

# A Drill Bit Condition Monitoring Based on Vibration Analysis: An Experimental Study

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**ABSTRACT:** This project presents a study on monitoring tool wear and failure in drilling using vibration signature analysis techniques. Discriminant features, which are sensitive to drill wear and breakage, are to be developed in both time and frequency domains. Condition monitoring is the process of monitoring a parameter of condition in machinery (vibration, temp, etc.) in order to identify a significant change which is indicative of a developing fault. It is a major component of predictive maintenance. It is an important technique in manufacturing industries for on-line monitoring of the processes and equipments. Diagnose the fault which can be addressed before they develop into a major failure. The ability of the monitoring feature to detect drill wear and breakage are to be verified experimentally. The drilling tests are performed using various mm diameter high speed twist drill, and workpieces. After the review of major, well established and mature approaches, new unsupervised approaches based on novelty detection are also briefly mentioned.

**KEYWORDS:** Drilling Machine, Vibration Analysis, Condition Monitoring.

## I. INTRODUCTION

Drilling is a widely used machining process; it represents approximately 40% of all cutting operations performed in industry. Typically, twist drills are used in a diameter range from 1 to 20 mm. In general, the failure of a twist drill occurs by one of two modes; fracture or chipping and excessive wear. Drill wear and breakage have a direct influence on the dynamic characteristics of the drilling process. A worn drill generates vibration signals indicative of the drill conditions. The vibrations can cause the drill to "wander" from its true centre or they may result in a tapered or oversized hole. These defects are of particular importance for high speed precision drilling. Such a process is common in the aircraft industry (e.g. machining of aluminium alloy parts), and in the automobile industry (e.g. machining of cast iron parts). Untended automation of drilling operations requires the development of reliable methods for on-line sensing of cutter breakage and wear.

Vibration analysis is a process of looking for anomalies and monitoring change from the established vibration signature of a system. The vibration of any object in motion is characterised by variations of amplitude, intensity, and frequency. These can correlate to physical phenomena, making it possible to use vibration data to gain insights into the health of equipment. Vibration analysis can be used to:

- Find a developing problem that can be repaired to increase machine lifetime.
- Detect and monitor a chronic problem that cannot be repaired and will only get worse.
- Establish acceptance testing criteria to ensure that installation/repairs are properly conducted.
- 24/7 continuous vibration monitoring can be used to predict failures as part of a predictive maintenance program.

Vibration Analysis:

Vibration analysis is one of the main methods in fault diagnosis. A review of the works in the area of vibration analysis for condition monitoring of brake components forms the theme of this section. The review of the literature made under the subsections of conventional methods, time domain analysis and frequency domain analysis and pattern recognition are described below.

Time Domain Analysis:

Time domain analysis is the analysis of mathematical functions or physical signals with respect to time. A time-domain graph shows how a signal changes over time, whereas a frequency-domain graph shows how much of the signal lies within each given frequency band over a range of frequencies.

#### Frequency Domain Analysis:

The vibration signal from a machine can be looked upon as its signature. Every component with its own spring-mass properties has its own characteristic frequency / frequencies; excitation of these contributes to the overall signature. As such the vibration level is only a total indicator of machine condition. A better approach will be to segregate vibration into distinct frequency regions and identify the vibration changes in each such region separately. In a way this amounts to the characteristic frequencies being given importance. In turn, this can lead to more specific information regarding machine condition. The frequency domain analysis techniques are centred on this idea.

#### Fault Detection:

A fault is an unexpected change or malfunction in a system. The term 'fault detection' is defined as the process of finding the condition of the bearing - good or faulty. Fault diagnosis is a closely associated term. It is defined as the process of identifying the condition of the element under study and cause of the problem.

#### Fault Diagnosis:

The process of diagnosis is performed with spectral comparison and trending; typically, only the frequencies identified as having significant changes are analyzed in detail for diagnostic purposes. The vibration spectrum of even relatively simple machines can be quite complex due to the multiple harmonic structures of the vibration from various components. Faults such as large wear and unbalance, are distributed faults causing a significant change in the mean amplitude of the vibration at discrete frequencies; these can be diagnosed easily. These faults manifest themselves as changes in a few associated frequencies in the spectrum. Eccentricity and misalignment cause low-frequency sinusoidal modulation resulting in an increase of sidebands of certain frequencies (depends on the component to be diagnosed) and their harmonics. Localized faults create short impulsive vibration, which transforms into a large number of low amplitude frequencies in the spectrum; they are difficult to diagnose or even detect.

## II. OBJECTIVES

Current vibration analysis methods limit the user to offline monitoring of drill bit. Other approaches of online tool condition monitoring have issues such as requiring much efforts to accomplish the calculations, lengthier process, extremely expensive, so the objectives of this project are

- To design and develop mechatronic interface for drill bit condition monitoring.
- To develop DAQ system for condition monitoring.
- To correlate the vibration response with particular drill bit failure condition.
- To classify faults based on change in response of vibration.

## III. LITERATURE REVIEW

**T. I. El-Wardany (1996)** is paper work deals with the development of vibration-based monitoring methods for detecting breakage of small size drills (3 mm diameter) and wear of larger size drills (6 mm diameter). The characteristics of the vibration signatures were examined in both time and frequency domains. Signature features were developed and were shown to be effective in detecting drill wear and breakage, while insensitive to variations in cutting conditions. The effectiveness of the proposed monitoring features was verified from drilling experiments using high speed steel twist drills and cast iron workpieces.

