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Importance of Active Head Restraint to protect from Whiplash Injury

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ABSTRACT

This paper reports how active head restraint protects from whiplash injury. Rear – end collisions even at relatively low impact speeds can result in neck injuries which lead to whiplash injuries. In case of rear impact active head restraint will adjust itself to correct position. After various surveys about road car crashes it had found that whiplash injury is serious problem & occurs frequently. So for the purpose of additional safety most of the car manufacturers are looking for Anti-whiplash solutions.

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I. INTRODUCTION

Head restraint in a car is most important safety feature rather than comfort. By definition Head restraint means a device whose purpose is to limit the rearward displacement of an adult occupant's head in relation to his torso in order to reduce the danger of injury to the cervical vertebrae (Whiplash) in the event of an accident.

Whiplash preventive measures have so far been focused on developments of the seat. Since the 70s head restraints have been implemented more and more frequently. To date all seating positions in most car models are fitted with head restraints. The whiplash injury reducing effects of head restraints have been shown to be relatively low, between 5% and 15%. In order to increase the vehicle crashworthiness in high-speed rear end crashes, vehicle seats have become stiffer since the late 80s. Stiffer seats have probably increased the whiplash injury risks in low-speed rear-end crashes. Based on this knowledge more advanced whiplash protection devices have been introduced in the market. The better protection is achieved through improved geometry and dynamic properties of the head restraint or by active devices that move in a crash as the body loads the seat. The main ways to lower the whiplash injury risk are to minimize the relative motion between head and torso, to control energy transfer between the seat and the body and to absorb energy in the seat back.

Whiplash was first introduced in Volvo cars in 1999. The seat back is in a crash moved rearwards and yields in a controlled way to absorb energy. In recent years some consumer rating programs have been developed and introduced.

II. LITERATURE REVIEW

[1] Michael Yuen, Mr., Lynne E. Bilston, Dr. have explained whiplash injury. Rearward impact at lower speed also causes whiplash injury. Whiplash injury is very serious it can damage neck permanently also can result in death.
Traffic accidents statistics in Japan show that 50% of injuries are occurs because of rear – end impacts & among these 90% are to the neck region as shown below.

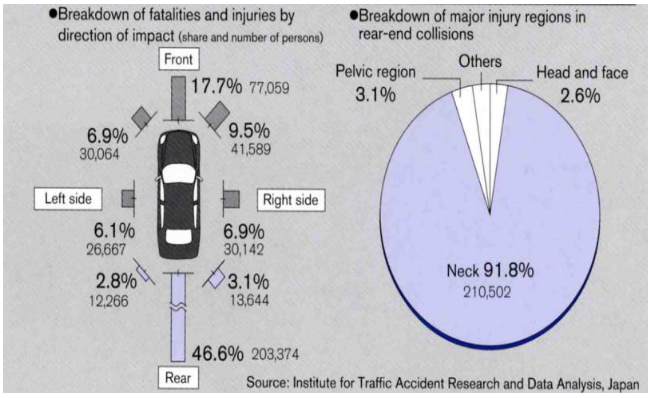

Fig.1 Annual fatal and injury – causing accidents involving vehicle occupants in japan

Head and neck motion during extension in a rear impact can be categorized into four main phases: initial position, s-shape, extension and hyper-extension (See Figure 2). During a rear impact the torso is accelerated forward by the seat back while the head lags behind due to inertia. The head begins to translate with the lower neck in extension and the upper neck in flexion. This phase is commonly described as the s-shape. Once the translation is complete, the head begins to rotate back in extension. The head will continue to rotate and reach a hyper-extension phase if no head restraint contact occurs.

