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**RESEARCH ARTICLE**

**VIBRATION ANALYSIS ON ROTATING SHAFT USING WEKA WAIKATO**

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**Abstract**

Vibration analysis is a technique used to evaluate the condition of machinery by examining the vibrational characteristics of a system as it operates. Rotating shafts are common components in many types of machinery, and vibration analysis can be used to identify potential problems with these shafts. This can be accomplished through the use of sensors and specialized software that measure and analyze the vibrational characteristics of the shaft as it rotates. By examining the frequency, amplitude, and other characteristics of the vibrations, it is possible to identify issues such as imbalances, misalignments, or bearing failures, and take corrective action to prevent more serious issues from occurring. Vibration analysis is an important tool for maintaining the reliability and efficiency of machinery, and can help to extend the service.

**Keywords:** vibration, weka waiato, frequency, analysis

**Introduction**

**A. Shaft Domain**

Rotating shaft vibration is the motion of a shaft as it rotates around its axis. This motion can be caused by various factors, such as imbalances in the shaft or its components, misalignments, or bearing failures. If not properly addressed, shaft vibrations can lead to problems such as reduced efficiency, increased wear on components, and ultimately,

equipment failure. Vibration analysis is a technique used to evaluate the condition of machinery by examining the vibrational characteristics of a system as it operates. This can be done using sensors and specialized software that measure and analyze the vibrational characteristics of a shaft as it rotates.

**B. Frequency Domain**

The frequency domain refers to the representation of a signal in terms of its frequency

content. In the context of rotating shaft vibration analysis, the frequency domain can be used to identify the specific frequency bands or "peaks" in the vibrational spectrum of a shaft that may indicate a problem. To analyze the frequency domain of a shaft's vibrations, a frequency spectrum analysis is often used. This involves breaking down the vibration signal into its individual frequency components and plotting the resulting spectrum. The spectrum can then be examined to identify any frequency bands or peaks that may be present. By analyzing the frequency domain of a shaft's vibrations, it is possible to identify problems such as imbalances, misalignments, or bearing failures.

### B. Signal Domain

To analyze the vibrations of a rotating shaft, a signal must be collected from the shaft using a transducer or vibration sensor. There are several types of sensors that can be used for this purpose, including accelerometers and velocity pickups. An accelerometer measures the acceleration of the shaft as it vibrates, while a velocity pickup measures the velocity of the vibrations directly. The output from these sensors is typically an electrical signal that can be processed and analyzed using specialized software. Once the signal has been collected, it can be processed and analyzed to determine the vibrational characteristics of the shaft. This may include measures such as the root mean square (RMS) velocity, which is a measure of the overall strength of the vibrations, and the frequency spectrum, which breaks down the vibration signal into its individual frequency components and plots the resulting spectrum

### C. Weka Waikato

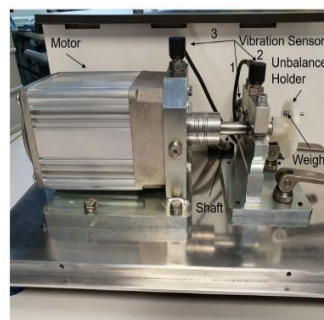
WEKA (Waikato Environment for Knowledge Analysis) is a collection of machine learning algorithms and data preprocessing tools developed by the University of Waikato in New Zealand. It is implemented in the Java programming language and is designed to be a comprehensive, easy-to-use platform for data mining and machine learning tasks. WEKA includes a wide range of algorithms for

classification, regression, clustering, and feature selection, as well as tools for preprocessing and visualizing data. It also provides a GUI (Graphical User Interface) that allows users to easily apply these algorithms to data sets and analyze the results. WEKA is widely used in academia and industry for research and development in the fields of data mining, machine learning, and predictive modeling.

