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Cam Profile Testing Machine

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Abstract:
The project, led by Prof. M. M. Bhoomkar, aims to design and fabricate a Cam Profile Testing Machine at PVG's Metrology Laboratory. The machine generates cam profiles, crucial for engine efficiency and regulating precise tapping movement. The goal is to reduce the time and expense associated with rework and rejection by using online cam on camshaft inspection. The machine will plot cam profiles of different cameras digitally using an interface connecting a microcontroller to the IDE. This project is more affordable and beneficial for small and medium-sized businesses, making it more accessible.

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I. Introduction

In today's contemporary context, the optimization of machinery efficiency is essential for ensuring high-quality production. The camshaft plays a crucial role in internal combustion engines, directly impacting engine performance. [1] Design & Manufacture - An Integrated Approach, Rod Black focuses on working of camshaft and its specifications. Even minor deviations in the cam profile can significantly affect operational efficiency. Historically, manual inspection methods and rigid maintenance schedules have been common but have limitations. They are often time-consuming and inadequate in detecting subtle defects like small cracks and abrasions, which can lead to performance issues. [2] Manufacturing Technology,2nd Edition, P.N. Rao, explore about various defects and causes.

In response to these challenges, our proposed model utilizes ultrasonic signals and Arduino to assess the health of camshafts. [3] Make. Getting Started with Arduino, 3rd Edition., Massimo Banzi, Michael Shiloh explores the limits of Arduino. Our primary objective is to develop a precise model capable of distinguishing between healthy and faulty camshafts. This approach aims to enhance equipment reliability, streamline maintenance practices, and reduce operational costs across various industrial sectors. Through our research efforts, we aim to advance predictive maintenance strategies and promote innovation in condition monitoring. By combining expertise with advanced technology, we strive to improve maintenance practices and optimize operational efficiency.

II. Component Selection

We have finalized the specifications for the following components:
Camshaft
Bearings
Rails and Block
Ultrasonic sensor
Motors
Motor Drivers
Microcontroller

Camshaft

Figure 1 - Camshaft of Maruti Suzuki Alto

Bearings

The 6003ZZ ball bearings, known for their reliability and durability, are double shielded electric motor quality. With dimensions of 17mm x 35mm x 10mm, they offer efficient load-bearing capacity, long-term use, and self-lubrication, ensuring smooth operation without frequent maintenance. [4] A Textbook of machine Design, R.S. Khurmi, J.K Gupta focuses on selection of mechanical components.

Rails and Block

Rails and blocks, made of special steel with 5 holes, slide vertically to fix the centre of a camshaft, with dimensions of 15mm linear guide rail, dynamic load up to 2,020 lbs, static load up to 3,930 lbs, and stock lengths up to 4 meters. Fig. 2 shows depiction of rails and blocks.[5] Shigley's Mechanical Engineering Design explores about designing of various components.

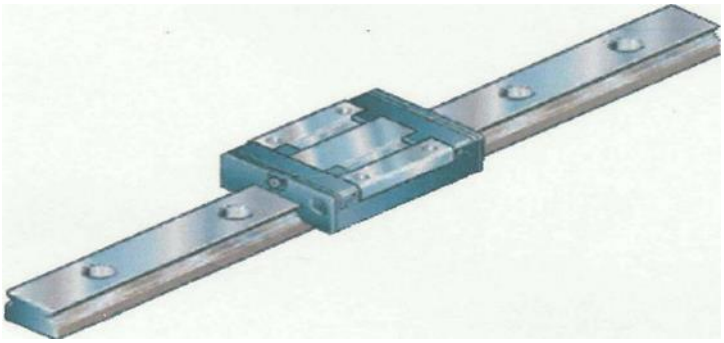

Figure 2- Rails and Blocks

Motors

2 DC motors to be used to control horizontal X-Y movement of the rail & block system. One motor is used to give the rotation to the camshaft to be tested.
A DC motor gear box is used to reduce the speed and increase the torque.
Additionally, a motor controller like ZK-MG can be used to control the motors.

