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A/P: LAVEL, TAL.KHED, DIST.RATNAGIRI.
Tel.: 02356 - 273134, Fax: 02356 – 262980
Website: www.git-india.edu.in, Email: principal@git-india.edu.in

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INDEX

Crack Identification in a Structural Beam Using Regression and Machine Learning Models

Vikas KHALKAR *
Department of Mechanical Engineering, Gharda Institute of Technology, Lavel, India, vikas_khalkar@rediffmail.com

Arul MOSHI
Department of Mechanical Engineering, JKKN College of Engineering and Technology, Vattamalai, Komarapalayam, India, moshibeo2010@gmail.com

Jyoti BORDE
Department of Computer Engineering, Gharda Institute of Technology, Lavel, India, India, jvkhalkar@git-india.edu.in

Raman BANE
Department of Computer Engineering, Yashwantrao Bhonsale College of Engineering, Sawantwadi, India, ramanbane@gmail.com

Lalitkumar JUGULKAR
Department of Mechanical Engineering, Rajarambapu Institute of Technology Islampur, Sangli, India, lmjugulkar@rit-india.edu

S BASKAR
Department of Automobile Engineering, Vels Institute of Science, Technology and Advanced Studies, Chennai, India, baskar133.se@velsuniv.ac.in

* Author to whom correspondence should be addressed

Abstract: - A manufacturing fault causes a defect consisting of a crack in the structure. Identification and classification are essential challenges in scientific research because cracks can lead to catastrophic system failure. Structural fitness tracking aims to diagnose and predict structural fitness. A complete crack detection method based on free vibration is widely used to find potential cracks in systems. However, bending stiffness methods are limited in predicting the crack parameters. Therefore, the bending stiffness approach has been used in the present work to determine the crack locations and depth in the cantilever beam. A dead weight was attached to the beam's free end, and two dial gauges were used. A gauge was attached to the free end of the beam to measure the free-end deflection. Another dial indicator was installed near the crack to measure the static deflection at the crack. Numerical and experimental analyses were performed on 25 cracked specimens to measure the static deflection and stiffness at two points. Regression models were developed for the crack parameters to predict them without the need for numerical and experimental analyses. Also, the ANN model was developed for the same purpose to relate the considered input and output variables. The crack depth and location results obtained from the regression and machine learning models are consistent with the actual values. The crack parameters were predicted using static two-point bending stiffness values as input, and the results were encouraging. Therefore, the static two-point bending stiffness approach may be widely used to detect future cracks in more complex structures.

Keywords: - Bending stiffness, Static deflection, ANN, Regression models, Dial gauges, ANSYS.

1. INTRODUCTION

The presence of a crack affects the mode shapes, natural frequencies, static deflection, and damping coefficient in beam-like structures. For a few decades, non-destructive methods for locating cracks in structures have relied on alterations in the physical properties. Using deflection measurements, Naik [1] developed a technique for checking the defects in lengthy pipelines. The stiffness of a spinning spring model closely mirrored the crack was calculated using fracture mechanics. The long pipes not only supported boundary conditions, but they also had cantilevers. Experiments using steel and aluminium pipes demonstrated the potency of the suggested strategy. Theoretical and experimental crack site predictions were in good agreement. The efficiency of a static deflection technique for inclined edge fracture diagnostics in a prismatic cantilever beam was demonstrated by Pansare and Naik [2]. Rotational springs were used to show how the inclined edge fracture made the beams flexible. They employed twenty-one mild steel specimens for the experimental studies. The experimental static deflection results provided precise fracture site estimates. Using the measurements of the damage-induced fluctuations in the static deflection of the beam under a specific loading condition, Caddemi and Morassi [3] had located the numerous open cracks in a beam. A comparable linear spring connecting the two neighboring beam segments simulated each break. In their research work, many open cracks in a beam were found using measurements of differences in the static deflection of the beam caused by damage under specific load conditions. Each break was simulated by a similar linear spring connecting the two adjacent beam segments. The pertinent requirements on the static measurements were presented and addressed for non-uniform beams with particular ideal boundary conditions, enabling the precise detection of the damage. The inverse analysis provided accurate closed-form representations of the position and severity of the fractures in terms of the observed data. It was based on an explicit description of the crack-induced change in the deflection of the beam under a particular load distribution. Comparative static testing on a steel beam with localized flaws supported the theoretical conclusions.

