A Fall Based Pelvic Bone Protector

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Abstract -This paper describes the development of an airbag system built in a hip belt that is designed to provide protection and monitoring of elderly people who are prone to falling related issues such as hip damage.Micro Electro Mechanical System(MEMS) accelerometer sensor is used to sense the variation in angle and acceleration of the person wearing the belt with respect to the x, y, z axis of the user's body. During the deviation in user's angle with respect to x axis i.e. as the body angle of users varies between 0 to 45 degree or 135 to 180 degrees, an airbag is inflated by sensing the change in angle. It indicates a fall. A Global System for Mobile communication (GSM) module is incorporated to send the messages to the user's care taker to indicate the abnormal activity. A buzzer is also added to the belt in order to indicate the people nearer the user that a fall has occurred and hence the user can get the required help. The entire system is connected to an Arduino nano, brain of the belt system.

Key Words:Airbag, Arduino nano, GSM, Hip Belt, MEMS Accelerometer sensor

1.INTRODUCTION

It is known that the world is facing a rapid increase in the aging population. With this anticipated increase, the proportion of fragile and dependent elderly people are also likely to increase significantly. This will lead to an exponential increase in the number of individuals suffering from health problems related to aging, i.e., injury caused by fall. Fall and fall-induced fractures are very common among the elderly people. Hip fractures mainly result in deaths and costs of all the fall-induced fractures. Along with physical injury fall can also result in other death causing problems like, pelvic bone damage and can also result inpsychological issueswhich lead toreduction in the quality of life of a person. Hip belts with airbag inbuilt in them are protective; they are made from a combination of neoprene and nylon that provide comfort to the person wearing it. They are widely demonstrated both biomechanically and clinically to be capable of reducing the incidence of hip fractures. In the present work, efforts are taken to develop the hip belt because the traditional type of belts have higher discomfort and sturdy which makes it unpleasant for the user. Basically, a Micro Electro Mechanical System (MEMS) sensing unit is used to detect imbalance of the elderly person and trigger the inflation of compact airbags in the belt. Two key issues are considered for the human airbag system. One is a compressible airbag that can be inflated instantly. One more thing is that it consists of a very small triggering device which is embedded in the belt with a very rapid and precise algorithm for recognition falling-down motion. In this paper, the design of the airbag deploying system and its feasibility on protecting the elderly people is developed and presented.

2.AIRBAG SYSTEM FOR PROTECTION

As mentioned earlier, hip fractures are due to fall experienced by elderly people. Therefore it is proposed to develop a system that protects them from fall and also indicate the occurrence to their guardian / care taker. Recent development in manufacturing technologies have made it possible to safely comprise in small, lightweight and low pressurized cylinders thereby making a personalized airbag system which is not only possible but economically feasible. The airbag restrained system for automobiles uses explosives and involve chemical reaction of Sodium azide to produce a huge amount of nitrogen gas to inflate the air bag. The inflation can be finished in 1/20 seconds. So, it is dangerous for elderly people to handle such explosives. Therefore, it is aimed to reduce the risk factor and the amount of chemical is reduced in the proposed air bag system. This airbag is designed in order to absorb shock caused due to fall and this airbag is inflated using Carbon dioxide (CO_2) cartridges so that damages caused due to the conventional nitrogen cartridges can be reduced. Since the nitrogen cartridges causes inflation due to the reaction of Sodium azide with other nitrogen, causing an explosive emission that system has been changed.

