Design & Development of Gear Conditioning Monitoring Instrument

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Abstract- *The gear is an integral part of the system and any error or misalignment in the gears may affect the system directly or indirectly. This can cause breakdown of a working system or mechanism. If a gear is misaligned it must be checked for alignment and if there are errors in the gear they must be reduced. These errors are detected by sensors. A sensor is simply a transducer or a device that senses a physical or electrical change and converts into a electrical pulse or signals. These signals or pulse are displayed on a screen. A graph of, error versus time is plotted and this graph tells us about the working of a gear is whether smooth or rough. A smooth working gear is a acceptable for complicated mechanism while a roughly working gear must be replaced. In many applications the gear must be accurate to the dimensions and must be errorless.*

Keywords- Error, Gear

I. INTRODUCTION

Cylindrical, involute gears are precision componentswith a relatively complex geometry that must be made accurately to fulfill their specification in terms of noise, power density and reliability. It is common for gears to specify.

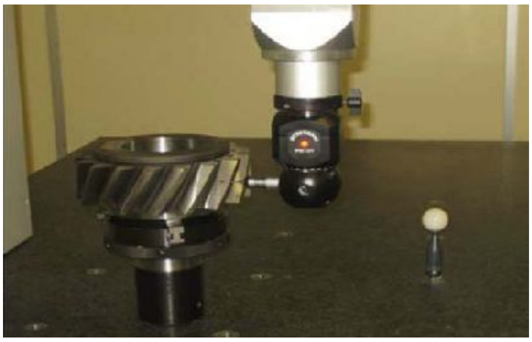

Figure 1 CMM used for gear measurement.

profile, helix and pitch tolerances in the 5–10 μm region, and many applications demand tighter tolerances. Modern machine tools, operated in a carefully controlled environment and correctly managed, can achieve these tolerances provided there is an appropriate independent method of measuring the geometrical accuracy of the gears and thus control the process. The traditional Golden Rule for metrology is that the uncertainty of a measurement process should be 10% of the tolerance inspected. Measurement uncertainty is the term used to quantify the unknown random and systematic errors that occur in any measurement process. With tolerances of 5–10 μm, with measurement uncertainty should be 0.5–1.0 μm on the shop floor, which is still too difficult to achieve, and even national measurement institutes (NMIs) around the world can just barely achieve these levels. Thus the shop floor measuring instrument capability is an important consideration when interpreting measurement result conformance with specification.

In recent years, the range of gear measuring equipment available to the gear manufacturer has expanded. There is greater choice of dedicated 4-axis CNC gear measuring machines (GMMs) with three linear axes, a rotary table and tailstock. General purpose coordinate measuring machines (CMMs) are now equipped with gear measurement software where previously only the highest quality machines were considered for gear measurement applications. Recent improvements in error mapping to improve measurement performance and the introduction of scanning probe systems has meant that now even relatively modest-cost CMMs can be considered for gear measurement applications. The gear manufacturer has a wider choice of measurement solutions than ever before, but how should the appropriate solution be selected?

It is surprising therefore, that when ISO published ISO18653 in 2003, Gears: Evaluation of Instruments for the measurement of Individual Gears and a supporting technical report (guidance document) ISO/TR 10064-5, that the gear industry has not adopted the recommendations and applied the standard more widely.

II. LITERATURE SURVEY

Ajinkya Chouthai, Rathin Karhu, Soham Kulkarni [1] paper illustrates a new method of measurement of revolutions per minute (RPM) using TSOP IR receiver. The principle of opto-coupler is used in measuring RPM in the infra-red (IR) range wherein TSOP is the IR receiver. New terms for RPM measurement have been defined which assist in calculating maximum RPM. The maximum RPM that can be measured using this method is over 140,000 for TSOP 1756.This method of RPM measurement can be used having significant advantages like compact size, accuracy, wide range of values and low cost.

Ratil Hasnat Ashique[2] described that an optical disc and microprocessor (i-8086 i-8087)- based speed measurement scheme is presented in this paper. Improvement of accuracy and minimization of phase angle error are achieved by varying sampling time in the speed detection algorithm. The scheme was implemented as an integral component of a vector control scheme for induction motors and was found to work effectively. They also concluded that the method requires minimum hardware components for its implementation. For medium range of speed, the scheme is found to work satisfactorily. It is observed that accuracy in detected speed is improved by varying sampling interval However, time lag exists between the detected and actual speed which requires instantaneous speed estimation algorithm. For very high speed, the time constant of the infra-red LED receiver constraints the pulse generation and limits its use.

Robert C. Frazer and Steven J. Wilson[3]described trial test of the calibration procedures outlined in ISO 18653—Gears: Evaluation of Instruments for the measurement of Individual Gears, shows that the results are reasonable, but a minor change to the uncertainty formulas recommended. Gear measuring machine calibration methods are reviewed. The benefits of using work piece-like artifacts are discussed, and a procedure for implementing the standard in the workplace is presented. Problems with applying the standard to large gear measuring machines are considered and some recommendations offered.

