and emerging developments in the field of Mechanical Engineering, highlighting the department's commitment to academic excellence and technological advancement.

As FISAT continues its journey as an autonomous institution, the Department of Mechanical Engineering remains dedicated to nurturing competent engineers through quality education, industry-oriented learning, interdisciplinary collaboration, research, and innovation. This magazine is a testament to the intellectual curiosity and collaborative spirit that define our department.

I sincerely congratulate the editorial team, faculty coordinator, and all the student contributors whose dedication and hard work have made this edition possible. Their efforts deserve appreciation and recognition.

I hope this edition of MECHSTREAK motivates our students to explore new ideas, embrace innovation, and contribute meaningfully to engineering and society. I extend my heartfelt best wishes to the entire Mechanical Engineering fraternity at FISAT for continued growth, success, and excellence in all future endeavors.

Dr. Sumanalal MR
Head of the Department
Department of Mechanical Engineering
FISAT, Angamaly

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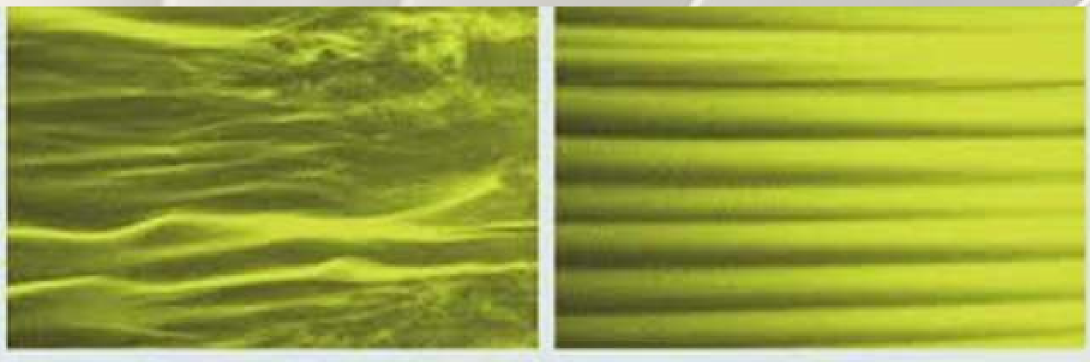
The Hidden Role of Surface Roughness in Turbine Flow Transition



Surface finish plays a critical role in the aerodynamic performance of gas turbine engine components. These surfaces are typically designed to be aerodynamically smooth to minimize losses and ensure efficient operation. However, during service, erosion, fouling, and wear progressively increase surface roughness, leading to higher fuel consumption, localized temperature rise, and in extreme cases, reduced stall margin. Despite these consequences, surface roughness effects are often underestimated during the design stage.

While extensive research exists on roughness effects in fully turbulent flows, the influence of roughness on laminar-to-turbulent transition has received limited attention. Advanced simulation-based research has explored how surface roughness alters subsonic boundary layer behaviour in typical turbomachinery environments.

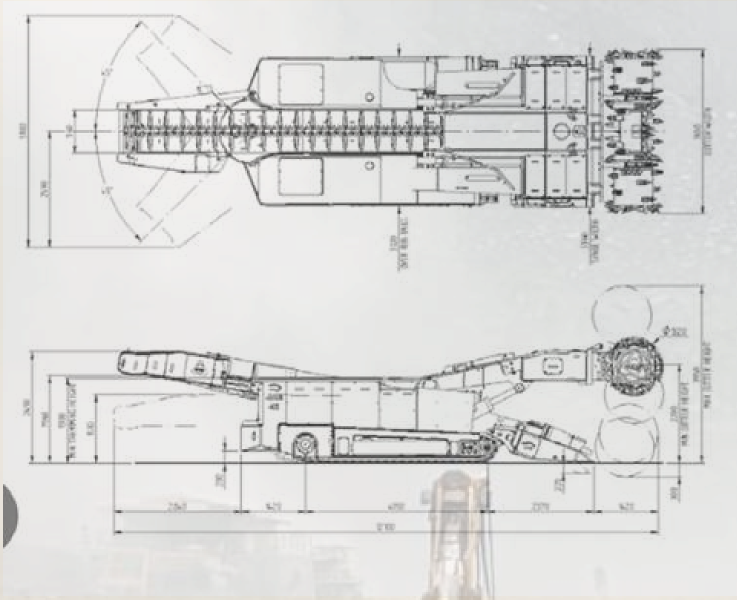
To isolate fundamental mechanisms, these studies often consider simplified configurations such as flow over a flat plate with distributed roughness elements, analysed using high-fidelity eddy-resolving numerical simulations.