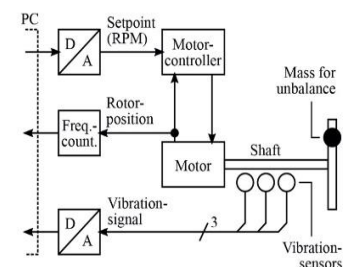
### E. Regression models

Regression models are statistical techniques used to predict the value of a dependent variable based on one or more independent variables. These models are used in a wide range of applications, including economics, biology, and engineering, to understand the relationship between different variables and to make predictions about future outcomes. There are several types of regression models, including linear regression, logistic regression, and polynomial regression. Linear regression is used to model the relationship between a dependent and independent variable as a linear equation, while logistic regression is used to predict a binary outcome (such as "success" or "failure"). Polynomial regression is used to model the relationship between variables as an nth-degree polynomial, allowing for the capture of more complex relationships.

### Analysis of vibration of a rotating shaft using different techniques of regression model



Measurement setup



Block diagram of the measurement setup

1. The setup for the simulation of defined unbalances and the measurement of the resulting vibrations is powered by an electronically commutated DC motor (WEG GmbH, type UE 511 T), which is controlled by

a motor controller (WEG GmbH, type W2300) and is fixed to the aluminium base plate by means of a galvanized steel bracket.

2. Vibration sensors (PCB Synotech GmbH, type PCB-M607A11 / M001AC) are attached to both the bearing block and the motor mounting and are read out using a 4-channel data acquisition system (PCB Synotech GmbH, type FRE-DT9837).

**Abbreviations and Acronyms**

1. **V<sub>in</sub>** : The input voltage to the motor controller V<sub>in</sub> (in V)
2. **Measured\_RPM** : The rotation speed of the motor
3. **Vibration 1**: The signal from the first vibration sensor
4. **Vibration 2**: The signal from the second vibration sensor
5. **Vibration 3**: The signal from the third vibration sensor

**Overview of the dataset components:**

V <sub>in</sub>	Measured_RPM	Vibration_1	Vibration_2
0.00E+00	1.04E+03	1.10E+00	2.11E+00
4.00E+00	1.04E+03	1.10E+00	2.11E+00
4.00E+00	1.04E+03	1.10E+00	2.11E+00
4.00E+00	1.04E+03	1.10E+00	2.11E+00
4.00E+00	1.04E+03	1.10E+00	2.11E+00
4.00E+00	1.04E+03	1.10E+00	2.11E+00
4.00E+00	1.04E+03	1.10E+00	2.11E+00
4.00E+00	1.04E+03	1.10E+00	2.11E+00
4.00E+00	1.04E+03	1.10E+00	2.11E+00

**Linear regression model technique for analysis:**

Linear regression can be used to analyse the vibration of a rotating shaft by fitting a linear model to the observed vibration data. This involves collecting a series of vibration measurements from the shaft at regular intervals, and then using a statistical method to fit a straight line to the data. The slope of this line can be used to estimate the stiffness

of the shaft, while the intercept can be used to estimate the displacement of the shaft at the starting point of the measurement. There are several different ways to perform linear regression, but one common method is the least squares method. This involves minimizing the sum of the squared differences between the observed data points and the fitted line. The linear regression model for analysing the vibration of a rotating shaft can be expressed mathematically as follows:

Where:

$$y = mx + b$$

y is the observed vibration of the shaft at a given time  
 m is the slope of the fitted line, which represents the stiffness of the shaft  
 b is the intercept of the fitted line, which represents the displacement of the shaft at the starting point of the measurement

To fit a linear model to the observed vibration data using the least squares method, we seek to minimize the sum of the squared differences between the observed data points and the fitted line. This can be expressed mathematically as follows

$$\sum (y - \hat{y})^2$$

Where:

Σ represents the sum over all of the data points  
 y is the observed vibration of the shaft at a given time  
 ŷ is the predicted vibration of the shaft at that time, as calculated using the linear regression model (y = mx + b)

The slope and intercept of the fitted line can be calculated by minimizing this sum of squared differences. This can be done using a variety of techniques, such as gradient descent or the normal equations.