Balkishan Banodiya, Vijay Kumar Karma [4] described the power transmission by the gears is mostly used in the industries, automobile gearbox, robotics office automation, etc. and this is possible mostly by the gearing. Gearing is one of the most critical components in mechanical power transmission systems. Transmission error is to be one of the main contributors to noise and vibration in gear set. This paper aim is to know about the gear "Transmission error". A transmission error is considered to be an important excitation mechanism for gear noise and vibration. The definition of a transmission error is "the difference between the actual position of the output gear and the position it would occupy if the gear drive were perfectly conjugate". The gear transmission error that widely occurs in the actual gear system which arise because of irregular shape tool geometry imperfect mounting misalignment of two gears and so on. The influence of transmission error cannot be determined by investigating the gears only.

From the above literature review it is concluded that Transmission Error actually arises due to:

- Tooth geometry errors: Profile error, pitch error and run out errors from manufacturing process.
- Elastic deformation: Local contact deformation at each meshing tooth pair and deflections of teeth in gear bodies due to the transmitted load through and transverse to the gear rotational axis.
- Imperfect mounting: Geometric errors in alignment, which may be introduced by static and dynamic elastic deflections in the supporting bearings and shafts.
- Lubricating film thickness etc.: The gear mesh stiffness is a time varying parameter that reflects gear mesh conditions as the number of teeth in contact varies, and as the line of contact of the engaged gear teeth varies

III. METHODS OF MEASUREMENTS OF TRANSMISSION ERROR

There are so many methods to measure the transmission error some are as

Pulse Timing method : That method are very old method and based and associated with optical encoder measurement of transmission error consists in using through shaft encoders to avoid couplings .The principle of this method pulse timing technique is integrated data acquisition ,The collection and storing of data with the time interval between the rising edges of the encoder signals .

Angular sampling method: This method is based on the angular displacement on either the pinion or gear shaft or as displacement along the gear line of action. In the following, only transmission error as an angular error on the pinion shaft is used.

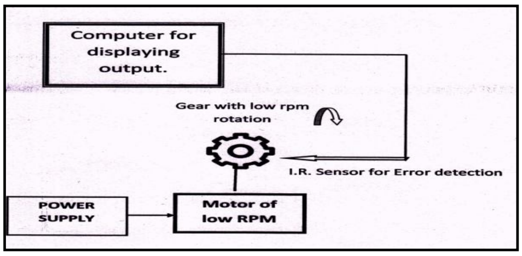

Fig 2. Concept of Gear Condition & Monitoring Instrument.

IV. DESCRIPTION OF ACTUAL WORKING MODEL

The actual working model consists of the following things and its function as follows.

1. Infrared Sensor:- The sensor is of the range of 5 cm.
2. The photo diode:- The photodiode is to receives the signal from infrared sensor for giving the response to the AURDINO software for plotting the graph.
3. Selection of motor:- We have selected the motor of 3 RPM
4. Transformer:- A transformer is a static electrical device that transfers electrical energy between two or more circuits.

The all the arrangement is as shown in Fig 3

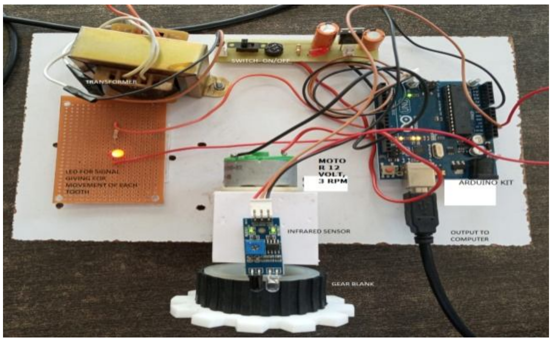

Fig.3.Arrangement of Electronic Components for the Testing Instrument

V. EXPERIMENTAL TESTING

The experimental and the procedure to carry out the testing of the instrument is as follows.

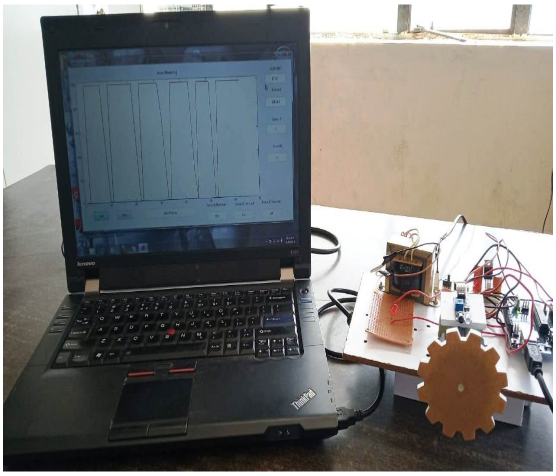

Fig 5. Experimental Set Up

The experimental set up consist of simple electric circuit which is shown in figure. Which consist of ARDUINO is an open-source electronics platform based on easy-to-use hardware and software. Arduino boards are able to read inputs - light on a sensor, a finger on a button, or a Twitter message - and turn it into an output - activating a motor, turning on an LED, publishing something online. You can tell your board what to do by sending a set of instructions to the microcontroller on the board. To do so you use the Arduino programming language (based on Wiring), and the Arduino Software (IDE), based on Processing.