Tufisi et al. [4] calculated the damage severity for the closed and open transverse fractures in beam-like structures using deflection under the weight of the undamaged and damaged beams. They validated the results by comparing the damage severity assessed using the stochastic hill climbing (SHC) approach with the severities indicated by the expert simulation tool. Kumar and Singh [5] looked at border distortion about wavelet scale and measurement resolution. The appropriate wavelet scale was selected based on the fracture localization and wavelet coefficient smoothness. Isomorphism was used to show how measurement resolution affects signal extension. The photographic approach was used to achieve the high-resolution measurement of the beam deflection. Panasare et al. [6] looked at the cracked cantilever beam for the static analysis. The researchers used the ANSYS Mechanical 16 simulation to investigate the cracked cantilever beam for static deflection. The static deflections that were obtained and those that were measured were compared. Furthermore, results were obtained from the generated reliable FEA model. Tufisi et al. [7] had suggested an analytical data creation method. This information is required to train the random forest model (RF), which monitors the structural health of the structures. The RF model was trained using normalized natural frequencies from multiple damaged samples. It was discovered that the RF model predicts how the structure will behave when cracks are still visible towards the cantilevered end. Ostachowicz [8] presented the method of analysis of the effect of two open cracks upon the frequencies of the natural flexural vibrations in a cantilever beam. Two types of cracks were considered: double-sided, occurring in the case of cyclic loadings, and single-sided, which is the principle that occurs as a result of fluctuating loadings. Cawley and Adams [9] described the method of non-destructively assessing the integrity of structures using measurements of the structural natural frequencies. It is shown how measurements made at a single point in the structure can be used to detect, locate, and quantify damage. Rizos et al. [10] studied the flexural vibrations of a cantilever beam with a rectangular cross-section having a transverse surface crack extending uniformly along the width of the beam. From the measured amplitudes at two points of the structure vibrating at one of its natural modes, the respective vibration frequency, and an analytical solution of the dynamic response, the crack location can be found, and depth can be estimated with satisfactory accuracy. Liang et al. [11] proposed a method that has practical applications in the detection of crack location and quantification of damage magnitude in a uniform beam. Their approach, which uses rotational massless springs in the beam element as a mechanical model, can be applied to structures under simply supported or cantilever boundary conditions. Khatir et al. [12] present a methodology based on non-destructive detection, localization, and quantification of multiple damages in simple and continuous beams and a more complex structure, namely a two-dimensional frame structure. The proposed methodology makes use of the Firefly Algorithm and Genetic Algorithm as optimization tools and the Coordinate Modal Assurance Criterion as an objective function. The results show that the proposed combination of the Coordinate Modal Assurance Criterion and Firefly Algorithm or Genetic Algorithm can be easily used to identify multiple local structural damages in complex structures. Sutar et al. [13] investigated the transverse crack in a cantilever beam by developing a Neural network-based controller. The input parameters to the controller are the relative divergence of the first three natural frequencies, and

Article

Damage Identification in a Cantilever Beam Using Regression and Machine Learning Models

July 2024 · Iranian Journal of Science and Technology - Transactions of Civil Engineering 48(3)
DOI:10.1007/s40996-024-01563-x

Authors:

Vikas Khalkar
GIT

Arul Marcel Moshi Antony Joseph Decruz

Logesh Kamaraj
Vel Tech Rangarajan Dr. Sagunthala R&D Institute of Science and Technology

