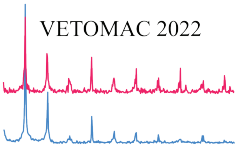

VETOMAC 2022

DEC 15-17, 2022

Department of Mechanical and Aerospace Engineering (DMAE), IOE Pulchowk

17th International Conference on
Vibration Engineering and Technology of Machinery

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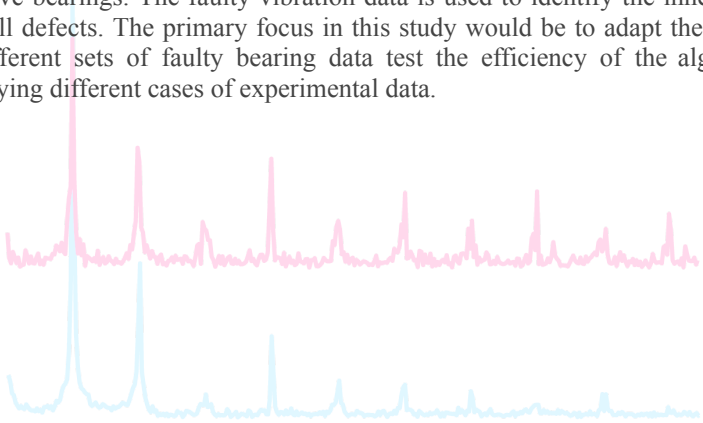
Paper No. 004 **Title:**

SIGNAL BASED CONDITION MONITORING OF ROLLING ELEMENT BEARINGS WITH DEFECTS

1) **Shravan Kumar Chandrsekaran***
2) **Rabindra Sah**

Abstract

Bearing is a crucial component when it comes to radial support and axial support for a rotating component. One simple defect induced inside the bearing can bring the working efficiency of a system down and sometimes the failure of the entire system. So continuous monitoring of such components is a serious concern to make sure that the fault is detected before the bad happens. In this paper, a signal-based identification algorithm based on advanced signal processing methods is used to analyze experimentally acquired benchmark data from defective bearings. The faulty vibration data is used to identify the inner raceway and ball defects. The primary focus in this study would be to adapt the algorithm for different sets of faulty bearing data test the efficiency of the algorithm in identifying different cases of experimental data.



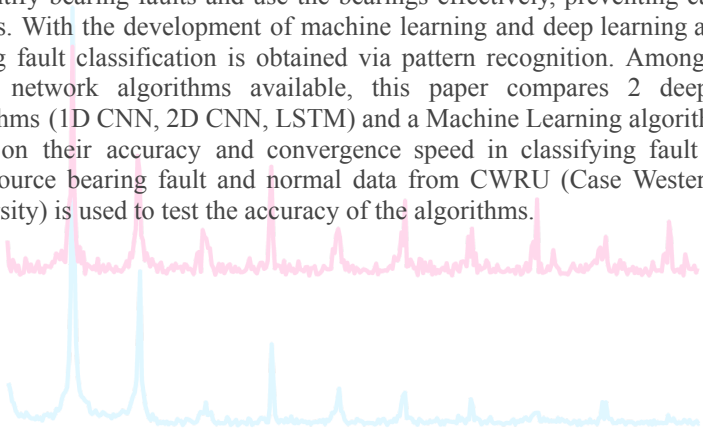
Paper No. 005 **Title:**

COMPARATIVE ANALYSIS OF VARIOUS MACHINE LEARNING AND DEEP LEARNING APPROACHES FOR BALL BEARINGS USING CASE WESTERN RESERVE UNIVERSITY DATASET.

1) **Mikesh Paudel**
2) **Sumit Bhatta**
3) **Sushil Sapkota**
4) **Aayush Bhattarai***

Abstract

Failure of ball bearings is a major cause of rotatory machine failure resulting in large economic losses and possible injury to human lives. Correct diagnosis helps to identify bearing faults and use the bearings effectively, preventing catastrophic failures. With the development of machine learning and deep learning algorithms, bearing fault classification is obtained via pattern recognition. Among the many neural network algorithms available, this paper compares 2 deep learning algorithms (1D CNN, 2D CNN, LSTM) and a Machine Learning algorithm (SVM) based on their accuracy and convergence speed in classifying fault data. The open-source bearing fault and normal data from CWRU (Case Western Reserve University) is used to test the accuracy of the algorithms.



Paper No. 010 **Title:**

PERFORMANCE ANALYSIS OF GRAVITATIONAL WATER VORTEX POWER PLANT WITH SPIRAL-CONICAL BASIN AND PROSPECTS OF INSTALLATION OF STAY VANES

1) **Prof. Dr. Tri Ratna Bajracharya**
2) **Reban Niraula***
3) **Ashesh Babu Timilsina**
4) **Manish Lama**
5) **Bhaskar Rasaily**
6) **Prajaya Pathak**

Abstract

Misalignment is the most prevalent cause of vibration in rotating machines and usually occurs in the combination of parallel and angular misalignments. Vibration due to this can damage essential components of the rotor system, such as the bearings, seals, gears, and couplings. The novelty of the work lies in the comparative analysis and vibration control of a residually bowed rotor system subjected to parallel, angular, and combined misalignments. The experimental set-up of a rotor-train system supported on rolling bearings equipped with the active magnetic bearing (AMB) has been developed, and the influence of residual bow at slow speed and varied types of misalignments in a flexible coupling is explored. Using an AMB close to the disc on the output rotor introduces an innovative approach to reducing vibrations. An electromagnetic actuator is built to create controlled forces in two orthogonal directions, and the transverse vibration is suppressed to a significant level using a feedforward PID controller. Misalignments are introduced by placing stainless steel pre-cut shims of various thicknesses below the bearing blocks of unknown residually wrapped-output rotor. The experiments were carried out by varying the rotating speed, and then the displacement and current signatures were captured utilizing the proximity and current probes, respectively. The present work uses a full spectrum to assess the misalignment by displaying distinctive vibration features (i.e., the forward and backward whirls). The findings suggest that the proposed experimental analysis for misalignment diagnosis in rotor systems equipped with AMB has a lot of potential to identify the type of misalignment and control of vibration.

Paper No. 011 **Title:**

CFX ANALYSIS TO STUDY THE EFFECTS OF BLADE EXIT ANGLE ON PERFORMANCE OF THE CENTRIFUGAL PUMP

1) **Janu Kumar Sah***
2) **Ishan Ghimire**
3) **Badal Tamang**
4) **Neeraj Adhikari***

Abstract

Modification in impeller geometry is an effective way to improve the performance of the centrifugal pump. Blade exit angle plays an important role in the performance of the pump. This paper presents the design and analysis of a centrifugal pump impeller and investigates the effect of blade exit angle on the impeller performance completely using the features available in ANSYS. Vista CPD is used to calculate the impeller and volute geometry for a pump with the head of 16 m, discharge rate of 0.2 m3/min (0.0033 m3/s) and rotational speed of 3000 rpm. A 3D model of the impeller is created using BladeGen and the impeller is meshed using TurboGrid. Then, CFX analysis is carried out in turbomode. Finally, parameterization technique is used to generate head-flow, total efficiency-flow and power-flow characteristic curves. This process is repeated for 6 different blade exit angles. The results show that the head and the shaft power increases as blade exit angle increases, significantly at higher flow rates. The blade exit angle does not have significant impact on the efficiency though.

Paper No. 012 **Title:**

COMBUSTION AND WAKE INSTABILITIES IN OBLIQUE DETONATION WAVES INDUCED BY BLUNT BODIES.

1) **Sanjeev Adhikari***
2) **Hao Tang**
3) **Sudip Bhattrai***

Abstract

Oblique detonation waves (ODW) forming over blunted geometries have widespread applications in high-speed air-breathing propulsion systems. They show intrinsically unsteady behavior arising from the shock-induced combustion, weak detonation waves, or region of shock-shock interaction that forms along the centerline of the domain. Such instabilities can occur both at the leading edge and aft of the normal wall of the blunted geometry. It can affect the transient output performance of the ODW engine. In particular, the aeroelasticity of the wedge can lead to an off-design operation of the combustor. The aeroelastic deformation are dependent on the material properties of the initiating wedge, as well as the transient of the flow field. To investigate such behavior, we performed a numerical analysis using an in-house solver written in OpenFOAM, while aeroelastic deformation were computed from ANSYS. Euler governing equations for compressible reacting flow were solved in OpenFOAM for two-dimensional and axisymmetric geometries. Notably, fluctuations at the blunted region due to shock-induced combustion or weak detonation waves were observed for a low inlet Mach number near the CJ Mach number. It was observed inherently for all Mach numbers due to shock-shock interactions at the wake region. The solver's capability to measure the unsteadiness of detonation waves was validated with the oscillation frequencies of the under-driven ODW obtained from Lehr's (Lehr 1972) experiment over a blunted body at Mach 4.18, which is near the CJ Mach number. Subsequently, the frequency of this unsteadiness over a blunted wedge geometry is investigated, and a correlation with the output performance is presented. The paper also investigates the scope of performing one-way loosely-coupled aeroelastic simulations during the design of the combustor.

Paper No. 016 **Title:**

MATHEMATICAL SIMULATION OF VIBRATION SIGNATURE OF THE DEFECTIVE BEARING ELEMENT

1) **Shravankumar Chandrasekaran***
2) **Prabu J**
3) **Jegadeesan K**
4) **T V V L N Rao***

Abstract

Rolling element bearings are used for power transmission as they carry the load by rolling elements between their raceway components. Bearing is the most essential part of rotating machinery as any fault in it can lead to the sudden failure of the machines. Earlier identification of fault may help in the prevention of the breakdown of machinery. Thus, condition monitoring helps to identify the defect in any component at an early stage. The defective bearing generates vibration and these signals of vibrations are used to diagnose bearings effectively. Vibration-based condition monitoring is an effective method that is widely used by researchers to predict the vibration response of the component. In this paper, a mathematical model of the bearing with the localized defect in its raceway subjected to an external load is developed and the vibration response is obtained. When the ball impacts the defect, the vibration signals are generated and are processed with Fast Fourier Transform of the enveloped signal obtained using Hilbert Transform of the vibration response. Numerical simulations are performed for the rolling element bearing using MATLAB environment for the diagnosis of the fault.

Paper No. 018 **Title:**

UNSTEADY NUMERICAL ANALYSIS OF TRANSONIC BUFFETING OVER SUPERCRITICAL AIRFOIL

1) **Spad Acharya***
2) **Sudip Bhattrai***
3) **Laxman Poudel**

Abstract

The interaction between the shock wave and the turbulent boundary layer in a transonic flow can create large-scale flow instability, also known as transonic buffeting. This self-sustaining shock oscillation occurs over a range of Mach numbers and angles of attack. The shock oscillates at a certain frequency called buffeting frequency. It generates pressure and lift fluctuations, limiting civil aircraft's flight envelope. The transient oscillations can also lead to complex aeroelastic characteristics of the wing surfaces. It can also impact aircraft's structural components, and may even lead to the destruction of wings or turbomachine blades. This research aims to investigate the effects of buffeting on a supercritical airfoil using computational methods. This research focuses on solving compressible, transonic, and turbulent flows over a Whitcomb integral supercritical airfoil using OpenFOAM. The rhoPimpleFoam solver, which uses the combined PISO and SIMPLE (PIMPLE) algorithm, is used to solve the transonic flow. The flow conditions are set at a range of transonic Mach numbers conducive to the occurrence of the buffeting, and the airfoil is set at a range of angle of attacks from 0° to 15°. The transonic flow is also studied in the oscillating airfoil. The impacts of buffeting on aerodynamic characteristics due to these shock oscillations are studied to attain proper insight into the buffeting phenomenon. Fluctuations in pressure, Mach Number, and aerodynamic forces are investigated. The relation of flow separation to shock oscillation is studied.

Paper No. 021

Title:

ASSESSMENT OF THE IMPACT OF BLAST WAVE ON SUBVERTICAL GEOGRAPHICAL TERRIAN USING NUMERICAL TECHNIQUES

1) **Siddhartha Paudel***
2) **Sudip Bhattrai***
3) **Kamal Paudel**

Abstract

Ammonium nitrate (NH4NO3) is a perilous and highly explosive material. The improper handling of NH4NO3 and a hazardous storing environment might become a source of explosion. The study of explosion scenarios and propagation of blast wave, and their impact on the surrounding environment is an ongoing field of numerical study. Recent case of NH4NO3 explosion in Beirut has raised concerned about the adequacy of criteria for storage and safety practices and has garnered interest to numerically study the explosion scenarios. The experimental analysis of blast wave after explosion and consequences of the propagation of blast wave on the environment is a challenging and costly study to undertake. This hinders large-scale experimental studies of such phenomena and is also a hazard to the environment. The current study focusses on the assessment of the impact of blast wave from an ammonium nitrate explosion on the subvertical geographical terrain using numerical techniques. The numerical study is performed in OpenFOAM using blastFoam as a solver. The terrain geometry is extracted from the open-source digital elevation model data sets. The meshing of the domain is performed using snappyHexMesh, which can handle the complexity of the terrain geometry. This study informs the assessment of hazard scenarios associated with the explosion and propagation of blast waves. In addition, reduction in strength of the blast wave caused by the terrain can also be assessed. For M20 and M30 concrete, the stress generated by the overpressure can withstand upto 3.1305 Mpa and 3.8340 Mpa respectively and beyond these stress the building cannot resist and start to crack. The current study can assist in setting the recommended practices for selection of the location of storage facilities and the associated measures.

Paper No. **Title:**

022 OPTIMIZATION OF NOISE IMPACT ON WHEELED MOBILE ROBOT BY MONTE CARLO SIMULATION METHOD.

1) **Mahesh Isher***
2) **Ramchandra Sapkota**
3) **Sanjeev Maharjan**

Abstract

Noise impacts due to various wheel-terrain interactions on wheeled mobile robot creates adverse situation in case of navigation on rough terrain. It is challenging to maintain robustness towards force distribution on wheels such that vehicle should not tip-over. Forces experienced by wheels must be recorded as a database and those further processed for probability distribution of a continuous variable. In this paper drawbar pull of the vehicle and power input of motor imbedded in it are considered as major variable to be controlled for minimum power consumption with optimum traction. Monte Carlo methods are employed for estimating a probability distribution of a system's output response from uncertain input parameters. Power and drawbar pull have been optimized to get better solution for stability of the vehicle with the application of Monte Carlo simulation techniques which gives mobility prediction that incorporates terrain uncertainty to navigate vehicle safely. An evaluation function designed with the data received has been further taken as input for noise strength.

Paper No. 023 **Title:**

STUDY OF PRESSURE PULSATIONS OF A FRANCIS TURBINE DUE TO ERODED GUIDE VANES.