The findings show that roughness elements within the boundary layer generate elevated shear layers and alternating high- and low-speed streaks. Secondary instabilities in these streaks destabilize the flow, triggering transition to turbulence. As roughness height increases, the dominant transition mechanism changes. Roughness elements protruding beyond the boundary layer produce turbulent wakes, causing rapid transition through vortex shedding. These insights highlight the importance of accounting for surface roughness and transition behaviour in gas turbine aerodynamic design.

ADWAITH MOHAN
S4 ME A

Vibration Control in Continuous Mining Machines

Continuous miners are widely used in underground coal and mineral extraction, especially in regions such as the United States and Australia. These machines are designed to achieve high productivity within strict geometric constraints, a requirement that has become more critical as modern mining increasingly targets thin coal seams and remnant deposits. A continuous miner typically consists of a heavy tracked chassis, a front-mounted loading table, a scraper conveyor, and a boom carrying a cylindrical or drum-type milling head that cuts the entire width of the heading.



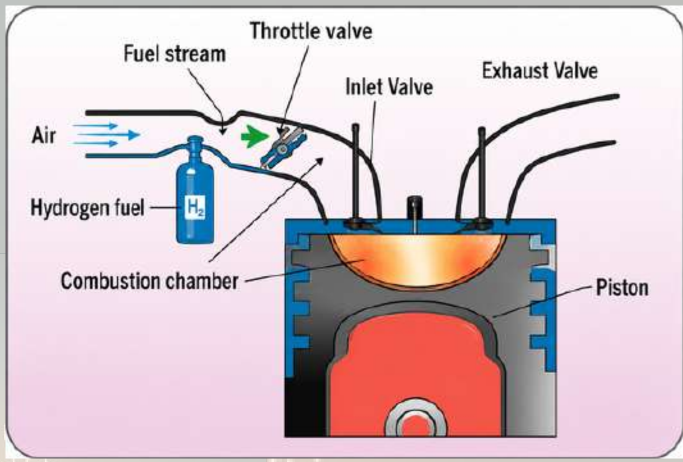
Recent technical developments focus on improving the cutter drum powertrain system. A novel approach involves integrating permanent magnet motors directly inside the cutting drum. This configuration enhances dynamic performance, enables modular design based on operating conditions, and reduces mechanical complexity. However, dynamic analysis of the mining process has revealed significant vibration issues, primarily caused by resonance frequencies within the machine structure. These vibrations accelerate wear and reduce machine service life.

Earlier solutions aimed at avoiding resonance through structural modifications and optimized mode shapes. More recent concepts emphasize active vibration control by regulating the angular velocity of the cutter drum and, if required, the boom. Smooth speed variation offers a promising method to suppress resonance-induced vibrations without compromising cutting efficiency. Overall, these advancements represent a shift toward smarter, more durable continuous mining machines suited to modern underground mining challenges.

CHRISTO PAUL BOBBY
S4 ME A

Hydrogen-Fueled Internal Combustion Engines

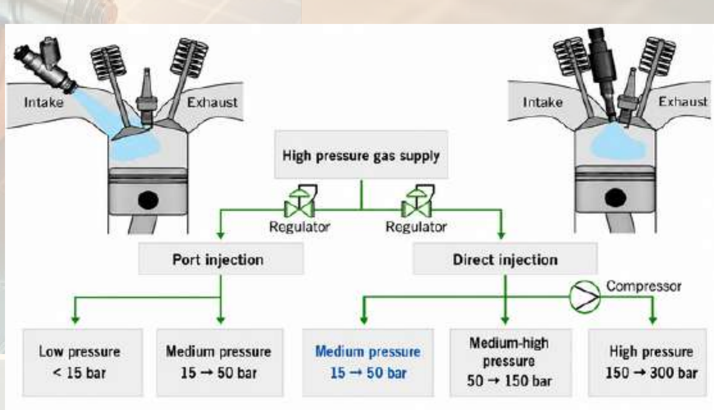
Hydrogen-fueled internal combustion engines are gaining attention as a practical pathway toward low-carbon mobility. By replacing conventional fossil fuels with hydrogen, these engines can operate with near-zero carbon dioxide emissions, as the primary combustion product is water vapor. A key advantage of hydrogen IC engines is their compatibility with existing engine platforms, allowing manufacturers to adapt current designs rather than develop entirely new propulsion systems.



