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Design of Smart Rolling Shutters for Low Cost Operations

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***Abstract:*— In today's industrial scenario, labor is a major expense in any product that is manufactured even in developing countries. In this regard most of the present day industries are shifting towards automation. In our project, we are designing a smart roller shutter system for low cost operations.**

Roller shutters have many applications some of which include factories, garages, schools and warehouses. The project prescribed provides excellent security benefits and in regions exposed to inclement weather, it can also be used as a method of insulation. Studies show those automatic roller shutters already in market have been the cause of a large number of accidents over the years. A lot of these incidents take place due to the failure of mechanisms during normal working hours or emergency situations. Introduction of a few smart safety sensors in this mechanism can help reduce the risks and accidents caused by these shutter operations. In conclusion, we wish to develop a system to help minimize the health hazards caused by the failure of automatic roller shutters.

***Keywords:*-- smart roller shutters, heat sensor, finger print scanner, piezo velocity transducer.**

I. INTRODUCTION

The rapid increase in use of automation in industries has led to a very large number of advantages; however, studies have shown that a lot of such automatic mechanisms have lead to innumerable accidents too.

In the past, manual metal shutters were utilized for security. They consist of a ribbed steel shutter that moves vertically while opening and rolls up and around the drum, guided by tracks and counterbalanced with springs. [1]

With the advancement in technology, manual shutters have been upgraded to automatic roll-up shutters. The roll-up door system uses a combination of electrical and mechanical system to achieve automatic locking and automated maneuvering of the roll-up door.[2]

The use of automated roller shutters in industries have made opening and closing of shutters easy, but at the same time, a large number of people get injured or in some cases lose their lives as a result of failure of mechanism.

Our design provides a few additional features like the use of sensors and braking mechanisms in order to reduce the number of accidents occurring due to mechanism failure.

1.2. Design

The design of the smart rolling shutter mechanism consists of the following components:

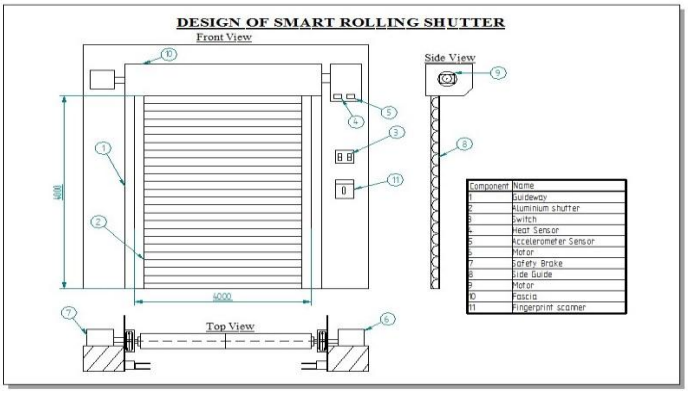

Fig 2.0 CAD Model of Smart Rolling Shutter Opening System

1.2.0 Working Principle

When a worker with a registered fingerprint places his finger over the scanner, a signal will be generated and sent to the switch to open the shutter and attendance is also marked. In case of sudden fall of the shutter, the piezo velocity transducer senses the velocity change and initiates the cone clutch braking mechanism. In case of a fire emergency, the prevailing high temperature is detected by the heat sensor. The heat sensor in turn sends a signal to the switch to open the shutter. The motor will be provided with a battery backup in case of power cut. A provision for manual opening is also installed as a last resort.

1.2.1 Motor and shutter system

The most popular and widely used amongst all the categories of doors is the motorized rolling shutter. We have selected aluminium with a mass per unit area of 10kg/m2 as

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the material of the shutter. We have selected a fire proof 750 W 240V tubular motor. The motor is provided with provision for manual opening of the shutter as an additional precaution. An external dc battery backup is provided.

1.2.2. Heat sensor

There will be a provision for the installation of a heat sensor. This sensor detects the presence of a fire thereby transmitting a signal to facilitate opening of the shutter so as to let out the people inside. An LH35[4] Precision centigrade temperature sensor can be used.

The output signal from this sensor switches on the motor and hence facilitates the opening of the shutter in case of a fire.

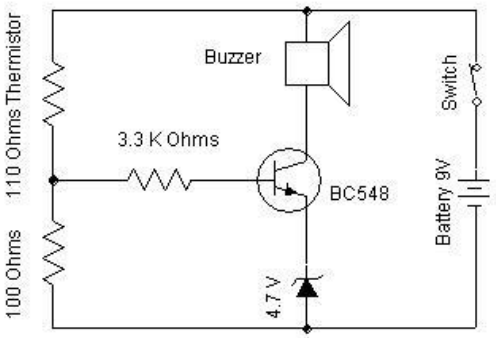

fig. 2.1 – Circuit diagram of LH35 heat sensor

1.2.3. Piezo velocity sensor.

Piezo velocity sensors are accelerometers which accumulate charges due to change in relative velocity. It consists of an embedded integrated solid state circuit.. If there is a sudden failure in the mechanism and the shutter falls, the sensor will detect a sudden increase in velocity and activate the braking mechanism of the shutter.

A 330500 Velometer Piezo[5] velocity sensor can be utilized. Unlike moving-coil velocity transducers, Velometer PVT sensors have no moving components and hence can resist wear and tear. The placement of these sensors can be at any angle of inclination.