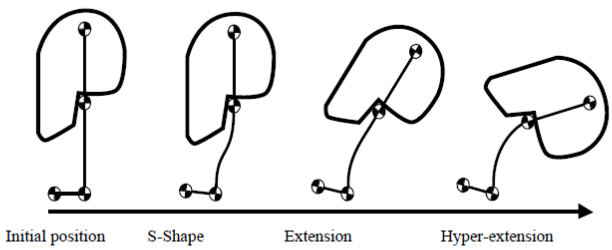

Fig.2 Head and neck motion in a rear impact

Effets of Whiplash Injury

- Although Whiplash is common in frontal and side impact accidents, it most frequently occurs in low speed, rear end collisions. Whiplash injuries are difficult to diagnose, difficult to treat and are estimated to cost the European society up to 10 billion Euro annually
- In some cases, effects of the injury may last for years or even be permanent
- The relatively short-term symptoms are associated with muscle and ligament trauma, while the long-term ones are associated with nerve damage.

[2] As per IIHS regulations gives guidance for head rest geometry& test requirements. Which are explained as below:

Measurement and Rating – The Initial Evaluation

2.1 Static Head Restraint Geometry

The first step in evaluating the rear crash protection afforded by vehicle seats and head restraints is to measure the static head restraint geometry relative to an average-size adult male. Detailed instructions for conducting the static geometry evaluation are described in A Procedure for Evaluating Motor Vehicle Head Restraints (RCAR, 2007),but note again that the geometric evaluation for this protocol makes no allowance for active head restraints, basing it solely on the static measurements as with all other head restraints. The following passage summarizes the principal concepts of the static geometry assessment.

Static geometric evaluations are based on measurements of height and backset that are made with a manikin representing an average-size adult male. To be rated at least marginal, the top of a restraint should be no lower than the center of gravity of the head (no more than 10 cm below the top of the head) and no farther than 11 cm behind the head. Otherwise, the head restraint geometric evaluation is poor. Higher head restraints provide protection for even taller occupants, and closer head restraints can reduce the time the head is unsupported in a rear crash. An acceptable geometric rating implies a head restraint no farther than 8 cm below the top of the head and no farther than 9 cm behind it. Good geometry implies a head restraint no farther than 6 cm below the top of the head and no farther than 7 cm behind it (see Figure 4).

Seats with fixed geometry are rated using the measured height and backset when the seat is adjusted according to the RCAR procedure. Seats with adjustable head restraints that cannot be locked into the adjusted position are rated based on measurements from the unadjusted (lowest and rearmost) position of the head restraint. Seats with locking head restraint adjustments are rated using the midpoint between the lowest/rearmost adjustment and the highest/foremost adjustment.

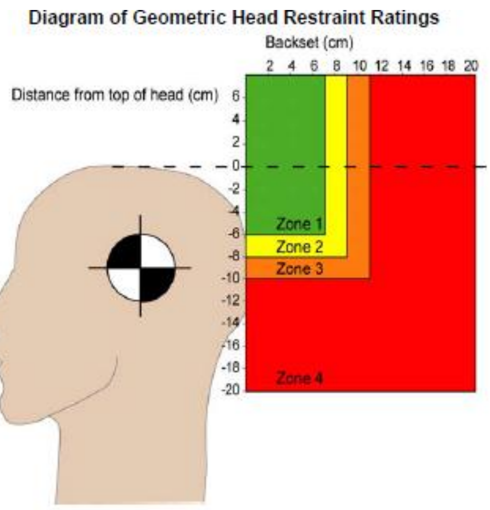

Fig.3 Geometric Head Restraint Ratings

For head restraints with marginal or poor geometry, the overall rating is poor. Head restraints with good or acceptable geometry undergo dynamic testing, as described above. Normally, the static evaluation of seat/head restraint geometry should be conducted with the seat and head restraint installed in the vehicle for which they are designed. When this is not possible (e.g., a new or prototype seat design), the static evaluation can be conducted with the seat and head restraint mounted on a crash simulator (sled) or other test fixture. The seat should be attached to the sled or test fixture so that its orientation relative to horizontal is the same as in the vehicle for which it is intended. Also, a representation of the vehicle floor immediately in front of the seat should be attached to the sled or test fixture at the same relative height so that the H-point machine's feet can be positioned as described in the RCAR procedure. All seat adjustments should be set as described in the RCAR procedure before installing the H-point machine and head restraint measuring device (HRMD). A static evaluation conducted in this way can be used to qualify/disqualify a seat/head restraint design for dynamic testing until the static measurement can be conducted in the vehicle.

