Engineering Management Research; Vol. 1, No. 2; 2012
ISSN 1927-7318 E-ISSN 1927-7326
Published by Canadian Center of Science and Education

Designing and Constructing a Smart Armor for Protecting Motorcyclists' Head and Neck in the Accident Time

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Received: April 6, 2012 Accepted: May 9, 2012 Online Published: July 11, 2012

doi:10.5539/emr.v1n2p66 URL: http://dx.doi.org/10.5539/emr.v1n2p66

Abstract

Background: In general, riding motorized two-wheeled vehicles carries a higher risk of being involved in a fatal accident than any other mode of transport. In some countries, the use of protective helmets while riding motorcycles is a legal requirement. That is, a helmet can be a lifesaver in an accident and can protect against severe head, brain and facial injuries, particularly integral helmets with full facial protection. The present paper introduces a newly invention of smart armor to protect motorcyclist's head and neck in an accident time and to minimize injuries.

Materials & Designs: The smart armor for protecting motorcyclist's head and neck was designed innovatively. The system was constructed from boxes settled on the motorcycle, including a power source, an incident detection sensor, a transmitter circuit and a transmitter circuit antenna. In addition, the helmet parts including a mechanical operator's box, mechanical force interface cables, helmet frame, balance surface, fixed neck guard and moving neck guard were constructed. The constructed system was formally registered by the Iranian Patent Organization in 2010.

Findings & Tests: The smart armor showed useful capabilities and was successfully tested by several motor cyclists in simulated accidents. The different mode of collision with obstacle ahead, back hit, and change angle more than 45 degrees from vertical mode of motorcycles were successfully tested.

Conclusions: The designed smart armor presented in this article, showed a suitable performance to protect motorcyclist's head and neck simultaneously. Therefore, it can be used as a suitable protective device for motorcycle riders.

Keywords: motorcyclist, accident, helmet, smart armor

1. Introduction

In general, riding motorized two-wheeled vehicles carries a higher risk of being involved in a fatal accident than any other mode of transport. In some countries, the use of protective helmets while riding motorcycles is a legal requirement. That is, a helmet can be a lifesaver in an accident time and can protect against severe head, brain and facial injuries, particularly integral helmets with full facial protection.

Road injuries cause many sudden deaths and disabilities, which in developing countries are increasing rapidly. Nearly 44% of death cases are due to road traffic injuries mainly by motorcycle riders. Lack of helmet will triple the risk of head injury for motorcyclists and bicyclists, while helmet reduces fatal and serious injuries significantly (Branas & Knudson, 2001).

Observing safety tips while driving especially in motorcycles is one of the necessary features of this vehicle. Using helmet as the easiest and least costly method of protecting is the most affordable way in order to provide safety and human life. Statistics shows that the most injuries and deaths resulted from motorcycle accidents are

due to head and neck injuries. People are always seeking ways to keep their health and safety and that the tendency toward safety tips can play an effective role in promoting personal and public health (Chiu et al. 2000). Using helmets by motorcyclists prevents head and neck injuries significantly. Concerning motorcycle accidents, the waste majority of studies have mentioned the injury preventing effect of helmet (Derrick & Faucher, 2009; Gabella et al.,1995; Gopalarishna et al., 1998; Houston & Richardson, 2007).

Although, several types of helmets for motorcyclists are commercially available on the markets, but they are not necessarily suitable for protecting motorcyclists' head and neck. Even though, such helmets cause odor, face and head perspiration and head pressure (Ichikawa, Chadbunchachai & Marui, 2003).

Accordingly, helmets need to be designed for the both purposes of protecting of head and neck injuries, as well as feasibility, and acceptability by motorcyclists. The designed smart armor introduced in the present paper, has all required features. It is acting based on transmitting and receiving FM waves, while motorcycle is angled over 45 degrees from its vertical mode, or while a strong force was entered to it from either front or back. The designed system works by sending FM waves to receiver that is connected to the motorcyclist. It will be transferred to an electric motor that controls helmet-attached operators. Then the holder lever will be activated and eventually the shield plate will be located on motorcyclists' face.

