ERGONOMIC SEAT DESIGN FOR FORK LIFTS

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***Abstract*: Manual handling has been replaced more and more often by the utilization of mechanized lifting and transport equipment. Forklift trucks are very commonly used for internal material handling. As Larsson and Rechnitzer (1994) put it: "Forklift trucks are the most conspicuous and successful work horse for internal material handling". Occupational driving has often been associated with a high prevalence of back pain. The factors that contribute to cause the pain are diverse and include prolonged sitting in improperly designed seats, poor postures, exposure to vibration. Seats are one of the most important components of vehicles and they are the place where professional driver spend most of their time. Discomfort analysis on forklift operators (Depending on previous research) shows that there are various discomforts in the body parts of operators like lower back, shoulder, neck, hip, foot etc. The present study evaluated the potential mismatch between the seat dimensions of existing forklift seats and anthropometric characteristics of all the forklift operators. The purpose is to propose a new seat dimension according to anthropometric data obtained.**

***Index Terms*: Forklift, Seat measurements, Anthropometric data, mismatch percentage.**

I. INTRODUCTION

Manual handling is any transporting or supporting of a load by one or more workers. It includes the following activities: lifting, holding, putting down, pushing, pulling, carrying or moving of a load. Manual handling is also sometimes called 'manual material handling' (MMH). Manual handling occurs in almost all working environments (factories, warehouses, building sites, farms, hospitals, offices). It can include lifting boxes at a packaging line, handling construction materials, pushing carts, handling patients in hospitals, and cleaning. Manual handling can result in fatigue, and lead to injuries of the back, neck, shoulders, arms or other body parts.

Damage to the musculoskeletal system of the body (muscles, tendons, ligaments, bones, joints, bursa, blood vessels and nerves) as a consequence of gradual and cumulative wear and tear through repetitive manual handling. These injuries are called 'musculoskeletal disorders.

According to OSHA (Occupational Safety and Health Administration), Work-related musculoskeletal disorders (WMSDs) are a group of painful disorders of muscles, tendons and nerves.

In order to reduce the negative effects associated with manual material handling mechanized material handling and fully automated machinery has been developed. Forklift is one among those mechanized material handling machine used for internal material handling.

II. FORKLIFTS

Forklift trucks are extremely useful vehicles for a wide variety of industrial operations. These vehicles are relatively small (length and width), powerful machines often capable of lifting extremely heavy loads. Although forklifts are well designed for lifting and moving the goods, these are causes the most of the accidents occurring at worksite in material handling operations.

Forklift

The typical condition of the forklift trucks also makes the operator physically weak and the discomfort to the operators and these may reflect on ergonomically aspects like MSDs, which in turn directly or indirectly affects the individual operator and the organization.

Truck drivers comprise a large population that are exposed to many risks associated with low back pain. High-mileage drivers have often been associated with high prevalence of musculoskeletal pain; poor postures in some types of trucks have been linked with neck and trunk pain; drivers are exposed to whole-body vibration for extended periods of time, and this has been associated with low-back pain.

III. FORKLIFT SEATING

Seats are one of the most important components of vehicles and they are the place where professional driver spend most of their time. For example, according to Occupational Outlook Handbook by United State Department of Labor, the truck drivers frequently work 50 or more hours a week. The truck drivers sit while they are driving their 50 hours per week. Assuming four weeks' vacation and one more for holidays, which is about 2350 hours driving time per year.

Posture of seated person is dependent on the design of the seat itself, individual sitting habits and the work to be performed. Seated postures are defined as the body position in which the weight of the body is transferred to a supporting area the ischial tuberosities of the pelvis and their supporting soft tissues.

Forklift Seat

IV. ANTHROPOMETRY

Anthropometry is the science that measures the range of body sizes in a population. When designing products, it is important to remember that people come in many sizes and shapes. Anthropometric data varies considerably between regional populations. For example, Scandinavian populations tend to be taller, while Asian and Italian populations tend to be shorter.