P. Harihara Sakthi Su
Dr. Mahalingam Colle

Show all 5 authors

Abstract

A manufacturing fault causes a defect consisting of a crack in the structure. Identification and classification are essential in scientific research because cracks can lead to catastrophic system failure. The purpose of structural fitness tracking is to diagnose and predict structural fitness. A complete crack detection method based on free vibration is widely used to find potential cracks in systems. However, static deflection methods are limited to predicting crack parameters. Therefore, this article uses the static deflection method to determine the crack locations and depth in the cantilever beam. A dead weight was attached to the beam's free end, and two dial gauges were used. A gauge was attached to the free end of the beam to measure the free-end deflection. Another dial indicator was also installed near the crack to measure the static deflection of the crack. Numerical and experimental analyses were performed on 48 cracked specimens to measure the static deflection at two points. A regression model was developed to calculate the crack parameters, i.e., crack locations and crack depths in beams. To evaluate the reliability of the developed regression model, a machine learning model, i.e., Artificial Neural Network (ANN) and Random Forest (RF), was used for prediction. Regression, ANN, and RF models were developed using numerical and experimental datasets. The crack depth and location results obtained from the regression and machine learning models are consistent with the actual results. The crack parameters were predicted using static two-point deflection as input, and the results were encouraging. Therefore, the static two-point deflection approach may be widely used to detect future cracks in more complex structures.

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Crack detection near the ends of a beam using wavelet transform and high resolution beam deflection measurement

Article

Mar 2021 · EUR J MECH A-SOLID

Ramnivas Kumar · Sachin kumar Singh

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Performance study and analysis of Al2O3 Nanofluid under different flow conditions

August 2024 · Interactions 245(1)
DOI:10.1007/s10751-024-02020-x

Authors:
V. Sivakumar
K. Visagavel
Kumaraswamy Jayappa
RL Jalappa Institute of Technology
Balaji Ellappan
Veltech Multitech Dr. Rangarajan Dr.Sagunthala Engineerin

Abstract and Figures

Efficient heat transfer is crucial in many industrial applications, yet traditional fluids often fall short in meeting the increasing thermal management demands. This study aims to address this problem by investigating the performance of Al2O3 nanofluids under various flow conditions to enhance heat transfer rates. The purpose of this research is to analyze how different concentrations of Al2O3 nanoparticles and varying Reynolds numbers affect the thermal performance of the nanofluids. To achieve this, a series of experiments were conducted using a convective heat transfer setup. Al2O3 nanoparticles were dispersed in a base fluid at concentrations ranging from 0.1% to 1.0% by volume. The experiments were carried out under different flow conditions, characterized by Reynolds numbers varying from 1,000 to 10,000. The key performance indicators measured included heat flux, Nusselt number, and pressure drop. The results demonstrated a significant enhancement in heat transfer rates with the addition of Al2O3 nanoparticles. Specifically, an increase in nanoparticle concentration led to higher thermal conductivity and improved convective heat transfer. Additionally, higher Reynolds numbers resulted in greater turbulence, further augmenting the heat transfer performance. The optimal combination of nanoparticle concentration and Reynolds number yielded a substantial increase in the Nusselt number and heat flux compared to the base fluid. Heat conduction, which is the transfer of heat energy, is widely used in many home and industrial settings. It has been a crucial area of study since ancient times. This research studied the efficiency of Al2O3 nano fluid in facilitating effective heat transmission in several sectors, including pigmenting, dying, and evaporators. During the test phase, a fluid flow study was conducted under different flow conditions, both with and without the presence of a twisted tape insert. The investigation revealed that the heat flux for demineralized water rose from 1256 W/m² to 1358 W/m², while for nano fluid at a lower Reynolds number of 5000, it climbed from 3075 W/m² to 4737 W/m². Insert was seen with the increase in wall temperature. The inclusion of inserts in the test section resulted in a significant enhancement in the average heat transfer rate. Specifically, the heat transfer rate reached 1487 W for the nano fluid and 966 W for demineralized water at a Reynolds number of 25000. The overall heat transfer coefficient increased by 39.3% for demineralized water with inserts at a Reynolds number of 25000. Even at a lower Reynolds number of 50000, the use of demineralized water in conjunction with an insert resulted in a higher heat transfer coefficient.

