© Universiti Tun Hussein Onn Malaysia Publisher's Office

JAPTT

https://publisher.uthm.edu.my/ojs/index.php/japtt

e-ISSN: 2821-286X

Journal of Automotive Powertrain and Transportation Technology

Analysis of Auto Release Seatbelt System for Multipurpose Vehicle

Mohamad Khairi Ahmad[1], Rahmah Mahmudin[1], Norirda Mohamed[1*], Nofrizalidris Darlis[1], Shaiful Fadzil Zainal Abidin[1], Mohamed Ihsan Sabri Mohamed Nazar[1]

[1]Centre of Automotive and Powertrain Technology, Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia, 84600 Pagoh, Johor, MALAYSIA

*Corresponding Author

DOI: https://doi.org/10.30880/japtt.2022.02.02.005
Received 20 July 2022; Accepted 05 October 2022; Available online 31 December 2022

Abstract: An automatic seat belt release system is provided for installation in conjunction with the vehicle's seat belt system. In the event that the vehicle sustains an impact of sufficient magnitude to necessitate the emergency release of the seat belt system, an electrically operated actuator located near the seat belt is actuated to release the seat belt system after 5 seconds time interval. The aim of this study is to design and develop coding language for Auto Release Seatbelt System. The system for Auto Release Seatbelt is installed inside the passenger cabin and the release mechanism fixed at the seatbelt buckle. The system is tested after the installation on a multipurpose vehicle (MPV). The 12V cigarette lighter socket is used to power the system. A crash collision impact sensor, an accelerometer, a gyroscope, a developer board, and a solenoid actuator comprise in the designed emergency release system. The crash collision impact sensor identifies when the vehicle collides, and the gyroscope sensor determines the vehicle's orientation after the impact, if the gyroscope detects no change in orientation, it triggers the development board's preset timer. The solenoid is activated to press the custom release mechanism that will remove the seat belt once the specified time period has passed.

Keywords: Seat belt, automatic, release, solenoid, gyroscope

1. Introduction

In this era, the number of automobiles on the road has multiplied many times in the modern period. As the number of cars on the road grows, so does the incidence of accidents, resulting in severe injury or death to the occupants. Injury and death are primarily caused by the harmful movement that occurs as a result of the accident. [1-5]

To prevent these problems, the 3-point seat belt system was developed to considerably reduce the harmful movements induced by collisions, hence reducing injury and fatality among vehicle occupants. The occupants of the vehicle travel at the same pace as the vehicle when it is in motion. If the vehicle comes to a sudden stop or crashes, the occupants continue to move at the same pace due to inertial force. Only seatbelts are designed to prevent this movement. The seatbelt holds the occupant in the seat in place, preventing them from falling out or injuring themselves by coming into contact with the car's interior [6-10]. The 3-point seat belts are extensively utilized in modern vehicles. The seatbelt usually comprises of a buckle, latch plate, retractors, and webbing. The seatbelt webbing is the flexible component of the seatbelt that wraps around the occupant and binds them to the seat during a collision. It is usually composed of polyester. During a collision, the retractor allows the occupant to move freely while still tightening the webbing [11-13]. The latch plate is a metal device that secures the webbing to the buckle by being fastened to it. Finally, the buckle is the part of the system that secures and releases the latch plate. It is designed to retain the latch plate firmly and to secure and release the latch plate with minimal force [14-18].

*Corresponding author: norirda@uthm.edu.my

2. Materials and Methods

Figure 1 shows the methodology flowchart of this study.

