Designing a Control Unit for Controlling Pressure While Assembling Bearing of Vehicle Shaft

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Abstract

In the ever-evolving landscape of automotive engineering and manufacturing, precision and reliability are paramount. The seamless integration of vital components, such as bearings within vehicle shafts, demands a meticulous approach. To ensure the utmost quality and performance, the project focuses on the development of a cutting-edge control unit designed to regulate and maintain optimal pressure during the assembly of bearings onto vehicle shafts.

If the bearing of wheel is not mounted in the limited range of pressure, there is a possibility of wheel separation or vehicle will get imbalance which would lead to major accidents.

The project represents a critical advancement in automotive mounting processes, as it addresses a crucial aspect of vehicle performance and longevity. The precise installation of bearings on shafts is fundamental to the functionality of various vehicle systems, from engines to suspension, and even steering. By developing a specialized control unit, we aim to enhance the efficiency, accuracy, and consistency of this critical assembly step, thereby contributing to the overall quality and durability of automotive products.

The primary objective of the project is to design, develop, and implement an advanced control unit specifically tailored for the precise regulation of pressure during the mounting of bearings in vehicle shafts. The control unit is designed to ensure the proper mounting of bearing in wheel shaft. Thus, by designing a control unit for the operation of a press machine by using AT 328 SMD we ensure that the bearing is assemble with accurate pressure in wheel shaft

The methodology is divided into three parts:

1. Design Analysis
2. Hardware description
3. Hardware programming

All these three parts were assembled together and experiments were then performed to build a system that can control the hydraulic pressure that was carried out.

Keywords: Hydraulic Press, Pressure, Automation technology, etc

1. Introduction

Accuracy and dependability are critical in the dynamic field of automobile engineering and production. A careful technique is necessary to ensure the smooth integration of essential parts, like bearings inside vehicle shafts. Our research focuses on creating a state-of-the-art control device that will maintain and adjust the ideal pressure while bearings are being assembled onto vehicle shafts, guaranteeing the highest level of quality and accuracy. Major accidents could result from wheel separation or vehicle unbalance if the wheel bearing is not assembled within the specified range. This research targets a vital component of vehicle longevity and performance, which constitutes a critical development in automotive assembly procedures. The correct positioning of bearings on shafts is essential for the operation of several car systems, including the suspension, steering, and engines.

Our goal is to improve the overall quality and longevity of automotive goods by improving the efficiency, accuracy, and consistency of this crucial assembly stage through the development of a specialized control unit.

The goal of this study is to automatically operate the press machine by regulating its force and speed. The field of hydraulics is vital to human existence. Given its status as a component of the industrial muscle and its position in contemporary automation technology, hydraulics is a highly versatile technology with a vast array of applications, demonstrating its significance.

The term "hydraulics" now refers to the use of fluids to transmit and control force and movement. Press working techniques involve cold working mild steel and other ductile materials in less time, with higher accuracy and at a lower cost, by using huge amounts of cost-effective tooling equipment design. The components produced cover a very broad range and are used in the industry to create large numbers of pressing economically; the rate of production and the cost of the press tool to be used must be taken into account. A press is a chipless manufacturing process used to create several types of sheet components.

Press-used components often have thin walls and a predetermined shape. The sheet metal work piece is cut or formed into the appropriate shape by applying a lot of force with press tools in the shortest amount of time during manufacturing. Metal forming presses were first equipped with a basic crank and lever mechanism that used a punch or ram to translate rotating action into linear motion. Punch or ram applied to the work item produces linear motion and the motor produces rotating motion. Arduino controller with an electronic pressure sensor. The relationship between the pressure needed to bend the material and its parameters is performed by it according to its programming. To ensure that the system is operating as intended, a simulation program called Automation Studio was used to mimic the system. In this paper, copper alloys of various thicknesses were examined. To verify the system's functionality and design, a laboratory setup was constructed to demonstrate how the system operates. Consequently, a proportionate connection between the ultrasonic and pressure sensors and the proportional valves has been established. By the end of this process, the force and speed can be adjusted based on the alloy type and thickness of the material. Lastly, a smart press that integrates with an automation system can be designed and put into operation.

2. Literature Review

The following literatures are directed to the work with proportional valves in electrohydraulic systems and the different control algorithms used for enhancing their performance.

Willy Lazuli and Bjorn Victor Lund (2010) presented in a study the results of modeling and simulation of a physical hydrostatic transmission with three different modeling tools; Simulink, Sim Hydraulics and

Simulation X. The aim has been to get the simulations from the different models to be as similar as possible to the two measured pressures and the rotational speed of the load. The Simulation X model gave the best results compared with the measurements. The largest challenge has been to simulate the model in Simulink and to find the frictional losses in the hydraulic motor by performing different tests. The solver in Simulink could not solve the equations and it was difficult to find the tests for finding two of the friction parameters

Denishet al., (2019) designed an Automatic Phase Sequence and Overload Protection using PIC Microcontroller. Single phase was taken from three phase supply for voltage and current measurement. Three phase supply was given as input to phase sequence detector module to check the phase sequence. Then the measured voltage, current and checked phase sequence was given to ADC pins of PIC 16F877A. Using the C-program dumped in PIC 16F877A, it compared the measured parameters with the predefined ranges used in the program and displays voltage and current values in the LCD as well as sent the signal to relay according to the results of comparison of the measured parameters.