From a mechanical engineering perspective, hydrogen IC engines benefit from robust durability, fast refueling, and simpler system architecture compared to fuel cells.

Hydrogen has favourable combustion characteristics, including a high flame speed and wide flammability range, which enable stable lean-burn operation and improved thermal efficiency. These properties make hydrogen particularly suitable for high-load and heavy-duty applications. However, several technical challenges must be addressed. Hydrogen's low ignition energy can lead to pre-ignition and backfiring, while high combustion temperatures may increase nitrogen oxide emissions.

Advanced fuel injection strategies, precise air-fuel ratio control, and optimized combustion chamber geometries are essential to mitigate these issues.

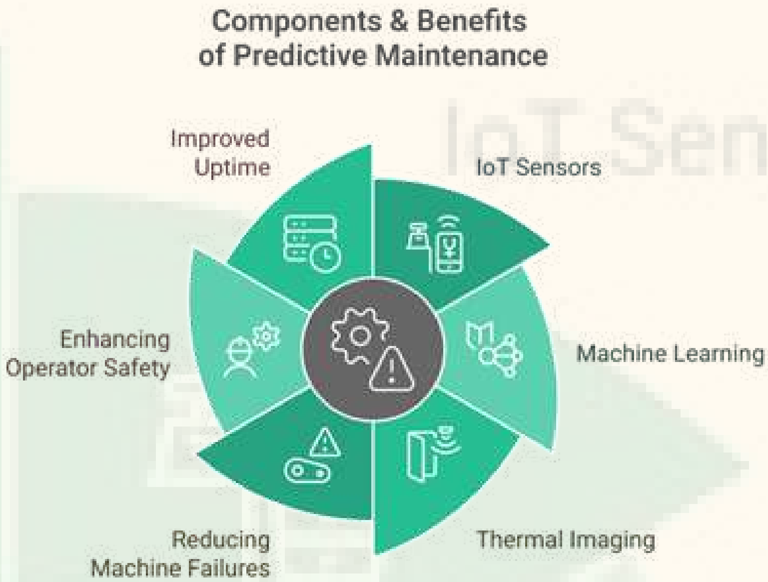


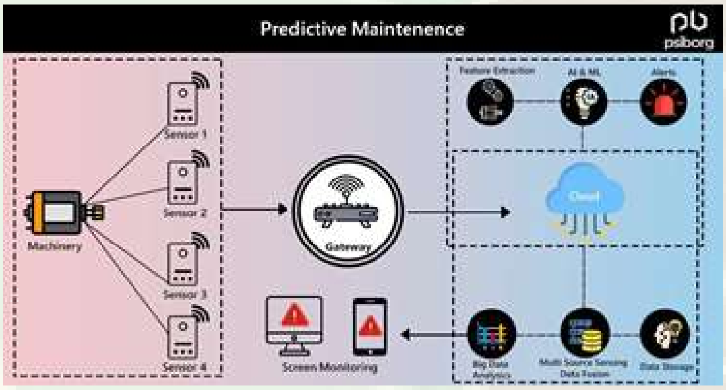
They are especially attractive for trucks, buses, and industrial machinery. Although not a complete replacement for electric powertrains, hydrogen-fueled IC engines offer a realistic transitional solution toward cleaner energy systems.

RAHUL R SANKAR
S4 ME B

Predictive Maintenance Using Mechanical Data

Predictive maintenance is transforming the way mechanical systems are monitored and maintained across industries. Unlike traditional maintenance strategies that rely on fixed schedules or reactive repairs, predictive maintenance uses real-time mechanical data to assess the actual condition of equipment and predict potential failures before they occur. This approach improves reliability while reducing downtime and maintenance costs.





Mechanical data such as vibration signatures, temperature variations, acoustic emissions, and rotational speed provide valuable insights into machine health. Changes in vibration patterns can indicate bearing wear, shaft misalignment, or imbalance, while abnormal temperature trends may signal lubrication failure or excessive friction. By continuously analyzing these parameters, early-stage faults can be detected well before they lead to catastrophic breakdowns.

Modern predictive maintenance systems combine sensors with data analytics and machine learning algorithms. These tools identify patterns, track degradation trends, and estimate the remaining useful life of components. In rotating machinery like pumps, turbines, and gearboxes, predictive maintenance has proven especially effective.