+2

Schematic layout of experimental… Actual experimental… SEM image of Al–2O3… Reynolds number vs. Heat flux… Reynolds number vs. Average he…

Figures - available from: Interactions

Interactions (2024) 245:213
https://doi.org/10.1007/s10751-024-02020-x

RESEARCH

Performance study and analysis of Al_2O_3 Nanofluid under different flow conditions

V. Sivakumar[1] · K. Visagavel[1] · J. Kumaraswamy[2] · E. Balaji[3] · V. Khalkar[4] · C. Gnanavel[5] · P. R. Kalyana Chakravarthy[5] · S. Baskar[5] · V. Vijayan[6]

Accepted: 18 July 2024 / Published online: 12 August 2024

Abstract
Efficient heat transfer is crucial in many industrial applications, yet traditional fluids often fall short in meeting the increasing thermal management demands. This study aims to address this problem by investigating the performance of Al_2O_3 nanofluids under various flow conditions to enhance heat transfer rates. The purpose of this research is to analyze how different concentrations of Al_2O_3 nanoparticles and varying Reynolds numbers affect the thermal performance of the nanofluids. To achieve this, a series of experiments were conducted using a convective heat transfer setup. Al_2O_3 nanoparticles were dispersed in a base fluid at concentrations ranging from 0.1% to 1.0% by volume. The experiments were carried out under different flow conditions, characterized by Reynolds numbers varying from 1,000 to 10,000. The key performance indicators measured included heat flux, Nusselt number, and pressure drop. The results demonstrated a significant enhancement in heat transfer rates with the addition of Al_2O_3 nanoparticles. Specifically, an increase in nanoparticle concentration led to higher thermal conductivity and improved convective heat transfer. Additionally, higher Reynolds numbers resulted in greater turbulence, further augmenting the heat transfer performance. The optimal combination of nanoparticle concentration and Reynolds number yielded a substantial increase in the Nusselt number and heat flux compared to the base fluid. Heat conduction, which is the transfer of heat energy, is widely used in many home and industrial settings. It has been a crucial area of study since ancient times. This research studied the efficiency of Al_2O_3 nano fluid in facilitating effective heat transmission in several sectors, including pigmenting, dying, and evaporators. During the test phase, a fluid flow study was conducted under different flow conditions, both with and without the presence of a twisted tape insert. The investigation revealed that the heat flux for demineralized water rose from 1256 W/m^2 to 1358 W/m^2, while for nano fluid at a lower Reynolds number of 5000, it climbed from 3075 W/m^2 to 4737 W/m^2. Insert was seen with the increase in wall temperature. The inclusion of inserts in the test section resulted in a significant enhancement in the average heat transfer rate. Specifically
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higher heat transfer coefficient.

Extended author information available on the last page of the article

Computer Modeling in
Engineering & Sciences

Tech Science Press

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REVIEW

Data-Driven Healthcare: The Role of Computational Methods in Medical Innovation

Hariharasakthisudhan Ponnarengan[1,*], Sivakumar Rajendran[2], Vikas Khalkar[3], Gunapriya Devarajan[4] and Logesh Kamaraj[5]

[1]Department of Mechanical Engineering, Dr. Mahalingam College of Engineering and Technology, Pollachi, Coimbatore, Tamil Nadu, 642003, India

[2]Department of Mechanical Engineering, JKKN College of Engineering and Technology, Kumarapalayam, Namakkal, Tamil Nadu, 637209, India

[3]Department of Mechanical Engineering, Gharda Institute of Technology, Lavel, Maharashtra, 415708, India

[4]Department of Electrical and Electronics Engineering, Sri Eshwar College of Engineering, Coimbatore, Tamilnadu, 641202, India

[5]Department of Mechanical Engineering, Vel Tech Rangarajan Dr. Sagunthala R&D Institute of Science and Technology, Chennai, 600062, India