Eryilmaz and Wilson developed a unified model for proportional control valves and analysed the effect of spool lapping on open-loop hydraulic system properties. The developed nonlinear equations were used to obtain simplified flow rate expressions under generally accepted assumptions. These unified model equations are useful for simulation and nonlinear controller design.

Renn and Tsai built an electro-hydraulic proportional flow control valve with lowest cost by developing a proportional switching solenoid. The fuzzy-logic controller was used to linearize the force/stroke characteristics of the normal switching solenoid valve.

Hamdan and Gao developed a Modified PID (MPID) controller to control and minimize the effect of hysteresis in Pneumatic proportional valves. It consists of four parts: Proportional-Integral-Derivative (PID) controller, a Feedforward term, an Anti-Windup mechanism, and a Bang-Bang controller. The result is a unique Modified PID (MPID) control scheme that demonstrates better command following and disturbance rejection qualities than a conventional PID (PID + Feedforward + Anti-windup) scheme, and also provides better step response, command following, robust control in the presence of significant dynamic variations in the valve, and greater bandwidth than conventional methods.

Kiković developed a mathematical model of filling chamber controlled with proportional spool valve. Use different geometry of valve output port; the aim was defining optional geometry so that pressure response in chamber is sufficiently linear and quick. Valve dynamics, the nonlinearity of the valve effective area with respect to the coil current, and the nonlinear turbulent flow through the valve orifice were also considered. The other construction aspects of proportional valve were analysed. For example, the spool spring constant has huge influence on time of pressure response and it is possible to have this time less than 1 sec what is demand for hydrodynamic brake.

Dobchuk developed a model reference control scheme to provide control of the valve spool displacement for a particular electrohydraulic proportional valve. He presented the conditions by which the linearizing feedforward controller produces excellent velocity tracking characteristics and concluded that the linearizing feedforward approach has the potential for excellent response, disturbance rejection and repeatability when used as a single component pressure compensated flow control device.

Ferreira et al. described a new semi-empirical modelling approach for hydraulic proportional spool valves to be used in hardware-in-the-loop simulation experiments. The model described the behaviour of the whole hydraulic valve package (valve, spool position transducer and electronic controller card). Spool dynamics are modelled by a non-linear second-order system, with limited velocity and acceleration, the parameters being adjusted using optimization techniques. The developed models use either data sheet or experimental values to fit the model parameters in order to reproduce both static (pressure gain, leakage flow rate and flow gain) and dynamic (frequency response) valve characteristics. The model accurately reproduces the amplitude Bode diagram up to 200 Hz. The phase response still has room for improvement, mainly at high frequencies.

Lee et al. introduced a tracking position controller (type PID) for a pneumatic actuator and evaluated it experimentally. The positioning system is composed of a pneumatic actuator and a 5- port proportional valve. The experimental results indicate that the tracking performance can be significantly improved with the proposed controller. If the model of dynamic nonlinearities such as friction and compliance are identified and incorporated into the feedback linearization, and if the noise coming from differentiating position is minimized by directly measuring the velocity, further improvement of tracking accuracy may be achieved.

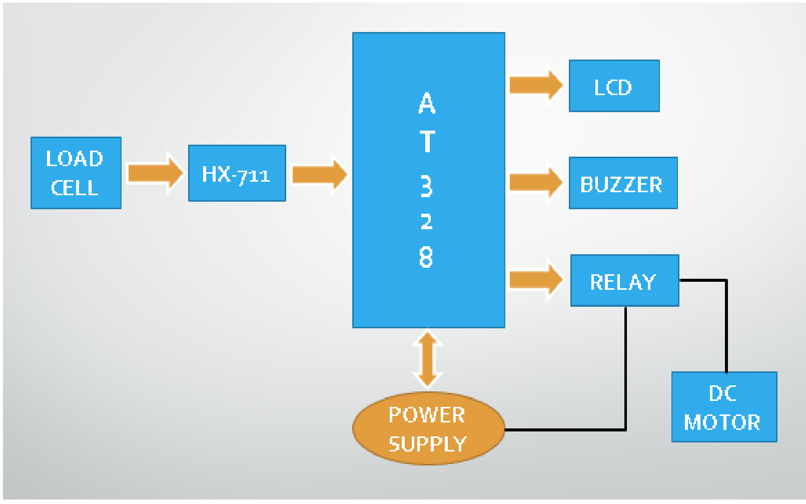
3. Problem Statement

A vehicle's wheel shaft bearing may not be assembled correctly, which could cause grinding or scraping sounds, wheel separation, or vehicle imbalance, which could be extremely dangerous and result in serious accidents. In addition to affecting overall vehicle performance and safety, this problem may result in premature wear on the bearing.

