Design and Development of Wheel Balancing Machine Experimental Setup

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Abstract:- **This project must be completed for the practical purpose for requirement stages in laboratory. This machine is consisting of Electric AC motor, Frame, V-belt driven shaft on two 6006 series spherical bearings, the wheel is mounted on the shaft attaching by an anchoring system and affix instrumentation is use to find (a) find amount of acceleration force due to vibration caused by non uniformly distributed mass, (b) to find counterweight mass on the wheel for the balancing (c) find position on the rim where mass is exactly added. The accelerometer is used for the linear acceleration caused due to unbalanced force which is acting on the wheel and ultrasonic sensor is also used to measure the distance from the wheel rim to the ultrasonic sensor by using Arduino circuits, analysis and display. We dealt with some technical issues, mechanical and instrumentation at one time. This is fairly good in comparison to the existing complicated wheel balancing machine for the final year project turned out to be an applied research project.**

Keywords: - Design, Balancing, Vibrations, Analysis, Counterweight

I. INTRODUCTION

Wheel balancing is also known as tyre balancing. It is the process of equalizing the weight of the combine tyre and wheel assembly so that it rotates smoothly at high speed. Balancing involves the putting the wheel assembly on a wheel balancing machine and rotate it to determine where the weight should be added on wheel rim. In essence, wheel and tyre are never exactly the same weight all around.

When man invented the wheel, he very quickly learned that if wasn’t completely round and if didn’t rotate evenly about its central axis, then he had a problem due to vibrating wheel, it causes damage to itself and in severe cases, be unusable. As that of replacing and remanufacturing of wheel is very difficult so it takes huge time consuming, considering all the reasons it’s necessary to found all solutions on this problems. This results shows that the wheel and shaft vibrations are minimized which is found in balance state. i.e., mass is evenly distributed either side of the wheel rim for the balancing purpose so result takes the minimizing the vibration of wheel it means resultant vibrations was at minimum. This had to be achieved during manufacturing for the maximum service life could be achieved from the system.

The purpose of the project is to describe the Experimental setup and Testing of Wheel Balancing Machine and convey the experiences we had during the design and practical setup of “Wheel Balancing Machine.”

MECHANICAL SYSTEM OF WHEEL BALANCING MACHINE

Dynamic balancing of a wheel requires that the wheel be in rotational motion. Rotational motion is accomplished by a 1440 rpm, 0.25 hp electric motor. Motor speed is reduced to 400-rpm shaft speed by a v-belt and pulley system attached to one end of the shaft. The wheel is attached to another side of the shaft by using a back cone system consisting of a faceplate, a cone of metal, a pressure cup and a nut. The metal cone helps to center the wheel, while the face plate and the cup make sure that the wheel is perpendicular to the shaft as the nut is tightened. The faceplate was welded to the shaft on the original system. In design of shaft faceplate shall be fitted and tightened to shaft to prevent welding distortions in that shaft. A square frame length is 36 inch and beadth is 18 inch and c section plate angle is 1.2 inch, height of the frame is 30 inch placed and supports the spherical bearings and the electric motor. The shaft is supported by the bearing housing which consisting two spherical bearings (6006).

Accelerometer sensor is mounted on the bearing housing it sensed acceleration force of wheel/tire and ultrasonic sensor are placed on the shaft frame which is perpendicular to the wheel rim. Both sensors are connected to each arduino circuits and its displays. Shaft is connected to driven pulley (7inch) and driven pulley is rotated with the help of diving pulley (2 inch). Electric motor is supported by vibration isolation. And this isolation mounted at the bottom of the frame. Some mechanical system arrangements are given in Fig. 9 and Photo of whole system is given in Fig. 10.

