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A STUDY ON WHIPLASH PROTECTION SYSTEM FOR SAVIOR OF HUMAN LIFE

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Todays scenario of modern age is very fast moving say aircrafts become supersonic, trains becomes bullet trains and cars are also not a exceptional case. so the accidental cases risen up very rapidely according to one survey. so to prevent human life from these accidents one techchnique is under study which is Whiplash protection system which also considers the advantages of ergonomics.

In the first European Whiplash project the rear impact loading phase was the main focus. The research at the time was mainly limited to the loading phase of rear impact, since most of the proposed injury mechanisms assume whiplash to occur in the loading phase. On the other hand, some of the mechanisms of whiplash injury are suggested to originate from the rebound phase of rear impact. The rebound phase involves neck flexion, as in frontal impact. Therefore, the current research aims at reducing whiplash in frontal and oblique impact and studies the rear-end rebound phase. In the end a test method will be proposed for evaluation of seats and restraint systems with respect to their whiplash protection. In this evaluation stage also a dummy is needed in order to assess the protection of a system.

Keywords: supersonic air craft, bullet trains, Whiplash protection system,rebound phase.

I. INTRODUCTION

During recent years the main focus in whiplash research has been on rear-end impacts. Rear-end impacts have the largest risk of whiplash injury and therefore much effort is being spent on decreasing this injury risk. The total number of frontal whiplash cases may be higher, despite the smaller risk. Therefore, it is clear that also in frontal impact there is a need for improvement of whiplash protection.

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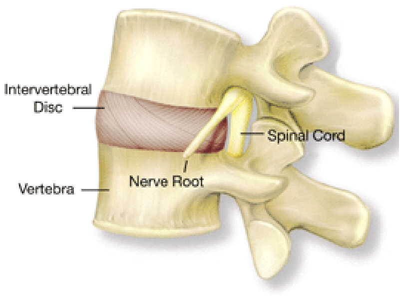
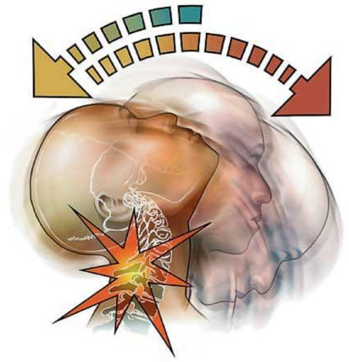
II. CONCEPT

2.1 Whiplash Injury

Whiplash is a relatively common injury that occurs to a person's neck following a sudden acceleration-deceleration force, most commonly from motor vehicle accidents Whiplash-a soft tissue injury to the neck-is also called neck sprain or neck strain. It is characterized by a collection of symptoms that occur following damage to the neck, usually because of sudden extension and flexion.





Hyperextension injury to the neck, often the result of being struck from behind, as by a fast moving vehicle in a car accident. Whiplash is a term used most often to describe the symptoms resulting from a car accident.

2.2 Whiplash Injury Reasons

In order to understand how a whiplash injury occurs, you need to understand the structure of your body. The main support structure of your body is your spine, which consists of interlocking bones called vertebrae. Each vertebra is separated by a tough sack of jelly, called a disc.

In minor cases, the quick jerk to the neck will only result is some muscle damage, which can heal. In more severe cases, the whiplash motion can strain and sometimes even rupture the squishy discs that separate the vertebrae. When the disc gets damaged, the injured person may experience extreme pain, numbness, tingling, and other unpleasant sensations in the neck.

2.3 Whiplash protection System

It is the type of protection system that had been implemented in the front seats of the four wheel vehicle in order to avoid the neck injury.

The WHIPS seat provides improved spinal support by virtue of its modified backrest characteristics and close proximity of the head restraint's position to the occupant's head.