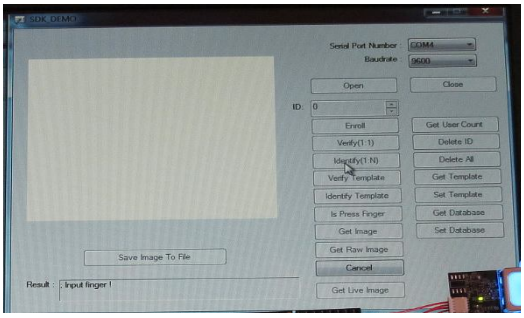

Fig 4 Arduino Software Home page

In our project the programming is done in connection with MATLAB software MATLAB (matrix laboratory) is a multi-paradigm numerical computing environment and proprietary programming language developed by MathWorks. MATLAB allows matrix manipulations, plotting of functions and data, implementation of algorithms, creation of user interfaces, and interfacing with programs written in other languages, including C, C++, C#, Java, Fortran and Python.

Although MATLAB is intended primarily for numerical computing, an optional toolbox uses the MuPAD symbolic engine, allowing access to symbolic computing abilities. An additional package, Simulink, adds graphical multi-domain simulation and model-based design for dynamic and embedded systems.

VI. EXPERIMENTAL PROCEDURE

1. Connect the output port to the right port of the PC or LAPTOP in which the software is installed.
2. Open MATLAB for getting the accurate result for error detection..
3. Set the COM PORT as COM3.
4. Set the Sensor A Threshold as in between 200 to 240 which is less than the limit of 254.
5. Click on Start and run the motor by switching it ON/OFF switch.
6. Observe the Signals which is generated by the sensor in connection with Arduino software.

For deliberately getting the error coat any one of the tooth with Teflon tape or simply marked it by permanent marker. So that infrared sensor detects the fault or error in the tooth profile.

VII. OBSERVATION

The observation is based on the monitoring the graph which usually a combination of a Bode magnitude plot, expressing the magnitude (usually in decibels) of the frequency response, and a Bode phase plot, expressing the phase shift.

Also the LED having red light illumination will start illuminate for the movement of each successive tooth while coming across it. At the same time it is observed that the green light of infrared sensors starts blinking which gives the sense of movement of each tooth. If it not blinks then there is a interpretation of the error in the tooth.While conducting the test is is assured that the Infrared sensor must be isolated from any source of light or sunlight.

VIII. CONCLUSION

We have conducted the experimental testing of the instrument and we have got very accurate results in the form of expected graph. The results are in the form of gaph. The tests were conducted for two conditions as follows.

1. Gear with no damage on tooth profile.
2. Gear with damage on tooth profile.

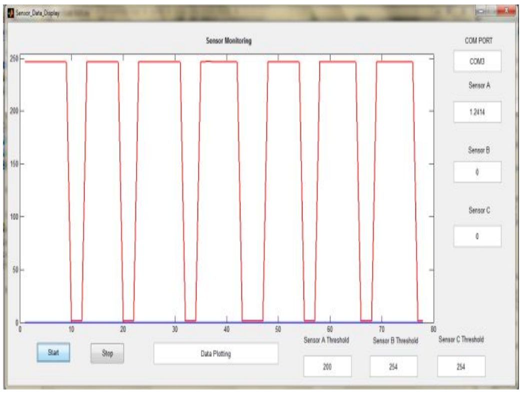

Fig 6.Continuos graph for no damage on tooth profile.

The graph in Fig 6. signifies that the wave forms are continuous in nature hence it is concluded that there is no damage on the tooth profile and its working is satisfactory. The graph is based on the phase shift method. The basis of the conclusion is due to the uniform

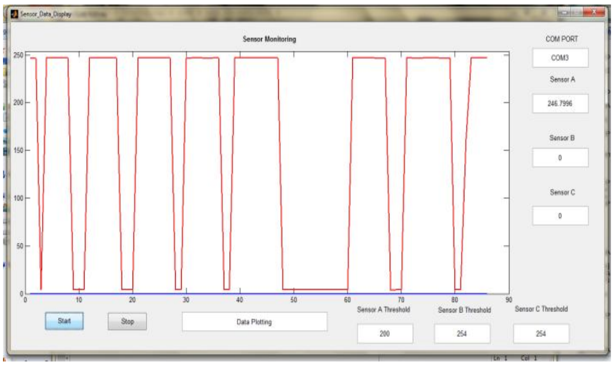

Fig 7 Discontinuos graph for no damage on tooth profile.

The graph in Fig.7 signifies that the wave forms are not continuous in nature hence it is concluded that there is damage on the tooth profile and its working is not satisfactory. The graph is based on the phase shift method and there is a large gap observed. The basis of the conclusion is due to the non uniform distribution of the waveforms for the complete revolution. The phases are not uniform in nature.

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