2. Materials & Designs

The designed smart armor was made of three main parts as follow:

1. The part attached to the motorcycle: It is a metal box, implanted by the accident detection sensor (Figure 1). This part consists of several components including:

1.1 The metal box: This box is used for keeping and embedding other components, which is installed on motorcycle.

1.2 The accident detection sensors: This sensor works based on gravity. It is a metal globe made of brass, which is connected to a bar from one side and to the globe and bowl joint, which can be rotated at different angles on the other side. This globe is connected to a soft flexible wire that is interface of the starter of transmitter circuit. The collection of brass globe and the globe and bowl joint act as a gravitational key. This brass globe is always stays vertically due to its weight and the bowl globe joint at its bottom. It does not change angle along with spiral or rotational motions of motorcycle at the horizon but when motorcycle is angled, over 45 degrees, it moves from vertical mode at touching and collision, and will be connected to the brass globe by a ring that is located next to it. It is also connects to stream patching wire in the starter key of transmitter circuit to be activated and for announcing the danger.

1.3 Power source: This source contains a 9-volt battery, to provide the required long time energy for activating of the transmitter circuit.

1.4 The transmitter circuit: This circuit broadcasts frequency waves of 760 kHz in space. The broadcast radiuses of waves are adjustable and according to experience of designing this system, it has considered equal to 10 meters radius until this smart armor could be activated when motorcyclist thrown and hanging in air.

1.5 The circuit antenna: This antenna reinforces generated waves in the transmitter circuit and provides possibility of more radiuses for waves by reinforcing them in free space.

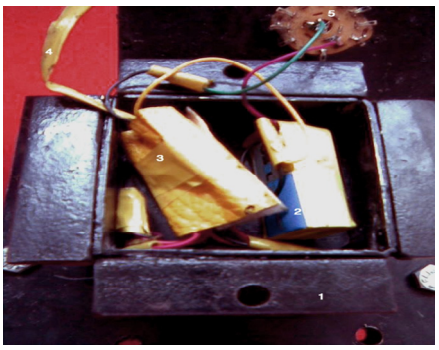

Figure 1. The part attached to the motorcycle

1. Metal box 2. Power source 3. Transmitter circuit 4. Transmitter circuit antenna 5. Switching power key

2. The part attached to the motorcyclist's waist: It contains a receiver system, which is attached to the motorcyclist waist for broadcasting waves by the transmitter circuit connected to the motorcycle. This receiver system consists of the following components (Figure 2).

2.1 Power source: A 12 volts power source includes eight 1.5 volts rechargeable batteries to store electrical power for providing the requested energy for receiver circuit and the electrical engine.

2.2 Receiver circuit: This circuit changes the received waves from the FM transmitter system to analog messages. Until the transmitter circuit does not send waves, it remains inactive. Receiver circuit consists of receiver antenna and circuit board.

2.3 Relay: It establishes an electrical stream to electrical motor enabling helmet guards. It will be activated after receiving an analog message and bobbin activation consequently.

Figure 2. The part attached to the motorcyclist's side

1. Receiver circuit 2. Power source 3. Relay 4. Receiver antenna

3. Helmet: It is the main part of smart armor surrounding the head and neck (Figure 4). It includes the following parts:

3.1 The mechanical operator box: It contains; operator's holder box, electrical motor, lever holder, dragger arm, ball bearings, springs, key switching power and interface cables of force transmission (Figure 3).

3.2 The main frame of helmet: The frame was made of composite and its inner lining was made from foam which covering motorcyclist's head and neck without touching them. When helmet used its weight, it will be segregated on the motorcyclist's shoulders and creates protective case around the head and neck.

3.3 The balance plate: This plate was used to create the helmet balance against aerodynamic forces.

3.4 The shoulder plates: These are used in order to transmit and divide forces and pressures on the motorcyclist shoulders and to help to the balance of helmet.

3.5 The front head shields: These are normally located on behind part of head and are not the obstacle for the motorcyclist sight. As soon as activation of the system, these plates are transferred to front of head very quickly and provide a strong guard for the front of head and temple. The inner part of these plates was made of leather and foam coverage to reduce the effects of incoming forces.

3.6 The fixed neck guard: It includes a compact air bag, which is installed on the top of shoulder plates as a fulcrum neck in accident times. When neck tilted and these guards were stabled, in the condition that smart system does not work under any reason, these guards work by inhibiting sudden and excessive movement of neck, prevent injuries for motorcyclist neck.

3.7 The moving neck guard: This includes a structure which is connected to the force transmission interface wire in the middle own part. This structure is located inside layer and is coated with leather. This guard pulled up

when the system was activated and along with fixed neck guard, it creates a soft, wide and tilting fulcrum preventing the motorcyclist neck injury in accident time.