WHIPS utilizes a specially designed hinge mount that attaches the back rest to the seat bottom,

III. 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

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

Before Exerting force

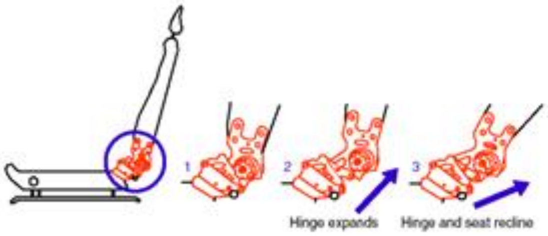
After Exerting force

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. 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



IV. METHODOLOGY

4.1 Selection of type of the Head Restraints

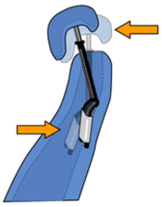
4.1.1 Reactive head restraints – RHR

The RHR system was introduced in 1997 as the world's first active, anti-whiplash head restraint and is standard equipment in all car models. It also provides multiple adjustment points to allow the head restraint to be ideally positioned for most front-seat occupants. Real-life crash statistics show that necks injuries are one of the most common results of rear-end. The RHR system is designed to limit the head movement of the occupant during the impact, helping to reduce the risk of whiplash injuries. The system is entirely mechanical and is based on the lever principle. An upper padded support is connected to a pressure plate in the backrest of the seat. In some rear collisions, the occupant's body will be forced by the crash pulse into the backrest, which moves the pressure plate towards the rear. Subsequently, the head restraint is moved up and forward to "catch" the occupant's head before the whiplash movement can start.

4.1.2 Pendulum System

The whiplash protection system used on Saab and Audi vehicles is a mechanical pendulum. When the occupant moves rearward (back and into the seat), their torso pushes against a plate that moves the head restraint upward and forward. This reduces the distance between the occupant’s head, and the head restraint, along with providing support and reducing injury to the occupant’s head. Springs in the seat structure return the head restraint to its normal position after the collision.

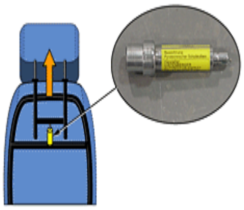
4.1.3 Spring Activated



The 2005 Mercedes-Benz M-Class features an optional spring-activated system for whiplash protection. If the sensing system detects a rear collision within a specific impact severity, it releases pre-tensioned springs inside the head restraints. This causes the head restraints to move immediately forward by about 40 mm and upwards by 30 mm. This movement is designed to support the heads of the front seat occupants at an early stage, lowering the possibility of a whiplash injury.After activation, the head restraints can be unlocked and returned to the original position using a tool supplied with the vehicle. Mercedes-Benz plans on making this option available on all models in the future.

4.1.4 Pyrotechnic Head Restraint

The pyrotechnic head restraint on the 2003 and newer BMW 7 Series is unique. On this system, a compressed gas cartridge at the base of the headrest frame activates during a rear collision, moving the headrest upward rather abruptly. The gas cartridge can be replaced, and the system reset if there is no further damage.

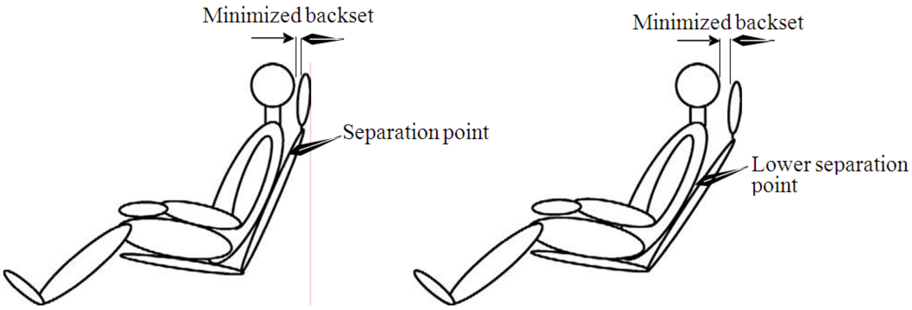


4.1.5 Pro-Active Head Restraints

The Pro-Active Head Restraints are linked to an electronic control unit. When the crash sensors on the car detect a rear impact of the defined severity, the control unit deploys the head restraint by activating preloaded springs inside it. The front of the head restraint moves up and forward to meet and support the head early in the crash phase, and thus helps to reduce the risk of injury