*Corresponding Author: Hariharasakthisudhan Ponnarengan. Email: harimeed2012@gmail.com

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ABSTRACT

The purpose of this review is to explore the intersection of computational engineering and biomedical science, highlighting the transformative potential this convergence holds for innovation in healthcare and medical research. The review covers key topics such as computational modelling, bioinformatics, machine learning in medical diagnostics, and the integration of wearable technology for real-time health monitoring. Major findings indicate that computational models have significantly enhanced the understanding of complex biological systems, while machine learning algorithms have improved the accuracy of disease prediction and diagnosis. The synergy between bioinformatics and computational techniques has led to breakthroughs in personalized medicine, enabling more precise treatment strategies. Additionally, the integration of wearable devices with advanced computational methods has opened new avenues for continuous health monitoring and early disease detection. The review emphasizes the need for interdisciplinary collaboration to further advance this field. Future research should focus on developing more robust and scalable computational models, enhancing data integration techniques, and addressing ethical considerations related to data privacy and security. By fostering innovation at the intersection of these disciplines, the potential to revolutionize healthcare delivery and outcomes becomes increasingly attainable.

KEYWORDS

Computational models; biomedical engineering; bioinformatics; machine learning; wearable technology

1 Introduction

Computational models have emerged as powerful tools in several fields, including biomedical engineering, that enable researchers and practitioners to simulate complex biological processes and systems with significant precision [1,2]. Computational models are mathematical and algorithmic representations of real-world occurrences designed to predict behavior, understand underlying mechanisms, and guide experimental and clinical practices. Computational models influence the increasing computational power and sophisticated software algorithms to handle large datasets and intricate systems that are often challenging to study through traditional experimental methods. These models are essential to address questions related to complex biological systems, their interactions and behaviors [3]. However, challenges exist in ensuring the reliability and robustness of these models for biomedical applications [4]. In biomedical engineering, computational models enable cost- and time-efficient evaluations of fundamental hypotheses and parameter sensitivity studies, ultimately aiding in optimizing scaffold design in tissue engineering [5]. Additionally, mathematical models are used to improve the design of biomimetic devices, such as optimizing the construction of biomimetic models and understanding oxygen heterogeneities in microfluidic devices [6]. Different types of computational models used in biomedical engineering are shown in Fig. 1.