From a mechanical engineering perspective, predictive maintenance enhances equipment availability, extends service life, and improves safety. As industries move toward smart manufacturing and Industry 4.0, the integration of mechanical data-driven maintenance strategies is becoming essential for efficient and sustainable operations.

NIKHIL RAJEEV
S4 ME B

Sustainable Manufacturing Processes

Sustainable manufacturing processes focus on producing goods while minimizing environmental impact and conserving resources. Industries are increasingly shifting from traditional high-waste methods to cleaner, more efficient production systems that balance economic growth with environmental responsibility. This approach integrates energy efficiency, material optimization, and waste reduction at every stage of manufacturing

One key aspect of sustainable manufacturing is the use of advanced technologies such as automation, data-driven process control, and predictive maintenance. These technologies help reduce energy consumption, improve machine efficiency, and prevent material loss due to unexpected failures. Additive manufacturing also plays an important role by enabling near-net-shape production, which significantly reduces material waste compared to conventional machining processes.

Another important strategy is the adoption of eco-friendly materials and closed-loop systems.

Recycling scrap materials, reusing process water, and implementing circular economy principles help manufacturers reduce dependence on raw resources. Life cycle assessment is increasingly used to evaluate the environmental impact of products from raw material extraction to end-of-life disposal.

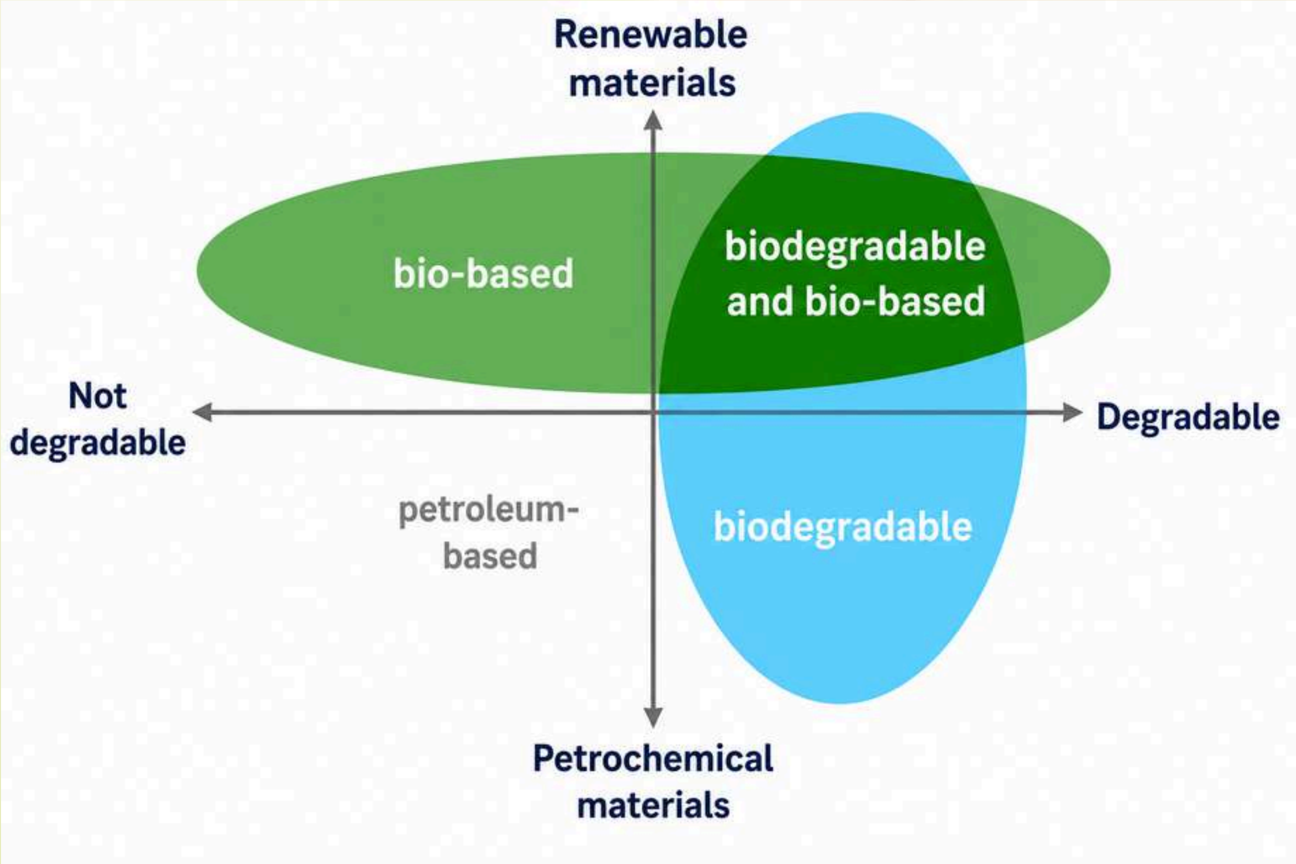
Sustainable manufacturing also improves workplace safety and long-term profitability. Lower energy usage, reduced waste disposal costs, and compliance with environmental regulations make industries more resilient and competitive. As global demand for environmentally responsible products grows, sustainable manufacturing is no longer optional but a critical pathway toward a cleaner and more efficient industrial future.