1) **Kushal Shrestha***
2) **Ravi Poudel***
3) **Suprim Shrestha**
4) **Bhola Thapa**
5) **Zhongdong Qiao**
6) **Zhiwei Guo**
7) **Shailesh Chitrakar**

Abstract

Erosion caused by the interaction of sediment particles with the turbine materials hamper the efficient production of electricity, but its effect can also be seen on the structural integrity of the turbine. In this study, the effect of erosion has been studied in terms of the additional pressure pulsations caused by the deteriorated geometry of the turbine component. The scanned eroded profile of a guide vane at Jhimruk Hydroelectric Center has been used for a CFD analysis including runner blade passage. A RANS based numerical model is prepared for a domain with two runners and three guide vanes. The boundary conditions are corresponding to the design conditions of the turbine, which are referred from previous studies. Comparing the results with the reference (non-eroded) case, it has been found that erosion in the clearance gaps of the guide vanes contribute to higher amplitude of Rotor Stator Interaction (RSI) pulsations, resulting in the vibration of turbine components. The results obtained from this study are expected to produce more realistic values of the pressure signals compared to previous studies, where the uniform erosion pattern was considered.

Paper No. 024 **Title:**

THEORETICAL INVESTIGATIONS ON A TUNABLE LINEAR PIEZOELECTRIC VIBRATION ENERGY HARVESTER

1) **Gokul R***
2) **Santhosh B***
3) **Ashesh Saha**

Abstract

Erosion caused by the interaction of sediment particles with the turbine materials hamper the efficient production of electricity, but its effect can also be seen on the structural integrity of the turbine. In this study, the effect of erosion has been studied in terms of the additional pressure pulsations caused by the deteriorated geometry of the turbine component. The scanned eroded profile of a guide vane at Jhimruk Hydroelectric Center has been used for a CFD analysis including runner blade passage. A RANS based numerical model is prepared for a domain with two runners and three guide vanes. The boundary conditions are corresponding to the design conditions of the turbine, which are referred from previous studies. Comparing the results with the reference (non-eroded) case, it has been found that erosion in the clearance gaps of the guide vanes contribute to higher amplitude of Rotor Stator Interaction (RSI) pulsations, resulting in the vibration of turbine components. The results obtained from this study are expected to produce more realistic values of the pressure signals compared to previous studies, where the uniform erosion pattern was considered.

Paper No. 025

Title:

DYNAMIC CHARACTERISTICS AND FLYING QUALITY ASSESSMENT OF A TWIN-BOOM FIXED-WING

1) **Ashish Karki***
2) **Sudip Bhattrai***
3) **Kamal Darlami**

Abstract

This article presents the study of the dynamic characteristics of a twin-boom unmanned aerial systems (UAS) with an inverted V-Tail configuration to assess its flying and handling quality. The UAS discussed in this article is an aircraft developed at Institute of Engineering (IOE), that mainly serves as a test platform for conducting aerial experiments. The maximum takeoff weight of the UAS is 11.8 kg with a wing span of 2.5 m. The UAS model was created in XFLR5 to calculate the state space matrix in the longitudinal and lateral direction. The characteristic roots of the state matrix represent the dynamic modes of oscillation of the aircraft. The flying quality of the UAS is also directly correlated with these dynamic modes, determined based on the damping and frequency of the oscillation that the UAS goes through while negating the disturbances. An aircraft model developed in X-Plane 11 simulator allowed to simulate flight in different flying conditions in a virtual environment. The dynamic modes of the aircraft are induced manually through the control stick input. The flight simulation in X-Plane 11 environment provides the qualitative and quantitative visualization of the dynamic characteristics of the UAS. The simulator also allowed to continuously record the performance and stability parameters, which, upon post-processing was used to assess the dynamic behavior of the aircraft. The characterization of the UAS informs the potential tests that can be performed using it as an aerial platform. This can also help ensure that the UAS characteristics are not closely correlated to the sensor data, to ensure the reliability and processability of the in situ measurements.

Paper No. 031 **Title:**

PHASE FIELD MODELING FOR FRACTURE MECHANICS APPLICATIONS

1) **P.C Sidharth***
2) **B.N. Rao**

Abstract

In the recent decade, there has been a growing interest in using the approach of phase-field to model fracture processes in various materials. Complex fracture phenomena such as crack initiation, branching, and coalescence are adequately described by the method without the use of any ad-hoc criterion. The method is getting increasingly popular, thanks to the easiness of implementation in cracks of complex topologies, especially in three dimensions. However, Conventional phase-field implementations simulate fracture processes using bi-linear finite element shape functions but at the expense of a very fine mesh. In contrast, exponential finite element (EFE) shape functions are able to predict sharp gradients in solution variables with coarse meshes due to their exponential nature. The ability to reduce the number of elements in the problem without sacrificing solution accuracy offers a possible benefit. In this study, crack predictions in two paradigmatic examples using automatically oriented exponential finite element shape functions are investigated in detail. Computational advantages are reported in terms of a reduction in the number of elements required and a weaker restriction on the length scale parameter.

Paper No. 035 **Title:**

NUMERICAL STUDY IN STRAIGHT-THROUGH, STAGGERED AND STEPPED LABYRINTH SEALS OF FRANCIS TURBINES

1) **Mamata Rijal***
2) **Ravi Poudel***
3) **Hari Prasad Neupane**
4) **Ole Gunnar Dahlung**
5) **Sailesh Chitrakar**
6) **Aasma Bhattarai**

Abstract

Labyrinth seals are primary non-contact seals between runner and turbine covers. They are used to achieve water tightness to reduce turbomachinery losses and consequently increase output power and efficiency. The labyrinth consists of two parts, a static seal connected to turbine covers and a rotating part connected to the runner. The labyrinth gap is small for a new turbine and leakage is low. Leakage increases with an increase in the gap due to wear in the seal. For the sake of simplicity of construction of numerical models, labyrinths geometry in Francis turbines is usually not included in a numerical model. This leads to the inaccurate prediction of turbine efficiency. This paper encompasses the numerical study carried out in labyrinth seals of Francis turbine of Jhimruk Hydropower Plant. As the flow conditions strongly influence the performance of labyrinth seals, flow in the two-dimensional geometry of different labyrinth seals like straight through, stepped and staggered have been investigated numerically. The numerical models were constructed with a structured grid using ICEM CFD. Also, the Grid Convergence Index (GCI) for the mesh was calculated. ANSYS Fluent has been used as a flow solver for a steady-state flow analysis with water as a working fluid. Furthermore, the dynamic characteristics of different labyrinth seals like stiffness, and damping have been studied using the transient simulation method. The pressure distribution, velocity vectors, turbulence vortices along with dynamic performances of the seals suggested that straight-through labyrinth seals have better sealing performance in Francis turbines.

Paper No. 040

Title:

STUDY ON THE EFFECT OF LATERAL-TORSIONAL COUPLING ON THE DYNAMIC VIBRATIONAL CHARACTERSTICS OF FLEXIBLE ROTATING CANTILIVER SHAFT-DISK SYSTEM

1) **Sandip Ghimire***
2) **Amrit Tiwari***
3) **Tri Ratna Bajracharya**
4) **Mahesh Chandra Luitel***

Abstract

The bending and torsional vibration concurrently exists in a rotating cantilever shaft disk system and furthermore the combined outcome of lateral and torsional vibration is a potential reason of system failure, necessitating its investigation to assist prevent future failures. Mathematical modeling of system is done by applying Lagrange's equation. Assumed mode method is used to discretize the partial differential equation. The governing equation for lateral vibration mode was found to be of linear 2nd order whereas for the coupled lateral-vibration model nonlinearity terms were introduced. A system parameter of overhung Pelton turbine was considered for the analysis. ODE solver based on Runge Kutta was used to solve the discretized equation. It has been found that the inclusion of coupled torsional-lateral effect has induced some substantial behavior on dynamic vibrational characteristic of the system.

Paper No. 041 **Title:**

EXPERIMENTAL STUDY OF CHARACTERISTICS SIGNALS PRODUCED IN FRANCIS TURBINES EXPOSED TO EROSIVE ENVIRONMENT

1) **Ravi Poudel***
2) **Aman Kapali**
3) **Bhola Thapa**
4) **Qian Zhongdon**
5) **Guo Zhiwei**
6) **Prajwal Sapkota***
7) **Sailesh Chitrakar***

Abstract

Vibration and pressure pulsations induced due to the eroded geometry of guide vanes and runner blades cause adverse effects to the efficiency and stability of the system. This research encompasses the experimental study of 2 KW Francis model runner in the Francis runner test rig available at Turbine Testing Laboratory. The model runner was tested in the rig with provision being made for sediment injection. Sediments with size less than 500 microns were used with concentration maintained within the range of 4072 - 15766 PPM. With gradual progression in the erosion of the runner, the signals from pressure sensor and torque transducer were recorded. With changes in the profile of runner blades and guide vanes due to erosion, there were changes in the pressure signals which were recorded and analyzed with respect to time. Rotor Stator Interaction excites the model turbine, and the mechanical response are taken by the pressure sensors mounted in the spiral casing, draft tube, and guide vanes. The measurements were made for output power, pressure at different sections (inlet, midspan and outlet) of spiral casing and draft tube (left and right side of cone). Pressure signals mounted in draft tube cone were recorded and evaluated by plotting them against the rotational position of the runner. It is observed that there is increase in pressure pulsations with increase in erosion of the runner. At 500 rpm distinct downward shift in the average pressure values were observed.

Paper No. 042 **Title:**

DYNAMIC MODELLING AND RESPONSE OF A PELTON BUCKET

1) **Amrit Tiwari***
2) **Mahesh Chandra Luintel***
3) **Sandip Ghimire***
4) **Bir Bahadur Chaudhary***

Abstract

The study of rotating cantilever beam has a wide range of practical engineering applications, including turbine blades, aircraft wings, etc. From the literature review, it was perceived that the research works lack the use of a rotating cantilever beam model for the vibrational study of a bucket of the Pelton turbine. This research work focuses the study of vibrational characteristics of a single bucket in the Pelton turbine under the action of jet force considering it as a rotating cantilever beam. The potential and kinetic energy are determined to obtain the mathematical model. Hamilton's principle is used to construct the governing equations for Cartesian deformation variables which include axial, and transverse deformations. Coriolis and Centrifugal Effects are indulged automatically, rather than the aid of ad hoc provisions. The dynamic force imparted by water jet is modeled in harmonic series by using Fourier Expansion. Equations were discretized using Galerkin's Method to obtain the dynamic response of the system. Performing the analysis in the bucket of length 75mm and attached with rotor rotating at speed of 1500 rpm, the first lower natural frequency is found to be 5281.4 Hz in the direction of jet for the first mode of vibration and the effect of Coriolis terms in natural frequency is found to be insignificant due to shorter length of the bucket. The bending stiffness was found to be increased with the increase in the rotational speed. Forced vibration analysis is carried out to determine the steady-state amplitudes of bending vibration. In the direction of jet, the maximum deformation is found to be 1.921 μm. The findings can be used as a guide for the dynamic analysis as well as a basis for design or advancement.

Paper No. 044 **Title:**

NUMERICAL STUDY OF PUMP AS TURBINE FROM THE PERSPECTIVE OF DYNAMIC STABILITY

1) **Arun Pandey***
2) **Nischal Pokharel**
3) **Amul Ghimire**
4) **Hari Prasad Neupane**
5) **Sailesh Chitrakar***

Abstract

A pump and a turbine have similar operating phenomena. By reversing the rotational direction of the impeller, a pump can be used as a turbine and vice-versa. Pump-turbines have benefits over conventional turbines in terms of availability, inexpensive manufacturing and maintenance costs, and a wide range of operations. Many micro-hydropower plants in Nepal are in a state of shutdown because of costly turbines and complicated repair and maintenance techniques. Using pump-turbines can be a better alternative in such sites. However, efficiency is not prioritized in such cases. It is recommended to operate such machines around the maximum efficiency point also by considering the prospects of unfavorable operating conditions such as cavitation, erosion, fractures, structural damages, and others. Such unfavorable operating conditions are the reasons for dynamic instability or vibrations in the system. The occurrence of vibrations results in pressure fluctuation in regions of the pump-turbines. The study of pressure fluctuation signals the occurrence of dynamic instabilities which can be done experimentally or numerically. This research work only focuses on the numerical portion. The numerical analysis was done using an open-source CFD tool, OpenFOAM to investigate pressure fluctuation at different locations in the spiral casing, draft tube, and more importantly in the RSI region of a reference case of a centrifugal pump operating in both pump and turbine mode. One of the pre-existing pumps was taken as the reference case. The study of pressure fluctuation in both pump and turbine modes was done. These results were then compared. Based on the results, the stability of both the turbine and pump mode of operation was analyzed. Past studies have concentrated more on efficiency, head, and power, neglecting the prospects of dynamic stability. The need for the inclusion of the prospects of dynamic stability in pump turbines is the main motive behind this research work. Operating a centrifugal pump in turbine mode generates wakes near the tongue and blade regions causing high-pressure fluctuation in the region which ultimately generates vibrations in the region.

Paper No. 045

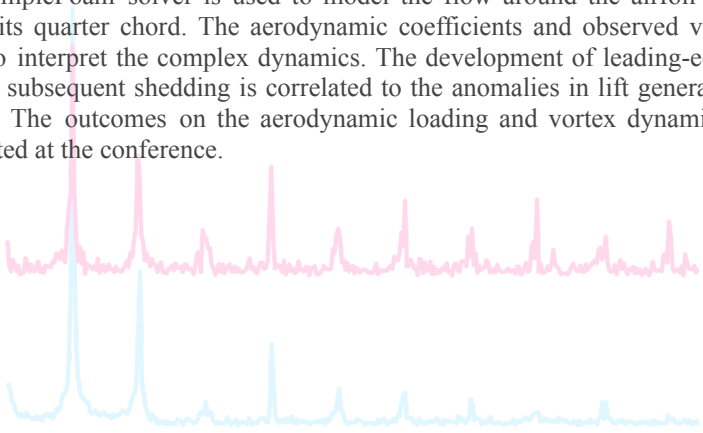
Title:

DYNAMIC STALL ON OSCILLATING NACA 4412 AIRFOIL

1) **Arun Pandey***
2) **Manish Timsina**
3) **Sandip Gautam**
4) **Anushka Subdei**
5) **Kamal Darlami**
6) **Nawraj Bhattarai**
7) **Sudip Bhattrai**

Abstract

Dynamically moving airfoils are ubiquitous with their presence in wind-turbine blades, helicopter rotor and maneuvering aircrafts. This intricate phenomenon needs a clearer understanding on how and why the aerodynamic forces vary on pitching airfoils. The present study analyzes underlying complexities in NACA 4412 airfoil in a state of dynamic stall for the reduced frequency of 0.0025 and 0.1. The pimpleFoam solver is used to model the flow around the airfoil oscillating about its quarter chord. The aerodynamic coefficients and observed vortices are used to interpret the complex dynamics. The development of leading-edge vortex and its subsequent shedding is correlated to the anomalies in lift generated by the airfoil. The outcomes on the aerodynamic loading and vortex dynamics will be presented at the conference.



Paper No. 047

Title:

ACTIVE VIBRATION SUPPRESSION WITH DISTURBANCE OBSERVER IN IN-PIPE INSPECTION ROBOT

1) **Bibhu Sharma***
2) **Prakash Basyal**
3) **Branesh M. Pillai**
4) **Jackrit Suthakorn**

Abstract

The use of mobile robots has eased the process of in-pipe inspection by expanding the aspect of accessibility. However, with the existence of numerous welds and dents, these robots receive significant vibration loading. For the robot, such vibrating platform impends damage over the vital sensors, actuators and static elements. In terms of performance, energy usage, navigation error, path error and accuracy are mainly affected. To address the challenge, passive suppression system based on traditional spring-damper system can be implemented. However, this might not be mechanically feasible as such robots have kinematic complication. This paper suggests the use of active vibration suppression with the help of primary actuating motors. The control system comprises of Disturbance Observer for force sensing that relies on the value of current. Because of the method, physical force sensors are not required for force sensing application. The model has been simulated based on a proposed design of in-pipe inspection robot. The simulation results suggest that the disturbance observer-based force sensing and compensation method can provide significant improvement in the robot that has to traverse through closed path with unstructured terrain.