NOMENCLATURE

A = total amplification of accelerometer signal
K = calibration constant for a balanced wheel of rim size R.
R = rim radius at which mass "m" is placed
S = sensitivity of accelerometer (usually in mV/g)
W = Total weight of the system
a = measured acceleration
g = standard gravitational acceleration
m = counterbalance mass
ώ = angular velocity of wheel

WHEEL BALANCING MACHINE INSTRUMENTATION

(a). Measurement of the Unbalance Force

An accelerometer attached to the frame of the machine is used to indirectly measure acceleration due to unbalance in the tire as tire rotates at about 400 rpm. Accelerometer output signal

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 8 Issue 06, June-2019

can be related to the counterbalance mass to be placed at the rim radius by [3]:

$$m= (a*W/g)/(\acute{\omega}^2 *R) \quad (1)$$

Accelerometer output voltage can be found by:

$$V = A*S*a \quad (2)$$

Using Eq. (3) in Eq. (2) one obtains:

$$m= (V *W/g)/(A*S*\acute{\omega}^2 *R) \quad (3)$$

Thus, the balancing mass to be placed on the rim can be calculated by:

$$m = K*V \quad (4)$$

Technical specifications for the ADXL335 accelerometer used for the wheel-balancing machine are given in Table 1.

For a 13 inch wheel, gives a calculated sensitivity of 300 mV/g for our system (R=13in, W=52 kg, N=400 rpm, ώ=41.88 rad/sec, S=300 mV/g, A=100)

Table 1. Technical Specifications for ADXL335 Accelerometer

Model No	: ADXL335
Sensitivity	: 300 mV/g
Natural frequency	: 1600 Hz for (Xout-Yout) and 550Hz for (Zout)
Range	: 3.6 g
Frequency Response	: 0.5 Hz to 5.5 kHz

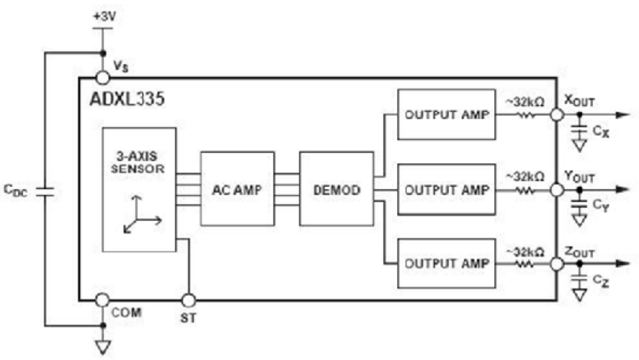


Fig. 1. Functional block diagram of ADXL335

Arduino UNO Microcontroller

The Arduino UNO is a microcontroller based on the ATmega 32P with 14 input and output pins. It consisting of a 6 analog inputs, USB connections, Power supply jack, 16 MHz quartz crystal, and reset button etc.,

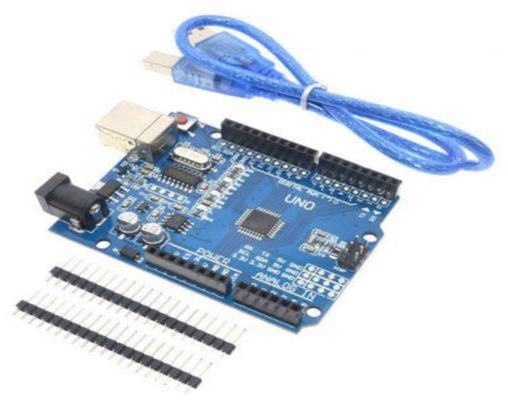
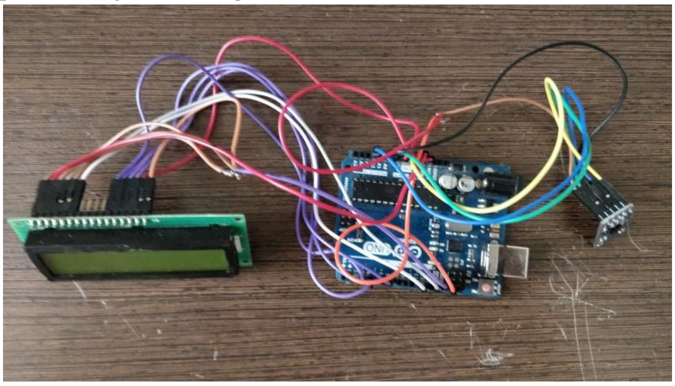


Fig. 2. Arduino UNO R3 ATmega328P

ADXL335 is powered by a 9v power source that causes it to g enerate 9v peak outputs. It has three analog outputs for X,Y an d Z axis which require an ADC microcontroller that is to provided by the analog functions of Arduino board.