Percentiles

Anthropometric dimensions for each population are ranked by size and described as percentiles. It is common practice to design for the 5th percentile (5th %) female to the 95th percentile (95th %) male. The 5th% female value for a particular dimension (e.g., sitting height) usually represents the smallest measurement for design in a population. Conversely, a 95th% male value may represent the largest dimension for which one is designing. The 5th% to 95th% range accommodates approximately 90% of the population. To design for a larger portion of the population; one might use the range from the 1st% female to the 99th% male

Anthropometry

Harry Saporta (2000) - explained that Msd's are among the leading causes of occupational injury and disability in the United States with low back pain the most common reason for the filling of workers compensation claims. Back pain accounts for about one fourth of all claims and for about 40% of absences from work. Also explains that the driver seat has to accommodate any operator between the 5th percentile female to the 95th percentile male. Studies concluded that the bus driver's seat had several shortcomings. Because of these shortcomings, drivers often modify the workstations through the use of portable seats or cushions to improve their postures and comfort. The findings of the study concluded that

- Insufficient adjustment ranges exist to accommodate a very high percentage of drivers
- An increase in the number and range of adjustments on the operator's seat should be made
- The overall dimensional constraints of the operator's workstation itself may be a limiting factor in the optimum use of seat adjustments

Rakesh Singh (2013) - To design and develop a comfortable driver's seat, cheaper in cost and adds value to the customer is an important issue in an automotive industry. It is tough to design such a driver car seat. However, taking account all these things, many researchers have put effort to design and developed a driver car seat considering various aspects (e.g., Biomechanical, materials, vibration absorption, safety etc.) which provides more comfortable value to driver with safety and operational durability, but still having a chance to do improvement in design and material to get an ideal designed driver car seat. This work aims to design and develop optimum driver car seat which is ergonomically satisfied have less weight and cheaper in cost. The modelling of a new driver car seat is done on AUTODESK INVENTOR software. In a new design, driver car seat lever system is replaced by a press button mechanism and an automatic seat adjusting lock system used to restrict the movement. The nylon material is used to fabricate the seat and simulation is done by using Autodesk Inventor software.

Milton Maada- Reports for adult population indicate that almost 80% of the adult population has reported some form of lower back aches. Each year American workers suffer more than300,000 lost-time injuries involving musculoskeletal disorders of the back, with the costs that run into billions of dollars. Sedentary tasks are known to be major contributing factors of back pain. Prior studies have indicated that the myoelectric activity of the lumbar region decreases when the back rest inclination of a seat increased. An increase in seat pan inclination so that it increases pressure on the leg muscles is also a cause for back pain. Seating posture is also known to be a leading cause of back pain. This study focuses on the response of the latissimusdorsi muscle in the trunk, to the backrest and seat angle inclinations for different seating postures.

R. T. Vyavahare (2014) – study explains that the word anthropometry was creates in 1870 by the Belgian mathematician, quelet. It is an integral part of the design where humans are involved. Agriculture is generally recognized as the nation's most hazardous industry and displays high risks of msd's with evidence in which the ergonomic risk factors are involved and be pointed out, there is very little history of application of ergonomic approaches in equipment design. Study also reveals that the comfortable range of elbow angle should be 100-1100.

V. PROBLEM FORMULATION

Discomfort analysis on forklift operators (Depending on previous research) shows that there are various discomforts in the body parts of operators like lower back, shoulder, neck, hip, foot etc. Reasons for these discomforts were also being investigated, following are the main reasons:

- Front back adjustment is not there for 31 % of forklifts. Drivers are feeling more comfortable if front-back adjustment is there.
- Up-down adjustment is not there in most of the vehicles, forklifts having this feature is more comfortable to drive said by drivers.
- Lumbar support is not there in any vehicle.
- Few vehicles are having back rest adjustment, drivers saying that it will be comfortable to drive if this adjustment is provided.
- Insufficient Front-back adjustment of seat pan

Present scenario of the seat

VI. RESEARCH METHODOLOGY

Literature review

Problem identification.

Collection of anthrapometric data of operators and calculate 5th and 95th percentile dimensions of seat.

To propose new seat dimensions

Finding mismatch percentage for existing and proposed dimensions

Conclusion.

