



# Journal of Applied and Computational Mechanics



Research Paper

## A New Taylor Series based Numerical Method: Simple, Reliable, and Promising

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**Abstract.** Taylor series method is a simple analytical method, which is accessible to all non-mathematician, has slow convergence. This paper develops a new Taylor series based numerical method to overcome the shortcoming of the Taylor series while maintaining its simplicity. Some examples are given, showing its reliability and efficiency. The proposed method is also proved to be extremely effective for initial value problems and boundary value problems. The method provides a universal approach to various highly non-linear problems, and it sheds a bright light on numerical theories for practical engineering applications.

**Keywords:** Taylor Series, Singular Boundary Value Problem, KDV equation, Burgers' Equation, System of Burgers Equation.

### 1. Introduction

For many years, the researchers used various real-life examples as test problems like Lane-Emden type equations, Burger equations, KDV equation, etc. to verify the numerical methods. In this work, we shall consider the following class of nonlinear ODEs and PDEs:

$$y''(x) + \frac{\alpha}{x}y'(x) = f(x, y(x)), \quad 0 < x < 1, \quad y(0) = c, y'(0) = d, \tag{1}$$

$$y''(x) + \frac{\alpha}{x}y'(x) = f(x, y(x)), \quad 0 < x < 1, \quad y'(0) = 0, \beta_1 y(1) + \beta_2 y'(1) = d, \tag{2}$$

$$y_i''(x) + \frac{\alpha}{x}y_i'(x) + h_i(x, y_1(x), y_2(x)) = 0, \quad 0 < x < 1, \quad y_i(0) = c_i, y_i'(0) = d_i, i = 1, 2 \tag{3}$$

$$y_i''(x) + \frac{\alpha}{x}y_i'(x) + h_i(x, y_1(x), y_2(x)) = 0, \quad 0 < x < 1, \quad y_i'(0) = 0, y_i(1) = c_i, i = 1, 2 \tag{4}$$

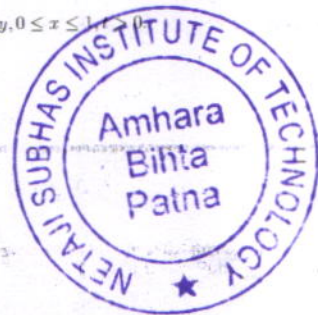
$$u_t + uu_x = \mu u_{xx}, \quad 0 \leq x \leq 1, t > 0, u(x, 0) = 2x. \tag{5}$$

$$u_t - 6uu_x + u_{xxx} = 0, \quad 0 < x < 1, \quad t > 0, u(x, 0) = -\frac{k^2}{2} \operatorname{sech}^2\left(\frac{kx}{2}\right), \tag{6}$$

$$\begin{cases} u_t + uu_x + vv_y = \frac{1}{Re}(u_{xx} + u_{yy}), u(x, y, 0) = x + y, 0 \leq x \leq 1, t > 0, \\ v_t + uv_x + vv_y = \frac{1}{Re}(v_{xx} + v_{yy}), v(x, y, 0) = x - y, 0 \leq x \leq 1, t > 0, \end{cases} \tag{7}$$

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## Development of a stable and optimised voltage and frequency controller for a self-excited induction generator system

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### ABSTRACT

A self-excited induction generator (SEIG) has the inability to maintain its terminal frequency and voltage with prime-mover speed and load perturbations. To address this issue, a generalised impedance controller (GIC) is attached to SEIG with feedback voltage processed through a proportional–integral (PI) controller. One algorithm is proposed to evaluate control gains of the PI controller to make the GIC-based SEIG system stable. As the conventional design of the PI controller performs poorly under different perturbations, this study is extended using the advanced computational intelligence-based particle swarm optimisation (PSO) technique to tune the coefficients of the PI controller and enhance the performance. The obtained THD of generator and load voltages and currents are within 0.23%. To validate the proposed technique, an experiment on a GIC-based SEIG system is carried out using a commercially available TMS320F2812 DSP processor.

### ARTICLE HISTORY

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### KEYWORDS

Self-excited induction generator; generalised impedance controller; PI controller; optimal control gains; particle swarm optimisation; total harmonic distortion

### Nomenclature

$v_w$	Wind speed
$P_t$	Wind turbine power
$C_p$ and $\lambda$	Power coefficients of the wind turbine and tip speed ratio, respectively
$s$ and $r$	Stator and rotor variables, respectively
$I$	Leakage component
$v$ and $i$	Instantaneous voltage and current, respectively
$I_m$ and $L_m$	Magnetising current and magnetising inductance, respectively
$r$ and $L$	Resistance and inductance, respectively
$\omega_m$	The mechanical rotor speed of SEIG
$\omega_r$	The electrical rotor speed of SEIG
$T_{\text{shg}}$ and $T_e$	Mechanical input torque and electromagnetic torque of the SEIG, respectively
$J$ and $P$	Moment of inertia and the number of poles of the generator, respectively
$I_{cd}$ and $I_{cq}$	Current through the excitation capacitor in the $d$ and $q$ axis, respectively
$C$	Excitation capacitor values both in the $d$ and $q$ axis, respectively
$R$ and $L_r$	Resistance and inductance of the load, respectively
$k_p$ , $T$ and $\tau$	Open-loop steady-state gain, time constant and time constant and

