An Ergonomics Study of Four Wheel Vehicles: A Review Paper

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Abstract *— In the present era of product development, designing a product is always most important stage to be considered. The success of product is mainly depends upon its efficiency and ease of use. And both these factors mainly depends upon the ergonomics of the product. Thus it been seen that ergonomics plays vital role for the success of a product. In this research work it has been tried to apply ergonomics principle particularly in the area of automobile field. A lot of work has carried out in this domain because it is always an area of concerned for the success of product. This paper gives quick view of different work related to the ergonomics study of four wheel vehicles and various consequence like fatigue, WSMD etc. Several applications of ergonomics have been proposed in the literature to solve the problem related with complicated mechanical design.*

Keywords - *Design Product, Ergonomics, WSMD*

I. INTRODUCTION

The Indian automobile industry being one of the largest automobile market in the world and it is continuously increasing and coming as one of the fastest growing automobile market. With the increase in competition between vehicle manufacturers, there is also increase in the number of options for vehicle selection. The selection of vehicle mainly depends upon many criteria such as market trend, vehicle manufacturer, safety, its performance, design, interior space and miscellaneous equipment offered. The product success mainly depends upon how much it is easy to use and efficient and for this proper designing of product is most important. Designing an automobile product such as car the number of inputs from many disciplines required like designers, body engineers, chassis engineers, market research, ergonomics engineers etc. Fundamental themes of ergonomics such as user centred design, user friendly design and usability have becomes buzz words within the design industry. In the time of design a product ergonomics method can be applied at earliest stage of the process, defining needs of the user and identifying opportunities for innovation Since this work is mainly related to ergonomics study of vehicle, the main focus is towards review the previous research work and understand various factors to be considered for ergonomic study.

The term ergonomics comes from the two Greek words- ERGO and NOMOUS, which means “work” and “natural law” respectively. Thus ergonomics means the natural law of doing work. Ergonomics approaches like fitting the equipment to the user, designing for most and system approach is to be follow during the design stage of product. The involvement of ergonomics engineer as a part of the vehicle development team is now an accepted practice in the automobile industry. The contribution of modern ergonomics to design and evaluation of system, product & working environment is very important. The designing process is not same as earlier when an engineer designed a whole machine or product, nowadays designing a product is a team effort. The role of ergonomist usually has an important one during the conceptual phase and in detailed design as well as in prototyping and evaluation of existing products and facilities. During the virtual design of any product, system or environment the consideration of ergonomics is must. If it not so, this may lead to the design which do not fit the physical, psychological or sociological needs of the user leading to ineffective, inefficient or unsafe design and the chances of product to be commercially successful will be less.

Ergonomics is all about ensuring a good fit between the people, the things they do, the object they use and the environment in which they work. Human factor engineering (or HFE) is also considering as an alternative term for ergonomics. Human- machine system defined as a system having set of elements, the relation between these elements and the boundary around them. Mainly system consists of

people and machine and perform a function to produce some form of output. In general inputs are received in the form of matter, energy and information. In ergonomics, human is a part of system and must and fully integrated into it at the design phase. Thus human requirement are system requirement rather than secondary consideration can be explain in general terms as requirement for- equipment that is usable and safe, tasks that are compatible with people's expectation and an environment that is comfortable and appropriate for the task.

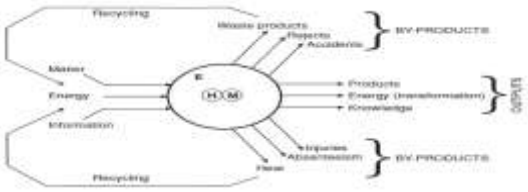

Figure 1 human- machine system

II. LITERATURE SURVEY-

Rajesh Kumar et.al [1] **-** performed the analysis of passenger car vehicle seat. In this study they found that comfort of seat can classified under two categories static and dynamic. Static comfort mainly related to support and form provided by seat itself, the posture and the orientation of occupant and location of the occupant relative to certain critical points in vehicle interior. On the other hand dynamic comfort is related to the level of vibration experienced by occupant sitting in car. They also analyse the factors like user subjectivity, seat geometry, occupant anthropometry and the amount of time spent affect the comfort during sitting. The analysis were performed on five seat (A,B,C,D&E) based on different criteria like fit parameters related anthropometric measurement and support parameters defined with respect to seated posture. Main attention was given to lumbar support and after H-point measurement, pressure mapping and survey (jury evaluation) concluded that seat A has less lumbar support.

