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Design Specifications and Ergonomic Evaluation of Car Seat (A Review)

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***Abstract*— The improvements in design of driver seats have been the area of immense interest for the past few years. Improper design and uncomfortable seats imposes a lot of stress upon different body parts of driver. It is the driver who gets more fatigue than the passengers. If the driver seat is not comfortable the performance of driver could decrease and there is possibility of fatigue and various other muscoskeletal disorders which could even lead to possibility of accident. This paper reviews about the various injuries and comfort or discomfort factors related to car seat design. A design evaluation is done in order to optimize the different parameters which could reduce the injuries related to seat, back and head rest. The included geometric parameters are seat back angle, seat pan angle, seat height, seat width etc. H-point, R-point and head restraint are the design specification used which could describe the correct seating position.**

Keywords—car seat, ergonomics, comfort, injuries, seat design

I. INTRODUCTION

Automobile seat play an important role in improving the comfort of professional driver. It is the driver who gets more fatigue than the passenger which is serious issue for the professional drivers. Therefore while considering vehicle seat human factors aspects play an important role. Automotive ergonomics is the study of how car seat can be designed better for human use. Onawumi (2012) has evaluated various musculoskeletal problems that are prevalent among professional drivers worldwide. Safety, comfort and effective seat system has been area where continuous research and efforts are being made. Different approaches have been taken into account for making automobile seat comfortable. Approaches like mechanical, pressure, vibration, ergonomic, medical etc. are being used (Fai et al. 2008). The goal of these various approach is to decrease risk of injury or fatigue to enhance workers productivity. So that it could maximize the natural ability of body to move and respond to physical stress. There are two types of body part injuries that occurred during driving. Whiplash injury and low back pain are two most common injuries which occur among the professional drivers. In a study conducted by Kamp (2012) described that seat should be designed according to contours of human body. He concluded that human body shape or contour, dimension of seat (width), side support and hardness or softness of seat material has a profound impact on human body. The important findings were hard seat with high support were sporty and seats which were softer considered luxurious. For driver posture is related to comfort and discomfort. Therefore it is necessary that interior dimensions factors could affect the car ergonomic factors. In a statement given by Kolich (2003) concluded that anthropometric criteria and ergonomic criteria should be applied simultaneously in order to fulfil the comfort, expectation of the population or users. If the driver or operator seat is not comfortable the performance of operator could get affected. Therefore for the optimal design of operator & driver seat various anthropometric data & technical design features should be considered (Mehta 2007). The society of automobile engineers (SAE) and Automotive Industry Standards (AIS) has configured the range of dimensions for car seat and location of specific control relative to the H-Point. Procedure for determining the H-point and torso angle is for 50^{th} percentile adult male in seating position for motor vehicle. The other geometrical parameter are seat back angle, seat width, R-point, head restraint etc. This paper deals with review of various injuries, comfort (discomforts) and design specification needed for designing car seat.

II. INJURIES RELATED TO POSTURE OF DRIVER SEAT

Low back pain: Low back pain is issue of concern for long distance drivers. Therefore a car seat should be designed to reduce the load in low back pain. Various efforts have been made to provide Lumbar support; side support; ischial tuberosity region as it is softer in femoral region; head rest which could adjust sagitally; rubber mat under seat. A sixty male subjected were selected which were taking 50min/trip & 5times/week. For 30 male subjected were replaced by new seat and remaining 30 with standard. Then the evaluation was done, three evaluations were done. In first examination low back load was taken by lumbar examination and subjective evaluation of low back pain was done. In second examination improvement of new seat was there, whereas in third examination the kinetic pain scores while bending backward and the lasegue test improved significantly for new seat. In this way it was concluded that the low back load in new seat was less than standard seat. All the factors like lumbar support, side support at the ischial tuberosity region and adjustable head rest and rubber mat resulted in lower back pain (Udo et al. 1997). Whiplash injuries: Injuries which are related to neck are called whiplash injuries or whiplash associated disorders. A low velocity rear end impact was tested with hybrid-III dummy with modified neck. The results showed that there had been considerable influence on the head neck restraints. Thus it showed the significant decrease in neck injury due to rear impact (Svensson et al. 1995). Though neck injuries are not life threatening but can lead to long term

consequences. There had not been not been a particular mechanism for occurrence of these injuries yet several mechanism occurred at different phases have been suggested from researchers from time to time. Volvo whiplash protection study (WHIPS) presented a biomechanical guidelines and test methods. These biomechanical guidelines aimed to reduce the risk of neck injuries due to rear impacts. WHIPS seat a new seat concept was developed using these guidelines and requirement. The new WHIPS seat comprised of new rectilinear and was added with modified backrest and head restraint. The WHIPS rectilinear is designed to give a controlled rearward motion for the backrest in case of impact which improves the occupant head and back when occupant rebounds in its position. The test results are summarized for improvement in neck injury in protection for rear impact (Lundell et al. 2008). Muscle Fatigue: Improper design of seat leads to muscle fatigue. Various seat adjustments (e.g. Seat rest & seat back angle) and pedal spring stiffness have complex influence on the muscle activation & spinal joint forces on human body (Moyd et al. 2013). In a study done by Grujicic (2010) concluded that long duration car driving leads to driver discomfort which causes the fatigue with the help of muscoskeletal modelling and simulation method main cause of long distance driving fatigue was investigated. Inversion-dynamic approach was used to deal with muscle redundancy problem in order to have minimum fatigue. As human body contain many muscles for driving various body joints. The results obtained gave a conclusion that various car seat/drivers kinematic (e.g. Seat rest angle, human body/car seat interface friction coefficient, longitudinal track position and presence/absence of lumbar support) on the factors controlling driving fatigue (e.g. Muscle activity, shear force etc.) has been investigated.