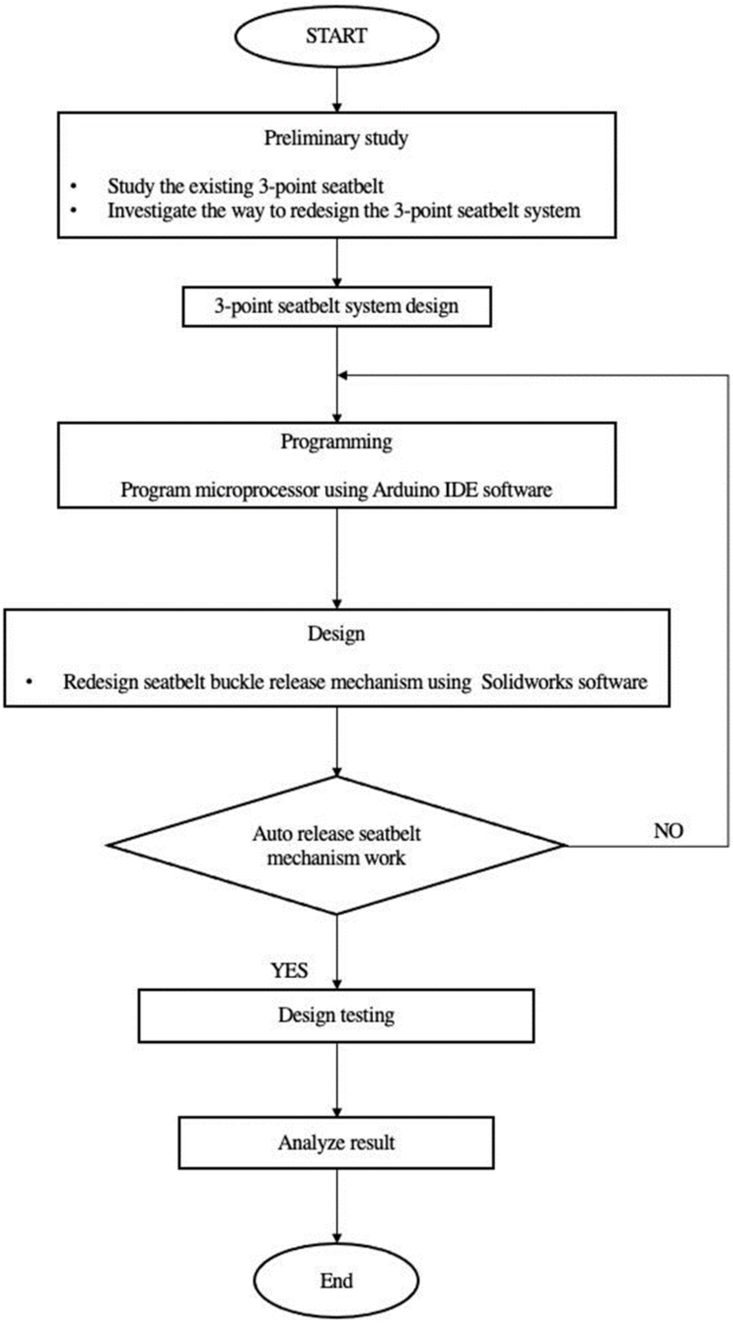

Fig. 1 - Methodology flow chart

2.1 Materials Preparation

Hardware equipment includes any physical equipment used to make up the device. Example of hardware device includes Arduino, crash collision impact sensor, microcomputer, gyroscope sensor, accelerometer sensor and others that were used in this project

- MPU 6050 Accelerometer and Gyroscope sensor
- Solenoid Actuator
- Crash Collision Impact Sensor
- Relay DC 12V

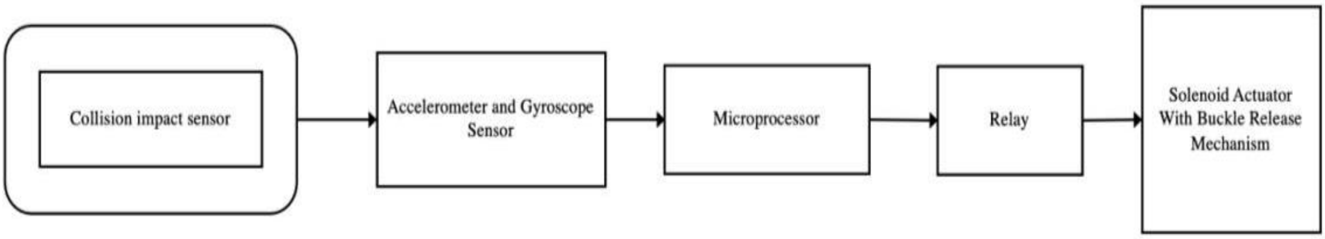

Fig. 2 - Block diagram of proposed system

2.2 Methods

The proposed system comprises a variety of sensors connected to a microprocessor as shown in Figure 3.3. It is composed of a crash collision impact sensor, a gyroscope sensor, and a release mechanism activated by a solenoid. The crash collision impact sensor detects the crash event. It transmits a signal to the CPU after detecting the collision.

