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**PROCEEDINGS OF  
MALAYSIAN TECHNICAL  
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CONFERENCE ON  
ENGINEERING AND TECHNOLOGY**

# The Modeling of Adaptive Neck Support System for Economy Class Aircraft Seat

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## Abstract

With the rapid development of technology, the comfort of service has become an important issue. Air travels, especially long distance, may cause both physiological and psychological discomfort to passenger. Passenger comfort is a main factor in user's acceptance of transportation systems. In order to improve the neck comfort during long haul air travel, an adaptive neck support system was developed and embedded in the economy class aircraft seat. In this paper, we describe the development of adaptive neck support system.

Keywords: Air travel, aircraft seat, adaptive system, neck support.

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## 1. INTRODUCTION

Air travel is becoming increasingly more accessible to people both through the availability of cheap flights and because the airlines are now able to cater for individuals of all ages and disabilities. Health problems may arise due to anxiety and unfamiliarity with airport departure procedures prior to flying, whilst during the flight, problems may arise as a result of the food served on board, differences in the environmental conditions inside the cabin (pressure, ventilation, humidity, noise and vibration), the risk of cross-infection from fellow passengers, seat position, posture adopted and duration of the flight. These can be further compounded by changes in time zones and meal times, which may continue to affect an individual's health long after arrival at the final destination [1]. Travel by air, especially long distance, is not a natural activity for human. Many people experience some degree of physiological and psychological discomfort and even stress during flying. Excessive stress may cause passenger to become aggressive, over-reaction, and even endanger the passenger's health [2,3]. A number of health problems can affect aircraft passengers.

Comfort is an attribute that today's passenger demand. The aircraft passenger comfort depends on different features and the environment during air travel. Seat comfort is a subjective issue because it is the customer who makes the final determination. Customer evaluations are based on their opinions having experienced the seat [4]. The aircraft passenger

seat has an important role to play in fulfilling the passenger comfort expectations.

The seat is one of the important features of the vehicle and in which passenger spends most of their time during air travel. The current economy class aircraft seat is a passive system where the passenger needs to do the adjustment manually. In the survey on seating comfort and discomfort [5], we also found that neck support is one of the top ranking comfort descriptors for economy class aircraft seat. The observation in the economy class aircraft cabin also indicates that most observed passengers preferred sitting posture with head facing forward. The head facing forward is the most comfortable head position [6]. In this paper, we describe the modeling of the developed adaptive neck support system for economy class aircraft seat.

## 2. EXISTING NECK SUPPORT

From the product search using web services, several neck supports related products were found. There are different types of neck supports that are used during air travel such as inflatable neck pillow [7], polyester filled pillow [7], memory foam pillow [7], feather filled pillow [8] and the aircraft seat with mechanical neck support [9-10].

Long-distance coach services, e.g. express buses, are transporting passengers from city to city and serve as main commuter for towns without any railway service [11]. The coach passenger seat is one of the important features to ensure the comfort of the passenger for long distance travel. For example, an



express coach that travels from Singapore to Thailand as shown in Figure 1 was equipped with neck, side and leg support for their passenger's comfort during long distance bus travel.



Fig. 1 The luxury coach seat (Photograph reprinted from [12])

### 3. THE ARCHITECTURE OF ADAPTIVE NECK SUPPORT SYSTEM

The architecture of a smart neck support system is shown in Figure 2. Both sides of the upper part of the aircraft passenger seat are embedded with air pressure sensors. The sensors are used to detect the passenger's head posture. The input parameter to the smart control module is the analog value from the air pressure sensor and the potentiometer. The output parameter is the analog value from the smart control module used to control the proportional solenoid valve. The proportional solenoid valve is used to control the air flow to and from the airbag. The smart control module is the core component of the system where it is used to mediate between sensors and actuators. The air pressure detection model is the main component in the smart control module. The database is used to record the airbag pressure as well as to provide input to the smart control module. The output from the system is the actuators.

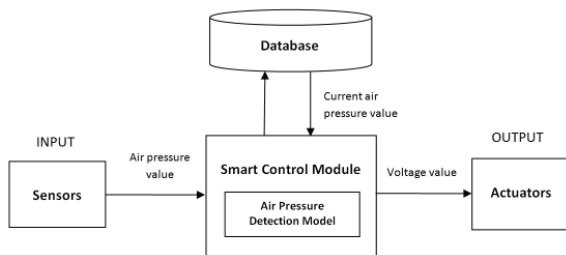


Fig. 2 The architecture of adaptive neck support system

### 4. THE AIR PRESSURE DETECTION MODEL

An air pressure detection model was developed. The objective of the developed air pressure detection model

is to detect the passenger's head position by using an airbag system. The developed model takes into account the passenger's head posture while computing the air pressure differences in the airbag. The air pressure detection model is used for the right airbag and the left airbag. The proposed model records the air pressure change in the airbags. The model can be easily modified to take into account any variation in the air pressure during implementation. For example, if the passenger's head is away from the supported airbag, the current air pressure in the airbag will change.