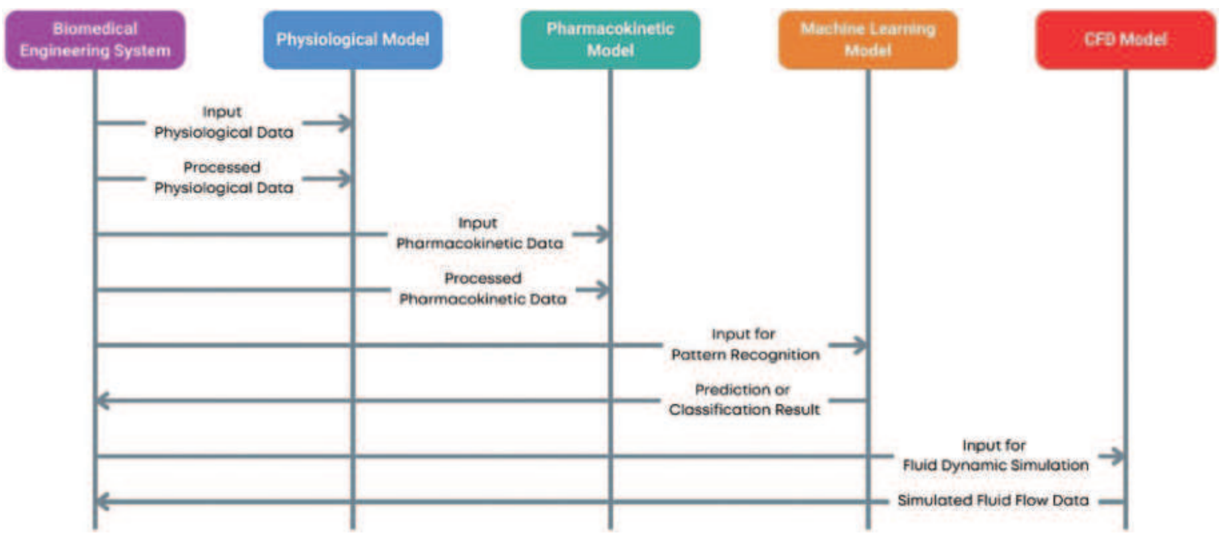


Figure 1: Computational models in biomedical engineering

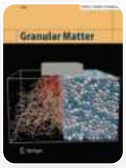
In biomedical engineering, computational models are critical in advancing our understanding of physiological processes and disease mechanisms. They offer a framework to integrate diverse data types—from molecular and cellular levels to tissue and organ scales into coherent simulations that provide insights into biological functions and pathologies [7]. For example, computational models can simulate the heart's electrical activity, predict the spread of infectious diseases, or optimize the design of medical devices [8]. These applications not only enhance our theoretical knowledge but also have practical implications for diagnostics, treatment planning, and the development of personalized medicine.

The development of computational models typically involves several key steps: defining the biological problem, formulating mathematical representations, implementing algorithms, validating models against experimental data, and refining models based on feedback. This iterative process ensures that the models are both accurate and reliable. Techniques such as finite element analysis [9–11], agent-based modeling, and machine learning [12,13] are commonly employed to build these models, each offering unique advantages depending on the specific application. The process of developing