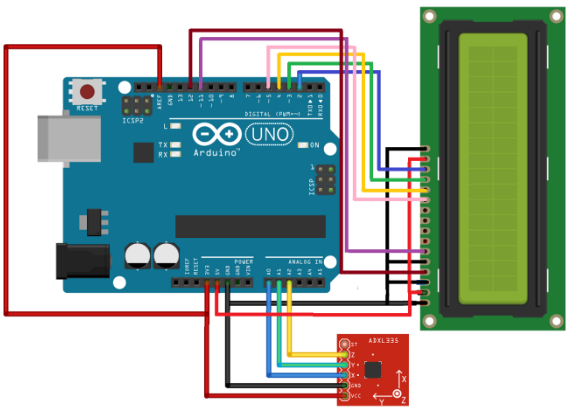


Fig. 3. Interfacing of accelerometer sensor ADXL 335 with Arduino UNO connections.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 8 Issue 06, June-2019

Table 2. Technical Specifications for Ultrasonic Sensor
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Model No	: HC-SR04
Supply Volt	: +5v DC
Global Current Consumption	: 15 mA
Ultrasonic Frequency	: 40k Hz
Maximal Range	: 258 cm
Minimal Range	: 3 cm
Resolution	: 1 cm
Trigger Pulse Width	: 10 µs
Outline Dimension	: 43x20x15 mm

Pins

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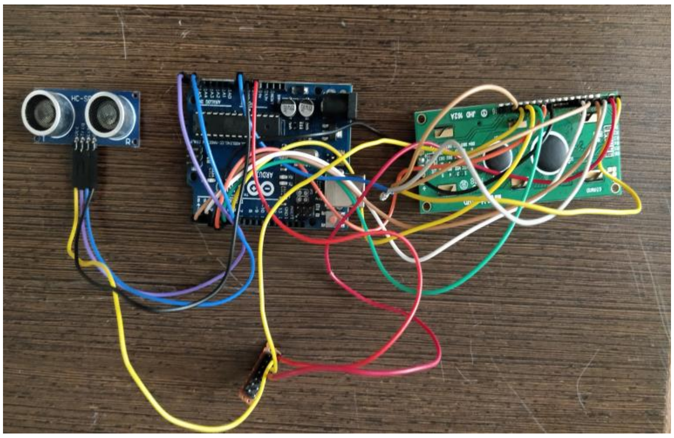
Trig	: Trigger (Input)
Echo	: Echo (Output)
GND	: GND

Ultrasonic sensor is non-contact distance measurement module, which is also compatible with electronic brick. This ultrasonic sensor module can be used for measuring distance, object sensor, motion sensors etc.

The module sends eight 40 KHz square wave pulses and automatically detects whether it receives the returning signal. If there is a signal returning, a high level pulse is sent on the echo pin. The length of this pulse is the time it took the signal from first triggering to the return echo.



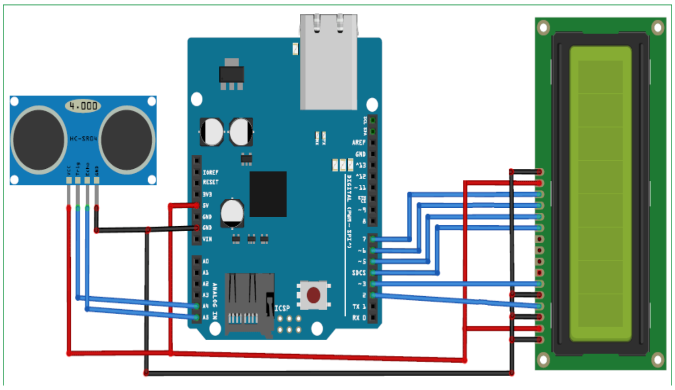


Fig. 4. Interfacing of Ultrasonic sensor HC-SR04 with Arduino UNO connections.

A. OBJECTIVES

1. To find amount of counter balance mass / weight required to balancing the wheel.
2. To find the position of counter balance mass / weight on the wheel rim.
3. To reduce the cost compared to actual machine.

B. METHODOLOGY

1. Find Problem statement
2. Selection of material / cone, key, shaft
3. Design of shaft and frame on CAD software.
4. Analysis of stress distribution on the shaft on ANSYS software,
5. Manufacturing and Testing.