### 1. Introduction

With conventional ways or by grid extension it may not be feasible to provide electricity to remote and isolated areas (Arthishri, Kumaresan, and Gounden 2018; Kumar, Namrata, and Samadhiya 2022). However, as an alternative wind energy can be used in these areas to produce electricity at a low cost (Sahu, Prusty, and Panda 2020; Sahu et al. 2020; Mishra et al. 2021; Sahu, Prusty, and Panda 2021). Different types of electrical generators, such as permanent magnet synchronous generators (PMSG), and self-excited induction generators (SEIG), can be employed in wind energy systems (Dewangan and Vadhera 2021). PMSG has significant features, such as high efficiency, high power density, the requirement of minimum maintenance and gearless operation. However, it is more costly and heavier than SEIG (Kumar, Krishnasamy, and Kaur 2020; Saha, Haque, and Mahmud 2017). Hence, significant features of SEIG, such as low cost, small size, no or minimum maintenance, robustness, simplicity and capability to produce power at different speeds (Kumar, Krishnasamy, and Kaur 2020; Taoufik, Abdelhamid, and Lassad 2018; Tahir et al. 2017) make suitable to generate power from the wind. In the year 1935 Basset discovered the self-excitation concept of the induction machine to operate as a generator. However, poor frequency and voltage regulation are the problems associated with SEIG under load and shaft or prime mover speed perturbations

  
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# An Evaluation and Analysis of Delay in Residential Building Construction Projects in India

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**Abstract**— Residential building projects in India plays a major role in its GDP. But, due to several factors this construction industry has become a problem for many involved in it directly or indirectly. Residential building projects are often delayed in India due to many factors. This research papers focuses on the identification and evaluation of factors which affect the delay in residential building projects in India. The two factors which have been studied in great details and discussed are cost escalation and cost overrun which affects the overall process of delay and creates several other problems. The research provides valuable insights in such factors.

**Keywords:** Building Construction Projects, Cost Overrun, Cost Escalation, Case Study, Questionnaire

## I. INTRODUCTION

In India, Construction Industry assumes a critical part in both monetary development and destitution decrease. The business burns-through around 40 to half of the public long term plan expense and adds to almost 20% of GDP. Development industry is the second biggest industry next just to farming as far as giving work in India (Construction Industry Development Council). Government is focusing on a financial development of around eight percent during the Twelfth five-year Plan (2012-1). Development projects involve high danger, long incubation period, significant expenses and spending plan imperatives. India is the second most crowded country on the planet with more than one billion individuals representing around 16% of the total populace. It is assessed that the populace living in metropolitan regions will increment from 29% in 2000 to 40 percent by 2030. Thusly the heightening interest requires sufficient structure framework offices at sensible expense (The India Infrastructure Report 1996).

Indian government has joined high need to the structure area (UK Trade and Investment). Fast development in the country in the course of recent years has extensively stressed its foundation. India needs huge interest in the foundation area as numerous corporate pioneers feel that the current framework is deficient to help their business needs and long-term development. India has been somewhat delayed in making building foundation in front of interest, and has commonly taken care of business when bottlenecks become evident (Survey report of KPMG International and Economist Intelligence Unit). Speculation necessity for lodging in metropolitan regions has been assessed at Rs.526000 million (US\$ 12.5 billion) in the 9th long term plan (1997-2002). Market size, market potential, workforce abilities are the main components for thinking about Foreign Direct Investment in Construction and Engineering in India. Unfamiliar financial backers in India anticipate high paces of profit from their ventures (FDI Confidence Audit: India

2001). In India, the exhibition record of fruitful execution of foundation projects has not been empowering. Cost overwhelm and cost acceleration are an integral part of the development projects.

## II. BACKGROUND AND LITERATURE REVIEW

The presentation of Government development projects is not found acceptable. Cost overwhelms and cost heightening are an integral part of the development projects in India. In India, all focal and state government supported super tasks and government assistance plans on a normal every year face cost heightening of about Rs. 400000 - 500000 million. The Infrastructure Monitoring Division (IMD) in the Program Implementation Wing is endowed with the checking of execution of the country's eleven key foundation areas viz. Force, Coal, Steel, Railways, Telecommunications, Ports, Fertilizers, Cement, Petroleum and Natural Gas, Roads and Civil Aviation. Venture Monitoring Division (PMD) screens all Central areas undertakings of the Government costing Rs.200 million or more.

As on March 2008, out of 909 ventures costing Rs.200 million or more, 346 tasks were running delayed concerning the most recent endorsed plan. The Cost heightening in 346 postponed projects is Rs.246890 million which is 13.33 percent of the most recent supported expense of Rs.1850890 million. Out of 515 activities, each costing Rs. 1000 million or more, have postponed in the scope of 1-96 months in regard of street, Steel, Power, Petroleum, Road Transport, Railways, Port and Shipping projects. The absolute expense of execution of 515 tasks when endorsed, was of the request for Rs.3534830 million however this was thusly changed to Rs.390640 million inferring an expense invade of 10.5 percent. The focal government-supported foundation tasks of over Rs. 1000 million is relied upon to ascend by another Rs. 460000 million when they are finished. Rail routes' tasks have announced greatest rate spike in their expected expenses. For a sum of 138 ventures, the expense is relied upon to practically twofold from Rs. 37,8630 million to Rs. 70,2370 million when they are finished (Indian Express, New Delhi, Oct. 10, 2008).