2.2 Dynamic Test Requirements

The dynamic test consists of a rear crash simulation in which a BioRID IIg dummy is positioned in the seat to be tested. The seat is attached to a crash simulation sled and accelerated/decelerated to represent a rear crash with a velocity change (delta V) of 16 km/h. The acceleration profile is roughly triangular, with a peak of 10 g and a total duration of 91 ms.

2.2.1 Dynamic Test Procedure

- **Acceleration or Deceleration Sled**

The dynamic test is intended to simulate a typical rear crash in which the rear-struck vehicle is initially stationary or moving forward very slowly. Consequently, an acceleration sled is recommended for these tests. A deceleration sled, on which the dummy is initially moving rearward at 16 km/h and then stopped, may be used if careful attention is paid to dummy positioning (see step 5.9.5 BioRID positioning requirements). In either case, some sled motion is allowed at the initiation of the test (T = 0). To accommodate different sled types and different relationships between sled motion and the recording of test data, test time will be indexed from the peak sled acceleration as described in section 7 Data Acquisition and Processing.

- **Laboratory Environment**

The temperature in the test laboratory should be 22.5 ± 3 degrees Celsius (67-78 degrees Fahrenheit) with a relative humidity of 10-70 percent. The BioRID test dummy and seat being tested shall be maintained at this temperature at least 3 hours prior to the test.

- **Set Seat Adjustments**

The various seat adjustments possible on many modern vehicle seats should be set according to the following instructions. Because the settings of some adjustments may affect the ranges of other adjustments, the seat should be set according to the order of the procedural steps outlined here. The seatback angle will be set in section 5.9; the initial setting is not important as long as it does not interfere with other adjustments. Seats with automatically adjusting head restraints (i.e., those for which head restraint height adjusts automatically when other seat adjustments are made) should be set according to the instructions in section 5.8.

- **Initial seat adjustments**

All seat adjustments should be set initially as follows
Seat track should be in its most rearward position.
Seat height should be set to its lowest position.
Seat tilt should be set to the extreme of its range that puts the cushion angle closest to zero (horizontal). Section 5.6.2 describes the method for measuring the cushion angle.
Cushion height should be set to its lowest position.
Cushion tilt should be set to the extreme of its range that puts the cushion angle closest to zero (horizontal). Section 5.6.2 describes the method for measuring the cushion angle.
Lumbar support should be set to its most rearward or least prominent position.
Upper seatback, if separately adjustable from the lower portion, should be rotated fully rearward.
Cushion extension should be set to its most rearward or least extended position.
Side bolsters should be set to the widest position.

2.3 Evaluation Procedure

- **2.3.1 Seat Design Parameters**

There are two seat design parameters: time to head restraint contact and maximum T1 acceleration.

Time to head restraint contact:

Time to head restraint contact must be less than 70 ms to pass this requirement. This limit reflects head restraint contact times achieved by seats with active head restraint designs and acceptable or better static geometry. Time to head restraint contact is the time after the beginning of the sled test (T = 0) that the dummy's head contacts the head restraint and maintains that contact for at least 40 ms. Contact is indicated by an electrical contact switch attached to either the dummy's head or the head restraint.

Note: Minor breaks in time to head restraint contact (up to 1 ms) are permissible if it can be proven that these are due to poor electrical contacts, however these must be investigated with reference to the film to ascertain whether the breaks in contact are not due to biomechanical phenomena such as ATD ramping, head restraint or seatback collapse, or "bounce" of the head during non-structural contact with the head restraint.