The gyroscope continuously checks the vehicle's orientation. After the microprocessor detects a collision through the crash collision sensor, it examines the vehicle's orientation. Only when the vehicle is stopped and at a safe angle does the microprocessor activate the release mechanism. A solenoid actuated will push the release mechanism. When the microprocessor transmits the signal to the release mechanism, the solenoid activates, pushing the release mechanism and thereby unlocking the seatbelt.

2.3 Procedure Flow

The system follows three steps in automatic seatbelt release in the vehicle as shown in Figure 3.

Fig. 3 - Procedure flow

The sensor is the process's beginning point. The collision impact sensor detects the car crash. The microprocessor is in charge of monitoring and controlling the system. The seatbelt is released by the actuating mechanism. At first, the system detects the car collision through the collision impact sensor. When a collision occurs, the inertia of the vehicle decreases abruptly; this abrupt drop in inertia is recorded by the accelerometer, and the microprocessor verifies the car's orientation using the gyroscope. When the gyroscope detects that the vehicle is stopped and in a safe orientation, an on-board timer is activated for 5 seconds. The microprocessor activates the releasing mechanism after the timed delay [12]. The Algorithm is shown in Figure 4.

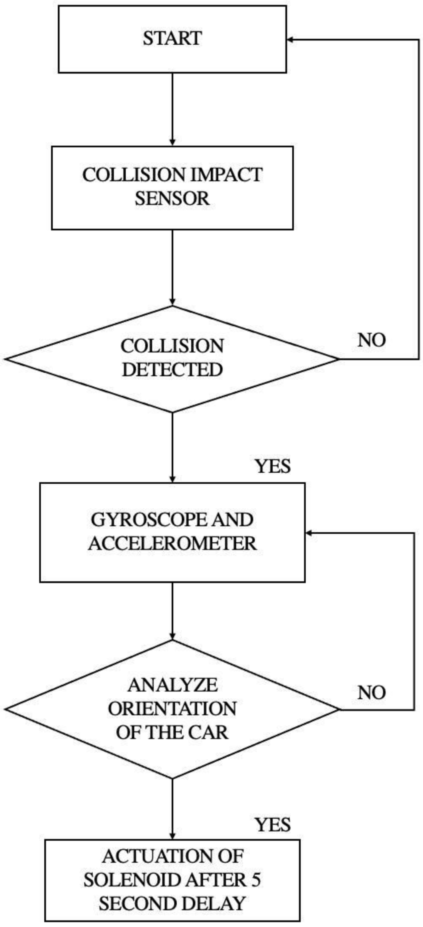

Fig. 4 - Algorithm used in the proposed system

2.4 Circuit Design

The circuit is designed to use minimal space and is powered by one power supply to operate the system.

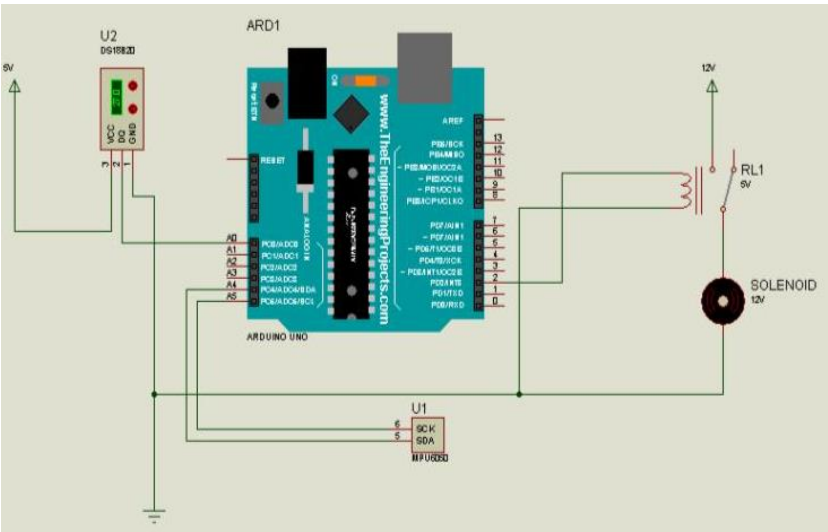

Fig. 5 - Circuit design

2.5 Release Mechanism Design

After the study on 3-point seatbelts is done, the best release feature is to implement a custom release mechanism into the seatbelt buckle. This design bypasses the main release button and will be connected to the solenoid.