Paper No. 049 **Title:**

COUPLED FIELD HARMONIC ANALYSIS ON A FLAT CANTILEVER PLATE FOR DEICING STUDIES

1) **Dr. S Satish Kumar***
2) **Dr. Venkat Iyengar S**
3) **Santhosh Kumar S**
4) **Siddeshwar Charantimath**
5) **Naga Charan K V**
6) **Siddanagouda Kandagal***

Abstract

In this numerical research paper, a parametric study is carried out on a novel electro-vibratory based deicing mechanism on a flat aluminum cantilever plate. Piezoceramic actuators (PZT) in the form of patches mounted on the plate are used for deicing. The deicing principle is based on the generation of Ice-Al plate debond shear stress using PZT patches. Suitable vibrational shear/twist modes are excited using PZT patches that will break the adhesive bond between the ice and the Al plate. Coupled field harmonic response analysis is carried out by coupling the Al flat cantilever plate structure and the electric PZT patches to estimate the critical shear/twist modes needed for deicing. The influence of variations in ice thickness and applied voltage for effective deicing are also discussed. It is observed that with increase in ice thickness the peak resonant frequency increases. For the same applied voltage, the maximum shear stress amplitude decreases with increase in ice thickness. There is a linear relation between PZT actuation voltage and in-plane shear stress for all the conditions with/ without ice.

Paper No. 051

Title:

EFFECT OF HYBRIDIZATION OF A GLARE PLATE WITH CENTRAL CUT-OUT SUBJECTED TO OFFSET LOW VELOCITY IMPACT

1) **Sasanka Kakati***
2) **Debabrata Chakroborty**

Abstract

In many structural components involving composite materials require existence of open holes to allow passage for access to inner components like wires, pipes and assemblies or for maintenance activities. The laminated structures being susceptible to delamination when subjected to low-velocity impact, it is important that investigation of the impact response for such components having open hole be done to assess their safety and integrity. The present analysis compares the low velocity impact responses of a GLARE plate with a central circular hole with that of a hybrid configuration considering Kevlar49 layers when subjected to impact by a steel spherical impactor. The effect of offsetting the impact relative to the hole position is investigated on the contact response and delamination at the interfaces are assessed. A finite element (FE) code using solid elements and incorporating Newmark-β integration scheme is developed to investigate the contact force, displacements and velocities of the impactor and the plate. In addition, modal analysis is also done to investigate the influence of hybridization on natural frequency. It is observed that considering a hybrid layup with Kevlar49 layers could reduce the effective contact force, weight of the structure and the excitation frequency of the lower vibration modes could be tailored as per requirement.

Paper No. 053 **Title:**

DEVELOPMENT OF CONDITION MONITORING OF HYDROPOWER SYSTEM USING VIBRATION SENSOR

1) **Subarna Paudel***
2) **Prajwal Sapkota**
3) **Sailesh Chitrakar**
4) **Bibek Aryal**
5) **Sushobhan Bhattarai**

Abstract

This paper reports the study and procedure development of non-intrusive condition monitoring for hydropower system. Condition monitoring technique is a necessity in hydropower systems for diagnosis of failures and faults as it can be used for measuring the operating conditions of the machine and recording the status of the equipment's. This helps to reduce major losses in operation, production and maintenance in the system as well as its advancement in the diagnosis system could help in early detection of failures. With the application of non-intrusive methods, the operation of the hydro-mechanical system will not be halted resulting in smooth yield. An experimentation is done at Turbine Testing Lab with the use of ADXL 335, an accelerometer for vibration monitoring in the shaft of pump. In this paper, vibration measurement technique is presented with experimental test rig and its procedure and applicability is investigated.

Paper No. 058 **Title:**

NUMERICAL INVESTIGATION OF PRESSURE FLUCTUATIONS IN FRANCIS TURBINE DUE TO FATIGUE CRACK IN RUNNER BLADES

1) **Aasma Bhattarai**
2) **Hari Prasad Neopane**
3) **Ole Gunnar Dahlhaug**
4) **Sailesh Chitrakar**
5) **Mamata Rijal**

Abstract

Hydropower plants are operated outside their design condition with frequent start and stop to compensate for the varying load demand. When operated in off-design conditions, pressure fluctuations are induced in the turbine components causing dynamic loads which cause a fatigue crack in runners. Results from past studies found an immediate increase in vibrations after the crack of the critical size in the runner. Nevertheless, in the early stage, the vibrational signals in the turbine were found to be too small to detect. This paper has adopted the numerical approach to detect critical crack formation by analyzing the pressure pulsations caused due to rotor-stator interaction (RSI). For this, the geometry of the reference case of the Francis turbine under the Francis-99 workshop series was used. A faulty runner was created by cutting off the T-joint between the blade and the shroud to imitate the shark bite on the blade. The RANS-based equation approach was used to solve the turbulence model by discretizing the domain using tetrahedral mesh. SST turbulent model, used in the numerical domain of runner, guide vanes, and the draft tube was taken for the study. Thus, obtained pressure pulsations in the reference turbine and the faulty turbine were compared and validated with the available experimental data. The results from the paper are expected to aid in collecting the dataset for the prediction of fatigue-causing vibration in the turbine and thus contribute to the predictive maintenance of the Francis runner.

Paper No. 063 **Title:**

ROBUST FEATURIZATION TECHNIQUE FOR FAULT DIAGNOSIS AND PROGNOSIS OF ROLLING ELEMENT BEARING USING AI AND ML METHODOLOGIES.

1) **Siddanagouda Kandagal**
2) **Nandakumar Abbigeri**

Abstract

Structural Health Monitoring (SHM) is an extremely difficult task, and this associated difficulty comes from the fact that “It is very difficult to predict when a system has diverged from its normal operating conditions”. In systems like nuclear power plants, wind turbines, etc, which operate in remote dynamic environmental conditions, predictive maintenance is becoming one of the primordial pre-requisites for commissioning such systems into service. Vibration-based predictive maintenance techniques are widely used in the industry where generally skilled personnel manages the maintenance operation. The availability and accessibility of skilled personnel is highly conditional, and many industries face the question of the affordability of such maintenance costs. This work concentrates on the development of robust and simple methodology for predictive maintenance of rolling-element bearings which are an integral part of any rotary machine. The methodology being developed majorly concentrate on the advantages offered by the data-driven problem-solving techniques. One of the observations that was encountered in the currently available literature was that of the non-availability of elegant technique to come up with robust features that can embed week bearing defect signatures. In this work a generalised technique is arrived at, which can be used to detect bearing defects with very high accuracy and the same technique is demonstrated to extend for classifying rotating machinery that are operating with bent shaft and near resonance conditions as well. The technique developed is extremely robust which can allow one to classify defects in typical rotating machinery with a very high degree of accuracy with very low prior signal processing there by reducing computation costs and allowing one for online monitoring. Firstly, a test rig (as shown in the figure-4) is fabricated with an intention to test for various bearing defects and also to validate the classification results near extreme operating conditions like resonance and bent shaft operating conditions in rotating machinery. A well collection of the data was performed, and this data was further used for featurization. The featurization technique along with the specified CNN (convolutional neural network) architecture is proposed and typical results are as shown below.

Paper No. 064 **Title:**

NONLINEAR ACTIVE VIBRATION ABSORBER FOR SIMULTANEOUS PRIMARY, PRINCIPAL PARAMETRIC AND SUBHARMONIC RESONANCES WITH 1:2 INTERNAL RESONANCE CONDITIONS

1) **Sibananda Mohanty**
2) **Santosha K Dwivedy**

Abstract

In the present work, vibration suppression of base excited spring-mass primary system under simultaneous subharmonic, principal parametric and primary resonance conditions is studied. To suppress the vibration of the primary system a spring-mass-damper and piezoelectric stack actuator based secondary system (SS) is used. The SS comprises time delay in the damper and uses time delayed feedbacks of the primary system (PS). Through the displacement, velocity and acceleration feedbacks, the SS physical properties are actively changed to suppress the vibration of the primary system for a broad range of operating frequencies. The method of multiple scales (MMS) is used to obtain the reduced equations from the governing equations considering 1:1 and 1:2 internal resonance conditions. These equations are then solved by Newton's method to study the frequency responses of the system for various parameters. These responses are compared with numerical method showing good agreement. From the parametric analyses the stable and unstable regions of operating frequencies are obtained and it is shown that with proper selection of time delay in damper and feedback gain the primary and secondary system responses can be minimized for a wider band of operating frequencies. This work is an extension of the authors previous published work [2] where superharmonic resonance with 1:1 internal resonance conditions have been studied.

Paper No. 066

Title:

DESIGN DEVELOPMENT AND ANALYSIS OF FLYWHEEL ENERGY STORAGE SYSTEM: A REVIEW

1) **Mohammad Asif Khan**
2) **Rajiv Tiwari**
3) **Harshal Bhalchandra Nemade**

Abstract

Energy storage systems (ESSs) are the technologies, that have advanced our society to the point where electrical network management becomes simple. The key features that interest the globe with the ESS technology include supply-demand balance, stability, voltage and frequency lag management, and an increase in power quality. However, being one of the oldest energy storage systems, flywheel energy storage (FESS) has developed a reputation for being environmentally beneficial and capable of storing megajoules of energy (MJ). This review paper presents the technologies used in flywheel energy storage systems (FESS), an overview of the types of electric machines used, different types of power electronics topologies used in FESS, types of material for the flywheel, and different types of bearing used in FESS. further, briefly introduce the working principle of Active magnetic bearing (AMB) used to control the vibrations, along with the various component utilized in rotor AMB system such as an amplifier, sensors, power supply, etc. finally, the future direction in FESS equipped with AMB within the paper's scope has been suggested.

Paper No. 068

Title:
DYNAMIC ANALYSIS AND OPTIMAL CONTROL OF A SINGLE-LINK FLEXIBLE MANIPULATOR

1) **Rajesh Ranjan**
2) **Santosha K Dwivedy**

Abstract

Flexible manipulators have several advantages over rigid manipulators, like low weight, smaller actuators, less power consumption, swift in action. However, they exhibit inherent structural deformations which are oscillatory in nature. Due to inherent flexibility of flexible-link manipulators (FLMs) residual vibrations of their end-point persists even after the end of their motions. This decreases the accuracy of their end-point positioning which can decrease their productivity in high speed engineering applications. Subsequent operations of FLMs depend on the settling time required for the attenuation of their residual vibrations. In the present study, dynamic analysis and control of a single link flexible manipulator with both link and joint flexibilities have been carried out using finite element method. The flexible link of the manipulator has been considered as Euler-Bernoulli's beam. Both modal analysis as well as transient analysis of the manipulator has been carried out using finite element method. Rayleigh's damping has been applied. The numerical solutions of their dynamic equations of motion have been obtained using the Newmark method. Linear quadratic regulator (LQR) optimal control has been applied. The results show that with the application of the LQR technique the residual vibrations of the end-effector of the manipulator can effectively be controlled.

Paper No. 072 **Title:** STUDY AND ANALYSIS OF PEEK MATERIAL FOR IN-HOUSE MANUFACTURING OF 1U CUBESAT STRUCTURE IN NEPAL

1) **Eliza Sapkota**
2) **Anuja Shrestha**
3) **Janardhan Silwal**
4) **Sirash Sayanju**
5) **Bikalpa Dhungana**
6) **Sagar Koirala**
7) **Trishna Shrestha**
8) **Ramila Thike**
9) **Abhas Maskey**

Abstract

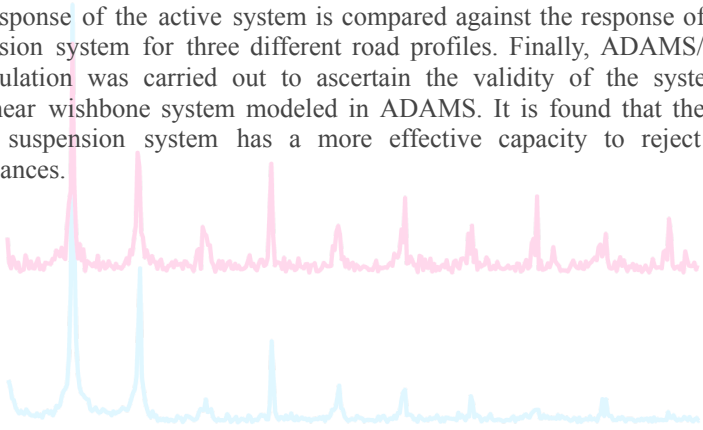
While there is an exponential increase in the number of CubeSats in orbit, the options for materials that can be used for structures are limited. Currently, the standard material can only be manufactured using CNC milling. To widen the manufacturing options for exploring complex designs, reducing mass, and rapid prototyping, additive manufacturing can provide an alternative technique while maintaining reliability. This paper provides the results of static and dynamic structural analysis done on a 1U CubeSat thermoplastic structure. Analysis of PEEK alongside Al6061 is presented. The equivalent stress of PEEK is simulated to be 1.5967MPa which is lower than their respective yield strength. For dynamic loading cases, the first mode of natural frequency is simulated to be 480.5 Hz each. Both satisfy the requirement for launch. Comparing these results with standard Al6061, the finite element analysis suggests that the customized, additively manufactured structure can safely withstand the extreme launch conditions while maintaining a Total Mass Loss of less than 1.0% for outgassing. The materials have the potential for countries with limited manufacturing capability like Nepal to design and manufacture their own space-grade structures.

Paper No. 076 **Title:** DESIGN, MODELING, AND CONTROL OF ACTIVE HYDRAULIC SUSPENSION SYSTEM FOR VEHICLES

1) **Nitesh Subedi**
2) **Prajwal Koirala**
3) **Mahesh Chandra Luitel**

Abstract

Suspension systems have been extensively used in automobiles for better ride comfort and stability. Long rides on irregular roads and infrastructure problems like uncomfortable seating may have a very bad impact on the human body. To reduce this factor, an active suspension system that uses hydraulic piston-cylinder arrangement to actuate necessary force is designed. The proposed hydraulic system uses a PID controller, which controls the hydraulic pump rpm and valve opening. The response of the active system is compared against the response of a passive suspension system for three different road profiles. Finally, ADAMS/MATLAB co-simulation was carried out to ascertain the validity of the system with a non-linear wishbone system modeled in ADAMS. It is found that the proposed active suspension system has a more effective capacity to reject the road disturbances.