II. THEORY

C. SELECTION OF MOTOR

6. According to the torque and speed requirement, motor is selected:
7. Power(P)= 0.25 hp, 240W
8. Single phase motor
9. Voltage(V)= 230V
10. Frequency=50-60Hz
11. Speed(N)=1440rpm

D. DESIGN OF THE SHAFT

Shaft is designed on strength basis. Transmission shafts are subjected to axial tensile force, bending moment or torsional moment or their combinations. Most of transmission shafts are subjected to combined bending and torsional moments. The designs of shaft consist of determining the correct shaft diameter from strength and rigidity considerations.

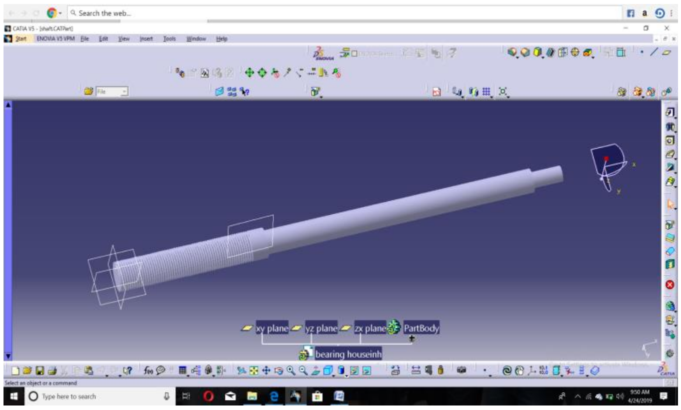


Fig. 5. Design of the Shaft on CATIA software

The ASME code is based on maximum shear stress theory of failure. Therefore, the equation can be written as;

$$\tau max = \frac{16}{\pi d^3} (\sqrt{(kbMb)^2 + (ktMt)^2}$$

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 8 Issue 06, June-2019

E. DESIGN OF THE CONE

Raw material of cone was of length 500mm and diameter 80mm. Firstly facing was carried out on raw material to reduce it's length. Facing was followed by turning to reduce it's diameter. After turning, tapering was done.

Fig. 6. Design of cone

F. DESIGN OF THE KEY

A key is defined as a machine element which is used to connect transmission shaft to rotating machine elements like pulleys, gears, etc. The primary function of key is to transmit the torque from shaft to the hub of mating element and vice versa.

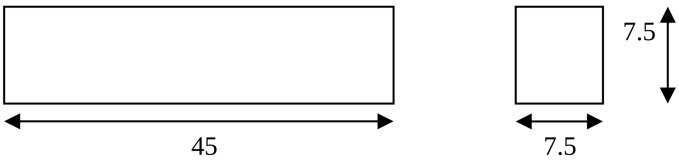


Fig. 7. Design of key

G. DESIGN OF REFFERENCE PLATE

Reference Plate is a mechanical component which similar to the circular disk mounted on the shaft. Actual function of this plate is to support the wheel / tyre with the help of the internal threaded part of the reference plate.