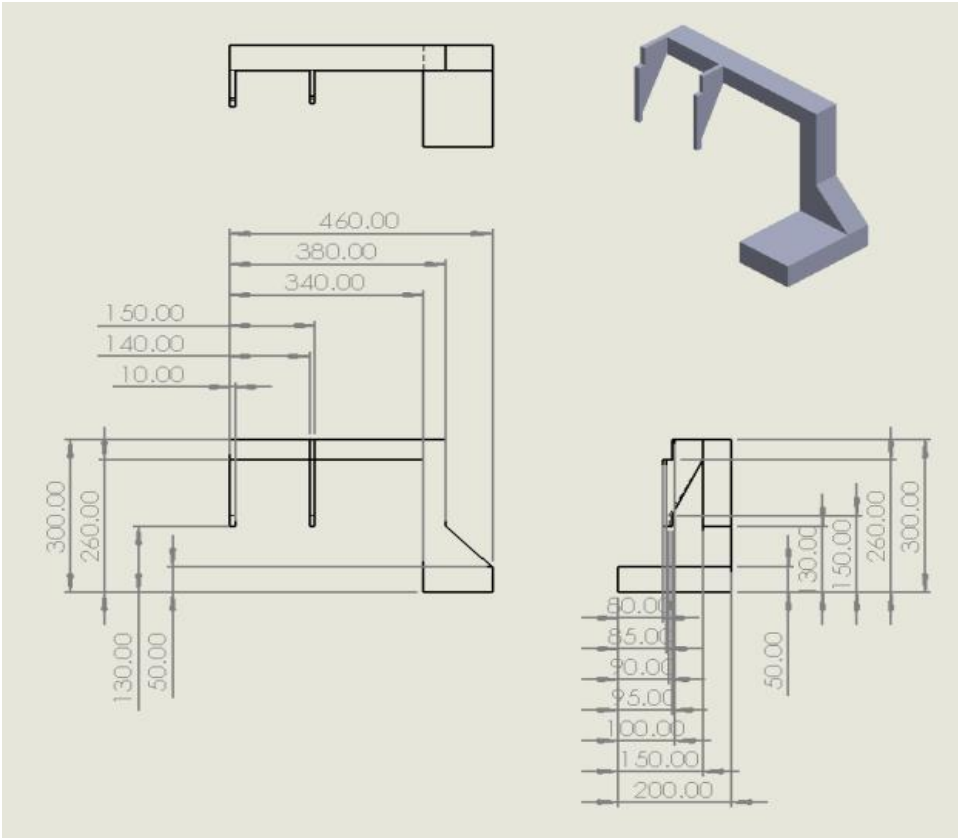

Fig. 6 - Seatbelt release mechanism design using SolidWorks

2.6 Programming

The Arduino IDE software is used to programmed the board. Table 1 shows a program for reading raw values from the MPU6050.

