

Green Frontiers

Emerging Technologies for a Sustainable Future



Editors

Dr. Tanay Pramanik

Dr. Sayantan Sil



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Preface

In an age marked by rapid scientific progress and increasing global challenges, the integration of knowledge across disciplines has become essential for meaningful innovation and sustainable development. *Green Frontiers: Emerging Technologies for a Sustainable Future* is conceived as a comprehensive academic work that brings together diverse fields of study to present a unified perspective on contemporary scientific and technological advancements. The book seeks to highlight how evolving knowledge systems can address pressing environmental concerns, enhance technological capabilities, and contribute to the betterment of society.

The primary purpose of this volume is to provide a balanced understanding of both foundational concepts and emerging trends across multiple domains. It explores critical issues such as environmental degradation, renewable energy development, advanced materials, and intelligent systems, emphasizing their interconnected nature.

The scope of the book is intentionally broad, encompassing insights from environmental science, physics, engineering, biotechnology, and applied sciences. It reflects the growing need to move beyond isolated disciplinary frameworks and adopt integrated perspectives that foster innovation.

This volume is designed to serve as a valuable resource for students, researchers, and professionals alike. Students will find it particularly useful in building conceptual clarity and gaining exposure to emerging areas of study.

The relevance of *Green Frontiers: Emerging Technologies for a Sustainable Future* lies in its focus on the dynamic relationship between scientific advancement and societal needs. As the world faces challenges such as climate change, resource scarcity, and technological disruption, there is an increasing demand for knowledge that is both comprehensive and applicable. It is hoped that this work will encourage critical thinking, inspire innovation, and enable readers to contribute effectively to a sustainable and technologically advanced future.

— Editorial Board

Table of Contents

Chapters	Title	Page No.
1	Ozone Layer Depletion and its Socioeconomic Impacts <i>Debkanta Ruj, Nilakshi Bhaumik, Roudraparna Chowdhury, Aritra Maity, Ankita Debnath, Joy Ganguly, Sayantan Sil, Tanay Pramanik</i>	7
2	Piezoelectric Materials: The Future of Portable Power <i>Roney Ghosh, Rajdeep Bhandari, Samik Sarkar, Sayan Roy, Chandan Adhikari, Sayantan Sil, Tanay Pramanik</i>	21
3	Effects of Sunspot Activity on Earth's Conditions <i>Biswajit Chatterjee, Debankita Poddar, Gourab Ghosh, Ayush Dey, Devjeet Ghosh, Jayanta Ghosh, Sayantan Sil, Tanay Pramanik</i>	29
4	A Brief Review of Brain-Computer Interfaces and their Applications <i>Isha Roy, Monit Bhattacharjee, Shreyani Sarkar, Snehel Singha, Soumili Saha, Jayanta Ghosh, Sayantan Sil, Tanay Pramanik</i>	39
5	The Evolution of Solar Photovoltaics: A Strategic Review of Future Global Energy Trends <i>Souhardya Ghosh¹, Swarup Garai¹, Soujanya Barman¹, Binit Kumar Saha, Debojyoti Deb, Chandan Adhikari, Sayantan Sil, Tanay Pramanik</i>	54
6	Water Pollution: A Review of Cause and Solution <i>Achintya jyoti, Soham Das, Sagnik Ghosh, Dibyangshu Ghosh, Satwik Mukherjee, Reshmi Bose, Sayantan Sil, Tanay Pramanik</i>	65
7	A Brief Review on Biomimicry: Giant Clams for Next-Generation Clean Energy Solutions <i>Devansh Ganguly, Koustav Ghosh, Kousambi Ghosh, Anish Ghosh, Hirak Kanti Dutta, Tamanna Pradhan, Subrata Dolui, Sayantan Sil, Tanay Pramanik</i>	78
8	Hydroponics-The Current and Future Scenario in the Art of Farming <i>Debarun Saha, Hood Rasool, Harshit Choudhary, Jiniya Sarkar, Bipasha Munshi, Sonia Kundu, Sayantan Sil, Tanay Pramanik</i>	85

9	Shaking Up Road Safety: Harnessing Non-Newtonian Fluid as Speed Breaker <i>Nilanjan Saha, Priyanshu Ghosh, Roshan Sarraf, Oishi Saha, Mou Das, Sayantan Sil, Tanay Pramanik</i>	98
10	Hybrid Engines: A Step Towards the Future of Cars <i>Soham Mukherjee, Praanit Chakraborty, Shankha Subhra Nag, Chandan Mondal, Rishav Goswami, Sayantan Sil, Tanay Pramanik</i>	106

“Innovation and sustainability are not opposites—they are partners in shaping the future.”