Dynamic Rating Requirements

Seat Design Criteria	Neck Force Classification	Dynamic Rating
T1 X-acceleration ≤9.5 g OR Time to head restraint contact ≤70 ms	Low	Good
	Moderate	Acceptable
	High	Marginal
T1 X-acceleration >9.5 g AND Time to head restraint contact >70 ms	Low	Acceptable
	Moderate	Marginal
	High	Poor

TABLE 1: DYNAMIC RATING REQUIREMENTS

Formulation of Overall Rating

Geometric Rating	Dynamic Rating	Overall Rating
Good	Good	Good
	Acceptable	Acceptable
	Marginal	Marginal
	Poor	Poor
Good Height	→	Good
Acceptable	Good	Acceptable
	Acceptable	Acceptable
	Marginal	Marginal
	Poor	Poor
Marginal	No dynamic test	Poor
Poor	No dynamic test	Poor

TABLE 2: DYNAMIC RATING REQUIREMENTS

[3] ECE – Regulation No. 17/ Add.16/Rev.4, UNECE is legal authority of United Nations which describes basic terminology of automotive seats, physical requirements, test procedure & approval.

3.1 Headrest Height Requirement

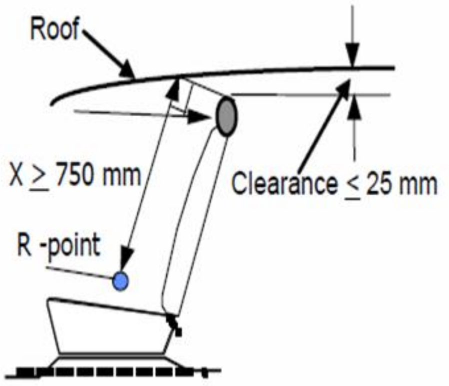

Figure 4: Headrest Height Requirement

For Fixed head restraints:

Front seat H/R height >800mm

For Adjustable head restraints:

A) Front H/R height (full-own) >750mm;

B) Front H/R height (full-up) >800mm

3.2 Tests for Head rest:

3.2.1 Headrest Performance and Seat back strength Test:

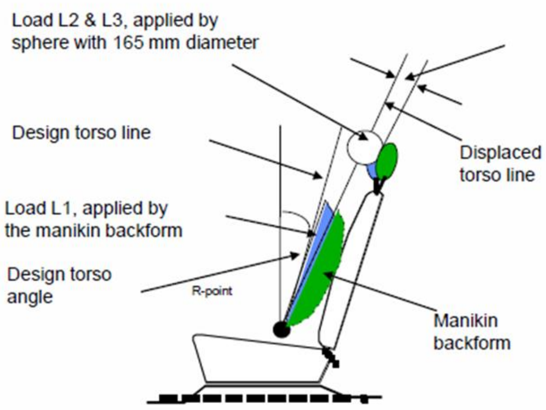

Figure 5: Headrest performance test set up

Test Steps:

Step-1: Head restraint to be in worst-case position

Step-2: Apply load to seat back that produces a 373 Nm rearward moment about H-Point.

Step-3: Using Ø165mm head form apply a 2nd load of 373 N at 65 mm below the top of H/R and seating center plane

Step-4: increase load at H/R to 890 N apply torque to seat back reproducing a moment of 530 Nm over H-point

Passing Criteria:

Head form displacement < 102mm. Displacement measured from and normal to displaced torso line.

3.2.2 Energy Dissipation Test

Application: all front and rear seats fitted with head restraints

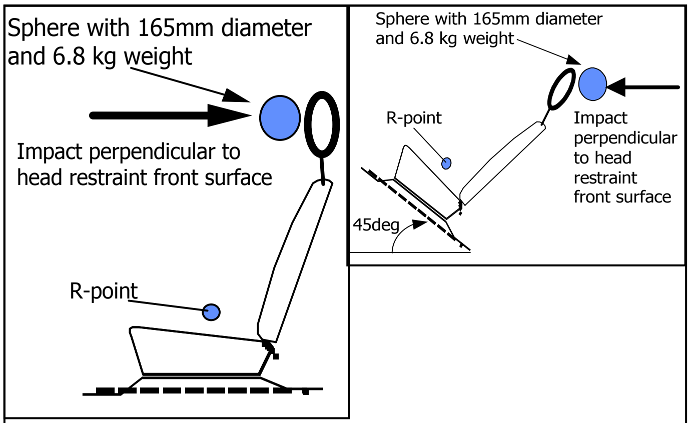

Figure 6: Energy dissipation test

Test Steps:

1. Seat track position (if available): worst case ((longitudinal/vertical)
2. Seat back position: design or close to 25deg (for backward impact) + 45deg tilted backwards (forward impact)
3. Head restraint position: fully down
4. Impact velocity: v > 24.1 km/h

Passing Criteria:

Permanent rupture and breakage of parts is not desired.