Paper No. 077 **Title:** STUDY OF MOTORCYCLE REAR SUSPENSION BEHAVIOR WITH LENGTH OF SWING ARM AND IT'S INCLINATION ANGLE

1) **Nitesh Subedi**
2) **Anup Pandey**
3) **Mahesh Chandra Luitel**
4) **Tilak Bhusal**

Abstract

The main purpose of the suspension system in vehicles is to reduce discomfort due to the bumps and imperfection, contributing to vehicle's handling and safety. This study focuses on the behavior of the swing arm suspension system with respect to arm length and inclination of arm. Response of the spring mass with road disturbance and variation of squat and anti-squat forces with suspension geometry is observed. It is found that with increase in swing arm length and inclination angle, the gain of the system alters along with both the natural modes.The variation of anti-squat percentage with the variation of swing arm length(lsa) and inclination angle (α) is studied. It is observed that as the length of the swing arm is increased, the anti-squat percentage approaches saturation. α also has a significant influence in anti-squat percentage. For very high as well as for very low alpha,the fluctuation of anti-squat percentage is high whereas for moderate alpha,the change in lsa doesn't bring significant fluctuation in anti-squat percentage.For α = 0.4c the anti-squat percentage fluctuates by only 8% even when the lsa changes from 0.4m to 0.8m.

Paper No. **Title:**

081 TORQUE CURVE ANALYSIS IN PELTON TURBINE BUCKET BASED ON TWO-PHASE UNSTEADY FLOW

1) **Anil Sapkota**
2) **Kamal Darlami**
3) **Dr. Tri Ratna Bajracharya**
4) **Ashesh Babu Timilsina**

Abstract

Pelton turbine is the most preferred option for hydropower plants having head more than 800 m thus is most preferred impulse type turbine in the hydropower industries. Referring to a Turbine selection nomogram, medium to high head with low to medium flow ranges have been designated as the optimum performance range for Pelton turbines. The working principle of Pelton turbine is transfer of direction of high speed jet by cup shaped bucket resulting in momentum transfer. Due to this action of impulse, the torque produced is not uniform in the Pelton turbine but rather rapidly fluctuates about a mean value in cyclic nature. In this study, this tendency of the power output in the Pelton turbine is studied. In particular, this study focuses on capturing this fluctuation by using a multiphase unsteady flow simulation in ANSYS CFX. The Pelton turbine considered in this study is the one designed and developed by Bajracharya 2007. The runner used for the study is a 16 bucket, 2 kW, 1450 RPM Pelton turbine runner with mean diameter of 175 mm. In computational domain, the bucket geometry is simplified removing root, hub, shaft, and the bucket reinforcing surfaces. Results obtained reveals overall nature of the torque curve is cyclic which is fluctuating about a mean value. The analysis of torque produced by inside and outside surfaces show that there is an unnecessary delay between the torque produced by outside surface and inside surface. The transition is not smooth which suggests possible design and/or manufacturing errors.

Paper No. 084 **Title:** ROTORDYNAMIC ANALYSIS OF THE BRIDGE CONFIGURED WOUNDED (BCW) INDUCTION MOTOR DUE TO ELECTROMECHANICAL FORCES

1) **Rakesh Deore**
2) **Sharukh**
3) **Bipul Brahma**
4) **Karuna Kalita**

Abstract

Induction motors that are used for industrial purposes have to operate under a wide range of speeds. So, the system's dynamic analysis is essential to understand its behavior. If the system is running at its resonance speed, the system's response becomes enormous & it may cause catastrophic failure. In the present work, the electromechanical rotordynamic model of the bridge configured wounded (BCW) induction motor due to coupled effect of rotor mass unbalance & nonlinear electromagnetic forces (only transverse forces) is developed. The nonlinearity in the system is solved by using the multiple scales method, where, it can be inferred that the analysis of nonlinear rotor systems is slightly different from the nonlinear rectilinear system for the amplitudes of synchronous whirling (also called forward whirling) mode and antisynchronous whirling (also called backward whirling) mode. The nonlinear dynamic behavior of electromagnetic force and its effect on both the antisynchronous whirling mode and the synchronous whirling mode is also examined. Later, these electromechanical interactions of the BCW induction motor may be helpful for the stability analysis of the rotordynamic system

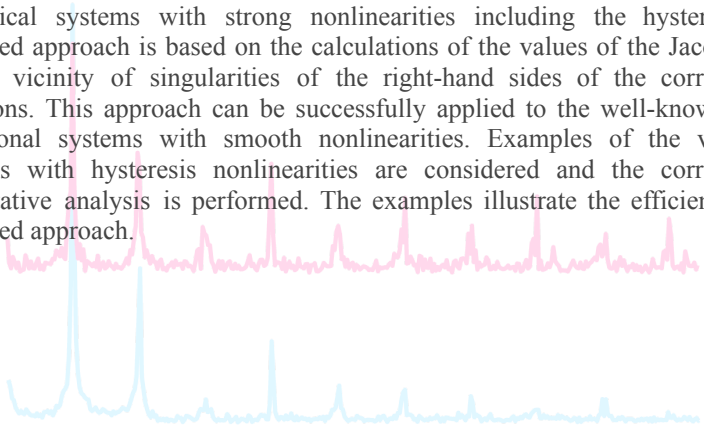
Paper No. **Title:**

085 A NOVEL APPROACH TO QUANTITATIVE IDENTIFICATION OF CHAOS IN VIBRATIONAL SYSTEMS WITH HYSTERESIS

1) **Mikhail Semenov**
2) **Peter Meleshenko**
3) **Sergei Borzunov**
4) **Alexander Proshunin**

Abstract

One of the most important problems of modern vibrational systems is related to the identification of the dynamical modes including chaotic regimes. The classical quantitative approach is related to the calculation of the Lyapunov spectra. In our work, we propose a novel approach to quantitative identification of chaos in dynamical systems with strong nonlinearities including the hysteresis. The proposed approach is based on the calculations of the values of the Jacobi matrix in the vicinity of singularities of the right-hand sides of the corresponding equations. This approach can be successfully applied to the well-known chaotic vibrational systems with smooth nonlinearities. Examples of the vibrational systems with hysteresis nonlinearities are considered and the corresponding quantitative analysis is performed. The examples illustrate the efficiency of the proposed approach.



Paper No. **Title:**

086 MODELLING AND NUMERICAL ANALYSIS OF A GEAR-ROTOR SYSTEM WITH TRANSMISSION ERROR AND BOWED-SHAFT INTEGRATED WITH ACTIVE MAGNETIC BEARINGS

1) **Pantha Pradip Das**
2) **Rajiv Tiwari**
3) **Dhrubajyoti Bordoloi**

Abstract

Study of vibration in geared-rotor is considered vital in order to take necessary precautions and avoid sudden failure of such machines. A gear pair's health is revealed by the amount of vibration it produces at the tooth mesh frequency. Under operation, a gear pair is continuously subjected to dynamic forces, which originate from tooth deformation due to meshing, transmission error, eccentricity, gear run-out, and residual shaft bow. When these faults occur simultaneously, it gives rise to a family of sidebands centred on the tooth mesh frequency and the harmonics of it. The amplitude and the spacing of these sidebands from the mesh frequency indicate the severity and the location of the fault. Therefore, in this study, a modelling and numerical investigation have been done to analyse the significance of sidebands on a gear-rotor system. The static and the fluctuating part of the transmission inaccuracy, along with faults like gear run-out, eccentricity error and shaft bow, are modelled in the formulation. The concept of vibration suppression of the gear-rotor system by active magnetic bearings (AMBs) is also mentioned. A PID controller has been modelled, whereby varying different gain parameters stabilization of the rotor vibration is achieved. Both orbital and full spectrum analysis is performed as to study the effect of residual bow in both the shafts, to see the appearance of the sidebands around the mesh frequency and its harmonics, and also to show the reduction in the amplitude of vibration by the use of AMBs.

Paper No.087 **Title**: EXPERIMENTAL EVALUATION OF PAYLOAD INDUCED OSCILLATIONS OF AN UNMANNED ROTORCRAFT SYSTEM

1) **Bimal Bhattarai**
2) **Ashish Karki**
3) **Sudip Bhattrai**
4) **Biman Rimal**

Abstract

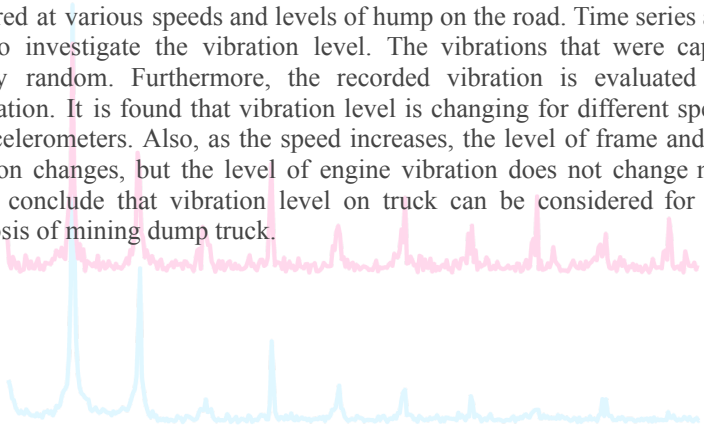
Among the wide-ranging fields of application for Unmanned Aerial Vehicles (UAV), Aerial delivery has demonstrated a high potential to become a mainstream delivery service in e-commerce industries. Among the methods of payload carriage with a UAV, a tethered carriage can be a flexible and heavy load capacity system. However, the change in dynamics of a rotorcraft due to a tethered payload leads to instability and reduced efficiency on a mission of the Unmanned Rotorcraft System (URS). For this paper, Pixhawk 4 controller-based quadrotor was assembled on an S500 frame due to its ubiquitous use in academia. The payload-induced oscillation data in non-dimensionalized tether length and payload weight were studied by flying the URS in two distinct autonomous missions. Furthermore, the inevitable vibrations due to extraneous factors were evaluated by conducting the autonomous mission with and without load conditions separately. Thus, obtained data were assessed case-specifically for different values of cable length, payload mass, speed, and altitude. These data were analyzed and plotted in MATLAB to study the effect of change in variables on the preset autonomous missions. This study found that destabilizing effect of an underactuated cable-suspended payload caused secondary oscillations, which led to reduced quadrotor performance with increased time to carry out the missions. Also, an increase in payload mass provided increased damping to the vehicle, however, with increased propeller vibrations. Oscillations characteristics were evaluated with data from different cases without quantifying oscillation parameters. Thus, to quantify and attenuate the oscillation, further work is necessary.

Paper No. 089 **Title**: EXPERIMENTAL STUDY OF VIBRATION LEVEL OF MINING DUMP TRUCK: A COMPARATIVE STUDY

1) **Nagesh Dewangan**
2) **Amiya Mohanty**

Abstract

Mining dump trucks deliver material for several hours a day in mines and are an important aspect of open cast mining. The vibration level of these trucks must be monitored in order to determine their condition. The objective of this study is to investigate the impact of vehicle speed on vibration levels and shock. The vibration level of a mining dump truck is measured using accelerometers mounted vertically above the suspension and at the bottom of the seat on floor, and longitudinally on top of the engine. The vibration of a mining dump truck is measured at various speeds and levels of hump on the road. Time series analysis is used to investigate the vibration level. The vibrations that were captured are entirely random. Furthermore, the recorded vibration is evaluated for level verification. It is found that vibration level is changing for different speeds in all the accelerometers. Also, as the speed increases, the level of frame and seat floor vibration changes, but the level of engine vibration does not change much. The results conclude that vibration level on truck can be considered for the health prognosis of mining dump truck.



Paper No. 090 **Title**: A CASE STUDY OF NOISE CONTROL IN DOMESTIC MIXER GRINDER

1) **Biren Kumar Pradhan**
2) **Raja Kumar**
3) **Amiya Mohanty**

Abstract

Mixer grinders are multipurpose, most used domestic appliances for food preparation and other regular kitchen activities. Amongst household appliances, mixer grinders are one of the strongest noise-radiating sources. In the design of domestic products, the design of sound has become an ideal consideration. Sound and sound quality is no longer a choice but a crucial and inherent feature in the product's functionality and explicit anticipation of the consumers. Although a century has passed since the first mixer grinder was patented, not many advances have been witnessed in sound and sound quality improvement of the emitted noise. The current study aims to develop a low-cost treatment procedure to reduce noise level and improve the quality of radiated sound without modifying the original design of the domestic mixer grinder. The noise sources were located precisely and accurately with the help of advanced engineering measuring instruments (Scanning laser vibrometer, Acoustic camera, and Head and torso simulator (HATS)). Computational fluid dynamics (CFD) was used to predict the actual flow behavior inside the mixer grinder. A novel attachment is developed with novel conceptualization and a detailed treatment procedure for the current application. After the final treatment, a maximum of 5.4 dB noise reduction, with a significant change in psychoacoustic parameters (loudness, roughness, and fluctuation strength), is achieved.

Paper No. 099 **Title**: COMPARISON OF NEW FUZZY LOGIC CONTROLLER ALGORITHM AND CLASSICAL PROPORTIONAL–INTEGRAL–DERIVATIVE CONTROLLER (PID) CONTROLLER FOR TRAJECTORY TRACKING

1) **Subodh Kumar Ghimire**
2) **Aayush Dulal**
3) **Keshav Rawal**

Abstract

In this research paper, we proposed a non-conventional fuzzy logic controller (FLC), which includes acceleration as one of its linguistic variables, addition to the techniques and approaches that have been discussed in this literature. It is used for tracking of the trajectory followed by the 3-Degree of Freedom (DOF) articulated robot. For a proportional–integral–derivative controller (PID) dominated industry of robot control, implementation of fuzzy logic is not a new topic. Use of joint acceleration as an input variable is a rather novel approach. This approach has been used for a planar and 2-DOF systems. This research builds on the same philosophy on a 3-DOF system with non-planar trajectory tracking and the effect of addition of variable acceleration along with the comparison of this approach with PID and a normal FLC has been studied. This research involves FLC and PID design and simulation on trajectories which have been selected with extreme and non-conventional scenarios in mind. A complete simulation environment is developed through MATLAB and Simulink software. The trajectory has been tested in presence of noise too. The performance of classical autotuned PID controller and fuzzy logic controller have been compared. The comparison shows that fuzzy logic controller is certainly better than the classical autotuned PID controller. Addition of acceleration as linguistic variable clearly has increased the efficiency of tracking the defined trajectory.

Paper No. **Title**:

104 DESIGN OF CHEMICAL PROPELLANT THRUSTER TO DEORBIT NANO SATELLITE: STUDSAT-II

1) **Prabin Sherpali**
2) **Roshan Sah**
3) **Sandesh Hegde**
4) **Bir Bahadur Chaudhary**

Abstract

An increase in the application of the satellite has skyrocketed the number of satellites, especially in the low earth orbit (LEO). The major concern today is after end-of-life, these satellites become debris which negatively affects the space environment. As per the International Guidelines of the European Space Agency, it is mandatory to deorbit the satellite within 25years of end-of-life. This paper is aimed to design the solid chemical propellant thruster to deorbit the StudSat-2 from its original orbit to the lower orbit. StudSat-2 carries the heritage of StudSat-1 which was successfully launched on 12th July 2010 AD and is the first Pico-Satellite in India by the undergraduate students of seven engineering colleges. This paper explains how a solid monopropellant thruster could be used to deorbit the satellite after the end-of-life with the least difficulty compared to other active and passive methods of deorbiting. The deorbiting mechanism consists of a solid propellant, Convergent-Divergent nozzle, ignition system, and electronic actuators. The components of the thruster were designed in the CATIA V5, and the combustion and flow analysis were done in ANSYS. The concept of Hohmann transfer was used to deorbit the satellite and STK was used to simulate it.