Research Methodology

VII. ANTHROPOMETRIC DATA OF OPERATOR

The anthropometric dimensions were measured using a chair with a horizontal surface, portable stadiometer, and measuring tape. All anthropometric measurements (except for stature) were made while the operator was sitting in an erect position on a chair, with his knees bent at 900. The measurements were made to the nearest millimeter. The following anthropometric dimensions were measured for each operator: popliteal height, buttock to popliteal length, elbow height (sitting), shoulder height (sitting), sitting height, hip breadth, shoulder breadth (biacromial), shoulder breadth and stature

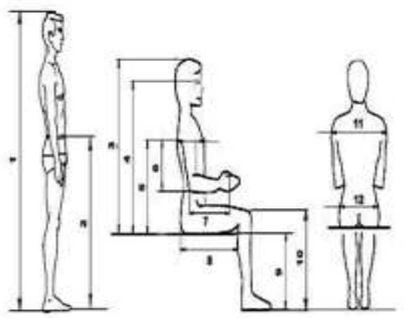


Fig 1: Anthropometric Measurements : 1. Stature 2. Waist height 3. Sitting Height 4. Sitting eye Height 5. Sitting Acromin height 6. Shoulder to elbow length 7. Elbow to Finger length 8. Buttock to popliteal length 9. Popliteal height 10. Knee height 11. Interscye breadth 12. Hip Breadth Sitting

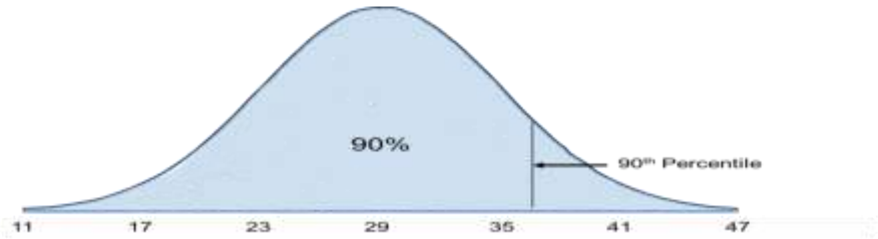
Anthropometric Measurements

COMPUTING PERCENTILE

The standard normal distribution can also be useful for computing percentiles. The median is the 50thpercentile, the first quartile is the 25th percentile, and the third quartile is the 75th percentile. In some instances, it may be of interest to compute other percentiles, for example the 5th or 95th. The formula below is used to compute percentiles of a normal distribution.

$$X = \mu + Z\sigma$$

Ϭ= S.D of variables,
Z= values from normal distribution for desired percentile.



Percentile	Z values
5th	-1.645
10th	-1.282
25th	-0.675
50th	0
90th	1.282
95th	1.645

Z values for commonly used percentiles

Measurements	Min	Max	Mean	SD	5th percentile	50th percentile	95th percentile
Stature (mm)	1580	1850	1681	61.28	1586	1681	1792
Waist height (mm)	903	1063	973	36.70	911	983	1029
Sitting height (mm)	761	944	846	43.30	762	852	921
Sitting eye height (mm)	676	835	748	36.96	680	752	814
Shoulder height (mm)	487	592	524	23.99	488	521	553
Shoulder to elbow length (mm)	230	383	302	41.41	242	295	380
Elbow to Finger length (mm)	403	462	436	15.50	413	432	460
Buttock to popliteal length (mm)	402	563	458	37.78	409	454	545
Popliteal height (mm)	378	522	427	36.43	381	421	513
Knee height (mm)	464	615	517	36.67	480	512	603
Shoulder width (mm)	260	418	304	44.06	267	286	411
Hip width (mm)	263	428	310	47.83	270	293	421

Calculated 5th 50th and 95th percentile

PROPOSED SEAT DIMENSIONS

Anthropometric data and existing seat dimensions are measured and 5th, 50th and 95th percentile has been calculated. By co-relating the seat measurements with anthropometric data new seat dimensions has been proposed

Seat dimensions	Min(mm)	Max(mm)

Seat height	415	
Pan depth	410	
Pan width	425	
Backrest height	440	
Backrest width	356	
Seat adjustment(vertical)	415	471
Seat adjustment(horizontal)	410	512
Backrest inclination	$12\text{-}19^0$	
Pan inclination	$8\text{-}13^0$	

Proposed seat dimensions

VIII. CONCLUSION

Material handling operation using forklifts having poorly designed seats imposes excessive physical loads on the operators. The present study evaluated the potential mismatch between the seat dimensions of existing forklift seats and anthropometric characteristics of all the forklift operators The results of the study provide evidence that there is a considerable mismatch between the existing forklift seats and body dimensions of the operators. The mismatch percentages for the backrest width, backrest height, seat height, seat width and seat depth were 95.34%, 32.67%, 78.7%, 92.8%, 57.6%, respectively. This meant that the existing combine seats were too high, too narrow and too shallow. Although the backrest height of the seats had a good fit for the majority of operators, the backrest width did not match their anthropometry of the operators. Such a condition may lead to increased discomfort and pain and tend to increase the risk for development of musculoskeletal problems among this population.