A single infrastructure project under ministry of health and family welfare reported maximum cost escalation of over 500%. About 250 projects of railways have reported cost escalation by about 88%. The situation is same with projects under ministry of water resources and ministry of information technology where cost of projects has escalated by 119% and 34% respectively. From 1<sup>st</sup> of Jan, 2009 the cost escalation has gone up by 41% from Rs. 918410 million to Rs. 1295600 million. It is unfortunate that despite repeated concern expressed by the government, the position instead of improving has rather worsened further and the escalation is



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## Numerical treatment of Burgers' equation based on weakly $L$ -stable generalized time integration formula with the NSFD scheme

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**Keywords:**  
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### ABSTRACT

In this study, we present a weakly  $L$ -stable convergent time integration formula of order  $N_1 > 3$  ( $N_1 \in \mathbb{Z}$  is odd) to solve Burgers' equation. The time integration formula for the initial value problem  $u'(t) = f(t, u)$ ,  $u(t_0) = \eta_0$  is formulated using backward explicit Taylor series approximation of order  $(N_1 - 1)$  and Hermite approximation polynomial of order  $(N_1 - 2)$ . We convert the Burgers' equation into the initial value problem using the nonstandard finite difference scheme for spatial derivatives and implement the derived integration formula. The nonstandard finite difference scheme makes it possible to choose several denominator functions. The method's convergence, stability and truncation error are also discussed. To show the correctness and effectiveness of the proposed technique, we present numerical solutions,  $\|e\|_2$  and  $\|e\|_\infty$  error norms in several tables and figures. Additionally, the numerical outcomes are compared with the results of some existing techniques and exact solutions.

### 1. Introduction

We consider the one-dimensional Burgers' equation [1] given by

$$\frac{\partial w}{\partial t} + w \frac{\partial w}{\partial x} - \frac{\nu_d}{2} \frac{\partial^2 w}{\partial x^2} = 0, \quad (x, t) \in (0, 1) \times (0, T), T > 0, \tag{1}$$

with the initial condition (IC)

$$w(x, 0) = f(x), \quad x \in [0, 1], \tag{2}$$

and the boundary conditions (BCs)

$$w(\alpha_i, t) = g_i(t), \quad \alpha_i = i, \quad i = 0, 1 \text{ and } t \in [0, T], \tag{3}$$

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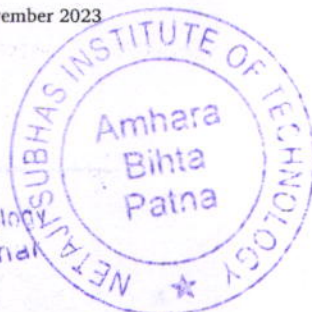
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# An Efficient Method for Feature Extraction and Selection in Power Quality Recognition

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## CONTENTS

1. Introduction
  2. Mathematical Tools for Feature Extraction, Selection, and Classification
  3. Proposed Method for Power Quality (PQ) Events Recognition
  4. Experimental Results and Discussion
  5. Conclusion
- References

**Abstract**—Since decade, many time-frequency analysis methods with combination of classifiers have been studied in literature for recognition of power quality (PQ) events. In these studies, feature extraction and selection have a vital role to enhance PQ classification accuracy and to reduce computational complexity for PQ recognition. This paper presents a new method to detect and classify PQ disturbances based on modified Stockwell Transform (ST) for extraction of features and Hybrid Grey Wolf Optimization (HGWO) for feature selection along with K Nearest Neighbor (KNN) classifier. Simulation of the proposed method using MATLAB is carried out through a wide range of eighteen synthetic PQ events to validate the effectiveness of the selected features. Further, an experiment is extended for six classes of real PQ events acquired from self excited induction generator (SEIG) system in a laboratory experimental setup. Proposed method is also employed on those real time data to study the classification accuracy performance. In these experiments, an impressive accuracy of 99.94% and 99.3% for synthetic and real time PQ event data, respectively are reported. Hence, it is observed from result analysis, this proposed method can be utilized for recognition of PQ events in real time power system.

## 1. INTRODUCTION

Over the past two decades, power quality issues become the major challenges due to extensive use of nonlinear loads, inverters, rectifiers, energy saving lamps, and adjustable speed drives in industrial, commercial, and domestic applications that cause distortion of supply voltage and current. Hence, Power quality (PQ) disturbance problems that include harmonics, sag with or without harmonics, swell with or without harmonics, spike, oscillatory transient, interruption, flicker and so on leads negative effects such as malfunction of equipment or even failure of sophisticated electronic devices [1]. Hence, identification of accurate PQ disturbances becomes vital and useful for power researchers to manage with the different range of PQ problems such as single and mixed types and demands efficient techniques to avoid harmful effects caused by these events.

**Keywords:** power quality, time-frequency analysis, modified Stockwell Transform, feature selection, Hybrid Grey Wolf Optimization, K Nearest Neighbor classifier

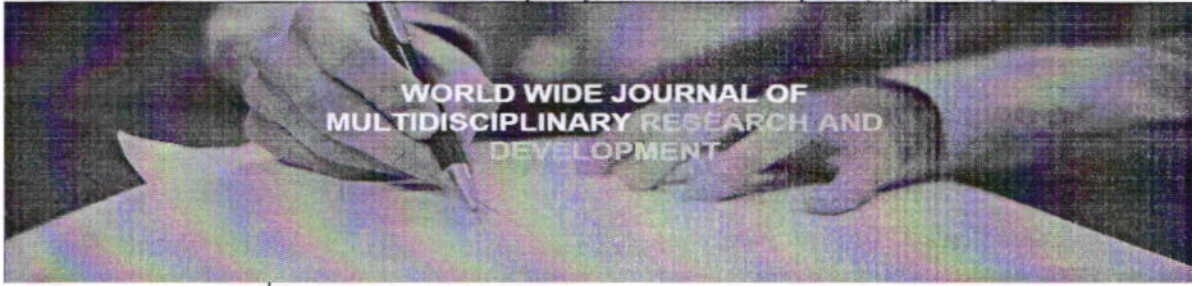
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This article has been corrected with minor changes. These changes do not impact the academic content of the article.