Table 1 - MPU6050 Code program

MPU6050 Code Program

```
#include <Wire.h>
#include <MPU6050.h>

MPU6050 mpu;

int sensor;
int relay = 2;
int toggle = 0;

void setup()
{
 Serial.begin(9600);

 Serial.println("Initialize MPU6050");

 while(!mpu.begin(MPU6050_SCALE_2000DPS, MPU6050_RANGE_2G))
 {
  Serial.println("Could not find a valid MPU6050 sensor, check
  wiring!"); delay(500);
 }


 checkSettings();
 pinMode(A0,INPUT);
 pinMode(relay,OUTPUT);
 digitalWrite(relay,LOW);
}

void checkSettings()
{
 Serial.println();

 Serial.print(" * Sleep Mode:          ");
 Serial.println(mpu.getSleepEnabled() ? "Enabled" : "Disabled");

 Serial.print(" * Clock Source:          ");
 switch(mpu.getClockSource()) {


  case MPU6050_CLOCK_KEEP_RESET: Serial.println("Stops the clock and keeps the timing
generator in reset"); break;
```

```
  case MPU6050_CLOCK_EXTERNAL_19MHZ: Serial.println("PLL with external
19.2MHz reference"); break;
  case MPU6050_CLOCK_EXTERNAL_32KHZ: Serial.println("PLL with external
32.768kHz reference"); break;
   case MPU6050_CLOCK_PLL_ZGYRO:      Serial.println("PLL with Z axis gyroscope reference");
break;
   case MPU6050_CLOCK_PLL_YGYRO:      Serial.println("PLL with Y axis gyroscope reference");
break;
   case MPU6050_CLOCK_PLL_XGYRO:      Serial.println("PLL with X axis gyroscope reference");
break;
  case MPU6050_CLOCK_INTERNAL_8MHZ: Serial.println("Internal 8MHz oscillator"); break;
 }

 Serial.print(" *                          ");
 Accelerometer:
 switch(mpu.getRange()) {

  case MPU6050_RANGE_16G:          Serial.println("+/- 16 g"); break;
  case MPU6050_RANGE_8G:          Serial.println("+/- 8 g"); break;
  case MPU6050_RANGE_4G:          Serial.println("+/- 4 g"); break;
  case MPU6050_RANGE_2G:          Serial.println("+/- 2 g"); break;
 }

 Serial.print(" * Accelerometer offsets: ");
 Serial.print(mpu.getAccelOffsetX());
 Serial.print(" / ");
 Serial.print(mpu.getAccelOffsetY());
 Serial.print(" / ");
 Serial.println(mpu.getAccelOffsetZ());

 Serial.println();
}

void loop()
{
 sensor = digitalRead(A0);
 Vector rawAccel = mpu.readRawAccel();
 Vector normAccel = mpu.readNormalizeAccel();


 Serial.print(" Xnorm = ");
 Serial.print(normAccel.XAxis);
 Serial.print(" Ynorm = ");
 Serial.print(normAccel.YAxis);
 Serial.print(" Znorm = ");
 Serial.println(normAccel.ZAxis);


 Serial.print("Crash Sensor: ");
 Serial.println(sensor);
```

```
 if(sensor == 0 && toggle == 0)
 {
  delay(5000);

  if(normAccel.ZAxis < 0 )
 {
  Serial.println("Car Tipped Over");
  toggle = 1;
  delay(2000);

 }

 if(normAccel.ZAxis > 0 )
 {
  Serial.println("Normal");
  digitalWrite(relay,HIGH);
  toggle = 1;
  delay(2000);
  digitalWrite(relay,LOW);
 }
 }

 delay(100);
}
```

2.7 Fabrication

After the circuit design and release mechanism are done, the hardware will be installed to create the system. The wire must be connected according to the circuit design. All the wire connection is secured by soldering to make sure it will last through the testing procedure.

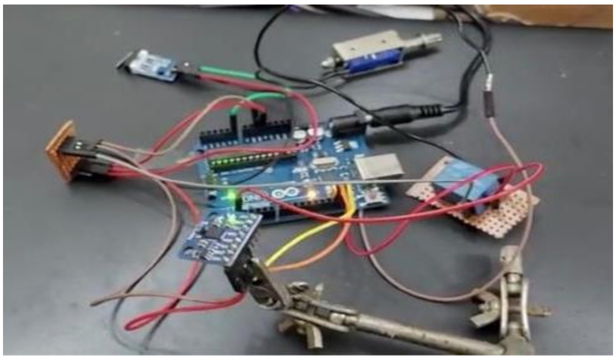

Fig. 7 - Circuit installation process

Due to the complexity and the small size of the release mechanism, the 3D printer is used to create the parts. The parts are made of ABS (Acrylonitrile Butadiene Styrene) material due to their resistance to impact and high temperature between -20 degrees Celsius and 80 degrees Celsius. In terms of 3D printing supports, ABS is easily printed and is low-cost.