Fig 1: Airbag system

3.SYSTEM DESIGN

3.1. Functional Block Diagram

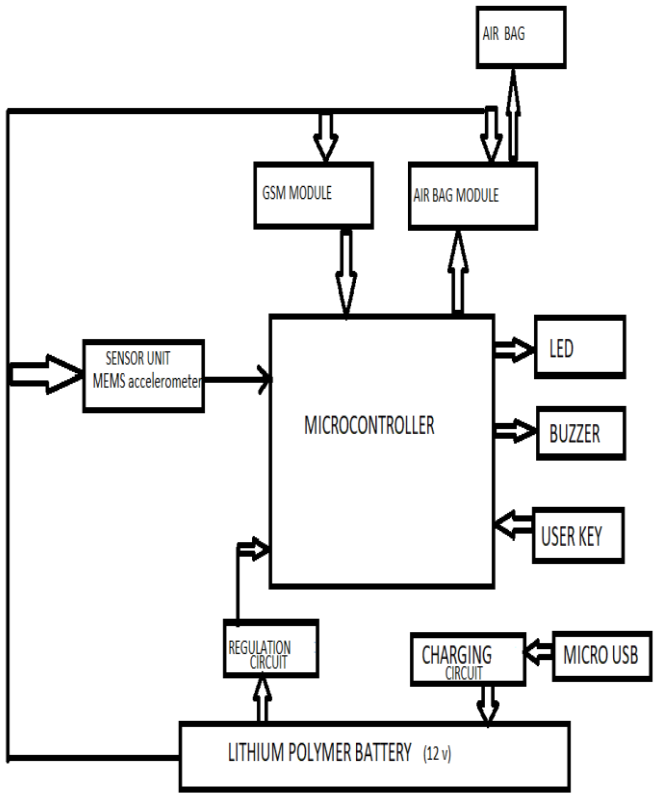

Fig 2: Functional block diagram

3.2. CO_2 cartridge design

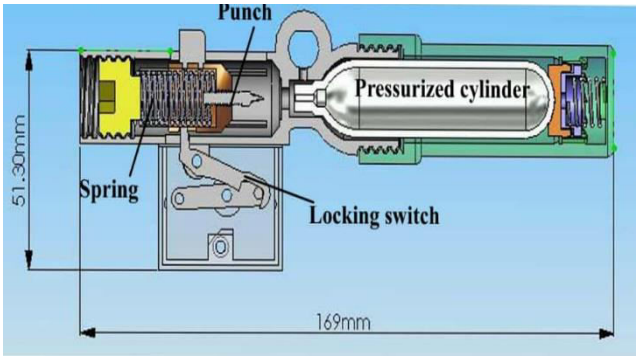

Fig 3: Inflation mechanism of airbag

Besides detecting the fall related motion, another key issue is how the cartridge opens and deploys the airbag. The mechanism followed here is releasing the CO_2 trapped inside a cartridge by using a loaded spring switch. This cartridge contains high pressure liquid CO_2 which gives a cold feeling during deployment of air bag which makes it different from the conventional air bags. The deploying mechanism involves a punch mounted on a launcher with a spring and locking switch. The spring is compressed by screwing and when the lock switch is triggered by the actuator, the compressed spring expands and its punch accelerates towards the cartridge to release the CO_2 in the air bag.

3.3. Airbag Design

Elderly people falling backwards have lower risk of hip fracture because the region at the back contain thick tissues there by giving a sturdy embodiment. The airbags are designed tocover the hip region and reduce the force of impact in that region. The study of hip protectors states that the energy shunting mechanism proves to give a great amount of protection but for this mechanism to be performed we require a firm and convex structure which is not possible for an airbag design. It is therefore possible to use energy absorbing mechanism to protect the elderly people that are prone to falling.

3.4. MEMS Accelerometer sensor

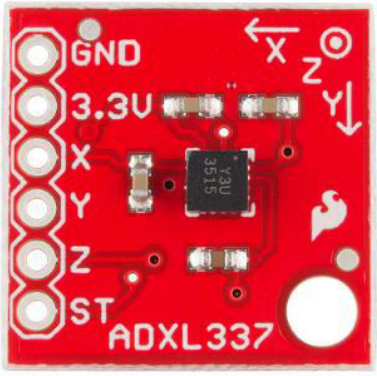

Fig 4: MEMS Accelerometer sensor

Here, ADXL377 MEMS accelerometer sensor is used to measure the variation in position of the person i.e. it detects the falling position of the elderly person. The main reason to use this type of mems accelerometer is because of it appealing features. ADXL377 is a small, thin low power complete 3-axis accelerometer with signal conditioned voltage output. The product measures accelerometer with a minimum full-scale range of ±200g. The sensor is designed to measure high acceleration resulting from high impact events without sensor saturation. The analog output of the sensor provides full visibility of an impact event so potentially critical data is not lost. The user can select the bandwidth of acceleration using x, y, z pins. Here, the x bandwidth is used as the normal position of a person in x axis. If there is any deviation in x position, the mems accelerometer will sense that and will produce an output accordingly.