**Susai Mary J (2019)** The objective of this study is to predict and classify the state of runout. Timely prediction of runout facilitates remedial action and improves the quality of components. An increase in amplitude of vibration signal accompanied by decrease in amplitude of force signal indicates the existence of runout. The runout was classified into four states as 'no runout' (<0.05 mm), 'normal' (0.05 mm–0.1 mm), 'initial state' (0.1mm–0.2mm), and 'runout' (>0.2mm). From the measured values of circularity it was observed that the circularity error of the drilled holes varies from 0.004 mm to 0.031 mm for different values of runout. It was evident that an increase in runout resulted in the increase in circularity error, causing an adverse effect in the assembly of components.

**U Natarajan (2006)** In this study, two Hidden Markov Models (HMM) such as bar-graph method and the multiple modelling methods have been used to determine the tool wear states in drilling operations. Cutting speed, feed rate, drill diameter and torque are taken as input parameters for the HMM bar-graph method. In order to increase the reliability of these outputs, a Decision Fusion Centre Algorithm (DFCA) is proposed which combines the outputs of the individual methods to make a global decision about the wear status of the drill tool. Maximum wear occurs at the cor-

ners of the cutting lips because these are the locations of the highest cutting speed. Therefore in this work, outer corner wear was selected as the criterion for drill wear to be analysed.

**GalipothuDheerajSimon (2019)**In this paper, flank wear of tool is monitored by measuring the vibration signals developed during the drilling process. Based on this data, the tool condition is categorized into wear or no-wear state and further into severely or gently operated. This information will be useful in developing an effective tool management system. The drilling induced vibration signals were acquired using an accelerometer whose output was conditioned by a DAQ card. Statistical features of the signal are extracted using MS Excel. K-star algorithm was used to classify the extracted signals with the help of Weka software and an accuracy of 79.56% was obtained. Classification accuracy depends on the careful selection of the subset of vibration features used in training the classifier.

**Garret O'Donnell (2001)** Author notes down the following points during his investigation.

- Fluctuation of the signal levels recorded from nominally identical drilling operations, both on the same workpiece and on different workpieces.
- High noise levels associated with the vibration and AE signals highlighting the problems faced by the use of these types of sensors in the manufacturing environment.
- The use of a feature based analysis of the signals e.g. dynamic identification of region 4/5 in the power signal) could increase the signal±noise ratio.
- Information relating to the product type change, supplier change and batch change are typically already available in factory data systems or line controllers. This information could be made available to the TCM system. Selection of an appropriate strategy could then take place, hence reducing the numbers of false alarms.

#### IV. METHODOLOGY

- Recognition of need.
- Selection of mechanical, instrumentation and control system (mechatronic system).
- Development of DAQ system.
- Hardware & Software Integration.
- System testing.
- Manufacturing of actual Condition Monitoring system.

#### V. BLOCK DIAGRAM

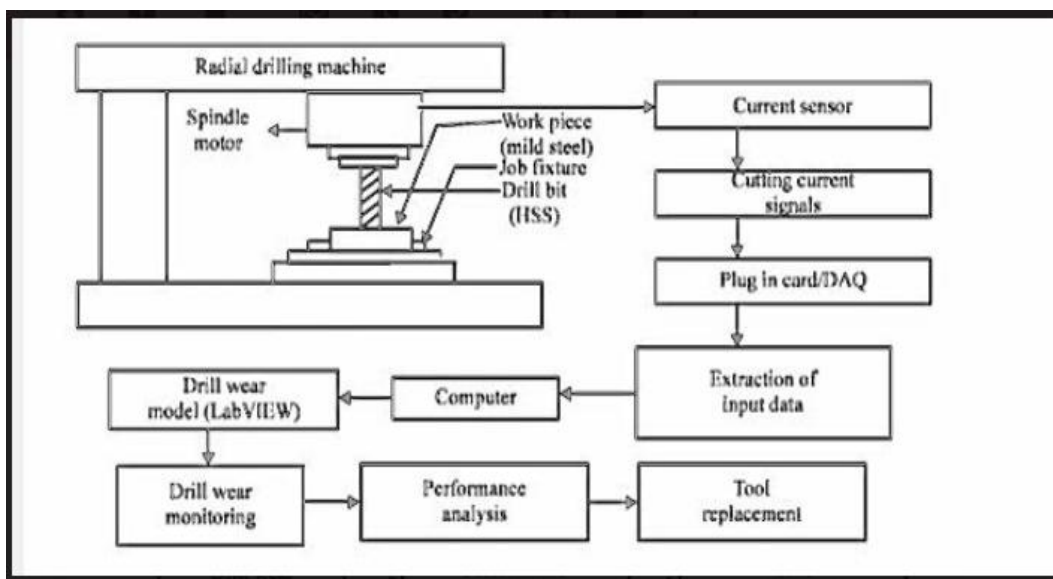


Fig 1: Experimental Setup

#### VI. CONCLUSION

The development of practical and reliable methods for detecting tool wear and failure in machining is essential for the realisation of intelligent and flexible manufacturing systems, In this study, the problem of on-line detection of tool fail-

ure in drilling has been studied.

The following conclusions were drawn from the development:

1. By studying various research papers related to machine condition monitoring we could say that it is possible to achieve the pre-detective failure signal for particular drilling machine.
2. The study shows that the Taguchi method usually used to reduce the number of experiments by using orthogonal arrays and also attempts to minimize the effects of control factors.
3. For a signal with a normal distribution that is normal bearing signal has a skewness value of 0. In addition kurtosis is obtained from the peak of the vibration signals.
4. From the case study we can say that the use of Taguchi Method for vibration analysis can be more reliable than the kurtosis method.
5. The required methodology for this experimental study was gained and will be performed accordingly.

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