3.8 The windbreaker glass: A clear plastic plate was used for keeping from inconvenience of wind to motorcyclist's eyes and face.

This invention has formally been registered by the Iranian Patent Organization (No: 38 564) in 2010.

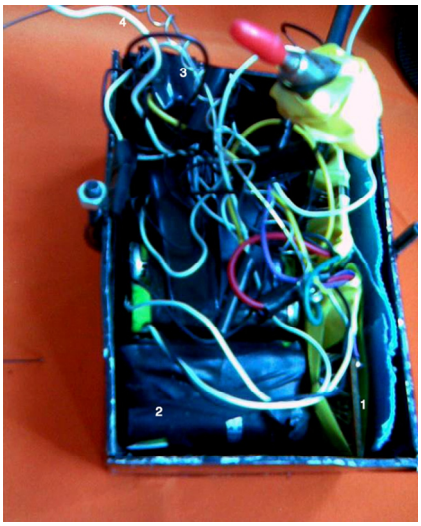

Figure 3. Mechanical operators of the helmet

1. Protective box of operators 2. Ball bearings 3. Electromotor 4. Switching power key 5. Dragger arm 6. Dragger springs 7. Mechanical force interface cables

Figure 4. The designed and constructed helmet

1. The main part of helmet 2. Balance plate 3. Fixed neck guard 4. Moving neck guard 5. A shoulder plates 6. Front head shield 7. Windbreaker glass

3. Tests & Findings

3.1 Device Details

Concerning the smart armor function, each three parts mentioned in the previous section, should appropriately be connected to the motorcycle. On diagnosing dangerous conditions by sensors attached to motorcycle, the messages are sent by the receiver attached to the motorcyclist's waist. Then by starting the engine, the

mechanical operators of helmet and its protective shield will be activated and motorcyclist's head and neck will be protected in accident times. The dangerous conditions sensor which is installed on the motorcycle will be activated. Then, the transmitter circuit broadcasts FM waves with 760 kHz frequency. On receiving these waves by receiver, the relay device, turns on and inputs electrical stream establishing the mechanical operator's box of helmet containing electrical motor, lever holder, puller arm and mechanical power transmission wires. After connecting electricity stream, electrical motor will be started and drag the lever holder, moving route of dragger arm will be released.

3.2 Field Tests

Under supper visions of expert representatives including mechanical and electrical engineers from the Faculty of Health and the Iranian Patent Organization and in order to test the system in terms of achieving the desired targets, 10 motorcyclists in simulated conditions for an accident time, did check the designed smart armor. All potential risks and hazards predicted for motorcyclists in accident times were considered. As soon as tilting the motorcycles to angle over 45 degrees from their vertical mode, or in a severe collision with obstacle in front or with another vehicle from back, the smart armor was activated quickly and appropriately. In all cases, the device worked properly on time and it was confirmed by all examiners and supervisors.

4. Discussion

Traffic accident is a type of injury, which affects the body by external force being applied in a sudden approach. Dealing with motorcycle accidents, it's important to understand the types of forces which a rider is subjected to, the body parts affected by these forces and how the body reacts against it.

Several studies have indicated a high correlation between fatal head injuries and motorcycles accidents, with helmets having been shown to be extremely effective in preventing serious head injury (Keng, 2005; Khorshidian, 2002; Kokotos & Linardatos, 2011; Kraus et al., 1994). The enforcement of laws relating to the mandatory use of motorcycle helmets in many countries across the world, has also confirmed to have significantly reduced both head injuries and fatalities (Lee et al. 2010; Mayrose, 2008; Nunley, 1995). Therefore, there is no doubt that using helmets by motorcyclists prevent head and neck injuries as shown in different risk estimates and accident analyses (Richter et al. 2001; Tzannatos & Kokotos , 2009; Van Camp et al., 1998).

The present designed and constructed device prevents from hit and injury to the head and neck of motorcyclists. The weight of helmet on motorcyclist's head does not press the head and neck and it does not cause perspiration and odor head and face. It works exactly on the time of accident without any delay.

The main weakness of the present work is its unattractive shape and appearance which the inventors hope to make it modernized and more updated according to the latest technology after finding a suitable sponsor interested in road traffic accident prevention. We hope by mass production of such preventive devices and reducing its cost consequently, all motorcyclists across the world could use them easily to reduce the traffic accidents significantly.

Acknowledgment

The unsparing assistance and cooperation from the authorities at the Ilam University of Medical Sciences are gratefully appreciated.

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