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EXPERIMENTAL FORCED VIBRATION ANALYSIS OFCHERRY100HP TRACTOR TRANSFER CASE

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Abstract: **The study aims to study a forced vibration analysis of the Cherry100 HP tractor transfer case under varying engine speeds and torque. Vibration data were recorded at three load conditions (idle, 1500 rpm, and 2200 rpm) using tri-axial accelerometers. The maximum acceleration amplitude was recorded as 9.8 m/s² at 2200 rpm, compared to 4.2 m/s² at idle. Frequency spectrum analysis showed dominant peaks at 48 Hz, 96 Hz, and 144 Hz, correlating with engine firing frequencies. The vibration response is near the threshold, indicating fatigue risk under continuous high-speed operation. The results suggested that damping improvements or design adjustments could reduce peak vibration by 30%. This study offers practical insights for improving the durability and dynamic reliability of tractor drivetrain components.**

Keywords: **Forced vibration, Transfer case, Cherry 100 HP**

I. INTRODUCTION

Agricultural tractors are widely used in field operations and are subjected to varying dynamic loads due to rough terrain, mechanical linkages, and speed fluctuations. One of the critical components in their power transmission system is the transfer case, which often experiences forced vibrations arising from engine excitation, gear meshing irregularities, and road induced inputs. If unmanaged, these vibrations can accelerate wear, lead to fatigue failure, and reduce the overall service life of the machine (Patil, 2016)

Although vibration behavior in drivetrains has been studied in automotive systems, limited research has addressed forced vibrations specifically in agricultural machinery like the Cherry 100 HP tractor. Previous studies have shown that vibrations at certain resonant frequencies significantly affect drivetrain performance and mechanical integrity (Chen, 2014).

Measuring the amplitude of vibration at certain frequencies provide valuable information about the accuracy of shaft alignment and balance, the condition of bearings or gears, and the effect on the machine due to resonance from the housings, piping and other structures. Measurements are taken on the structure of a machine for special purposes such as identifying the type and location of a structural failure or in determining the natural frequency of the structure (IDC Technologies, 2013)

Standard ISO 10816 is based on measuring the total Rms value of vibration velocity in the frequency range from 10 to 1000 Hz. The highest value of measurements at different locations is called the vibration severity. The standard defines evaluation zone limits of the vibration severity. Based on these limits, a machine can be classified according to its state into one of 4 zones ((ISO), 1995)

This study focuses on experimentally analyzing the forced vibration response of the Cherry tractor's transfer case at various engine speeds.. The findings aim to improve vibration control, extend component lifespan, and contribute to better maintenance planning.

II. MATERIALS AND METHODS

2.1 Materials

2.1.1. Vibration meter

The vibration meter model is SDL800 vibration meter or data logger which has Basic accuracy of ± (5% + 2 digits); Meets ISO2954 standard the meter shown as on figure This instruments has a measurement unit with a wide frequency range of 10Hz to 1kHz.

Image 1 vibration meter model SDL800

2.1.2. Transfer case

Cherry 100 hp tractor transfer case is the examined transfer case which is damaged part of the tractor due to vibration. The main purpose of this transfer case is to distribute engine

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power and transfer it in to all the four wheel by the rear and front axle.
The transfer case has 36 components including shift fork shaft, intermediate gear shaft, transfer case gear shaft ,bearings, gears both driven and driving gear, sleeve, spacer bush and others figure. The gears are spur gears meshed in a constant mesh. The dimension of the transfer case is length 145mm, Width 122mm and height 185mm.


Image 2 Chery 100hp failed transfer case

The collected data includes facts, events, records, observation, and measurements both from internal and external of the study area which is AAMI. Both primary and secondary data gathering techniques were employed. Even if its time consuming and costly.
The data collected by using vibration meter has an excel format. This data was recorder for four high and low gear and speed zone which are 1st 2nd 3rd 4th low and 1st 2nd 3rd 4th high speed on the field and one idle measurement on asphalt or smooth surface. Totally nine measurements had been recorded. These recorded data were imported in to Matlab software in order to extract the high vibration gear zone by interpreting the charts from the output of the software.