Paper No. **Title**:

106 EROSION AND CAVITATION INDUCED VIBRATION IN KALIGANDAKI A HYDROPOWER PLANT: A CASE STUDY

1) **Shekhar Aryal**
2) **Sailesh Chitrakar**
3) **Rajendra Shrestha**
4) **Ajay Kumar Jha**

Abstract

Erosion of turbines due to excessive sediment content in the flow is an inevitable problem in hydropower plants of Indian Subcontinent. Kaligandaki A is one such hydropower plants which face extreme consequences of sediment laden rivers. Turbine components like guide vanes and runner are the most vulnerable regions in terms of erosion because of the complexity of flow behavior. Erosion of turbine further aggravates the flow due to deteriorated surface and reduces the overall performance of the power plant. Previous studies have focused on erosion mechanism of turbines at different operating conditions with some mitigating measures. In this study, the effects of erosion on dynamic performance of the turbines are carried out. A case study of the selected power plant is conducted. The severity of erosion and cavitation in this power plant is studied based on observation of the damaged turbines and sediment characteristics. The annual data from the power plant obtained from the existing sensors are extracted and analyzed. A trend analysis of the obtained signals during repaired and eroded condition is developed. This analysis is expected to provide support for early fault detection and diagnosis of the turbines during the course of operation in sediment laden conditions.

Paper No. **Title**:

109 DYNAMIC ANALYSIS OF A SPAN MORPHING TELESCOPIC BEAM

1) **Debashish Singha**
2) **Senthil Murugan**

Abstract

This paper studies the dynamic response of a span morphing beam based on a telescopic beam mechanism. The telescopic beam mechanism is modeled using a coupled double cantilever beam model, which consists of a host beam that is fixed at its root, and a sliding beam that is fixed at its root to a slider that slides over the host beam. The cantilever beams are considered to be rigid and attached at its root to a rotational spring, having stiffness equivalent to the bending stiffness of the respective beams. Assuming the deflection of the telescopic beam to be small a linear dynamic model of the coupled cantilever beam system is developed. The dynamic response of the host beam obtained by numerical simulations shows harmonic oscillations with gradually increasing magnitude while in the morphing process and post-morphing process the beam shows sustained oscillations with multiple harmonics. Whereas the sliding beam shows some unusual transients while the morphing process. The detailed results of the linear dynamic model of the coupled cantilever beam system will be discussed in the full paper.

Paper No. **Title**:

111 IMPACT OF MAINTENANCE ON PERFORMANCE AND RELIABILITY FOR HYDROPOWER PLANT: A CASE STUDY OF PANAUTI SMALL HYDROPOWER PLANT

1) **Roshan Pandey**
2) **Rajendra Shrestha**
3) **Nawraj Bhattarai**

Abstract

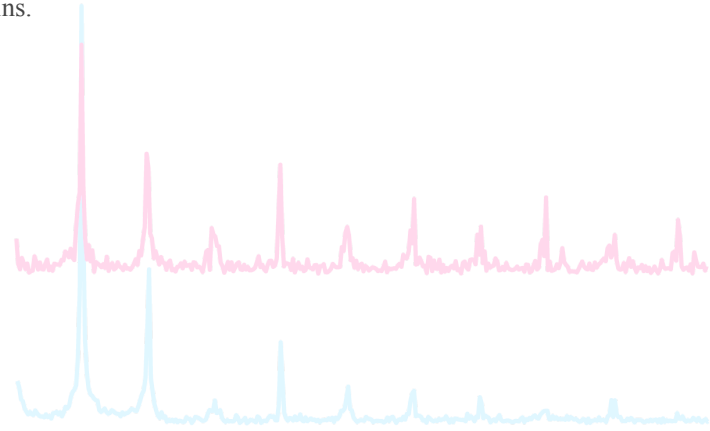
About 20% world's total electricity production is generated from hydropower and it's a clean and cheap commercial energy source having huge potential as an electricity commodity for Nepal. Even Small Hydro Power (SHP), less than 10 MW occupies a significant contribution to a generation. More than 65% of hydropower installed is of small type. Besides this, there are many problems and challenges regarding hydropower and even more in SHP. The problems are insufficiency of regular maintenance, maintenance protocols, technical audit, equipment testing, calibration, and standards guidelines. This research paper mainly focuses on the status of Panauti SHP in terms of performance. The detailed case study of Panauti hydropower plant, 2.4 MW results on mechanical system mainly viz. turbine, shaft and bearing as the major area of consideration. The detailed study of the plants recommends the rectification of the prominent issue of those components regarding the performance and reliability. Being one of the oldest hydropower plants with a long shaft span goes through several times of maintenance and upgrading. The parameters like the speed of shaft and runner, the temperature on bearing and shaft, alignment of the shaft, leakage in turbine casing along with maintenance protocols are the major factor for wear and tear, vibration, and fatigue damages to the components in general. This provides the analysis of the effect of changes in parameters associated with the performance and efficiency of the plants such as the temperature of the surrounding, frequency of turbine speed variation, and severity of machine condition indicated by the testing devices. In this paper, various parameters were measured for the smooth running of hydro turbines in the Panauti SHP. The study finding recommends proper calibration, monitoring, schedule maintenance, components testing, national standards, and guidelines for the future development of such plants in Nepal.

Paper No. 118 **Title**: HARVESTING ENERGY WITH TWO LOOSELY COUPLED HORIZONTAL BEAMS

1) **Piotr Wolsczak**
2) **Grzegorz Litak**
3) **Andrzej Koszewnik**
4) **Slim Naifar**
5) **Sonia Bradai**
6) **Olfa Kanoun**
7) **Andrzej Rysak**

Abstract

We present the study of a system of two flexible mechanically or magnetically coupled beams. Piezoelements are placed on the beams, which convert the kinetic energy of vibrations into electrical energy. The system is tested in order to develop an energy harvester. Beam coupling causes a nonlinearity phenomenon that extends the effective frequency range. Various beam coupling systems were investigated, and the records were statistically analyzed in the time and frequency domains.



Paper No. **Title**:

119 MPC-BASED TRAJECTORY GENERATION FOR WHEELED ROBOT NAVIGATION

1) **Nitesh Subedi**
2) **Prajwal Koirala**
3) **Mahesh Chandra Luintel**
4) **Sanjeev Maharjan**
5) **Ankit Kharel**
6) **Anusha Acharya**

Abstract

Wheeled robots are propelled using motorized wheels for navigation. The trajectory generation problem refers to the determination of a set of control inputs to achieve the desired motion of the robot. This study aims to develop a feedback system that plans the trajectory of the wheeled robot taking account of the current state and environment. The trajectory generator needs to lead the robot toward the goal location while avoiding the obstacles and fulfilling other dynamic and static constraints. To design the trajectory generator, an optimal control problem is formulated for the wheeled robot. The optimal control problem is transcribed into a non-linear programming problem and solved in terms of state-control pair at each time step. This method of controlling the robot for a finite-length time horizon using the real-time information updates is also called Model Predictive Control (MPC). The proposed trajectory generation system is developed, and then re-implemented in Python to test against Turtlebot3 Waffle in Gazebo environment using Robot Operating System (ROS). Finally, the proposed system used in an actual robot with the necessary hardware and software augmentation. Results obtained in the simulated environment for a number of cases are validated using the physically implemented robot.

Paper No. **Title**:

120 VIBRATION ANALYSIS AND CONTROL STUDY OF OFFSHORE JACKET PLATFORM USING SMA DAMPERS FOR WAVE AND SEISMIC LOADINGS

1) **Kaustobhmoni Hazarika**
2) **Jonnalagadda Srinivas**

Abstract

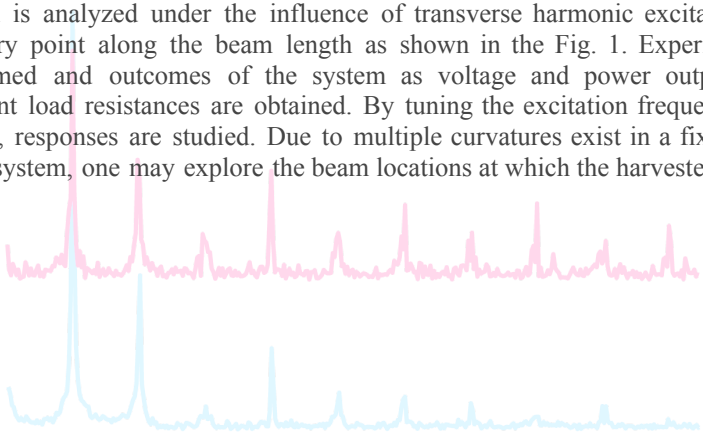
Offshore jacket platforms are widely used for expedition and storage of resources available in oceans, and in establishing wind-mills. Wave-induced vibrations are major cause of reducing the service life of offshore jacket platforms and increasing the chances of failure due to fatigue loading. Thus, it is important to characterize and control the vibrations due to wave and seismic loadings. In this work, a model of jacket platform is designed and analysed initially for its modal and transient characteristics under regular and irregular wave loads. In order to control excessive vibrations, shape memory alloy (SMA) dampers are used. The equations of motion are formulated using equivalent lumped parameter model and are solved to obtain the free and forced vibration results. Effects of extreme regular sea waves, irregular waves and earthquakes on platform structures has been studied during this research. Finally, optimum parameters of SMA dampers are established via a parametric study. SMA dampers are found to be more effective in controlling the wave induced loadings. To effectively control seismic excitations, a combination of dampers are required.

Paper No. 121 **Title**: FIXED-GUIDED BEAM BASED PIEZOELECTRIC ENERGY HARVESTER (FG-PEH): AN EXPERIMENTAL INVESTIGATION

1) **Ranit Roy**
2) **Anshul Garg**
3) **Arunjyoti Borgohain**
4) **Santosha K Dwivedy**

Abstract

In the present work, a fixed-guided beam based system is investigated as a piezoelectric energy harvester (FG-PEH). A piezoelectric patch is attached near the fixed end of the beam. The uni-morph fixed-guided piezo-beam system has been designed considering Euler-Bernoulli beam assumptions. The dynamics of the system is analyzed under the influence of transverse harmonic excitation at an arbitrary point along the beam length as shown in the Fig. 1. Experiments are performed and outcomes of the system as voltage and power output across different load resistances are obtained. By tuning the excitation frequency of the exciter, responses are studied. Due to multiple curvatures exist in a fixed-guided beam system, one may explore the beam locations at which the harvested power is more.



Paper No. **Title**:

124 INITIAL INVESTIGATION ON TUNNABLE BANDGAPS CREATED BY VIBRATION ABSORBERS MADE OF MAGNETORHEOLOGICAL ELASTOMERS

1) **Valterson Marques dos Santos**
2) **Fabricio Cesar Lobato de Almeida**
3) **Viviane Cassol Marques**
4) **Paulo Jose Paupitz Goncalves**
5) **Marcos Silveria**

Abstract

Classified as a smart material, the Magnetorheological Elastomer (MRE) is a material which is able to change its Young's Modulus when such material is exposed to an external magnetic field. MREs are made of a rubber matrix, that can be natural or synthetic rubber embedded with metallic particles. The iron particles has ferromagnetic characteristics that on external magnetic field applied responsible for giving the wanted behavior of tuning some mechanical properties. This material is generally used as an absorber and has advantages over magnetorheological fluid (MR fluids), such as no leaking or particle dispersion in the fluid. This work investigates the use of a mechanical system composed by a mass supported by a MRE base, here named as MRE absorber, coupled to a beam to act as a vibration isolation mechanism. The MRE absorber is investigated numerically using the finite element approach as one way to tune bandgaps over a certain frequency range, where the Young's modulus of the MRE, i.e. stiffness, changes as a function of the applied external magnetic field. It is shown that this configuration has a good potential to create tunable bandgaps in waveguide structures.

Paper No. **Title**:

125 TRANSIENT RESPONSE ANALYSIS OF SIMPLY SUPPORTED PELTON TURBINE DURING STARTING AND SHUTDOWN

1) **Bir Bahadur Chaudhary**
2) **Amrit Tiwari**
3) **Prabin Sherpali**
4) **Mahesh Chandra Luintel**

Abstract

Classified as a smart material, the Magnetorheological Elastomer (MRE) is a material which is able to change its Young's Modulus when such material is exposed to an external magnetic field. MREs are made of a rubber matrix, that can be natural or synthetic rubber embedded with metallic particles. The iron particles has ferromagnetic characteristics that on external magnetic field applied responsible for giving the wanted behavior of tuning some mechanical properties. This material is generally used as an absorber and has advantages over magnetorheological fluid (MR fluids), such as no leaking or particle dispersion in the fluid. This work investigates the use of a mechanical system composed by a mass supported by a MRE base, here named as MRE absorber, coupled to a beam to act as a vibration isolation mechanism. The MRE absorber is investigated numerically using the finite element approach as one way to tune bandgaps over a certain frequency range, where the Young's modulus of the MRE, i.e. stiffness, changes as a function of the applied external magnetic field. It is shown that this configuration has a good potential to create tunable bandgaps in waveguide structures.

Paper No. 128 **Title**: CONDITION MONITORING OF PUMP SYSTEMS IN WATER SUPPLY FACILITIES USING VIBRATIONAL ANALYSIS

1) **Samiksha Dhakal**
2) **Sarthak Pandey**
3) **Prabin Paudel**
4) **Nischal Shrestha**
5) **Neeraj Adhikari**
6) **Roshan Pandey**

Abstract

Centrifugal pumps are one of the complex machineries extensively used in water supply systems. Faults induced in pump-motor system during the course of time cause performance degradation and adversely affect the supply systems impacting a large number of households in Kathmandu Valley. Condition monitoring of the system can be performed by using vibration analysis to detect mechanical faults in pumps. Assessment of four different system of motors coupled with centrifugal pumps being used in water supply stations governed by KUKL, Nepal is done to investigate their mechanical condition. The frequency spectrum of vibration response generated from four distinct locations of horizontally mounted motor-pump system is obtained from the measurement of vibration sensor. Most common defect of bearing wear and looseness is predicted from the spectral analysis. Bearing equations verify the fault predictions done from spectrum analysis to diagnose the predicted faults of bearing wear. Analysis of symptoms of faults seen in the system and mechanical correction measures required to prevent the faults is put forward after the monitoring and diagnosis which assists to reduce the downtime and increase the uptime of pumping system in the water supply systems.

Paper No. 129 **Title**: INVESTIGATION OF CHATTER VIBRATION ON WIRE ARC ADDITIVE MANUFACTURED PRODUCTS DURING THE MILLING OPERATION

1) **Atul Singh Rajput**
2) **Ritam Sharma**
3) **Rinku Kumar Mittal**
4) **Sajan Kapali**

Abstract

Wire Arc Additive Manufacturing (WAAM) is a layer-by-layer manufacturing, capable of producing near net shape in a short period of time due to its high deposition rate as compared to other commercially available metal 3D printing techniques. The recent development in the WAAM increases its efficiency through uniform and defect-free deposition, producing cost-efficient and viable production. However, the poor surface quality of the WAAM products is still a significant drawback necessitating post-processing to increase the effectiveness and accuracy of the manufactured products. Machining operations are capable of enhancing the surface quality of the WAAM products. Furthermore, the rapid heating and cooling during the WAAM increase uneven hardness subsequently on the workpiece surface, leading to the wear of the cutting tool during machining operation. The blunt tool further increases the amplitude of the self-excited vibration called chatter during machining. The existence of chatter vibration during the machining operation decreases machining efficiency by reducing the product's surface quality and dimensional accuracy and serves damage to the cutting tools. The current work aims to analyze the increased chatter vibration amplitude during milling operation of the WAAM products.