Clogging reduction by addition of small particles of various material densities

Research Published: 10 July 2024

Volume 26, article number 76, (2024) Cite this article

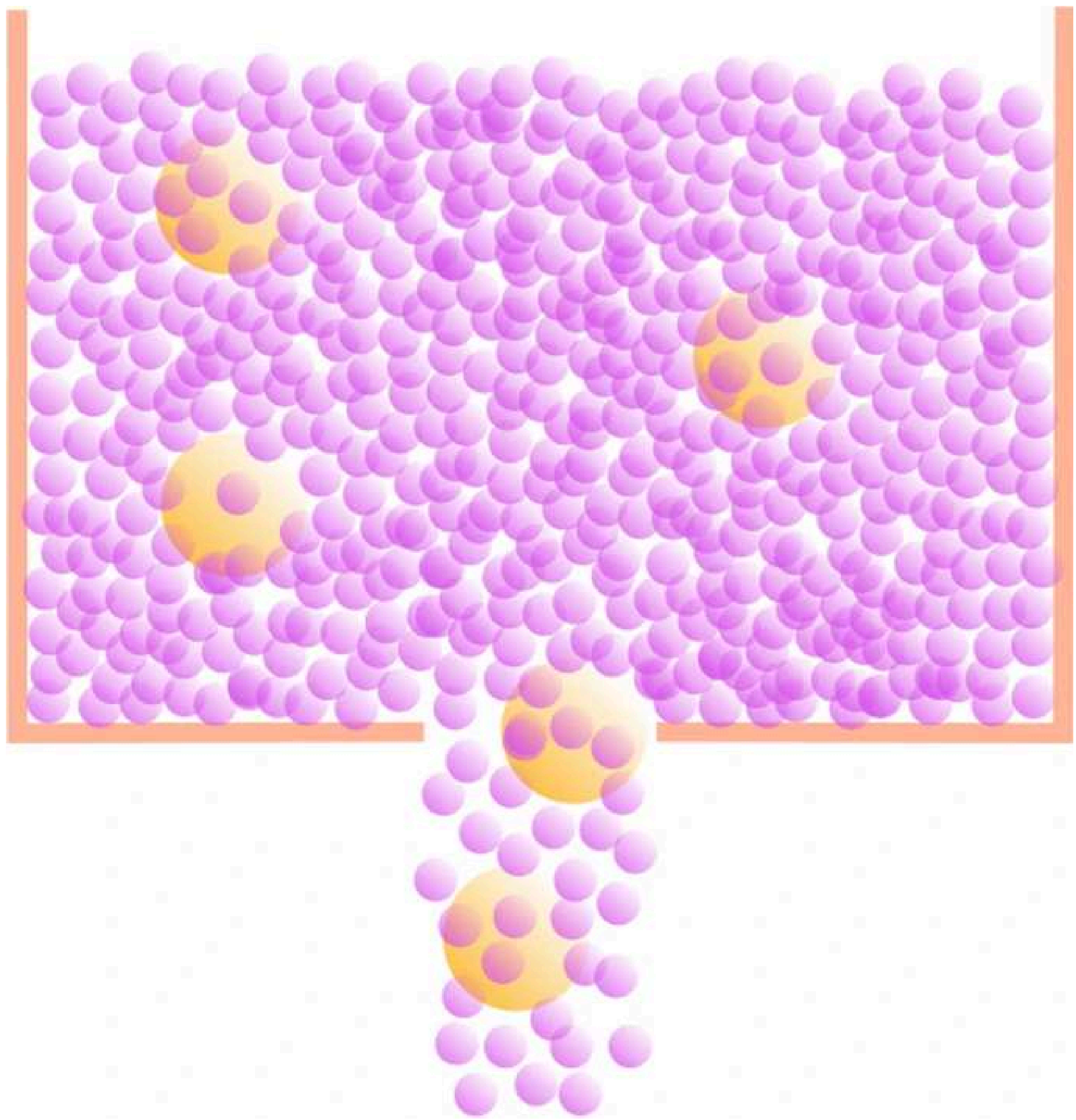


Sandip H. Gharat, Julián Montero & Luis A. Pugnaloni

Abstract

We present an experimental investigation on the flow and clogging of bi-disperse mixtures of coarse and fine grains of different densities passing through small orifices. We vary the density ratio (coarse/fine) from 1.87 down to 0.79 by using amaranth seeds, glass and ceramic beads of similar size as the fine species in combination with 2.0 mm glass beads as the coarse grains. We analyzed the effect of the density ratio on the effective flow rate of the coarse species, the segregation during flow and the clogging for a range of orifice diameters. As in previous studies, the flow of the coarse grains is facilitated by the fine species, which prevents clogging. We show that the effective flow rate of the coarse species is virtually independent of the density ratio. These results suggest that in practical applications with the goal of clogging reduction, the density of the fine species used to ease the flow is not a relevant parameter and can be selected based on practical or economic constraints.

Graphic abstract



Bionanomaterials in Food Systems: Sources, Synthesis, Properties and Opportunities

Review Published: 28 November 2024

Volume 15, article number 5, (2025) Cite this article

BioNanoScience

Aims and scope

Submit manuscript

Palak Atul Karwatkar, Sunil Jayant Kulkarni & Ajaygiri Kamalgiri Goswami

Abstract

The integration of bionanomaterials into food systems represents a significant advancement in enhancing food properties, safety and quality. This review article provides a comprehensive overview of bionanomaterials, encompassing their definition, sources, synthesis methods, properties and applications within food systems. Various synthesis methods, green synthesis, physical methods and chemical methods are reviewed in this article. Key properties of bionanomaterials relevant to food systems are detailed. Applications of these materials are vast, ranging from improved food packaging with enhanced barrier properties to antimicrobial food preservation, nutrient delivery systems for food fortification and sensors for quality monitoring. The article also addresses future perspectives and opportunities in the field. The conclusion summarizes

the key findings and underscores the importance of continued research and development to fully realize the benefits of bionanomaterials in enhancing food systems.