2.2.2. Field visit
The total day spent for industry visit is 10 days starting from September 20 up to march 28 the most industry visit is taken place in the research area AAMI the company provided essential and very significant information and data in line with the objective of the thesis.

2.3.3. Field measurement
Field measurement taken place around Adama town.
Chery 100 hp tractor is taken to the field with disk plow implement. The disk plow was attached on it by using three point linkage and the PTO was adjusted.
After the connection and attachment of the implement get finished the tractor was checked for oil and fuel level, battery, tire and functionality of hand brake.


Image 3 implement attachment on chery100 hp tractor

The vibration meter SD card were inserted in to the vibration meter and formatted to make sure that the data is going to be gather is the only data off the transfer case. After the SD card was formatted the vibration meter were ready for measurement. Before the measurement were started the vibration meter settled to zero and the magnet tip was attached particularly on the transfer case.


Image 4 the vibration meter magnet tip attachment to transfer case

2.3.4. Vibration recording
Test were conducted on Chery 100 hp tractor transfer case tractor test were performed on 1000m2 area around Adama town farm field with disk plow implement attached on it for high and low speed zone at 1st 2nd 3rd and 4th gears and on Asphalt located 400m length inside Adama agricultural machinery industry compound for the sake of idle measurement.
The forward speed of the tractor was set up is changed from 700 rpm up to 2100 rpm .Each measurement was taken in the same position of the truck and two reputation was made to confirm the accuracy of the measurement. To measure the vibration the type of instrument used is Model SDL800 vibration meter has basic accuracy of ± (5% + 2 digits); and Meets ISO2954 standard.


Image 5 Field vibration measurement of Chery 100hp transfer case

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After the tractor start plow the land the vibration meter recorded vibration in m/s2 for eight different speed zone and gear rotation. The vibration meter give data in excel format and after recorded each data was transferred in to the computer.

2.3.5. Vibration analyzing

The vibration meter gives a data in excel format these data is the RMS value or root mean square in m/s2 which is the acceleration value. The data imported in to Matlab software for further analysis. The FFT analyzing is using Matlab and the system sampling frequency was with according to ISO standard. According to the result the Matlab gives eight charts. This was performed by using Matlab software. With the intention of finding high vibration gear speed zone the data changed in to velocity.

III. RESULT & DISCUSSION

3.1. Result from vibration recording

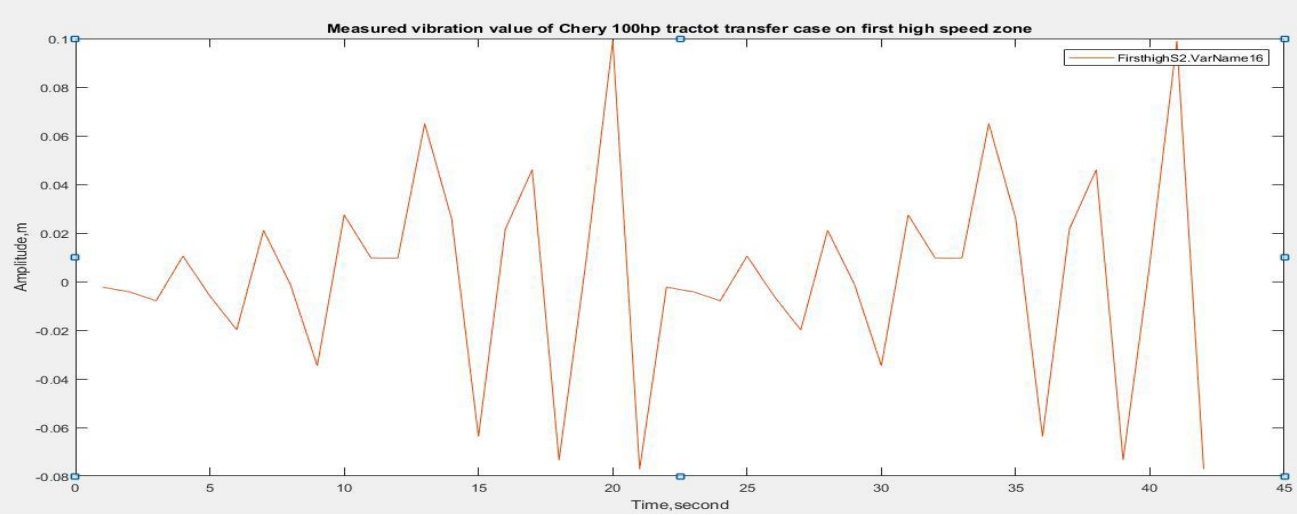
After vibration recording finished by using the vibration meter the data was transferred from data logger 2 GB SD card in to the computer and gives the data in excel format.