— Paul Polman

Former CEO, Unilever; Sustainability Leader

CHAPTER 9

SHAKING UP ROAD SAFETY: HARNESSING NON- NEWTONIAN FLUID AS SPEED BREAKER

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Abstract

The review article deals with the modern-day application of non-Newtonian fluids as an innovative solution for taking road safety to the next level. Originally speed breakers were built with the help of solid materials, but this approach certainly had some limitations. Non-Newtonian fluids manifest unique behavioral patterns that can be harnessed to construct dynamic and effective speed-reduction techniques. By studying the science and logic behind non-Newtonian fluids, their real-life applications, and their materialistic properties, this article hunts through the capabilities of non-Newtonian fluids to change the run-of-the-mill way we approach road safety and traffic management. We discuss the challenges, advantages, and future possibilities of utilizing non-Newtonian fluids as speed breakers to enhance the quality of life we spend while driving.

Keywords:

Non-Newtonian Fluids, viscosity, shearing stress, speed breakers, road safety

Introduction

In our quest to upgrade road safety and minimize the risks related to speeding vehicles, we have relied on conventional methods for a very long time. These methods, though reliable, often have a set of drawbacks involved. It includes wear and tear on the vehicle tires, passenger discomfort, and noise pollution. As we move forward in our hunt to catch up with something more efficient and innovative

solutions, the world of materials sciences has opened a fascinating path for dealing with these issues: using non-Newtonian fluids as speed breakers.

In this world exists a category of fluids that defy the platitudinous rules of fluid dynamics. These fluids master their own will, challenges the statement of Sir Isaac Newton's law of viscosity. The viscosity of these fluids can change when it is subjected to a huge amount of shearing stress. This unique property makes them the best choice for its use in traffic management.

In this review article, we tend to dive into the exciting and unrealistic world of non-Newtonian fluids as speed breakers, traversing our way to explore the science behind these magical substances and their potential applications in the field of road transportation. By looking into the advantages, challenges, and speed-reduction mechanisms, we tend to focus on a concept that can change the way to enhance road safety. As we proceed forward in this journey, we intend to keep producing some promising facts which will surely increase your faith in non-Newtonian fluids as speed breakers.

Review of Literature

A) Study

1) Basics of a conventional speed-breaker:

Speed breakers are elevated road surfaces designed in a unique fashion such as to slow down vehicles as they pass over them. Ideally, breakers were designed to satisfy the following requirements:

- i) It must not harm the vehicle or cause any damage to the tires of the vehicle and should not be the cause of discomfort for the driver as well as the individual sitting inside the vehicle.
- ii) To keep the pedestrians safe and ensure a smooth traffic flow.

2) Types of Speed Breakers:

- i) **Speed Hump:** Speed hump, is an upraised traffic-controlling device placed on roads to slow down the speed of approaching vehicles. They are usually made of asphalt, concrete, or any other material that is durable. They are designed

to force drivers to slow down as they approach the hump and then proceed at a reduced speed over it.



Figure 1: Speed Hump [1]

- ii) **Speed Bump:** A speed bump is an elevated traffic-controlling device that is placed on roads to slow down vehicles. Made up of concrete, asphalt, or any other durable material, speed bump forces a driver to come to a complete stop or pass over it with minimal speed.



Figure 2: Speed Bump [2]

3) The design of conventional Speed Breakers:

- i) **Length:** Generally, speed breakers length ranges from 10 to 14 feet (3 to 4.3 meters)
- ii) **Width:** The width of a speed breaker ranges between 12 to 14 feet (3.7 to 4.3 meters).
- iii) **Height:** The height of a standard speed breaker can vary from 3 to 4 inches (7.6 to 10.2 centimeters). A typical speed hump height is 2 to 3 inches (5.1 to

7.6 centimeters).