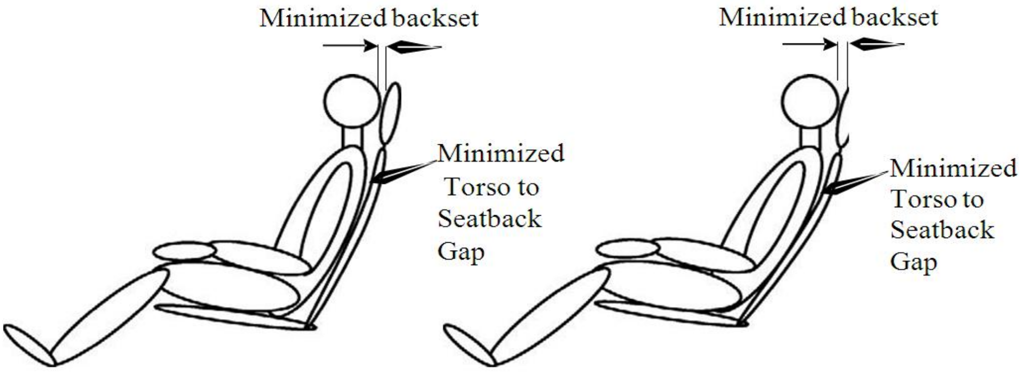
4.2 Concept Design

The initial concept was to develop a backset reducing active head restraint. For vehicle occupants it was observed that as the initial seatback angle increases, the separation point between the upper torso and seat back becomes lower. This is due to the occupant maintaining an upright head and torso posture. The idea was to develop a seat that conforms to the occupant prior to and during a rear impact at any seatback angle. Initial MADYMO model simulations showed that a modified head restraint would optimize its position relative to the occupants head. The concept seat model showed improved performance over a standard seat model. The results were directly due to the backseat being minimized.



Initial concept seat schematic .Upright seatback angle on the left and more inclined angle on the right. This seat design attempts to minimize seatback anglesThis conforming seatback concept was carried through to the final concept design. Refinements to the design minimized the backset and also the torso to seatback gap. The concept seatback attempts to mimic the curvature of the spine and maintains close proximity to the thoracic spine. The head restraint is also positioned so that height and backset are optimal. Any initial seat back angle will result in a properly adjusted seat configuration. The result is a seat that conforms to the occupant in all seating positions.

The initial idea was to develop some type of active head restraint to minimize backset. Through the preliminary study it was concluded that a typical active head restraint would only be useful with an upright seatback angle. Since occupants adjust the seatback to a range of angles and the fact that torso loading during rear impact causes the seatback to rotate, it was concluded that a seat system should be devised to maintain an optimized seatback and head restraint position through a range of seatback angles.

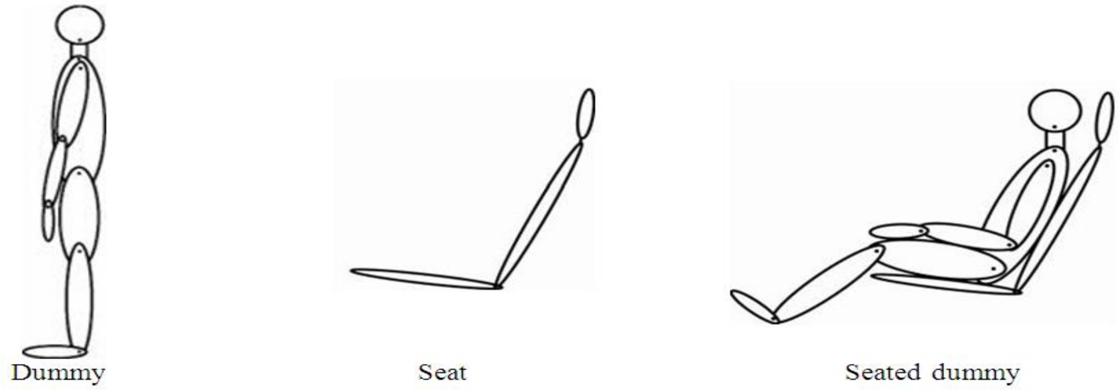


Final concept seat schematic. Upright seatback angle on the left and more reclined angle on the right.This seat design attempts to minimize backset for all seatback angles. This seatback design conforms to the natural curvature of the occupant’s spine