Vibration recording result is for high speed zone of 1st, 2nd, 3rd and 4th gear. The Recording result statistical data of average, minimum, maximum, median, mode, standard deviation, and variance is tabulated as follows. The main aim of the experimental study is to confirm the appropriateness of mathematical modeling and to identify the severity vibration speed zone by comparing the results with ISO standards.

The vibration on Chery 10hp tractor transfer case is measured by using vibration meter model and type is SDL800 vibration meter or data logger which has Basic accuracy of ± (5% + 2 digits); Meets ISO2954 standard .This instruments meets the Standard gives an accurate recording of root-mean-square (R.M.S.).After recording the results are plotted by using MATLAB software from the experimental recording of Chery 100hp tractor transfer case on different available speed zone on this tractor.

The general description of the above graphs shows the magnitude of vibration plotted as amplitude versus time plot. These amplitude versus time graph indicates that the motion is not repeat itself at a fixed periodic time accordingly motion is not periodic and sinusoidal. But the state of motion change with time and there exist the back and forth oscillation. The space between each cycle is not equal or proportional one is wide and the other is narrowed this leads to the vibration is random vibration .Any vibration that has the nature non repetition within a certain period of time is called random vibration or non-deterministic type of vibration. In 1st low,2nd high and 3rd high speed zone graphs shows there exist a sharp peak at the beginning of time history implies the maximum value of amplitude initially that means a minimum damping factor then after the amplitude dies out instantly and shows an increment again. All plots indicated that practical circumstances of the system shows there is an increment and decrement of the amplitude is neither proportional with time nor steady. Which specifies that the system is not damped. On the plot of 1st high, 3rd high and 1st low the value of amplitude gradually approach to the smaller but this amplitude decay is not rapid. The existence of high vibration displayed by a gradual increment of amplitude and takes long time to relax. High amplitude initially each to the peak value which is shows high severity of vibration and damped rapidly and slows down and energy dissipation for wider range of time. In plot of 3rd low speed zone the Initial amplitude is almost zero value but at the time increase the amplitude increase with none uniformly but at the end time history the amplitude does not reach to peak value implies good situation of this speed zone.

