THE POSSIBILITY OF USING AN AIRBAG AS AN ALARM FOR INJURIES AT WORK

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Abstract: *Chest injuries are rare but extremely life-threatening and can occur in all industries. Although popular belief is otherwise, most injured persons can be saved by appropriate surgical treatment. Thanks to the use of airbags as an alarm for workplace injuries, an injured worker can notify nearby colleagues without being aware of it. This alarm is triggered when the load exceeds 15 kilograms or when there is a loss of pressure in the airbag, indicating a strong impact in the body region where the airbag is located. In an enclosed environment, a receiver is located inside or outside the work area that responds to this alarm and alerts other workers to an injury that occurred through visual and audible signals. Airbags as workplace injury alarms can be used successfully in a variety of fields and work environments, particularly in forestry, agriculture, mining, construction, and machine room operations.*

Key words: *injury at work, chest, alarm, airbag*

1. INTRODUCTION

Although the most frequently injured parts of the body of forest workers are the extremities such as legs (34%), arms and hands (26.9%), and then the head and neck area (15.2%) (Tsioras et al., 2014) injuries of the chest are not as common (about 7%) (Potocnik et al., 2009), but they are life-threatening. They occur in all industries, not only in forestry. However, forestry is one of the high-risk groups because it works in difficult terrain and with equipment that is often insufficient to protect the workers.

The most common chest injuries are: severe chest contusion, rib or sternum fracture, ruptured lung due to the sharp edge of a broken rib entering the lung, which may be the result of a lung puncture or a foreign object entering the chest, collapsed lung due splashing or bleeding, etc.

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Contrary to popular belief, most injured people can be saved by appropriate surgical treatment. However, due to the above-mentioned injuries, the injured worker is often unable to ask for help promptly because he is in a state of shock or unconsciousness, which prevents him from requesting the fastest possible help.

Ibrahim et al. (2023) investigated the use of an airbag and signaling during falls in the elderly. This system can be attached to the waist belt like an airbag. It is wirelessly connected to the elderly person's cell phone, for which an Android mobile application was created to receive alerts from the system. The system detects the fall using a gravity sensor connected to the "Arduino board". When the gravity sensor detects a fall, the system activates the air valve and inflates the airbag from the air reservoir. The system then sends an alert via Bluetooth to the person’s application, which is specified as the contact for the elderly person. Arduino boards are used for fall detection based on set threshold values (Manigandan & Norman, 2015).

This model was developed by Toshiy et al. (2009), who conducted studies on 16 subjects simulating a fall. They then developed a fall detection algorithm that could detect signals 300 ms before a fall. This signal served as a trigger to inflate the airbag to a capacity of 2.4 l.

Following a similar model, thanks to the use of an airbag as a workplace injury alarm, an injured worker can send a call for help to the adjacent group of workers without even being aware of it.

The aim of this work is to show the principle of operation and the possibility of using an airbag as an alarm for workplace injuries.

2. WORK METHODOLOGY

For the purposes of this work, a prototype was made that consists of several elements. These elements are: an airbag, a pressure sensor that processes the pressure difference and provides at its output a voltage signal ranging from 0 to 5 V, an electronic part that increases the input signal provided by the pressure sensor and sends a pulse to the transmitter of the remote part of the device through the input signal comparator, which has the task of turning on the receiver through radio signal that reports a possible injury to the worker.

The input signal, i.e. increasing the pressure in the airbag, represents the pressure of a foreign object on the chest, abdomen or part of the body most at risk in the workplace, a place with a high risk of injury. The receiver is located in the protective helmet of the worker of the adjacent group, which warns of possible injury to the worker by vibration and a light signal, on which the airbag with the alarm is placed. This concept refers to the workers who are in the field and do not have direct mutual communication due to distance, noise, work organization, etc.

In an enclosed space, the receiver that triggers the alarm is placed in the inner or outer part of the work area, where other workers are warned of the injury by a light and sound signal. On the circuit board of the electronic part, there are two potentiometers, with which we set the lower and upper air pressure thresholds, based on which the alarm signal is sent.

An alarm signal is also sent when the pressure in the airbag drops below the limit set on the potentiometer for the lower threshold. This means that there has been an injury, an impact with the sharp object, which has caused the airbag to burst.

3. RESULTS

In this work, the radio signal range was measured between the transmitter, which is connected to the airbag through an electric valve, and the receiver, which is located in the protective helmet and is connected to the vibration motor, which is firmly attached to the inside of the protective helmet, and the LED which flashes when the alarm is activated and is located directly above the worker's eyes.

Based on the measurements, we came to the result that the ultimate range of radio waves between the transmitter and the receiver is up to 120 meters without concrete or metal obstacles, i.e. in an open space. Considering the fact that the working groups, for example in the construction industry, are located at a much shorter distance, the mentioned range is quite sufficient.

Measurements of the pressure exerted on the airbag were also carried out in order to trigger the alarm. The airbag is loaded with a weight of 15 kilograms, and this weight was sufficient to trigger an alarm to inform a worker in another workgroup or a light and sound signal in the workshop that an injury had occurred.

For the purpose of this work, the airbag was repeatedly loaded with a constant pressure of 15kg or more, and the prototype reacted at different pressures depending on the position of the weight itself, sending a signal of possible injury at work. The reason for the deviation from the value of 15 kg, which was set as the limit for triggering the alarm, is due to the fact that the airbag tends to deform, affecting the change in its internal pressure, which is the basis for triggering the alarm (table 1). Since a prototype was made for the purposes of this work, which is still in the testing phase, the measurements were not performed on a group of workers under different working conditions, but only experimentally.