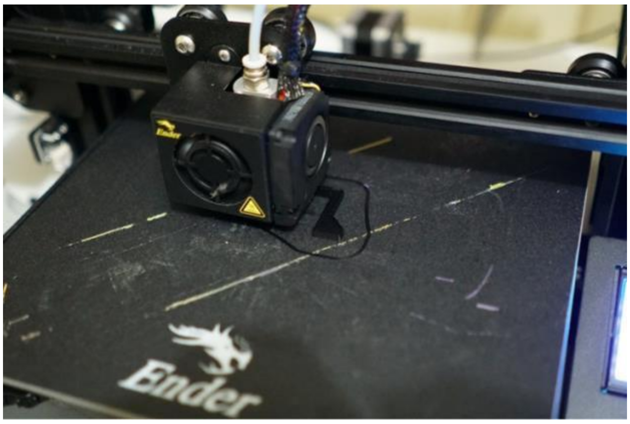

Fig. 8 - 3D printing process

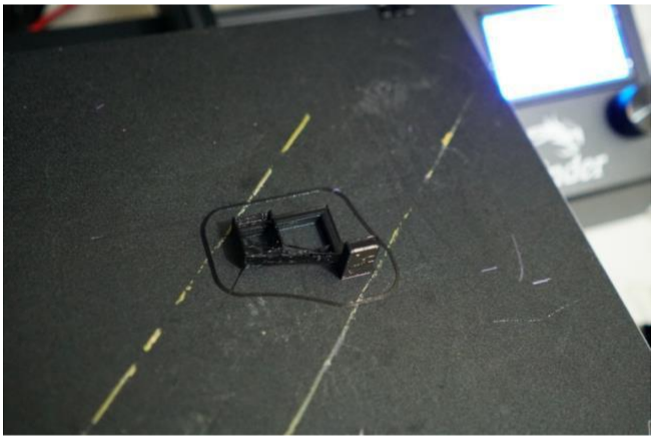

Fig. 9 - End product by 3D printing

3. Results and Discussion

The result for the design is analyzed and discussed is based on the testing result. The size of the buckle with the release feature is well fitted to the conventional car seatbelt. The collision impact sensor is attached to the car front bonnet to simulate the ABS collision sensor position. The microprocessor and the sensors are placed at the center of the car body to detect the car orientation accurately. The cigarette lighter socket is used to power the system.

Fig. 10 - Impact collision sensor is attached to the car front bonnet

Fig. 11 - The seatbelt auto release mechanism is installed to buckle

Fig. 12 - The microprocessor and sensors are installed

3.1 Results

The testing process is conducted in two situations. First, the collision impact sensor is triggered when the car is in normal orientation. Second, the collision impact sensor is activated when the car is tilted. Both procedures are to determine the activation of the solenoid to trigger the release mechanism.

The collision impact sensor is triggered to start the system. After 5 seconds, the solenoid actuated and hold down the release mechanism thus releasing the seatbelt.

3.2 Normal Orientation Test

Fig. 13 - Car in normal orientation testing

Fig. 14 - Solenoid hold down the release mechanism to unlock the seatbelt

3.3 Tilted Orientation Testing

The collision impact sensor is triggered to activate the system. After 5 seconds, the solenoid is not actuated thus the buckle still locking the seatbelt from release.

Fig. 15 - Car in a tilted orientation

3.4 Discussions

In normal orientation test the gyroscope and accelerometer sensors determine when the car is in a safe position for the solenoid to be triggered. The user must still pull the seatbelt since the retractor is insufficiently forceful to return the seatbelt webbing to its original position.