ASHIK BENNY
S6 ME A

Bio-Based and Biodegradable Engineering Materials

Bio-based and biodegradable engineering materials are gaining significant attention as industries seek sustainable alternatives to conventional petroleum-based materials. These materials are derived from renewable biological sources such as plants, agricultural waste, and natural fibres, making them environmentally friendly and resource efficient. In recent years their development has accelerated due to stricter environmental regulations and growing demand for sustainable products.

One major advantage of bio-based materials is their reduced carbon footprint. During their life cycle, they generate lower greenhouse gas emissions compared to traditional plastics and composites. Biodegradable polymers such as polylactic acid and polyhydroxyalkanoates are increasingly used in packaging, consumer products, and even selected automotive components. Natural fibre composites reinforced with jute, hemp, or flax are also being adopted for lightweight structural applications.

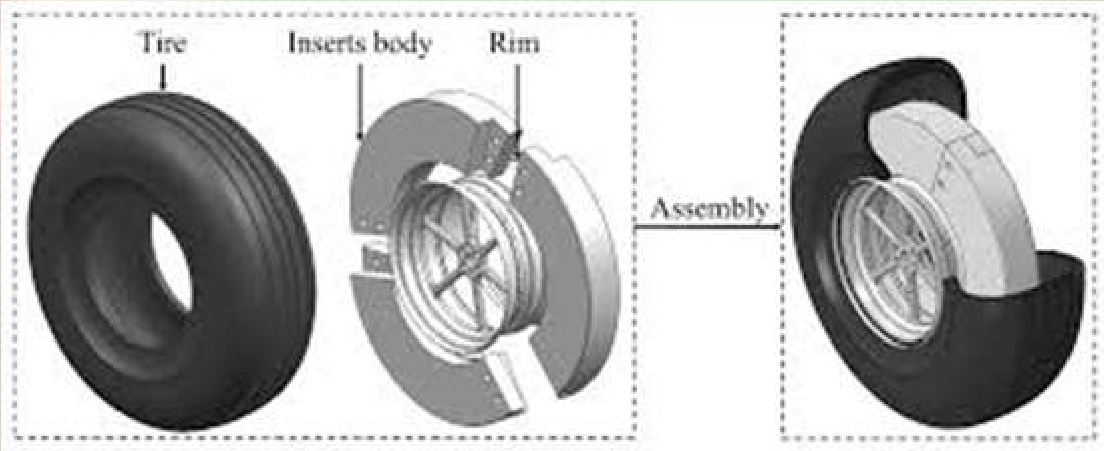


Despite their benefits, challenges remain in terms of mechanical strength, durability, and moisture resistance. Ongoing research focuses on improving material performance through surface treatments, hybrid composites, and advanced processing techniques. Additives and bio-resins are also being developed to enhance thermal stability and load-bearing capacity.

Bio-based and biodegradable engineering materials represent a crucial step toward sustainable manufacturing. With continuous innovation, they offer the potential to reduce environmental impact while meeting the functional requirements of modern engineering applications.

ANAND R NATH
S6 ME A

Mechanical Challenges of F-1 Tire Dynamics



Formula 1 tire dynamics present some of the most demanding mechanical challenges in motorsport. F-1 tires operate under extreme conditions, experiencing high speeds, heavy braking forces, rapid acceleration, and intense lateral loads during cornering. Managing these forces while maintaining grip and durability is critical to overall car performance.