- iv) **Slope:** A slope or ramp is constructed on both sides of the breaker to allow the vehicle to pass smoothly and gradually. The slope is generally about 1:20, it implies for every 20 feet of length, the height increases by 1 inch.
- v) **Width of top surface:** The top surface of the speed bump is typically around 6 to 12 feet (1.8 to 3.7 meters) wide.

4) Drawbacks of Conventional Speed Breakers

In urban and suburban areas of a country, effective traffic management plays a key role in enhancing road safety and the development of the country. Among the numerous methods for traffic calming, the use of speed breakers is the most effective and efficient way, but the utilization of conventional speed breakers is often associated with numerous issues. Some of the problems associated are listed below:

- i) **Passenger Discomfort:** Speed breakers are made in such a way that they are capable of slowing down vehicles. Sometimes slowing down results in a complete halt or reducing speed drastically. As a result, vehicle occupants may not feel very much comfortable.
- ii) **Amplified noise pollution:** An abrupt change in elevation may cause noise pollution, especially when a heavy goods vehicle crosses it. It could be a serious problem in residential areas during nighttime.
- iii) **Traffic congestion:** In roads with heavy traffic density speed breakers may lead to traffic jams.
- iv) **Accessibility challenges for the disabled:** Speed breakers can pose challenges for people with disabilities or mobility issues, making it difficult for them to cross the road safely.

5) Average Speed Profile

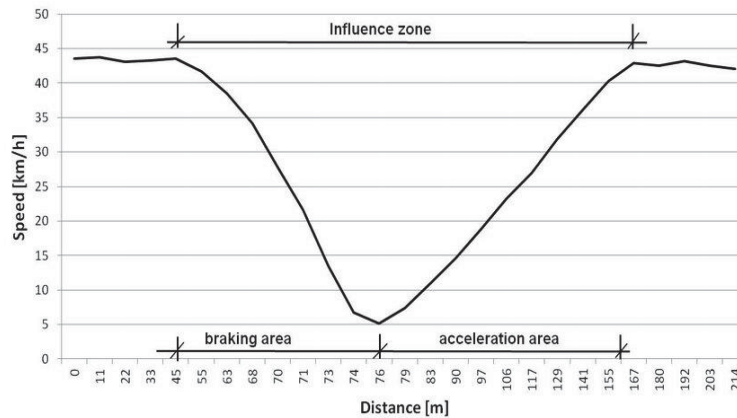


Figure 3: Average Speed Profile [3]

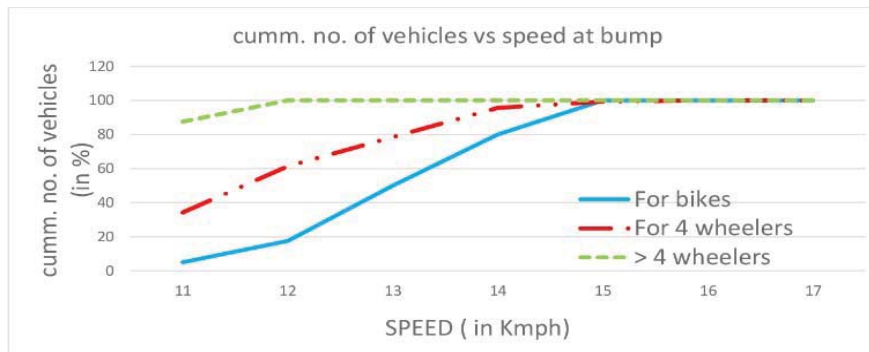


Figure 4: Speed distribution of Vehicles over Speed breakers [4]

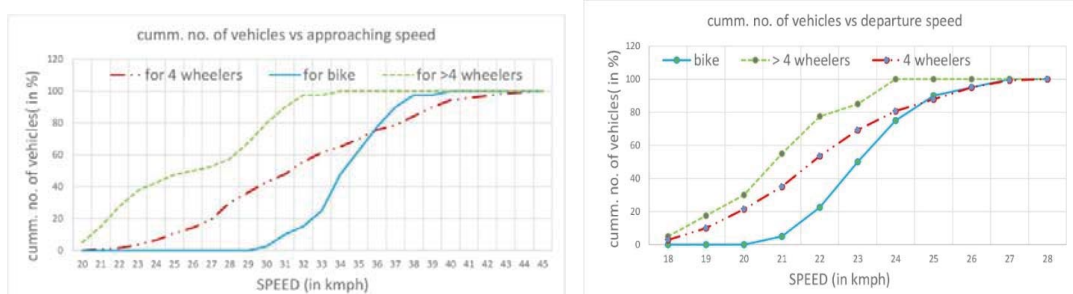


Figure 5: Speed Distribution for approaching speed of vehicles [4]