4.3 Rigid Body Dynamic Modelling

Rigid body dynamic modelling is used extensively in research and development of new vehicles as well as the analysis of current vehicles in an effort to study and increase safety.

Rigid body modelling involves the creation of tree structures comprised of individual rigid bodies that are connected by kinematic joints. The result is a multibody system that can represent objects such as crash test dummies, car seats and vehicle interiorsThe rigid bodies are defined by attributes such as dimension, mass, inertial properties and joint type. The geometric location of these attributes can also be specified. Joint stiffness, damping and friction can also be specified. Ellipsoids can be attached to each rigid body to represent the space occupied by each body. Force penetration attributes can be assigned to each ellipsoid to represent contact between various bodies.

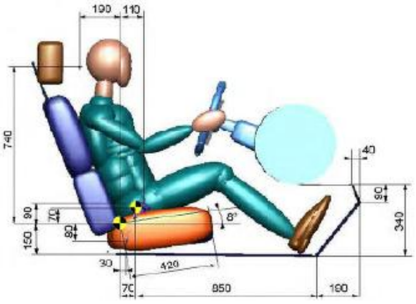


Dummy Seat Seated dummy

Examples of rigid body models.

Finite element models allow for more detailed and complex models; however the construction of these detailed models is time consuming. Detailed validation is also required. Making changes to these models is also difficult. Furthermore, the time required to solve these models can be large. In comparison, rigid body modelling packages generally ship with libraries of validated dummies that can be incorporated into a new model. The versatility of the software allows for modifications to be made efficiently. The modified model can then be solved in a matter of minutes. The minimal computation time makes rigid body modelling ideal for research and development work where constant modifications are being made to the multibody systems. For these reasons, multibody dynamic modelling was used as a design tool.

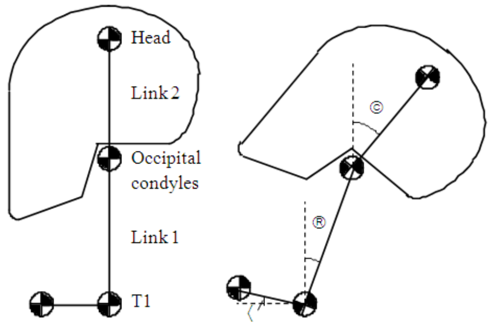
4.4 Madymo



Is an acronym for "Mathematical Dynamic Model." According to the literature, it is the world's most sophisticated and well validated multi-body mathematical model. It means that this computer model is essentially a very complex series of equations and relationships describing the human body for one thing. Every major body part becomes a three-dimensional ellipsoid mass with a known center of gravity, dimensional size and known inertial properties. Each of these body parts is connected to others with linear elastic springs and visco elastic dashpots using the appropriate type of joint model to best simulate a human. A finite seat belt/shoulder harness with and airbag system completes the package.

To calculate the internal/external forces acting on a human body that is exposed to a complex crash scenario, including seat belts, a should harness and the loads of each; ballistic impaction with an airbag, steering wheels and/or other internal car parts; to account for all of the major joints of the body/spine, muscle loads, weight, etc., would require a team of mathematicians a year to calculate. MADYMO can do it all in a matter of minutes in simple cases. In more complex cases in which airbag deployment was involved, the calculations could take a full day; and all this for an MVC that took perhaps one full second to happen. With programs like this, it is clear to see why we field practitioners keep insisting that people really do get injured in even relatively slow (5 mph) rear impacts. MADYMO confirms for us that injuries do take place.