Ultrasonic sensor

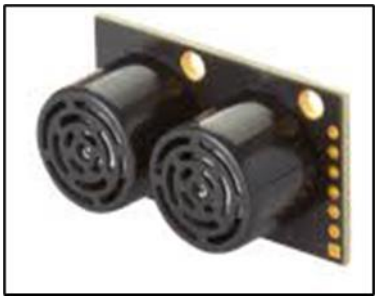

Figure 3 - MB-1604 HRLV EZ0T

The MB1604 HRLV-EZ0T ultrasonic sensor is chosen due to its high sensitivity and cost-effectiveness. It is a 42kHz ultrasonic rangefinder, RoHS compliant, with a factory accuracy of 1% or better, making it ideal for various applications. Fig. 3 shows the MB- 1604 sensor.

Features:
42kHz Ultrasonic Sensor to Measure the Distance.
RoHS Compliant.
Supports Multiple Output Formats.
Virtually No Sensor Dead Zone.
Factory Accuracy of 1% or Better.
Designed for easy integration into your project.

Motor Driver

Figure 4- ZK-MG motor drivers

The ZK-MG motor driver is a high-power PWM DC motor governor that adjusts motor speed and frequency, ensuring stable motor operation. It is widely used for driving motors, light brightness control, speed control, and signal generators. Note: it is not a voltage converter. Fig. 4 shows motor drivers.

Features:
Working Voltage: DC 5V-30V
Rated Current:5A
Peak Current: 15A
Power: 150W(Max)
Work Frequency: 1KHz-99KHz
Frequency Accuracy: 1%
Frequency Resolution: 1KHz
Duty Cycle: 0%-100%
Duty Cycle Resolution: 1%
Work temperature: -40~85℃
Working Humidity: 0%-95%RH

Microcontrollers

We have finalized the Arduino Uno Microcontroller as the electronic backend of the system. It has 14 digital input/output pins (of which 6 can be used as PWM outputs) which is perfect for this project.

Benefits Of The Same Include:
Easy interfacing with the computer.
Simpler and Compact design.
Economically cheaper alternate.

III. Construction And Working

In this experimental setup, two DC servo motors, regulated by Bangood-ZK-MG motor drivers, control motion and speed. One motor drives a camshaft assembly, while the other is integrated with an MB1604 HRLV-EZ0T ultrasonic sensor. The camshaft's rotation speed is meticulously controlled for precise data acquisition. Positioned strategically, the ultrasonic sensor collects dynamic data from the rotating camshaft, utilizing ultrasonic waves to capture critical parameters such as distance or object presence. The Arduino Uno microcontroller serves as the central control unit, collecting, processing, and displaying data in real-time. Through data conversion algorithms, the Arduino Uno presents numerical data via the Serial Monitor function and graphical visualization using the Serial Plotter feature within the Arduino application interface. This comprehensive setup enables researchers to manipulate, monitor, and analyse dynamic parameters in mechanical systems, offering significant potential for diverse applications and experimental validations.

IV. Procedure

1) Mount the camshaft.
2) Lock it securely.
3) Set the desired speed
4) Locate the first cam using the X and Z Rails and controllers.
5) Run the program using a serial plotter.
6) Wait for data to be acquired.

7) Repeat steps for adjacent cams.
8) Unmount the camshaft

V. Result And Discussion

The distances measured from the patches of the cam are gathered in integer format. This numerical data is subsequently utilized to generate a Serial plot employing Arduino software. A continuous stream of numerical data is received from sensors, and the Arduino Software consistently generates a plot illustrating distance versus time. Should there be any patches or irregularities on the cam, the graph adjusts accordingly.

VI. Conclusion

Our equipment is a cost-effective solution for small and medium-sized industries, offering quality while minimizing costs. It operates semi-automatically, saving time and manpower. Using Arduino Uno as a microcontroller, it ensures flexibility in operational sequence modification. The small, portable, and economical machine has an accuracy of 0.01mm for lift measurement and 10 deg. for angular accuracy. It requires no skilled labour and takes 20 minutes to check an entire camshaft.

References

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[5] Shigley's Mechanical Engineering Design, Pg No. 562.