Hanumant N Kale et.al [2] **-** studied about the various parameter involved in the design of driver seat. Designing a seat is complicated system consist of so many parts, adjustment as well as safety system. Authors showed how poorly designed driver seat affects the driver health and psychological condition of mind and discussed about all the parameters like anthropometry of human, ergonomics related parameters, seat materials, safety related parameters, comfort related parameters as well as weight and aesthetics with classification and basics of driver seat. He stated that apart from all other parameter safety and health related parameters are very important.

Peter Le et.al [3] **-**identified how physiological measures relate to vehicle seating discomfort. The study consisted of anthropometric characteristics of 12 people and was evaluated via three physiological measures–near infrared spectroscopy, electromyography and pressure mapping. Subjective discomfort in specific body location was predicted with help of conditional discomfort model through dichotomised physiological responses and anthropometry to predict subjective discomfort in specific body location. The author highlighted role of few anthropometric factors play in physiological responses of the body during prolonged sitting and revealed that height and weight affects the level of comfort of neck and buttocks respectively while driving.

Nishant Srivastava et.al [4] **-** reviewed about the overall design and contour of vehicle seat for comfort and safety of drivers and passengers. He also find out that how improper design and unbalanced pressure distribution lead to the problem of pain, shoulder pain, lower back pain and injury from lifting increased. In the end author concluded that overall contour and proper designing directly and indirectly affects human life and also suggested for proper design of vehicle to reduce the problem of MSD among drivers.

Ankit Jhinkwan et.al [5] – reviewed about the various injuries, comfort and discomfort factors related to the improper seat design of car and evaluate the design in order to optimize the different parameters which could reduce the injuries related to seat back and head rest. Also discussed about the geometric parameters such as seat back angle, seat pan angle, seat height, seat width and H & R point which could describe correct seating position. In this paper authors suggested that seat of driver should be ergonomically designed according to the contours of human body and head restraint so that it could provide necessary support to head & neck and leads to decreases the chance of injury.

Niel Manfield et.al [6] **–** highlighted the effect of changing road condition and seat foam composition on driver discomfort in vehicle seats. The research consists of two separate study one measured discomfort ratings for two condition comprising of vibration exposure followed by static sitting in a car seat and other study measured discomfort rating for three period where participant were sitting in one of two car seat of different composition which is either exposed to vibration or not. The study is completed with help of driving simulator. Authors find that after 40 minutes there is discomfort in both the seat but the difference was insignificant and suggested for long duration dynamic testing while developing vehicle seats

Marry E Mossey et.al [7]- explored the driver interactions with steering wheels in four vehicles by using anthropometric data, driver hand placement and driver grip design preference. The study was completed by the formation of two groups of participant one age between 47 to 69 years and other 18 to 29 years. There demographic data were collected and with the help of t test authors recommended for work in steering wheel grip design and naturalistic driver hand positioning are also discussed.

Vignesh T. Shekar et.al [8] **-** established a set of guidelines exclusively for designing bus and coach driver workspace. Discussed about the various systems in the drivers workspace and their relevance to drivers ergonomics. With the help of mannequins which were modelled using CATIA HBR (Human Builder 2) module and virtual evaluations were done using CATIA DH2 configurator, virtual ergonomics checks were done on vehicle Digital Mock Ups (DMU). Besides studying the driver's reachability of controls and other ergonomics aspects the authors emphasised on understanding the factors influencing driver's field of vision.

Kedar Chimote et.al [9] **-** recommended best possible alternatives of driver's seat with the aid of ergonomics and advanced design tools like CAD,CAE . A survey was conducted amongst the truck drivers to examine the travel time factors & seat discomforts and leads to the conclusion that it is important to design the comfortable seat for truck drivers keeping in the view the ergonomic factors such as anthropometry, physiological work load, physiological stress etc. In the end authors concluded that comfort and safety are two features for driver which is essential. The conceptual model is created using CAD packages and various comfort level test is carried out to analyse various driving conditions.