4.6 Data Processing



T1 angle: □
Link 1 angle: □
Link 2 angle: □
Neck angle: □ = □ - □
Head angle: ϕ = □ - □ - □

Two pivot neck link model describing Link 1 (□) and Link 2 (□) angles relative to the sled and actual change in neck (□) and head (ϕ) angles.

All MADYMO model input files were created using a text editor. The models were then run in a Unix environment on a Dec-Alpha workstation. Output from each MADYMO simulation was processed using MATLAB. Several scripts were written to process the time history files and generate plots. Custom routines were used to transfer the linear acceleration output file to MATLAB. Custom scripts then found and plotted the maximum accelerations of the head and T1. An indexing function was then used to determine the corresponding time of these maximum values. This data was then used to calculate and plot NIC values as a function of time. The routine was also used to load the relative displacement output file. Coordinates from this file were then used to calculate the T1 (□), link 1 (□) and link 2 (□) angles relative to the sled These angles were then used to calculate the

actual change of head (ϕ) and neck (□) angles.

4.7 Model Development

Geometrical and mechanical properties were based on production seat attributes. The seat model featured a tubular steel perimeter frame with ellipsoids attached to the frame to simulate upholstery and allow contact interaction with the dummy. The model was then validated against sled test data. This model was used to study the relationship between the seat back, head restraint and occupant. Simulations were repeated with a range of seatback angles from 0 to 45 degrees from vertical. This was done to evaluate how different angles would affect head and neck kinematics. The dummy was positioned with an upright torso and a head angle of 0 degrees. With an upright initial seatback angle the backset was 70mm while the torso to seatback distance was 25mm. During impact, the upper torso would contact the seatback before the head would contact the head restraint. The torso loading caused the seatback to rotate rearward and consequently moves the head restraint further rearward. With more reclined initial seatback angles the backset and torso to seatback distance increased. During impact, there was an increase in time before contact between the torso to seatback and head to head restrain .It was concluded that this was due to the fixed angle relationship between the seatback and head restraint.

The concept seat was modelled next and went through several iterations during the design. The aim of the design was to develop a seat system that would maintain an optimized seatback and head restraint position through a range of seatback angles. Simulations showed that this configuration was effective in minimising backset prior to and during a rear impact. The final design allowed for the concept seat to be set up as a standard seat by for comparative testing. This idea was carried through to the final seat design.

V.OPERATION

Geometry from the MADYMO concept seat models was used to create 3D CAD components that were then used to assemble a 3D model .Engineering drawings were generated from the 3D models to be used during the manufacturing process. To ensure the suitability of materials chosen for construction, engineering analysis was performed on critical areas of the design. Maximum loads were determined through the expected peak accelerations and the mass of the dummy. Geometry from the MADYMO concept seat models was used to create 3D CAD components that were then used to assemble a 3D model .Engineering drawings were generated from the 3D models to be used during the manufacturing process. To ensure the suitability of materials chosen for construction, engineering analysis was performed on critical areas of the design. Maximum loads were determined through the expected peak accelerations and the mass of the dummy. A worst case scenario of the entire dummy mass loading one side of the seat frame was assumed. This was coupled with a factor of safety to ensure a safe threshold. Beam bending calculations were performed for the frame and shear pin calculations were performed for all fastener locations.

5.1 Operation Involved For Testing Of Prototype 1

Rear impact crash testing of the concept seat was conducted on a custom designed rebound crash sled at the Prince of Wales Medical Research Institute. The sled was calibrated for a change in velocity (Δv) of 12.5kph and peak acceleration of 70m/s^2 (7.1g).

The concept seat was rigidly mounted to the sled via a custom built frame. The seat was set to align the seatback centre line at both 15 and 25 degrees from the vertical. A THOR dummy was positioned with an upright driving posture using an inbuilt tilt sensor system. A lap belt was used to restrain the dummy's abdomen and both feet were secured to the footrest with webbing. This was only precaution to protect the dummy from potentially falling out of the seat on the rebound phase

Direction of inbound travel

Sled configured for a low-speed rear impact simulation with a THOR dummy. The sled travels from left to right and rebounds off the spring barrier. The high-speed camera in the foreground is used to record each test for optical marker analysis.