Paper No. **Title:**

131 EXPERIMENTAL INVESTIGATION ON AIR FILM THICKNESS MEASUREMENT OF AIRFOIL THRUST BEARING LEADING TO PERFORMANCE EVALUATION UNDER DIFFERENT OPERATING CONDITIONS.

1) Ravikumar R N

Abstract

Air foil bearings have become the most preferred bearing for different high-speed applications in view of their capability to work in hostile environments. In the present paper, an attempt has been made to experimentally measure the air film thickness and relate the same with the load-carrying capabilities. A versatile instrumented test rig has been designed and fabricated for the purpose. In this investigation, measurement of air film thickness in thrust bearing using proximity probes has been carried out. The test unit essentially consists of a high-speed drive unit (40,000 rpm) with a facility to parametrically test the foil bearing for performance defined in terms of load-bearing capacity. The major factors contributing to the load-carrying capacity of thrust foil bearing include the operating parameters in terms of rotational speed, geometric parameters in terms of foil dimensions (size, shape, thickness, etc.), response parameters in terms of air film thickness and material properties of the foil together having control on resulting bearing coefficient defined in terms of stiffness and damping. The experimental result presented in this paper essentially concentrates on the variations in film thickness as a function of operating speeds for different initial gaps between the runner and bearing at static conditions. The load-carrying capacity for each of the cases is also presented, and it is observed that the decrease of the gap between the runner and bearing base under static conditions would result in relatively higher load carrying capacity along with the decrease in minimum air film thickness. Experiments have also been conducted to identify the lift-off speed for a preloaded bearing.

Paper No. 133 **Title**: SINGLE-SENSOR ANALYTICS FOR REAL-TIME MONITORING OF DYNAMICAL SYSTEMS THROUGH ERROR-FEEDBACK MECHANISM

1) **Satyam Pandey**
2) **Basuraj Bhowmik**
3) **Budhaditya Hazra**

Abstract

Research in condition monitoring has witnessed advancements in recent years in terms of development in signal processing tools for monitoring vibrating systems. In this context, recursive singular spectrum analysis (RSSA) is a real-time algorithm for online condition monitoring, primarily focusing on filtering and fault detection. However, enhancification is necessary for time-varying non-stationary signals, which masks important information relating to signal statistics. Catering to this, this work proposes an enhanced RSSA framework with an error-feedback mechanism such that a unified framework for filtering, identification of damages along with enhancification, and modal identification is achieved with improved accuracy. The proposed algorithm recursively updates the Hankel matrix for single sensor econometrics by employing Eigen perturbation for the online decomposition of single sensor data along with the error-feedback mechanism. Recursive update of the Hankel matrix removes unwanted noise present in the response, extracts a specific mode, and demasks the system response for extracting the damage information of the structure in real-time. Case studies pertaining to AM–FM signals, operational noise in structural systems, and experimental trials from a milling machine under various operating conditions are undertaken. It was observed that the error-feedback mechanism minimizes the generated error terms associated with the perturbation leading to robust spatio-temporal anomaly detection, identification of modal responses, and de-masking of signal components in real-time. This outlines the capability of the error-feedback mechanism in conjunction with the traditional RSSA framework for improved condition monitoring of systems with single-channel analytics in real-time for numerical as well as practical problems.

Paper No. **Title**:

135 VARIATION IN NATURE OF VORTEX INDUCED VIBRATION(VIV) WITH CHANGE IN GEOMETRY OF THE VIBRATING BODY.

1) **Prashant Prasar***
2) **Ishan Kafle**
3) **Jaya Paudel**
4) **Nischal Raut**

Abstract

VORTEX: the whirling motion inhibited by fluids. The difference in velocity of streams forms vortices. An object when placed in a vortex, induces vibration in the body due to the motion of fluids around because of the elastic behavior of the fluid and body. This vibration is referred to as vortex-induced vibration (VIV). The phenomenon has resulted in destruction of structures(Tacoma Narrow Bridge incidence 1940) and disturbances in marine engineering. On the contrary, Vortex Bladeless is a vortex-induced vibration resonant wind generator. Vortex induced vibration produces different frequencies and lift with the difference in their geometry. Taking the statement as reference, research goes through simulating circular and elliptical cross-section of vibrating body to predicts nature of vibration varied at some constant Reynolds number. The results of this paper can be helpful to predict the most optimized way of converting the wind energy into different form of energy maximizing the oscillation. On the other hand, minimization of VIV is useful for the reduction of effects on structural integrity of building structures as well as reduction of fluttering effect on aircraft.

Paper No. 136 **Title**: NONLINEAR FORCED VIBRATION ANALYSIS OF LAMINATED COMPOSITE CONICAL SHELLS

5) **Mohd Taha Parvez**
6) **Mirza Shariq Beg**
7) **Ahmad Saood**
8) **Arshad Husain Khan**

Abstract

Curved structural/machinery units often in the form of conical shells have wide ranging applications where they are exposed to dynamic loads leading to large amplitude vibrations. The linear strain displacement relationship assumption lead to erroneous displacement/stress predictions, therefore the inclusion of geometric nonlinearity happens to be indispensable for efficient component design. The present analysis is intended to inspect the effects of cone angle on the linear and nonlinear forced vibration response of a laminated conical shell under harmonic excitations. The governing equations of the motion are obtained using FEM based on first order shear deformation theory. The analysis is carried out in the time domain using modified shooting technique along with continuation schemes. The scheme employed is competent to get the culminate stable and unstable branches post bifurcations. The linear and nonlinear vibration response corresponding to variations in the forcing frequency for laminated conical open shells has been obtained. The assessment of linear and nonlinear frequency response curves exhibits large differences between the two. Frequency response curves, response history, FFT of the response and the phase plane plots have been acquired to analyze the influence of cone angle on the steady state forced vibration response.

Paper No. **Title:**

137 ON THE NONLINEAR STEADY STATE PERIODIC FORCED VIBRATION RESPONSE OF RECTANGULAR PLATES

1) **Ahmad Saood**
2) **Ahmad Ali Khan**

Abstract

The nonlinear forced vibration analysis of an isotropic rectangular plate undergoing significant amplitude vibration when subjected to uniformly distributed harmonic force is presented in this paper. The forcing frequency is varied near the first natural frequency and the variation of the non-dimensional peak amplitude at the centre of the plate is obtained by considering the linear and nonlinear strain displacement relationships. In the present analysis, the CO continuous, eight-noded quadrilateral shear flexible element with five nodal degrees of freedom has been used based on the first-order shear deformation theory (FSDT). The geometric nonlinearity for the isotropic plates is included by using Von Kármán relations for small and moderately large deformation. The governing equation of motion has been obtained using Hamilton's principle, which has been solved using the modified shooting method and continuation arc length/pseudo arc length schemes for completing the frequency response curves. A detailed parametric study has been carried out to investigate the effects of load amplitude on the linear and nonlinear steady-state periodic responses of the isotropic rectangular plate. The linear frequency response reveals a huge displacement/stress amplitude as compared to the nonlinear frequency response. The nonlinear dynamics of an isotropic plate are explored using cyclic stress variation plots, phase plane plots and frequency spectra.

Paper No. Title:

143 NONLINEAR DYNAMIC ANALYSIS OF A SPAN MORPHING TELESCOPIC BEAM

1) **Debashis Singha**
2) **Dr Senthil Murugan**

Abstract

Morphing structures are capable of changing its geometrical configurations based on the functional requirements and have applications in industrial robots, telescopic cranes and morphing aircraft [1-4]. This paper studies the linear and nonlinear dynamic response of a span morphing beam based on a telescopic type mechanism [1,2]. The telescopic beam mechanism is modeled as a coupled, double cantilever beam model [3,4]. It consists of a primary host beam which is fixed at one end. Then, a secondary sliding beam is considered to extend or retract (i.e morph) in and out of the host beam. Initially, the linear dynamic models of the morphing cantilever beam system are developed. Due to morphing the phenomena, equations of motions results as PDE with variable coefficients. Numerical simulations show that the dynamic response of the primary beam increases significantly during the span extension process. In the post-morphing process, the primary host beam shows sustained oscillations with multiple harmonics. Meanwhile, the secondary sliding beam shows unconventional transient response. Numerical simulations are performed for various span morphing speeds. The dynamic response characteristics show significant variations with the span morphing speeds. In the second part of this study, geoemtrically non-linear dynamic models of the morphing, double cantilever beam system are developed [5]. Numerical simulations are performed for various cases of span morphing speed. The detailed derivations of dynamic models and numerical results for various morphing scenarios of this nonlinear telescopic beam will be given in the full paper.

Paper No. **Title:**

144 STATIC AND DYNAMIC BEHAVIOUR ANALYSIS OF A COMPOSITE MATERIAL FOR WIND TURBINE BLADE USING FINITE ELEMENT ANALYSIS

1) **Subigyamani Bhandari**
2) **Nishan Adhikari**
3) **Prabhat Kiran Bhandari**
4) **Sagar Sharma Timilsina**
5) **Durga Bastakoti**

Abstract

Wind energy sources constitute a major portion of renewable energy globally, and the blades used in a wind turbine are the most important and costly component, so proper material selection of the blades crucial. Wind turbine blades are designed using various types of materials like glass fiber and Aluminum alloy 2024. This study focuses on studying and comparing the behavior of a Polyetheretherketone (PEEK) CF50 composite wind turbine blade with that of Aluminum alloy 2024 and Epoxy-Glass Fiber Composite. The three-dimensional model of the wind turbine blade was designed using SolidWorks software. The model was then imported to ANSYS software to perform static, modal, and harmonic analyses using the Finite Element Analysis (FEA). The static analysis yielded that PEEK CF50 is as structurally safe as the other two composites. The maximum frequency corresponding to the maximum displacement was found to be greater than 4 Hz for each blade. This peak frequency exceeded the frequency ranges of 1P and 3P excitation ranges, thus proving PEEK CF50, like Aluminum alloy and Epoxy Glass Fiber Composite, is an acceptable composite for a wind turbine blade.

Paper No. 149 **Title**: ANALYSIS OF OCCUPATIONAL EXPOSURE TO WHOLE-BODY VIBRATION IN THE ACTIVITY OF MECHANIZED EXTRACTION OF EUCALYPTUS WOOD

1) **Ricardo Miyajima**
2) **Roldao Carlos**
3) **Quinny Soares Rocha**
4) **Danilo Simoes**

Abstract

The mechanized extraction of wood is carried out in planted forests, in which the operators of self-propelled forest machines, such as grapple skidders, travel over obstacles, such as forest residues and stumps, which can generate occupational health risks. Thus, it was analyzed whether the levels of whole-body vibration transmitted by grapple skidders in mechanized extraction of wood in Eucalyptus planted forests are above the threshold limit value and action limit established for prevention purposes. We pondered two grapple skidders, with whole-body vibration data collected over a one-hour period and limits assessed as per the American Conference of Governmental Industrial Hygienists. In both grapple skidders evaluated, the daily 8-hour vibration exposure presented values above the action limit and the vibration dose value exceeded the threshold limit value, characterizing the activity as unhealthy and indicating the need to adopt preventive control measures.

Paper No. Title:

152 MACHINE LEARNING BASED FAULT CLASSIFICATION FOR HELICOPTER GEARBOX USING ACCELERATION SIGNALS

1) **Aparna Subramaniam**
2) **Aravin Mohan**
3) **Sujatha Chandramohan**
4) **Hamid Ali**

Abstract

The aim of this work is to classify a gearbox as one with or without gear fault using machine learning (ML) based classification techniques. Typically, the gears in a gearbox go through rough operating conditions and develop faults such as cracks and tooth spall; hence condition monitoring is crucial for operational safety and flight worthiness. The presence of background noise and many modulation effects in gearbox vibration data make reliable fault diagnosis difficult. The gearbox under study is the main gearbox (MGB) of a helicopter; this is a two-stage powertrain with spiral bevel gear input and collector stages which steps down the high input speed from the engine and provides torque to the main rotor and other accessory systems. The ground test rig consisted of a new serviceable MGB of a helicopter, an AC motor and a loading unit to conduct closed loop testing. Six uniaxial accelerometers were glued to the bearing housing on either side of the MGB and the signals were recorded using an LMS SCADAS data acquisition system. An optical tachometer was fixed against the input shaft to obtain time synchronous averaged (TSA) signals. The maximum operating speed of the gearbox was 7300 rpm and the maximum load 17000 Nm. The setup was run for seven load-speed combinations and data acquired. Non-ML based classification was tried out initially using input features consisting of statistical descriptors extracted from the TSA acceleration signals such as root mean square (RMS), kurtosis and crest factor and gear specific descriptors such as zero order figure of merit (FM0), energy ratio, sideband energy ratio, sideband level factor, amplitudes of the gear mesh frequency (GMF) and its harmonics. Subsequently, classical machine learning algorithms such as logistic regression (LR), random forest (RF), support vector classifier (SVC) and kernel support vector machine (KSVM) were used for classification on two sets of data. They were: (i) Data Set 1: the complete data set with saturated (clipped) time records (real-life data) and (ii) Data Set 2: with the clipped time records removed for some load conditions and for some accelerometer outputs so that the resulting data was clean. All these techniques gave very promising results with classification accuracy close to 100 over al1 load-speed conditions for the clean data (Data Set 2) and for the clipped data (Data Set 1) as well. Such classification work across multiple operational conditions, with multiple baseline/normal signatures and multiple signatures with faulty component, has not been reported.

Paper No. **Title:**

154 MODAL ANALYSIS OF A FLEXIBLE ROTOR SUPPORTED ON GRANULAR LUBRICATED JOURNAL BEARING

1) **Faisal Rahmani**
2) **Jayanta Kumar Dutt**

Abstract

Journal bearings are essential components of heavy rotating machineries due to their excellent lubrication and load bearing capabilities. Conventional oils are generally used for bearing lubrication. Viscosity of these oils decrease with increasing temperature; thus, restricting the usage of oils in high temperature environment. Solid granular particulates are a viable alternative as a lubricant for high temperature conditions. Several studies in literature demonstrate the suitability of granular lubricants in bearings from the tribological perspective. However, studies on the dynamics of rotor supported on such bearings are not found in literature. The study of the dynamics is important because rotors experience self-excited whirling which lead to unwanted vibrations. The objective of this work is to study the modal characteristics of a flexible rotor supported on granular lubricated journal bearings and the influence of grain size. A simplified grain theory considering the theory of dense gases to describe the granular collisions, is used to obtain the governing equation for lubrication. The stiffness and damping coefficients of the granular film are estimated through finite perturbation technique. The equations of motion for the rotor-bearing system are obtained by discretization of rotor-shaft through finite element formulation, using 2-noded Timoshenko beam elements with 4 degrees of freedom per node. The equations of motion are used for eigenvalue analysis, determination of mode shapes, modal damping factors, stability limit speed, and unbalance response. It is found that the grain particle size significantly influences the modal characteristics of the rotor-shaft system. Bearings lubricated with larger particles exhibited higher stability limit speeds.