3.5. Microcontroller- Arduino Nano

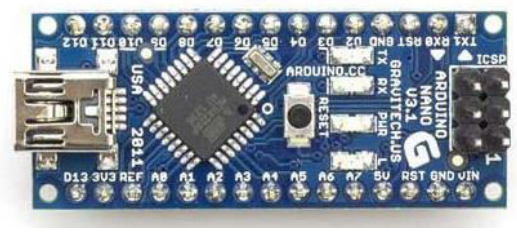

Fig 5: Microcontroller- Arduino Nano

The Arduino nano is used as the basic microcontroller. Originally, the Arduino uno was used to develop the model but with Arduino uno, an external power supply was required to provide the supply to it. Since the portable device has been planned for development, the Arduino nano is used in the present work. Also, this gives high performance and consumes lesser power which makes it more reliable to use. The Arduino nano operates under 5V and also 7-12V. 12V lithium polymer battery is used as the power supply to this microcontroller. It has advanced RISC Architecture.

3.6. GSM module

Fig 6: GSM module

The Global System for Mobile communication (GSM) is used to establish communication between mobile device or computing machine. GSM module is completely simple in design and also compact in structure. It can be easily embedded to the circuit being used in the device. It is compact and does not require internet for communication which makes it very reliable. Here, the GSM module is used for communication with the victim's guardian i.e., when the fall takes places the microcontroller send command to the GSM module that sends a message to the guardian intimating that such an incident has occurred.

3.7. Hip Belt

Here the hip belt used is a regular spine protector belt. This belt is made up of a combination of neoprene and nylon thus giving the user a comfortable feeling and it is also stretchable so that it can be used by people of various hip sizes

4.WORKING

The working of the device involves the sensing of the position of the person , when the angle deviates a little more than x axis , the mems accelerometer provides an output that leads to the deploying mechanism where the compressed spring expands and its punch accelerates towards the cartridge to release the CO_2 in the air bag . This also triggers a buzzer indicating that the user has experienced a fall in order to seek help from the people surrounding the user, then the GSM is immediately activated and the message is sent to the guardian of the user that the incident has occurred.