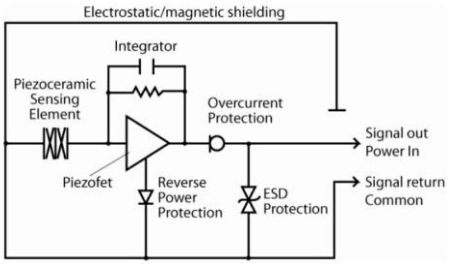

fig. 2.2 – Circuit diagram of Piezo velocity transducer

1.2.4 Fingerprint scanner

A fingerprint scanner has been included in the system to prevent the entry of unauthorized personnel into the premises. It also monitors the daily attendance of the employees. The fingerprint scanner uses an Arduino for its functioning. A matching algorithm is used to compare registered fingerprints against users fingerprint for verification. On confirmation, the shutter will open and the attendance is added.

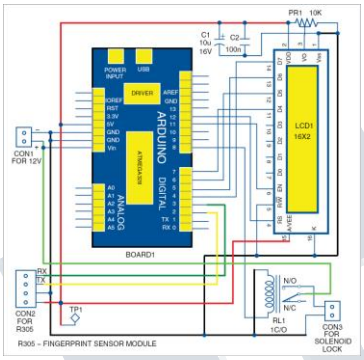

fig. 2.3- circuit diagram for finger print scanner with Arduino

Device No.	Type	Base oxide thickness (Å)	N dose ($x10^{15}$ cm^{-2})	T_{XPS} (Å)	EOT (Å)	% N
W1	PNO	15	0.0 + 2.8	18.48	14	23
W2	PNO	20	0.0 + 2.9	22.34	17.7	20
W3	PNO	20	0.0 + 5.3	23.16	15.6	35
W4	PNO	20	0.0 + 6.8	24.37	14.6	43
W5	PNO	25	0.0 + 3.1	28.3	23.5	17
W6	PNO (Moderate PNA)	20	0.0 + 2.7	24.09	20.2	17
W7	RTNO	25	0.8 + 0.0	26.43	22.5	6

1.2.5 Braking Mechanism

The braking mechanism used is a conical clutch. It performs the same function as a disc or plate clutch, but it can transfer a much higher torque due to the wedging action. Change of gears consume lesser time as the cone clutch need not be pushed completely.

These days cone clutches are finding their way in low peripheral speed applications.

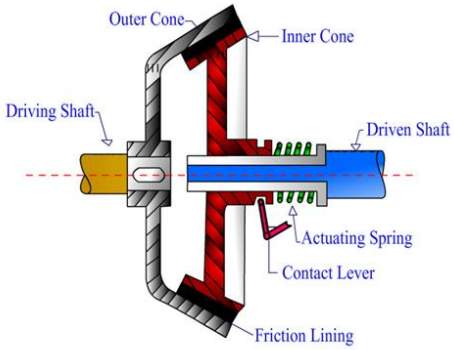

Fig 2.4 – Diagrammatic representation of cone clutch

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1.2.6 Limiting Switches

Our system consists of a roller shutter; therefore, there are chances that the shutter may completely unwind and hit the floor. To avoid this, limiting switches have been installed. A limiting switch is used to prevent the movement of the shutter past some predetermined point which is mechanically operated by the motion of the shutter itself.

1.3 Calculations

Material – Solid aluminium
Mass per unit area – 10 kg/m2
Dimensions – 4m * 4m (Can be altered according to the need)
Area = 16 m2
Mass of the shutter = Area * mass per unit area ...equation (1)
=16*10 = 160kg
Radius of pulley = 0.125m
Weight of shutter = mass * acceleration due to gravity ...equation(2)
= 160*9.81 = 1569.6 N
Frictional resistance (F)= co-efficient of friction(μ) * Weight ... equation(3)
Co-efficient of friction between steel and aluminim (μ) = 0.61[3]
Fr = 0.61 * 1569.6 = 957.456N ...
From equation (3)
Total Force to be overcome = Weight of shutter + frictional resistance ... equation(4)
= 1569.6+957.456 = 2527.056N
Torque needed = total force * Radius of pulley ... equation(5)
= 2527.056*0.125
= 315.882Nm
Power of motor = 750 W
Speed of motor = 21 rpm
Available torque = (P*60)/2□ *N ... equation(6)
= (750*60)/ 2□ *21
= 341.046Nm .

1.4 Advantages

- This system provides security by checking for intruders and can also be used to take attendance of the employees due to the installation of a fingerprint scanner.
- It automatically opens when a fire is detected ensuring the safety of the workers.
- It prevents the sudden falling of the shutter due to the presence of a velometer PVT to avoid injuries to the people under it.
- The cone clutch braking mechanism is more efficient and more durable as it resists wear and tear.
- The tubular motor suggested consumes less electric power

1.5 Conclusion

The current smart rolling shutter designed acts as a security system, since only the registered fingerprint is recognized by the scanner ensuring that the person is trained to operate the same. By providing the fingerprint, the system not only allows him to further use the facility but also registers the attendance for the operator. This enhances the security by providing details about the operators who have used the system and at what time. In case of any emergency like a sudden fall of the shutter, the piezo velocity transducer senses the velocity change and initiates the cone clutch braking mechanism. In case of a fire emergency, the prevailing high temperature is detected by the heat sensor. The heat sensor in turn sends a signal to the switch to open the shutter. With the above mentioned smart rolling shutter system, the rolling shutters offer a safe operation technique for multiple utilities. The cost of implementation and running is low since the a major parts integrated to the tubular motor which is readily available and operation costs compared with other types is low.

1.6 Acknowledgment

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