Paper No. 155 **Title**: THE ANALYSIS OF CHUCKING OF WORKPIECE ON CHATTER DURING TURNING OF INCONEL 718 FOR GAS TURBINE APPLICATION

1) **S Gururaja**
2) **Kundan Singh**
3) **Brajesh Panigrahi**
4) **Sreejith S**

Abstract

The avoidance of chatter during the manufacturing of turbine blades can be ensured either by selecting the stable process parameters before machining or by altering the process parameters during the machining by identifying chatter onset. Chatter strongly depends on the dynamics of the workpiece, which remains fixed in the rotating chuck. In the present work, three different lengths of workpiece Inconel 718 have been chucked to analyze their effects on the modal parameters of the workpiece. The natural frequency estimated by the finite element simulation of chucked workpiece increases the frequency by 50.3% with an increase in the chucked length from 40 mm to 70 mm. Furthermore, the increase in frequency is 66.76% by increasing the chucked length from 70 mm to 100 mm. A variation in chucked lengths also changes the modal stiffness, which is difficult to estimate from finite element simulation. Hence, experimental modal analysis has been carried out to estimate the modal frequency, modal stiffness and modal damping for all three chucking lengths, i.e., 40 mm, 70 mm, and 100 mm. An increase in natural frequency has been obtained by 140% due to an increase in chucking length of workpiece by 150% from 40 mm to 100 mm. The dynamic stiffness increases by 71.6% due to an increase in chucking length from 40 mm to 100 mm. However, a decrease in damping has been observed due to increase in chucking length from 40 mm to 100 mm. The predicted stability lobe diagram clearly shows the significant change in the stable depth of cut due to different chucking lengths. This predicted stability will immensely help in deciding the length of the workpiece to be fixed in the rotating chuck during the turning of Inconel 718.

Paper No. **Title**:

156 MULTI-PARAMETRIC MODEL PREDICTIVE CONTROL APPLIED TO SEMI-ACTIVE SUSPENSION SYSTEM

1) **Radhe Saini**
2) **Hemantha Kumar**
3) **Sujatha Chandramohan**
4) **Ramin Sedaghati**
5) **Muthukumaran Packirisamy**

Abstract

Model predictive control (MPC) is a technique which determines control actions at each time instant by solving a constrained optimization problem. Although MPC easily handles actuator and input constraints imposed in a typical semi-active suspension system, its high computational cost prevents it from responding to the rapid dynamics of such systems. Alternatively, multi-parametric programming technique can shift the online computations of MPC offline by constructing an offline map of control actions associated with a state or uncertainty vector. As a result, control actions can be evaluated using simple algebraic functions, thus reducing the computational cost. In this study, a multi-parametric MPC (mpMPC) controller is applied to a semi-active quarter car suspension system incorporated with a magnetorheological (MR) damper. Using multi-parametric programming, an offline solution is computed for a typical quadratic cost objective function subject to input and physical constraints. Subsequently, these are implemented in simulation studies with bump road input conditions at various vehicle velocities. The control performances and computational costs are compared to those of conventional MPC controllers. Since mpMPC provides an exact solution as that of conventional MPC, control performances of both the controllers are identical; however, mpMPC resulted in a significant reduction in computational costs.

Paper No. 157 Title:

ON THE UNIQUE MATHEMATICAL ANALYSIS OF MAGNETO-RHEOLOGICAL ELASTOMERS UNDER LARGE TENSION-COMPRESSION OSCILLATORY LOADINGS

1) **Hossein Vatandoost**
2) **Ramin Sedaghati**
3) **Subhash Rakheja**
4) **Muthu Packirisamy**
5) **Sujatha Chandramohan**

Abstract

Smart magneto-rheological (MR) elastomers (MREs) possess magnetic field-dependent properties (e.g., stiffness and damping) that hold great promise for many important applications, particularly in noise and vibration control. MREs have shown a higher MR effect in axial mode as compared with shear mode. However, characterizing MREs in compression/tension mode has received little attention due to many complexities in experimentation. In this study, an experimental test rig was designed to perform compression/tension characterization of MREs under large amplitude oscillatory (LAO) loadings. Unlike the shear mode characterization, which always yields symmetric stress-strain curves with respect to the origin, we observed asymmetric compression/tension characteristics (e.g., stress-strain hysteresis) of MREs under LAO loadings. Therefore, the behavior of MREs in loading and unloading cycles substantially differs, particularly at higher strain amplitude. Unique determination of MRE properties at the end of these two cycles is, thus, of fundamental necessity for developing MRE-based devices. The measured stress of the MREs was decomposed into elastic, viscous, and viscoelastic components using Chebyshev functions to analyze their asymmetric characteristics. This kind of triple-components decomposition has not been reported yet. Compared with Fourier approximation, where the coefficient of its orthogonal functions depends on the highest order selected/truncated, the coefficients of the Chebyshev functions are unique and truncated-independent. The proposed stress decomposition methodology can be used to develop physically motivated models to subsequently design and control engineering structures with tension-compression MREs and to benefit from all their advantages.

Paper No. Title:

159 DESIGN AND ANALYSIS OF RADIAL FLUX MR DAMPER FOR E-BIKE APPLICATIONS USING RADIAL BASIS FUNCTION WITH DIFFERENT CONTROL STRATEGIES

1) **Devikiran Pinjala**
2) **Shravya Pendyala**
3) **Hemantha Kumar**

Abstract

Vehicular suspension, a part of automotive technology trending for decades in the field of research. The improvements in this field ranged from simple fixtures to changes in the entire suspension system. The research work presented is on the modelling of semi-active control using a Magneto-rheological (MR) damper into a rear suspension system of a bicycle. This work focuses on the preparation and rheometric characterization of MR fluid as well as the design, development, characterization, modelling and control of custom-made MR damper. It also focuses on the modelling of a two-wheeler that represents an e-bike and its control with the implementation of MR damper into its rear suspension system. A bicycle (Crest Make: Atlas) was remodeled into a 250W e-bike with all the required electronics fit to it. The suspension parameters of this vehicle are considered for the simulation and response of the MR damper fit vehicular suspension. Finite element method magnetics (FEMM) analysis has been performed to obtain the efficient MR damper piston design and the obtained design provides a magnetic flux density of 0.38T in the fluid flow gap of the damper. Once the design parameters are confined, the damper has been fabricated and filled with the prepared MR fluid and characterized on a damper testing machine. The characterization was performed by influencing the damper with the set of frequencies and amplitudes so as to attain its force-displacement and force-velocity characteristics. Based on the obtained damper characteristics, a radial basis function (RBF) based non-parametric modelling technique has been used to mathematically model the MR damper. A two-wheeler model that represents the bicycle is coupled with an MR damper model in the rear suspension system in order to obtain the dynamic analysis of the system using MATLAB/ Simulink with a random road input profile. Sliding mode control, sky hook and groundhook control strategies were implemented in controlling the designed two-wheeler model and the obtained results show an improvement of 13% in the sprung mass RMS acceleration using SMC control over MR damper off-state condition.

Paper No. **Title**:

160 SUSPENDED MICROFLUIDIC PLATFORM FOR ENGINE CONDITION MONITORING

1) **Ayobami Elisha Oseyemi**
2) **Ramin Sedaghati**
3) **Pragsen Pillay**
4) **Subhash Rakheja**
5) **Sujatha Chandramohan**
6) **Muthukumaran Packirisamy**

Abstract

Vehicular suspension, a part of automotive technology trending for decades in the field of research. Condition or health monitoring of engines and machines is essential for the smooth running of any industry. The state of the lubricating fluids—oils and lubricants, which are vital fluids that keep engines running—can be used to predict the conditions of machinery. In this regard, we propose a suspended microfluidics-based sensor platform for engine condition monitoring. The design incorporates microfluidics into a microcantilever (MCL) platform to allow for high-sensitivity passive flow monitoring. The interaction between flow and the bending characteristic of the suspended mechanical structure will help identify changes in the liquid flow properties, including density, dynamic viscosity, and kinematic viscosity, from which we can obtain useful information on the conditions of engines at specific points in time. Here, we present the model, design, and parametric analysis in terms of fluid-structural interaction properties that would enable the design of the sensing platform for various applications. Our results demonstrate the capability of this concept to take engine condition monitoring to new heights.

Paper No. **Title**:

161 A PARAMETRIC STUDY OF EFFECT OF THREE-AXLE RAILWAY BOGIE WHEELBASE ON VERTICAL DYNAMICS OF TRACK

1) **Sandeep Kumar Karn**
2) **Om Prakash Yadav**
3) **Anirudh Gautam**
4) **Nalinaksh S. Vyas**

Abstract

With the increasing demand for goods transportation, a higher load per axle is needed at higher speeds for economic benefits. Presently, each wagon has two bogies, and each bogie is equipped with two axles. Increasing axle load is limited by the strength of the track. Ongoing research in the Slovak Republic and South Korea has considered use of three-axle bogie in place of two-axles. One of the potential applications of three-axle bogies is in heavy haul freight trains in the Indian Railways. BOXNHL wagons, used for iron ore transportation have capacity of 153.75 tonnes, although a maximum of 79.28 tonnes payload is only transported using two-axle bogies with 25 tonnes axle load and in the form of large size ore particles. Instead of large particles, crushed particles can be transported using three-axle bogies, which will improve payload capacity by 44 \%. However, three-axle bogies are already in use in India and other countries in locomotives. These bogies cannot be directly used in wagons due to various dynamical constraints, majorly due to their longer length, about twice the length of the two-axle bogie. A longer bogie requires a high angle of attack while negotiating sharp curves, causing increased lateral rail-wheel contact forces, resulting in high derailment coefficient, wheel-rail wear, and noise. On the other hand, reducing wheelbase to reduce the overall length of bogies affects vertical dynamics, rail-wheel contact forces, and track components. This study attempts to analyse the effects of reduced wheelbase on the transmissibility of vertical dynamic load to the sleepers and the subgrade in the case of a three-axle bogie. In the study, the periodic structure theory is used and the track is considered as an infinite structure. The reference cell of infinite structure is composed of a rail element of the length of sleeper spacing, rail pad, fastener, and ballast. The rail is modelled as an Euler-Bernoulli beam, and sleepers are considered as lumped masses. Fastener and rail pad connecting rail with sleeper and ballast are modelled as Kelvin-Voigt linear spring-damper models. Wheel-rail contact forces are modelled as moving forces. The model is first solved for a single moving force, followed by multiple moving forces using the principle of superposition. It has been observed that the variation in wheelbase has a significant effect on vertical dynamic forces transfer.

Paper No. **Title**:

169 SIGNATURE INVESTIGATION OF EROSION INDUCED VIBRATION IN FRANCIS TURBINE

1) **Rakish Shrestha**
2) **Prithvi Gurung**
3) **Amul Ghimire**
4) **Sailesh Chitrakar**
5) **Samman Pradhan**

Abstract

Sediment erosion in Francis turbines is one of the biggest challenges to overcome in hydropower in Nepal. As Francis turbines are reaction turbines and are repeatedly operated outside their optimal range due to the effects of sediment erosion cracks and thinning of the material can be formed in the runner which could expose the turbine to severe pressure fluctuations. The resulting vibration if not monitored in time could cause more downtime in the hydropower. Therefore, vibrational analysis in the Francis turbine in order to predict the anticipated damage is very important. This study explores the effect of erosion on the Francis turbine runner and analyzes the resulting vibrations. For the simulation of the effect of erosion, the runner of Kaligandaki "A" Hydropower Plant (HPP) has been injected with the sediment properties at the Best efficiency point (BEP) operating conditions. Four erosion models have been defined for the prediction of erosion in runner blades. The highly erosive region in the runner blade is found in the suction side of trailing edge near the shroud. For the simulation of vibration, the geometry of a distorted runner profile having three different sizes of material loss due to different levels of severity of erosion and with guide vanes has been created, with the maximum cut of 0.3m. The three eroded runners are defined as edge cut (EC), Medium cut (MC), and Large cut (LC) according to the level of material loss in the blade. The normal runner without any erosion effect is also considered for the reference case. The pressure profile is obtained after performing transient simulation in all 4 cases of the runner (3 eroded, 1 reference). The pressure profile of each eroded case is compared and analyzed with the reference case. It is found that no significant pressure pulsation at the vaneless space between guide vanes and runner occurs for the EC and MC eroded runner. On the other hand, the LC case runner has a significant pressure drop when the eroded blade interacts with the guide vane. The abnormal pressure fluctuation repeated periodically with the runner revolutions, which could give rise to vibration in this region of the turbine during operation. The study shows the LC runner blades with a circular cut of size 0.3 m and runners with greater material loss size than LC would induce significant vibration in the Francis turbine.

Paper No. **Title**:

187 ANALYTICAL AND NUMERICAL INVESTIGATIONS ON AN NES BASED VIBRATION ABSORBER ENERGY HARVESTER SYSTEM

1) **Santhosh B**
2) **Praveen Krishna I R**
3) **Rony Philip**

Abstract

This work investigates a combined vibration absorber energy harvester system with a nonlinear energy sink (NES) analytically and numerically. The harmonically excited linear system is connected with an NES absorber system to efficiently transfer energy from the primary system to the absorber system through Targeted Energy Transfer (TET). The piezoelectric transduction mechanism between the primary and secondary systems will convert the dissipated vibration to useful energy that can be used for further applications. Analytical investigation of the system is performed using the complex averaging method (CXA) to derive the slow flow, which can provide more insight into the dynamics of the system. The frequency response of the system is investigated using the harmonic balance method (HBM) to identify the regions of stable and unstable periodic solutions. It is observed that in the regions of unstable periodic solutions, Strongly Modulated Response (SMR) occurs, which is effective in vibration absorption. The variation of the system parameters on the frequency response is further investigated using the HBM.

Paper No. **Title**:

191 RANDOM VIBRATION FATIGUE LIFE CALCULATION OF TRANSIT COMPRESSOR PACKAGE

1) **Abhiram Krishna B**
2) **Santhosh B**
3) **Bharatkumar Valand**
4) **Nirav Thaker**

Abstract

Due to different operating conditions, transit compressor packages are subjected to complex random loads, which lead to fatigue failure of it's components. One of the primary components in a transit compressor package is the air filter bracket. It occasionally fails under random loading conditions and significantly impacts the functioning of the compressor package. This work aims to perform a random vibration analysis of a transit compressor package and find the damage factor of the air filter bracket assembly using finite element analysis combined with the Steinberg approach. The analysis uses two materials for the air filter bracket (S355JR and SS316). Modal analysis is conducted to identify the dominant modes of vibration. The finite element analysis shows that the stresses are within the allowable limit, and the damage factor is less than one for both materials. Based on the analysis, it is found that the stress handling capacity of S355JR is more and therefore suggested as an appropriate material for the air filter bracket.