Journal of the Indian Chemical Society
Volume 102, Issue 1, January 2025, 101540

Intensification of hydrodynamic cavitation induced degradation of Brilliant Blue dye using various additives

Sonali P. Jadhav [a] [b], Parag R. Gogate [b]

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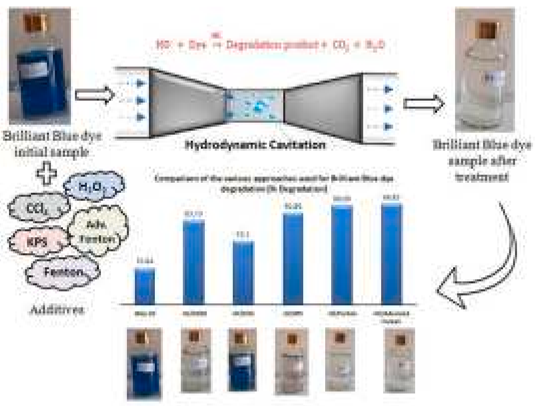
Highlights

- Use of hydrodynamic cavitation for intensified brilliant blue degradation.
- Understanding into effect of different operating parameters and combinations.
- Ultrasound combined with advanced Fenton is best pretreatment approach.
- Toxicity analysis results confirmed no additional toxicity is induced.
- Cavitational yield is higher for the combination approaches.

Abstract

Dye contaminated wastewater is a major concern and development of new approaches for remediation is important requirement. In the current work, degradation of brilliant blue dye using hydrodynamic cavitation is studied individually and coupled with different additives like hydrogen peroxide, carbon tetrachloride, potassium persulphate, Fenton's reagent and advanced Fenton reagent. Initially the optimum conditions for individual cavitation have been obtained by conducting experiments at varying initial dye concentration, pressure and pH of dye solution. The established optimum conditions as 50 ppm dye concentration, 3 bar pressure and pH of 3 resulted in 35.84 % degradation. Combining HC with H_2O_2 resulted in 83.73 % degradation at optimum loading of 1500 ppm of H_2O_2 whereas 63.10 % degradation was obtained for CCl_4 at 1000 ppm. Using 0.6 g/l loading of KPS and 1:2 ratio of H_2O_2 to $FeSO_4$ in the Fenton resulted in 90.86 % and 98.09 % degradation respectively whereas near complete degradation (99.85 %) was observed for 1:1 ratio of H_2O_2 to iron powder in the advanced Fenton approach. The kinetic study showed that brilliant blue degradation follows pseudo first order kinetics for all processes. Mineralization studies confirmed maximum COD reduction of 78.26 % for HC/Fenton combination. Toxicity analysis test was also conducted using *Escherichia coli* and *Staphylococcus aureus* for brilliant blue dye samples before and after treatment which confirmed that the treated samples are not toxic. Overall, HC/Advanced Fenton process was elucidated as the best treatment approach for remediation of brilliant blue present in the effluents.

Graphical abstract



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Keywords

Enhancing Cyclone Intensity Prediction Through Deep Learning Analysis of Imagery Datasets

| Conference paper | First Online: 25 September 2024

| pp 205–217 | Cite this conference paper

Computation of Artificial Intelligence and Machine Learning

(ICCAIML 2024)

Jyoti Dinkar Bhosale, Suraj S. Damre, Ujwala V. Suryawanshi & Rajkumar B. Pawar

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Abstract

Cyclones pose a significant threat, causing widespread devastation and loss of life. Early prediction of cyclone intensity plays a crucial role in mitigating their impact. In recent years, deep learning has emerged as a promising technique for image analysis. This paper introduces a deep learning-based method for estimating cyclone strength using image datasets. By leveraging convolutional neural networks (CNNs), the proposed approach extracts essential information from satellite imagery to forecast cyclone intensity. The model is trained on a comprehensive historical dataset sourced from the National Hurricane Center's HURDAT2 database and validated on new cyclone data. Evaluation metrics such as mean absolute error, mean squared error, and root mean squared error demonstrate the effectiveness of the CNN model in accurately estimating cyclone intensity. Training the CNN model on the historical dataset employs supervised learning, where labeled examples consisting of satellite data and corresponding cyclone intensities are utilized. Through this process, the model discerns patterns and correlations within the satellite data, enabling it to make precise predictions for unseen cyclone data.