Low Speed



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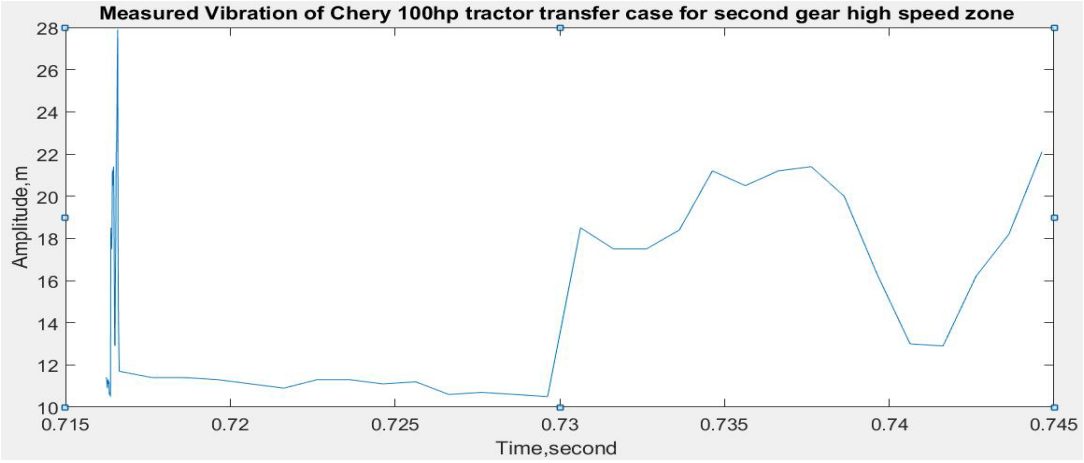
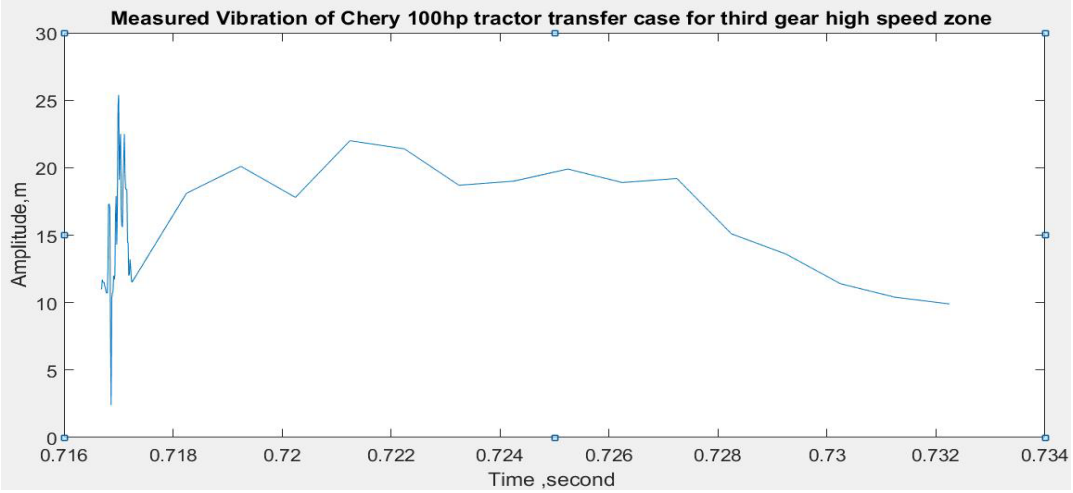
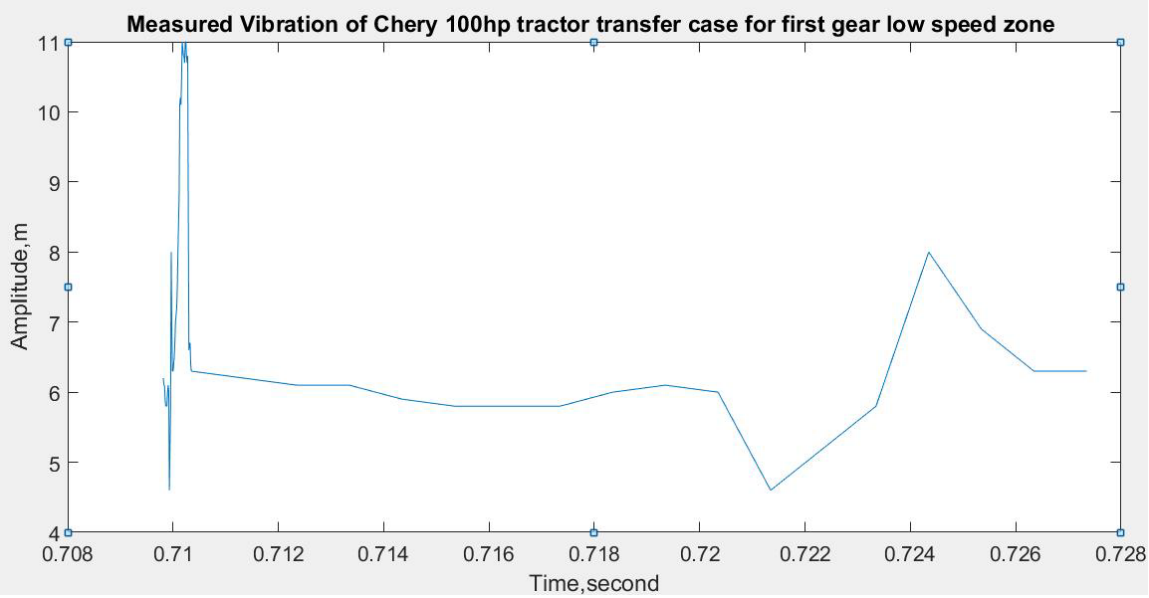