Mike Kolich et.al [10] **-** stated that there are no fail free designs and how this is especially true when it comes to automotive seating comfort where the characteristics and preference of individual customer are many and varied. They proposed the application of an analytical technique common to engineering circle called Design Failure Mode and Effect Analysis (DFMA) and demonstrated DFMA could have a valuable role to play in seating comfort development and ergonomics by supplying strong evidence for the advantages of particular design alternatives.

Rahul Shaik et.al [11] **-** focused on various risk factors which lead to musculoskeletal disorders in auto rickshaw driver. The study involved 300 participant who interviewed with help of Nordic Musculoskeletal questionnaire (NMQ) &inch tape and vibrometer were used to measure risk factors like vibration and measures workspace envelope. The authors highlighted that lower back, knee, neck and ankle troubles are more prevalent in auto rickshaw drivers and concluded that increasing age, work experience, maximum working hours per week, increased left shoulder to handle distance and greater driver seat vibrations are increasing the risk of MSD and restricted lower cabin space and reduced shoulder to handle distance on right side also increasing the risk of musculoskeletal disorder.

Onawumi et.al [12] **-** studied how ergonomic factors influencing safety, comfort and performance of Nigerian taxicabs drivers while driving. The studied involved the PEIA, PIE survey and analysis of workplace which were used in the evaluation of ergonomic suitability of driver. Six models of vehicles were considered in this research. These were Nissan, Mazda, Toyota, Mitsubishi, Peugeot and Opel. The driver's workplaces were studied in relation to their ergonomic suitability. They proposed for legislative instruments which were control frivolous importation of vehicles that do not meet ergonomic standard. Also stated that government should establish an ergonomic department in the Ministry of Productivity whose responsibility for development of reliable database for different categories of user population in the country and also suggested to the manufacturer of products where vehicle are imported from should be properly informed and mandated to produce to specifications arrived at using the Nigerian anthropometric database.

Begum Nurun Nahar et.al [13] **-** performed a survey on professional taxi driver with help of questionnaire. The study demonstrated that 78% of car drivers reported lower back pain for at least one day during past 12 months. Their study also revealed the effect of age, daily and cumulative driving in drivers and stature become a cause of risk factors of lower back pain. The authors stated that high level of lower back pain among drivers is associated with long working hours and years of driving and suggested for shortening of driving time and introduction of appropriate resting area should be considered.

Somnath Gangopadhyay et.al [14] **-** performed an ergonomics study on the musculoskeletal disorder among Indian bus conductor. A questionnaire based on modified Nordic Musculoskeletal questionnaire (NMQ), assessment of physical and physiological parameters, analysis of working posture and a detailed work study were performed. The authors reported that MSD mainly affecting leg, knee, shoulder and back areas and increases day by day and stated that bus conductor were continuously standing for long period and their serve workload may result in the development of MSD.

Kishor Powar et.al [15] **-** designed a truck cabin for improved ergonomics and comfort for driver in Indian driving condition and the main attention was kept on the psychological and behavioural pattern of Indian driver along with the ergonomics issues. They highlighted the importance of design of interior of a cabin of a truck considering ergonomics, comfort and aesthetics for existing driving conditions in India. With the help of CATIA V5R16 digital model for the concept was produced with all the detailing of cabin interior parts and design was analysed by RULA analysis method using human activity analysis. In the end author introduced new modern style of interior design with simple straight line composition and a combination of dark and light colours and all the ergonomics consideration were included in design and validated by software analysis.