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## A Mathematical Model Explains the Prognostic Influence of C1q Polymorphism on Rituximab Treatment of Nodular Lymphoma

Pushpam Kumar Sinha

### Abstract

A particular monoclonal antibody (mAb) binds to a particular antigen on the target cell, and thereby kills the target cell by direct killing, or by Antibody-dependent Cellular Cytotoxicity (ADCC), or by Complement-dependent Cytotoxicity (CDC), or by Antibody-dependent Cellular Phagocytosis (ADCP). Rituximab is one of the anti-CD20 mABs which has been found to be effective in killing the cancer cells in the patients of Nodular Lymphoma (NL). Three different treatment efficacies of Rituximab have been demonstrated in NL patients in the background of C1q polymorphism: in the background of null C1q Rituximab fails completely, in the background of low levels of C1q protein the patient response is high, and in the background of high levels of C1q protein the patient response is low. Assuming that the killing of the cancerous cells in the patients of NL by Rituximab treatment is CDC dominant, I propose a mathematical model which captures qualitatively the different treatment efficacies of Rituximab in NL patients in the background of C1q polymorphism. I also argue in the end that the killing of the cancerous cells in the patients of NL by Rituximab treatment is perhaps CDC dominant. The purpose of developing the mathematical model in this work has been to show the scientists the way to determine if CDC is the dominant mechanism of killing by Rituximab.

**Keywords:** Monoclonal antibodies; Antigen; Immune cells; Malignant; Complement unit.

### 1. Introduction

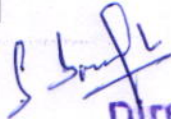
#### 1.1 The biology

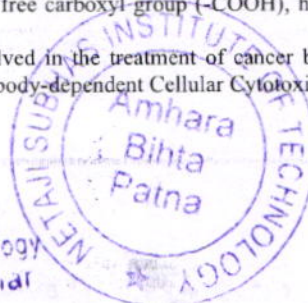
Around the years 1990s monoclonal antibodies mABs were found to be potent treatments/drugs against cancer, and the first such drug to be approved was Rituximab (Zahavi and Weiner 2020; Maloney et al. 1997). The antigen which Rituximab targets is CD20. CD20 is a protein found to be plentifully expressed on the cancerous B cells, otherwise normally expressed on mature B cells but not on immature B cells (Zahavi and Weiner 2020). Hence Rituximab is the drug of choice against Nodular Lymphoma (NL). NL is most popularly known as Follicular Lymphoma (FL). NL/FL is the uncontrolled malignant growth of the certain class of B cells known as centrocytes and centroblasts.

The simplified structure of an antibody is shown in Figure 1 (Chiu et al. 2019; Chailyan et al. 2011). The antibody is basically a multi-chain multi-protein unit also known as immunoglobulin. There are two light chains and two heavy chains, each possessing both the variable regions and the constant regions. The main active part of the antibody lies in the variable region, which binds to the target antigen. There are two such binding regions on a single antibody. That part of the variable region which binds to the target antigen is known as Complementarity Determining Region (CDR), and it comprises 3 loops each from the heavy chain and the light chain (Chailyan et al. 2011). The various fragments Fab, Fv, and Fc of the antibody are also shown in Figure 1. The antigen binding region is terminated by the free amine group (-NH<sub>2</sub>), hence also known as the N-terminal end of antibody. The Fc region of the antibody is terminated by a free carboxyl group (-COOH), hence also known as the C-terminal end of antibody.

The probable mechanisms involved in the treatment of cancer by mABs are direct killing (Zahavi and Weiner 2020), Antibody-dependent Cellular Cytotoxicity (ADCC) (Zahavi and

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RESEARCH ARTICLE

# A Machine Learning Approach to Predict the Performance of Refrigerator and Air Conditioning Using Gaussian Process Regression and Support Vector Methods

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**Abstract:** *Aim:* The aim of this study is to develop machine learning models for the performance of refrigerator and air-conditioning system.

*Background:* The coefficient of performance (COP) of refrigerator and air-conditioning (RAC) is a complex function of evaporative temperature and concentration of nanoparticles in lubricants. In recent years, researchers have focused on experimental studies for the improvement of COP. Further, few researchers have applied simulation techniques such as fuzzy system, artificial neural network (ANN), simulated annealing, etc. to vapour compression refrigeration (VCR) cycle. Though, there is a scarcity of modeling research work for the performance of RAC system.

*Objective:* The study aims to develop the machine learning predictive models for the performance of refrigerator and air-conditioning system using experimental data.

*Methods:* The experiment was performed on VCR system to determine COP. Three different concentrations of lubricants (added 0.5, 1.0 and 1.5 g nano-TiO<sub>2</sub> particle on 1 liter of polyolester (POE) oil) were used. The experimentally calculated COP was used to train and test the machine learning models. Gaussian process regression (GPR) and support vector regression (SVR) methods were applied to develop the models.

*Results:* The experimental result reveals that the COP increases with increasing the concentration (of nano particles) at a given temperature. The addition of 0.5 and 1.0 g TiO<sub>2</sub> in the POE oil shows better rate of increment in the COP in comparison to addition of 1.5 g TiO<sub>2</sub> in the POE oil. Machine learning models using GPR and SVR with RBF kernel function is the most appropriate machine learning model for the nonlinear relationship between the output parameter (COP) and the input parameter (evaporative temperature and concentration of TiO<sub>2</sub>).

*Conclusion:* The present study was conducted to investigate the machine learning approaches for the performance of RAC system using experimental data sets. The experimental result shows that R134a and TiO<sub>2</sub>-POE nano-lubricants work efficiently and the coefficient of performance of VCR system increases with concentration of nanoparticles. The developed model performance is compared using coefficient of correlation and RSME values. After comparison, it is concluded that RBF based GPR model is the best fit machine learning model to predict the COP in the context of any other model for this data set.

