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Implementation of Automated Pneumatic Bumper in a Mining Cart

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Abstract: *When it comes to Automation, Hydraulics and Pneumatics plays a significant role in it. Our aim of the project is to implement an Automated Pneumatic Bumper system in Mining Cart which is used in the process of material handling in underground Mining. This bumper activation takes place only during the time of collision. The overall system consists of ultrasonic sensor module, pneumatic cylinder, mini air compressor, solenoid valve, Arduino UNO and the bumper arrangement. The ultrasonic sensor module senses any obstacle within 2feet at the time of collision. Here it is not required to check the speed of mining cart as it runs on constant speed motor. If any obstacle is sensed, this ultrasonic sensor sends signal to solenoid valve. The solenoid valve allows the flow of compressed air from compressor into the pneumatic cylinder. The bumper attached to the end of piston rod of pneumatic cylinder moves forward as a result of outward stroke of piston. This pneumatic bumper system is used to protect the Mining Cart from direct collision with another Mining Cart and Spillage (or) Wastage of materials can also be avoided.*

Key Words: **Mining Cart, Bumper, Ultrasonic sensor, Solenoid valve, Arduino UNO, Pneumatic Cylinder**.

1. INTRODUCTION

In the process of underground mining, the materials such as coal, gold are carried out from the underground by small carts running through railway tracks. These carts generally runs on a dc supply as the usage of diesel, petrol kinds of fossil fuels are highly flammable in that area. Implementing an automated bumper setup in this place is going to be highly effective in the times of human intervention and vehicular collision in the tracks. If there is a collision between two carts, the materials carried by the carts are spilled on the tracks on certain amount. As a result it causes a loss of money due to material wastage and also involves certain amount of labour costs in cleaning the spillage. So, implementing an automated bumper system in this area is also efficient and effective in terms of costs as it is going to absorb some amount of impact by avoiding direct impact with obstacle which as a results it nullifies the repairing cost of Cart.

1.1 Concept of Pneumatics

The word Pneumatics was derived from the Greek word 'Pneuma' which means' breath of life'. The Pneumatic system involves the conversion of fluid power into mechanical output. The mechanical output is in terms of piston movement in the pneumatic cylinder. Here the fluid medium used is compressed air. In this pneumatic system frequent maintenance is not required like that of hydraulic system. Moreover the pneumatic systems are safer, reliable and easy to design.

The field of pneumatics has a wide variety of applications in various fields such as mining, dentistry, automotive, manufacturing and other fields.

1.2 Automation in Mining Industry

After the implementation of Industry 3.0, automation started to play a significant role in the mining sector. The introduction of automation into mining sector greatly reduces the human involvement in the mining pits. As a result it is effective and effective not only in terms of cost and money but also in terms of safety. Recent advancements in autonomous robots have paved the way for efficient exploration of mining sites.

2. DESCRIPTION OF MAJOR COMPONENTS

A) Ultrasonic sensor

Ultrasonic sensors are used for obstacle detection. The ultrasonic transmitter sends a high frequency wave. The ultrasonic receiver receives the waves which got reflected from the obstacle. Based on the time taken by the wave signals to reach the receiver , the distance can be calculated . It is connected to Arduino UNO.

Fig -1: Ultrasonic sensor

B) Single acting pneumatic cylinder

Generally pneumatic cylinder converts the fluid power into mechanical output and the fluid medium is compressible air. In single acting pneumatic cylinder either the forward or return stroke takes places through the action of compressed air. The other stroke takes place through the action of spring which is an in-built component of single acting cylinder. The compressed air from the compressor is transferred through rubber hoses connected with solenoid valve.

Fig-2: Single acting pneumatic cylinder

C) Solenoid valve

Solenoid valve is an electromechanical valve which converts the electrical input into mechanical output. It is connected to Arduino UNO. Here the mechanical output is produced in terms of plunger movement. This plunger movement controls the flow of compressed air from compressor into the cylinder.

Fig -3: Solenoid valve

D) Rotary compressor

Compressors are used for compressing the atmospheric air and supply to the cylinder. In this project, a mini rotary compressor is used because we require only a small amount of discharge. It is powered through a DC supply.

Fig-4: Rotary compressor

E) Arduino Uno

Arduino Uno is a user friendly microprocessor which is based on the microchip ATmega328P micro controller. These types of microprocessors are used because it can be programmed as per our convenience. It has a set of digital and analog pins. In this project the ultrasonic sensor and solenoid valve are connected to Arduino. It is powered through separate 5v dc supply.

Fig-5: Arduino UNO

3. PROPOSED DESIGN

Fig-6: overall Outer Design
(Software used: PTC Creo)

4. WORKING PRINCIPLE

The overall basic principle behind the project is the conversion of fluid power into mechanical power. The compressor compresses the atmospheric air and it is driven by dc supply. The solenoid valve controls the flow of compressed air into the cylinder and it is connected with Arduino. The ultrasonic sensor module comprises of ultrasonic transmitter and receiver senses the obstacle and it is also connected with Arduino. Arduino Uno runs through a 5v dc supply. The bumper attachment is connected at the end of piston of single acting pneumatic cylinder. The compressed air comes through rubber hose from solenoid valve. The arduino Uno is programmed in such a way that the ultrasonic sensor will be sending signal to solenoid valve if the obstacle is measured within 2feet.