In Tilted orientation testing the gyroscope and accelerometer detect that the car orientation is tilted thus the microprocessor did not trigger the solenoid to actuate the release mechanism. The user must manually unlock the seatbelt buckle to release the seatbelt. After the crash sensor is activated it will send a signal to ECU for examining the car orientation through the gyroscope sensor. If the car is in the normal orientation, it will release the seatbelt after a predetermined time has passed

4. Conclusion

In this work, the Auto Release Seatbelt System is created and a good performance is obtained. The objective of this project is achieved. The programmed system works as desired in a different situation. The seatbelt buckle with auto-release mechanism design can be installed on a conventional seatbelt buckle. This system can be operated through a crash sensor and ECU when it is implemented in the new production car. The seatbelt buckle is unlocked after the crash sensor is activated and a signal is sent to the ECU to examine the car orientation through the gyroscope sensor. If the car is in normal orientation the seatbelt is released after predetermine time is passed. The system will shorten the time for the crash victim trapped to escape the vehicle or be rescued thus it can save the life of the crash victim. The Auto Release Seatbelt System will increase the survival rate of the vehicle occupant after the crash.

Acknowledgement

This research was supported by Universiti Tun Hussein Onn Malaysia (UTHM) through Tier 1 (vot H804).

References

[1] Abbott, H. C. (1942). Common Fire Hazards. Fire Protection Engineering: A Symposium of Papers Presented at a Summer Conference at the Massachusetts Institute of Technology, 56– 72

[2] Wan Suaidi, S. N. S.., bin Azizul, M. A.., & bin Sulaiman, S. (2021). The Effect of Fused Deposition Modelling Process Parameters on The Quality of Abs Product. Journal of Automotive Powertrain and Transportation Technology, 1(1), 45–58.

[3] Baharol Maji, D. S., & Mustaffa, N. (2022). CFD Analysis of Rear-Spoilers Effectiveness on Sedan Vehicle in Compliance with Malaysia National Speed Limit. Journal of Automotive Powertrain and Transportation Technology, 2(1), 26–36.

[4] Azmi, M. A. I.., & Mustaffa, N. (2022). Experimental Evaluation of Brake Response Time on Motorcycle Brake Lamp. Journal of Automotive Powertrain and Transportation Technology, 2(1), 37–46.

[5] Arndt, S. M., Mowry, G. A., & Arndt, M. W. (1993). Characterization of Automotive Seat Belt Buckle Inertial Release

[6] Francis, B. V.., bin Azizul, M. A.., & bin Sulaiman, S. (2021). Study on Characteristic of Motorcycle Suspension. Journal of Automotive Powertrain and Transportation Technology, 1(1), 34–44.

[7] Castle, A. B. (1971). A study of seat belt buckle release methods. https://doi.org/10.6028/NBS.RPT.10387

[8] D'Ausilio, A. (2012). Arduino: A low-cost multipurpose lab equipment. Behavior Research Methods, 44(2), 305–313. https://doi.org/10.3758/s13428-011-0163-z

[9] Egelhaaf, M., & Wolpert, D. (2011). Post Collision Vehicle Fire Analysis. 22nd International Technical Conference on the Enhanced Safety of Vehicles (ESV), No. 11-0315, 1–14

[10] Kendall, J., & Solomon, K. A. (n.d.). Air Bag Deployment Criteria

[11] Righi, N., & Eurafrica Videomatic Srl Societa, I. (n.d.). Date of Patent: 54 Automatic

[12] Release Device for Seat Belts On Motor-Vehicles or The Like 75) Inventor: 73 Assignee (Issue 1)

[13] Smith, J. E., & Hall, M. J. (2005). Injuries caused by seatbelts. Trauma, 7(4), 211–15. https://doi.org/10.1191/1460408605ta348oa

[14] Stats, C., Hs, D. O. T., Laws, M., Law, D., Carolina, N., & Carolina, S. (2010). Traffic Safety Facts: Lives Saved in 2009 by Restraint Use and Minimum-Drinking-Age Laws (DOT HS 811383 (Issue September)

[15] US20170274868A1. patent. (2017)

[16] Vivekanandan, D., & Rufus, K. (2018). Automatic Seatbelt Release System. http://iaetsdjaras.org/

[17] Williams, A. F., Wells, J. K., & Lund, A. K. (1988). Driver use of, and reaction to, automatic seat belts in ford and gm cars. Journal of Public Health Policy, 9(2), 222–232. https://doi.org/10.2307/3343006

[18] Zlatanov, N. (2016). Arduino and Open Source Computer Hardware and Software. Journal of Water, Sanitation and Hygiene for Development, 10(11), 1–8