In order to minimize reliance on imported controllers from overseas businesses, optimize manufacturing costs, and boost the competitiveness of the electric vehicle firm, develop an affordable solution for monitoring temperature and pressure in bearings used in electric vehicles.

4. System Design

Figure 1: Block Diagram



In this prototype model, a pressure of up to 1 kg is delivered to the load cell, which is then transformed into an electrical signal by a voltage-sensitive load cell.

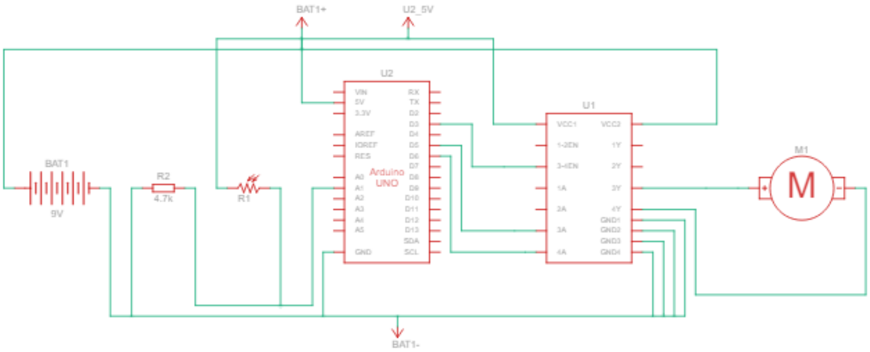
The load cell's output voltage reference is fed into the HX-711's input, which transforms the analog signal into a digital signal. Additionally, the Arduino UNO, which is coupled to an SMD ATmega 328 microcontroller, receives the digital signal from the HX-711. The ATmega 328, which regulates the output connected to the Arduino board, checks and processes the C program produced for the Arduino UNO.

An LCD is connected to an Arduino Uno, allowing it to show the load cell's pressure as well as whether or not the weight that the Arduino is configured to measure falls within the specified range.
When the load cell experiences pressure within the specified range, that is, above 500 grams, it will first check with the Arduino microcontroller software. The microcontroller will then send a signal to the relay, which will control the associated Dc motor to switch it off.

5. Experimentation

Test Case 1: When the pressure is applied up to 250gm the motor is remained ON.
Test Case 2: When the pressure is applied at accurate 500gm the motor turned OFF.
Test Case 3: When the pressure is applied above 500gm the motor will remain OFF.

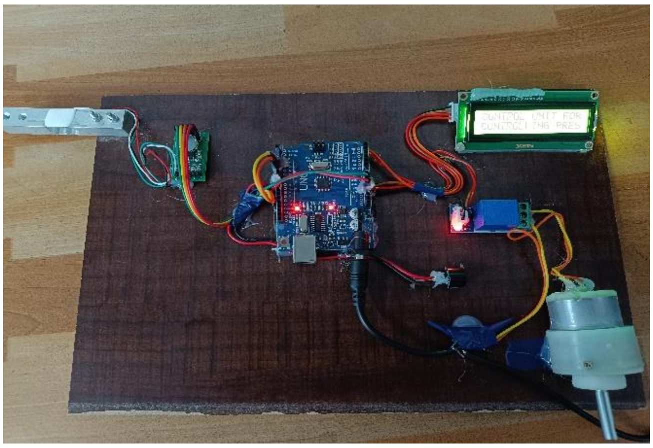
Figure 2: Circuit Diagram



6. Results

It's also crucial for one to understand that hydraulic presses come in automatic and manual varieties. It is vital to follow certain safety precautions, such as barrier guards and interlocking, when using manual hydraulic presses to ensure both your own safety and the safety of your employees. In summary, both automatic and manual hydraulic presses are subject to safety regulations. Use every safety precaution that is advised. For industrial uses, hydraulic presses are quite beneficial. Its operation is also quite straightforward.
The hardware setup for the project is depicted in the following figure:

Figure 3: Hardware Setup



7. Conclusion

Using a microcontroller, we designed and implemented an automatic pressure control system. Our key goal is to create a system that efficiently satisfies the requirements.

The implementation's components were reasonably priced and conveniently accessible. By its loads, this system keeps the pressure constant. The project's device features a very basic structural design. As a result, these gadgets are incredibly inexpensive when compared to other gadgets on the market. As previously indicated, the systems have the potential to make a significant contribution in a number of sectors. However, for these kinds of systems to be a superior option, they still require some sort of enhancement.

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9. References

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