**Decision table technique for analysis:**

A decision table is a tool used in system analysis and decision-making to organize and clarify the possible outcomes of a complex problem. In the

context of analyzing the vibration of a rotating shaft, a decision table could be used to organize and evaluate the different factors that could contribute to the vibration, such as shaft misalignment, imbalance, or bearing defects. The decision table would list the various possible causes of the vibration and the corresponding actions that should be taken to address them, such as realigning the shaft or replacing a bearing. This technique can be useful for breaking down a complex problem into manageable components and identifying the most likely cause of the vibration.

the vibration of a rotating shaft can be analyzed using the following mathematical formulas:

Balance correction: The unbalance of the shaft can be calculated by using the vibration data and the following equation:  $Unbalance = (m_1 * r_1^2 + m_2 * r_2^2 + \dots + m_n * r_n^2) / (I * \omega^2)$

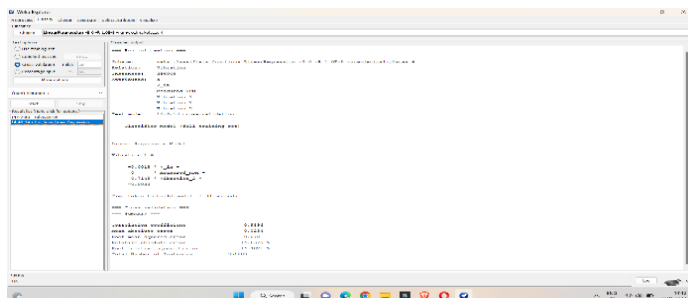
Frequency Analysis: FFT (Fast Fourier Transform) can be used to analyze the vibration signal and determine the dominant frequency of the vibration.

Torsional vibration analysis: Torsional vibration can be calculated by using the following equation:  $Torsional\ Vibration = (T_{max} - T_{min}) / (T_{max} + T_{min})$

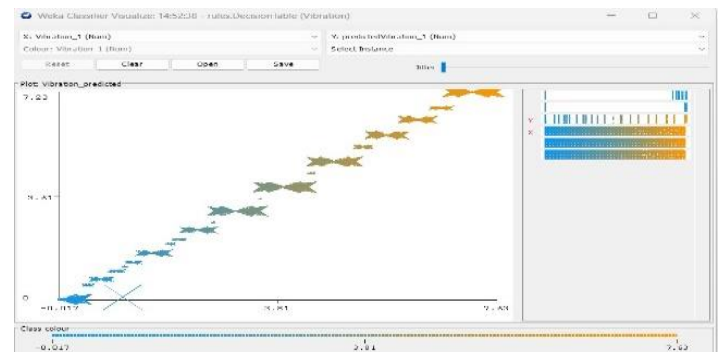
It's important to note that these equations are only examples, and the specific calculations used will depend on the type of shaft, the vibration data, and the cause of the vibration being investigated.

## Experimental result

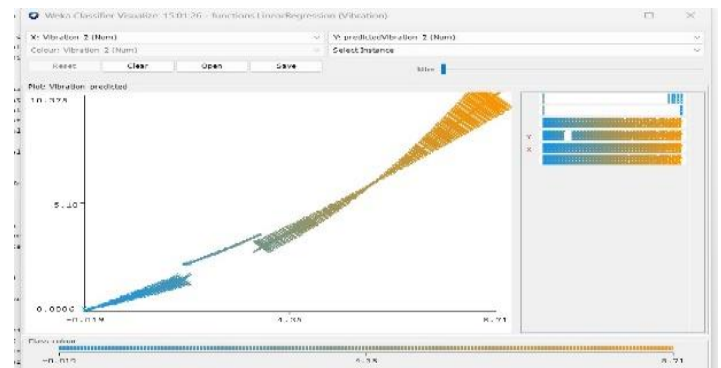
### Analysis of vibration 1 using linear regression:



### Analysis of vibration 1 using decision table:



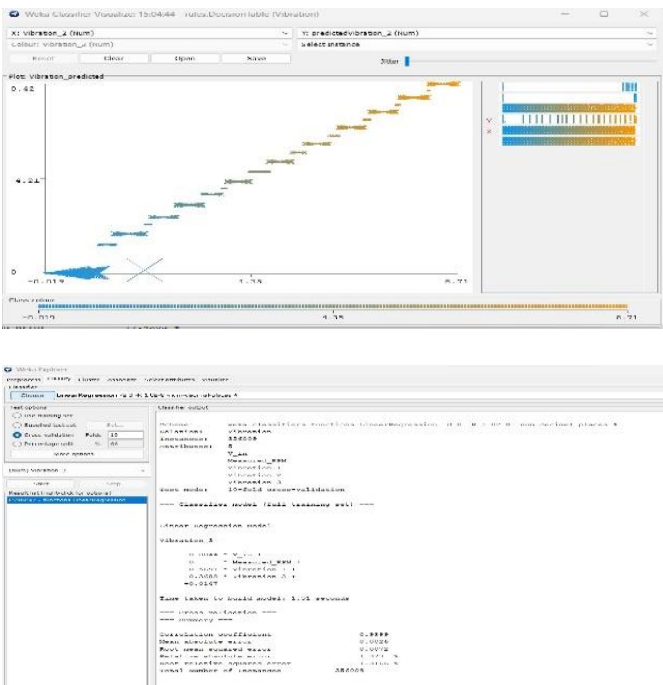
### Analysis of vibration 2 using linear regression:



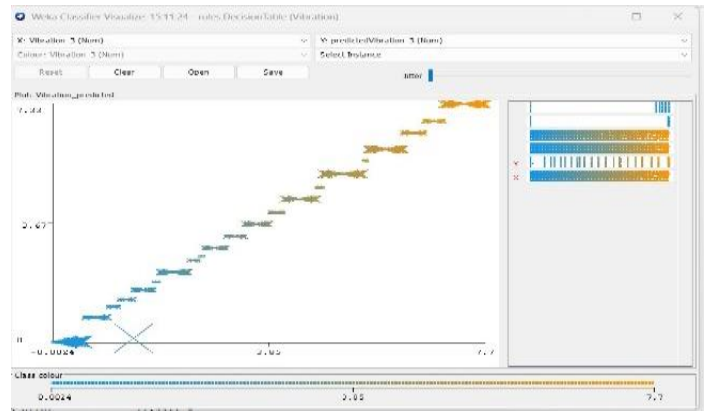
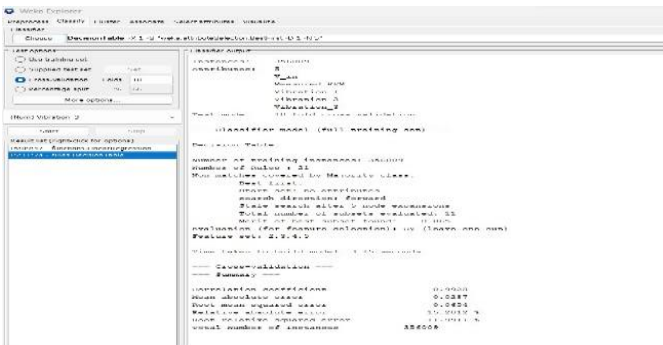
### Analysis of vibration 2 using decision table:



### Analysis of vibration 3 using linear regression:



### Analysis of vibration 3 using decision table:



### Conclusion

In conclusion, the analysis of rotating shaft vibration is a complex task that involves identifying the cause of the vibration and taking appropriate measures to address it. The decision table technique can be used to organize and evaluate the different factors that could contribute to the vibration, such as shaft misalignment, imbalance, or bearing defects. Mathematical calculations, such as balance correction, frequency analysis, and torsional vibration analysis, can be used to analyze the vibration data and determine the cause of the vibration.

It's important to note that the analysis of rotating shaft vibration is not only limited to decision table and mathematical calculations, other techniques such as modal analysis, Finite element method, experimental modal analysis etc can also be used depending on the level of understanding required and the complexity of the problem.

Ultimately, the goal of the analysis is to identify the cause of the vibration, take appropriate measures to address it, and ensure the safe and reliable operation of the shaft and the equipment it drives.

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