Tri-axial accelerometer blocks were used to attach Entran EGE 750g accelerometers to the head centre of gravity and T1. An additional accelerometer was attached to the sled to measure the x acceleration. An Applied Measurement signal conditioner was used to acquire data at 10 kHz in accordance with SAE J211/1 standards. A Phantom high-speed camera recording at 500 frames per second was used to record each test for marker analysis and visual inspection. The camera and data acquisition are both triggered by an optical switch on the side of the sled. The optical switch set-up doubles as a time trap to measure impact and rebound velocity.

Optical markers were applied to several key locations including the head centre line, head centre of gravity, the occipital condyles, T1 via a custom made bracket and the sled .The high- speed video was processed to generate single images at 2ms intervals. Code was written in MATLAB to track the optical marker locations. The coordinates where then used to calculate the T1 (□), link 1 (□) and link 2 (□) angles relative to the sled .These angles were then used to calculate the actual change of neck (□) and head (ϕ) angles. This procedure was based on techniques developed during the MADYMO modelling study

A THOR dummy in the standard seat configuration (left) and the concept seat configuration (right). Note how the concept seat conforms to the dummy and minimizes the initial backset.

5.2 Design Improvements For Prototype 2

5.2.1 Head Restraint Geometry

The head restraint on Prototype 1 was positioned too close to the dummy head for the concept seat configurations with an initial backset of 10mm.The results were minimized accelerations and NIC values, however the backset was deemed impractical for production seats since the proximity of the head restraint could induce occupant discomfort. Consequently, the head restraint mounting plates were redesigned to allow for a more realistic head restraint position with an initial backset of 40mm for the concept seat.

5.2.2 ACTIVE HEAD RESTRAINT

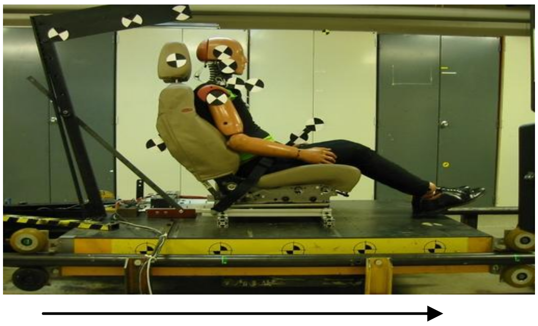
With this increased backset for the concept seat configuration, it was decided that it would be of interest to evaluate whether an active head restraint would contribute to reducing the amount of head and neck motion and hence injury risk. A design based on the SAHR concept was thus incorporated. A plate attached to a steel mesh frame was incorporated into the seat back that could be loaded by the torso during a rear impact. Through a lever mechanism, the rearward translation of the plate moves the head restraint upward and forward. Since the active head restraint mechanism was to be incorporated into the existing concept seat, it was important to design the mechanism around the new seatback design. Initially there were concerns about how changing seat back angles would affect the initial head restraint position. This was solved by locating the upper hinge of the active head restraint mesh in a suitable location. To be able to compare the difference between both standard seat and concept seat with and without an active head restraint, a pair of lock pins was added to the design. When installed, these extra pins rigidly lock the active head restraint mechanism.

5.3 Operation Involved For Testing Of Prototype 2 With A Biorid Dummy

Rear impact sled testing of the concept seat with a seated BioRID dummy was conducted to verify the design. The intention was to run a series of tests with the seat in both standard and concept configuration and compare how each seat influences the dummies motion

Rear impact crash testing of the concept seat was conducted on a non-rebound crash sled at Chalmers University of Technology in Gothenburg, Sweden. The sled was calibrated for a change in velocity (Δv) of 12.5kph and peak acceleration of 70m/s^2 (7.1g).