**Keywords:** Coefficient of performance, gaussian process, kernel functions, machine learning, nano-lubricants, refrigeration and air-conditioning, support vector.

## 1. INTRODUCTION

In today's world, living and nonliving entities depend on physical environment conditions to a great extent, and the

energy crisis is also increasing day by day. A large amount of electrical energy is consumed by the thermal system like refrigerator and air-conditioning (RAC) system. The higher performance of the RAC system helps to save energy in daily life. The Performance of the RAC system is measured by the coefficient of performance (COP). COP depends on the cooling load in the evaporator and work-done on the compressor. The performance of RAC can be enhanced by either

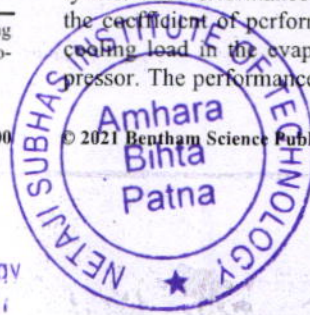
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## RESEARCH ARTICLE

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**Background:** The coefficient of performance (COP) of refrigerator and air-conditioning (RAC) is a complex function of evaporative temperature and concentration of nanoparticles in lubricants. In recent years, researchers have focused on experimental studies for the improvement of COP. Further, few researchers have applied simulation techniques such as fuzzy system, artificial neural network (ANN), simulated annealing, etc. to vapour compression refrigeration (VCR) cycle. Though, there is a scarcity of modeling research work for the performance of RAC system.

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**Methods:** The experiment was performed on VCR system to determine COP. Three different concentrations of lubricants (added 0.5, 1.0 and 1.5 g nano-TiO<sub>2</sub> particle on 1 liter of polyolester (POE) oil) were used. The experimentally calculated COP was used to train and test the machine learning models. Gaussian process regression (GPR) and support vector regression (SVR) methods were applied to develop the models.

**Results:** The experimental result reveals that the COP increases with increasing the concentration (of nano particles) at a given temperature. The addition of 0.5 and 1.0 g TiO<sub>2</sub> in the POE oil shows better rate of increment in the COP in comparison to addition of 1.5 g TiO<sub>2</sub> in the POE oil. Machine learning models using GPR and SVR with RBF kernel function is the most appropriate machine learning model for the nonlinear relationship between the output parameter (COP) and the input parameter (evaporative temperature and concentration of TiO<sub>2</sub>).

**Conclusion:** The present study was conducted to investigate the machine learning approaches for the performance of RAC system using experimental data sets. The experimental result shows that R134a and TiO<sub>2</sub>-POE nano-lubricants work efficiently and the coefficient of performance of VCR system increases with concentration of nanoparticles. The developed model performance is compared using coefficient of correlation and RSME values. After comparison, it is concluded that RBF based GPR model is the best fit machine learning model to predict the COP in the context of any other model for this data set.

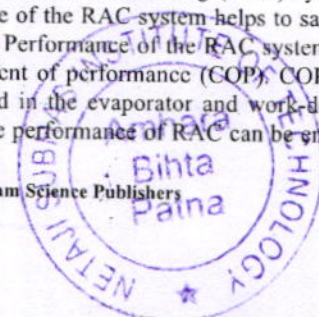
**Keywords:** Coefficient of performance, gaussian process, kernel functions, machine learning, nano-lubricants, refrigeration and air-conditioning, support vector.

## 1. INTRODUCTION

In today's world, living and nonliving entities depend on physical environment conditions to a great extent, and the

energy crisis is also increasing day by day. A large amount of electrical energy is consumed by the thermal system like refrigerator and air-conditioning (RAC) system. The higher performance of the RAC system helps to save energy in daily life. The Performance of the RAC system is measured by the coefficient of performance (COP). COP depends on the cooling load in the evaporator and work done on the compressor. The performance of RAC can be enhanced by either

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## RESEARCH ARTICLE

# A Machine Learning Approach to Predict the Performance of Refrigerator and Air Conditioning Using Gaussian Process Regression and Support Vector Methods

Harinarayan Sharma<sup>1</sup>, Sonam Kumari<sup>2</sup>, Aniket K. Dutt<sup>1</sup>, Pawan Kumar<sup>3,\*</sup> and Mamookho E. Makhatha<sup>3</sup>

<sup>1</sup>Department of Mechanical Engineering, Netaji Subhas Institute of Technology, Bihta, Bihar, India; <sup>2</sup>Department of Computer Science and Engineering, Netaji Subhas Institute of Technology, Bihta, Bihar, India; <sup>3</sup>University of Johannesburg, Faculty of Engineering and the Built Environment, Department of Engineering Metallurgy, John Orr Building, DFC, 25 Louisa St, Doornfontein, Johannesburg, 2028, South Africa

**Abstract:** *Aim:* The aim of this study is to develop machine learning models for the performance of refrigerator and air-conditioning system.

**Background:** The coefficient of performance (COP) of refrigerator and air-conditioning (RAC) is a complex function of evaporative temperature and concentration of nanoparticles in lubricants. In recent years, researchers have focused on experimental studies for the improvement of COP. Further, few researchers have applied simulation techniques such as fuzzy system, artificial neural network (ANN), simulated annealing, etc. to vapour compression refrigeration (VCR) cycle. Though, there is a scarcity of modeling research work for the performance of RAC system.