Table 1. Measurement results *(Source: Authors)*

Measurement results

Number of measurements	1	2	3	4	5	6	7	8	9	10	11	12
Prototype reaction (kg)	15.10	15.50	15.08	15.02	15.06	15.01	15.11	15.12	15.06	15.90	15.80	15.10
Average value (kg)	15.24											

In this prototype, we used potentiometer RV1 to set the lower threshold value and potentiometer RV2 to set the upper threshold value of the air pressure at which the alarm signal is sent. For the purposes of this work, the lower pressure threshold of the cushion is set to 140 mmHg or 0.187 bar, while the upper threshold is set to 250 mmHg or 0.333 bar. The pressure change sensor sends a 4.18 V signal at its output and triggers the alarm when the pressure in the airbag drops below 140 mmHg or 0.187 bar. If the pressure in the airbag reaches a value of more than 250 mmHg or 0.333 bar, the pressure sensor also sends a signal to activate the alarm. This means that an unplanned high pressure has occurred in the airbag caused by an injury, foreign object impact, contusion, etc.

An alarm is also triggered if the negative pressure in the airbag is below 140 mmHg or 0.187 bar. In this case, it is assumed that the airbag was punctured due to the penetration of a foreign object that caused the injury. However, if the worker suddenly faints and is unable to call for help, the worker himself triggers the alarm by releasing the safety valve, which causes the pressure in the airbag to drop below the lower threshold on the potentiometer RV1, which also triggers the alarm.

The voltage in the pressure sensor is directly and proportionally related to the pressure in the airbag. When the pressure in the airbag drops below 140 mmHg or 0.187 bar, then the voltage in the pressure sensor drops below 4.18 V and the alarm is triggered. Likewise, when the pressure in the airbag rises due to a crush or impact and exceeds 250 mmHg or 0.333 bar, the voltage in the pressure sensor rises above 4.88 V and the alarm is triggered. These values are logical because the working voltage of the pressure sensor is from 0 V to 5 V (Table 2).

Table 2. Voltage and pressure when the alarm is activated *(Source: Authors)*

<table>
<tr><th>„Lower threshold“ of alarm activation</th><th>Safe zone</th><th>„Upper hreshold“ of alarm activation</th></tr>
<tr><td>Air sensor voltage</td><td rowspan="12">In this zone, the alarm activation is disabled because the parameters on the potentiometers for the "lower" and "upper threshold" of the alarm activation are set so.</td><td>Air sensor voltage</td></tr>
<tr><td>Alarm start</td><td>Alarm start</td></tr>
<tr><td>(V)</td><td>(V)</td></tr>
<tr><td>4,18</td><td>4,88</td></tr>
<tr><td>Airbag pressure</td><td>Airbag pressure</td></tr>
<tr><td>(bar)</td><td>(bar)</td></tr>
<tr><td>0,187</td><td>0,333</td></tr>
<tr><td>A millimeter of mercury</td><td>A millimeter of mercury</td></tr>
<tr><td>(mmHg)</td><td>(mmHg)</td></tr>
<tr><td>140</td><td>250</td></tr>
</table>

The safe zone, i.e. the range in which no alarm is triggered is between 140 mmHg and 250 mmHg, allowing workers to perform their jobs without triggering alarms unnecessarily. If a pressure of more than 15 kilograms is applied to the cushion due to crushing, in the airbag the pressure in the pressure sensor rises above 250 mmHg or 0.333 bar, the voltage rises above 4.88 V and the alarm is triggered.

4. CONCLUSION

The application of the airbag is suitable for use in different fields and for different purposes. In this work, it has been shown that it can be used as an alarm device for workplace injuries, especially in areas with a high frequency of injuries, such as forestry. It can be used especially in the exploitation of the forests, where the most common injuries occur during logging and wood products manufacturing, where bruises and impacts occur during tree felling.

The alarm is triggered not only in the event of a load of 15 kilograms or more but also in the event of a loss of airbag pressure, which means that there has been a strong impact in the area of the body where the cushion is located.

It should be noted that the use of such a device is also possible in economic sectors, where workers are often buried by earth collapses during the excavation of trenches, deep canals, etc. Due to the noise at the workplace and the medical condition of the injured worker, communication, i.e. calling for help, would be possible through this device, which would reduce the possibility of death after more serious injuries.

REFERENCES

Petros A. Tsioras, Christian Rottensteiner, Karl Stampfer, (2014). Wood harvesting accidents in the Austrian State Forest Enterprise 2000–2009, Safety Science, Volume 62, ISSN 0925-7535, https://doi.org/10.1016/j.ssci.2013.09.016.

PotoCnik, I., Pentek, T. i Poje, A. (2009). Severity Analysis of Accidents in Forest Operations. Croatian Journal of Forest Engineering, 30 (2), https://hrcak.srce.hr/47892

Ibrahim, M., Shawish, S., Aldroubi, S., Dawoud, A., Abdin, W. (2023). Airbag Protection and Alerting System for Elderly People. Appl. Sci. 13, 9354. https://doi.org/10.3390/app13169354

Manigandan, S., Norman, S.R. (2015). Fall detection system for elderly person monitoring using GSM network. Int. J. Adv. Eng. 1.

Toshiy, T., Senio, M., Takumi, Y., Masaki, S., Mitsuo, U., Osamu, T. (2009). A Wearable Airbag to Prevent Fall Injuries. Eee Transactions On Information Technology In Biomedicine, Vol. 13, No. 6.