One major challenge is temperature control. Tires must operate within a narrow temperature window to deliver optimal grip. Excessive heat leads to degradation and blistering, while low temperatures reduce traction. Mechanical factors such as suspension geometry, camber angles, and wheel alignment directly influence how heat is generated and distributed across the tire surface. Load variation is another key issue. During braking and cornering, vertical loads on the tires change rapidly, affecting contact patch size and grip consistency.

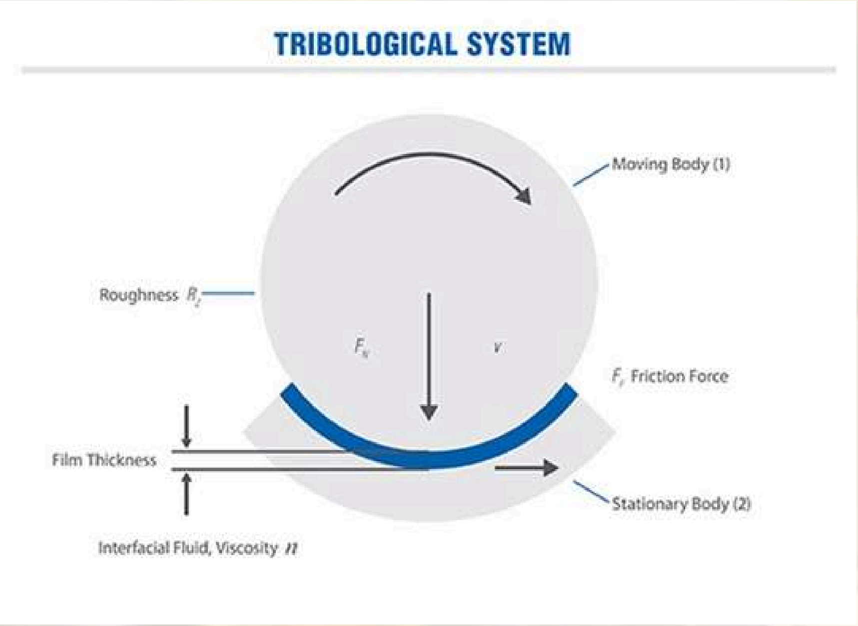
Engineers must carefully tune suspension stiffness and damping to maintain stable tire behavior without compromising responsiveness. Tire deformation under load also impacts rolling resistance and energy loss.

Wear and degradation further complicate tire dynamics. Mechanical abrasion, combined with thermal stress, alters rubber properties over a race distance. Drivers must adapt their driving style, while engineers analyze real-time data to manage tire life effectively.

In Formula 1, tire dynamics sit at the intersection of mechanics, materials, and vehicle dynamics. Mastering these challenges often determines race outcomes.

RICHARD ANTO VARGHESE
S6 ME B

Tribology in High-Speed Machinery



Tribology, the study of friction, wear, and lubrication, plays a critical role in the performance and reliability of high-speed machinery. Components such as bearings, gears, shafts, and seals operate at extremely high rotational speeds, where even small frictional losses can lead to excessive heat generation and premature failure. Effective tribological design is therefore essential for achieving efficiency and long service life.