Let,

- $P_{current}$  = current air pressure in the airbag
- $P_{recorded}$  = recorded air pressure when passenger is in touch with the airbag
- $n_1$  = value for upper threshold
- $n_2$  = value for lower threshold

$P_{airbag}$  is the difference between the recorded air pressure and the current air pressure.  $P_{airbag}$  is defined as

$$P_{airbag} = P_{recorded} - P_{current} \quad (1)$$

$P_{airbag}$  is used for data logging purpose.

Mathematically,

When passenger is in touch with the airbag,

$$P_{current} < P_{recorded} + n_1 \ \&\& \ P_{current} > P_{recorded} - n_2$$

: comparing the airbag pressure

If the current air pressure in the airbag is within the defined upper threshold and the lower threshold, the adaptive neck support system is activated.

When passenger is away from the airbag that supports the neck,

$$P_{current} < P_{recorded}$$

: comparing the airbag pressure

The current air pressure in the airbag will decrease to a value that is less than the recorded air pressure when the head is not in touch with airbag. Hence the system can infer that passenger's head has left the airbag and deactivate the adaptive neck support system. The algorithm of air pressure detection model for the right airbag and the left airbag is shown in Figure 3.

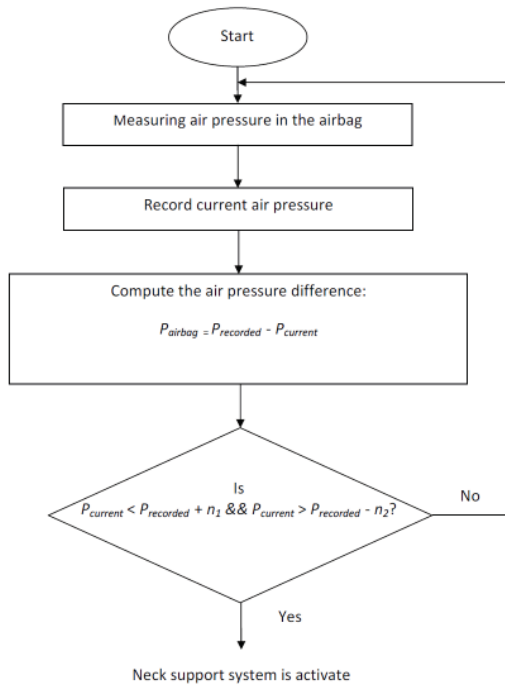


Fig. 3 The algorithm of air pressure detection model

### 5. MECHANICAL MODELING OF ADAPTIVE NECK SUPPORT AIRBAG

The airbag in this study is a prototype that is used to support the neck. The neck support includes interconnected airbags to allow for the airflow between the bags. The interconnections also allow for the neck support to support and rotate the passenger’s head near to the seat centre when the passenger is in a contact position for some time. The mechanical model of the airbag can be used to design an airbag that is reliable and able to withstand the passenger head pressure.

The behavior of the airbag can be modeled in a simplified schematic as shown in Figure 4. The force that is caused by the weight of the supported head is equal to the increased pressure in the airbag.

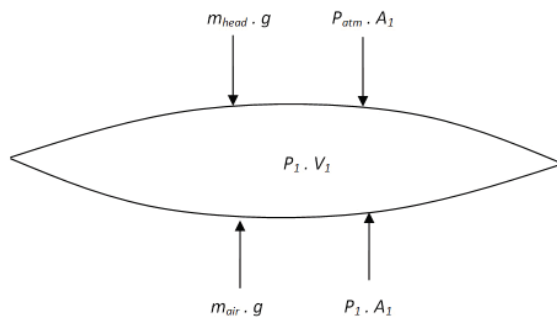


Fig. 4 The schematic of the forces on airbag

As showed in Figure 4, the total force that acts on the airbag is derived as:

$$F_{airbag} = \Sigma F = (m_{air} \times g) + (P_1 \times A_1) - (m_{head} \times g) - (P_{atm} \times A_1) \quad (2)$$

Where

- $F_{airbag}$  = force on airbag (N)
- $m_{air}$  = mass of air in airbag (kg)
- $g$  = gravitational force (Nm<sup>2</sup>Kg<sup>-2</sup>)
- $P_1$  = pressure of air in airbag (Nm<sup>-2</sup>)
- $A_1$  = area in airbag (m<sup>2</sup>)
- $m_{head}$  = mass of passenger’s head (kg)
- $P_{atm}$  = atmospheric air pressure (Nm<sup>-2</sup>)

The airbag prototype is rectangular in shape; the volume of the airbag is described as

$$V_{supported} = (l \times w) (h - x) \quad (3)$$

Where,

- $V_{supported}$  = Volume of airbag when supporting head (m<sup>3</sup>)
- $l$  = Length of airbag (m)
- $w$  = Width of airbag (m)
- $h$  = Height of airbag (m)
- $x$  = Height difference of airbag (m)

### 6. CONCLUSION

In this paper, we have presented the modeling of the adaptive neck support system to improve the neck comfort during long haul air travel. The architecture of adaptive neck support system described the system structure which consists of sensor, actuator, database and central processor. The air pressure detection model was related to the airbag system. The air pressure detection model is used for the implementation of adaptive neck support system, the airbag is capable to detect the passenger’s head posture and support the passenger’s neck adaptively. Next, mechanical model was developed to predict the behavior of the airbag system.

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