Sam Brook et.al [16] **-** studied about the factors influencing the driving comfort associated with the leg during actuation of the acceleration and brake pedals. Developed an ergonomic data measurement system that integrates five subsystems – an electrogoniometery system, a pressure pads, an electromyography system, the vehicle on board diagnostic system, a GPS system and audio visual system. Two muscles had been selected for monitoring during drive events: Tibialis Anterior and the Soleus which are located in low leg and responsible for the Dorsiflexion/ Plantarflexion of the ankle. With the help of questionnaire to evaluate subjective comfort during test drive and verbal feedback from the driver was collected throughout the driving event. The results showed that first two drivers operates the accelerator pedal mainly in plantraflexion around the midpoint of MVC range while the other driver operated the accelerator pedal in the middle of the dorsiflexion range which could explain higher level of discomfort. The author concluded that with help of integrated measurement system a robust platform is develop for collecting objective ergonomic data which could enhance the understanding of driver's lower leg comfort factor in relation to actuation of acceleration and brake pedal.

Olanrewaju O. Okunribido et.al [17] **-** conducted cross sectional study to investigate worker exposure to Manual Material Handling (MMH) and Whole Body Vibration (WBV) as risks of Lower Back Pain (LBP). With the help of validated questionnaire, information about driving experience, driving posture and previous medical history was collected. The study comprised of two parts self-assessments by questionnaire and systematic observation. The criteria for questionnaire assessments were a minimum one year in present job or total of five year of continuous driving experience. The data gathered was analysed with the help of statistical analysis using statistical package SPSS 11.1 for Windows and difference between the means tested by student's t test. The author suggested various strategies for controlling risks of LBP and reduces the prevalence of back problems. The results showed that city bus driver spend about 60% of daily work time actually driving often with torso straight or unsupported; perform occasional and light MMH and experience discomforting shock/ jerking vibration events. Transient and mild LBP was found to be preventing among the drivers and a need for ergonomic evaluation of driver's seat was suggested.

Massinmo Bovenzi et.al [18] **-** investigated the prevalence of Low Back Pain (LBP) among the Italian professional drivers exposed to whole body vibration and ergonomic risks factors. The questionnaire which is originally developed within the European Project Vibration Network (VINET) is divided into four sections and used for data collection. The data obtained is analysed with the help of STATA software version 8.2 (STATA Corporation 2004). The difference between two or more means was tested with student's t test or one way analysis of variance (ANVOA). Thus result of study concluded that professional driving in industry is associated with an increased risk of work-related LBP. Exposure to whole body vibration (WBV) and physical banding factors at work are important components of the multifactorial origin of Lower Back Pain (LBP) in professional drivers.

Wassim El Falou et.al [19] **-** studied about the fatigue, discomfort and performances of driver's seated for long duration in car seat. Surface electromyography (SEMG) is used for the study of muscle activity as it provides the only non- invaise

index of the level of muscle activation present. Four experimental configurations were used with and without vibration for two seats. Data were acquired using a software programme developed using Labview (National Instruments Corporation Austin, USA). Analogue to digital conversion was performed with an ATM10 16XE10 card. The statistical analyses were performed with statistical package for social sciences. In the end authors concluded that low level of subjective discomfort were reported by driver seated in a car seat for long duration. Despite low levels of discomfort the methodology used enabled a reduction in performance to be detected. As expected performance was reduced when drivers were in an uncomfortable seat in the presence of vibration.

Saumya et.al *[20]* - investigated about the prevalence of work related musculoskeletal disorder on various body segments. With the help of snow ball sampling techniques respondent were selected and using exploratory cum causal research design to obtain and analyse data. From the study, author concluded that the work of driver is highly stressful and many factors like prolonged sitting, whole body vibration etc. make taxi drivers distinct from other professions in terms of exposure to risks of work related musculoskeletal disorder.

III.CONCULSION:

On the basis of the literature review carried out following conclusion have been drawn:

[1.] Absence of Indian anthropometric data consideration during the design of vehicle for the Indian market.

[2.] Most of the study related to ergonomics in automobile design is limited to driver's seat only. There is no proper study carried to find optimum result considering the control parameters like accelerator pedal, steering wheel, gear lever etc. of a car.

[3.] In the initial phase of vehicle design the importance should be given to proper ergonomic design parameters otherwise it will lead to health problems of drivers like musculoskeletal disorder (MSD), neck discomfort, torso discomfort and lower extremity discomfort etc.

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