The concept seat was rigidly mounted to the sled via a custom built frame. The seat was set to align the seatback centre line at both 15 and 25 degrees from the vertical. A BioRID dummy was positioned with an upright driving posture. A digital angle finder was used on a H-Point tool to set the pelvis to 26.5 degrees and the head to 0 degrees for each test. A lap belt was used to restrain the dummy's abdomen



Direction of inbound travel

The initially stationary target sled configured for a low-speed rear impact simulation with a BioRID dummy. A rear impact is simulated when a bungee propelled bullet sled impacts a length of flat bar situated laterally across the rear of the target sled. The bar deforms and the impact causes the target sled to accelerate.

Tri-axial accelerometer blocks were used to attach Endevco 2000g accelerometers to the head centre of gravity and T1. An additional accelerometer was attached to the sled to measure the x acceleration. A Brick data acquisition system was used to acquire data at 10 kHz in accordance with SAE J211/1 standards

A Kodak high-speed camera recording at 1000 frames per second was used to record each test for marker analysis and visual inspection. The camera and data acquisition are both triggered by a contact switch on the rear of the sled that is triggered at the time of impact.

Optical markers were applied to several key locations including the head centre of gravity, the chin, T1 via a custom made bracket and the sled. The high-speed video output single images with 1ms intervals. Track Eye software was used to track the optical markers and to conduct depth scaling to account for markers in different planes. The coordinates where then used to calculate the T1 (□), link 1 (□) and link 2 (□) angles relative to the sled as in the data processing. These angles were then used to calculate the actual change of neck (□) and head (ϕ) angles. This procedure was based on techniques developed during the MADYMO modelling study.

A BioRID dummy in the standard seat configuration (left) and the concept seat configuration (right). Note how the concept seat conforms to the dummy and minimizes the initial backset.

VI. FABRICATION

6.1 Design specification of seat

- The concept seat design should effectively minimize differential motion between the head and neck during a rear impact collision.□ □ Contact between the occupant and seat should occur earlier to uniformly cushion both the torso and head.

- The design should reduce the injury potential of an occupant regardless of the seat back angle prior to and during a rear impact collision.
- The design should be compatible with production seat dimensions.
- No protruding components that would increase injury potential to occupants.
- The device should be able to return to pre-impact state after a collision.
- Mechanical linkages should be used instead of electronic or pyrotechnic devices if possible. □ □ □
- The device should be practical, economical and manufacturable.
- The device should not induce injury.
- An additional idea was to determine whether it would be advantageous to implement an active type head restraint into the design
- The initial idea was to obtain two identical standard production seats. One seat would be modified into a concept seat and the remaining seat would be used as the benchmark. By basing the concept seat on production seat geometry, it would be possible to make a sensible comparison between the two seats in terms of anti-whiplash performance.
- As the design evolved, it was determined that it would be possible to combine both the standard seat and concept seat configurations into a single seat. The concept seat system was designed to be a removable sub-assembly. It was therefore possible to revert the concept seat back to a typical standard seat for comparison purposes.
- Geometry from the MADYMO concept seat models was used to create 3D CAD components that were then used to assemble a 3D model. Engineering drawings were generated from the 3D models to be used during the manufacturing process.
- To ensure the suitability of materials chosen for construction, engineering analysis was performed on critical areas of the design. Maximum loads were determined through the expected peak accelerations and the mass of the dummy. A worst case scenario of the entire dummy mass loading one side of the seat frame was assumed. This was coupled with a factor of safety to ensure a safe threshold. Beam bending calculations were performed for the frame and shear pin calculations were performed for all fastener locations.

VII. APPLICATION

These type of the Seat that had been successfully installed in the following cars

VolvoXC60
Alfa Romeo MiTo
Volkswagen Golf VI
Audi A4
Renault Koleos
BMW X3
Renault Kangoo
Renault Megane

Honda Accord Euro
Skoda Superb
Hyundai i30
Ford Fiesta
Mercedes-Benz M-Class
Citroen Berlingo
Citroen C5
Ford Kuga
Suzuki Splash
Peugeot 308 CC