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## 1. INTRODUCTION

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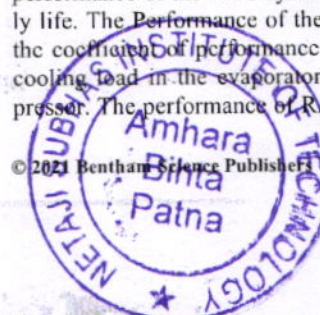
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# Prediction of surface roughness for CNC turning of AISI 1030 steel : A machine learning approach

Authors HARINARAYAN SHARMA, ANKIT SAHAY, SONAM KUMARI, ANIKET K. DUTT

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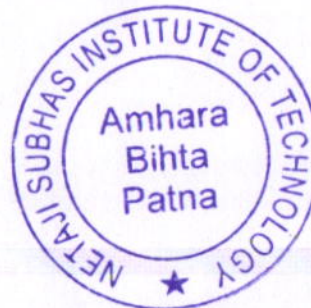
Issue 1-2

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# Prediction of surface roughness for CNC turning of AISI 1030 steel : A machine learning approach

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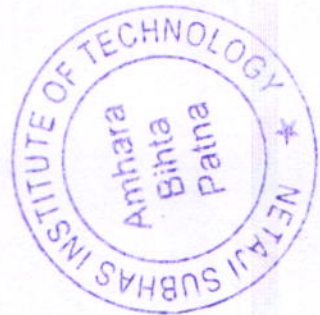
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# Prediction of surface roughness for CNC turning of AISI 1030 steel : A machine learning approach

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# On a weakly $L$ -stable time integration formula coupled with nonstandard finite difference scheme with application to nonlinear parabolic partial differential equations

Mukesh Kumar Rawani<sup>1</sup> | Lajja Verma<sup>2</sup> | Amit Kumar Verma<sup>1</sup> | Ravi P. Agarwal<sup>3</sup>

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In the present paper, we establish an efficient numerical scheme based on weakly  $L$ -stable time integration convergent formula and nonstandard finite difference (NSFD) scheme. We solve Burgers' equation with Dirichlet boundary conditions as well as Neumann boundary conditions. We also solve the Fisher equation. We use Hermite approximation polynomial of order five and backward explicit Taylor's series approximation of order six to derive the numerical integration formula for the initial value problem (IVP)  $y'(t) = g(t, y)$ ,  $y(t_0) = \rho_0$ . We combine this method with the NSFD scheme and convert the problem into the system of algebraic equations. We discuss the convergence, truncation error, and stability of the developed method. To demonstrate the efficiency of the developed method, we compare the numerical results with some existing numerical results and exact solutions.

## KEYWORDS

$A$ -stable, Burgers' equation, Fisher equation, Hermite interpolation, Hopf-Cole transformation,  $L$ -stable, nonstandard finite-difference

## MSC CLASSIFICATION

35K60

## 1 | INTRODUCTION

Consider one-dimensional Burgers' equation with viscous coefficient  $\nu_d$ , given by

$$\frac{\partial \omega}{\partial t} + \omega \frac{\partial \omega}{\partial x} - \frac{\nu_d}{2} \frac{\partial^2 \omega}{\partial x^2} = 0, (x, t) \in \Omega_T, \quad (1.1)$$

where

$$\Omega_T = (\eta_0, \eta_1) \times (0, T],$$

with the initial condition (IC)

$$\omega(x, 0) = f(x), x \in (\eta_0, \eta_1), \quad (1.2)$$

and the Dirichlet boundary conditions (BCs)

$$\omega(\eta_\ell, t) = 0, \ell = 0, 1, \forall t \in (0, T], \quad (1.3)$$

## Optimization of Test Procedure for Simulation of Paper Laminate in Axial Loading Conditions Using FRANC2D and CASCA

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Srijan Sengupta<sup>4,d</sup>, A.K. Dutt<sup>5,e</sup> and M.E. Makhatha<sup>1,f</sup>

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**Keywords:** paper laminate, plastic bags, finite element methods, stress contour

**Abstract.** In present investigation, an attempt was made to optimise the peak stress for paper laminate composite using FRANC2D software. It was observed that the laminate having the triangular geometry supposed to be most appropriate as it has the lowest value of peak stress contour compared to other models like parallel strip, up-down tapered and down-up tapered. The minimum peak stress was observed for the samples having triangular geometry while the maximum was observed for down-up tapered samples. Therefore, the hypothesis adopted to use in-built materials with variables reinforcement area and strip geometry and length in the FRANC2D software to optimize the sample geometry and then apply it to the paper laminate by considering its mechanical properties might be use to optimize the peak stress of paper laminate composite in tensile loading conditions. It was also observed a length of one-quarter of the length of the plane strip, might be the optimum length of the paper laminate samples. However, it feels that, the above model can be further modified considering a more significant mechanical properties as well as different sample geometries.

### Introduction

Single-use plastic bags have wider applications in local markets such as grocery stores, vegetable stores, supermarkets, etc. These bags are cost-effective, strong lightweight, and easy to use. Even though they have good features/properties in terms of application, the government is banning plastic bags. This is primarily because of the hazardous effect associated with plastic bags [1-3]. The single-use plastic bags are mainly prepared using high-density polyethylene (HDPE), which makes it hazardous to disposal in the environment [4-7]. The plastics bags found to be degrading and pollution aquatic life, animals, and soil pollution [8]. These bags are non-biodegradable and dumping these in dump yards or open environment release much toxic gas/liquid to the environment, also called white pollution. Additionally, there is a problem with blockage and clogging of drains [9-11]. The first world countries started using bio-degradable plastic for general purpose. Biodegradable plastic has an advantage as it degrades and does not hamper the environment. But, the cost of biodegradable plastic bags is very high, which limits their usage in India and other third world countries [12-15]. To overcome this inverse challenge, India has resurged traditional paper bags as an option. These paper bags can be a potential substitute for single-use plastic bags from grocery stores to supermarkets. The raw materials can be extracted