3.3 Types of anti-whiplash Headrest-

3.3.1 Passive Headres

3.3.2 Active Headrest

3.3.1 Passive Headrest-

Passive Headrest does not contain any kind of mechanism. It just try to maintain backset distance as minimum as possible.

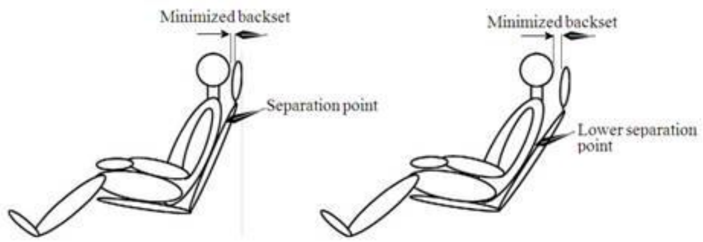

Figure 7: Passive Headrest Requirement

3.3.2 Active Headrest-

Principle of Whiplash Protection System

The Main Principle of Anti Whiplash Seat is to minimizing the degree of accident in the neck due to rapid movement of head and to design the seat's backrest and a head restraint that is sufficiently high and positioned close to the head are also important factors. The principle is based upon the following parameters which has been explained below

3.2.2.1 The Principle of Active Head Restraints

Here when the force is exerted on the Seat from the head of the persons due to sudden acceleration, the special type of the mechanism in the restraints will helps avoiding the equal and opposite force that exerts from the seat

3.2.2.2 The Seat Design

The Seat will made up of Wire Frames which reduces the impact of the forces that exerts from the human body.

3.2.2.3 Mechanism of the Seat

In an impact from the rear, immense force may be exerted on the vulnerable neck. The body is pushed forward and if the head does not accelerate together with the body, the neck can be over-stretched.

Active Headrest Study

Based on the principles of active headrest we have found implementation of one mechanism to actuate during rear crash. It is not working on any sensors it is mechanically actuated and mechanism comes back to its original position by spring force.

Working principle

Active headrest moves forward to support the head due to rearward movement force of occupant.

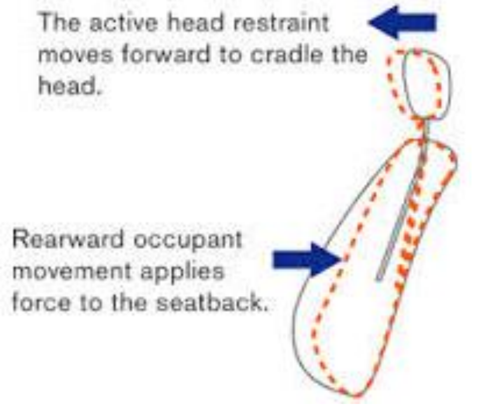

Figure 8: Working principle

III. Objective

Our objective of this research paper is to show importance of active head restraint in rearward impact & how it safeguards from whiplash injury.

Most of the OEMs like Toyota, Mercedes Benz are focusing on safety of occupant & their cars are having active head restraints. But because of cost point of view Indian car manufacturers are not looking forward into this.

IV. CONCLUSION

After studying the above research paper we have concluded that active head restraint is need of future cars. Existing active head restraints are made up of very high cost.

New proposals with mechanical linkages with low response time can be cost effective & can be use in Indian cars which may results in minimisation of whiplash injury.

REFRENCES

[1] Michael Yuen 1, Lynne E. Bilston 2, “Development of an Anti-Whiplash Seat”

[2] IIHS regulations, A Procedure for Evaluating Motor Vehicle Head Restraints (Issue 3),2008.

[3] ECE – Regulation No. 17/ Add.16/Rev.4.

[4] Rojin S 1,Vishkaie 2, “Reduce/ Prevent Whiplash Injuries in Car Accidents”