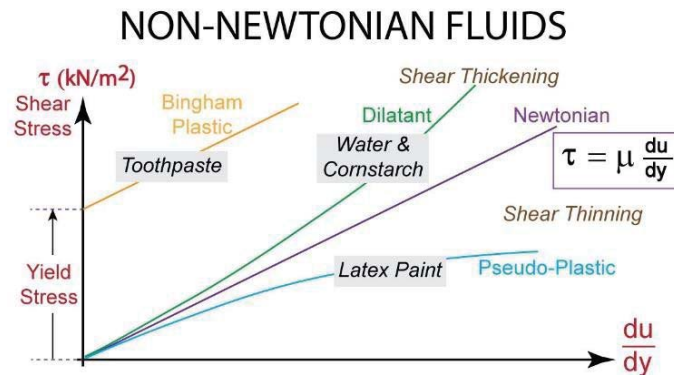


Figure 6: Speed distribution for Departure [4]

B) Basic concept of non-Newtonian fluids

In this whole world of physics and fluids, there exists a class of fluids which tend to shake up the whole department of fluid mechanics. These fluids have a capability to defy sir Isacc Newton's Laws of viscosity. Well, we welcome you to the fascinating world of non- Newtonian fluids.

Now, what exactly is non-Newtonian fluids? Let's explore this captivating world. Non-Newtonian fluids are such fluids that tend to deviate from the behavioral pattern of conventional fluids. There are many factors where this class of fluid deviates from ideal behavior. Variable viscosity is one of the major governing factors that determines the behavioral pattern of non-Newtonian fluids [5].

C) Design

Now that we have learnt about the basic concepts of non-Newtonian fluid, lets dive into the ethereal world of the same. Let's continue our expedition by understanding the real-life applications of our flexi flow fluid. One of the most pivotal uses of non-Newtonian fluid is its use in speed breakers.

Let us imagine a speed breaker that will adjust itself depending on the speed of the vehicle passing over it as if it can read your speed with its mind. So, let us explore the science behind this extraordinary magic.

As non-Newtonian fluids are capable of changing their viscosity when subjected to sudden stress. When a vehicle runs over a tube on the road that is filled with non-

Newtonian fluid which in our case is the speed breaker. The speed breaker can thus have a variable characteristic hardness depending upon the speed of the vehicle. Speed breakers are designed in such a way that they can reduce the speed of an approaching vehicle and not cause any jerks while passing over it. This is where the role of non-Newtonian fluid comes into play, it reduces the jerking effect caused by conventional speed breakers.

Any speed breaker consists of an outer shell and bottom plate. In the case of a non-Newtonian fluid breaker, the shell part is 70% filled with non-Newtonian fluid in a rubber membrane tube. The remaining 30% of the space is left so that the fluid can flow inside the rubber membrane and execute its application properly.

D) Working

As a vehicle passes over this flexi flow breaker depending upon the speed of the vehicle the breaker will alter its hardness. The higher the speed of the vehicle the breaker is nothing short of a concrete breaker. But for slow vehicles, the occupants can feel the world jiggling below their vehicle wheels. As the velocity gradient of slow-moving vehicles is very low, hence liquid behavior tends to predominate over solid behavior thus the situation becomes such that the vehicle passes over some fluid.



Figure 7: vehicle passing over a non-Newtonian fluid speed breaker [6]

Conclusion:

In our ever-evolving world filled with surprises, inventions, and innovations, the utilization of non-Newtonian fluid in speed breakers has greatly enhanced road safety measures. Not only does it enhance road safety, but it also solves many drawbacks associated with the conventional speed breakers we see in our day-to-day lives. By

using these modern-day breakers, we can now have comfortable breakers, efficient and smooth traffic flow, reduced noise pollution, etc.

Using non-Newtonian fluids as speed breakers has many future aspects. Out of these, the most highlighted aspect is being able to generate electricity from it. As a car passes over the breaker, mechanical work is done, this mechanical work done can be converted to electrical energy to power the street lights or signal lights.

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