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## Restoration Mechanism and Sub-Structural Characteristics of Duplex Stainless Steel with an Initial Equiaxed Austenite Morphology during Post-Deformation Annealing

Pawan Kumar<sup>1,a\*</sup>, Peter Hodgson<sup>2,b</sup>, Hossein Beladi<sup>2,c</sup>,  
Amit Roy Chowdhury<sup>3,d</sup>, M.E. Makhatha<sup>1,e</sup> and A.K. Dutt<sup>4,f</sup>

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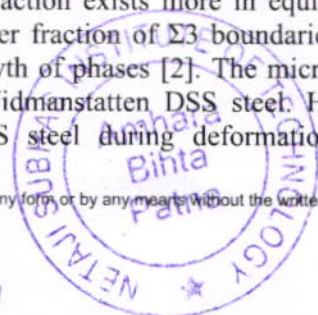
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**Keywords:** uni axial compression, post deformation annealing, restoration mechanism, substructure, misorientation.

**Abstract.** Uni-axial compression (UAC) tests and further post deformation annealing (PDA) were done for 23Cr-6Ni-3Mo duplex stainless steel (DSS). The initial morphology was equiaxed (EQ) in nature. In the first stage of PDA, austenite showed limited static recrystallization (SRX) followed by static recovery (SRV); however ferrite showed static recovery (SRV). In the second stage of PDA, the austenite showed grain coarsening followed by disintegration of substructures (DIS); and ferrite revealed mostly SRV leading to grain coarsening. The third stage of PDA envisages substructural disintegration of unstable substructure leading to saturation in both austenite and ferrite. The substructural characteristics were provided by Electron backscattered diffraction (EBSD) and its post processing were done by using HKL Channel 5 software.

### Introduction

Duplex stainless steel (DSS) consists of two separate phases namely austenitic and ferritic phases, which makes its application wide for structural purposes. The duplex nature exists in DSS due to the presence of a two-phase ferritic and austenitic stainless steel microstructure. In our last research work on 23Cr-6Ni-3Mo duplex steel, we reported the restoration mechanism and structural characteristics during post deformation annealing [1]. We studied the Widmanstätten austenite morphology in the previous work [1]. Here, in current research work, we studied the restoration mechanism and substructural characteristics during post deformation annealing (PDA) of equiaxed (EQ) austenite in DSS steel. The ferrite/austenite properties of equiaxed austenite DSS steel are difficult from Widmanstätten austenite DSS steel [2]. The restoration mechanism during post deformation annealing could be strain partitioning of austenite and ferrite phases of DSS steel. At inter-phase boundary nucleation sites, static recrystallization (SRX)/meta-dynamic recrystallization (MDRX) may occur during post deformation annealing. These nucleation sites of inter-phase boundary affect the strain partitioning and in result microstructure significantly. Few researchers have found that role of the interphase boundary becomes significant during the bulging recrystallization mechanism [3-7]. The  $\Sigma 3$  boundaries fraction exists more in equiaxed austenite DSS steel compared to Widmanstätten steel [2]. A higher fraction of  $\Sigma 3$  boundaries in equiaxed steel is ascribed to a different mode of kinetics and growth of phases [2]. The microstructure and restoration mechanism is different for equiaxed and Widmanstätten DSS steel. Haghdadi et al investigated the dynamic restoration of equiaxed DSS steel during deformation at elevated



## THE IMPACT OF ARABIC LANGUAGE ON HINDI: AN INVESTIGATION

**S. HASAN IMAM ARSHI**

Research Scholar  
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Magadh University, Bodh-Gaya.

### ABSTRACT:

*Borrowing is a common phenomenon found in every language. We find that every language has a cluster of words borrowed from different languages of the world. The main reason of borrowing is the close contact due to business visits or invasion. There are plenty of words found in Hindi, whose origin are Arabic. In day-to-day speech, we find that fifty percent of Arabic words are used freely. It is not used only by the Muslim population of India only, but by the rest and every section of India. The reason behind that the Muslim religious scholars, businessmen and rulers visited India for a long time. Now these days, students of middle east come to India for higher education and due to their contact we use many Arabic words freely. I was also a student of Arabic in Jamia Islamia, Saharanpur during my study. I have learnt so many Arabic words which we use commonly as Hindi. Another reason is that the Mughal rulers ruled over India for a long time and during their rule they use and spread Arabic words. In ancient times, the Arab visited India for business purpose. Due to their interactions, a lot of Arabic words were mixed with Hindi and later on they became Hindi. With the help of this paper, an attempt has been made to find out the possibilities of borrowings and usage of Arabic word in Hindi, since, the arrival of Arabs in eighth century till the present time.*

**Key words:** borrowings, Arabic language, Muslim scholars, Influence of Arabic, Mughals

### 1. INTRODUCTION

Borrowing means words are taken from one language to another language. In this concern, Crystal states that, "A term used in comparative and historical Linguistics to refer to a linguistic form taken over by one language or dialect from another". (Crystal, 58). Borrowing is very common in the modern languages such as English, Urdu and Hindi. As we know that India is large country in which different cultures are found. Due to this many languages are spoken. History has shown that India has always kept its doors open for people and cultures across the world. India had a close interaction with the Arab world from the ancient time. As an observation they came to our country in the early part of eighth century. Arabs visited India regularly for the commercial purposes, before the advent of Islam. Regular visits introduced Indian language, culture and civilization to the Arab world. This is the result of inter-cultural dialogues exchange between two grand civilizations. As we know that civilization is the collection of lived practices that enables a society to make sense of its existence. In the 11<sup>th</sup> century, most part of northern India was ruled by the rulers of different countries. From 1526 to 1856, Mughals ruled over India; the language of the Mughal court was Persian and so on. This is the main reason of the existence of language of common man in the northern part of India.