It can be concluded that the design and manufacturing of forklift seat should be made based on the anthropometric characteristics of actual users to avoid unnecessary demands on them. Thus, the proposed seat dimensions more appropriate for the study population were given according to the anthropometric data obtained.

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REFERENCES

[1] Harry Saport, Durable Ergonomic Seating for Urban Bus Operators Submitted Tri-County Metropolitan Transportation District of Oregon November, 2000

[2] Rakesh Singh, Designing of High Comfort, Reliable and Economical Driver Car Seat, International Journal of Emerging Technology and Advanced Engineering (ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 3, Issue 10, October 2013)

[3] Milton Maada-GormohSaidu, Effects of automobile seating posture on trunk muscle Activity.

[4] Chin- chiuanlin, Ergonomic assessment of excavator seat. International journal of applied science and engineering 2011, 92: 99-109

[5] Matthew P. Reed,Lawrence W. Schneider,Design Criteria for Automobile Seatbacks Based on Preferred Driver Postures

[6] PachlingVishwanath K, Reviwe of design aspects of major components of Automotive Seat, Asian Journal of Engineering and Technology Innovation 01(01)2013 33-38

[7] Onawumi, Ergonomic Investigation of Occupational Drivers and Seat Design of Taxicabs in Nigeria, ARPN Journal of Science and Technology, VOL. 2, NO. 3, April 2012 ISSN 2225-7217

[8] CheeFai Tan, Subjective and Objective Measurements for Comfortable Truck Driver's Seat, AVEC '08 – 141

[9] T.C Fai, Vehicle seat design: state of the art and recent development, Proceedings World Engineering Congress 2007 (pp. 51-61), Penang Malaysia, Institutions of Islamic Countries [ISBN 978-983-43571-1-5]

[10] Guenter F. Mueller, Sitting Comfort of Ergonomic Office Chairs—Developed Versus Intuitive Evaluation, International Journal of Occupational Safety and Ergonomics (JOSE) 2010, Vol. 16, No. 3, 369–374
[11] R.T. Vyvahare, S.P. Kallukar. Anthropometric and strength data of Indian agricultural workers for equipment design: a review. CIGR journal vol 14, no4. December 2014.
[12] Tim Springer, The Future of Ergonomic Office Seating
[13] Rhonda A kinghorn, Truck driver anthropometric data: Estimation of the current population,Intternational Journal of Industrial Ergonomics 15 (1995) 199-204s 15
[14] Raymond Brodeur, Herbert M. Reynolds, KalRayes Yuntao Cui, The Initial Position and Postural Attitudes of Driver Occupants Posture, June 21, 1996, ERL-TR-95-009Estimation of the current population
[15] Shen, W. and Vertiz, A. (1997) Redefining Seat Comfort. SAE Paper 970597.
[16] Survey of Auto Seat Design Recommendations for Improved Comfort by Matthew P. Reed
[17] Corlett, E. N. and Bishop, R. P. A Technique for Assessing Postural Discomfort. Ergonomics 19(2),175-182, 1976
[18] J. Hoy, N. Mubarak, S. Nelson, M. Sweerts de Landas, M. Magnusson, O. Okunribido, M. Pope "Whole body vibration and posture as risk factors for low back pain among forklift truck drivers". Journal of Sound and Vibration 284 (2005) 933–946
[19] Olanrewaju O. Okunribido, Steven J. Shimbles, Marianne Magnusson, Malcolm Pope "City bus driving and low back pain: A study of the exposures to posture demands, manual materials handling and whole-body vibration". Applied Ergonomics 38 (2007) 29–38
[20] Mike Kolich "Automobile seat comfort: occupant preferences vs. anthropometric accommodation ". Applied Ergonomics 34 (2003) 177–184
[21] R. Verschoore, J.G. Pieters, I.V. Pollet "Measurements and simulation on the comfort of forklifts ". Journal of Sound and Vibration 266 (2003) 585–599