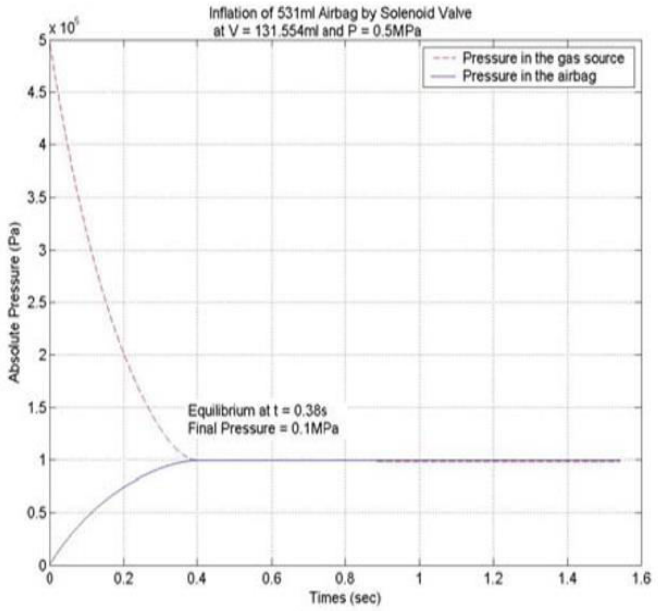

Chart 1(a): Inflating time of nitrogen cartridge

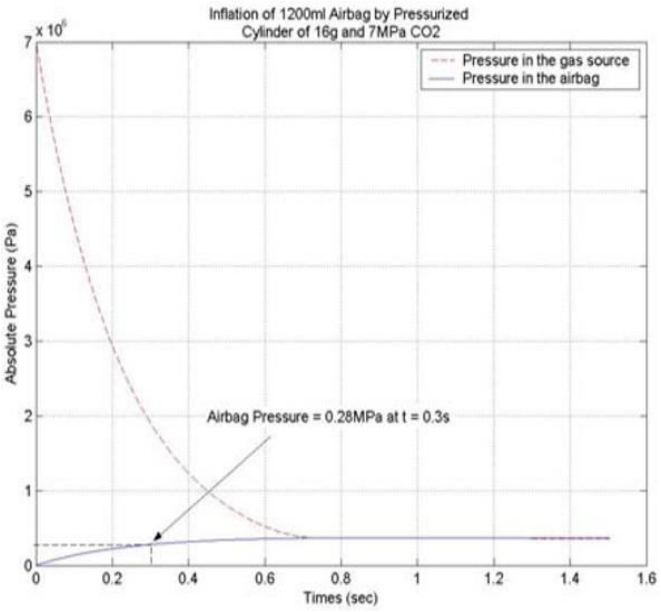

Chart 1(b): Inflating time of CO2 cartridge

The Chart 1 (a) and Chart 1 (b) shows that the inflating time and pressure involved for deploying the air bag by using nitrogen cartridge.

From the graph, it can be inferred that the falling time with respect to the CO_2 cartridge is lesser than that of the rising time with respect to the nitrogen cartridge.

This is because the CO_2 cartridge gives high pressure to inflate the air bag than that of the nitrogen cartridge and also it inflates the air bag without involving any type of hazardous chemical reaction.

Chart 2 and Table 1 shows the output of the MEMS Accelerometer sensor with respect to the change in the angle of the sensor.

Table- 1: Output of MEMS accelerometer sensor with respect to change in angle

S.NO	Angle in degree	Output voltage in mV	Indication
1	0	412	FALL
2	30	361	FALL
3	40	323	FALL
4	45	302	NO FALL
5	60	281	NO FALL
6	90	263	NO FALL
7	120	287	NO FALL
8	135	305	NO FALL
9	140	327	FALL
10	150	377	FALL
11	180	417	FALL

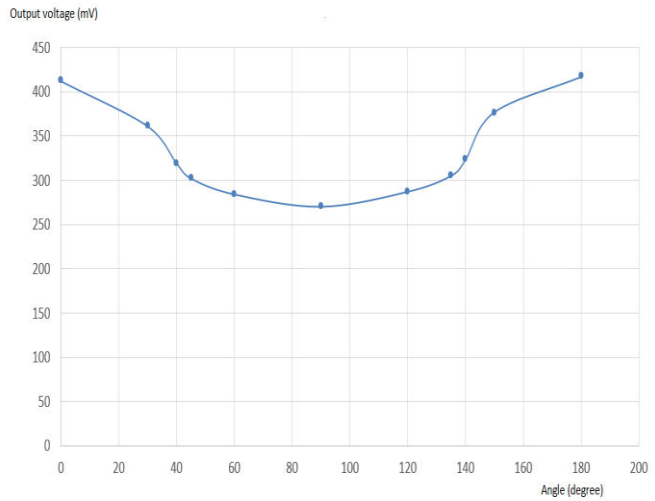

Chart 2: Output of MEMS accelerometer sensorwith respect to change in angle

5. CONCLUSION

The process of developing a prefall inflating belt for prevention of hip damage is reported in this paper. A belt to protect people from hip injures is developed by automatically inflating a airbag that absorbs shock of fall and it's impact on human body The sensors with which it is being built serves as the heart of the device. The entire operation is battery powered which makes it portable and easy to use. The use of this device may also save lives and reduce injuries from fall at construction sites and other locations too.

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