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# Prediction of the Propagation of Fatigue Cracks in Part-Through Cracked Pipes with CASCA and FRANC2D

Pawan Kumar<sup>1</sup> · Mamookho Elizabeth Makhatha<sup>1</sup> · Srijan Sengupta<sup>2</sup> · Aniket Kumar Dutt<sup>3</sup>

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**Abstract** The pipes are subjected to different load conditions such as internal stress, compression, tension, bending and/or any combination thereof. These various types of load conditions induce new cracks and/or cause propagation of the existing cracks. In this study, a TP316L stainless steel pipe subjected to four-point bend testing was examined to predict the propagation of fatigue cracks in a part-through cracked pipe using the CASCA and FRANC2D programs. Two different methods based on “rigidity” and “stress intensity factor” have been proposed for converting a three-dimensional pipe into a two-dimensional beam for modeling.

**Keywords** Partially cracked pipes · Fatigue crack propagation · Four-point bending test · Stress intensity factor

## 1 Introduction

Pipes are commonly used in factories and in industries such as heat transfer in nuclear power plants and gas transportation. The growth of fatigue cracks that predict the existing surface defects is important in determining the criteria for

acceptability of defects. Many researchers have studied the nature of cracks under various loading conditions and the fatigue failure of pipes with surface and other defects [1–7]. There are many constructive ways to investigate fatigue cracks in advanced structural elements, but these methods are naturally destructive and time-consuming [8–15]. To solve these problems, many analytical methods have been proposed based on fracture mechanics and finite element methods [8, 9]. Three-dimensional analysis of local cracks in pipes requires a lot of computational work to get the correct grid pattern and huge storage space on a computer. In this study, two different methods were proposed for predicting the fatigue crack growth behavior of TP316L stainless steel pipe in a two-dimensional growth simulator on its outer surface. In the first method, the task of a three-dimensional pipe was transformed into the problem of a two-dimensional beam by deflecting the pipe at four points equal to the curvature of the beam. However, in the second method, stress intensity factors in the beams and pipes used for the four-point bend test were absorbed. Then, using the CASCA grid generator program and the FRANC2D-based crack expansion simulation program, crack propagation simulations on beam sizes obtained by two methods were performed.

## 2 Materials and Methods

The alloy used in the present investigation was TP316L stainless steel. The chemical composition of the material is presented in Table 1. The tensile properties of flat specimens fabricated from straight pipe were determined as per ASTM E8 standards and are shown in Table 2. Prediction of the propagation of fatigue cracks in partially cracked pipes using the gamma function and exponential model were reported in an earlier work by Kumar et al. [8, 9]. The

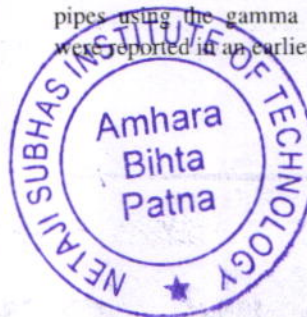
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Review

# A Review on a Class of Second Order Nonlinear Singular BVPs

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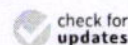
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† Amit K. Verma dedicates this review to supervisor Prof. Rajni Kant Pandey, IIT Kharagpur.

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**Abstract:** Several real-life problems are modeled by nonlinear singular differential equations. In this article, we study a class of nonlinear singular differential equations, explore its various aspects, and provide a detailed literature survey. Nonlinear singular differential equations are not easy to solve and their exact solution does not exist in most cases. Since the exact solution does not exist, it is natural to look for the existence of the analytical solution and numerical solution. In this survey, we focus on both aspects of nonlinear singular boundary value problems (SBVPs) and cover different analytical and numerical techniques which are developed to deal with a class of nonlinear singular differential equations  $-(p(x)y'(x))' = q(x)f(x, y, py')$  for  $x \in (0, b)$ , subject to suitable initial and boundary conditions. The monotone iterative technique has also been briefed as it gained a lot of attention during the last two decades and it has been merged with most of the other existing techniques. A list of SBVPs is also provided which will be of great help to researchers working in this area.

**Keywords:** review; nonlinear; singular; boundary value problems; Lane–Emden; Sturm–Liouville

**MSC:** 34B05; 34B10; 34B15; 34B16; 34B18; 34B24; 34B27

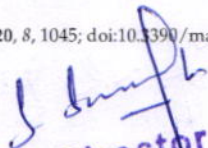
## 1. Introduction

The analysis of many important problems in science and engineering requires the solution of nonlinear singular differential equations. In the last few decades, several researchers explored the properties of solutions of nonlinear singular differential equations, and different methods like shooting method, nonlinear alternative, and upper-lower solution technique, etc. have been utilized. Difficulties arise when we deal with nonlinear singular boundary value problems (BVPs). The aim of this survey is to explore properties of nonlinear singular differential equations subject to certain initial and boundary conditions. First of all, we classify singularities and their occurrence in practical applications.

Consider the following general linear homogeneous differential equation of order 2

$$P(x)y''(x) + Q(x)y'(x) + R(x)y(x) = 0, \tag{1}$$

where  $P(x)$ ,  $Q(x)$ , and  $R(x)$  are continuous. A point on which we wish to study the properties of solutions of a differential equation (DE) may be classified depending on the behavior of  $P(x)$ ,  $Q(x)$ , and  $R(x)$  around that point.

  
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