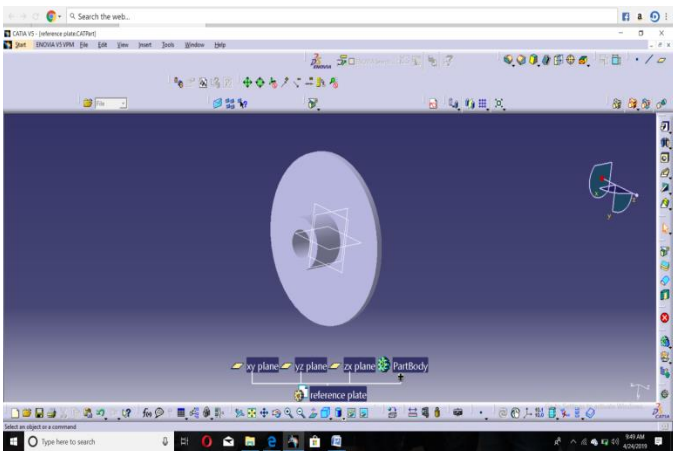


Fig. 8. Design of Reference Plate on CATIA software

H. EXPERIMENTAL SETUP

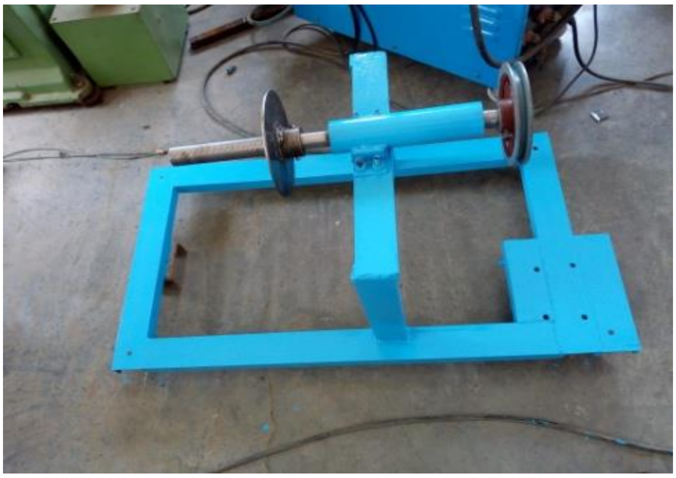


Fig. 9. Mechanical Component (frame) of the Wheel Balancing Machine

Fig 10. Photo of Whole System

I. RESULT TABLE

For (R13)			
Side	Calculated mass (gm)	Time (sec)	Attached Mass (gm)
Inner	19.80 gm	10 sec	20 gm
Outer	0.11 gm	10 sec	0.0 gm
For (R15)			
Side	Calculated mass (gm)	Time (sec)	Attached Mass (gm)
Inner	5.35 gm	10 sec	5 gm
Outer	0.14 gm	10 sec	0.0 gm

III. ASSEMBLY DESIGN OF WHEEL BALANCING MACHINE

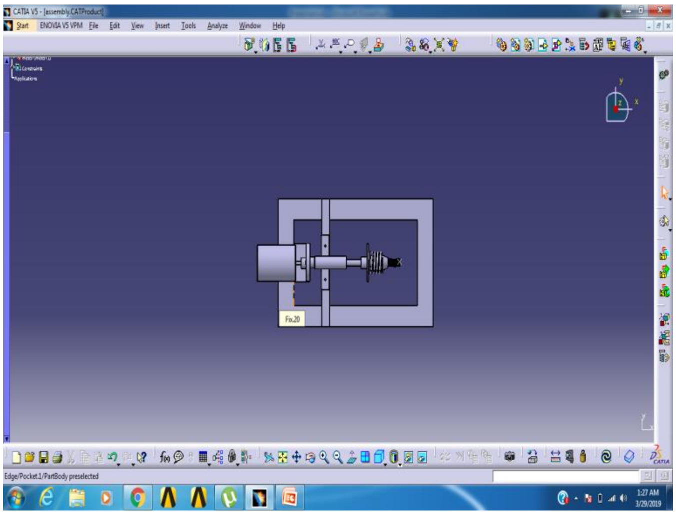


Fig. 9. Design of Assembly Wheel Balancing Machine on CATIA software.

CONCLUSION

Conclusion of this paper includes of performance and accuracy of the sensors, improvement in the bending strength, and reduction in the cost of machine, optimization and design modification is also included in the conclusion of this paper.

Next planned projects are:

1. Find exact position of counter balance mass automatically while starting or stopping the wheel.
2. Using multiple coding and programming on single Arduino Uno microcontroller.
3. To get exact results by using force sensors instead of accelerometer sensor.

ACKNOWLEDGEMENT

It is precious moment to acknowledge the various individuals who helped me during completion of this paper.

Firstly, I would like to thanks my guide Prof. S.T.Dudhbhate, and Prof. G.B.Patil for his valuable guidance, support and continuous encouragement during completion of paper. I am thankful to Prof.S.S.Dol, Prof.G.S.Patil and Prof. V.S.Shinde the H.O.D. of Mechanical Department of our college for his valuable support and guidance. I am also thankful to Prof. S. S.Potdar, BE-Project Co-ordinator of our college for his constant encouragement.

Lastly I thanks to “KJ College of Engineering and Management Research, Pune” and well wishers who have contributed directly or indirectly for successful completion of this paper.

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