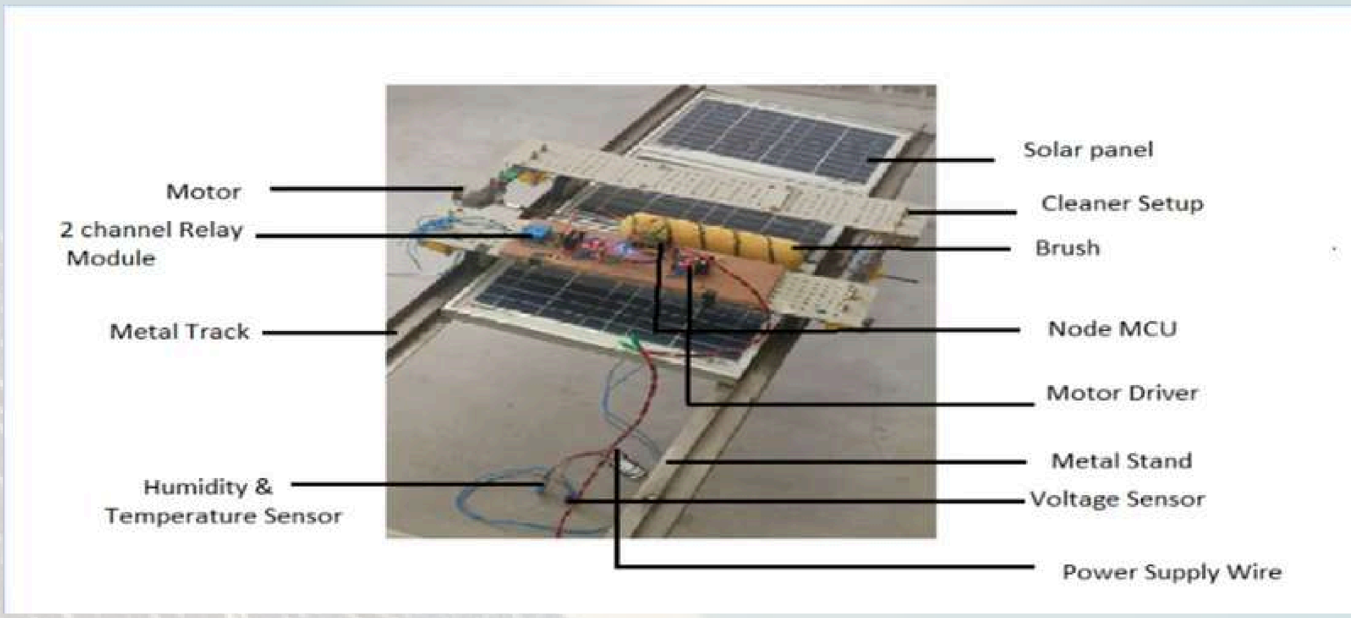
One major challenge in high-speed machinery is maintaining a stable lubrication film. At high speeds, lubricant behavior changes due to shear thinning, temperature rise, and centrifugal forces. Engineers must carefully select lubricants with suitable viscosity, thermal stability, and additives to ensure continuous separation between moving surfaces.

Advanced lubrication techniques such as hydrodynamic and elastohydrodynamic lubrication are commonly employed to reduce direct surface contact.Wear control is another key concern. High-speed contact increases the risk of surface fatigue, scuffing, and adhesive wear. Surface engineering methods like coatings, surface texturing, and material hardening are used to improve wear resistance and reduce friction. Precision manufacturing and tight tolerances also help minimize vibration and uneven loading.

In modern industries such as aerospace, automotive, and power generation, tribology directly influences efficiency and reliability. Proper tribological optimization enables high-speed machines to operate safely under extreme conditions.

ANAND SHIVAN
S8 ME A

Smart Self-Cleaning Solar Panel System with Dust Detection



Solar photovoltaic panels are an important renewable energy source, but their efficiency decreases due to dust accumulation, pollution, and environmental exposure. Regular manual cleaning increases maintenance cost and water usage.

This article proposes an innovative smart self-cleaning solar panel system that uses a dust detection sensor, automatic cleaning mechanism, and performance monitoring unit. A transparent sensor layer detects dust buildup by measuring changes in sunlight reaching the panel. When dust exceeds a limit, a low-power vibration system or motorized wiper automatically removes the dust without frequent human intervention.

A microcontroller monitors voltage, current, and power output to identify performance reduction and notify users through a monitoring system. The proposed technology improves energy generation, reduces maintenance effort, saves water, and increases the reliability of solar power systems.

Future improvements can include AI-based prediction of cleaning requirements using weather and pollution data, making solar installations more efficient and autonomous.

AALIYA M A
S4 ME A

Vision

To develop as a center of excellence in Mechanical Engineering, moulding competent engineers with social commitment, capable of undertaking technical responsibilities and innovative challenges.

Mission

M1: To build a strong foundation in Mechanical Engineering and allied areas.
M2: To mould students with good leadership qualities and nurture their entrepreneurship skills.
M3: To encourage the students for finding solutions to real engineering world problems.
M4: To provide a platform for professional development and lifelong learning along with awareness of social responsibilities.

Programme Educational Objective (PEO)

PEO 1: Graduates of the program will emerge as true professionals, capable of designing and analyzing products or processes based on engineering practices and scientific knowledge for the benefit of society.
PEO 2: Graduates of the program will be equipped to shape their career and will be able to take up challenges and find solutions to problems related to Mechanical Engineering or allied fields.
PEO 3: Graduates of the program will succeed in multicultural and multidisciplinary environment, imbibing the spirit of lifelong learning and societal commitment.

SAE FISAT IGNITING MINDS

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MECHFISAT