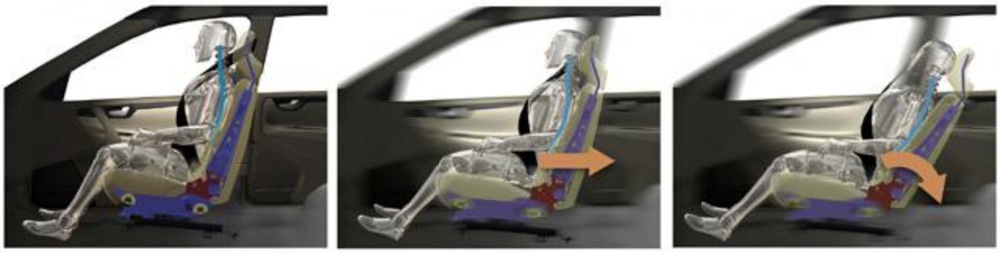
VIII. CASE STUDIES

8.1 Volvo S80 Whiplash Protection System

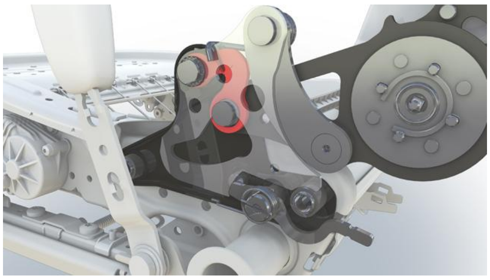
Volvo's unique **Whiplash Protection System (WHIPS)** is a form of protection integrated into the front seats which supports the seat occupant's entire back and head in a rear-end collision. This protective system cushions the movement through energy-absorbing deformation elements between the backrest and seat cushion. If a rear-end collision occurs, the backrest follows the occupant's rearward movement in order to reduce the forces on the neck. This technology was introduced in 1998 on the **Volvo S80** and **WHIPS has been a standard feature on all Volvo models since 2000.** According to Volvo's Accident Research Team, this system reduces the long-term effects of whiplash injuries by half. The new Euro NCAP evaluation procedure for whiplash protection consists of a number of different tests. Firstly, the seat's geometry is measured, for example, the position of the head restraint, in order to determine how well the seat can protect against injuries in a collision. Three tests are then conducted in a testing rig with varying degrees of collision severity. This rig is used to simulate a situation in which a stationary car is subjected to a rear-end collision.

EuroNCAP has instituted a new assessment protocol for evaluating the degree of whiplash protection offered by passenger cars in rear-end collisions.

The Volvo S80 was the first car with WHIPS. That was back in 1998 and by 2000 WHIPS was fitted as standard in all Volvo's front seats. The system has undergone continuous refinement and development over the years and this year we are actually celebrating its tenth birthday. Proper whiplash protection should reduce the head's movement in relation to the upper body. The relative movement between different body parts should be as little as possible. Our unique WHIPS protection system has therefore been designed to distribute the incoming forces along the entire back and head and to dampen the path of the force by moving with the body.



The backrest accompanies the body's movement backward and tilts somewhat to the rear relative to the seat cushion. This reduces the force being exerted on the back and neck. What is more, Volvo's whiplash protection is positioned close to the head and high up, giving the head excellent support. WHIPS have shown itself to be a very effective form of protection in rear-end collisions.



IX.CONCLUSION

The aim of this seminar is to develop an anti-whiplash car seat. The design was based on the idea that the extent of whiplash injury can be reduced by controlling the differential motion of the head .The initial idea was to develop a car seat with an active head restraint to control the motion of the head and neck. The reason for this is that during a rear impact, the torso loads the seatback and causes it to rotate rearward and hence forces the fixed head restraint away from the head. This allows the head to translate and rotate further than expected.

A modular design was used to enable the new seatback design to be removed and allow the seat to be configured as a standard seat. An active head restraint mechanism was incorporated into the design, which allowed rearward torso translation into the seatback to activate a mechanism to position the head restraint further forward and upward. This mechanism could be locked to revert the head restraint design to a standard configuration. These features made it possible to have four different seat configurations in one seat. A standard seat with and without an active head restraint and a concept seat with and without an active head restraint.

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