III. EFFECT OF VARIOUS COMFORT EVALUATION TECHNIQUES ON DRIVER CAR SEAT.

Sitting comfort and discomfort are defined as independent entities associated with different factors; discomfort is related to biomechanics and fatigue factors and comfort to a sense of well being and aesthetics. Comfort could be categorised as static comfort and dynamic comfort by wolfel (2008). Static comfort is related to right posture in this back rest inclination angle it could be also be calculated by load due to gravity. But two main factors which effect the static seating comfort are pressure distribution of the cushion and the back rest angle. Similarly in dynamic comfort seat transfer function which is affecting the driver seat. Seat transfer function is related to the vibration produced on the seats. Various parts of body are affected during driving but design of headrest along with neck support should be provided to increase the car comfort. The head rest should be adjusted as mentioned by Franz (2012). There are various factors which affect the headrest and neck support, but which effects most is the pressure distribution between head and head rest, material of foam and the position of head and neck support. In order to prevent from whiplash injury which occurs when there is rear impact on neck or head region an articulation was done on upper part of the seat back rest by Denis (2012). This articulation was done 43.5cm above the H-point with an average sitting height of 88cm. The concept of articulated seat was meant to give support to back so that person could be in its natural posture. The pressure distribution between human and seat varies as it depends upon the seating position. In pressure distribution the pressure is lowest at the intervertebral disc for the most comfortable posture acc to Zenk (2012) and pressure is up to 0.5 bar at this position while it is 1.6 bar at the upright seat position. Similarly back support or back rest comfort is also important. Comfort is directly related to drive experience. Climatic conditions effects the driver condition therefore thermal comfort plays an important role in improving the driver as by Cengiz (2007). An experimental study was done on ten participants for 1hr on sunny day. It was carried out air temp of 25 degree celsius in fiat mera (car's name). From this it gave a conclusion that for evaluating the thermal comfort skin wittedness data are more important than skin temp data. Waist area has maximum temperature as compared to other areas. Vibration produced in the car seat creates the discomfort for the driver and its effects the performance of the driver. An experiment was performed by Wassim (2003) with the surface electromyography (SMEG) tool which is used to study the muscle activity. Two seats were taken one with vibration effect on it and another with comfortable seat without vibration. The performance with vibration seat was worse. Subjective discomforts were reported when subject was in car seat for 150 min. For achieving a correct ergonomic design and comfort in automobile seat joint angle are necessary to work with. Joints such as ankle, knee, hip, shoulder and elbow should be optimized according to Susanne 2014. The research was to detect the different joint angles which are used frequently in interior car design. Thirty different sources were taken on automobile sitting posture till date. In today's competitive market customer expectation continue to rise. It therefore becomes difficult for producer to develop its product based on consumer needs. Thus in order to provide the qualitative nature of the consumer to produce some methods have been developed which could transform qualitative parameter into numerical value in order to improve the produce. One such method is heuristic multi criteria decision making technique by Hamed (2012). Another is axonometric design principle by Kolich (2006) for the comfortable automatic seats.

IV. DESIGN PARAMETERS/SPECIFICATIONS RELATED TO CAR DRIVER SEAT

Ergonomic design process is the most referred in study of car driver posture. The design of driver posture with seat, head and back rest are related which effect the posture of driver seat. The interaction of car driver body with cushion and backrest was done with multi-factor method. The optimum lumbar flexion angle was calculated which is an indicator of postural comfort (Giuseppe et al. 2002). Seat back rest angle, head rest and seat rest angle should be adjusted properly in order to provide the driver comfortable while operating. Seat inclination angle of 90 degree having no lumbar support received low comfort score. But inclination with 120 degree without lumbar support provided much comfort (Meauchen et al.). Seat back angle if adjustable should be positioned with respect to rearward inclination close to 25 degree from the vertical torso line (IS: 13749-1993). Interaction of foam material with seat back and with seat bottom is could indeed possibly determine the equilibrium static position of seat occupant. Therefore the static equilibrium postion considerably differs with respect to the type of foam used. By this we could calculate the effect on H-point location with the use of different type of foam used in seat design (Ippili et al. 2007). There are various parameters

set by Automobile Industry of India these are determination of H-point and torso angle is calculated with the help of 3DH machine for 50th percentile adult male in seating position of motor vehicles (IS: 13749-1993). H-point and R-point are important design specification used by car manufacturers. H-point is the pivot centre of torso and thigh of 3DH machine installed in the vehicle seat. R point or seating reference point is the design point defined by vehicle manufacturer for seating position and it is establish with respect to 3-D reference system (AIS-097, 2007). Height of head restraint should not be less than 750mm in front seat and this value should be obtained in position between highest and lowest position of adjustment. The head of person should be provided with proper support for normal seated person. Head restraint area should not less 85 mm to each side of vertical plane (AIS-016/2000).

CONCLUSION

The following conclusion can be drawn from study:

1. Driver seat is to be ergonomically designed according to the contours of human body which in case could lead decrease in comfort level and increase in discomfort level.
2. Improper design of driver seat of car leads to various injuries. A good driving position and correct posture is vital for the efficient practise driving in order to avoid various injuries.
3. Head and neck are the sensitive part of body. Head restraint should be designed so that it could provide necessary support to head and neck which could further decrease the chances of injury.

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