The automated bumper activation wont takes place unless the ultrasonic sensor senses obstacles like humans and other mining carts in the tracks. If there is no obstacle sensed by ultrasonic sensor module, it doesn't send any signal to solenoid valve which does not cause any further actuation. But as soon as the ultrasonic sensor senses the obstacle it sends the signal to solenoid valve. The solenoid valve after receiving the signals from ultrasonic sensor, converts the electrical signal to mechanical output (plunger movement) As soon as the plunger opens, it allows the flow of compressed air from rotary air compressor into single acting pneumatic cylinder through rubber hoses. The flow of

compressed air into the cylinder allows the extension of bumper as it is attached to the end of piston. The bumper remains extended as long as ultrasonic sensor sends signal to solenoid valve. So when the ultrasonic sensor doesn't senses any obstacle, it stops sending signals to solenoid valve. When the signals doesn't reach solenoid valve, the plunger gets closed and it doesn't allow the flow of compressed air into the cylinder. Finally the bumper retracts by the action of spring present inside the single acting pneumatic cylinder.

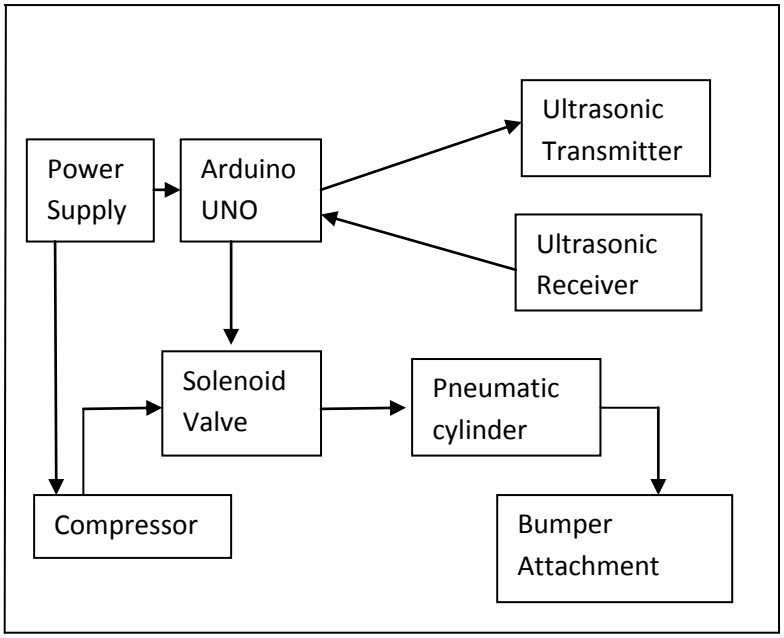

Fig-7: Block Diagram of the Project

5. DESIGN REQUIREMNETS AND CALCULATIONS

A) Force exerted on bumper

For single acting pneumatic cylinder,
Bore diameter = 40 mm
Maximum stroke = 40 mm

Area of cylinder = $(\pi/4) \times (40^2)$
A= 1256.63 mm ^{2}

Force exerted on the bumper = Force acting inside the cylinder
Force = Pressure × Area
Pressure = 3 bar (compressor outlet)

P= 0.3 N/mm ^{2}

Force exerted on the bumper = 0.3 × 1256.63

Force exerted on bumper = 376.98 N

B) Air consumption by cylinder

Standard air consumption for 40mm bore size cylinder=0.014 litre per mm stroke
(as per ROTEX pneumatic catalog)

Total air consumption for 1 cycle = 0.014 × 40=0.56 litre

(There is no need of air consumption for return stroke as it takes place through spring action)

5. OUTCOMES OF PROJECT

- The impact of collision got reduced.
- The spillage and wastage of materials are prevented.
- The additional labour costs which were involved in clearing the tracks during spillage are eliminated.

6. ADVANTAGES

- Safer system
- More reliable
- Easy to design and construct
- Less initial cost

7. CONCLUSION

The significance of implementing Advanced Automation in every industry is the requirement of good quality, high amount of productivity and an increased amount of safety in their sector. When it comes to Automation, the use of sensors and transducers are irresistible. Our project of Implementing Automated Pneumatic Bumper in Mining Cart is greatly effective and efficient in terms of materials handling or transferring materials from mining pits. Because of its simplicity it can be implemented in both front and back side of mining cart because of its simplicity in construction and it doesn't require equipment other than additional pneumatic cylinder. This pneumatic bumper concept can also be applied to automobiles such as cars and trucks as it will be efficient during the time of accident.

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BIOGRAPHIES

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