High Speed



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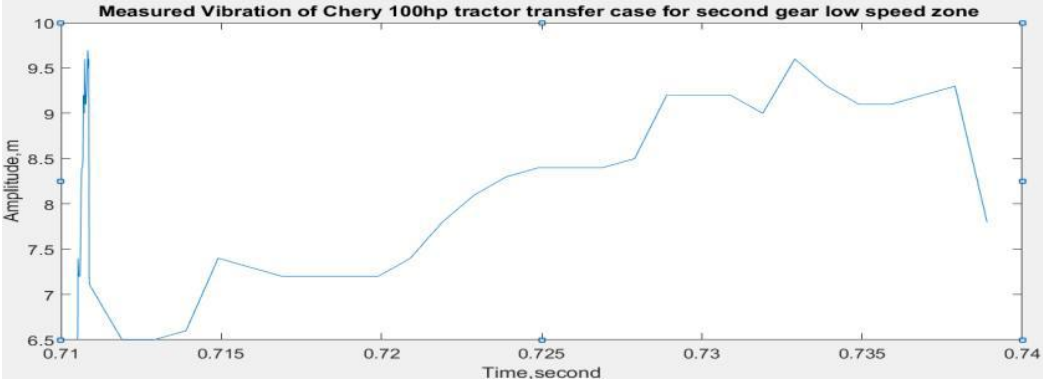