Paper No. 193 **Title**: SUPERVISED MACHINE LEARNING MODEL FOR CONDITION MONITORING USING CROSS MODALITY TRANSFER LEARNING

1) Sudhendu Ahir

Abstract

Vibration signatures are routinely used for condition monitoring of rotary induction machines. The sources of vibrations can directly be traced to the mechanical state of the machine thus providing a direct link to its health. Nonetheless, collecting vibration data may not always be feasible due to accessibility constraints or because of the presence of other sources of vibrations and noise in the environment. Therefore, the last couple of decades have seen a development of electric current based condition monitoring for such machines. Such current based condition monitoring systems are primarily supervised machine learning models, trained on historical data. However, training such a machine learning model ignores all the past learnings from condition monitoring done using vibration data. Therefore, in this article an attempt has been made to perform transfer learning of knowledge from vibration based condition monitoring to current based condition monitoring. Many of the mechanical faults can be directly related to underlying current signatures however a one to one mapping does not exist for all such faults. Several other electrical faults such as stator gap variability, impedance mismatch, etc. may not have any mechanical counterpart.

Paper No. **Title**:

195 INFLUENCE OF SPHERICAL AND ELLIPSOIDAL SHAPES ON THE PRESSURE PULSATION AND VIBRATION PHENOMENA IN A RECIPROCATING COMPRESSOR MANIFOLD

2) **Przemyslaw Mlynarczyk**
3) **Damian Brewczyński**
4) **Joanna Krajewska-Śpiewak**
5) **Paweł Lempa**
6) **Jarosław Błądek**
7) **Kamil Chmielarczyk**

Abstract

Periodic work flow of the volumetric compressors causes the pressure and mass flow pulsations. Most of the phenomena triggered by pressure pulsation, like vibrations, energy loss, valves wear are harmful to the installation and its components. Wide range of compressors, from large, low-speed natural gas compressors to small, compact refrigeration compressors with variable speed makes it difficult to find a ubiquitous solution for this problem. Variable frequency of pressure pulsations and vibrations of the pipeline limits the effectiveness of Helmholtz resonators and tuned mass dampers. One of the possibilities to attenuate pulsations, in a wide range of frequency, is to place shaped nozzles in the compressor discharge manifold. The nozzles significantly affect the compression power by restricting the flow from the wall-to-center of the pipe. Therefore, the influence of elements placed on the axis of the pipeline with a spherical and ellipsoidal shape were investigated. The conducted research allowed to assess the impact of such a nozzle on the damping of pressure pulsations and longitudinal vibrations of the pipeline. The results of the performed tests show significant differences between the influence of the spherical and ellipsoidal shape on the damping of pulsations and vibrations for different excitation frequencies. The averaged value of the attenuation for different frequencies is higher for the sphere shape.

Paper No. 198 **Title**: EFFECTS OF VARIATION OF MID-SPIRAL ANGLE OF BEVEL GEAR ON THE VIBRATION OF A GEARBOX

1) **Anuradha Gollapudi**
2) **Sagi Rathna Prasad**
3) **Piyush Shakya**
4) **A. Seshadri Sekhar**

Abstract

The complex gearbox configuration involving numerous spiral bevel gear pairs, helical gear pairs, and planetary gear sets makes its analysis tedious and challenging. Further, the high-speed rotational requirements of the gears make the system even more vulnerable to excessive vibrations, affecting the gearbox performance. In the literature, it has already been proved from the experimental results that the spiral bevel gear pairs gearbox gives rise to highest peaks than any other types of gears present in the system and thus, making it extremely important to focus more on the analysis of spiral gears to bring down the vibration in the gearbox. However, literature is scantly found on these gears due to their three-dimensional geometric and dynamic complexities and is still actively being researched. Hence, the current study mainly aims to understand the influence of mid-spiral angle, one of the significant geometry defining parameters of spiral bevel gear, on the vibrational behaviour of a gearbox. The hybrid model involving both the finite element and lumped mass method has been used to obtain the vibration data of the gearbox, and the effects of varying the mid-spiral angle of the gear have been investigated. The results of this study may aid in designing the spiral gear pair for better gearbox performance and may be useful in many places, including helicopters.

Paper No. **Title**:

207 ACROSS-WIND RESPONSE CONTROL OF CHIMNEYS WITH TUNED MASS DAMPERS

1) **Saba Rahman**
2) **A.K Jain**
3) **K.N Jha**
4) **T.K Datta**
5) **S.D Bharti**

Abstract

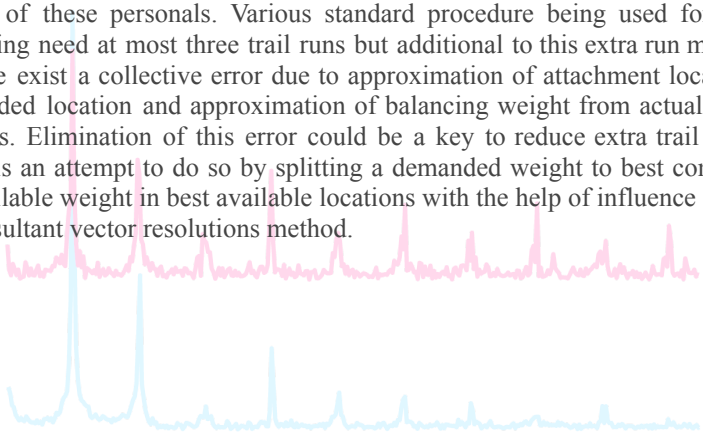
The effectiveness of tuned mass dampers (TMDs) for response control of circular concrete chimneys across wind vibration s investigated in this study. A concrete chimney of height of 360m with varying diameters is considered. Across wind, force is simulated using the Vickery & Basu model. Three different cases of placement of tuned mass dampers (TMD) along the height of the chimney have been considered based on its uncontrolled modal response. In one case single TMD (STMD) is placed at the tip of the chimney where the amplitude of vibration is largest and is tuned with fundament frequencies whereas in another case STMD is placed at the lock-in location where Strouhal frequency is locked with the fundamental frequency of the chimney. MTMDs are placed at the regular interval at the top one-third height of the chimney. The coupled differential equation is solved using the numerical integration technique in frequency domain analysis. The controlled and uncontrolled response of the circular chimney is showed in terms of the performance criteria mentioned in the paper. It is concluded in the study that MTMDs are effective controllers for tall chimneys.

Paper No. 208 **Title**: OPTIMAL DISTRIBUTION OF PROPELLER DYNAMIC BALANCING CORRECTION WEIGHTS TO MATCH PRE-DEFINED ATTACHING POINTS

1) **Dipesh Thapa**
2) **Sudip Bhattrai**
3) **Laxman Poudel**

Abstract

A field dynamic balancing of propeller need frequent engine run up that comes with additional cost, time and pollution. Moreover aircraft maintenance personnel get exposed to more air and noise pollution during propeller balancing than general aircraft departure due to longer exposure time and power run requirements. Hence any attempt to reduce the number of trail run will save cost, environment and health of these personals. Various standard procedure being used for dynamic balancing need at most three trail runs but additional to this extra run may require if there exist a collective error due to approximation of attachment location from demanded location and approximation of balancing weight from actual balancing weights. Elimination of this error could be a key to reduce extra trail runs. This paper is an attempt to do so by splitting a demanded weight to best combinations of available weight in best available locations with the help of influence coefficient and resultant vector resolutions method.



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1) **Rakish Shrestha**
2) **Prithvi Gurung**
3) **Amul Ghimire**
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211 EFFECTS OF VARIATION OF MID-SPIRAL ANGLE OF BEVEL GEAR ON THE VIBRATION OF A GEARBOX

1) **Anuradha Gollapudi**
2) **Sagi Rathna Prasad**
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Abstract

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Paper No. 212 **Title**: VIBRATION ANALYSIS OF CARBON STEEL PIPES IN OIL INDUSTRY

1) Mussab Zarog

Abstract

The repeated motion of a particle about its mean position is termed vibration. Vibration Analysis of piping elements in Oil &Gas industry is very crucial since it might lead to fracture and leakage which considered to be significant threat to plants and might cause a shutdown, besides threatening the safety of the employees as well as the surrounding environment. This study aims to investigate and analyze the flow-induced vibration in the piping system within Mina' Al Fahal, in Oman. Direct measurements of vibration (both magnitude, and frequency) were conducted for this purpose, and at different locations on different sizes of carbon steel pipelines within the Mina' Al Fahal with different sizes (40.30,24, 12,8, and 4 inch pipes). The effects of size, location of vibration were examined. Measurement of vibration frequency and amplitude of vibration were carried out for all pipes' sizes. The results shows great dependency of the location of dampers on the level of vibration as opposed to the negligible effect of pipe size. The study also propose further investigation of the oil flowrate on the level of vibration.

Paper No. 213 **Title**: STATISTICAL FEATURES OF VIBRATIONS SYSTEMS FORCED BY STOCHASTIC IMPULSES

1) **Adnieszka Ozga**
2) **Grzegorz Litak**
3) **Piotr Wolszczak**
4) **Marek Sulewski**
5) **Natalia Frankowska**
6) **Przemysław Frankiewicz**

Abstract

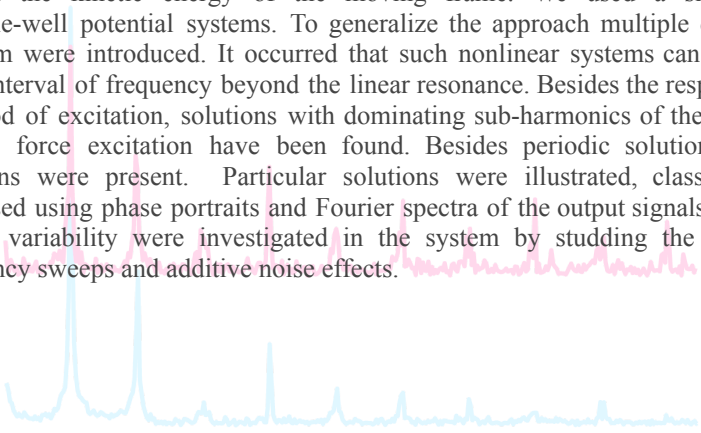
With the help of mathematical models it is possible to obtain the value if the random variable recorded in the form of a temporal series describing the position of the system. The vibrations of this system are forced by a random series of stochastic impulses of a given distribution. The article discusses the reasoning that leads to opposite reasoning. Solving of a inverse problem consisting in the search for a similar distribution of impulses through an analysis of courses and subsequent raw moments calculated from these courses gives rise to numerous difficulties that have to be coped with in stages. One of the stages that are discussed in the paper makes use of non-supervises machine learning to determine the potential of application of the algorithms of artificial intelligence for solution of the problem.

Paper No. **Title**:
MECHANICAL ENERGY HARVESTING WITH NONLINEAR EFFECTS

1) **Grzegorz Litak**

Abstract

Energy from ambient vibration sources can be captured and used to power sensors in monitoring systems and small portable devices by energy harvesters. An important issue is to reach a compromise between the maximum power output and the width a frequency transmission band because of the natural variability of the ambient vibration sources. In this context, energy harvesting systems based on nonlinear mechanical resonators and piezoelectric transducers have been applied to harvest the kinetic energy of the moving frame. We used a single- and multiple-well potential systems. To generalize the approach multiple degrees of freedom were introduced. It occurred that such nonlinear systems can work in a wide interval of frequency beyond the linear resonance. Besides the response with a period of excitation, solutions with dominating sub-harmonics of the harmonic inertial force excitation have been found. Besides periodic solutions chaotic solutions were present. Particular solutions were illustrated, classified, and discussed using phase portraits and Fourier spectra of the output signals. Effect of source variability were investigated in the system by studding the excitation frequency sweeps and additive noise effects.



Paper No. **Title**:

FAILURE ROOT CAUSE ANALYSIS FOR HIGH JOURNAL BEARING VIBRATIONS OF VCM PLANT PROPANE GAS CENTRIFUGAL COMPRESSOR AND ITS DESIGN IMPROVEMENTS FOR STABLE OPERATION

1) **Varuna Reddy. P**
2) **Arjunappa. M**
3) **Ramababu. K**

Abstract

A four stage Centrifugal refrigeration gas compressor was in operation in VCM plant having suction pressure of 1.31 Bar a, Discharge pressure of 11.31 Bar a, Saturated temperature of -36 C at inlet wheel 1, Discharge at 4th wheel 31.99 C, Mass flow of 8.7 Kg/S with cooling duty of 2250KW, running at a speed of 12030RPM had operational instabilities due to inadequate Suction heads. Hence it had frequent startups and shut-downs due to high Journal Bearing Vibrations. Ever since the compressor haven't achieved the designed throughput of 45TPH but always runs at lower designed throughput of 50 to 60%. By carrying out manual adjustments of processes parameters like evaporator % levels, HGBP%, PRV%, Valve adjustments, upstream and downstream strainers changes allows to ramp up the compressor to 80% throughput to 36TPH. The compressor used to be stable for a short while and suddenly goes to instability followed with shut-down due to high Trip vibrations levels i.e., 75 microns on NDE Balance piston side. Upon opening the compressor, found the balance piston Laby seal ring cracks, heavy rubbing/scoring marks and material losses. Each shutdown costs to the company a revenue loss of USA$ 50000/day

A thorough study was conducted in design review of Balance piston, interaction with operational and maintenance personal, review of control room data logger and maintenance records to establish most probable causes for high Journal Bearing Vibrations which were responsible for instability and compressor shut-down. Beside these, root cause analysis/Ishikawa brain storming was done on all attributes and arrived the conclusions i.e., 1. Process parameters upsets due to design adequacies 2.Inadequate mechanical strength of Balance piston ring 3. Inadequate Gaps between stationary and rotary Laby seals

Implementation of all improvements the compressor is now continuously running with less than 20 microns of Journal Bearings vibrations and designed throughput of 45TPH since Dec 2021

Paper No. **Title**:

DEEP AND SHALLOW-PARALLEL MACHINE LEARNING PROTOCOLS FOR SINGLE AND MULTI-LABEL FAULT DIAGNOSIS IN ROTATING MACHINERY

1) Vyas

Abstract

Two major issues in fault classification in machinery concern the need of pre-processing raw data collected by sensors and identification in cases where more than one fault exist simultaneously, i.e. where multi-label faults are present. A Convolution Neural Network (CNN) based Deep architecture for classification of Single faults from raw time domain data and a similar but shallower Parallel Multiple Binary Classifier Network for Multi-label Fault Classification, will be discussed. Experiments on a Rotor-Bearing Fault Simulator are described. In the case of Single-Label fault classification, Support Vector Machines (SVMs), Clustering, Artificial Neural Networks (ANNs) and other algorithms have been used in the past. These procedures require the raw time-domain data collected by sensors, to be first processed and handcrafted into parameters like Fast Fourier Transform (FFT) coefficients, Statistical Moments, etc. before being fed as inputs. Usage of ANN with raw time domain data is inadequate as it suffers from the vanishing gradient problem. A Deep Learning Multi-channel Convolutional Neural Network (McCNN) architecture is discussed, which eliminates this problem and employs the RGB image analogy for channelizing raw time-domain vibration signals from various sub-systems of the rotor-bearing installation. It is shown that this architecture effectively works on raw time-domain data and recognizes all kinds of Single-Label Faults. For Multi-Label faults also, which generally get classified as erroneous Single-Label type through routine codes, the parallel architecture is demonstrated to give good results.