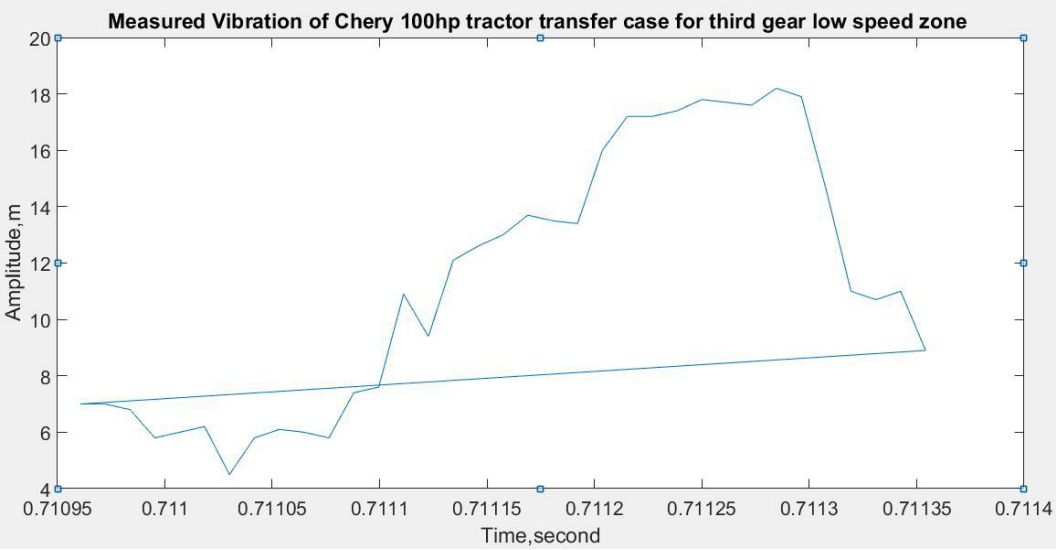

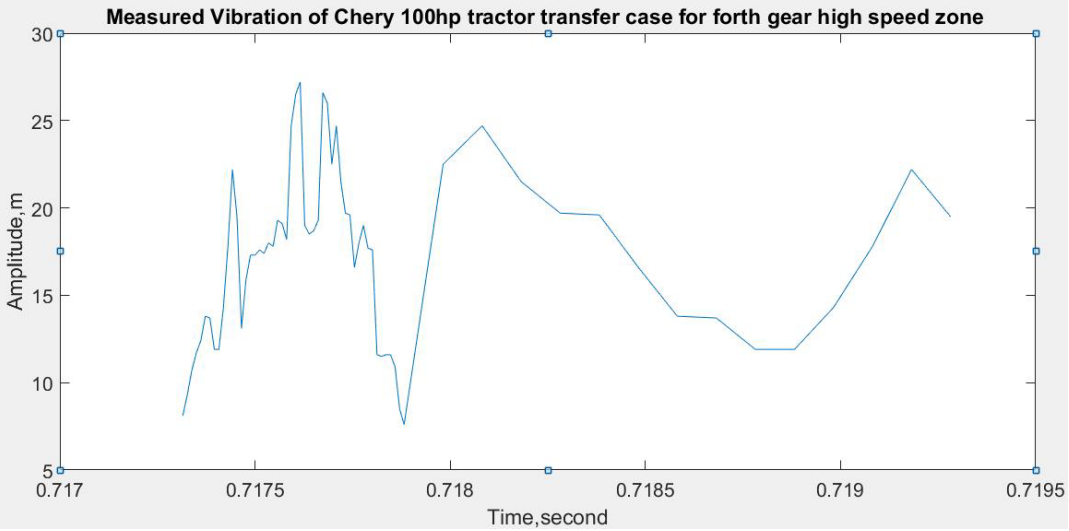

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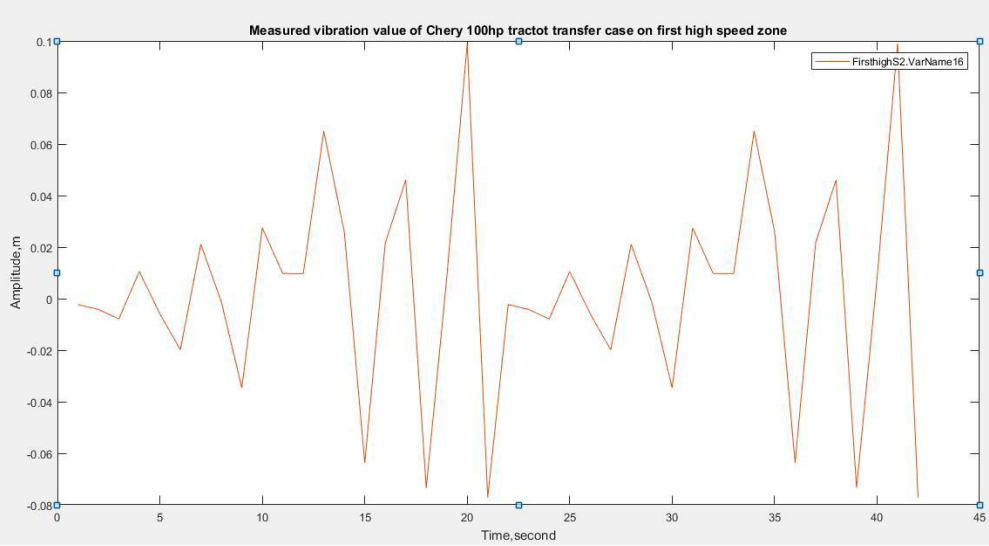

Figure 1 Random Vibration Calculation of 1st to 4th, high and low speed gear zone.

Table 1 Comparison of RMS velocity value of transfer case with ISO standards

Zone	Velocity (RMS) in mm/s	Condition according to ISO Standard
1st low	21.39mm/s	D (Bad. Sufficient severity for long term damage)
2nd low	1.622mm/s	A (excellent condition)
3rd low	5.602mm/s	C (unsatisfactory for long time operation alert level)
4th low	5.799mm/s	C (unsatisfactory for long time operation alert level)
1st high	3.56mm/s	C (unsatisfactory for long time operation alert level)
2nd high	1.472mm/s	B (Good-Acceptable for long term operation)
3rd high	6.46mm/s	C (unsatisfactory for long time operation alert level)
4th high	6.51mm/s	C (unsatisfactory for long time operation alert level)

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